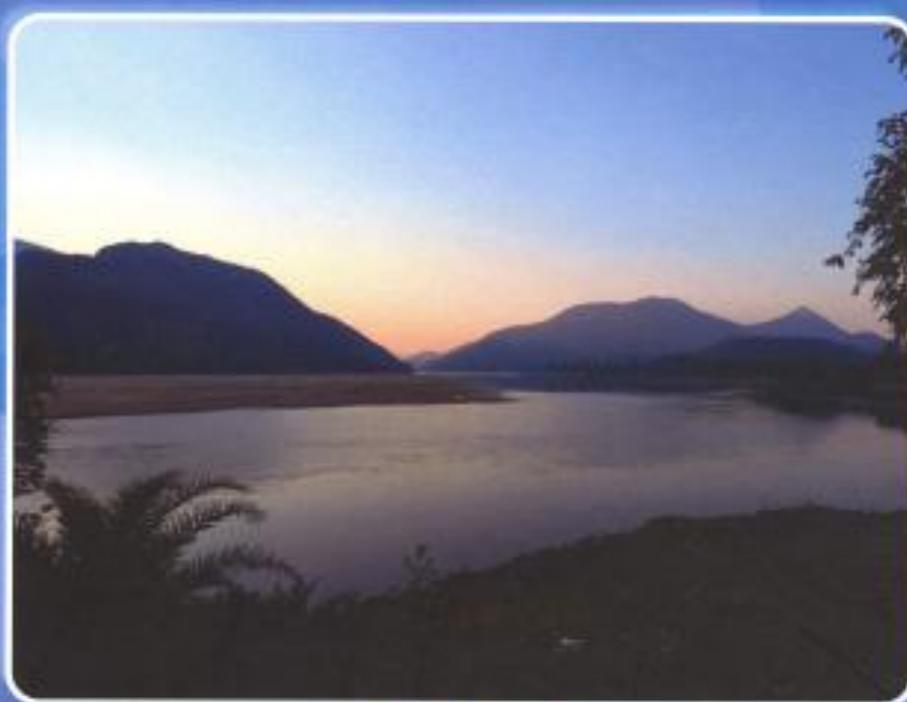


# **WATER QUALITY OF MAJOR RIVERS OF ODISHA**

## **(During 2011-2015)**



**2016**



**STATE POLLUTION CONTROL BOARD, ODISHA**  
A/118, NILAKANTHA NAGAR, UNIT-VIII,  
BHUBANESWAR-751012

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Front cover page design depicts the picture of Mahanadi river near Satakosia Reserve Forest and Back Cover page design depicts the picture of Kantilo Nilamadhav temple near Mahanadi river



**Shri R. Balakrishnan, IAS  
Chairman**



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## **FOREWORD**

The State Pollution Control Board, Odisha has been monitoring the water quality of nine river basins, Mahanadi, Brahmani, Baitarani, Rushikulya, Nagavali, Subarnarekha, Budhabalanga, Kolab and Vansadhara, in the state of Odisha, under the Central Pollution Control Board sponsored National Water Quality Monitoring Programme (NWMP). This report describes the finding of the water quality of these rivers during the period 2011-2015. Water quality of the rivers has been assessed in terms of three classification schemes, Use based, Biological and Wholesomeness. In most of the river stretches, the critical parameters governing the water quality appear to be of organic origin (Biological Oxygen Demand (BOD), Total Kjeldahl Nitrogen (TKN), Total and Fecal Coliform bacteria).

I take this opportunity to thank all those who have been involved in this exercise.

**(Shri R. Balakrishnan)**

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# CONTENTS

		Page No.
<b>Chapter I</b>	<b>Introduction</b>	01
	1.0 River basins in Odisha	02
	1.1 Mahanadi	07
	1.2 Brahmani	11
	1.3 Baitarani	14
	1.4 Rushikulya	17
	1.5 Nagavali	19
	1.6 Subarnarekha	21
	1.7 Budhabalanga	23
	1.8 Kolab	25
	1.9 Vansadhara	27
	Bibiliography	27
<b>Chapter II</b>	<b>Water quality monitoring and assessment</b>	29
	2.0 Water quality monitoring	29
	2.1 Water quality monitoring stations	29
	2.2 Water quality monitoring parameters	39
	2.3 Season description	39
	2.4 Significance of water quality parameters	39
	2.5 Water quality assessment	44
	Bibiliography	51
<b>Chapter III</b>	<b>Water quality status of Mahanadi river system</b>	52
	3.1 Use based water quality status	52
	3.2 Biological assessment of water quality	54
	3.3 Water quality in terms of wholesomeness	55
	3.4 Water quality in terms of COD and Alkalinity	56
	3.5 Water quality trend	56
	3.6 Polluted river monitoring stations in Mahanadi river system	58
	3.7 Water quality index of monitoring stations in Mahanadi river system	58
<b>Chapter IV</b>	<b>Water quality status of Brahmani river system</b>	118
	4.1 Use based water quality status	118
	4.2 Biological assessment of water quality	120
	4.3 Water quality in terms of wholesomeness	120
	4.4 Water quality in terms of COD and Alkalinity	121
	4.5 Water quality trend	121
	4.6 Polluted river monitoring stations in Brahmani river system	123
	4.7 Water quality index of monitoring stations in Brahmani river system	123
<b>Chapter V</b>	<b>Water quality status of Baitarani river basin</b>	169
	5.1 Use based water quality status	169
	5.2 Biological assessment of water quality	171
	5.3 Water quality in terms of wholesomeness	171
	5.4 Water quality in terms of COD and Alkalinity	172
	5.5 Water quality trend	172
	5.6 Polluted river monitoring stations in Baitarani river system	173
	5.7 Water quality index of monitoring stations in Baitarani river system	173
<b>Chapter VI</b>	<b>Water quality status of Rushikulya river</b>	195

	6.1	Use based water quality status	195
	6.2	Biological assessment of water quality	197
	6.3	Water quality in terms of wholesomeness	197
	6.4	Water quality in terms of COD and Alkalinity	198
	6.5	Water quality trend	198
	6.6	Polluted river monitoring stations in Rushikulya river	198
	6.7	Water quality index of monitoring stations in Rushikulya river	199
<b>Chapter VII</b>		<b>Water quality status of Nagavali river</b>	<b>208</b>
	7.1	Use based water quality status	208
	7.2	Biological assessment of water quality	210
	7.3	Water quality in terms of wholesomeness	210
	7.4	Water quality in terms of COD and Alkalinity	211
	7.5	Water quality trend	211
	7.6	Polluted river monitoring stations in Nagavali river	212
	7.7	Water quality index of monitoring stations in Nagavali river	212
<b>Chapter VIII</b>		<b>Water quality status of Subarnarekha river</b>	<b>223</b>
	8.1	Use based water quality status	223
	8.2	Biological assessment of water quality	224
	8.3	Water quality in terms of wholesomeness	224
	8.4	Water quality in terms of COD and Alkalinity	225
	8.5	Water quality trend	225
	8.6	Polluted river monitoring stations in Subarnarekha river	226
	8.7	Water quality index of monitoring stations in Subarnarekha river	226
<b>Chapter IX</b>		<b>Water quality status of Budhabalanga river</b>	<b>232</b>
	9.1	Use based water quality status	232
	9.2	Biological assessment of water quality	233
	9.3	Water quality in terms of wholesomeness	234
	9.4	Water quality in terms of COD and Alkalinity	235
	9.5	Water quality trend	235
	9.6	Polluted river monitoring stations in Budhabalanga river	235
	9.7	Water quality index of monitoring stations in Budhabalanga river	236
<b>Chapter X</b>		<b>Water quality status of Kolab river system</b>	<b>246</b>
	10.1	Use based water quality status	246
	10.2	Biological assessment of water quality	247
	10.3	Water quality in terms of wholesomeness	248
	10.4	Water quality in terms of COD and Alkalinity	248
	10.5	Water quality trend	248
	10.6	Polluted river monitoring stations in Kolab river system	249
	10.7	Water quality index of monitoring stations in Kolab river system	249
<b>Chapter XI</b>		<b>Water quality status of Vansadhara river</b>	<b>256</b>
	11.1	Use based water quality status	256
	11.2	Biological assessment of water quality	258
	11.3	Water quality in terms of wholesomeness	258
	11.4	Water quality in terms of COD and Alkalinity	259
	11.5	Water quality trend	259
	11.6	Polluted river monitoring stations in Vansadhara river	259
	11.7	Water quality index of monitoring stations in Vansadhara river	259
<b>Chapter XII</b>		<b>Conclusion</b>	<b>268</b>

## **LIST OF FIGURES**

- Fig. 1.1 River basin map of Odisha with district boundaries
- Fig. 1.2 Coverage of river basins (in percentage) in Odisha
- Fig. 1.3 Map of Mahanadi basin in Odisha
- Fig. 1.4 Area coverage of districts (in percentage) in Mahanadi basin in Odisha
- Fig. 1.5 Schematic diagram of the Mahanadi river system in Odisha
- Fig. 1.6 Map of Brahmani basin map in Odisha
- Fig. 1.7 Area coverage of districts (in percentage) in Brahmani basin in Odisha
- Fig. 1.8 Schematic diagram of Brahmani river system in Odisha
- Fig. 1.9 Area coverage of districts (in percentage) in Baitarani basin in Odisha
- Fig. 1.10 Map of Baitarani basin in Odisha
- Fig. 1.11 Schematic diagram of Baitarani river system
- Fig. 1.12 Map of Rushikulya Basin
- Fig. 1.13 Area coverage of districts (in percentage) in Rushikulya basin
- Fig. 1.14 Area coverage of districts (in percentage) in Nagavali basin in Odisha
- Fig. 1.15 Map of Nagavali basin in Odisha
- Fig. 1.16 Area coverage of districts (in percentage) in Subarnarekha basin in Odisha
- Fig. 1.17 Map of Subarnarekha basin in Odisha
- Fig. 1.18 Area coverage of districts (in percentage) in Budhabalanga basin in Odisha
- Fig. 1.19 Map of Budhabalanga basin in Odisha
- Fig. 1.20 Area coverage of districts (in percentage) in basin in Odisha
- Fig. 1.21 Map of Kolab basin in Odisha
- Fig. 1.22 Area coverage of districts (in percentage) in Vansadahara basin in Odisha
- Fig. 1.23 Map of Vansadhara basin in Odisha
- Fig. 3.1 Frequency of violation of BOD in Mahanadi River (2011-2015)
- Fig. 3.2 Frequency of violation of BOD in Ib River, Bheden River and Tel River (2011-2015)
- Fig. 3.3 Frequency of violation of BOD in Kathajodi River, Serua River, Kuakhai River, Daya River and Birupa River (2011-2015)
- Fig.3.4(a) Spatial variation of BOD in Mahanadi River (Hirakud-Sonepur D/s) (2011-2015)
- Fig.3.4(b) Spatial variation of BOD in Mahanadi River (Tikarpada-Paradeep D/s) (2011-2015)
- Fig.3.4(c) Spatial variation of BOD in Ib, Bheden and Tel Rivers (2011-2015)
- Fig.3.4(d) Spatial variation of BOD in Kathajodi, Serua, Kuakhai, Daya and Birupa Rivers (2011-2015)
- Fig. 3.5(a) Spatial variation of TC in Mahanadi River (Hirakud-Sonepur D/s) (2011-2015)
- Fig.3.5(b) Spatial variation of TC in Mahanadi River (Tikarpada-Paradeep D/s) (2011-2015)
- Fig.3.5(c) Spatial variation of TC in Ib, Bheden and Tel Rivers (2011-2015)
- Fig.3.5(d) Spatial variation of TC in Kathajodi, Serua, Kuakhai, Daya and Birupa Rivers (2011-2015)

- Fig. 4.1 Frequency of violation of BOD in Brahmani River (2011-2015)
- Fig.4.2 Frequency of violation of BOD in Sankh River, Koel River, Nandira Jhor, Kisinda Jhor and Kharasrota River (2011-2015)
- Fig.4.3 (a) Spatial variation of BOD in Brahmani River (2011-2015)
- Fig.4.3 (b) Spatial variation of TC in Brahmani River (2011-2015)
- Fig.4.4 (a) Spatial variation of BOD in Sankh, Koel, Nandira Jhor, Kisinda jhor and Kharasrota River (2011-2015)
- Fig.4.4 (b) Spatial variation of TC in Sankh, Koel, Nandira Jhor, Kisinda jhor and Kharasrota River (2011-2015)
- Fig. 5.1 Frequency of violation of BOD in Baitarani, Dhamra and Kusei Rivers (2011-2015)
- Fig. 5.2 Spatial variation of BOD in Baitarani, Dhamra and Kusei rivers (2011-2015)
- Fig. 5.3 Spatial variation of TC in Kusei, Baitarani and Dhamra rivers (2011-2015)
- Fig. 6.1 Frequency of violation of BOD in Rushikulya river (2011-2015)
- Fig. 6.2 Spatial variation of BOD in Rushikulya river (2011-2015)
- Fig. 6.3 Spatial variation of TC in Rushikulya river (2011-2015)
- Fig. 7.1 Frequency of violation of BOD in Nagavali river (2011-2015)
- Fig. 7.2 Spatial variation of BOD in Nagavali river (2011-2015)
- Fig. 7.3 Spatial variation of TC in Nagavali river (2011-2015)
- Fig. 8.1 Frequency of violation of BOD in Subarnarekha river (2011-2015)
- Fig. 8.2 Variation of BOD in Subarnarekha river (2011-2015)
- Fig. 8.3 Variation of TC in Subarnarekha river (2011-2015)
- Fig. 9.1 Frequency of violation of BOD in Budhabalanga river (2011-2015)
- Fig. 9.2 Spatial variation of BOD in Budhabalanga river (2011-2015)
- Fig. 9.3 Spatial variation of TC in Budhabalanag ariver (2011-2015)
- Fig. 10.1 Frequency of violation of BOD in Kolab river system (2011-2015)
- Fig. 10.2 Variation of BOD in Kolab river system (2011-2015)
- Fig. 10.3 Variation of TC in Kolab river system (2011-2015)
- Fig. 11.1 Frequency of violation of BOD in Vansadhara river (2011-2015)
- Fig. 11.2 Spatial variation of BOD in Vansadhara river (2011-2015)
- Fig. 11.3 Spatial variation of TC in Vansadhara river (2011-2015)

## **LIST OF TABLES**

Table 1.1	Basin features of major rivers flowing in Odisha
Table 2.1	River system-wise distribution of water quality monitoring stations
Table 2.2	Details of water quality monitoring stations
Table 2.3	Use based classification
Table 2.4	Primary water quality criteria
Table 2.5	Tolerance limits for other parameters
Table 2.6	Biological Indicators
Table 2.7	Standards for regular monitoring parameters
Table 2.8	Standards for special parameters
Table 2.9	Prioritization of river monitoring stations based on BOD values
Table 2.10	Category of water quality based on CWQI values

### **Mahanadi River System**

Table 3.1	Seasonal average values of pH, DO, BOD and TC in Ib river at Sundargarh, Jharsuguda , Brajaraj nagar U/s and Brajaraj nagar D/s
Table 3.2	Seasonal average values of pH, DO, BOD and TC in Bheden river at Jharsuguda, Hirakud Reservoir, Upstream and Downstream of Power Channel
Table 3.3	Seasonal average values of pH, DO, BOD and TC in Mahanadi river at Sambalpur U/s, Sambalpur D/s, Sambalpur FD/s at Shankarmath and Sambalpur FFD/s at Huma
Table 3.4	Seasonal average values of pH, DO, BOD and TC in Mahanadi river at Sonepur U/s and Sonepur D/s, Tikarpada and Narasinghpur
Table 3.5	Seasonal average values of pH, DO, BOD and TC in Mahanadi river at Munduli, Cuttack U/s, Cuttack D/s and Cuttack FD/s
Table 3.6	Seasonal average values of pH, DO, BOD and TC in Mahanadi river at Paradeep U/s, Paradeep D/s, Tel river at Monmunda D/s and Birupa river at Choudwar
Table 3.7	Seasonal average values of pH, DO, BOD and TC in Kathajodi river at Cuttack U/s, Cuttack D/s, Cuttack FD/s at Mattagajpur and in Serua river at Cuttack FD/s at Sankhatrasa
Table 3.8	Seasonal average values of pH, DO, BOD and TC in Kuakhai river at Bhubaneswar FU/s and Bhubaneswar U/s, in Daya river at Bhubaneswar D/s and Bhubaneswar FD/s
Table 3.9	Annual average and Range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit
Table 3.10	Annual average and range values of Ammonical Nitrogen (mg/l)
Table 3.11	Seasonal average values of Electrical Conductivity (microSiemens/cm)
Table 3.12	Annual average and Range values of Sodium Absorption Ratio (SAR) and Boron ( B)
Table 3.13	Annual average and Range values of Total Dissolved Solids (TDS) and Total Hardness (TH )

Table 3.14	Annual average and Range values of Nitrate (as NO <sub>3</sub> )
Table 3.15	Annual average and Range values of Chloride
Table 3.16	Annual average and Range values of Sulphate
Table 3.17	Annual average and Range values of Fluoride
Table 3.18	Annual average and Range values of Metals
Table 3.19	Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class
Table 3.20	Annual average and Range of (Nitrite+Nitrate)- Nitrogen values
Table 3.21	Annual average and Range values of Total Suspended Solids (TSS)
Table 3.22	Percentage violation and Annual Range of Fecal Coliform (FC) values
Table 3.23	Annual average and Range values of Total Phosphate-P
Table 3.24	Annual average and Range of values of Total Kjeldahl Nitrogen (TKN)
Table 3.25	Annual average and Range of values of Chemical Oxygen Demand (COD)
Table 3.26	Annual average and Range of values of Total Alkalinity
Table 3.27	Polluted river monitoring stations in Mahanadi river systems
Table 3.28	CWQI of Mahanadi river system during 2011-2015
Table 3.29	Category of water quality of Mahanadi river system during 2011-2015 based on CWQI values

### **Brahmani River System**

Table 4.1	Seasonal average values of pH, DO, BOD and TC in Sankh river at Sankh U/s and in Koel river at Koel U/s
Table 4.2	Seasonal average values of pH, DO, BOD and TC in Brahmani river at Panposh U/s, Panposh D/s, Rourkela D/s, Rourkela FD/s at Attaghat and Rourkela FFD/s at Biritola
Table 4.3	Seasonal average values of pH, DO, BOD and TC in Brahmani river at Bonaigarh, Rengali and Samal
Table 4.4	Seasonal average values of pH, DO, BOD and TC in Brahmani river at Talcher FU/s, Talcher U/s, Talcher D/s and Talcher FD/s
Table 4.5	Seasonal average values of pH, DO, BOD and TC in Nandira jhor at Nandira D/s and in Kisindajhor at Kisindajhor
Table 4.6	Seasonal average values of pH, DO, BOD and TC in Brahmani river at Dhenkanal U/s, Dhenkanal D/s
Table 4.7	Seasonal average values of pH, DO, BOD and TC in Brahmani river at Bhuban and Kabatabandha
Table 4.8	Seasonal average values of pH, DO, BOD and TC in Brahmani river at Dharmasala U/s and Dharmasala D/s
Table 4.9	Seasonal average values of pH, DO, BOD and TC in Brahmani river at Pottamundai and in Kharasrota river at Khanditara, Binjharpur, Aul

Table 4.10	Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit
Table 4.11	Annual average and range values of Ammonical Nitrogen (mg/l)
Table 4.12	Seasonal average values of Electrical Conductivity (microSiemens/cm)
Table 4.13	Annual average and range values of Sodium Absorption Ratio (SAR) and Boron (B)
Table 4.14	Annual average and range values of Total Dissolved solids (TDS) and Total Hardness (TH)
Table 4.15	Annual average and range values of Nitrate (as NO <sub>3</sub> )
Table 4.16	Annual average and range values of Chloride
Table 4.17	Annual average and range values of Sulphate
Table 4.18	Annual average and range values of Fluoride
Table 4.19	Annual average and range values of Metals
Table 4.20	Annual average and Range of Saprobic index (SI) , Diversity Index (DI) and Biological Class
Table 4.21	Annual average and Range of (Nitrite+Nitrate)-Nitrogen values
Table 4.22	Annual average and Range of Total Suspended Solids (mg/l)
Table 4.23	Percentage violation and annual range of Fecal Coliform (FC) values
Table 4.24	Annual average and Range values of Total Phosphate-P
Table 4.25	Annual average and Range values of Total Kjeldahl Nitrogen (TKN)
Table 4.26	Annual average and Range values of Chemical Oxygen Demand (COD)
Table 4.27	Annual average and Range values of Total Alkalinity
Table 4.28	Polluted River Monitoring Stations in Brahmani River System
Table 4.29	CWQI of Brahmani river system during 2011-2015
Table 4.30	Category of water quality of Brahmani river system during 2011-2015 based on CWQI values

### **Baitarani River System**

Table 5.1	Seasonal average values of pH, DO, BOD and TC in Baitarani river at Joda, Anandpur, Jajpur, Chandbali U/s
Table 5.2	Seasonal average values of pH, DO, BOD and TC in Baitarani river at Chandbali D/s, in Kusei river at Deogaon and in Dhamra river at Dhamra
Table 5.3	Seasonal average values of pH, DO, BOD and TC in Salandi river at Bhadrak U/s and Bhadrak D/s
Table 5.4	Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit
Table 5.5	Annual average and range values of Ammonical Nitrogen
Table 5.6	Seasonal average values of Electrical Conductivity (microSiemens/cm)
Table 5.7	Annual average and range values of Sodium Absorption Ratio (SAR) and Boron
Table 5.8	Annual average and range values of Total Dissolved Solids (TDS) and Total Hardness (TH)
Table 5.9	Annual average and range values of Nitrate (as NO <sub>3</sub> )

Table 5.10	Annual average and range values of Chloride, Sulphate and Fluoride
Table 5.11	Annual average and range values of Metals
Table 5.12	Annual average and range values of (Nitrite+Nitrate)- Nitrogen
Table 5.13	Annual average and range values of Total suspended solids (TSS)
Table 5.14	Percentage violation and Annual range of Fecal coliform (FC) values
Table 5.15	Annual average and range values of Total Phosphate-P
Table 5.16	Annual average and range values of Total Kjeldahl Nitrogen (TKN)
Table 5.17	Annual average and range values of Chemical Oxygen Demand (COD)
Table 5.18	Annual average and range values of Total Alkalinity
Table 5.19	Polluted river monitoring stations in Baitarani river system
Table 5.20	CWQI of Baitarani river system
Table 5.21	Category of water quality of Baitarani river system based on CWQI values

### **Rushikulya River**

Table 6.1	Seasonal average values of pH, DO, BOD and TC in Rushikulya river at Madhopur and Potagada
Table 6.2	Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit
Table 6.3	Annual average and Range values of Ammonical Nitrogen
Table 6.4	Seasonal average values of Electrical Conductivity (microSiemens/cm)
Table 6.5	Annual average and Range values of SAR and Boron (B)
Table 6.6	Annual average and Range values of Total Dissolved Solids (TDS) and Total Hardness (TH)
Table 6.7	Annual average and Range values of Nitrate (as NO <sub>3</sub> ) (mg/l)
Table 6.8	Annual average and Range values Chloride, Sulphate and Fluoride
Table 6.9	Annual average and Range values of Metals
Table 6.10	Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class
Table 6.11	Annual average and Range values of (Nitrite+Nitrate)-Nitrogen
Table 6.12	Annual average and Range values of Total Suspended Solids (TSS)
Table 6.13	Percentage violation and Range of Fecal coliform values
Table 6.14	Annual average and Range values of Total Phosphate-P
Table 6.15	Annual average and Range values of Total Kjeldahl Nitrogen(TKN)
Table 6.16	Chemical Oxygen Demand (COD) and Total Alkalinity
Table 6.17	Polluted river monitoring stations in Rushikulya river
Table 6.18	CWQI of Rushikulya river and category of water quality based on CWQI values

## **Nagavali River**

Table 7.1	Seasonal average values of pH, DO, BOD and TC in Nagavali river at Penta U/s, Jaykaypur D/s and Rayagada D/s
Table 7.2	Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit
Table 7.3	Annual average and Range values of Values of Ammonical Nitrogen (mg/l)
Table 7.4	Seasonal average values of Electrical Conductivity (microSiemens/ cm)
Table 7.5	Annual average and Range values of SAR and B
Table 7.6	Annual average and Range values of TDS and Total Hardness (TH)
Table 7.7	Annual average and Range values of Nitrate (as NO <sub>3</sub> )
Table 7.8	Annual average and Range values of Chloride, Sulphate and Fluoride
Table 7.9	Annual average and Range values of Metals
Table 7.10	Annual average and Range of Saprobic Index (SI), Diversity Index (DI) values (DI) and Biological Class
Table 7.11	Annual average and Range values of (Nitrite+Nitrate)-Nitrogen
Table 7.12	Annual average and Range values of Total Suspended Solids (TSS)
Table 7.13	Percentage violation and Annual range of Fecal coliform values
Table 7.14	Annual average and Range values of Total Phosphate-P (mg/l)
Table 7.15	Annual average and Range values of Total Kjeldahl Nitrogen (TKN)
Table 7.16	Annual average and Range values of Chemical Oxygen Demand (COD) and Total Alkalinity
Table 7.17	Polluted river monitoring stations in Nagavali river
Table 7.18	CWQI of Nagavali river during 2011-2015 and category of water quality based on CWQI values

## **Subarnarekha River**

Table 8.1	Seasonal average of pH, DO, BOD and TC values in Subarnarekha river at Rajghat
Table 8.2	Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit at Rajghat
Table 8.3	Annual average and range values of Ammonical Nitrogen
Table 8.4	Seasonal average values of Electrical Conductivity (microSiemens/cm)
Table 8.5	Annual average and range values of SAR and B values
Table 8.6	Annual average and range values of TDS and Total Hardness (TH)
Table 8.7	Annual average and range values of Nitrate (as NO <sub>3</sub> ) (mg/l)
Table 8.8	Annual average and range values of Chloride, Sulphate and Fluoride
Table 8.9	Annual average and range values of Metals (mg/l)
Table 8.10	Annual average and range values of SI and DI and Biological class

Table 8.11	Annual average and range values of (Nitrite+Nitrate)-Nitrogen and Total Suspended Solids (TSS)
Table 8.12	Percentage violation and Annual range of Fecal coliform values
Table 8.13	Total Phosphate-P (mg/l)
Table 8.14	Total Kjeldahl Nitrogen (TKN) (mg/l)
Table 8.15	Chemical Oxygen Demand (COD) (mg/l) and Total Alkalinity
Table 8.16	CWQI of Subarnarekha river and Category of water quality based on CWQI Values

### **Budhabalanga River**

Table 9.1	Sesaonal average values of pH, DO, BOD and TC in Budhabalanga river at Baripada D/s, Balasore U/s and Balasore D/s
Table 9.2	Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit
Table 9.3	Annual average and range values of Ammonical Nitrogen
Table 9.4	Seasonal average values of Electrical Conductivity (microSiemens/cm)
Table 9.5	Annual average and range values of SAR and B
Table 9.6	Annual average and range values of TDS and Total Hardness
Table 9.7	Annual average and range values of Nitrate (as NO <sub>3</sub> ) (mg/l)
Table 9.8	Annual average and range values of Chloride, Sulphate and Fluoride
Table 9.9	Annual average and range values of Metals
Table 9.10	Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class
Table 9.11	Annual average and Range values of (Nitrite+Nitrate)-Nitrogen
Table 9.12	Annual average and Range values of Total Suspended Solids (TSS )
Table 9.13	Percentage violation and Annual range of Fecal coliform values
Table 9.14	Annual average and range of Total Phosphate-P and Total Kjeldahl Nitrogen (TKN)
Table 9.15	Chemical Oxygen Demand (COD) and Total Alkalinity
Table 9.16	Polluted river monitoring station in Budhabalanga river
Table 9.17	CWQI of Budhabalanga river and category of water quality based on CWQI values

### **Kolab River System**

Table 10.1	Seasonal average values of pH, DO, BOD, TC and EC in Kerandi river at Sunabeda
Table 10.2	Annual average and range values of BOD and Total Coliform and frequency of deviation from criteria limit
Table 10.3	Annual average and range values of Ammonical Nitrogen
Table 10.4	Annual average and range values of SAR and B
Table 10.5	Annual average and range values of TDS and Total Hardness

Table 10.6	Annual average and range values of Nitrate (as NO <sub>3</sub> )
Table 10.7	Annual average and range values of Chloride, Sulphate and Fluoride
Table 10.8	Annual average and range values of Metals
Table 10.9	Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class
Table 10.10	Annual average and range values of Nitrite+Nitrate)-Nitrogen
Table 10.11	Annual average and range values Total Suspended Solids (TSS)
Table 10.12	Percentage violation and Annual range of Fecal coliform values
Table 10.13	Annual average and range values Total Phosphate-P and Total Kjeldahl Nitrogen (TKN)
Table 10.14	Annual average and range values Chemical Oxygen Demand (COD) and Total Alkalinity
Table 10.15	CWQI of Kolab river system and category of water quality based on CWQI values

### **Vansadhara River**

Table 11.1	Seasonal average values of pH, DO, BOD TC in Vansadhara river at Muniguda and Gunupur
Table 11.2	Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit
Table 11.3	Annual average and Range Values of Ammonical Nitrogen
Table 11.4	Annual average and Range Values of SAR and B
Table 11.5	Annual average and Range Values of TDS and Total Hardness
Table 11.6	Annual average and Range Values of Nitrate (as NO <sub>3</sub> )
Table 11.7	Annual average and Range Values of Chloride, Sulphate and Fluoride
Table 11.8	Annual average and Range Values of Metals (mg/l)
Table 11.9	Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class
Table 11.10	Annual average and Range Values of (Nitrite+Nitrate)-Nitrogen
Table 11.11	Annual average and Range Values of Total Suspended Solids (TSS)
Table 11.12	Annual Range Values and Percentage violation of Fecal coliform
Table 11.13	Annual average and Range Values of Total Phosphate-P and Total Kjeldahl Nitrogen (TKN)
Table 11.14	Annual average and Range Values of Chemical Oxygen Demand (COD) and Total Alkalinity
Table 11.15	CWQI of Vansadhara river and category of water quality based on CWQI values

## EXECUTIVE SUMMARY

The State Pollution Control Board, Odisha, is monitoring the water quality of nine river systems of the state, viz. Mahanadi, Brahmani, Baitarani, Rushikulya, Nagavali, Subarnarekha, Budhabalanga, Kolab and Vansadhara under the National Water Quality Monitoring Project (NWMP) and State Water Quality Monitoring Project (SWMP) at 69 monitoring stations as given in Table-1. The report describes summary of the findings made during the period 2011-2015. This report is in continuance of earlier two reports by the Board under the title "Water quality of major rivers in Orissa" published in the year 2007 and "Water quality of major rivers of Odisha (during 2007-2010) published in the year 2012.

Sl. No.	River basin	NWMP	SWMP
1.	Mahanadi	<b>Ib</b> : Sundargarh, Jharsuguda Brajarajnaragar U/s, Brajarajnaragar D/s <b>Bheden</b> : Bheden R. before Jharsuguda Hirakud reservoir Power Channel D/s <b>Mahanadi</b> : Sambalpur U/s, Sambalpur D/s, Sambalpur FFD/s at Huma, Sonapur U/s, Sonapur D/s, Tikarpada, Narasinghpur, Mundali, Cuttack U/s, Cuttack D/s, Paradeep U/s, Paradeep D/s <b>Tel</b> : Monmunda <b>Kathjodi</b> : Cuttack D/s <b>Serua</b> : Sankhatrasa <b>Kuakhai</b> : Bhubaneswar FU/s, Bhubaneswar U/s <b>Daya</b> : Bhubaneswar D/s, Bhubaneswar FD/s <b>Birupa</b> : Choudwar D/s	<b>Mahanadi</b> : Sambalpur FD/s at Shankarmath, Power channel U/s, Cuttack FD/S  <b>Kathjodi</b> : Cuttack U/s, Cuttack FD/s at Mattagajpur
2.	Brahmani	<b>Sankh</b> : Sankh U/s <b>Koel</b> : Koel U/s <b>Brahmani</b> : Panposh U/s, Panposh D/s, Rourkela D/s, Rourkela FFDS at Biritola, Bonaigarh, Rengali, Samal, Talcher FU/s, Talcher U/s, Talcher D/s, Talcher FD/s, Dhenkanal D/s, Bhuban, Dharmasala U/s and Dharmasala D/s, Kabatabandha, Pottamundai <b>Kharasrota</b> : Khanditara, Aul	<b>Brahmani</b> : Rourkela FDS at Attaghat, Dhenkanal U/s <b>Nadira</b> : Nadira D/s at Dasnalli <b>Kisindajhor</b> : Kisindajhor <b>Kharasrota</b> : Binjharpur
3.	Baitarani	<b>Baitarani</b> : Joda, Anandpur, Jajpur, Chandbali U/s and Chandbali D/s <b>Dhamra</b> : Dhamra <b>Kusei</b> : Deogan	<b>Salanadi</b> : Bhadrak U/s and Bhadrak D/s -
4.	Rushikulya	Madhopur, Potagarh	-
5.	Nagavali	Penta U/s, Jaykaypur D/s, Rayagada D/s	-
6.	Subarnarekha	Rajghat	-
7.	Budhabalanga	Baripada D/s, Balasore D/s	Balasore U/s
8.	Kolab	Kerandi river at Sunabeda	-
9.	Vansadhara	Muniguda, Gunupur	-

## **WATER QUALITY ASSESSMENT**

The following water quality parameters are monitored at all locations on monthly basis.

- (a) *Physical parameters* : Temperature, pH, Alkalinity, Total suspended solids (TSS).
- (b) *Indicators of organic pollution* : Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonical (Ammonium + ammonia)-Nitrogen, Total Kjeldahl Nitrogen (TKN). Free ammonia-Nitrogen is calculated from pH and Ammonical nitrogen values.
- (c) *Bacteriological parameters* : Total Coliform and Fecal Coliform.
- (d) *Mineral constituents* : Electrical Conductivity (EC), Total Dissolved Solids (TDS), Boron, Total hardness, Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate, Fluoride.
- (e) *Nutrients* : Nitrate (Nitrate+ Nitrite)-Nitrogen, Phosphate- phosphorous.
- (f) *Metals* : Chromium (Cr) (total and hexavalent), Iron (Fe), Nickel (Ni), Copper (Cu), Zinc (Zn), Cadmium (Cd), Mercury (Hg), Lead (Pb)
- (g) *Biological Indices* : Saprobic Index (SI) and Diversity Index (DI). Biological indices are calculated on quarterly basis during January, March and October. Monsoon period is excluded from the biomonitoring studies.

Water quality of the rivers has been assessed in terms of three classification schemes – viz. Use based, Biological and Wholesomeness.

### **Use based classification**

The standards prescribed for the tolerance limits for inland surface waters (IS.2296-1982 - Second revision) for the following five designated best uses of a part of river body or whole of it, are considered for assessment of the water quality of the rivers under study.

- Class-A - Drinking water source without conventional treatment but after disinfection.
- Class-B - Outdoor bathing.
- Class-C - Drinking water source with conventional treatment followed by disinfection.
- Class-D - Fish culture and wild life propagation.
- Class-E - Irrigation, industrial cooling or controlled waste disposal.

### **Biological assessment of water quality**

Biological assessment is based on the fact that pollution of water bodies will cause changes in the physical and chemical environment of water, which, in turn, will disrupt the ecological balance of the ecosystem. Through bio-monitoring, the cumulative effects of all the pollutants can be determined and the overall health of the ecosystem can be assessed.

Biomonitoring results are generally expressed in terms of two indices, namely, Saprobic index (SI) and Diversity index (DI). Basing on the SI and DI values and BOD values, water quality are

categorized into Clean (High Biodiversity with  $DI > 0.6$ ,  $SI = 6-10$ ,  $BOD < 3 \text{ mg/l}$ ), Slight to Moderate Pollution (Moderate Biodiversity with  $DI = 0.2 - 0.6$ ,  $SI = 2 \text{ to } 6$ ,  $BOD = 3 \text{ to } 6 \text{ mg/l}$ ) and Heavy to Severe Pollution (Poor Biodiversity with  $DI < 0.2$ ,  $SI$ ,  $BOD > 6 \text{ mg/l}$ ).

### **Water quality in terms of wholesomeness**

The basic objective of the Water (Prevention and Control of Pollution) Act, 1974, which governs the water quality management in the country, is "to provide for the prevention and control of water pollution and maintaining or restoring the wholesomeness of water". Therefore, the first priority in water quality assessment and management should be to maintain and restore to a desirable level of the environmental quality of a water ecosystem. Accordingly specific requirements for "Acceptable", "Desirable" and "Excellent" levels of wholesomeness with short, medium and long term goals have been laid down (Water Quality - Criteria and Goals, CPCB, MINARS/17/2001/2002).

### **Identification of polluted river monitoring stations**

As the level of BOD varies in river water along its stretch, attention for pollution control measures varies with the degree of pollution level with respect to BOD values. Therefore, CPCB has prioritized the monitoring stations into five categories from Priority - I to Priority -V based on the BOD concentrations as follows.

<b>Category</b>	<b>BOD limit, mg/l</b>
Priority-I	Monitoring locations with BOD concentration greater than 30 mg/l
Priority-II	Monitoring locations with BOD concentration between 20- 30 mg/l
Priority-III	Monitoring locations with BOD concentration between 10-20 mg/l
Priority-IV	Monitoring locations with BOD concentration between 6-10 mg/l
Priority-V	Monitoring locations with BOD concentration between 3- 6 mg/l

The degree of violation is calculated with respect to water quality criteria for BOD in drinking water source with conventional treatment followed by disinfection (i.e. for Class-C). The polluted locations in a continuous sequence is called polluted river stretches.

### **Water Quality Index**

Water quality index (WQI) is used to indicate the overall water quality of a water body. It is also used to evaluate the water quality profile of the entire stretch of a river and to identify the gap between the existing and desired water quality significant enough to plan for pollution control management. WQI is expressed in terms of a number which is derived from the integration of certain physico-chemical and biological constituents of water which have significant impact on the beneficial uses of the water body. Most of water quality indices being used in different parts of the world are based on the water quality index developed by the U.S. National Sanitation Foundation (NSFWQI). Canadian Council of Ministers of the Environment (CCME) developed the water quality index (CWQI) (CCME, 2003), which has been

used by environmental authorities in several nations to assess water quality of rivers and other aquatic resources. The CWQI is derived from a number of use-based variables and has the advantage of considering the type of physico-chemical and biological variables depending upon the overall use of the water segment. The formulation of CWQI has the flexibility in using the number of such variables and the tolerance limits for various uses of water segment or whole of the water bodies.

## **WATER QUALITY STATUS**

### **Mahanadi River System :**

Water quality of the Hirakud reservoir almost conforms to Class - B, except for TC values. The water quality at all stations except Sambalpur D/s, Sambalpur FD/s at Shankarmath, Cuttack D/s (Kathajodi), Bhubaneswar D/s and FD/s (Daya) can be classified as Class-C. The water quality at the downstream of Sambalpur, Cuttack and Bhubaneswar do not conform to Class- C with respect to both BOD and TC. Further, the water quality at all stations conform to Class-D and E. However, due to tidal influence, water quality of Mahanadi river at Paradeep do not qualify even for Class-E with respect to several parameters like EC, SAR, Chloride, sulfate and total dissolved solid.

Taking into consideration the observed biological indices and the BOD values, it may be concluded that the river stretches monitored at Brajarajnagar D/s (Ib), Sambalpur D/s (Mahanadi), Cuttack D/s (Mahanadi), Cuttack D/s (Kathajodi) and Bhubaneswar D/s (Daya) are in a state of slight to moderate pollution.

With regard to wholesomeness, water quality at all stations are below acceptable level, mostly due to FC, TKN, TSS and phosphate. An additional factor at Paradeep is EC.

Comparison of BOD data obtained during the period 2011-2015 with the tolerance limits for Class-C revealed that there are fourteen polluted river monitoring stations on Mahanadi river and its distributaries. The polluted monitoring locations in a continuous sequence are identified as the polluted river stretches. Thus, there are five polluted river stretches, such as Sambalpur stretch (3 km) (Priority-V) and Cuttack stretch (15 km) (Priority-V) on Mahanadi river, Cuttack stretch (19 km) (Priority -II) on Kathajodi river, Cuttack stretch (4 km) (Priority- V) on Serua river and Bhubaneswar stretch (30 Km) (Priority IV) on Daya river. Besides these, Paradeep D/s (Priority-V) on Mahanadi river and Bhubaneswar U/s (Priority-V) on Kuakhai river have also been identified as the polluted river monitoring stations.

The Canadian Water Quality Indices (CWQI) of Mahanadi river system are calculated taking into four critical variables such as pH, DO, BOD and TC. Based on CWQI values, water quality of Ib river at Sundargarh, Jharsuguda, Brajarajnagar U/s and Brajarajnagar D/s vary within Good-Excellent category. Water quality of Bheden river at Jharsuguda, Hirakud reservoir, Power Channel and of Tel river at Monmunda also vary within Good-Excellent category.

In the Sambalpur stretch of Mahanadi river, water quality is within Fair-Good range at the upstream of Sambalpur town, which has been lowered to Marginal category at the downstream of the Sambalpur town. From Sonepur to Munduli, water quality of Mahanadi river remained mostly within Good – Excellent. Water quality of Birupa river at the downstream of Choudwar town vary within Fair-Good category.

In the Cuttack stretch of Mahanadi river, water quality has also been lowered from Good-Excellent category at the upstream of Cuttack town to Poor-Marginal category at the downstream of Cuttack town.

Similar observation has also been made at the Cuttack stretch of Kathajodi river and Bhubaneswar stretch of Daya river.

The deterioration of water quality at these downstream stations of Sambalpur, Cuttack and Bhubaneswar are due to either BOD or TC or both.

For CWQI evaluation at Paradeep, major water quality determining parameters taken as variables are conductivity, chloride, sulfate, SAR (calculated from calcium, magnesium and sodium values), total dissolved solids and boron and compared with the respective tolerance limits of irrigation water quality. Water quality at Paradeep U/s varied within Marginal-Fair (CWQI Score : 44.72-69.82) , whereas at Paradeep D/s, the water quality lowered to Poor category (CWQI Score : 12.60 - 31.67) and thus makes the water unsuitable for irrigation.

### **Brahmani River System :**

Water quality of Brahmani river at all the monitoring stations except at Rourkela stretch conforms to Class-C, except for TC values at some stations. The water quality at Panposh D/s, Rourkela D/s, Rourkela FFD/s at Biritola do not conform to Class- C with respect to both BOD and TC. Water quality of two tributaries like, Nandira jhor and Kisindajhor also do not conform to Class-C with respect to BOD and TC. Whereas water quality of the other two tributaries like Sankha and Koel river and of its distributary, Kharasrota river conform to Class-C except for TC in most of the occasions. However, water quality at all stations conform to Class-D and E.

Taking into consideration the observed biological indices and the BOD values, it may be concluded that the river stretches monitored at Panposh D/s, Rourkela D/s and Talcher D/s are in a state of slight to moderate pollution.

The present level of wholesomeness of water at all stations are below acceptable level due mostly to FC, TKN, TSS and phosphate.

Comparison of BOD data with the tolerance limits for Class-C revealed that there are six polluted river monitoring stations on Brahmani river system. As the polluted monitoring locations in a continuous sequence are identified as the polluted river stretches, there is only one polluted river stretch, that is Rourkela stretch (19 Km) (Priority-IV) along the Brahmani river. Besides this, Nandira D/s (Priority-IV) on Nandira jhor and Kisindajhor (Priority-IV) on Kisindajhor have also been identified as the polluted river monitoring stations.

The CWQI values of Brahmani river system calculated basing on four critical variables such as pH, DO, BOD and TC revealed that , water quality of Sankh river at Sankh U/s remained in Good category, water quality of Koel river at Koel U/s varied within Fair-Good category, water quality of Brahmani river except at Rourkela stretch and Dhenkanal stretch varied within Fair- Good category. In the Rourkela stretch, water quality is within Fair-Good category at the Upstream of Rourkela city which is lowered to Poor-Marginal category at the downstream of the Rourkela town. Similarly water quality of Brahmani river at the downstream of Dhenkanal town has also been lowered to Marginal-Fair category . In Rourkela stretch both BOD and TC are water quality deteriorating parameters, whereas in Dhenkanal, TC is the major water quality deteriorating parameter.

Water quality of Kharasrota river at the three monitoring stations, namely, Khanditara, Binjharpur and Aul, remained mostly in Good category.

## **Baitarani River system :**

The water quality of Baitarani river system at all the nine stations mostly do not conform to Class-C with respect to either BOD or TC or both. Water quality at all stations conform to Class-D. Further, water quality at all stations except at Chandbali U/s, Chandbali D/s and Dhamra conform to Class-E. Due to tidal influence on the river, water quality at Chandbali and Dhamra is not fit for irrigation purpose.

The present level of wholesomeness of water at all stations are below acceptable level due mostly to FC, TKN, TSS and phosphate. At Chandbali and Dhamra, the other downgrading parameter is EC.

Comparison of BOD data with the tolerance limits for Class-C revealed that there are two polluted river monitoring stations i.e. Jajpur (Priority-V) on Baitarani river and Bhadrak D/s (Priority-V) on Salandi river

The CWQI values of Baitarani river system calculated basing on four critical variables such as pH, DO, BOD and TC revealed that water quality of Baitarani river at Joda and Jajpur remained within Fair-Good category, at Anandpur varied within Fair-Excellent category, of Kusei river at Deogaon in Marginal category, of Salandi river at the upstream of Bhadrak town in Fair category and at Bhadrak D/s in Marginal category.

Due to tidal influence at Chandbali U/s, Chandbali D/s and Dhamra, the CWQI values are calculated using EC, SAR (calculated from calcium, magnesium and sodium), chloride, sulfate, TDS and boron as the variables and comparing them with the respective tolerance limits for irrigation water quality. Based on CWQI values, it is observed that water quality at Chandbali U/s varied within Poor-Fair category (CWQI Score : 42.96-66.67), at Chandbali D/s varied within Poor-Marginal category (CWQI Score : 38.24-56.50) and at Dhamra remained at Poor category (CWQI Score : 13.76-19.40).

## **Rushikulya River :**

Water quality of the river at Madhopur do not conform to Class-C which may be due to instream activities on the river. As the river enters its tidal zone at Potagada, there is significant deterioration in the water quality due to sea-river interaction which is clearly evident from higher EC, SAR, Chloride and Sulphate values. At Potagada, the water becomes unsuitable for most of the designated uses of inland surface water.

Taking into consideration the observed biological indices and the BOD values the river stretch at Potagarh is observed to be in a state of slight to moderate pollution (that is, B-C) during 2011, 2013 and in a state of slight pollution (B) during 2012, 2014 and 2015.

In terms of wholesomeness, the water quality is below acceptable level due mostly to FC, TKN, TSS and phosphate. At Potagada, the other downgrading parameter is EC.

Comparison of BOD data with the tolerance limits for Class-C revealed that both the stations can be identified as the polluted river monitoring stations under Priority-V category. As the polluted monitoring locations in a continuous sequence are identified as the polluted river stretches, the stretch from Madhopur- Potagada (5 Km) may be identified as the polluted river monitoring stretch.

The CWQI score at Madhopur calculated using pH, DO, BOD and TC parameters as the variables revealed that water quality remained within Marginal - Good category. Whereas, CWQI score at Potagada calculated using EC, SAR (calculated from calcium, magnesium, sodium and potassium), chloride, sulfate, TDS and boron as the variables and comparing them with the respective tolerance limits

for irrigation water quality, revealed that water quality remained at Poor category (CWQI Score : 14.94-27.24). The water quality deterioration at Potagada is mainly due to tidal effect.

### **Nagavali River :**

Water quality at all the three stations of Nagavali river do not conform to Class-C. TC is the major violating parameter at Penta U/s, whereas both BOD and TC are the violating parameters at Jaykaypur D/s and Rayagada D/s. However, water quality at all the three stations conform to Class-D and E.

Biomonitoring studies reveal that the river stretch at these three stations are in a state of slight to moderate pollution.

With regard to level of wholesomeness of the river water, the quality remain below the “acceptable” level most of the time due to TKN and FC values.

Comparison of BOD data with the tolerance limits for Class-C revealed that the river stretch from Jaykaypur D/s to Rayagada D/s (11 km) has been identified as the polluted river stretch under priority-V category.

The CWQI values calculated using the parameters like pH, DO, BOD as variables revealed that water quality of Nagavali river at Penta U/s remained in Fair- Good category whereas, the water quality at the downstream of Jaykaypur and Rayagada are in Marginal-Fair category. Occasional deviation of TC values beyond the tolerance limit and BOD lowers the water quality at the downstream stations.

### **Subarnarekha River :**

Water quality of Subarnarekha river at Rajghat do not conform to Class-C with respect to TC. Biological indices and the BOD values at Rajghat revealed that the water quality at Rajghat is in a state of slight to moderate pollution (that is, B-C). In terms of wholesomeness, the water quality satisfies the criteria for the 'desirable' class, with respect to all the parameters, except fecal coliform and TKN, in respect of which the water is below acceptable quality.

The criteria parameter BOD at Rajghat on Subarnarekha river was meeting the tolerance limit of 3.0 mg/l of Class-C during the study period 2011-2015 and hence is not categorized as a polluted river monitoring station with respect to BOD.

The CWQI values at Rajghat calculated by using the parameters pH, DO, BOD and TC as variables revealed that water quality of Subarnarekha river at Rajghat always remained in Good category with CWQI score in the range 81.83 – 85.33.

### **Budhabalanga River :**

Water quality of Budhabalanga river at all stations do not conform to Class-C. At Baripada D/s and Balasore U/s, the water quality downgrading parameter is TC while at Balasore D/s, the water quality downgrading parameter are both BOD and TC. . However, water quality at all the three stations conform to Class-D and E.

Biomonitoring studies reveal that the river stretch at Baripada D/s, Balaosre U/s and Balasore D/s are in a state of slight to moderate pollution. In terms of wholesomeness, the water quality satisfies the criteria for the “acceptable” level, with respect to all the parameters, except fecal coliform and TKN, in respect of which the water is below “acceptable” level.

Comparison of BOD data revealed that there is only one polluted river monitoring station, that, Balaosre D/s.

The CWQI values calculated by using the parameters pH, DO, BOD and TC as variables revealed that water quality of Budhabalanga river at Baripada D/s remained within Marginal- Good, at Balasore U/s remained within Fair-Good category and at Balasore D/s remained within to Marginal- Fair category.

### **Kolab River System :**

Water quality of Kerandi river (a major tributary of Kolab river in Odisha part) at Sunabeda do not conform to Class-C with respect to TC alone. Water quality at the station conform to Class-D and E.

Biomonitoring studies reveal that the river stretch at Sunabeda is in slight to moderate pollution (that is, B-C) category. In terms of wholesomeness, the water quality satisfies the criteria for the 'Excellent' class, with respect to all the parameters, except fecal coliform, in respect of which the water is below "acceptable" level.

The criteria parameter BOD at Sunabeda never exceeded the tolerance limit of 3.0 mg/l of Class -C and therefore is not categorized as a polluted river monitoring station with respect to BOD.

The CWQI values calculated using the variables such as pH, DO, BOD and TC revealed that the water quality at Sunabeda is ranked as Fair during 2013 and 2014 and as Good during 2011, 2012 and 2015.

### **Vansadhara River :**

Water quality of Vansadhara river at Muniguda and Gunupur do not conform to Class-C with respect to TC alone. Biomonitoring studies reveal that the river stretch at Muniguda and Gunupur are in "slight to moderate pollution" category. In terms of wholesomeness, the water quality mostly satisfies the criteria for the 'excellent' class, with respect to all the parameters, except TSS, fecal coliform and TKN in respect of which the water is of below acceptable quality. There is no polluted river monitoring stations on the river with respect to BOD.

The CWQI values calculated using the variables such as pH, DO, BOD and TC revealed that the water quality at Muniguda remained within Good-Excellent category, whereas, water quality at Gunupur remained within Fair-Good category.

## CHAPTER-I

### INTRODUCTION

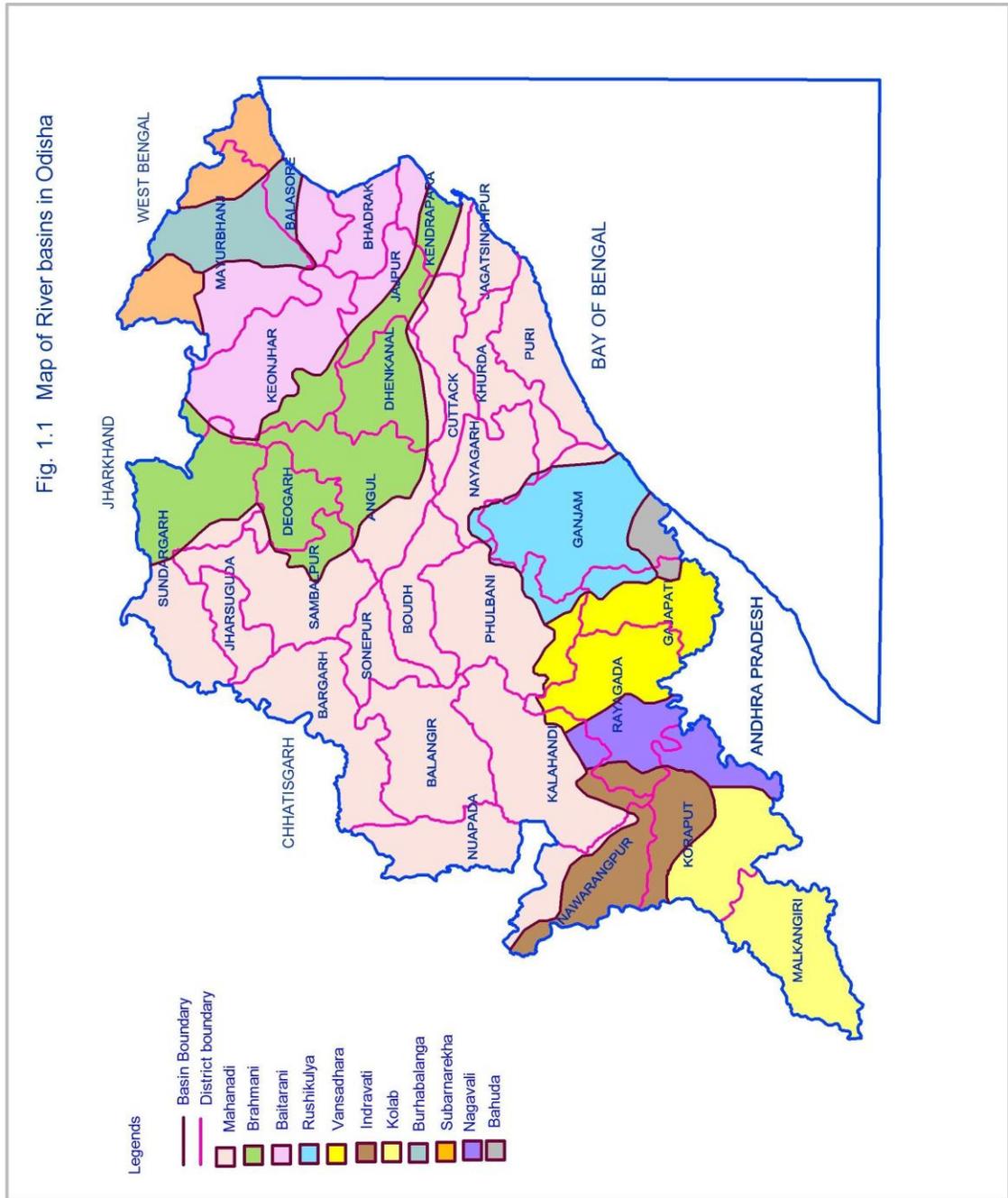
Fresh water, a scarce natural resource, is subjected to diverse uses for sustenance of human civilization. Conscious use of water in a sustainable manner can overcome the concerns of water availability and quality to maximum extents. Various policies and programmers are being formulated in national level and international level for the judicious, equitable and economical use of water resources. Taking into cognizance the existing situation of water availability, its various uses and management perspectives, National Water Policy, 2012 of India has been formulated. The objective of the policy is to propose a framework for creation of a system of law and institution; and propose a plan of actions with a unified national perspective.

In the policy document it is stated that water quality and quantity are interlinked and need to be managed in an integrated manner, consistent with broader environmental management approaches. Water related data at the national/ state level are one of the prime requisites for resource planning. Water quality monitoring is an integral part of the water resource management plans. Monitoring comprises all activities to obtain “information” with respect to the water system, types of water use i.e. instream use or abstractive use, nature of the source such as surface water (rivers, lakes), ground water or sea water, quantifying the pollution load identifying the polluting sources.

The Central Pollution Control Board (CPCB) has established the water quality monitoring network under the project head “National Water Quality Monitoring Programme” to monitor the surface as well as ground water bodies across the country. State Pollution Control Boards in 27 states and Pollution Control Committees in six Union Territories of the Country are monitoring their surface water bodies under this programme. State Pollution Control Board, Odisha is monitoring the water quality of rivers flowing in nine river basins of Odisha under this programme.

#### 1.0 RIVER BASINS IN ODISHA

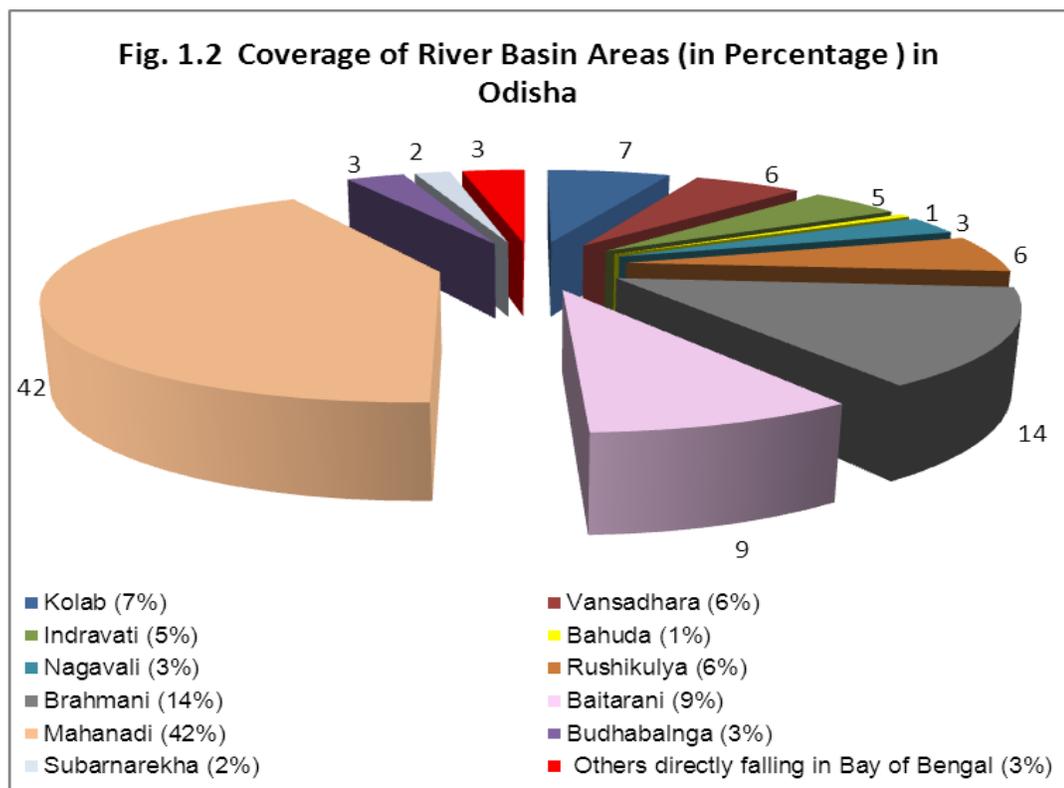
The total geographical area of Odisha (1,55,707 square km) is divided into eleven river basins covering a geographical area of 1,50,460 square km and minor river basins of 5247 square km which drains directly into the Bay of Bengal. Out of eleven river basins, seven basins like Mahanadi, Brahmani, Subarnarekha, Nagavali, Vansadhara, Kolab and Budhabalanga are interstate either due to their origin or fall-out in the sea of the adjoining state. All the rivers flowing in the state are either originating from Central Plateau of India or Eastern Ghat region and flow along the direction of lower contour to join the main stream, which ultimately flow in eastward direction to join Bay of Bengal.



Based on the catchment area of the basin, rivers in Odisha can be divided into three groups as follows.

(i) Large	River basins with catchments of 20,000 sq. km. and above	Mahanadi, Brahmani, Godavari (Indravati and Kolab)
(ii) Medium	River basins with catchments of 2,000 sq. km. to 20,000 sq. km.	Baitarani, Subarnarekha, Budhabalanga, Rushikulya, Vansadhara and Nagavali
(iii) Minor	River basins with catchments of 2,000 sq. km.	Bahuda

Salia, Hoskura, Jambhira, Panchpara etc. are the other small rivers flowing in the State. River Basin map of Odisha with district boundaries is presented in Fig. 1.1. Pie-chart indicating the coverage of river basins (in percentage) in Odisha is given in Fig. 1.2. Basin features of the rivers whose water quality status is discussed in this report are summarised in Table-1.1.



## Water Quality of Major Rivers of Odisha

Main features	Mahanadi	Brahmani
<b>Origin</b>	From Amarakantak hills of the Bastar Plateau near Pharsiya village in Chhattisgarh	Formed by the combined waters of Koel and Sankh rivers at Vedavyasa near Rourkela of Sundargarh District.
<b>Basin area (sq km)</b>	1,41,134	39,116
<b>Basin area in Odisha (sq km)</b>	65,628	22,516
<b>% to Geographical area of State</b>	42.15	14.46
<b>Total length (km)</b>	851	799
<b>Total length in Odisha (km)</b>	494	461
<b>Water Resource ((Million m<sup>3</sup>) (Average)</b>	59155	18577
<b>Water Resource ((Million m<sup>3</sup>) (75% Dependable)</b>	48732	14011
<b>Per capita water availability (2001), (m<sup>3</sup>)</b>	3551.06	3634.95
<b>Major Tributaries</b>	Seonath, Hasdeo, Mand, Ib, Jonk, Ong, Hariharjore, Tel, Jeera	Koel, Kuradhi, Mankara, Samakoi, Ramiala, Karo, Sankh, Rukura, Gohira, Tikira, Singdajhor, Nigra, Barjor, Nandira
<b>Major Distributaries</b>	Kathajodi, Birupa, Kuakhai, Daya, Bhargavi, Kushabhadra, Biluakhai, Devi, Kandala, Luna, Chitrotpala, Karandia, Paika and Badagenguti	Kharasuan
<b>Districts covered in Odisha (% of geographical area of the district )</b>	Sundargarh (39%), Jharsuguda (100%), Sambalpur (79%), Angul (33%), Dhenkanal (11%), Cuttack (99%), Jagatsinghpur (100%), Khordha (98%), Puri (70%), Phulbani (81%), Sonapur (100%), Balangir (100%), Bargarh (100%), Nuapada (100%), Boudh (100%), Kalahandi (78%), Kendrapara (21%), Nawarangpur (37%), Deogarh (15%), Jajpur (2%), Ganjam (1%) Nayagarh (91%)	Sundargarh (59%), Deogarh (85%), Sambalpur (21%), Angul (66%), Keonjhar (21%), Dhenkanal (89%), Jajpur (63%), Kendrapara (42%), Cuttack (1%)

## Water Quality of Major Rivers of Odisha

Main features	Baitarani	Rushikulya	Nagavali	Subernarekha
<b>Origin</b>	Gonasika hills of Keonjhar district	Near village Madhabari of Phulbani district	Bijipur hills of Eastern ghats in Kalahandi district	Near Nagri village of Chotnagpur plateau in Ranchi district
<b>Basin area (sq km)</b>	14,218.	8,963.	9,275	19,277
<b>Basin area in Odisha (sq km)</b>	13,482	8,963	4,500	29,83
<b>% to Geographical area of State</b>	8.66	5.76	2.89	1.92
<b>Total length (km)</b>	440	175	217	446
<b>Total length in Odisha (km)</b>	360	175	125	81
<b>Water Resource ((Million m<sup>3</sup>) (Average)</b>	7568	3949	2853	2308
<b>Water Resource ((Million m<sup>3</sup>) (75% Dependable)</b>	5434	2782	2322	2308
<b>Per capita water availability (2001), (m<sup>3</sup>)</b>	1976.01	1341.87	4291.89	2365.24
<b>Major Tributaries</b>	Deo, Salandi, Kanjhari, Musal, Arredi, Siri, Kukurkata, Gahira, Remal	Mahanadi, Baghua, Badanadi, Dhanei	Jhanjavati, Vegavati Subarnamukhi	Kanchi, Karkari, Khadkei
<b>Major Distributaries</b>				
<b>Districts covered in Odisha (% of geographical area of the district )</b>	Keonjhar (79%), Bhadrak (100%), Jajpur (35%), Kendrapara (37%), Mayurbhanj (10%), Balasore (30%), Sundargarh (2%), Angul (0.5%)	Ganjam (90%), Phulbani (10%), Gajapati (9%), Nayagarh (9%), Khurda (2%)	Koraput (23%), Rayagada (29%), Kalahandi (6%)	Mayurbhanj (21%), Balasore (21%)

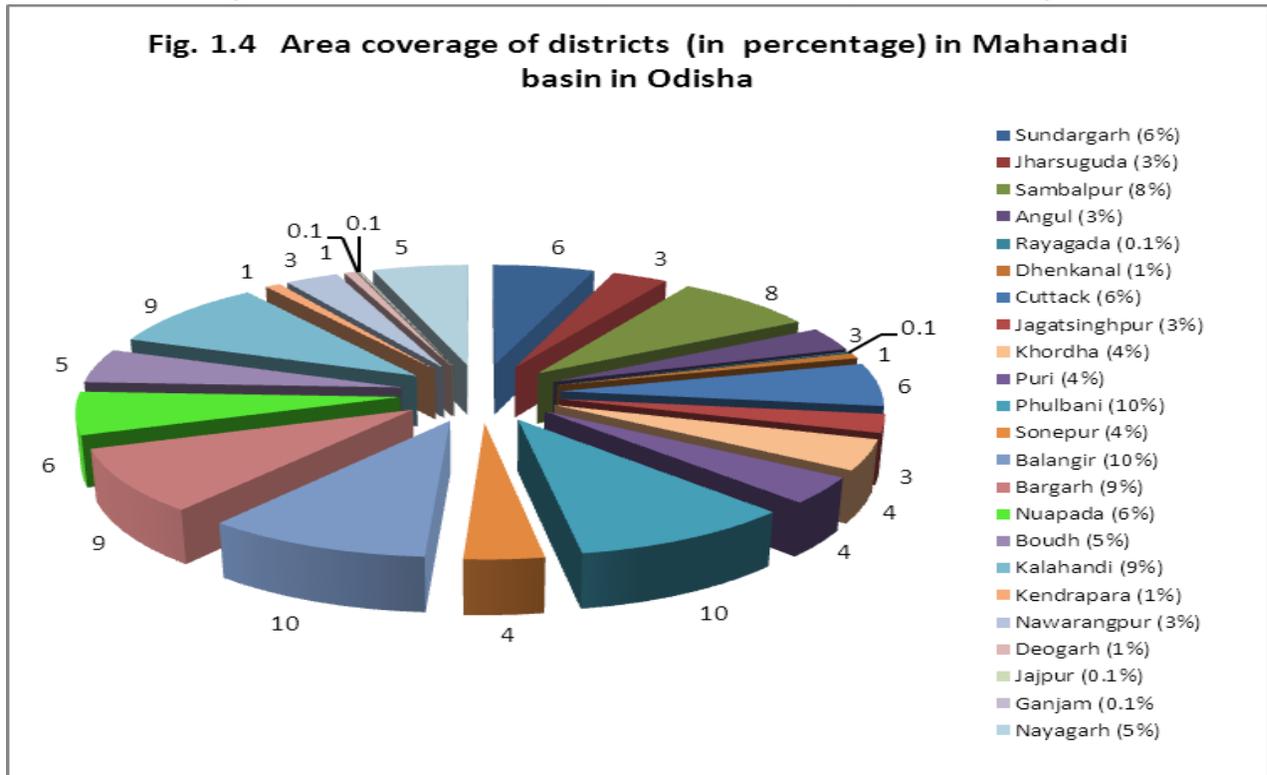
## Water Quality of Major Rivers of Odisha

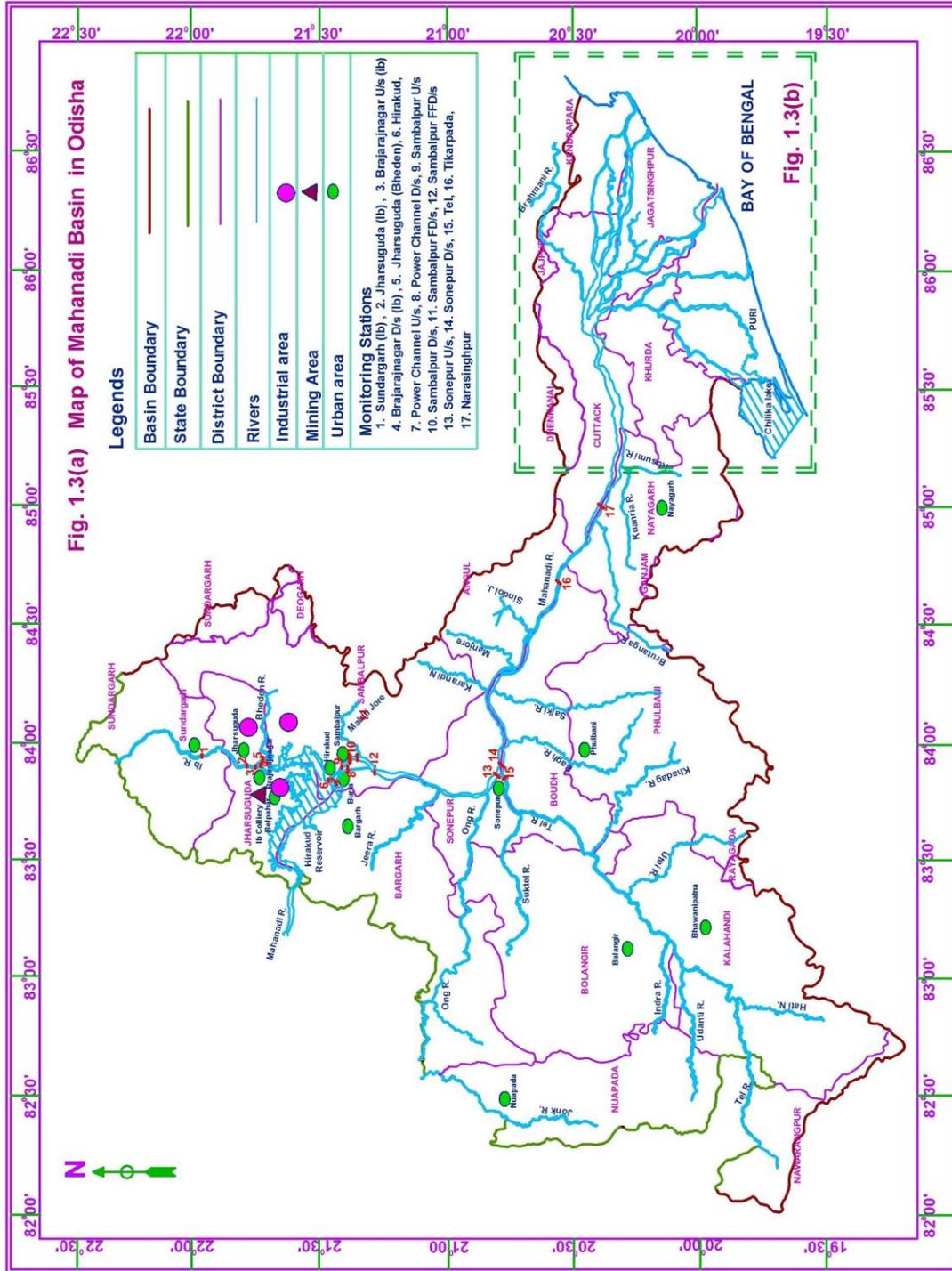
Main features	Budhabalanga	Kolab	Vansadhara
<b>Origin</b>	Similipal range of hills in Mayurbhanj district	Hill ranges of Koraput district	Near village Lanjigarh of Kalahandi district
<b>Basin area (sq km)</b>	4,838	20,247	11,377
<b>Basin area in Odisha (sq km)</b>	4,838	10,300	8,960
<b>% to Geographical area of State</b>	3.11	6.61	5.75
<b>Total length (km)</b>	198.75	418	239
<b>Total length in Odisha (km)</b>	198.75	60 km.	160
<b>Water Resource ((Million m<sup>3</sup>) (Average)</b>	3111	11089	5083
<b>Water Resource ((Million m<sup>3</sup>) (75% Dependable)</b>	2521	8885	3881
<b>Per capita water availability (2001), (m<sup>3</sup>)</b>	1616.61	2263.65	8174.97
<b>Major Tributaries</b>	Sunei, Kalo, Katra, Sana Nadi	Kerandi, Potteru, Sileru, Machkund	Chauldhua, Pandaka lake, Gangudi, Sananadi, Harabhangi, Pedagoda, Mahendratanya
<b>Major Distributaries</b>			
<b>Districts covered in Odisha (% of geographical area of the district )</b>	Mayurbhanj (39%), Balasore (19%)	Maklanigiri (100%), Koraput (51%)	Rayagada (56%), Gajapati (88%), Phulbani (9%), Kalahandi (6%)

1.1 MAHANADI

River Mahanadi rises from a small pool located at about 6 km from Pharsiya village in the Amarkantak hills of Bastar plateau, which lies to the extreme south east of Raipur district of Chhattisgarh State. Out of its total length of 851 km, it covers 494 km in Odisha state. Ib, Ong, Tel, Hariharjore and Jeera are the main tributaries and Kathajodi, Kuakhai, Devi and Birupa are the major distributaries of Mahanadi in Odisha. The multipurpose Hirakud Dam over the Mahanadi at Sambalpur is nearly 400 km from the mouth and is located exactly at the midpoint of the trunk stream. The river Ib joins Mahanadi near Bagra and enters into the Hirakud reservoir from the left. From Sambalpur, the river flows southwards till it joins with Ong and Tel. Tel is biggest tributary of Mahanadi at Sonepur, from where again the river flows eastwards to join the Bay of Bengal. Before entering into the coastal plain and forming the delta, the river traverses through the Eastern Ghats cutting across a 60 km long “Satkosia Gorge” overlooked by precipitous hills and lush green tropical forests. Finally the river emerges out of the Eastern Ghats near Naraj, about 10 km to the west of Cuttack city. The deltaic action starts near Naraj where the river first divides into two major distributaries, i.e., the Mahanadi on the north and the Kathjodi on the south. Traversing through the districts of Cuttack and Puri from west to east through a large number of distributaries, it has developed an extensive delta. Map of Mahanadi basin in Odisha is given in Fig. 1.3 (a and b). Mahanadi basin covers 23 revenue districts, 7 nos. in full and 16 nos. partially. Area coverage of districts (in percentage) in Mahanadi basin in Odisha is presented in Fig. 1.4.

Schematic diagram of the Mahanadi river system in Odisha is presented in Fig.1.5.





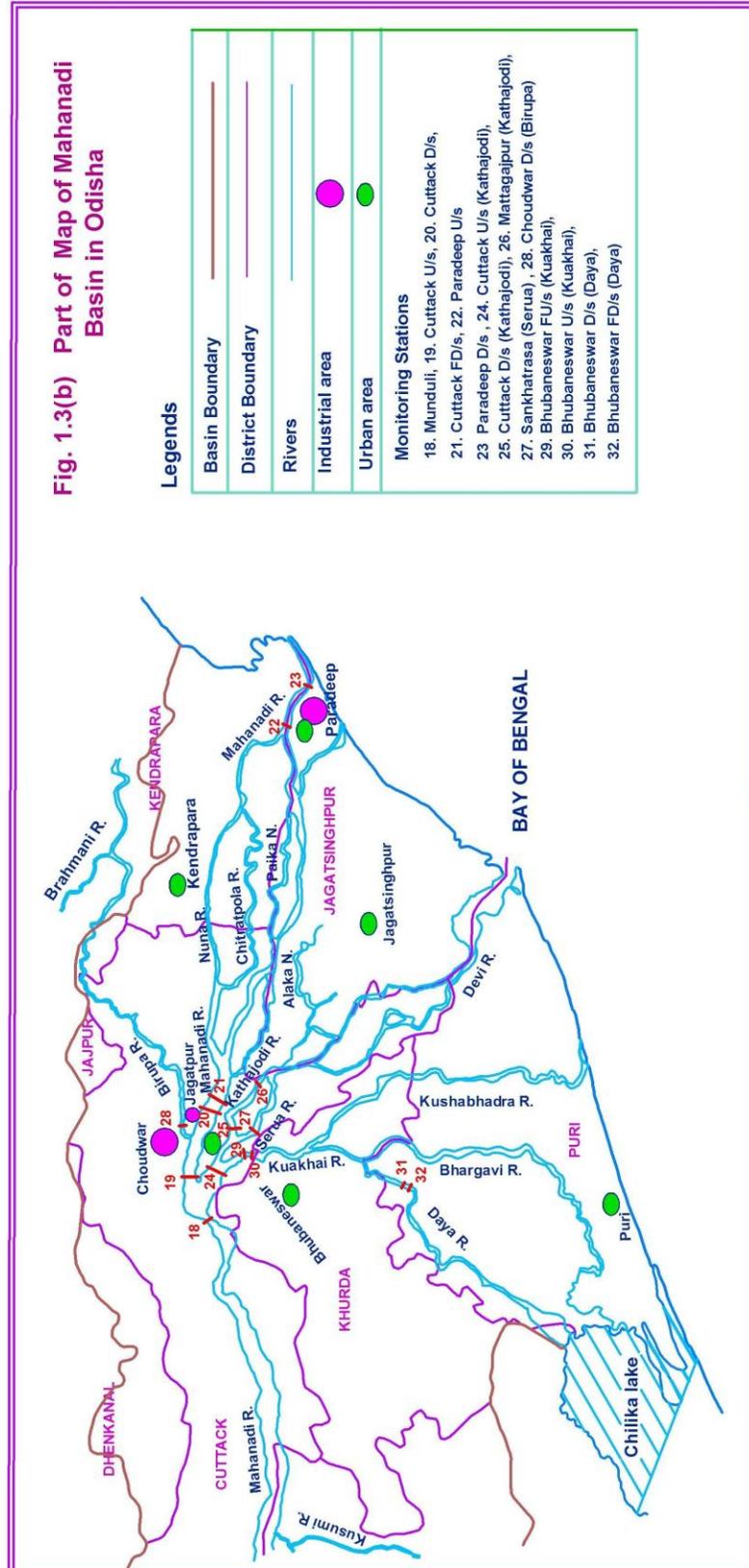
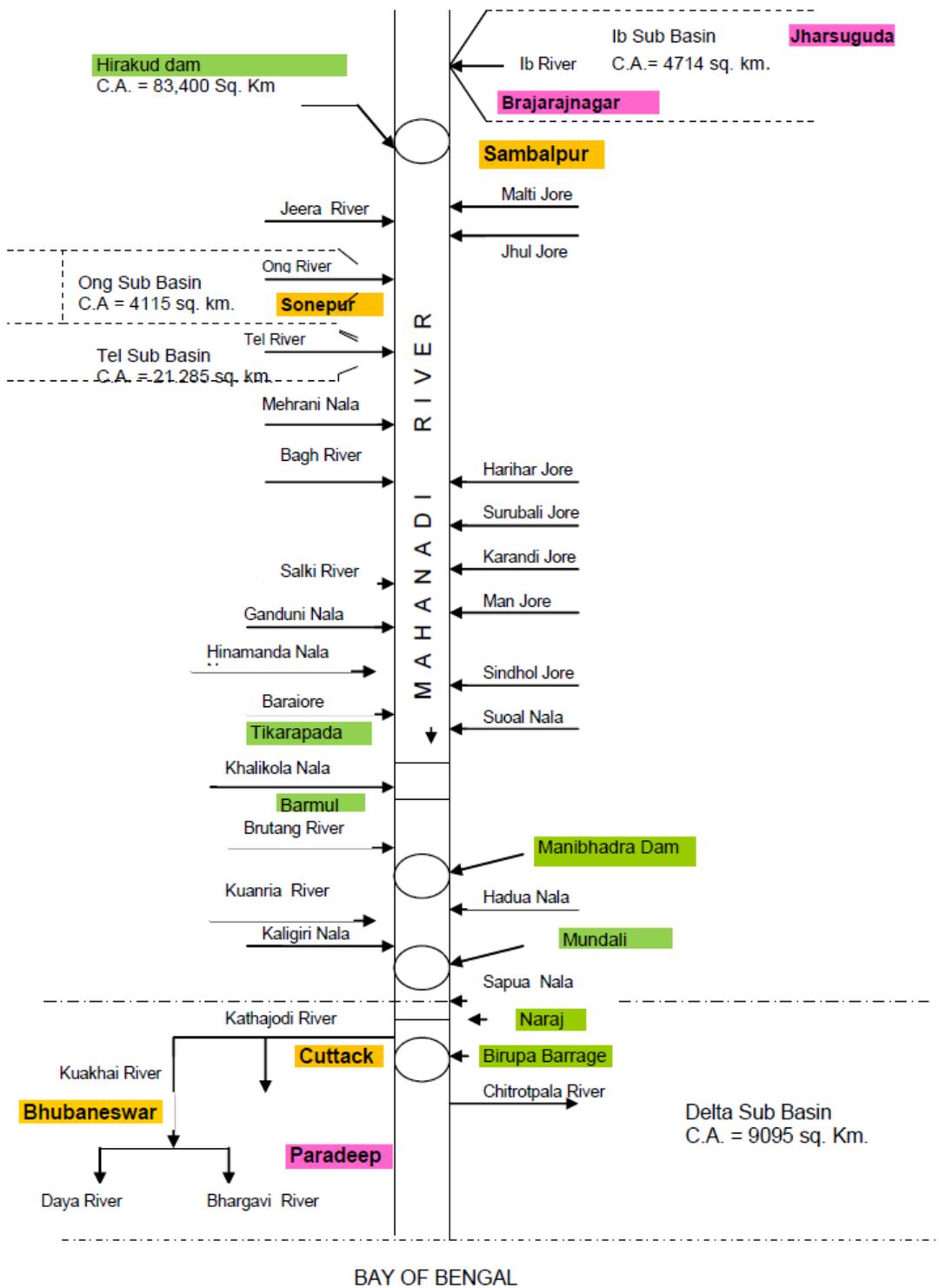


Fig 1.5 Schematic Diagram of Mahanadi River System indicating major towns and industrial areas



All the major branches and sub-branches including Mahandi river falls into Bay of Bengal except Daya and Bhargavi which fall into Chilika lake.

Major towns located on the bank of Mahanadi river are Sambalpur, Sonepur, Sundargarh and Paradeep. Bhubaneswar city is located on the bank of river Kuakhai and Cuttack city is located in between Mahanadi and Kathajodi rivers.

## **1.2 BRAHMANI**

Brahmani, the second major river in Odisha, is formed by the combined waters of South Koel and Sankh rivers at Vedvyasa near Rourkela in the Sundargarh district. The left bank tributary South Koel originates near Nagri village in the Ranchi district of Jharkhand state. After its confluence with river Karo in Singhbhum district, it is known as Koel. From Manoharpur, it flows in the south-west direction for a distance of about 54 km upto Vedvyasa where the right bank tributary Sankh joins with it. River Sankh originates at an elevation of 1000 m near village Lupungpat in Ranchi district of Jharkhand state.

River Brahmani travels south ward through valleys incised in the Gadjat Hills to form the famous Gangpur Basin. In this stretch the river is joined by several fast flowing tributaries. The deltaic region of Brahmani starts from Jenapur at RD (river distance) 315.00 km, where the Kalamitra island divides the river into two branches. The left branch is called Brahmani main and the right branch is called Kharasuan, which again joins the Brahmani river at RD 429.00 km. River Birupa, a distributary of Mahanadi river, joins Brahmani river at RD 372.00 km. In place of being a receiving stream, it now branches into numerous spill-channels which criss-cross the spill channels of river Baitarani and ultimately joins river Baitarani at RD 446.00 km to form Dhamra mouth before finally being discharged into Bay of Bengal at RD 461.00 km.

The basin area of river Brahmani in Odisha constitutes 57.63 % of the total basin area. Map of Brahmani basin in Odisha is given in Fig. 1.6. The basin covers 9 revenue districts of the State. Area coverage of districts (in percentage) in Brahmani basin in Odisha is presented in Fig. 1.7. Major towns located on the bank of Brahmani river are Rourkela, Angul, Talcher and Dhenkanal. The schematic diagram of Brahmani river system in Odisha is presented in Fig.1.8.

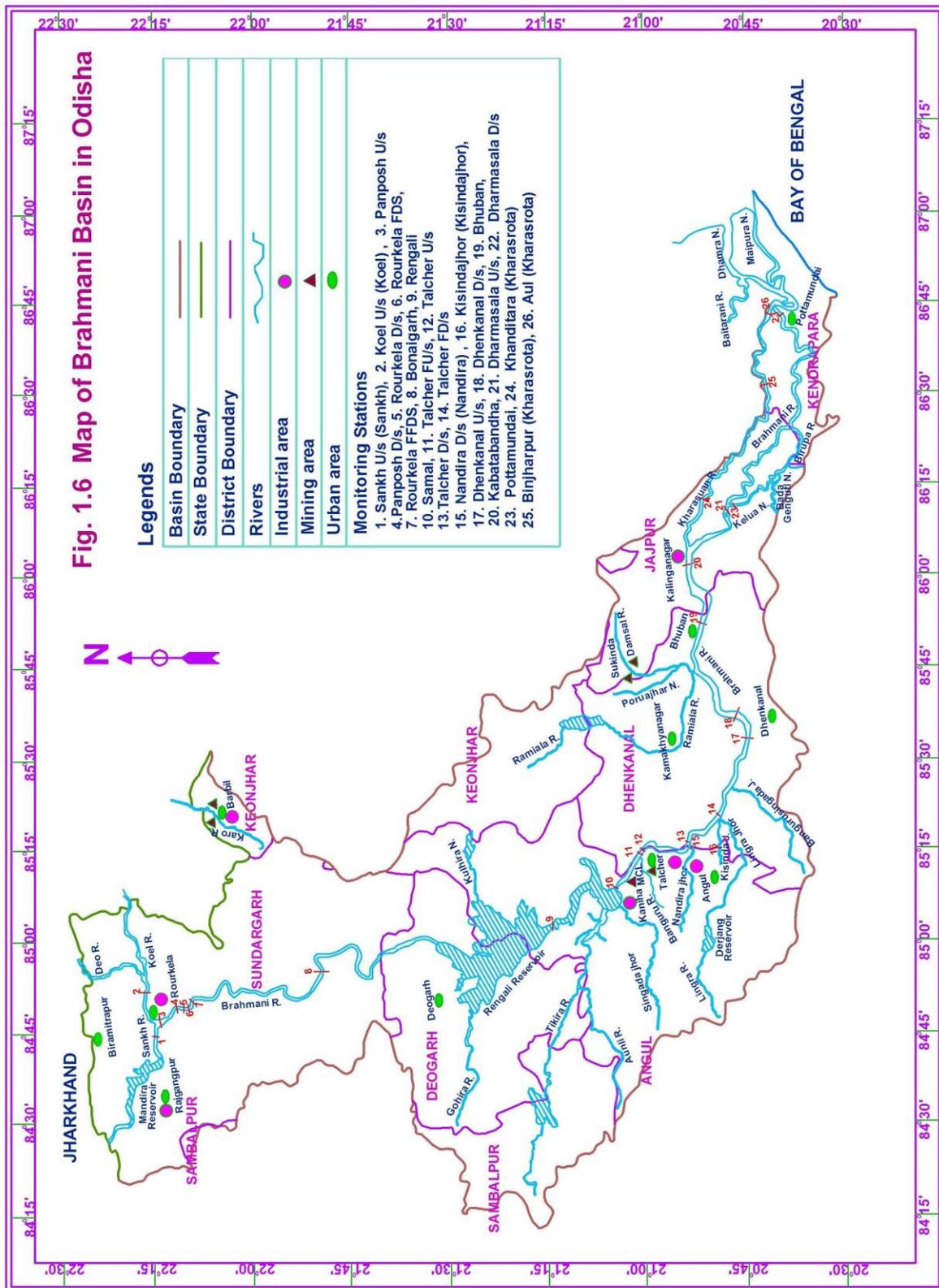
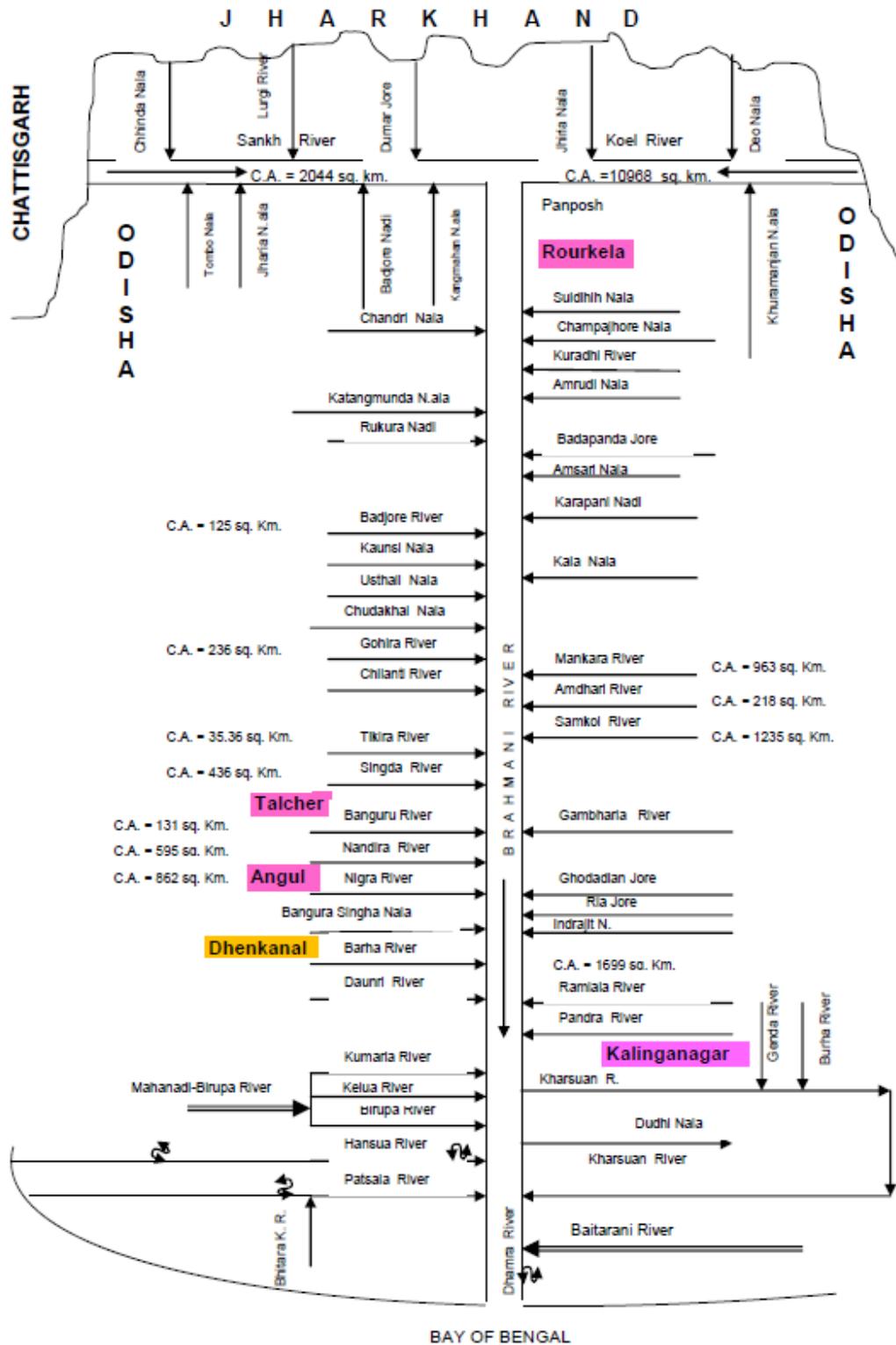
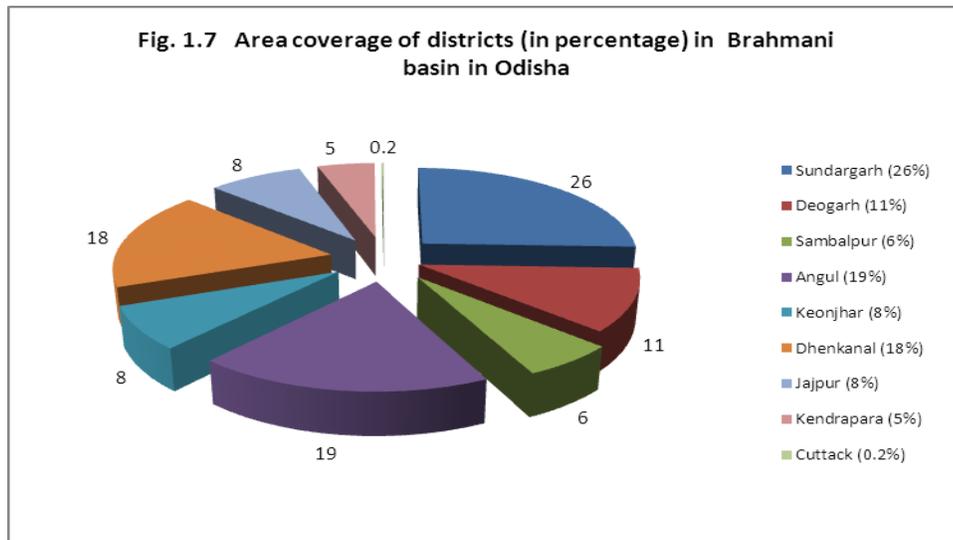


Fig. 1.8 Schematic Diagram of Brahmani River System indicating major towns and industrial area

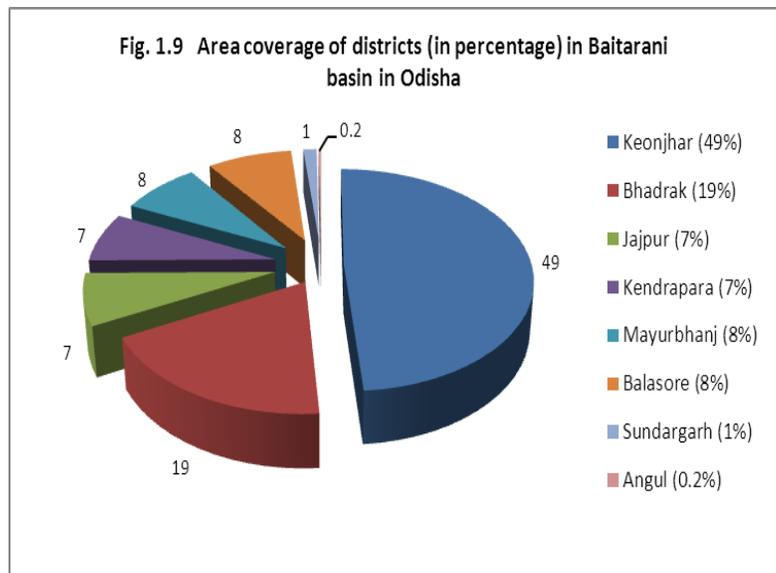




### 1.3 BAITARANI

Baitarani river originates at an elevation of 900 m above mean sea level from Guptaganga hills in Gonasika of Keonjhar district. The beginning portion of Baitarani acts as the boundary between Odisha and Jharkhand states. It first flows in a north-easterly direction for about 80 km and then takes a south-easterly direction for the next about 170 km to reach Jajpur. Here the river turns left to flow towards east and enter the littoral plain or delta. The river enters plains at Anandpur and creates deltaic zone below Akhuapada. The river traverses a total distance of 360 km in Odisha before joining with Dhamra river and finally falls into Bay of Bengal. Deo, Salandi, Kanjhari, Musal, Arredi, Siri, Kukurkata, Kusei, Gahira and Remal are the major tributaries of Baitarani river.

A major portion of the basin (94.8%) lies within the state of Odisha, while a small patch of upper reach (5.2%) lies in Jharkhand state. Area coverage of districts (in percentage) in Baitarani basin in Odisha is presented in Fig. 1.9. The basin covers 8 revenue districts of the State. The main urban centres in Baitarani basin are Keonjhar, Joda, Jajpur, Vyasaganagar, Bhadrak, Anandpur, Chandbali and Dhamnagar. Map of Baitarani basin in Odisha is given in Fig. 1.10. The schematic diagram of Baitarani river system in Odisha is presented in Fig. 1.11.



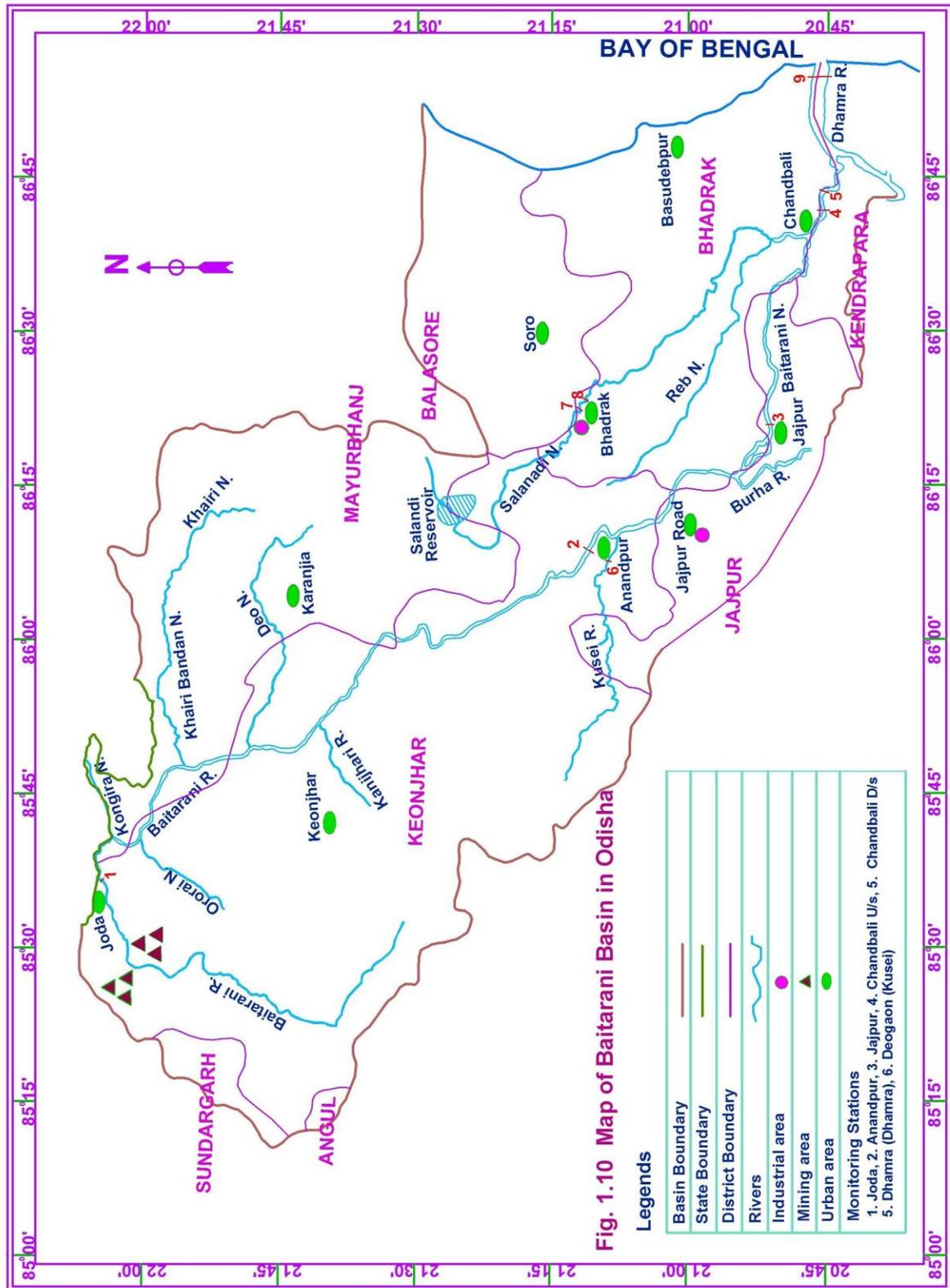
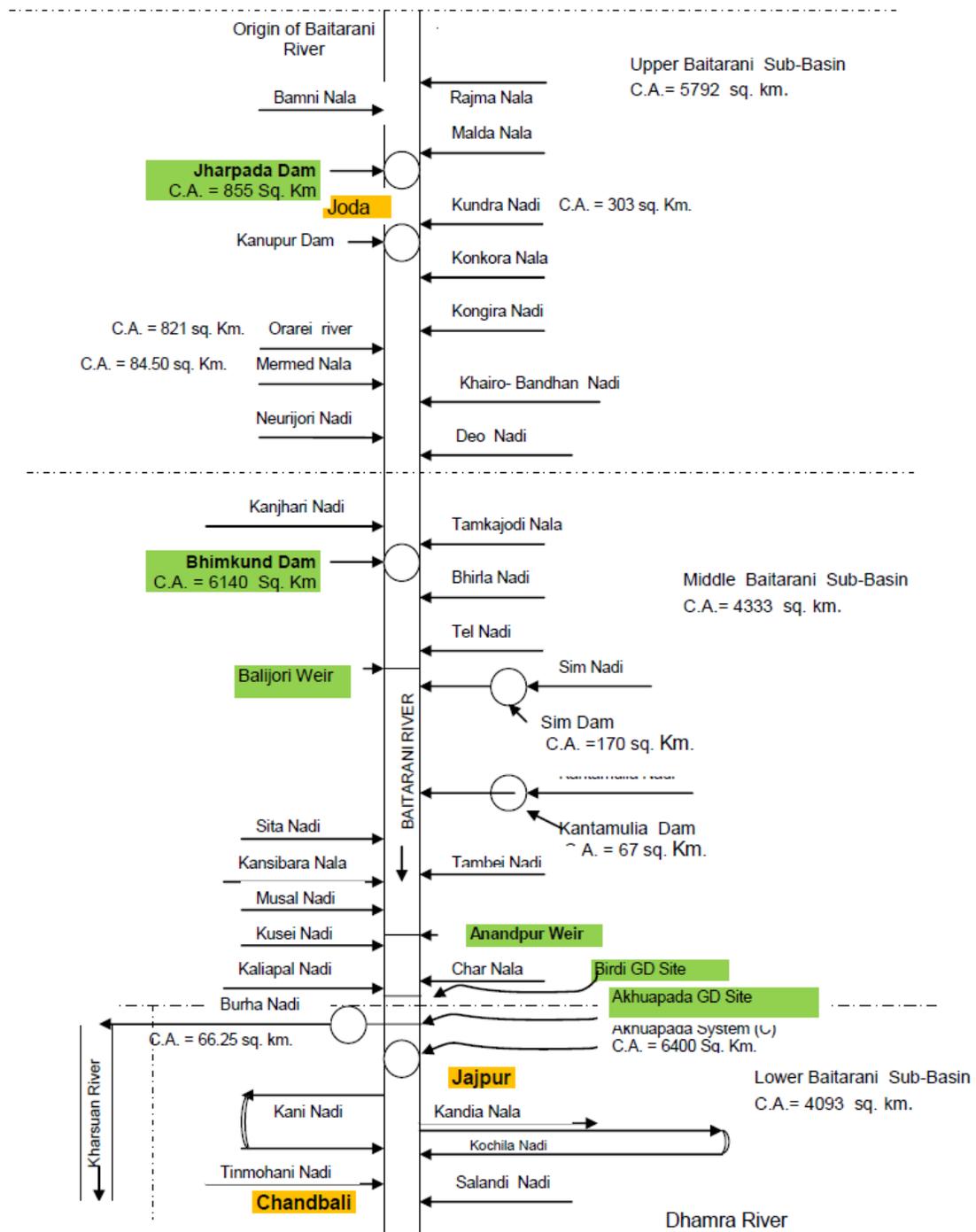


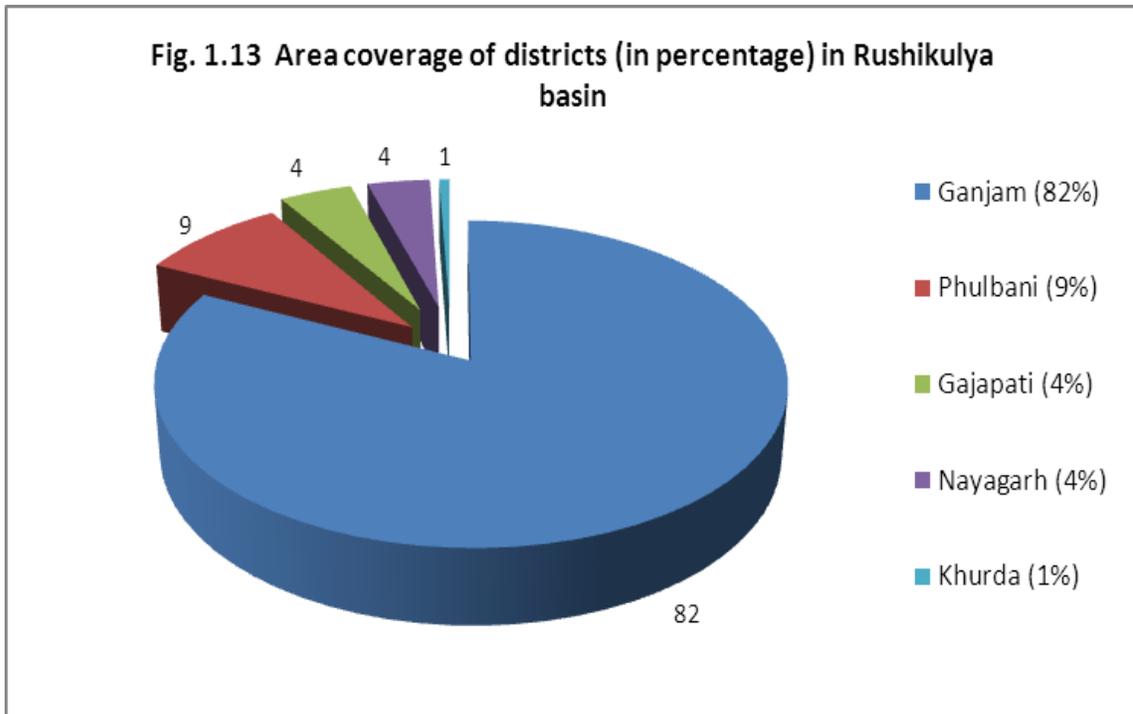
Fig. 1.11 Schematic Diagram of Baitarani River System indicating major towns

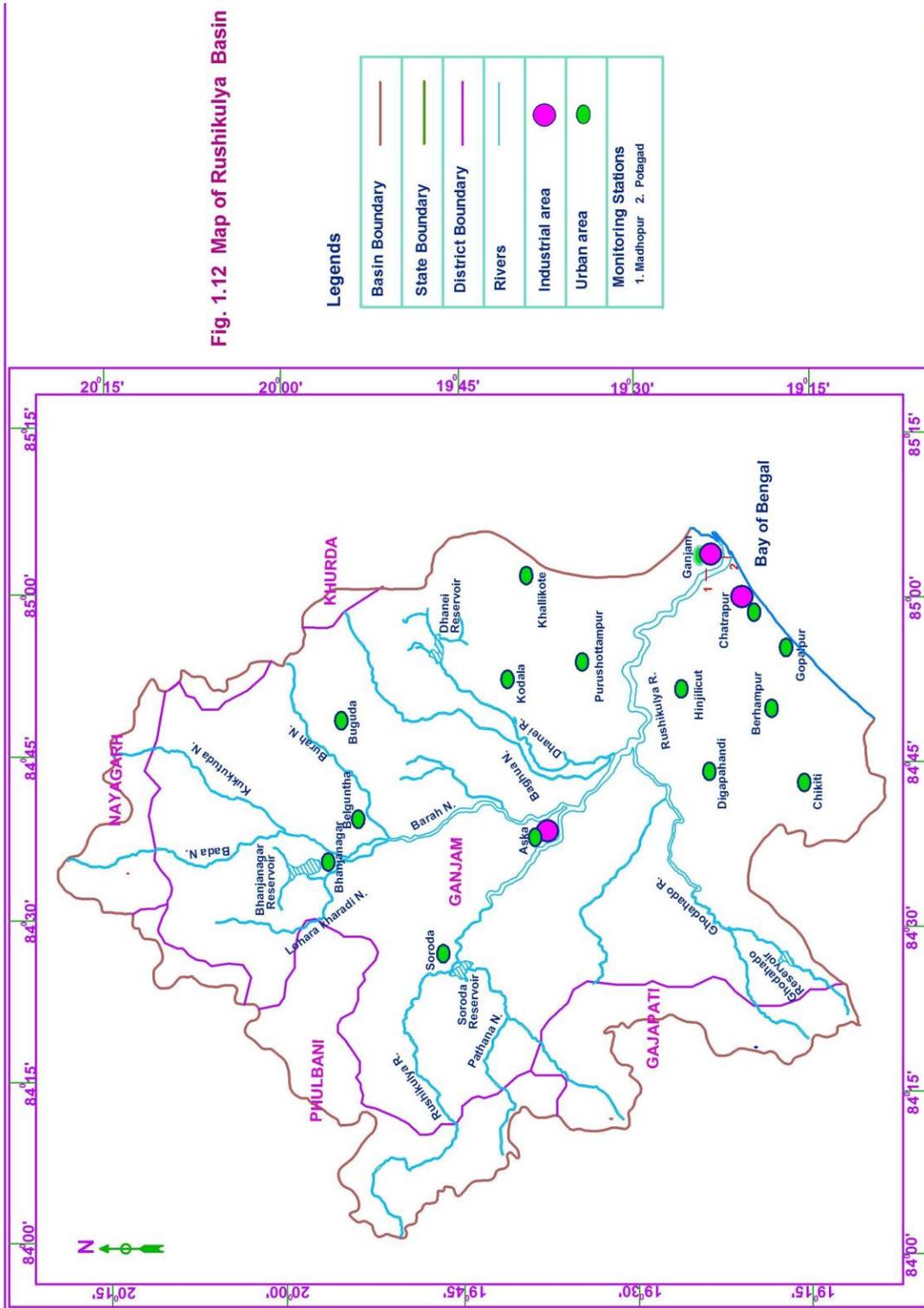


## RUSHIKULYA

Rusikulya river originates at an elevation of 1000 m above mean sea level, from the Rushyamala hills of the Eastern ghats near Madhabari village of Phulbani district of Odisha. The river traverses a total distance of 175 km. in south direction before outfalling into Bay of Bengal at Puruna Bandha in Chhatrapur of Ganjam district. It has no delta at its mouth. Major tributaries of the river Rushikulya are Padma, Boringanalla, Joro, Badanadi, Baghua, Dhanei and Ghodahada.

Map of Rushikulya Basin is given in Fig. 1.12. The basin covers 5 revenue districts of the State. Area coverage of districts (in percentage) in Rushikulya basin is presented in Fig. 1.13. The main urban centres in Rushikulya basin are Berhampur, Aska, Bhanjanagar and Chhatrapur.

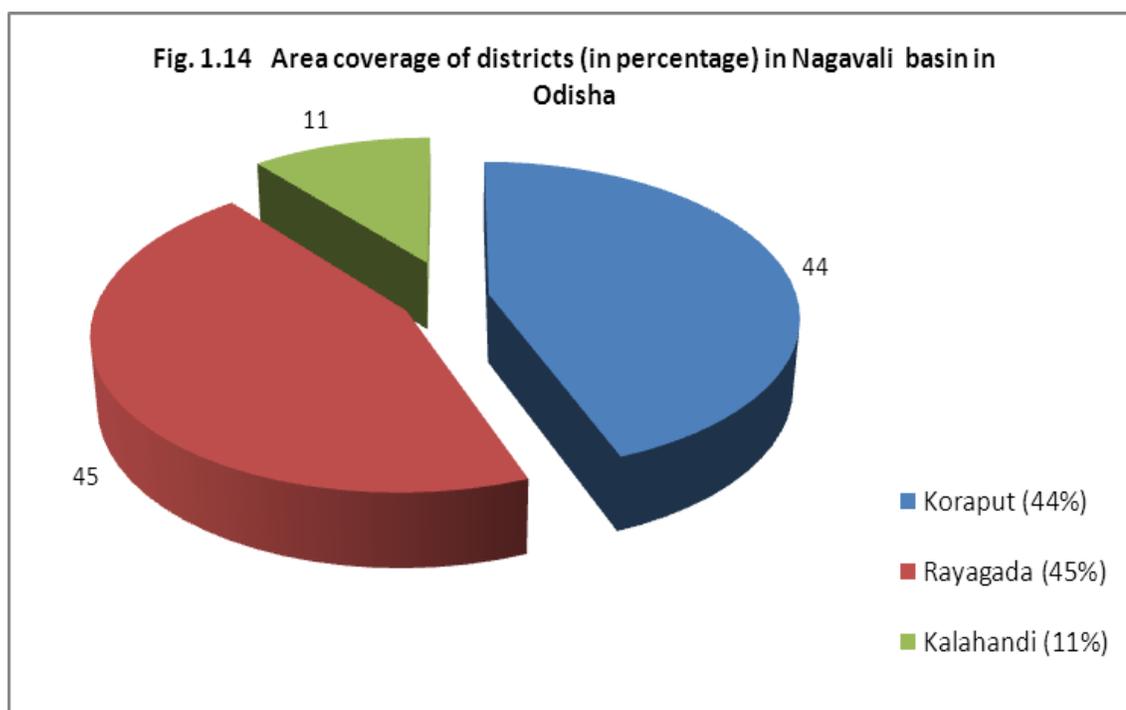


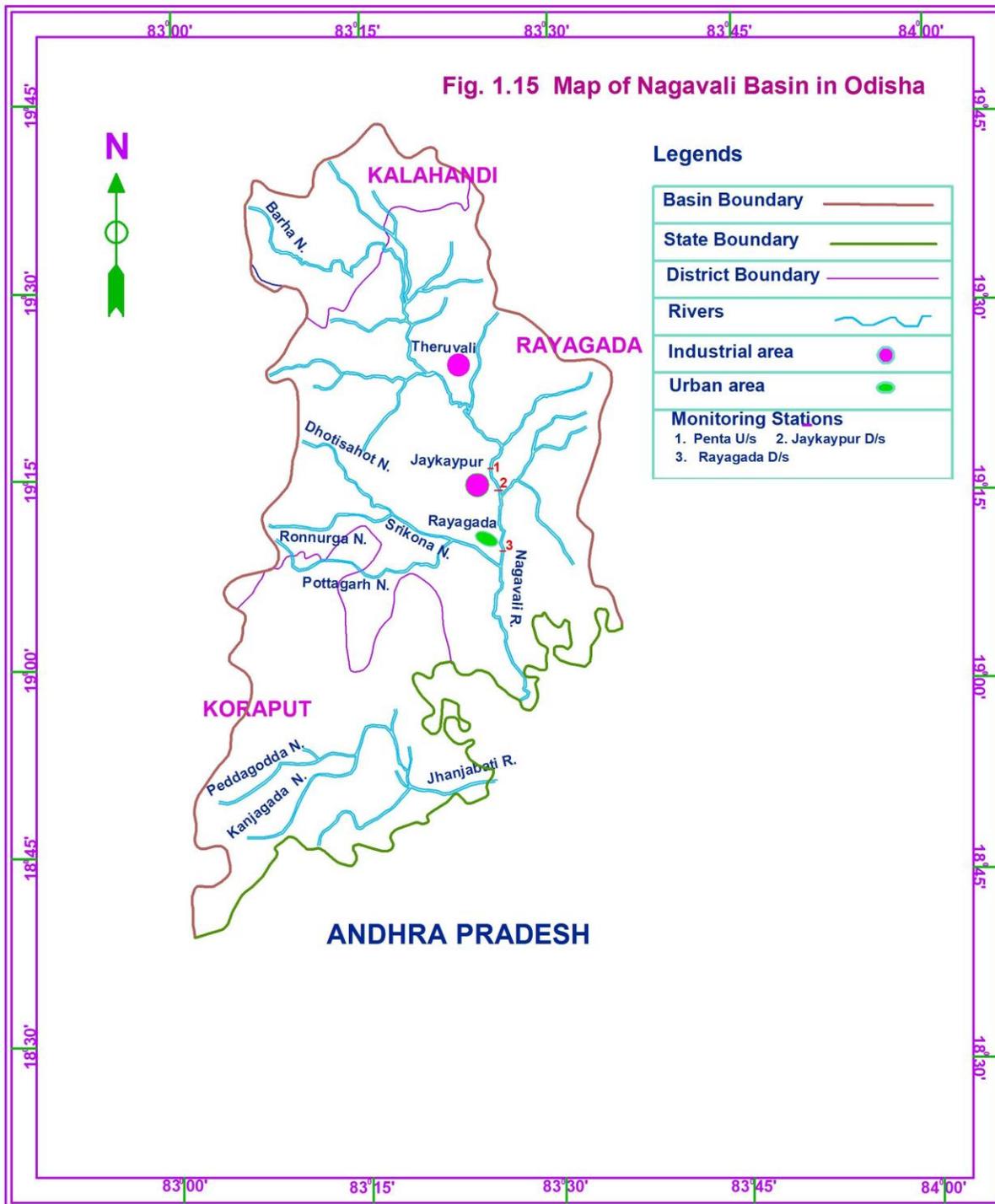


## 1.5 NAGAVALI

Nagavali river originates from the Bijipur hills of the Eastern Ghat near village Lakhabahal in Kalahandi district of Odisha. It is an interstate river with a total length of 217 km flowing through Odisha and Andhra Pradesh. It covers 125 km stretch in Odisha state and has a basin area of 48.8% of total basin area. From its origin to its exit from Odisha at Karada village of Rayagada, it flows mostly through very scarcely populated areas with almost no industrial and mining activities. The prominent tributaries are Pitadar nalla, Datteinannda nallah, Sananadi, Barha Nadi, Baldiya Nadi, Sat Nallah, Sitagura nallah, Ghora nallah, Srikona Nadi, Bonamarha Nadi, Errigeda Nallah, Jhanjhabati river.

Nagavali basin covers 3 revenue districts of the State. Area coverage of districts (in percentage) in Nagavali basin in Odisha is presented in Fig. 1.14. There is only one major town, Rayagada in the Odisha portion of Nagavali river basin. Map of Nagavali basin in Odisha is given in Fig. 1.15.

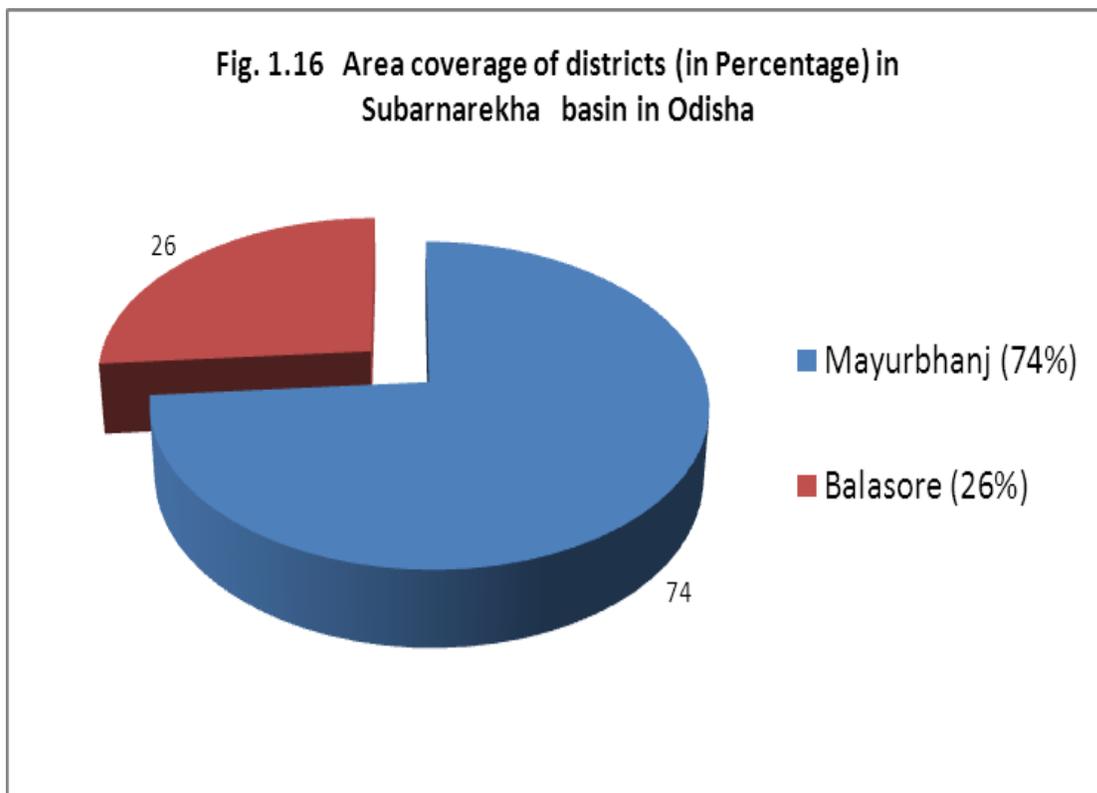


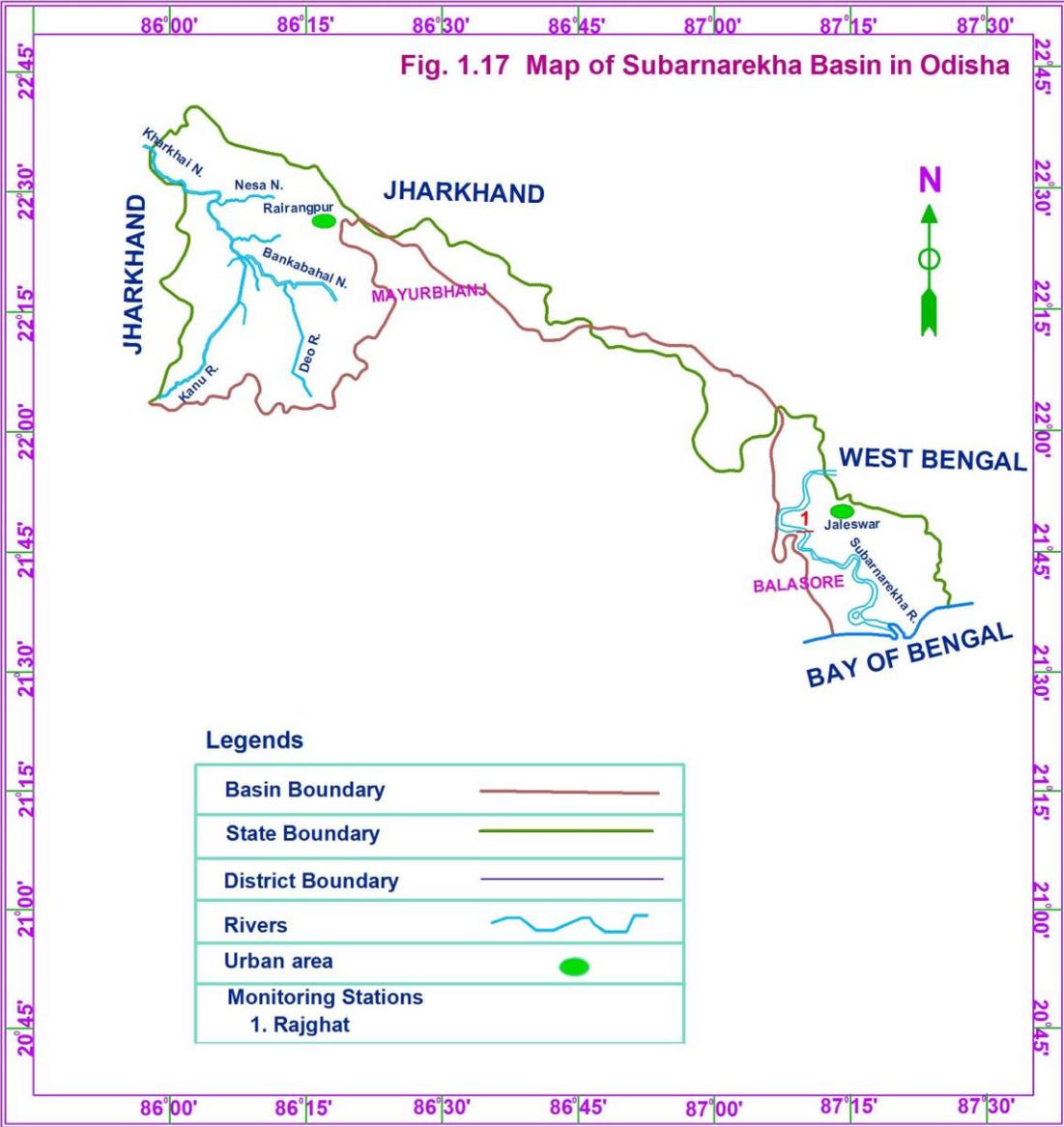


## 1.6 SUBARNAREKHA

River Subarnarekha originates near Nagri village of the Chotnagpur plateau, 15 km. southeast of Ranchi in Jharkhand state. This is an interstate river flowing through three states, Jharkhand, Odisha and West Bengal, covers 446 km. from its origin to the mouth in Bay of Bengal. Only a small stretch (81 km.) of this interstate river flows through Odisha, before falling into the Bay of Bengal at Bhograi block of Balasore district. The basin area in Odisha is 15.5% of the total basin area of the river. The prominent tributaries of Subarnarekha river are Raru river, Kanchi river, Damra river, Karru river, Kharkhai river, Chingaru river, Gurma river, Garra river, Singaduba river, Kodia river, Dulunga river and Khaijori river.

The basin covers only two revenue districts of Odisha, i.e. Mayurbhanj and Balasore. Area coverage of districts (in percentage) in Subarnarekha basin in Odisha is presented in Fig. 1.16. There is only one major town, Jaleswar in the Odisha portion of this basin. Map of Subarnarekha basin in Odisha is given in Fig. 1.17.

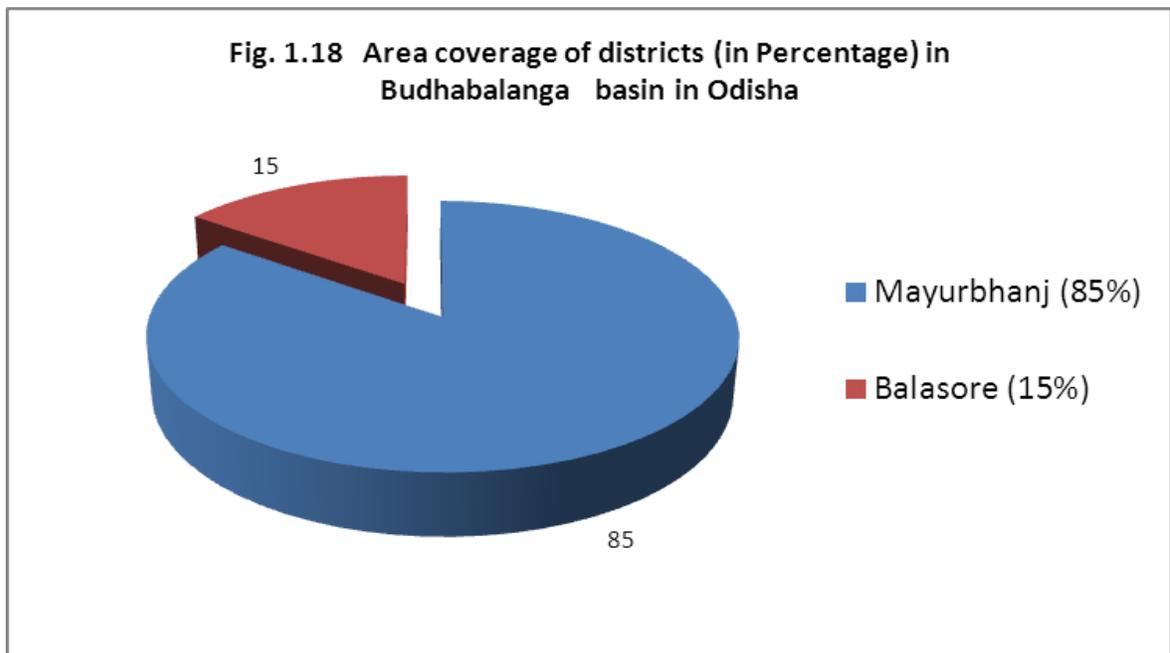


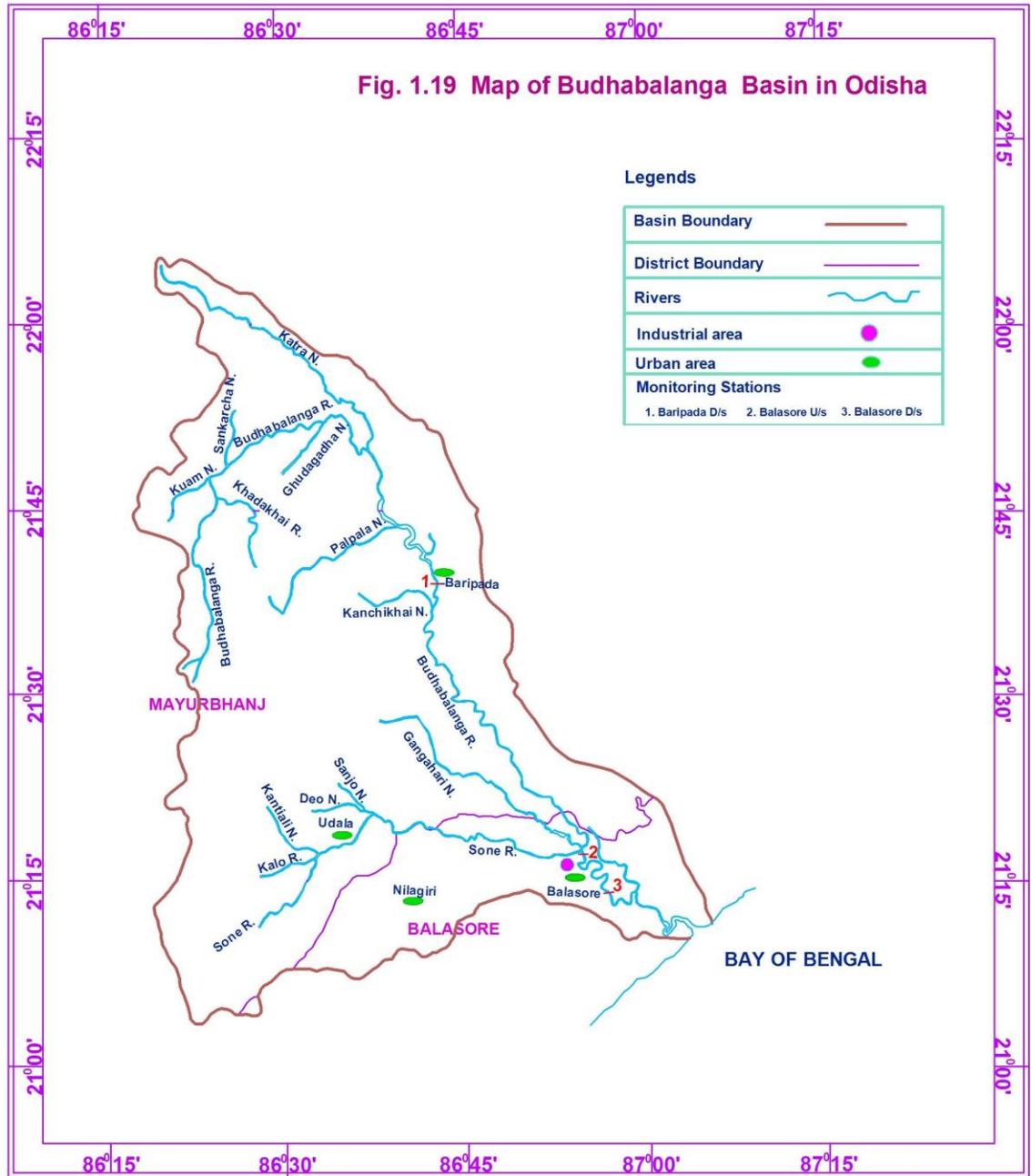


### 1.7 BUDHABALANGA

River Budhabalanga originates from the Similipal range of hills in Mayurbhanj district and plunges through Barehipani falls, the second highest waterfall in India. It then flows in a northerly direction upto the village Karanjiapal in Bangiriposi police-station. Thereafter, it turns to the north-east and flows along the railway track up to the village Jhankapahadi. There it changes its course to the south and meets the Katra nala. Then the river passes through Baripada town and Balasore town before it finally empties into the Bay of Bengal near Balaramgadi village of Balasore district. The river travels a total length of 198.75 Km. The other tributaries of the river are the Palpala, Sone, Sunei, Kalo, Sanjo, Deo, Gangahari and Chipat all of which are hill streams rising from the Shimilipal hills.

The river has a basin area of 4838 sq. km. in Odisha. Map of Budhabalanga basin is given in Fig. 1.18. The basin covers only two revenue districts of Odisha, i.e. Mayurbhanj and Balasore. Area coverage of districts (in percentage) in Budhabalanga basin in Odisha is presented in Fig. 1.19.

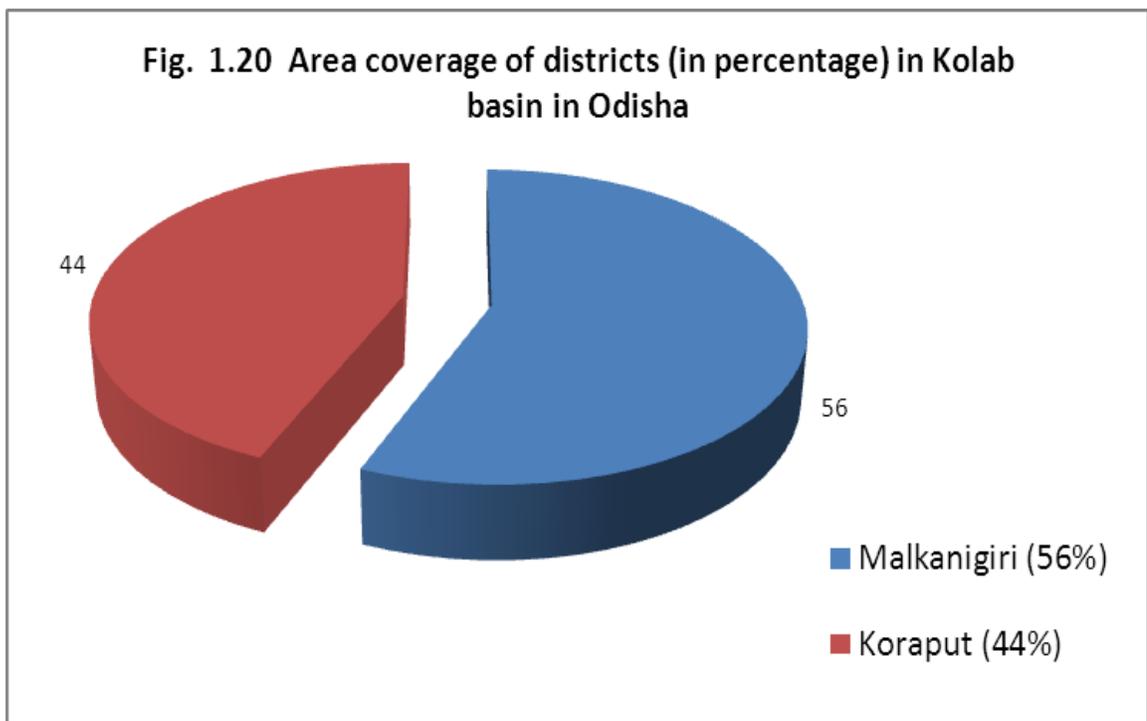


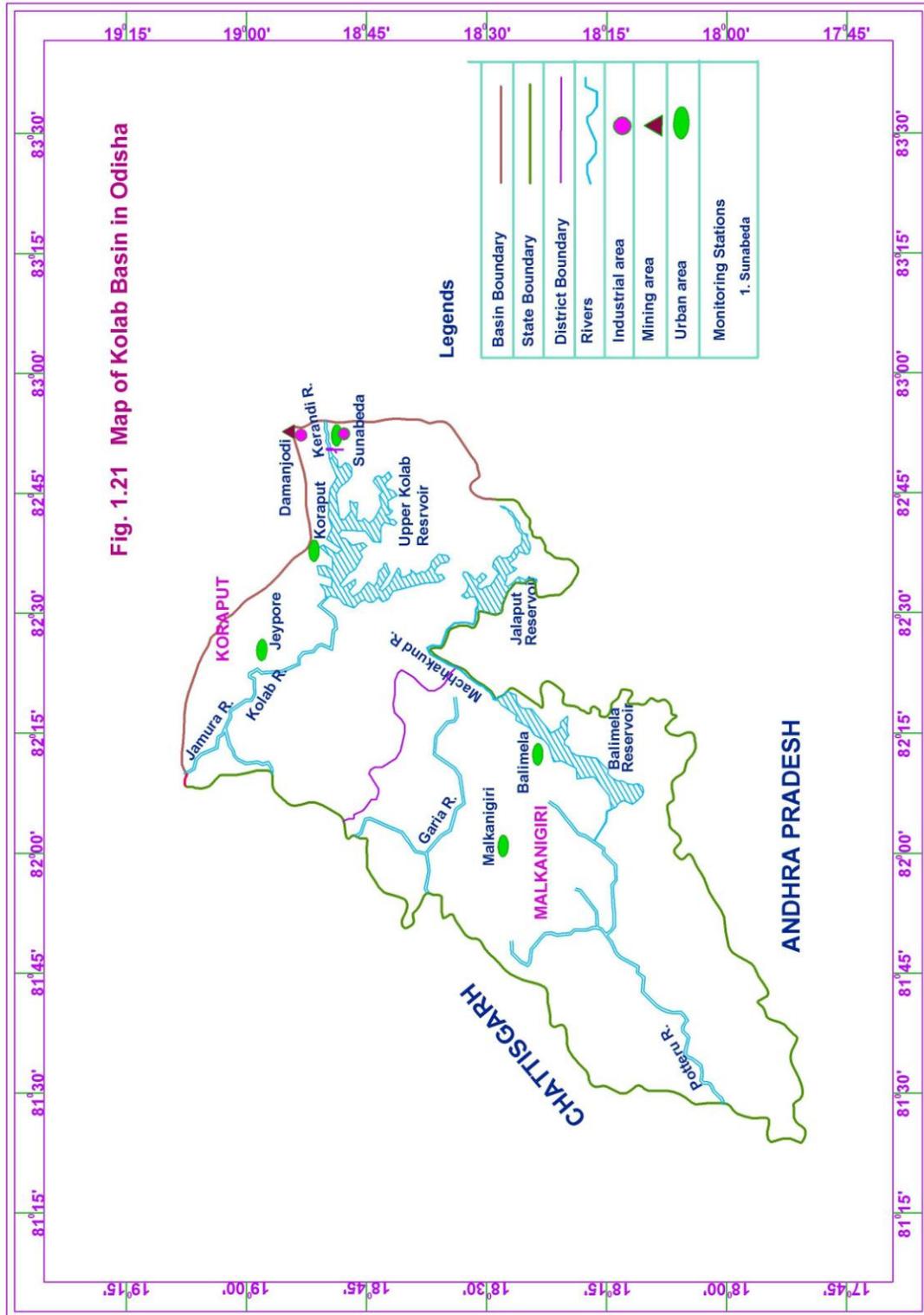


## 1.8 KOLAB

Kolab river originates from the Sinkaran hills of of the Eastern Ghats in Koraput district at an elevation of about 1372 meters above mean sea level and finally meets the Godavari river near the village Kunavaran in Andhra Pradesh. The river in its lower reaches is known as Saberi river. The river travels a total length of 198.75 km upto its confluence with Godavari river. Of this length, only 60 km long stretch of the river lies within Odisha. The prominent tributaries of Kolab river are Kerandi nallah, Guradi nallah, Jam Nadi, Malengar river, Dharmagega nallah, Mullervagu nallah, Potteru Vagu nallah, Machhakunda River, Sileru river.

The river has a basin area of 10,300 square km in Odisha. The basin covers only two revenue districts of Odisha, i.e. Malkanigiri and Koraput. Area coverage of districts (in percentage) in Budhabalanga basin in Odisha is presented in Fig. 1.20. The river traverses through mostly hilly areas. There are only two major towns, Jeypore and Koraput in the Odisha portion of this basin. Map of Kolab basin in Odisha is given in Fig. 1.21.

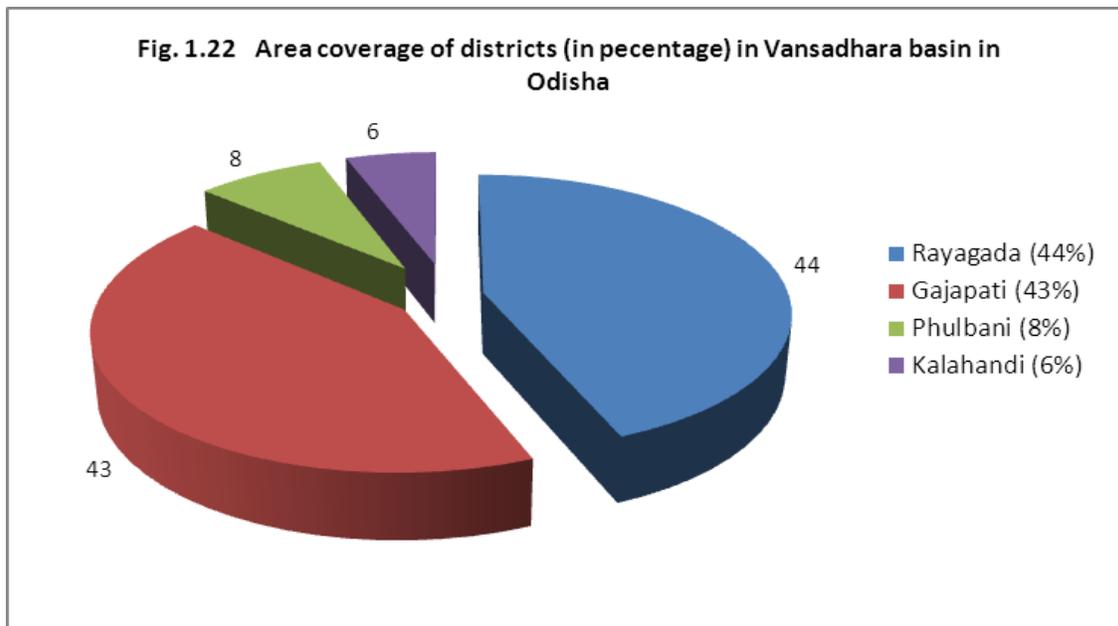




## 1.9 VANSADHARA

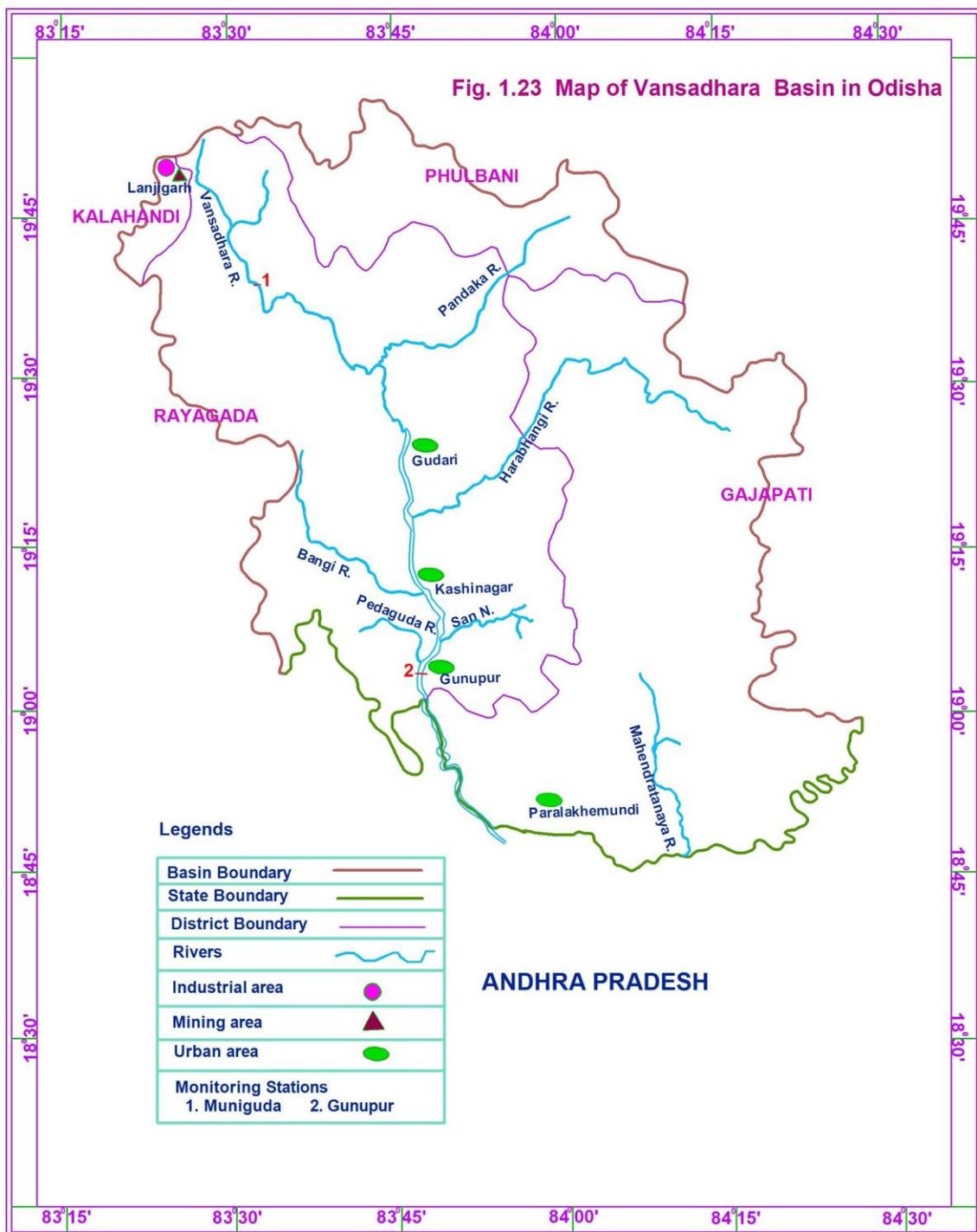
Vansadhara river originates from the flanks of the Durgakangar hills (Lingaraj hills) of the Eastern Ghats near Lanjigarh village in Kalahandi district of Odisha. The river traverses a distance of 239 km before its outfall into Bay of Bengal at Kalingapatanan in Andhra Pradesh State. Of its total length, 160 km long stretch of the river lies within Odisha. The prominent tributaries of Vansadhara river are Bhangi, Pedagoda, Badanallah, Chauladhua Pandaka nallah, Badajhar, Harbhangi, Sananadi, Mahendratanya rivers.

The river has a basin area of 8960 square kmin Odisha which is 78.8% of the total basin area of the river. The basin covers four revenue districts of Odisha. Jeypore, Koraput, Gunupur, Parlakhemundi are the major towns in Odisha portion of the basin. Area coverage of districts (in percentage) in Budhabalanga basin in Odisha is presented in Fig. 1.22. Map of Vansadhara basin in Odisha is given in Fig. 1.23.



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## **CHAPTER-II**

### **WATER QUALITY MONITORING AND ASSESSMENT**

#### **2.0 WATER QUALITY MONITORING**

The Preamble of Water (Prevention and Control of Pollution) Act, 1974 states the Pollution Control Boards in States as well as in Centre to maintain and restore the wholesomeness of water bodies in India. Water quality monitoring is the foremost step required in the development, management and restoration of water resources. Monitoring is defined as the long-term, standardised measurement and observation of the environment in order to define status and trends. The State Pollution Control Board, Odisha is monitoring the water quality of rivers with the following objectives.

1. To assess the present water quality status,
2. To evaluate the water quality trend over a period of time.
3. To assess the fitness of water for different uses,
4. To assess the nature and extent of pollution control needed in different water bodies or their part, and
5. To plan rational water quality management.

#### **2.1 WATER QUALITY MONITORING STATIONS**

Central Pollution Control Board (CPCB) has established the National Water Quality Monitoring Project (NWMP) to assess the water quality of aquatic bodies wholeover the India. Under this Program, State Pollution Control Board, Odisha monitors the water quality of nine river systems viz. Mahanadi, Brahmani, Baitarani, Rushikulya, Nagavali, Subarnarekha, Budhabalanga, Kolab and Vansadhara at 66 stations. Besides these, the Board is also monitoring the water quality of Mahanadi, Brahmani, Baitarani and Budhabalanga rivers at 13 more stations under the State Water Quality Monitoring Programme (SWMP). River system-wise distribution of water quality monitoring stations are listed in Table 2.1

**Table 2.1 River system-wise distribution of water quality monitoring stations**

River System	NWMP	SWMP	Total
Mahanadi river system	27	5	32
Brahmani river system	21	5	26
Baitarani river system	7	2	9
Rushikulya river	2	-	2
Nagavali river	3	-	3
Subarnarekha river	1	-	1
Budhabalanga river	2	1	3
Kolab river system	1	-	1
Vansadhara river	2	-	2
Total	66	13	79

River system monitoring includes the monitoring stations over the main river, its tributaries and distributaries. In Mahanadi river system, 47 % monitoring stations are located on main river, 19% stations are on tributaries and 34 % stations are on distributaries. In Brahmani river system, 73% monitoring stations are located on main river, 15 % stations are on tributaries and 12 % stations are on distributaries. Similarly in Baitarani river system, 66% stations are on main river and 33% are on tributaries. Whereas in Kolab river system, the only monitoring station is located on its major tributary.

Details on the monitoring stations along with the justification for their selection, date of commencement of monitoring by the Board, approximate riverine distance from its starting point in Odisha (in case of interstate rivers) or from its origin, designated best use of the monitoring stations are described in Table 2.2. All stations are being monitored on monthly basis since 01.01.2011.

Table- 2.2 Details of water quality monitoring stations

(1) Mahanadi river system

Sl. No.	Monitoring Station	Date of commencement by the Board (dd-mm-yy)	Approx. distance (Km.) from starting point in Odisha	Justification on the site selected	Designated Best Use	Longitude (Deg-Min-Sec)	Latitude (Deg-Min-Sec)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Ib River (Tributary)</b>							
1	Sundargarh	03.01.1988	28	Water intake point. Major human settlement	C	84°03'25.62" E	22°08'08.68"N
2	Jharsuguda	03.01.1988	69	Impact of industrial and mine discharges, water intake point	C	83°56'51.53"E	21°51'49.41"N
3	Brajarajnaragar U/s	03.01.1988	73	Water quality before industrial impact, water intake point and major human settlements	C	83°56'28.95"E	21°49'25.65"N
4	Brajarajnaragar D/s	03.01.1988	75	Impact of industrial and mine discharges	C	83°56'40.83"E	21°49'25.65"N
<b>Bheden River (Tributary)</b>							
5	Jharsuguda	01.01.2009	-	Impact of large scale iron and steel industry and aluminium smelter unit in the catchment of Bheden river	C	84°00'37.74"E	21°46'49.61"N
<b>Hirakud reservoir</b>							
6	Hirakud	03.01.1988	0	Multipurpose dam (irrigation and Hydroelectricity)	C	83°51'02.74"E	21°30'43.21"N
<b>Power Channel (A channel from Hirakud reservoir confluence with Mahanadi river after traversing 44 Km)</b>							
7	Power Channel U/s	01.01.2009	-	Upstream of Burla town, large medical college, hospital, universities, other educational complexes, nursing homes and Health care units	C	83°51'29.00"E	21°30'38.83"N
8	Power Channel D/s	01.01.2009	-	Downstream of Burla and Chiplima township	C	83°55'00.81"E	21°21'13.57"N
<b>Mahanadi river</b>							
9	Sambalpur U/s	03.01.1988	6	Upstream of Sambalpur town	C	83°55'02.00"E	21°29'47.11"N
10	Sambalpur D/s	03.01.1988	13	Impact of domestic wastewater	C	83°58'13.62"E	21°27'44.04"N
11	Sambalpur FD/s at Shankarmath	01.01.2009	21	To assess water quality after confluence of Haradajhor, Malatijhor which also carries wastewater of the Sambalpur town	C	83°58'40.40"E	21°23'27.60"N

Table- 2.2 Contd..

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
12	Sambalpur FD/s at Huma	01.01.2009	22	To assess water quality improvement along Sambalpur stretch	C	83°57'53.02"E	21°22'27.52"N
13	Sonepur U/s	03.01.1988	91	Downstream of Confluence of major tributary (River Ong)	C	83°54'02.80"E	20°51'40.30"N
14	Sonepur D/s	01.01.1990	98	Downstream of Confluence of major tributary (River Tel) and municipal sewage discharge	C	84°00'08.90"E	20°50'71.30"N
15	Tikarpada	04.01.1989	200	Crocodile breeding research center and sanctuary	C	84°47'00.34"E	20°35'33.37"N
16	Narsinghpur	04.01.1989	260	Thickly populated area with intensive agricultural practice	C	85°16'17.83"E	20°22'04.30"N
17	Mundali	01.01.2009	316	Water intake point of Bhubaneswar city	C	85°45'50.52"E	20°28'13.04"N
18	Cuttack U/s	03.01.1988	322	Upstream of Cuttack city	C	85°48'35.37"E	20°29'45.62"N
19	Cuttack D/s	03.01.1988	337	Impact of waste water discharge of Cuttack city and industrial waste discharge from Jagatpur Industrial Estate	C	85°56'23.21"E	20°27'26.35"N
20	Cuttack FD/s	01.07.2001	342	To assess water quality improvement along Cuttack stretch	C	85°58'43.89"E	20°26'16.51"N
21	Paradeep U/s	01.01.2009	410	Water quality of Mahanadi before industrial activity at Paradeep	C	86°34'25.61"E	20°19'57.02"N
22	Paradeep D/s	01.07.2001	426	Impact of wastewater discharge of Paradeep Industrial Area		86°42'55.36"E	20°17'31.37"N
<b>Tel River (Tributary)</b>							
23	Monmunda	01.01.2009	-	Major tributary of Mahanadi river	C	83°54'37.60"E	20°49'35.58"N
<b>Khajodi River (Distributary)</b>							
24	Cuttack U/s	03.01.1989	-	Upstream Cuttack city	C	85°46'33.46"E	20°28'49.80"N
25	Cuttack D/s	03.01.1989	-	Waste water discharge of Cuttack city	C	85°53'32.02"E	20°25'48.44"N
26	Cuttack FD/s at Mattagajpur	01.07.2001	-	Downstream of sewage treatment plant of Cuttack city , thickly populated village at the down stream of Cuttack city	C	85°57'06.36"E	20°25'57.77"N

Table- 2.2 Contd..

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Serua river (Distributary)</b>							
27	Cuttack FD/s at Sankhatrasa	01.01.2009	-	Thickly populated village at the downstream of Cuttack city, Impact of intense agricultural activities	C	85°54'27.63"E	20°23'42.03"N
<b>Kuakhai river (Distributary)</b>							
28	Bhubaneswar FU/s	01.01.2009		Upstream of Bhubaneswar city	C	85°51'40.31"E	20°19'38.46"N
29	Bhubaneswar U/s	03.01.1988	-	Water Intake point of Bhubaneswar city	C	85°52'27.33"E	20°18'46.10"N
<b>Daya river (Distributary)</b>							
30	Bhubaneswar D/s	03.01.1990	-	Impact of wastewater discharge of Bhubaneswar city	C	85°46'08.97"E	20°08'17.09"N
31	Bhubaneswar FD/s	01.01.2009	-	To assess improvement of water quality	C	85°45'29.31"E	20°08'20.91"N
<b>Birupa river (Distributary)</b>							
32	Choudwar D/s	01.07.2001	-	Downstream of Choudwar town	C	85°55'51.87"E	20°30'42.78"N

(2) Brahmani River System

Sl. No.	Monitoring Station	Date of commencement by the Board (dd-mm-yy)	Approx. distance (Km.) from starting point in Odisha	Justification on the site selected	Designated Best Use	Longitude (Deg-Min-Sec)	Latitude (Deg-Min-Sec)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Sankha River (Tributary)</b>							
1	Sankha U/s	01.01.2009	13	Downstream of Mandira dam	C	84°44'59.66"E	22°14'58.08"N
<b>Koel River (Tributary)</b>							
2	Koel U/s	01.01.2009	24	Before confluence with River Sankha and after wastewater discharge of Koel nagar	C	84°50'27.99"E	22°16'27.78"N

**Table- 2.2 Contd..**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Brahmani River</b>							
3	Panposh U/s	04.01.1985	0	Water quality before Industrial activity after confluence of Sankha and Koel	C	84°47'57.19"E	22°14'12.24"N
4	Panposh D/s at Deogan	04.01.1985	6	Impact of industrial activities like Rourkela Steel Plant and domestic wastewater discharge from Rourkela city	C	84°49'43.44"E	22°12'04.98"N
5	Rourkela D/s at Jalda	01.01.1990	8	To assess water quality improvement at further downstream of Rourkela city and identification of polluted stretch	C	84°49'41.06"E	22°10'54.96"N
6	Rourkela FDS at Attaghat	01.01.2009	14	-do-		84°51'19.24"E	22°09'02.82"N
7	Rourkela FDS at Biritola	01.01.2009	25	-do-		84°53'52.10"E	22°04'28.70"N
8	Bonaigarh	04.01.1985	66	To assess the improvement of water quality	C	84°56'52.27"E	21°50'17.29"N
9	Rengali	04.01.1985	152	A multipurpose dam	C	85°06'27.40"E	21°16'44.55"N
10	Samal	04.01.1985	185	Samal barrage, water intake well of Talcher Super Thermal Power Plant, Kaniha	C	85°07'50.48"E	21°04'19.10"N
11	Talcher FU/s	01.01.2009	201	Intake well of MCL, Talcher	C	85°14'55.83"E	20°59'46.52"N
12	Talcher U/s	01.01.1990	211	Water intake point of industries and mines	C	85°14'27.14"E	20°55'08.33"N
13	Talcher D/s	04.01.1985	219	Impact of industrial and municipal discharge. Downstream of the confluence of Nandira jhor with Brahmani	C	85°17'32.21"E	20°52'20.25"N
14	Talcher FD/s	01.01.2009	226	To assess water quality improvement at further downstream of Angul-Talcher area	C	85°18'58.45"E	20°49'30.31"N
15	Dhenkanal U/s	01.01.2009	253	Upstream of Dhenkanal town		85°33'21.75"E	20°44'46.94"N
16	Dhenkanal D/s	01.01.2009	273	Downstream of Dhenkanal town	C	85°46'05.86"E	20°52'19.32"N
17	Bhuban	04.01.1985	294	A major human settlement with water intake point	C	85°51'33.59"E	20°51'40.40"N
18	Kabatabandha	01.01.2009	312	Before impact of Industrial activity in Kalinganagar area	C	86°00'38.30"E	20°53'20.44"N
19	Dharmasala U/s	04.01.1985	333	Thickly populated area with intensive agriculture practice, Downstream of industrial activities at Kalinga Nagar	B	86°08'42.24"E	20°47'23.83"N

Table- 2.2 Contd..

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
20	Dharmasala D/s	19.12.2013	338	Further downstream of industrial activities at Kalinga Nagar	B	86°09'45.08"E	20°46'59.17"N
21	Pottamundai	04.01.1985	402	Thickly populated area, Tidal effect	B	86°35'22.15"E	20°35'51.06"N
<b>Nandira River (Tributary)</b>							
22	Nandira D/s	01.07.2001	-	Natural rivulet carries wastewater from the industries and townships before confluence with river Brahmani		85°15'26.59"E	20°53'16.85"N
<b>Kisinda jhor (Tributary)</b>							
23	Kisinda jhor	01.07.2001	-	Impact of industrial activity like NALCO Smelter, Iron & Steel units		85°16'45.58"E	20°49'06.73"N
<b>Kharasrota River (Distributary)</b>							
24	Khanditara	01.01.2009	-	Agricultural and other human activities. Downstream of industrial activities at Kalinga Nagar	C	86°12'01.02"E	20°51'11.49"N
25	Binjharpur	01.01.2009	-	Agricultural and other human activities	C	86°30'26.27"E	20°41'13.60"N
26	Aul	01.01.2009	-	Tidal effect	C	86°39'08.76"E	20°41'39.28"N

**(3) Baitarani river system**

Sl. No.	Monitoring Station	Date of commencement by the Board (dd-mm-yy)	Approx. distance (Km.) from starting point in Odisha	Justification on the site selected	Designated Best Use	Longitude (Deg-Min-Sec)	Latitude (Deg-Min-Sec)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Baitarani river</b>							
1	Joda	04.01.1986	0	Major Iron and Manganese deposits of the state	C	85°30'49.12"E	22°01'52.67"N
2	Anandpur	04.01.1986	144	Major human settlement	C	86°07'07.78"E	21°12'41.13"N
3	Jajpur	04.01.1986	201	Mass bathing, religious importance	C	86°20'11.50"E	20°51'20.71"N

**Table- 2.2 Contd..**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
4	Chandbali U/s	04.01.1986	260	Tidal impact, major human settlement	C	86°44'23.33"E	20°46'21.52"N
5	Chandbali D/s	19.12.2013	265	Tidal impact, major human settlement	C	86°45'20.33"E	20°46'31.52"N
<b>Dhamra River</b>							
6	Dhamra	04.01.1986	283	Confluence of Brahmani, Baitarani and Birupa river, tidal effect , fishing activities	C	86°53'57.78"E	20°47'32.05"N
<b>Kusei River (Tributary)</b>							
7	Deogaon	01.01.2009	-	Impact of iron mining activities in Daitari Hill range, industrial activities	C	86°02'24.97"E	21°19'30.39"N
<b>Salandi River (Tributary)</b>							
8	Bhadrak U/s	22.02.2014	-	Upstream of Bhadrak town	C	86°28'46.01"E	21°03'45.48"N
9	Bhadrak D/s	22.02.2014	-	Downstream of Bhadrak town	C	86°30'10.99"E	21°03'45.38"N

**(4) Rushikulya River**

Sl. No.	Monitoring Station	Date of commencement by the Board (dd-mm-yy)	Approx. distance (Km.) from starting point in Odisha	Justification on the site selected	Designated Best Use	Longitude (Deg-Min-Sec)	Latitude (Deg-Min-Sec)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Madhopur	01.01.1992	168	Water intake point of Chhatrapur and Ganjam	C	85°00'34.18"E	19°25'00.47"N
2	Pottagarh	01.01.1992	175	Impact of industrial activities at Ganjam and tidal effect	C	85°03'22.88"E	19°22'29.35"N

Table- 2.2 Contd..

## (5) Nagavali River

Sl. No.	Monitoring Station	Date of commencement by the Board (dd-mm-yy)	Approx. distance (Km.) from starting point in Odisha	Justification on the site selected	Designated Best Use	Longitude (Deg-Min-Sec)	Latitude (Deg-Min-Sec)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Penta U/s	01.01.2009	73	Upstream of Jaykaypur towns and water intake point of J. K. Paper Mill	C	83°25'03.93"E	19°15'20.04"N
2	Jaykaypur D/s	01.07.2001	75	Downstream of wastewater discharge of J.K. Paper mill	C	83°25'28.60"E	19°14'54.74"N
3	Rayagada D/s	01.07.2001	97	Downstream of Rayagada town	C	83°24'51.82"E	19°04'35.79"N

## (6) Subarnarekha River

Sl. No.	Monitoring Station	Date of commencement by the Board (dd-mm-yy)	Approx. distance (Km.) from starting point in Odisha	Justification on the site selected	Designated Best Use	Longitude (Deg-Min-Sec)	Latitude (Deg-Min-Sec)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Rajghat	01.07.2001	25	Interstate river	C	87°09'47.45"E	21°45'53.50"N

Table- 2.2 Contd..

**(7) Budhabalanga River**

Sl. No.	Monitoring Station	Date of commencement by the Board (dd-mm-yy)	Approx. distance (Km.) from starting point in Odisha	Justification on the site selected	Designated Best Use	Longitude (Deg-Min-Sec)	Latitude (Deg-Min-Sec)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Baripada	01.01.2009	89	Downstream of Baripada town	C	86 <sup>0</sup> 43'04.43"E	21 <sup>0</sup> 55'27.18"N
2	Balasore U/s	01.01.2009	153	Upstream of Balasore town and water intake point of Balasore town	C	86 <sup>0</sup> 54'59.78"E	21 <sup>0</sup> 32'52.94"N
3	Balasore D/s	01.01.2009	165	Downstream of Balasore town	C	86 <sup>0</sup> 59'36.41"E	21 <sup>0</sup> 29'11.03"N

**(8) Kolab River System**

Sl. No.	Monitoring Station	Date of commencement by the Board (dd-mm-yy)	Approx. distance (Km.) from starting point in Odisha	Justification on the site selected	Designated Best Use	Longitude (Deg-Min-Sec)	Latitude (Deg-Min-Sec)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Sunabeda	01.01.2009	36 Km	Intake well of NALCO Refinery and HAL	C	82 <sup>0</sup> 49'24.54"E	18 <sup>0</sup> 45'21.85"N

**(9) Vansadhara Basin**

Sl. No.	Monitoring Station	Date of commencement by the Board (dd-mm-yy)	Approx. distance (Km.) from starting point in Odisha	Justification on the site selected	Designated Best Use	Longitude (Deg-Min-Sec)	Latitude (Deg-Min-Sec)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Muniguda	01.01.2009	52	Downstream of Vedanta Alumina Project	C	83 <sup>0</sup> 31'39.69"E	19 <sup>0</sup> 34'53.62"N
2	Gunupur	01.01.2009	130	Interstate boundary	C	83 <sup>0</sup> 48'46.62"E	19 <sup>0</sup> 05'34.95"N

## 2.2 WATER QUALITY MONITORING PARAMETERS

The following water quality parameters are monitored at all locations.

- (a) *Physical parameters* : Temperature, pH, Alkalinity, Total suspended solids (TSS).
- (b) *Indicators of organic pollution* : Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonical (Ammonium + ammonia)-Nitrogen, Total Kjeldahl Nitrogen (TKN). Free ammonia-Nitrogen is calculated from pH and Ammonical nitrogen values.
- (c) *Bacteriological parameters* : Total Coliform and Fecal Coliform.
- (d) *Mineral constituents* : Electrical Conductivity (EC), Total Dissolved Solids (TDS), Boron, Total hardness, Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate, Fluoride. Sodium Absorption Ratio (SAR) is calculated from Calcium, Magnesium, Sodium and Potassium values.
- (e) *Nutrients* : Nitrate (Nitrate+ Nitrite)-Nitrogen, Phosphate- phosphorous.
- (f) *Metals* : Chromium (Cr) (total and hexavalent), Iron (Fe), Nickel (Ni), Copper (Cu), Zinc (Zn), Cadmium (Cd), Mercury (Hg), Lead (Pb)
- (g) *Biological Indices* : Saprobic Index (SI) and Diversity Index (DI). Biological indices are calculated on quarterly basis during January, March and October. Monsoon period is excluded from the biomonitoring studies.

## 2.3 SEASON DESCRIPTION

In the subsequent Chapters, water quality data in some Tables are described in terms of seasonal values. The seasons are defined as follows :

Winter (W) : December, January, February

Summer (S) : March, April, May, June

Monsoon (M) : July, August, September

Post Monsoon (PM) : October, November

## 2.4 SIGNIFICANCE OF WATER QUALITY PARAMETERS

### 2.4.1 Physical parameters

**pH:** pH is a measure of acidity. Neutral (neither acidic nor alkaline) water has a pH of 7. Water of low pH (less than 7-acidic) has the ability to dissolve many metals and carry their toxicity. Besides, highly acidic (low pH) or alkaline (high pH) nature of water may themselves be detrimental to certain vital biological processes.

**Alkalinity:** The alkalinity of water is a measure of its capacity to neutralize acids. Except at very high pH (greater than about 9.5), the alkalinity of natural waters can be assigned entirely to dissolved

bicarbonates and carbonates without serious error, unless associated with petroleum or natural gas or high dissolved carbon. As far as is known, alkalinity of water has little public health significance except that highly alkaline waters are usually unpalatable. Alkalinity in industrial water supplies is desirable because water with high alkalinity is much less corrosive. However high alkalinity is not desirable for industries involved in food production.

**Total Suspended Solids (TSS):** In water quality considerations, the term TSS is usually referred to larger settleable solids. Besides giving the problems in filtration and disinfection (the solids may prevent effective contact between the disinfecting agents and the target organism), TSS can adversely affect the fish population by any of the four means, namely, by (i) acting directly on the fish, (ii) preventing the successful development of fish eggs and larvae, (iii) modifying natural movement and migration of fish and (iv) reducing the abundance of food available to the fish. Use of water with a large amount of TSS for irrigation might lead to formation of crusts on top soil which inhibits water infiltration.

#### 2.4.2 Indicators of Organic Pollution

**Dissolved Oxygen (DO)** : DO is a measure of the amount of oxygen freely available in water. It is commonly expressed as concentration in terms of mg/l or as percentage of saturation, which is temperature dependent. DO concentration in fresh water averages about 0.001% (10 ppm) by weight, which is 40 times less than the weight of oxygen in an equivalent volume of air. While the concentration of oxygen in air varies little, the amount of DO in aquatic ecosystems varies widely, depending upon various factors.

DO is the single most important gas for most aquatic organisms and is essential for self purification processes of a water body. The aesthetic qualities of water require sufficient DO to avoid the onset of septic conditions with their attendant malodorous emissions. Insufficient DO in the water columns causes anaerobic decomposition of many organic materials present. Such decomposition tends to cause the formation of noxious gases such as hydrogen sulfide and methane, in addition to carbon dioxide. Traditionally, the waste treatment requirement was based on the removal of oxygen demanding materials so as to maintain the dissolved oxygen concentration in receiving waters at prescribed levels.

**Biochemical Oxygen Demand (BOD)** : Most industrial and municipal wastes contain high concentrations of organic substances. Their presence encourages the growth of decomposers, which consume large quantities of oxygen. The amount of dissolved oxygen needed by decomposers to decompose organic materials in a volume of wastewater is called Biochemical Oxygen Demand. Thus BOD is a measure of the contamination of wastewater.

**Chemical Oxygen Demand (COD)** : Besides organic matter, the wastewater may also contain chemicals that are susceptible to reaction with oxygen (oxidation). The extent of pollution due to these substances is expressed in terms of Chemical Oxygen Demand (COD).

**Ammonia**: Ammonia is present in most waters as a normal biological degradation product of nitrogenous organic matter. Some industrial effluents also contain ammonia. Free ammonia in water is known to be toxic to fishes and the toxicity varies with the pH of the water. In most natural waters, the

pH range is such that the ammonium fraction of ammonia predominates. However, in highly alkaline waters, the free ammonia fraction can reach toxic levels. Lethal concentrations of ammonia for a variety of fish species are in the range of 0.2 to 2.0 mg/l.

**Total Kjeldahl Nitrogen (TKN):** TKN values are more important for stagnant water, since higher TKN values indicate a potential for eutrophication or higher level of ammonia in water, which may be toxic.

### 2.4.3 Bacteriological Quality of Water

**Coliform group of bacteria :** A wide range of pathogenic micro-organisms are potentially transmittable to man through drinking and bathing. The coliform group of bacteria include microorganisms of diverse characteristics – 16 groups comprising of 256 species, which by physical and biochemical laboratory procedures are found to fit in the domain of coliform classification. In addition to groups and species which originate from the intestinal tract of human and other warm blooded animals, there are other types of coliform bacteria that are not derived from sewage or body wastes. The accepted standard tests for bacterial contamination of water involves the determination of the indicator organism the coliform group of bacteria as a whole (Total Coliform Count). Thus at present total coliform is taken as an indicator of the bacterial contamination and fecal coliform as the indicator of fecal contamination of water.

### 2.4.4 Mineral Constituents

**Electrical Conductivity (EC) and Total Dissolved Solids (TDS):** TDS is generally associated with inorganic salts and there is a close parallelism between TDS and conductivity. Though there is no generally valid exact quantitative relationship between TDS and conductivity, high conductivity indicates high TDS. Excess dissolved solids are objectionable in drinking water because of possible physiological effects and unpalatable taste. Agricultural uses of water also are limited by excessive TDS concentration and EC values.

**Boron (B) :** Although an essential element for plant growth, boron in excess of 2 mg/l in irrigation water, becomes toxic for most of the field crops, affecting the metabolic activities of the plant.

**Sodium Absorption Ratio (SAR) :** SAR gives the concentration of sodium, relative to the concentrations of calcium and magnesium and is a guide to judge the sodium hazards of irrigation water. SAR is calculated as per the procedure given in IS : 2296 – 1982.

$$SAR = \frac{A\sqrt{2}}{\sqrt{(B + C)}}$$

Where A, B and C are respectively the sodium, calcium and magnesium contents in milliequivalents per litre.

**Hardness :** Hardness is caused by divalent metallic cations. Such ions are capable of reaction with certain anions present in the water to form scales. The principal hardness causing cations are calcium,

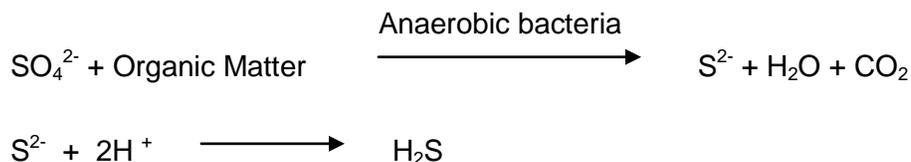
magnesium, strontium, ferrous and manganous ions. The important anions with which they are usually associated are bicarbonate, sulfate, chloride, nitrate and silicates. Waters are commonly classified in terms of the degree of hardness, as follows:

<u>Hardness (mg/l)</u>	<u>Degree of Hardness</u>
0 – 60	Soft
61 – 120	Moderately hard
121 – 180	Hard
More than 180	Very hard

Except their adverse action with soap, hard waters are as satisfactory for human consumption as soft waters.

**Chlorides** : Chlorides occur in all natural waters in widely varying concentrations. Water bodies may also receive chlorides through discharge of industrial effluent. Chlorides in reasonable concentrations are not harmful to humans. At concentrations 250 mg/l and above, they give a salty taste to water, which is objectionable to many people. For this reason, chlorides are generally limited to 250 mg/l in supplies intended for public use. In many areas of the world where water supplies are scarce, sources containing as much as 2000 mg/l are used for domestic purposes without the development of adverse effects once the human system becomes adapted to the water. Although chloride is essential for plants in low amounts, it can cause toxicity to certain crops at high concentrations.

**Sulfates**: Sulfate ion is one of the major anions which occur in natural water. It is important in public water supplies because of its cathartic effects upon humans when it is present in excess amounts. For this reason the recommended upper limit is 250 mg/l in waters intended for public consumption. Sulfates are important in both public and industrial water supplies because of the tendency of water containing appreciable amounts to form hard scales in boilers and heat exchangers. Sulfates are also of concern because they are indirectly responsible for two serious problems often associated with the handling and treatment of wastewaters. These are odour and sewer corrosion problems resulting from reduction of sulfates to hydrogen sulfide under anaerobic conditions.



**Fluorides** : In public water supplies, a fluoride concentration upto about 1 mg/l is considered desirable. Excess fluoride is detrimental to human health, causing fluorosis. Fluorides in water bodies may be of geological origin or from discharge of certain industrial effluents.

#### 2.4.5 Nutrients

**Nitrate** : Nitrate can enter into water bodies through municipal, industrial wastewaters and sewage discharges. In natural waters high nitrate may induce eutrophication. Nitrates at reasonable concentrations are rapidly excreted in the urine. High intake of nitrate, however, is a health hazard, under conditions that are favourable to their reduction of nitrite in the gastrointestinal tract, which then reacts with blood stream to produce methemoglobin with consequent impairment of oxygen transport.

**Phosphate** : Phosphates may enter into water bodies from human and animal excreta, runoffs from agricultural fields using phosphatic fertilizers and some industrial effluents. Excess phosphate may induce excessive plant growth leading to eutrophication and interfere with coagulation in water treatment plants.

#### 2.4.6 Metals

**Lead** : Average abundance of lead in earth's crust is 13 ppm; in soil it varies within the range 2.6 - 25 ppm, in stream water is 3 microgram/l and in groundwater less than 0.1 mg/l. Lead has no beneficial or desirable nutritional effects. It is a toxic metal that tends to accumulate in the tissues of man and other animals. The common symptoms of lead poisoning are anemia, paralysis of nerves etc.

**Cadmium** : Average abundance of cadmium in earth's crust is 0.16 ppm; in soil it varies within the range 0.1 to 0.5 ppm, in stream water is 1 microgram/l and in groundwater it varies within the range 1 to 10 microgram/l. Cadmium is toxic to man when ingested or inhaled. Drinking water containing excess cadmium leads to a disease called itai-itai, characterized by rheumatic symptoms with intense pain in the bones caused by a loss of bone minerals.

**Mercury** : Average abundance of mercury in earth's crust is 0.09 ppm; in soil it varies within the range 30 to 160 ppb, in stream water is 0.07 microgram/l and in groundwater it varies within the range 0.5 to 1 microgram/l. Mercury may be found in the surface waters through discharge of effluents from industries using mercury (e.g. electrolytic methods using mercury cell). Biologically it is a nonessential or nonbeneficial element. Its high toxic potential is known since a long time. Symptoms of mercury poisoning include pharyngitis, vomiting followed by ulcerative hemorrhage, hepatitis and circulatory collapse.

**Chromium** : Chromium is found in air, soil some foods and most biological systems and in its trivalent state is an essential trace element for humans. It is rarely found in natural waters. Average abundance of chromium in earth's crust is 122 ppm; in soil it varies within the range 11 to 22 ppm, in stream water is 1 microgram/l and in groundwater it varies within the range 100 microgram/l. Unlike the trivalent chromium, hexavalent chromium is irritating and corrosive to mucous membrane, it is absorbed via ingestion through the skin and by inhalation which ultimately leads to lung cancer, ulceration, variety of respiratory complications and skin affects. Hexavalent chromium in appreciable quantities are found in the chromite mines discharge waters and the effluents of chromium based industries.

**Iron** : Average abundance of iron in earth's crust is 6.22%, in soil it varies within the range 0.5 to 4.3 %, in stream water is 0.7 mg/l and in groundwater it varies within the range 0.1 to 10 mg/l. Iron is an essential trace element required by both plants and animals. Major iron polluting sources are industrial wastes, mine drainage waters and iron bearing ground water. Though the daily nutritional requirement for iron is 1 – 2 mg, excessive presence of iron is objectionable in water supplies, since it affects taste, stain clothes and plumbing fixtures. High iron concentrations in natural waters affect aquatic life.

**Nickel** : Average abundance of nickel in earth's crust is 1.2 ppm and in soil it remains within 2.5 ppm. Nickel can occur as a leachate from nickel bearing ores and does not normally occur in natural waters. However, in stream water it may remain within 1 microgram/l and in groundwater it varies within the range 100 microgram/l. Nickel in excess amount is toxic to plants and certain types of aquatic life (crustaceans).

**Copper** : Average abundance of copper in earth's crust is 68 ppm; in soil it varies within the range 9 to 33 ppm, in stream water it ranges within 4 to 12 microgram/l and in groundwater it remains below 0.1 mg/l. Copper is an essential trace element for propagation of plants, performs vital functions in several enzymes and plays a major role in synthesis of chlorophyll. Concentration of copper as found in natural waters are not known to have to any adverse effect for humans. However, long oral administration of excess quantities of copper may result in liver damage. Excess copper is also toxic to aquatic life.

**Zinc** : Average abundance of zinc in earth's crust is 76 ppm; in soil it varies within the range 25-68 ppm, in stream water it remains within 20 microgram/l and in groundwater it remains below 0.1 mg/l. Industrial effluents (galvanizing, electroplating etc.) are the major source of zinc in natural waters. Zinc is an essential and beneficial element in human metabolism. However, under certain conditions of hardness, dissolved oxygen and temperature, zinc can be toxic to aquatic life.

## 2.5 WATER QUALITY ASSESSMENT

### 2.5.1 Use based water quality status

Natural water bodies are used for various competing as well as conflicting demands. Each use has a different water quality requirement from the other. Therefore, to attain the objective of restoration of water quality of a water body or a part of it, the concept of "Designated Best Use" has been developed. According to this concept, out of several uses a water body is put to, the use which demands highest quality of water is termed as Designated Best Use (DBU) and accordingly the water body is designated. Meaningful evaluation of water quality status requires that the quality be viewed in the context of the uses which the society wishes to make of the stream or a part of it.

In India, water quality is usually assessed in respect of five broad categories as described in Table 2.3.

**Table 2.3 Use based classification**

Class	Use
A	Drinking water source without conventional treatment, but after disinfection
B	Organised outdoor bathing
C	Drinking water source with conventional treatment followed by disinfection
D	Fish culture and wild life propagation
E	Irrigation, Industrial cooling or controlled waste disposal

Water quality parameters relevant to the above uses, are described in IS: 2296/1982.

In this Report, classification of river water is discussed in respect of those parameters, considered to be of primary concern for the designated best use. These primary water quality criteria (Table 2.4 ) are derived from the criteria developed in other parts of the world, namely USA, UK, Germany and Japan (CPCB: ADSORBS/3/78-79, ADSORBS/2/80-81).

*(a) Water Quality in respect of primary criteria*

The primary water quality criteria for the aforementioned use based classes are given in Table 2.4.

**Table 2.4 Primary Water Quality Criteria**

Parameter	Quality Criteria				
	Class- A	Class - B	Class - C	Class - D	Class - E
pH	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 8.0
DO (mg/l), Min	6.0	5.0	4.0	4.0	-
BOD (mg/l), Max	2.0	3.0	3.0	-	-
TC (MPN/100 ml), Max	50	500	5000	-	-
Free Ammonia-N (mg/l), Max	-	-	-	1.2	-
EC (microSiemens/cm), Max	-	-	-	1000	2250
SAR, Max	-	-	-	-	26
B (mg/l), Max	-	-	-	-	2.0

Even with this restriction in parameters, classification based on one of them, may or may not necessarily be the same on the basis of other parameters. In such cases, the lowest class indicated by any one of the parameters should normally be viewed as the overall water quality status at the particular site.

*(b) Water quality in respect of other parameters*

Tolerance limits for other parameters are presented in Table 2.5.

**Table 2.5 Tolerance limits for other parameters**

Parameter	Tolerance limits (mg/l)				
	Class-A	Class-B	Class-C	Class-D	Class-E
TDS, Max	500	--	1500	--	2100
Hardness (as CaCO <sub>3</sub> ), Max	300	--	--	--	--
Chloride, Max	250	--	600	--	600
Sulphate, Max	400	--	400	--	1000
Fluoride, Max	1.5	1.5	1.5	--	--
Nitrate (as NO <sub>3</sub> )	20	--	50	--	--
Pb, Max	0.10	--	0.10	--	--
Cd, Max	0.01	--	0.01	--	--
Hg, Max	0.001	--	--	--	--
Cr(VI), Max	0.05	0.05	0.05	--	--
Fe, Max	0.3	--	50	--	--
Cu, Max	1.5	--	1.5	--	--
Zn, Max	15	--	15	--	--
Cyanide, Max	0.05	0.05	0.05	--	--

### 2.5.2 Biological Assessment of Water Quality

Biological assessment is based on the fact that pollution of water bodies will cause changes in the physical and chemical environment of water, which, in turn, will disrupt the ecological balance of the ecosystem. Through bio-monitoring studies, the cumulative effects of all the pollutants can be determined and the overall health of the ecosystem can be properly assessed. Benthic macroinvertebrates are regarded as the best indicator of pollution as they are sedentary, sessile, long-lived and easily collectable.

Biomonitoring results are generally expressed in terms of two indices, namely the Saprobic index (SI) and Diversity index (DI). Determination of SI involves preparation of an inventory of the presence of benthic macro-invertebrate fauna upto the family level with taxonomic precision and expressing the SI on a scale of 1-10. The methodology for DI involves pair-wise comparison of sequentially encountered benthic individuals upto the species level. The diversity is the ratio of total number of different animals (runs) and the total number of organisms encountered. The DI has a value between 0 to 1. The criteria used for classification of water quality on the basis of biological indicators are given in Table 2.6 (Environmental Atlas of India, CPCB, 2001).

**Table 2.6 Biological Indicators**

Indicator	Water Quality
High Biodiversity DI $\geq$ 0.6 SI = 6-10 BOD $\leq$ 3 mg/l	Clean
Moderate Biodiversity DI = 0.2 - 0.6 SI = 2 to 6 BOD = 3 to 6 mg/l	Slight to Moderate Pollution
Poor Biodiversity DI $\leq$ 0.2 SI $\leq$ 2 BOD $\geq$ 6 mg/l	Heavy to Severe Pollution

### 2.5.3 Water Quality in terms of Wholesomeness

The basic objective of the Water (Prevention and Control of Pollution) Act, 1974, which governs the water quality management in the country, is “to provide for the prevention and control of water pollution and maintaining or restoring the wholesomeness of water”. Since the Act does not define the level of “wholesomeness” to be maintained or restored, the CPCB linked wholesomeness to the quality as required for designated uses by humans. Criteria were developed for different uses, which were subsequently adopted as the Indian Standards by the Indian standards Institution, later named as the Bureau of Indian Standards.

Over the years it was felt that the designated use concept with the objective of protecting the direct beneficial uses to humans and classifying water quality accordingly, needs to be reviewed and “wholesomeness” should incorporate an overall integrated view of the water ecosystem. The first priority in water quality assessment and management should be to maintain and restore to a desirable level of its environmental quality. Accordingly specific requirements for “Acceptable”, “Desirable” and “Excellent” levels of wholesomeness with short, medium and long term goals have been laid down (Water Quality- Criteria and Goals, CPCB, MINARS/17/2001/2002).

Parameters for the above classifications are grouped in three categories.

- i. Simple parameters (Sanitary surrounding, general appearance, colour, smell, transparency, presence of fish and insects),
- ii. Regular monitoring parameters, and
- iii. Special parameters to be monitored when need or apprehensions arise.

#### (a) Wholesomeness in terms of regular parameters

The requirements in respect of regular monitoring parameters for different classes are given in Table-2.7.

**Table 2.7 Standards for regular monitoring parameters**

Sl. No.	Parameter	Requirements		
		Excellent	Desirable	Acceptable
1	pH	7.0-8.5	6.5-9.0	6.5-9.0
2	DO (% saturation)	90-110	80-120	60-140
3	BOD (mg/l)	Below 2	Below 5	Below 8
4	EC (micromhos/cm)	< 1000	< 2250	< 4000
5	(Nitrite+Nitrate)-N (mg/l)	< 5	< 10	< 15
6	Suspended solids (mg/l) (non-monsoon)	< 25	< 50	< 100
7	*FC (MPN/100 ml)	< 20	< 200	< 2000
8	Bio assay (Zebra fish)	No death in 5 days	No death in 3 days	No death in 2 days

\* FC values should meet for 90 % of samples

(b) *Wholesomeness in terms of special parameters*

Acceptable limits for the special parameters that are relevant to the present study are given in Table 2.8.

**Table 2.8 Standards for special parameters**

Sl. No.	Parameter	Requirement, Max		
		Excellent	Desirable	Acceptable
1	Total phosphorous	0.1	0.2	0.3
2	TKN	1.0	2.0	3.0
3	(Ammonium +Ammonia) N	0.5	1.0	1.5
4	Zinc	0.1	0.2	0.3
5	Nickel	0.05	0.10	0.20
6	Copper	0.02	0.05	0.10
7	Chromium (Total)	0.02	0.05	0.10
8	Lead	0.02	0.05	0.10
9	Cadmium	0.001	0.0025	0.005
10	Mercury	0.0002	0.0005	0.001

Concentration of all parameters are in mg/l

**2.5.4 Water quality in terms of COD and Alkalinity**

The two water quality classification schemes described earlier (use based and quality in terms of wholesomeness), do not stipulate any standard for COD and Alkalinity.

Some European Countries prescribe a maximum limit for COD as 20 and 25 mg/l for water quality to be classified as 'excellent' and 'good' respectively. In India, the maximum permissible limit for COD for an industrial effluent to be discharged into inland surface water is 250 mg/l, under the Environment Protection Act. Hence even in the Indian context, it is perhaps reasonable to assume that a COD concentration of 25 mg/l or less, may be the desirable limit in a water body, since discharge standards are generally based on the assumption of ten times dilution.

Alkalinity of natural water should be more than 20 mg/l (as calcium carbonate) for freshwater aquatic life, unless natural concentrations are less. Maximum alkalinity in water as a source of supply to many industries, prior to treatment, range from about 120-500 mg/l (as calcium carbonate). However for bottled and canned soft drink industries, the alkalinity should not exceed 85 mg/l (as calcium carbonate)

### 2.5.5 Identification of polluted river monitoring station

As the level of BOD varies in river water along its stretch, attention for pollution control measures varies with the degree of pollution level with respect to BOD values. Therefore, CPCB has prioritized the monitoring stations into five categories from Priority –I to Priority -V based on the BOD concentrations as described in Table 2.9. The degree of violation is with respect to water quality criteria for BOD in drinking water source with conventional treatment followed by disinfection (i.e. for Class-C). The polluted locations in a continuous sequence is called polluted river stretches.

**Table 2.9 Prioritization of river monitoring stations based on BOD values**

Category	BOD limit, mg/l
Priority-I	Monitoring locations with BOD concentration greater than 30 mg/l
Priority-II	Monitoring locations with BOD concentration between 20- 30 mg/l
Priority-III	Monitoring locations with BOD concentration between 10-20 mg/l
Priority-IV	Monitoring locations with BOD concentration between 6-10 mg/l
Priority-V	Monitoring locations with BOD concentration between 3- 6 mg/l

### 2.5.6 Water Quality Index

Water quality index (WQI) is used to indicate the overall water quality of a water body. It is also used to evaluate the water quality profile of the entire stretch of a river and to identify the gap between the existing and desired water quality significant enough to plan for pollution control management.

WQI is expressed in terms of a number which is derived from the integration of certain physico-chemical and biological constituents of water which have significant impact on the beneficial uses of the water body. Several water quality indices have been developed to evaluate the water quality. Most of these are based on the water quality index developed by the U.S. National Sanitation Foundation (NSFWQI). Nine water quality variables such as pH, dissolved oxygen (DO), temperature change, biochemical oxygen demand (BOD), turbidity, total phosphorous, nitrate, total solids and fecal coliform are used to determine the NSFWQI (Ott, 1978).

Canadian Council of Ministers of the Environment (CCME) developed the water quality index (CWQI) (CCME, 2003), which has been used by environmental authorities in several nations to assess water quality of rivers and other aquatic resources. The CWQI is derived from a number of use-based variables and has the advantage of considering the type of physico-chemical and biological variables depending upon the overall use of the water segment. The formulation of CWQI has the flexibility in using the number of such variables and the tolerance limits for various uses of water segment or whole of the water bodies.

In the present report, CWQI has been used to evaluate the water quality status of the rivers. As most part of the rivers are designated as Class C, criteria pollutants such as pH, DO, BOD and TC are used as variables and corresponding tolerance limits for Class C surface water bodies has been used for calculation of CWQI scores. However, at the mouths of the rivers with the sea, due to tidal influence of the sea, water quality of the river is significantly changed and here, parameters like electrical conductivity, chloride, sulfate, sodium absorption ratio etc. play a major role in determining the water quality. Therefore, in such cases, parameters prescribed for irrigation water quality (Class E), like, electrical conductivity, chloride, sulfate, sodium absorption ratio, boron and total dissolved solids are taken into consideration for calculation of CWQI score.

Calculation of the CWQI comprises of following three factors.

**Factor 1 : F<sub>1</sub> (Scope)** : Scope assesses the extent of water quality guideline non-compliance over the time period of study, which means the number of water quality parameters whose tolerance limits are not met during the period.

$$F_1 = \frac{\text{Number of failed variables}}{\text{Total number of variables}} \times 100$$

Where, the variables indicate those water quality parameters for whose threshold limits are specified and observed values at the sampling sites are available for index calculation.

**Factor 2 : F<sub>2</sub> (Frequency)** : Frequency assesses the number of occasions when the variables are not meeting the tolerance limits (that is, failed tests).

$$F_2 = \frac{\text{Number of failed tests}}{\text{Total number of tests}} \times 100$$

**Factor 3 : F<sub>3</sub> (Amplitude)** : The amount by which the tolerance limits of each variables are not met. This is calculated in three steps as follows.

*Step-1 : Calculation of Excursion* : The number of times by which an individual concentration is greater than the tolerance limit (or less than when the tolerance limit is minimum), is termed as "excursion". When the test value must not exceed the tolerance limit,

$$\text{Excursion}_i = \frac{\text{Field test value}_i}{\text{Tolerance limit}_i} - 1$$

When the test value must not fall below the tolerance limit,

$$\text{Excursion}_i = \frac{\text{Tolerance limit}_i}{\text{Field test value}_i} - 1$$

*Step-2 : Calculation of normalized sum of excursion (nse)* :

The collective amount, by which the individual tests are out of compliance, is calculated by summing the excursions of individual tests and then dividing the sum by total number of tests.

$$nse = \frac{\sum_{i=1}^n excursion_i}{number\ of\ tests}$$

Sep-3 : Calculation of  $F_3$

$F_3$  is calculated by an asymptotic function that scales the normalized sum of the excursions from the tolerance limits (nse) to yield a value between 0 and 100.

$$F_3 = \frac{nse}{0.01\ nse + 0.01}$$

The CWQI is finally calculated as follows :

$$CWQI = 100 - \frac{\sqrt{(F_1^2 + F_2^2 + F_3^2)}}{1.732}$$

The factor of 1.732 has been introduced to scale the index from 0 to 100. Since the individual index factors can range as high as 100, it means that the vector length can reach a maximum of 173.2 as shown below.

$$\sqrt{100^2 + 100^2 + 100^2} = \sqrt{30000} = 173.2$$

The above formulation produces a value between 0 and 100 and thus gives a numerical value to the state of water quality. The water quality is ranked in following five categories.

**Table 2.10 Category of water quality based on CWQI values**

Sl. No.	CWQI values	Category
1.	95 – 100	Excellent
2.	80 – 94	Good
3.	60 – 79	Fair
4.	45 – 59	Marginal
5.	0 – 44	Poor

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**WATER QUALITY STATUS OF MAHANADI RIVER SYSTEM  
(Mahanadi, Ib, Bheden, Tel, Kathajodi, Serua, Kuakhai, Daya and Birupa rivers)**

Water quality of Mahanadi river system is monitored on the main river Mahanadi starting from Hirakud reservoir upto its tidal limit at Paradeep, on its tributaries like Ib, Bheden and Tel rivers and on its distributaries like Kathajodi, Kuakhai, Daya and Serua rivers.

**3.1 USE BASED WATER QUALITY STATUS**

**3.1. Water Quality in respect of primary criteria**

The seasonal average values of pH, DO, BOD and TC of 32 monitoring stations distributed over Mahanadi, Ib, Bheden, Tel, Kathajodi, Kuakhai, Daya and Birupa rivers, pertaining to the period 2011-2015 are described in Tables 3.1-3.8.

**pH and DO :** As may be seen from the data, the seasonal average values of pH mostly remain within the tolerance limit and varies in the range 7.3 - 8.4 . At most of the monitoring stations, DO values conform the tolerance limits for Class A (6.0 mg/l, minimum). However on few occasions, monthly DO values do not conform the tolerance limit for Class C rivers (4.0 mg/l, minimum) at six monitoring stations. Such deviations occur at Cuttack FD/s (Mahanadi) (June, 2011), Cuttack FD/s at Mattagajpur (Kathajodi) (February, March, and November during 2011 ; January, May, June, July and October during 2012 ; January-May and October during 2013; January, March, September and December during 2015), Cuttack FD/s at Samnkatrasa (Serua) (May, 2014), Bhubaneswar U/s (Kuakhai) (July, 2012), Bhubaneswar D/s (Daya) (May and July during 2014; March and June during 2015), Bhubaneswar FD/s (Daya) (July, 2012 ; May and July during 2014).

**BOD :** Seasonal average of the BOD values at all the sampling stations conform to Class-C water quality except at Sambalpur D/s and Sambalpur FD/s at Shankarmath, Cuttack D/s on Mahanadi river, Cuttack D/s and Cuttack FD/s at Mattagajpur on Kathajodi river, Cuttack FD/s at Sankhatrasa on Serua river, Bhubaneswar D/s and Bhubaneswar FD/s on Daya river. Out of these eight violating stations, seasonal average of BOD values at Cuttack FD/s at Mattagajpur on Kathajodi river mostly remain above 5.0 mg/l. Frequency of violation of monthly BOD values as well as magnitude of deviation from the tolerance limit (3.0 mg/l, max) is less in Sambalpur stretch and Cuttack stretch of Mahanadi river, in comparison to that in Cuttack stretch of Kathajodi river and Bhubaneswar stretch of Daya river.

**TC :** The seasonal average of TC values at Sambalpur D/s, Shankarmath and Huma on Mahanadi river, Cuttack D/s and FD/s (both on Mahanadi and Kathajodi rivers) and Bhubaneswar D/s and FD/s in Daya river do not conform to Class-C inland surface water quality. The magnitude and frequency of violations of TC from the stipulated value (less than 5000 MPN/ 100 ml) at these seven stations are far too large for the water quality to be classified as Class-C. At all other stations, wide fluctuation in TC values has been observed during the study period.

The annual average and the range of BOD and TC values at all the 32 monitoring stations during the period 2011-2015 are given in Table 3.9. Frequency of violation of BOD and TC values from the stipulated values (3.0 mg/l and 5000 MPN/100 ml respectively) are also given in Table 3.9. Percent violations of BOD in the main river, its tributaries and distributaries during the entire period under report are presented in Figs. 3.1, 3.2 and 3.3 respectively. From the data and figures, it is evident that maximum number of deviation from tolerance limits for BOD are observed at Cuttack FD/s at Mattagajpur on Kathajodi river (91%), Bhubaneswar D/s on Daya river (81%), Cuttack D/s on Kathajodi river (68%) and at Bhubaneswar FD/s on Daya river (63 %).

Spatial variation of annual average values of BOD and TC during the period 2011-2015 in the stretches of Mahanadi river system are presented in Fig. 3.4 (a)-(d) and Fig 3.5 (a)-(d) respectively.

**Free Ammonia :** The annual average and range values of ammoniacal nitrogen and free ammonia are presented in Table-3.10. Free ammonia values at all stations conform to the stipulated values for Class-D inland surface water. No regular pattern can be discerned regarding the level of ammonia in the river. Since ammonia is naturally present in domestic sewage and is also produced largely by deamination of nitrogen containing organic compounds, such observations are not entirely unexpected.

**EC, SAR and B :** As described in Table 2.4, EC, SAR and B are considered to be three primary water quality criteria for water to be used for irrigation purpose (Class-E). Seasonal average values of EC at these monitoring stations are given in Table 3.11. Except at the monitoring stations near river mouth, that is, Paradeep U/s and Paradeep D/s, EC values remain far below the permissible limit of 2250 microsiemens/ cm. Wide fluctuations in EC values at Paradeep U/s and Paradeep D/s have been observed due to tidal influence on the river.

Annual average and range of values for SAR and B at these 32 monitoring stations are given in Table 3.12. Similar to the observations for EC, except at Paradeep U/s and Paradeep D/s, SAR values and Boron value at all other stations remain far below the permissible limit of 26 and 2.0 mg/l respectively. Wide range of fluctuation in values of EC, SAR and Boron are observed at Paradeep U/s and Paradeep D/s which may be ascribed to the tidal effect as these two stations are very close to the Mouth of Mahanadi river with the Sea. Therefore river water of the entire stretch of Mahanadi river system except the stretch from Paradeep U/s to Paradeep D/s is suitable for irrigation purpose.

### 3.1.2 Water quality in respect of other parameters

**TDS and Total Hardness :** Annual average and range of values for total dissolved solids (TDS) and total hardness during the period 2011-2015 are given in Table 3.13. Comparison with the required TDS concentration and hardness of different use classes (Table 2.5), it is seen that the entire river stretch conform to Class-A, except at Paradeep U/s and Paradeep D/s. In terms of degree of hardness, the river water except at Paradeep U/s and Paradeep D/s may generally be described as moderately hard (Hardness 61 to 120).

**Nitrates :** The river water is very low in nitrate concentrations as revealed from the data given in Table 3.14. The nitrate values in the entire stretch never exceeded the stipulated value for Class-A (20 mg/l).

**Chloride, Sulphate and Fluoride :** Annual average and range of values for chloride, sulphate and fluoride at these monitoring stations are given in Table 3.15, Table 3.16 and Table 3.17 respectively. Tolerance limits for chloride, sulphate and fluoride for different classes of inland surface waters are given in Table 2.5. A comparison with the values of these parameters at different sampling stations, as described in Table 3.15- 3.17 indicate that the water quality in respect of chlorides, sulphates and fluorides, conform to the highest class (i.e. Class-A). However, on one occasion fluoride concentration remained above the tolerance limit at Power Channel U/s (June,2014). Monthly fluoride content in Bheden river at Jharsuguda exceeded the tolerance limit of 1.5 mg/l for 19 % of time during the entire period. At Paradeep U/s and D/s, most of the time the chloride content as well as sulphate content remained above the stipulated limit for Class-E inland surface water bodies. This may be attributed to the tidal effect. Fluoride content at these two stations remained well within the tolerance limit.

**Metals:** Water pollution from metal constituents is expected to occur due to industrial effluents (unless some metals have geological origin). Data given in Table 3.18 (a) represents the annual average and range of concentrations of chromium (VI) and mercury during 2014 and 2015, whereas Table 3.18 (b)-(h) represent the annual average and range of concentrations of total chromium, iron, nickel, copper, zinc, cadmium and lead respectively during the period 2011-2015. From the tables, it is observed that the concentration of these metals are well within the respective tolerance limits (Table 2.5).

### 3.1.3 Use based classification

From the water quality data and frequency of violation discussions, it may be reasonable to conclude that the water quality at all stations except Sambalpur D/s, Sambalpur FD/s at Shankarmath, Cuttack D/s, Paradeep U/s and D/s, Cuttack D/s and FD/s (Kathajodi), Cuttack FD/s (Serua), Bhubaneswar D/s and FD/s (Daya), can be classified as class C/D/E. It may be safe to classify the water quality of Sambalpur D/s, Sambalpur FD/s at Shankarmath, Sambalpur FFD/s at Huma, Cuttack D/s, Cuttack FD/s, Cuttack D/s and FD/s (Kathajodi), Bhubaneswar D/s and FD/s (Daya), as Class D/E. In most of the cases, parameter responsible for downgrading the water quality is either BOD or TC or both. Water quality at Paradeep U/s and D/s do not qualify even for Class E due to several parameters ( EC, SAR, Chloride).

## 3.2 BIOLOGICAL ASSESSMENT OF WATER QUALITY

The annual average and range of Saprobic Index (SI) and Diversity Index (DI) values observed at eight monitoring stations such as Brajarajnar D/s, Sambalpur D/s, Cuttack U/s (Mahanadi), Cuttack D/s (Mahanadi), Cuttack D/s (Kathajodi), Bhubaneswar U/s, Bhubaneswar D/s and Choudwar D/s during the period 2011-2015 are presented in Table 3.19.

Taking into consideration the observed biological indices, that is, SI and DI values, and the BOD values (Tables 3.9), it may be concluded that the river stretches along these monitoring stations are in a state of slight to moderate pollution (that is, B-C), as per the criteria given in Table 2.6. However, during 2011, biological class of Mahanadi river at Cuttack D/s was moderate to heavy pollution category (C-D).

### 3.3 WATER QUALITY IN TERMS OF WHOLESOMENESS

#### 3.3.1 Wholesomeness in terms of regular parameters

The requirements in respect of regular monitoring parameters for different levels of degree of wholesomeness of water bodies are given in Table-2.7.

Of the 8 parameters listed in Table 2.7, results of bioassay are not available. Hence presently the water quality are assessed with regard to the remaining seven parameters.

Annual average and range values of (Nitrite+Nitrate)- Nitrogen at all the monitored stations during 2011-2015 are given in Table 3.20. Annual average and range values of total suspended solids including monsoon period and excluding monsoon period are given in Table 3.21. Considering the pH, DO, EC and (Nitrite+nitrate)-N values, the present level of wholesomeness of the river water may be considered as “desirable” except at Paradeep. Inclusion of TSS (during non-monsoon period) into the water quality assessment reveals that water quality at all stations meet the “acceptable” limit.

However, the situation changes entirely on introduction of BOD and FC values in the above assessment. Out of 32 monitoring stations, water quality of the Kathajodi river at Cuttack D/s and Cuttack FD/s (Mattagajpur) and of Daya river at Bhubaneswar D/s do not meet the limit for “acceptable” criteria. Similarly, investigation on the percent violation of Fecal coliform values from 2000 MPN/100 ml (limit for Acceptable) (Table 3.22), the river water quality is not even “acceptable” during most part of the period under report.

#### 3.3.2 Wholesomeness in terms of special parameters

Acceptable limits for the special parameters that are relevant to the present study are given in Table 2.8.

Annual average and range values of total ammonical nitrogen ((ammonium+ammonia)-N) at all the monitoring stations are given in Table 3.10. The data reveals that total ammonical nitrogen remain within the within “acceptable” limits except at Cuttack FD/s on Kathajodi river and Bhubaneswar D/s and Bhubaneswar FD/s on Daya river.

From the annual average and range values of total phosphate-P values at all the monitoring stations given in Table 3.23, it is observed that water quality at all the stations except Cuttack FD/s (Kathajodi) are within acceptable limit.

Annual average of TKN values (Table 3.24) at most of the monitored locations during 2011, 2012 and 2013 do not meet the “acceptable” limit. However, during 2014 and 2015, water quality at all locations except Cuttack FD/s on Kathajodi river and Bhubaneswar D/s and Bhubaneswar FD/s on Daya river conform to acceptable limit (3 mg/l).

It is evident from Table 3.18 for metals that the concentration of total chromium, zinc, copper, nickel, lead, cadmium and mercury in the river water at all the monitored locations during the study period remain within the acceptable limits.

Thus it may be summarized that, in terms of wholesomeness, the water quality at all stations except Cuttack FD/s at Mattagajpur, Bhubaneswar D/s and FD/s conform to “acceptable” level. At these three stations, the water quality downgrading parameters are BOD, TKN and Phosphate. However, with respect to FC, the water quality at all stations do not meet the “acceptable” limit at most of the time under period of study. Further at Paradeep U/s and D/s, the water quality does not meet the acceptable limit in respect of electrical conductivity.

### **3.4 WATER QUALITY IN TERMS OF COD AND ALKALINITY**

Annual average and range of COD values and alkalinity values during the period of study are given in Tables 3.25 and 3.26 respectively. COD levels at all stations generally remain less than 25 mg/l except on few occasions of the study period in Sambalpur stretch of Mahanadi river, Cuttack D/s and FD/s on Mahanadi river, Paradeep U/s and D/s on Mahanadi, Cuttack stretch on Kathajodi and Serua river, Bhubaneswar U/s on Kuakhai river and Bhubaneswar D/s and FD/s on Daya river. and Paradeep D/s (Mahanadi), COD levels at all other stations generally remain less than 20 mg/l. Alkalinity levels at all stations are well within the acceptable limits for most beneficial uses.

### **3.5 WATER QUALITY TREND**

#### **3.5.1 Mahanadi River**

About 86% of the catchment (72,691 sq. km out of a total of 84,372 sq. km) of the Mahanadi river system is in Madhyapradesh and Chhatisgarh states. Major tributaries of Mahanadi river like Seonath, Jonk, Hosdeo and Mond flowing in these two states ultimately drains into the Hirakud reservoir. Several large towns and industries (Rajnandagoan, Bhillai, Durg, Shimoga, Raipur, Bilaspur, Korba etc.) are located on the banks of these tributaries. In Odisha, the river Ib flowing through Sundargarh, Jharsuguda and Brajarajnagar area drains into the Hirakud reservoir. But in spite of all the activities at the upstream, water quality of the Hirakud reservoir almost conforms to Class-B, except for TC values.

Sambalpur is the major urban area (population about 1.5 lakhs, district and division headquarters) is located immediately downstream of Hirakud reservoir (about 5 km). Apart from being a source of water supply, Mahanadi at Sambalpur is used for instream use like bathing, washing and receive untreated wastewater disposal which is responsible for the observed deterioration of water quality at Sambalpur D/s. From Sambalpur D/s to Sonapur (about 78 km along the river course), the river travels through a region with no major urban settlement or wastewater outfall. Sonapur is the confluence point of Mahanadi with two of its important right bank tributaries namely Ong and Tel. Thus the water quality at Sonapur U/s, which is immediately downstream of Ong confluence, is quite satisfactory. Though Sonapur is the district headquarters with all consequent activities, the deterioration in the water quality at Sonapur D/s is not much as expected. This is primarily because Sonapur D/s on Mahanadi is actually the downstream of its confluence with river Tel, which has a significant annual average flow with very low pollution load. Moreover, in spite of being the district headquarters, Sonapur is still a small town (population: about 19000) with no noticeable growth in urban activities.

The 102 km stretch of the river from Sonapur D/s to Tikrapada does not have any industry or urban settlement on its banks (except two small sub-divisional towns – Boudh and Athamallick) and

there is no major wastewater outfall. From Tikarapada to Narasinghpur (about 60 km), the river flows almost completely undisturbed. The Tikarapada – Narasinghpur sub-basin is neither agriculturally nor industrially prosperous and human activities on its banks are scarce. Hence relatively clean, unpolluted water is expected at Tikarapada and without much change in quality at Narasinghpur.

During its course from Narasinghpur to Cuttack (about 56 km), the river enters into its deltaic region, characterized by high population density and intense agriculture activities. Hence there is some deterioration in the quality of water entering into Cuttack (Cuttack U/s) particularly in respect of TC, but still conforming to Class C. Within the city (population: about 5.35 lakhs) the river receives considerable untreated wastewater and the water quality gets further deteriorated at Cuttack D/s.

Spatial variation in annual average values of BOD and TC along the river stretch during the period 2011-2015 is shown in Fig. 3.4.(a)-(b) and Fig. 3.5 (a)-(b) respectively.

### **3.5.2 Ib River**

Water quality of this left bank tributary of Mahanadi is monitored at four locations – Sundergarh, Jharsuguda, Brajarajnagar (U/s and D/s). Till about late nineties, the water quality at Brajarajnagar was a matter of much concern due to discharge of effluent from a large paper mill. The mill has been closed since December 1998. Since none of the three towns is a large urban centre and there is no organized domestic wastewater discharge to the river, the water quality generally conforms to Class- C. Of late, Jharsuguda has turned into an important industrial hub of the state. However, the impact of industrial activities has not much impact on the water quality of Ib river. Spatial variation in annual average values of BOD and TC along the river stretch during the period 2011-2015 is shown in Fig. 3.4.(c) and Fig. 3.5 (c) respectively.

### **3.5.3 Bheden River**

Water quality of this left bank tributary of Ib river is monitored at only one location – Jharsuguda, which is the downstream of M/s Vedanta Aluminium Ltd. However, no significant impact on the water quality of Bheden river at Jharsuguda is noticed. Water quality generally remains at the Class- C level. Variation in annual average values of BOD and TC in Bheden River over the years from 2011 to 2015 is presented in Fig.3.4 (c) and 3.5 (c).

### **3.5.4 Kathajodi and Serua River**

Water quality of Kathajodi river, a distributary of Mahanadi river, has been greatly influenced by the discharge of partially treated or untreated wastewater of the Cuttack city. Significant deterioration in water quality of the river below Class-C with respect to BOD and TC at the downstream of Cuttack town and further downstream of Cuttack town at Mattagajpur has been observed. Water quality of Serua river (a distributary of Kathajodi river) at Cuttack further downstream also does not conform to Class-C with respect to BOD and TC. Spatial variation in annual average values of BOD and TC in Kathajodi and Serua rivers over the years from 2011 to 2015 is presented in Fig.3.4 (d) and 3.5 (d).

### 3.5.5 Birupa River

Birupa, another distributary of Mahanadi is monitored at the downstream of Choudwar, a small town, which had in the past, significant industrial activities with a textile, a large pulp and paper and a charge chrome industry with its thermal power plant. Presently only the charge chrome industry with its thermal power plant is in operation with marginal water pollution potential. The water quality generally conforms to Class C. Variation in annual average values of BOD and TC in Birupa river over the years from 2011 to 2015 is presented in Fig.3.4 (d) and 3.5 (d).

### 3.5.6 Kuakhai and Daya Rivers

The monitoring stations on Kuakhai river (a distributary of Kathajodi River) at the further upstream of Bhubaneswar and Upstream of Bhubaneswar are located at the upstream of the water intake point (sub surface water through bore wells) of the Public Health Engineering Department, for the Bhubaneswar city. The water quality of Kuakhai river at these two stations generally conform to Class-C with respect to BOD with occasional deviations. However, TC is the major downgrading parameter at these stations because of which water quality does not conform to Class-C most of the time under the study.

Bhubaneswar D/s on Daya river (a distributary of Kuakhai river) is just beyond the city limits. The river receives the city wastewater, atleast through one organized outfall, the Gangua Nallah, in between, as a consequence of which the water quality is downgraded beyond Class-C in respect of BOD and TC and unacceptable for most beneficial uses. Though the water quality trend is improved at Bhubaneswar FD/s, still does not conform to Class-C.

Spatial variation in annual average values of BOD and TC in Kuakhai and Daya rivers over the years from 2011 to 2015 is presented in Fig.3.4 (d) and 3.5 (d).

## 3.6 POLLUTED RIVER MONITORING STATIONS IN MAHANADI RIVER SYSTEM

The monitoring stations of rivers in Mahanadi river systems not meeting the tolerance limit of 3.0 mg/l for the criteria parameter BOD of Class-C are identified as polluted river monitoring stations and have been categorized into different priority classes as proposed by CPCB (Table 2.9). Comparison of BOD data obtained during the period 2011-2015 (Table 3.9) with the tolerance limits for Class-C revealed that there are fourteen polluted river monitoring stations. The polluted monitoring locations in a continuous sequence are identified as the polluted river stretches. The list of polluted river monitoring stations with annual BOD range and priority class is given in Table 3.27. There are five polluted river stretches, such as Sambalpur stretch (3 km) (Priority- V) and Cuttack stretch (15 km) (Priority-V) on Mahanadi river, Cuttack stretch (19 km) (Priority -II) on Kathajodi river, Cuttack stretch (4 km) (Priority-V) on Serua river and Bhubaneswar stretch (30 Km) (Priority IV) on Daya river. Besides these, Paradeep D/s (Priority-V) on Mahanadi river and Bhubaneswar U/s (Priority-V) on Kuakhai river have also been identified as the polluted river monitoring stations.

## 3.7 WATER QUALITY INDEX OF MONITORING STATIONS IN MAHANADI RIVER SYSTEM

The Canadian Water Quality Indices (CWQI) of 32 monitoring stations on Mahanadi river system are calculated for the period 2011-2015 (Table 3.28). For the CWQI evaluation, four critical variables

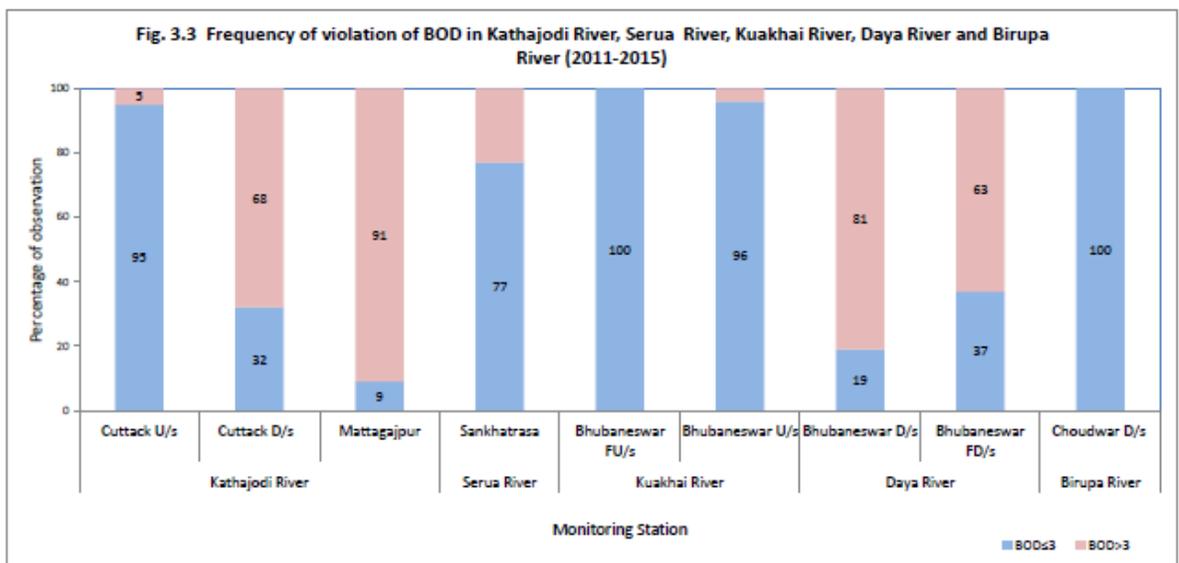
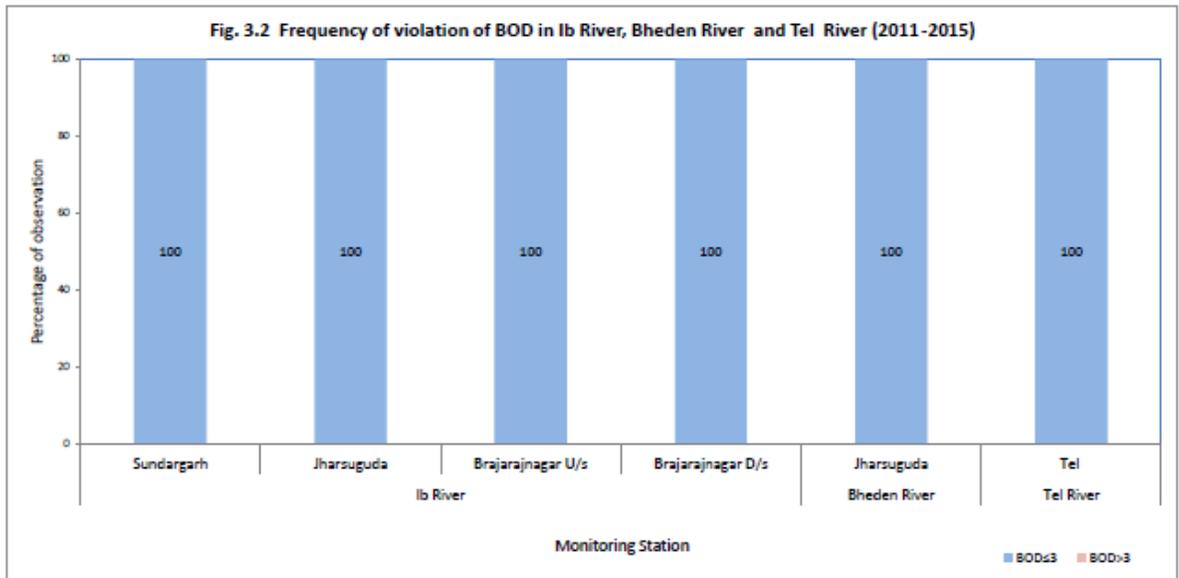
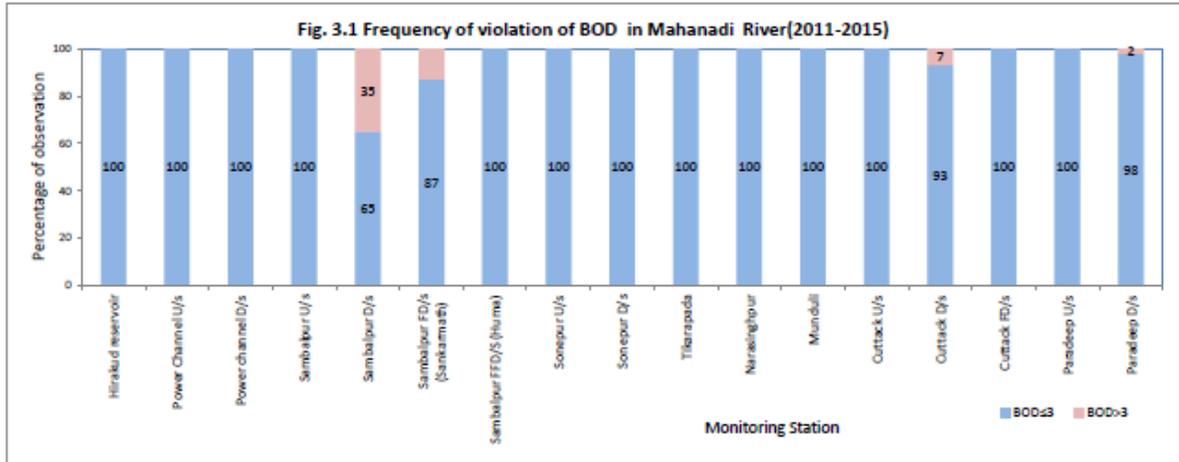
such as pH, DO, BOD and TC are taken into consideration. Based on the CWQI values, the water quality of the monitoring stations are ranked into different categories as recommended in Table 2.10. As evident from the Table 3.29 for the category of water quality based on CWQI values, water quality of Ib river at Sundargarh, Jharsuguda, Brajaraj Nagar U/s and Brajaraj Nagar D/s vary within Good-Excellent category during this study period, though water quality at Brajaraj Nagar D/s during 2015 has been lowered to Fair category. Water quality of Bheden river at Jharsuguda, Hirakud reservoir, Power Channel and of Tel river at Monmunda also vary within Good-Excellent category. The variation in water quality status at these stations is due to the occasional observation of high values of total coliform beyond the tolerance limit.

In the Sambalpur stretch of Mahanadi river, water quality is within Fair-Good range at the upstream of Sambalpur town, which has been lowered to Marginal category at the downstream of the Sambalpur town. However, the water quality has been improved to Fair-Excellent at Huma, which is the further downstream station of Sambalpur town. From Sonepur to Munduli, water quality of Mahanadi river remained within Good – Excellent, except during the year 2014 when water quality of Narasinghpur and Munduli has been lowered to Fair category. Water quality of Birupa river at the downstream of Choudwar town varies within Fair-Good category. The lowering of water quality at the downstream of Sambalpur town is due to high values of either BOD or TC or both.

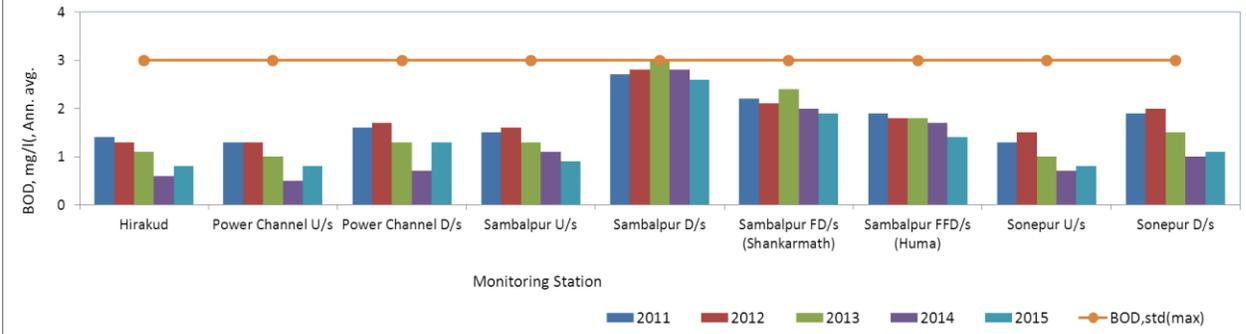
In the Cuttack stretch of Mahanadi river, water quality has also been lowered from Good-Excellent category at the upstream of Cuttack town to Poor- Marginal category at the downstream of Cuttack town. Similar observation has also been made at the Cuttack stretch of Kathajodi river and Bhubaneswar stretch of Daya river. The deterioration of water quality at these downstream stations are due to either BOD or TC or both.

As most part of the domestic wastewater of Cuttack town is discharged to Kathajodi river rather than into Mahanadi river, water quality at Cuttack D/s on Kathajodi river remains almost in Poor category. Similarly, as major portion of wastewater of Bhubaneswar town is discharged to Daya river through Gangua nallah, water quality at Bhubaneswar D/s on Daya river remains almost in poor category.

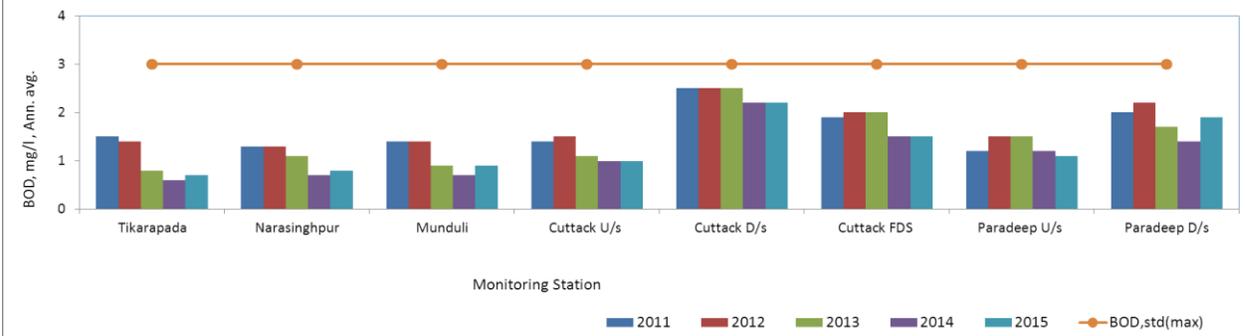
The CWQI score at Paradeep U/s and Paradeep D/s calculated taking pH, DO, BOD and TC as variables, remained within Fair-Good category. However, as these two stations are very near to the mouth of the river, the major water quality determining parameters here are conductivity, chloride, sulfate, calcium, magnesium, sodium and potassium. Therefore, recalculation of CWQI score considering conductivity, SAR (calculated from calcium, magnesium and sodium values), chloride, sulfate, total dissolved solids and boron as the variables and comparing them with the respective tolerance limits of irrigation water quality, it has been observed that water quality at Paradeep U/s varied within Marginal-Fair (CWQI Score : 44.72-69.82), whereas at Paradeep D/s, the water quality lowered to Poor category (CWQI Score : 12.60 - 31.67) and thus makes the water unsuitable for irrigation. The water quality downgrading parameters are EC, SAR, chloride, sulfate, total dissolved solids and boron which owe their origin from the tidal effect.



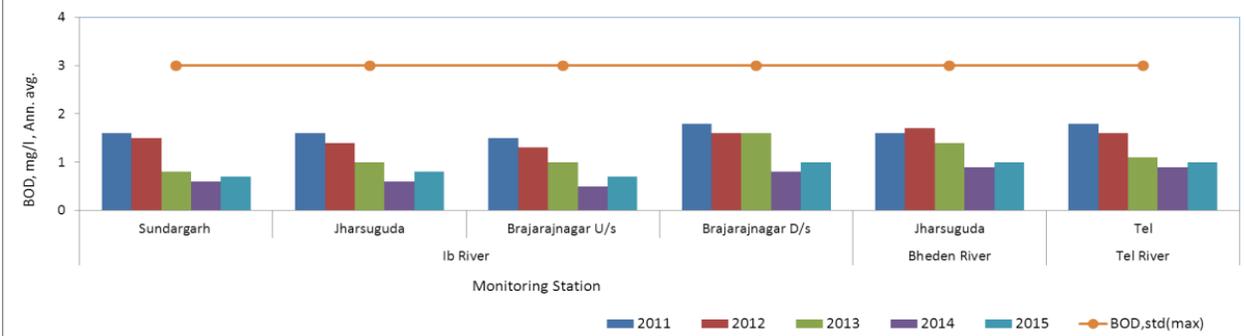
**Fig.3.4(a) Spatial variation of BOD in Mahanadi River (Hirakud-Sonepur D/s) (2011-2015)**



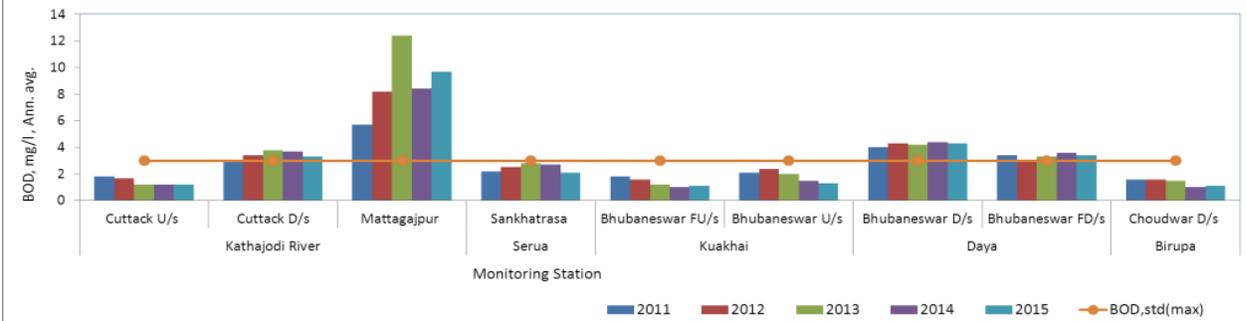
**Fig.3.4(b) Spatial variation of BOD in Mahanadi River (Tikarpada-Paradeep D/s) (2011-2015)**

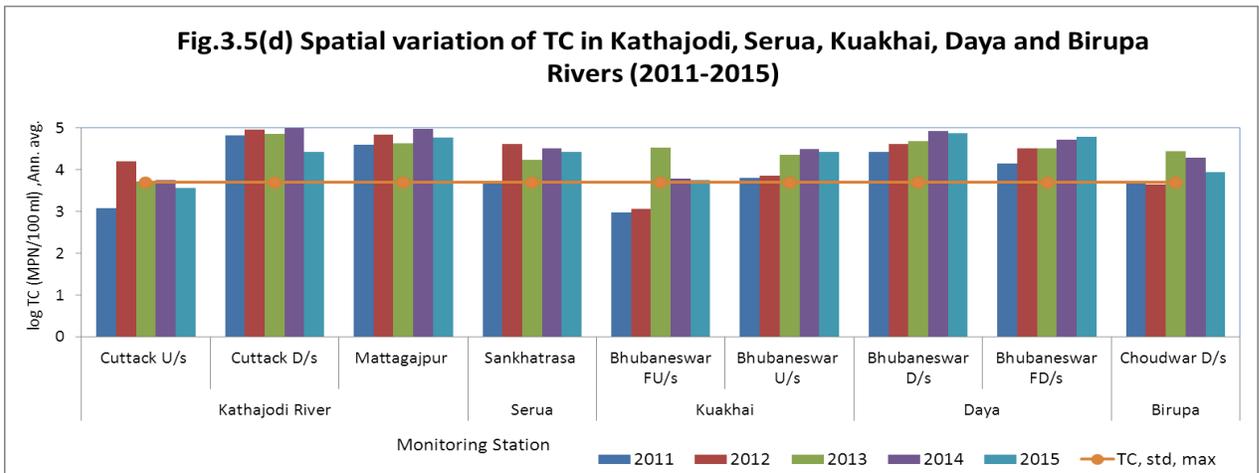
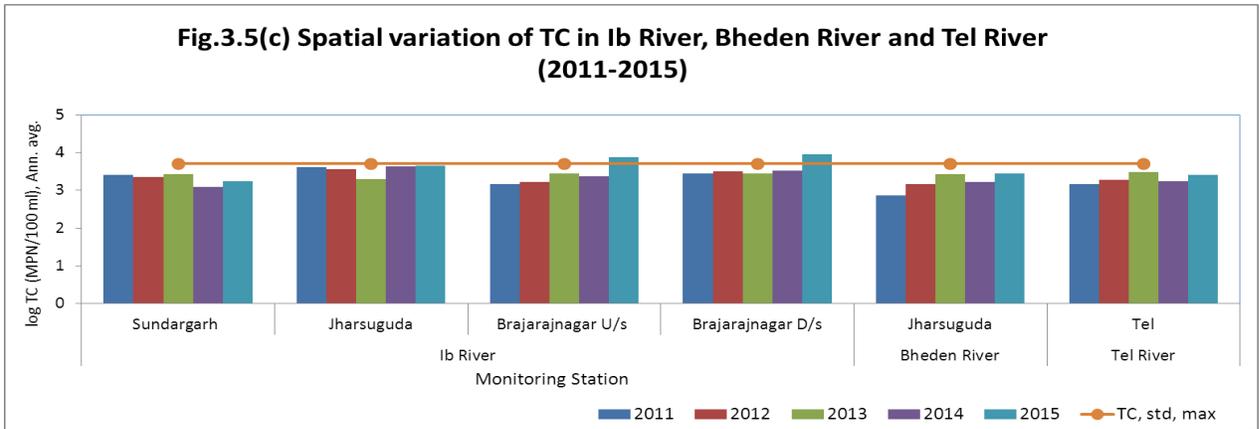
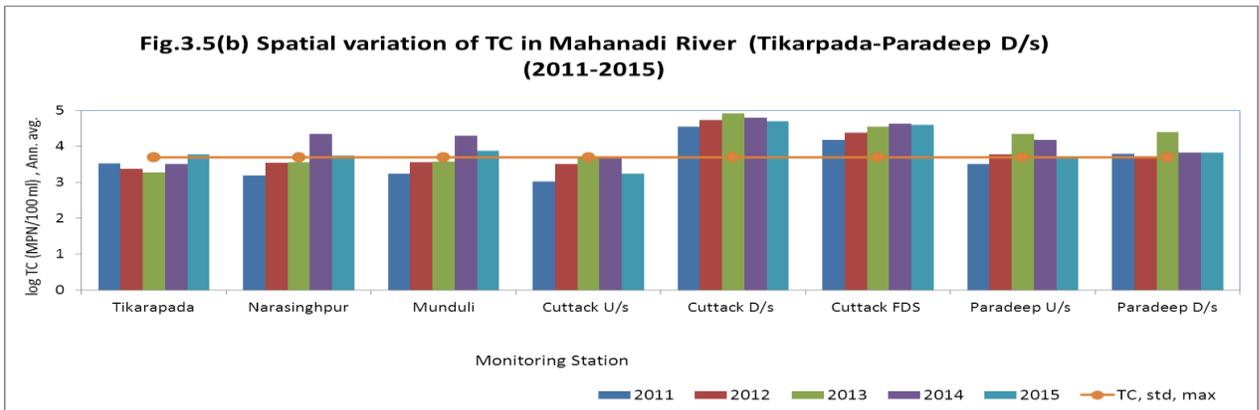
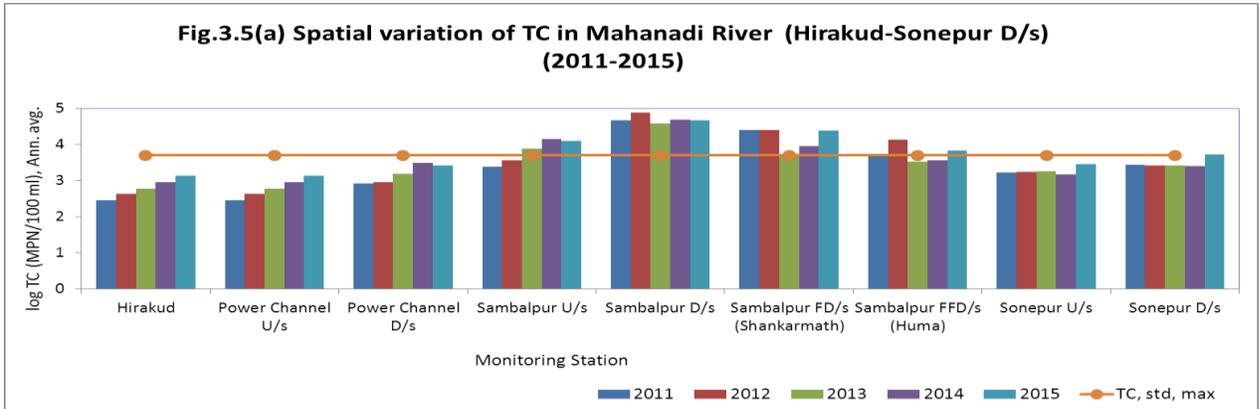


**Fig.3.4(c) Spatial variation of BOD in Ib River, Bheden River and Tel River (2011-2015)**



**Fig.3.4(d) Spatial variation of BOD in Kathajodi, Serua, Kuakhai, Daya and Birupa Rivers (2011-2015)**





Water Quality of Major Rivers of Odisha

**Table 3.1 : Seasonal average of pH, DO, BOD and TC values in Ib river at Sundargarh, Jharsuguda, Brajaraj Nagar U/s and Brajaraj Nagar D/s**

Parameter	Year	Sundargarh				Jharsuguda				Brajaraj Nagar U/s				Brajaraj Nagar D/s			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	7.9	8.1	7.9	7.6	8.1	8.0	7.8	7.4	7.8	8.2	7.9	7.3	8.1	8.1	7.8	7.8
	2012	8.1	7.6	7.5	7.7	7.7	8.2	7.2	8.1	7.8	7.8	7.4	7.2	8.1	7.8	7.4	7.8
	2013	8.0	8.1	7.8	7.9	8.2	8.2	7.6	7.9	8.2	8.1	7.6	8.2	7.7	7.7	7.6	8.2
	2014	7.6	8.1	7.6	7.5	8.0	8.1	7.8	7.6	7.6	7.8	7.9	7.9	8.0	8.1	7.6	7.9
	2015	7.6	8.0	7.6	8.2	7.9	8.1	7.2	7.7	7.6	8.1	7.6	8.2	7.8	8.1	7.6	8.2
DO (mg/l)	2011	8.6	7.1	6.7	7.3	8.8	7.2	6.2	7.6	8.0	7.8	6.8	7.4	8.5	7.4	6.9	7.4
	2012	8.5	8.0	7.6	7.5	8.4	7.6	7.7	7.3	8.7	8.0	7.8	7.5	8.8	7.9	7.3	7.1
	2013	8.4	7.2	6.7	5.9	8.6	7.5	6.9	7.3	8.4	7.8	6.8	6.9	8.1	7.4	6.8	6.9
	2014	8.2	7.3	7.2	7.5	7.2	7.3	7.4	6.8	8.3	7.4	7.5	7.7	8.4	7.4	7.3	7.6
	2015	8.8	7.2	6.8	7.8	8.8	7.0	6.5	8.2	8.8	7.8	6.9	8.8	8.2	7.5	6.7	8.2
BOD (mg/l)	2011	1.2	1.9	1.9	1.2	1.3	2.0	1.7	1.2	1.4	1.6	1.7	1.2	1.9	1.7	2.1	1.7
	2012	1.5	1.6	1.6	1.5	1.5	1.1	1.9	1.4	1.3	1.0	1.4	1.6	1.9	1.3	1.7	1.9
	2013	1.0	1.0	0.8	0.4	1.2	1.3	0.8	0.4	1.2	1.1	0.8	0.4	1.7	1.9	1.3	0.7
	2014	0.4	0.5	0.7	0.6	1.1	0.5	0.9	0.4	0.8	0.5	0.6	0.7	1.1	0.9	0.9	0.9
	2015	1.0	0.5	0.8	0.4	0.9	0.8	1.0	0.5	0.6	0.9	0.5	0.5	0.9	1.1	1.0	0.8
TC ('00) (MPN/ 100 ml)	2011	10.20	10.10	66.80	9.20	18.00	18.25	98.67	18.60	10.70	11.33	23.00	14.00	15.00	25.50	43.33	21.45
	2012	17.00	17.73	43.33	11.00	44.00	33.50	65.80	7.90	19.00	16.75	24.00	5.60	30.33	41.00	35.00	7.95
	2013	16.67	34.98	26.97	14.00	11.30	17.58	29.33	13.00	28.63	22.10	27.67	24.00	19.97	29.75	35.33	26.00
	2014	4.00	11.55	11.63	23.00	7.80	9.65	93.00	73.00	43.00	20.33	26.67	24.00	46.00	23.48	31.67	54.50
	2015	15.83	14.98	11.43	7.95	14.77	48.23	28.00	79.50	40.63	53.48	98.00	94.50	71.67	50.60	113.00	105.00

Water Quality of Major Rivers of Odisha

**Table 3.2 : Seasonal average of pH, DO, BOD and TC values in Bheden river at Jharsuguda, Hirakud Reservoir, Upstream and Downstream of Power Channel**

Parameter	Year	Jharsuguda				Hirakud				Power Channel U/s				Power Channel D/s			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	7.7	7.9	7.8	7.6	8.2	7.9	7.9	7.6	7.9	7.8	7.8	7.8	8.0	8.0	8.1	7.6
	2012	8.1	8.0	7.6	7.5	8.1	8.0	8.0	7.8	8.1	8.0	8.0	7.9	8.1	8.1	8.2	7.8
	2013	7.4	8.2	7.7	8.0	8.0	8.0	7.8	7.9	8.2	8.0	7.8	8.0	7.4	8.2	8.1	7.9
	2014	8.0	8.0	7.8	8.0	8.1	8.1	8.0	7.8	7.8	8.2	7.8	7.8	8.0	7.9	7.6	7.7
	2015	7.7	8.2	7.6	8.2	7.9	8.0	7.4	8.3	7.8	7.8	7.7	8.3	7.7	7.7	7.8	8.3
DO (mg/l)	2011	8.7	6.3	6.7	7.5	8.8	7.7	6.6	7.5	7.3	7.1	6.1	6.2	7.1	7.0	6.3	6.1
	2012	8.6	8.0	7.7	7.8	7.5	7.6	7.4	7.2	8.3	7.0	7.1	8.1	7.9	6.4	6.9	7.6
	2013	9.5	8.0	7.2	7.0	8.2	7.4	6.7	6.3	8.3	7.2	6.4	6.1	7.8	6.9	6.4	5.8
	2014	8.4	7.6	7.1	7.6	8.1	7.3	7.3	6.9	7.5	7.0	5.3	6.4	7.0	6.5	5.2	7.1
	2015	8.5	7.0	6.9	9.5	8.1	7.1	7.2	8.1	7.1	7.2	6.1	8.4	7.6	6.9	6.2	8.1
BOD (mg/l)	2011	2.3	1.2	2.0	0.9	1.2	1.4	1.7	1.0	1.6	1.4	1.3	0.7	1.9	1.5	2.0	1.3
	2012	1.7	1.6	1.6	2.2	1.7	1.4	1.2	1.1	1.3	1.4	1.2	1.1	1.6	1.7	1.6	1.8
	2013	1.6	1.6	1.2	0.5	1.4	1.4	0.8	0.7	1.2	1.2	0.8	0.4	1.7	1.7	0.9	0.6
	2014	1.2	0.8	1.1	1.0	0.7	0.4	0.8	1.0	0.6	0.5	0.5	0.5	0.8	0.6	0.8	0.9
	2015	1.0	1.1	0.7	1.2	0.7	0.7	1.2	0.7	0.7	0.7	1.1	0.6	0.9	1.5	1.6	1.2
TC ('00) (MPN/ 100 ml)	2011	6.65	7.25	7.80	8.15	13.00	15.85	26.67	16.50	0.95	3.58	3.67	1.60	2.70	10.98	10.37	5.20
	2012	12.90	18.48	12.67	10.45	23.67	16.45	16.00	3.70	2.43	3.00	7.37	3.00	13.83	5.05	11.57	4.10
	2013	9.60	18.20	48.33	33.00	17.97	15.33	28.10	33.00	9.60	6.88	1.26	7.00	14.33	15.78	9.37	31.00
	2014	33.00	6.88	25.20	13.15	7.80	5.50	36.63	107.00	7.80	4.85	16.77	6.40	13.00	26.08	7.77	18.50
	2015	21.30	13.70	46.67	38.50	34.00	11.30	49.67	19.00	3.87	7.00	30.43	12.50	73.97	23.25	37.63	21.00

Water Quality of Major Rivers of Odisha

**Table 3.3 : Seasonal average of pH, DO, BOD and TC values in Mahanadi river at Sambalpur U/s, Sambalpur D/s, Sambalpur FD/s at Shankarmath and Sambalpur FFD/s at Huma**

Parameter	Year	Sambalpur U/s				Sambalpur D/s				Sambalpur FD/s at Shankarmath				Sambalpur FFD/s at Huma			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	7.8	7.8	7.8	7.6	7.6	7.8	7.8	7.6	7.5	8.0	8.0	7.8	8.0	8.0	7.8	7.8
	2012	7.9	8.0	7.9	8.1	8.0	7.9	8.4	7.7	8.1	7.7	8.2	7.9	8.2	7.8	7.8	8.3
	2013	8.1	8.2	8.0	8.1	8.2	8.1	7.4	7.9	7.5	7.6	7.7	7.6	7.6	8.1	7.9	7.9
	2014	8.0	7.9	7.7	8.2	8.2	8.2	7.5	8.1	7.7	7.9	7.5	7.8	8.2	8.2	8.0	7.7
	2015	7.8	7.7	7.7	8.2	8.0	7.9	7.7	8.2	7.9	8.0	7.7	7.8	8.0	8.1	8.0	8.4
DO (mg/l)	2011	8.3	6.5	6.6	7.7	7.7	5.8	6.2	6.6	7.3	6.6	5.8	6.4	8.1	7.1	6.9	7.2
	2012	8.4	8.1	7.4	7.7	8.4	7.2	5.8	6.8	7.5	6.9	6.4	6.9	8.6	7.3	6.5	7.1
	2013	8.0	7.2	7.4	7.5	7.2	6.6	7.0	6.4	7.5	6.6	6.7	5.8	8.3	7.1	7.0	6.9
	2014	8.5	6.7	6.8	8.3	6.7	8.6	6.2	7.8	6.4	6.2	5.5	7.0	7.8	7.1	6.7	7.8
	2015	7.2	7.5	6.8	8.5	6.4	6.7	6.3	8.2	7.2	6.6	5.8	8.1	9.0	6.8	6.3	8.0
BOD (mg/l)	2011	1.3	1.6	1.9	1.0	3.5	2.5	2.7	2.1	2.9	2.3	2.3	1.6	2.6	2.1	1.7	1.2
	2012	1.6	1.8	1.6	1.5	2.8	2.4	2.2	4.1	1.7	1.4	2.2	3.4	1.5	1.6	1.7	2.8
	2013	2.4	1.2	0.9	0.4	3.4	3.2	2.6	2.2	2.7	3.0	2.1	1.4	2.0	2.3	1.2	1.3
	2014	0.5	1.3	0.7	1.7	3.4	3.4	1.7	3.0	3.1	2.5	1.2	2.0	2.6	2.0	1.0	1.6
	2015	1.1	1.2	0.7	0.5	3.1	2.6	2.6	2.2	2.2	2.0	1.6	1.9	1.7	1.5	1.4	1.3
TC ('00) (MPN/ 100 ml)	2011	14.50	12.85	48.67	25.70	291.50	417.50	723.33	380.00	92.50	182.25	416.67	238.50	17.00	71.20	70.33	27.00
	2012	14.33	66.50	26.00	19.50	893.33	1090.00	498.33	390.00	333.33	247.50	376.67	150.00	22.80	123.50	233.33	140.00
	2013	76.33	85.50	63.67	33.00	256.67	487.50	413.33	220.00	69.00	28.50	58.00	110.00	62.00	33.00	35.33	49.00
	2014	49.00	59.75	332.67	49.00	920.00	610.00	470.00	205.00	350.00	57.50	47.67	94.50	13.00	20.23	32.67	23.00
	2015	91.33	180.75	186.33	28.50	300.00	465.00	786.67	315.00	184.00	203.50	406.67	140.00	143.33	51.75	52.00	71.50

Water Quality of Major Rivers of Odisha

**Table 3.4 : Seasonal average of pH, DO, BOD and TC values in Mahanadi river at Sonepur U/s and Sonepur D/s, Tikarpada and Narasinghpur**

Parameter	Year	Sonepur U/s				Sonepur D/s				Tikarpada				Narasinghpur			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	7.9	8.1	7.9	8.0	7.6	8.3	8.0	8.0	8.1	8.2	8.0	7.4	8.1	8.2	7.9	7.8
	2012	8.0	7.7	8.2	7.6	8.2	8.0	8.2	8.2	8.2	7.8	7.8	7.1	8.1	8.1	8.1	8.3
	2013	7.9	8.2	8.0	8.0	8.0	7.9	7.8	8.1	8.0	8.1	8.0	8.2	8.2	8.0	7.9	8.1
	2014	8.3	8.2	7.8	7.9	8.4	8.1	8.2	7.8	8.2	7.9	8.0	7.9	8.4	8.3	7.9	8.0
	2015	7.9	8.1	7.8	8.3	8.2	8.1	7.8	8.3	8.0	8.1	8.0	8.4	8.2	8.3	8.1	8.2
DO (mg/l)	2011	8.8	6.9	6.5	7.5	9.5	7.4	6.2	6.5	8.7	7.4	6.4	7.3	8.6	8.2	6.3	8.1
	2012	8.6	8.3	7.4	7.8	8.7	7.5	7.1	7.6	8.5	8.4	8.1	7.9	8.3	8.0	7.8	8.0
	2013	8.3	7.3	6.9	7.2	8.0	7.6	7.3	7.7	8.5	7.2	7.5	8.2	8.8	7.4	6.6	7.2
	2014	8.2	7.5	7.2	8.0	7.6	7.9	7.7	8.0	8.4	8.0	7.9	7.7	8.5	7.2	6.6	7.4
	2015	8.4	7.2	6.8	8.7	8.3	6.8	6.4	8.3	8.1	7.6	6.6	7.7	8.3	7.5	7.5	8.5
BOD (mg/l)	2011	1.0	1.3	1.8	1.0	1.9	1.9	2.0	1.5	0.9	1.5	1.9	1.4	0.9	1.4	1.2	1.5
	2012	1.2	1.6	1.6	1.2	1.7	2.2	2.0	1.8	1.6	1.3	1.6	1.4	1.2	0.9	1.8	1.8
	2013	1.2	1.1	0.9	0.4	1.9	1.6	1.3	0.7	1.1	0.8	0.5	0.3	1.6	1.2	0.7	1.0
	2014	0.8	0.4	0.9	0.7	1.0	0.8	1.0	1.3	0.4	0.6	0.6	0.7	0.2	0.7	0.5	1.0
	2015	0.8	1.0	0.9	0.5	1.0	1.5	1.2	0.6	0.7	0.6	0.8	0.7	0.9	1.1	1.0	0.4
TC ('00) (MPN/ 100 ml)	2011	15.50	11.18	19.97	12.20	19.50	21.00	49.67	19.50	18.00	20.60	69.67	19.50	8.65	13.50	22.00	16.00
	2012	28.33	17.18	25.33	10.50	23.67	21.73	39.00	24.00	30.67	27.75	31.00	10.80	16.33	40.00	65.67	14.00
	2013	1.93	15.88	29.97	22.00	3.63	21.03	48.33	22.00	12.17	14.10	32.67	7.90	65.00	32.50	11.10	13.00
	2014	7.80	2.25	33.40	18.50	17.00	17.53	32.30	33.50	23.00	5.63	18.60	44.50	23.00	14.30	581.00	34.00
	2015	6.40	18.63	65.43	30.95	13.30	56.48	98.30	45.00	60.93	43.55	144.00	19.00	199.00	60.23	74.63	32.50

Water Quality of Major Rivers of Odisha

**Table 3.5 : Seasonal average of pH, DO, BOD and TC values in Mahanadi river at Munduli, Cuttack U/s, Cuttack D/s and Cuttack FD/s**

Parameter	Year	Munduli				Cuttack U/s				Cuttack D/s				Cuttack FD/s			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	8.1	7.7	8.1	8.3	8.3	8.2	7.7	8.1	7.9	8.2	7.8	8.1	8.2	8.1	8.1	8.2
	2012	7.9	8.2	8.1	7.9	8.1	7.9	8.1	8.3	7.9	8.2	7.8	8.1	8.2	8.4	8.1	7.7
	2013	7.5	7.8	7.6	8.0	8.2	8.2	8.0	8.3	7.8	8.1	7.6	8.2	8.2	8.0	7.8	8.2
	2014	8.2	8.2	7.7	7.8	8.3	8.0	7.8	7.7	7.6	8.0	7.9	7.8	7.9	8.2	7.8	7.6
	2015	8.1	8.2	8.0	8.0	8.2	8.0	8.0	7.8	8.2	8.0	8.0	8.4	8.2	8.2	8.2	7.8
DO (mg/l)	2011	9.0	7.6	6.2	8.0	8.9	8.7	6.2	8.8	8.2	7.3	6.2	7.5	8.4	6.0	6.3	7.5
	2012	8.5	7.3	7.5	8.2	8.2	8.9	7.5	8.2	8.6	7.7	7.5	7.0	8.5	7.7	7.5	7.6
	2013	8.5	7.5	6.4	7.1	8.4	7.9	6.8	7.4	7.8	7.3	6.6	7.2	7.9	7.8	7.0	7.7
	2014	7.8	7.7	6.6	7.3	8.4	8.7	6.7	8.0	7.6	7.6	6.8	7.3	8.2	7.3	6.7	8.0
	2015	8.2	7.7	7.6	8.3	8.6	7.8	6.8	8.5	7.8	6.8	6.8	8.0	8.1	7.1	7.0	8.1
BOD (mg/l)	2011	1.4	1.3	1.9	1.3	1.3	1.4	1.5	1.5	2.4	2.7	2.7	2.1	1.8	2.1	2.3	1.7
	2012	1.6	1.3	1.3	1.5	1.0	1.4	1.6	1.8	2.0	2.3	2.4	3.3	1.3	1.7	2.1	2.6
	2013	1.3	1.0	0.6	0.8	1.4	1.4	0.9	0.8	3.1	2.7	2.1	2.0	2.4	2.1	1.7	1.5
	2014	0.5	0.8	0.7	1.1	1.2	0.9	1.2	0.9	2.5	2.2	1.9	2.4	1.1	1.6	1.3	1.8
	2015	0.7	1.1	0.9	0.6	0.8	1.3	1.1	0.7	2.5	2.1	2.1	2.4	1.7	1.4	1.6	1.7
TC ('00) (MPN/ 100 ml)	2011	20.65	15.00	27.33	7.75	6.35	11.18	13.67	8.90	116.00	344.75	640.00	200.00	23.00	105.75	366.00	92.50
	2012	13.10	54.25	56.67	4.10	10.80	11.93	85.33	19.50	440.00	835.00	440.00	295.00	176.33	320.00	167.33	120.00
	2013	24.00	28.33	64.33	13.00	27.67	52.75	59.10	7.90	440.00	635.00	445.00	350.00	396.67	400.00	326.67	240.00
	2014	54.00	18.13	601.67	30.50	23.00	31.50	102.00	33.50	540.00	460.00	1020.00	445.00	170.00	190.00	1020.00	240.00
	2015	77.30	85.48	140.33	45.00	6.80	17.83	13.00	32.50	333.33	480.50	766.67	260.00	122.67	294.48	730.00	165.00

Water Quality of Major Rivers of Odisha

**Table 3.6 : Seasonal average of pH, DO, BOD and TC values in Mahanadi river at Paradeep U/s, Paradeep D/s, Tel river at Monmunda D/s and Birupa river at Choudwar**

Parameter	Year	Paradeep U/s				Paradeep D/s				Monmunda				Choudwar			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	7.9	8.0	8.1	8.1	8.1	8.0	8.0	7.8	8.1	7.8	8.0	8.0	7.9	8.2	7.9	7.9
	2012	7.9	8.0	7.7	8.1	8.0	7.9	8.3	7.8	8.0	8.0	7.9	8.0	8.1	8.0	8.1	7.8
	2013	8.1	8.1	8.1	7.9	8.2	8.1	8.0	8.2	7.7	7.9	8.0	8.4	7.7	7.8	7.9	7.7
	2014	8.0	8.1	7.6	7.7	8.0	7.9	7.7	7.9	8.4	8.1	8.2	8.4	7.5	8.2	7.8	8.1
	2015	7.9	8.2	7.8	7.6	7.9	8.1	7.8	8.1	8.1	8.0	8.1	8.4	8.0	8.2	8.0	8.2
DO (mg/l)	2011	9.1	7.7	6.6	7.5	6.9	6.7	6.1	7.6	9.1	6.5	6.9	8.0	7.7	7.2	6.4	8.4
	2012	8.5	6.8	7.8	8.4	7.4	6.3	8.0	7.9	8.9	7.7	6.7	8.6	8.5	7.3	11.8	7.4
	2013	8.6	7.3	7.2	7.2	8.2	7.4	7.0	7.4	9.1	7.8	6.6	6.9	8.2	7.2	6.8	7.0
	2014	6.4	6.7	6.2	8.5	6.3	6.2	6.2	7.5	8.4	7.4	6.9	7.8	8.7	6.7	6.4	7.8
	2015	8.2	7.5	7.2	8.2	7.5	7.1	7.0	7.7	8.8	7.1	6.8	8.7	8.0	6.9	7.1	8.1
BOD (mg/l)	2011	2.0	1.2	1.0	1.0	2.2	1.5	1.6	2.8	1.6	1.7	2.1	1.6	1.9	1.2	1.9	2.0
	2012	1.9	1.7	1.3	1.4	2.8	2.2	1.8	2.2	1.5	1.5	2.0	1.3	1.2	1.9	1.5	1.4
	2013	1.5	1.7	1.0	2.1	2.1	2.0	1.3	1.0	1.5	1.2	0.8	1.2	1.1	1.8	1.4	1.0
	2014	0.5	1.2	1.2	2.0	0.8	1.1	1.1	2.2	0.8	0.8	1.1	1.1	0.7	0.9	1.4	1.0
	2015	0.5	1.1	1.2	1.6	2.0	2.0	1.6	2.5	0.8	1.3	0.9	0.7	1.5	1.2	0.8	1.0
TC ('00) (MPN/100 ml)	2011	19.50	27.38	44.67	28.50	2.35	19.10	194.67	30.00	9.70	14.50	15.33	15.50	11.70	54.50	56.33	36.50
	2012	30.67	83.25	92.00	25.00	25.00	46.25	82.67	28.00	18.67	27.08	18.63	12.50	79.67	38.50	73.33	35.50
	2013	39.00	71.25	76.00	1600.00	47.67	14.42	238.30	1600.00	2.43	21.30	55.33	49.00	37.00	91.50	226.67	1600.00
	2014	92.00	10.90	394.00	66.50	27.00	5.41	107.00	150.00	13.00	6.28	31.00	28.50	79.00	50.25	586.00	23.00
	2015	143.00	28.63	65.00	13.45	103.00	12.58	148.00	18.70	6.73	24.00	56.63	7.95	36.33	29.75	164.00	166.00

Water Quality of Major Rivers of Odisha

**Table 3.7 : Seasonal average of pH, DO, BOD and TC values in Kathajodi river at Cuttack U/s, Cuttack D/s, Cuttack FD/s at Mattagajpur and in Serua river at Cuttack FD/s at Sankhatrasa**

Parameter	Year	Cuttack U/s				Cuttack D/s				Cuttack FD/s at Mattagajpur				Cuttack FD/s at Sankhatrasa			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	8.1	8.1	8.0	8.3	8.1	8.2	7.9	7.9	7.6	7.2	7.7	7.7	7.9	8.1	7.7	8.2
	2012	8.0	8.2	7.8	7.7	8.2	8.3	7.4	7.9	7.5	7.5	7.7	7.7	8.2	8.1	7.69	8.1
	2013	8.0	8.3	8.0	8.3	8.2	8.3	8.1	7.6	8.0	7.7	7.5	7.2	8.2	8.2	7.8	8.3
	2014	8.3	8.1	7.9	7.8	8.0	7.9	7.7	7.4	7.8	7.7	8.2	7.6	7.8	7.9	7.9	7.8
	2015	8.1	8.1	8.0	7.9	8.2	8.0	8.3	8.3	7.3	7.3	6.9	7.7	7.7	8.2	8.2	8.3
DO (mg/l)	2011	9.1	8.3	6.6	7.8	7.8	7.5	6.3	7.7	4.4	6.1	6.8	7.1	7.8	7.6	6.4	7.8
	2012	8.5	8.0	7.0	7.9	8.0	7.0	7.6	7.0	4.7	3.7	4.0	4.8	8.2	9.3	7.0	7.2
	2013	8.4	7.8	7.1	7.4	6.9	7.1	6.8	7.6	3.6	2.5	5.3	3.6	7.5	7.6	7.1	7.5
	2014	8.2	8.1	6.7	7.2	6.0	7.1	7.4	7.2	6.0	6.9	7.0	8.0	6.2	7.5	7.4	6.5
	2015	8.1	7.7	7.2	8.4	6.9	6.9	6.8	7.7	4.2	5.0	5.3	4.0	7.4	7.5	7.4	8.3
BOD (mg/l)	2011	1.5	2.5	1.6	1.4	3.7	3.4	3.0	2.6	9.9	5.8	2.7	6.1	3.0	2.6	1.9	1.8
	2012	1.5	2.1	1.4	1.5	3.0	2.8	3.2	4.4	9.1	9.6	5.9	6.3	2.2	2.0	2.0	3.4
	2013	1.6	1.4	1.1	0.6	4.2	4.1	3.2	3.6	14.1	16.6	6.0	5.3	3.3	3.0	2.3	2.7
	2014	1.6	1.0	1.4	1.4	5.4	4.5	2.5	3.0	6.1	10.8	7.6	4.3	4.2	3.6	1.7	1.7
	2015	1.3	1.3	1.0	0.7	3.4	3.1	3.4	3.3	10.8	11.0	9.6	7.9	3.0	2.1	1.6	1.6
TC ('00) (MPN/100 ml)	2011	5.10	14.50	16.00	8.20	675.00	580.00	816.67	635.00	200.00	645.00	144.67	485.00	13.20	27.50	73.00	102.00
	2012	12.47	13.08	582.00	25.00	603.33	1270.00	1020.00	445.00	543.33	987.50	743.33	295.00	116.33	397.50	786.67	180.00
	2013	39.00	53.00	68.67	14.00	540.00	650.00	630.00	540.00	376.67	517.50	390.00	350.00	350.00	147.50	146.67	14.00
	2014	23.00	33.75	89.33	88.50	920.00	1430.00	1020.00	410.00	1600.00	852.50	1183.33	635.00	540.00	152.00	443.33	445.00
	2015	24.00	46.33	45.30	19.00	326.67	290.75	253.33	175.00	560.00	390.00	1146.67	175.00	381.33	274.48	200.00	150.00

Water Quality of Major Rivers of Odisha

**Table 3.8 : Seasonal average of pH, DO, BOD and TC values in Kuakhai river at Bhubaneswar FU/s and Bhubaneswar U/s, in Daya river at Bhubaneswar D/s and Bhubaneswar FD/s**

Parameter	Year	Bhubaneswar FU/s				Bhubaneswar U/s				Bhubaneswar D/s				Bhubaneswar FD/s			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	7.9	7.8	7.8	8.0	7.9	7.6	7.5	7.8	7.3	7.4	7.6	7.7	7.5	7.8	7.4	7.8
	2012	7.8	8.2	7.9	7.8	7.8	8.1	7.6	8.0	7.3	8.3	7.8	7.5	7.6	7.7	7.6	7.5
	2013	7.7	8.3	7.9	7.7	7.8	7.9	7.6	8.3	7.7	7.9	7.6	8.0	7.1	7.8	7.4	7.9
	2014	8.1	8.2	8.0	7.9	7.9	8.1	7.7	7.3	7.9	7.7	7.2	8.0	7.8	7.6	7.2	7.8
	2015	8.2	8.3	7.8	8.3	8.1	8.2	7.8	8.3	7.9	7.6	7.4	7.8	7.7	7.5	7.7	8.2
DO (mg/l)	2011	9.0	9.4	8.5	8.0	7.9	6.2	6.5	7.6	7.2	6.3	6.2	6.1	7.6	6.0	5.9	6.4
	2012	7.9	8.8	7.8	7.5	7.2	7.2	6.2	6.3	7.1	7.1	5.9	5.7	8.0	7.1	6.2	6.2
	2013	8.3	8.1	7.6	7.4	7.4	7.0	7.2	7.4	6.6	5.9	5.7	6.6	5.9	6.7	5.6	5.3
	2014	8.5	7.8	7.5	8.7	8.5	7.2	6.7	8.1	7.8	5.4	4.8	6.9	7.2	4.9	5.0	6
	2015	8.1	7.4	7.8	8.6	8.2	7.2	7.1	8.5	6.3	4.0	4.6	6.7	6.8	5.3	5.3	6.5
BOD (mg/l)	2011	1.5	2.1	1.9	1.5	2.4	2.4	2.1	1.8	4.1	5.4	3.8	2.6	3.3	4.3	3.4	2.7
	2012	1.3	1.7	2.1	1.0	2.1	2.3	2.3	2.5	4.4	4.1	3.9	4.4	2.8	3.1	2.9	3.4
	2013	1.7	1.1	0.9	1.4	2.9	1.9	1.6	0.6	4.4	4.4	4.3	3.4	3.4	3.5	3.4	2.9
	2014	1.3	0.7	1.2	0.8	1.2	1.3	1.8	1.8	5.4	4.9	3.6	3.8	4.7	4.1	2.6	4
	2015	1.4	0.9	1.1	1.2	1.2	1.1	1.5	1.5	5.0	4.4	4.0	3.8	4.1	3.7	2.7	3.3
TC ('00) (MPN/100 ml)	2011	3.85	8.38	12.43	11.50	26.00	61.25	106.33	36.00	317.00	152.25	526.67	140.00	210.00	75.00	220.33	70.00
	2012	9.60	9.48	19.33	4.35	47.67	106.75	101.00	22.50	106.67	261.00	806.67	445.00	109.00	150.50	730.00	295.00
	2013	21.67	18.30	28.50	7.90	35.33	79.25	580.33	14.00	413.33	420.00	706.67	240.00	330.00	230.00	496.67	170.00
	2014	4.50	43.50	54.33	52.50	240.00	96.00	503.33	380.00	350.00	1005.00	666.67	730.00	240.00	602.50	666.67	445.00
	2015	100.63	62.25	58.10	44.50	314.67	243.50	153.00	540.00	770.00	587.25	730.00	1600.00	230.00	524.50	633.33	1260.00

**Table-3.9 Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit**

Monitoring Station		2011	2012	2013	2014	2015
Sundargarh (lb)	BOD	1.6 (0.5-2.6)	1.5 (1.0-2.2)	0.8 (0.3 - 1.5)	0.6 (0.3 – 0.8)	0.7 (0.2-1.9)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	2513 (140-17000)	2241 (790-5400)	2678 (790 – 54000)	1234 (330– 3300)	1725 (490-5400)
	F*	1/12	2/12	2/10	0/11	1/12
Jharsuguda (lb)	BOD	1.6 (0.8-2.5)	1.4 (0.5-2.2)	1.0 (0.3 – 1.6)	0.6 (0.3 – 1.2)	0.8 (0.2-1.4)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	4135 (220-17000)	3609 (790-16000)	1973 (230 – 3300)	4306 (78 – 24000)	4433 (700-16000)
	F*	3/112	2/12	0/10	3/11	4/12
Brajarajnar U/s (lb)	BOD	1.5 (1.0-2.2)	1.3 (0.6-1.8)	1.0 (0.4 – 1.6)	0.5 (0.2 – 1.0)	0.7 (0.3-1.7)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	1481 (700-2800)	1676 (330-2800)	2734 (940 – 5400)	2365 (130 – 5400)	7416 (790-16000)
	F*	0/12	0/12	1/10	2/11	7/12
Brajarajnar D/s (lb)	BOD	1.8 (1.2-2.4)	1.6 (0.8-2.3)	1.6 (0.7 – 2.2)	0.8 (0.2 – 1.3)	1.0 (0.4-1.9)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	2774 (790-6300)	3191 (490-5400)	2759 (790 – 3900)	3245 (490 – 9200)	8862 (940-16000)
	F*	1/12	2/12	0/10	3/11	9/12
Jharsuguda (Bheden)	BOD	1.6 (0.7-2.4)	1.7 (1.3-2.3)	1.4 (0.4 – 2.2)	0.9 (0.1 – 1.5)	1.0 (0.4-0.7)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	723 (470-1400)	1456 (490-3500)	2717 (490 – 7900)	1695 (230 –4900)	2781 (490-9400)
	F*	0/12	0/12	1/10	0/11	1/12
Hirakud	BOD	1.4 (0.9-2.0)	1.3 (1.0-1.8)	1.1 (0.4 – 2.2)	0.6 (0.2 – 1.3)	0.8 (0.2-1.9)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	1978 (940-4300)	1376 (310-2800)	2246 (230 – 4900)	3533 (78– 16000)	2943 (630-9200)
	F*	0/12	0/12	0/10	3/11	3/12
Power Channel U/s	BOD	1.3 (0.6-1.8)	1.3 (1.0-1.6)	1.0 (0.4 – 1.8)	0.5 (0.4 – 0.7)	0.8 (0.3-1.4)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	283 (45-630)	425 (110-1400)	592 (78 – 1300)	885 (170– 3500)	1383 (130-5400)
	F*	0/12	0/12	0/10	0/11	1/12
Power Channel D/s	BOD	1.6 (1.0-2.3)	1.7 (1.2-2.0)	1.3 (0.6 – 2.3)	0.7 (0.3 – 0.9)	1.3 (0.4-2.3)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	848 (230-1700)	888 (170-2800)	1522 (210 – 3400)	3069 (140 – 16000)	2648 (790-9200)
	F*	0/12	0/12	0/10	2/11	2/12

Table 3.9 Contd..

Monitoring Station		2011	2012	2013	2014	2015
Sambalpur U/s	BOD	1.5 (0.8-2.1)	1.6 (1.1-2.4)	1.3 (0.3 – 3.6)	1.1 (0.5 – 1.8)	0.9 (0.3-1.9)
	F*	0/12	0/12	1/10	0/11	0/12
	TC	2457 (840-9200)	3608 (700-16000)	7710 (3300 – 17000)	14036 (2400 –92000)	12692 (2200-35000)
	F*	1/12	2/12	7/10	5/11	9/12
Sambalpur D/s	BOD	2.7 (1.8-3.8)	2.8 (1.7-4.9)	3.0 (2.2 – 4.2)	2.8 (1.2 – 3.9)	2.6 (1.8-4.1)
	F*	5/12	3/12	5/10	5/11	2/12
	TC	47692 (4300-160000)	76042 (3500-160000)	38300 (7000 – 92000)	49091 (13000 –160000)	46742 (7900-160000)
	F*	11/12	11/12	10/10	11/11	12/12
Sambalpur FD/s at Shankarmath	BOD	2.2 (1.1-2.9)	2.1 (1.0-3.7)	2.4 (1.4 – 3.6)	2.0 (1.1 – 3.1)	1.9 (1.2-3.3)
	F*	0/12	3/12	2/10	1/11	1/12
	TC	25592 (1500-92000)	25575 (7900-54000)	5260 (1100 – 13000)	9127 (2200 –35000)	24200 (5400-92000)
	F*	10/12	12/12	3/10	8/11	12/12
Sambalpur FFD/s at Huma	BOD	1.9 (1.0-2.9)	1.8 (1.3-3.0)	1.8 (0.4 – 2.6)	1.7 (0.8 – 2.6)	1.4 (0.8-2.5)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	5223 (700-26000)	13662 (840-35000)	3330 (1300 – 4900)	3708 (490 – 17000)	6792 (1300-13000)
	F*	2/12	9/12	0/10	1/11	5/12
Sonepur U/s	BOD	1.3 (0.7-2.1)	1.5 (0.9-2.3)	1.0 (0.4 – 1.4)	0.7 (0.2 – 1.1)	0.8 (0.2-1.5)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	1692 (630-4300)	1749 (170-3500)	1790 (130 – 4900)	1485 (78 – 9200)	2893 (330-16000)
	F*	0/12	0/12	0/10	1/11	3/12
Sonepur D/s	BOD	1.9 (0.8-2.8)	2.0 (1.4-2.6)	1.5 (0.7 – 1.8)	1.0 (0.4 – 1.9)	1.1 (0.3-1.8)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	2717 (1100-9200)	2588 (270-5400)	2593 (220 – 6300)	2500 (330– 5400)	5406 (490-16000)
	F*	1/12	1/12	2/10	3/11	5/12
Tikarapada	BOD	1.5 (0.8-2.4)	1.4 (1.0-1.8)	0.8 (0.3 – 1.6)	0.6 (0.3 – 0.8)	0.7 (0.2-1.4)
	F*	0/12	0/12	0/10	0/11	0/11
	TC	3345 (940-8400)	2393 (460-5400)	1880 (490 – 7900)	3275 (230 – 17000)	5973 (230-24000)
	F*	2/12	1/12	1/10	2/11	3/11
Narasinghpur	BOD	1.3 (0.6-1.8)	1.3 (0.5-1.9)	1.1 (0.6 – 1.8)	0.7 (0.2 – 1.4)	0.8 (0.4-1.9)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	1553 (790-2800)	3567 (1100-9400)	3603 (230 – 9200)	22102 (130 – 160000)	5657 (490-16000)
	F*	0/12	3/12	3/10	3/11	6/12

Table 3.9 Contd..

Monitoring Station		2011	2012	2013	2014	2015
Munduli	BOD	1.4 (1.0-2.9)	1.4 (0.4-2.4)	0.9 (0.5 – 2.0)	0.7 (0.4 – 1.5)	0.9 (0.5-1.6)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	1757 (450-3500)	3629 (330-9200)	3783 (330 – 9200)	19659 (460 – 160000)	7715 (490-24000)
	F*	0/12	4/12	3/10	5/11	6/12
Cuttack U/s	BOD	1.4 (0.7-2.4)	1.5 (1.0-2.0)	1.1 (0.6 – 1.8)	1.0 (0.7 – 1.5)	1.0 (0.5-2.0)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	1038 (330-1700)	3256 (470-11000)	4552 (790 – 16000)	4817 (790 – 16000)	1748 (130-5400)
	F*	0/12	3/12	2/10	5/11	1/12
Cuttack D/s	BOD	2.5 (1.8-3.6)	2.5 (1.6-3.9)	2.5 (1.6 – 2.8)	2.2 (1.7 – 2.5)	2.2 (1.5-2.8)
	F*	1/12	3/12	0/10	0/11	0/12
	TC	35675 (2200-160000)	55417 (24000-160000)	82000 (35000 – 160000)	62455 (22000 – 160000)	51017 (3300-160000)
	F*	11/12	12/12	10/10	11/100	10/12
Cuttack FDS	BOD	1.9 (1.0-2.8)	2.0 (1.0-2.8)	2.0 (1.4 – 2.4)	1.5 (1.1 – 2.0)	1.5 (1.0-2.0)
	F*	0/12	0/12	0/10	0/10	0/12
	TC	14925 (1100-92000)	24517 (9200-54000)	35800 (22000 – 54000)	42818 (11000 –160000)	39549 (490-92000)
	F*	5/12	12/12	10/10	11/11	9/12
Paradeep U/s	BOD	1.2 (0.6-2.1)	1.5 (0.8-2.6)	1.5 (0.6 – 2.1)	1.2 (0.5 – 2.0)	1.1 (0.2-2.2)
	F*	0/11	0/12	0/10	0/11	0/12
	TC	3209 (1500-7000)	5900 (2100-22000)	22020 (2200 – 160000)	15187 (170 –92000)	4953 (460-16000)
	F*	1/11	5/12	6/10	7/11	4/12
Paradeep D/s	BOD	2.0 (0.7-3.0)	2.2 (0.7-3.7)	1.7 (1.0 – 2.7)	1.4 (0.8 – 2.7)	1.9 (0.8-2.9)
	F*	0/12	1/12	0/10	0/11	0/12
	TC	6159 (220-54000)	4875 (1700-11000)	24860 (78 – 160000)	6802 (<2 – 22000)	6756 (230-24000)
	F*	1/12	3/12	5/10	5/11	5/12
Monmunda (Tel)	BOD	1.8 (1.2-2.3)	1.6 (0.9-2.3)	1.1 (0.7 – 1.8)	0.9 (0.3 – 1.3)	1.0 (0.6-2.7)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	1487 (840-2400)	1858 (170-5400)	3058 (230 – 7900)	1755 (230 – 5400)	2517 (230-13000)
	F*	0/12	1/12	3/10	1/11	1/12
Cuttack U/s (Kathajodi)	BOD	1.8 (1.1-4.1)	1.7 (1.2-3.6)	1.2 (0.4 – 1.8)	1.2 (0.6 – 1.6)	1.2 (0.5-1.8)
	F*	2/12	1/12	0/10	0/11	0/12
	TC	1222 (390-1700)	15889 (390-160000)	5140 (1300 – 16000)	5600 (1300 – 16000)	3627 (130-16000)
	F*	0/12	3/12	3/10	5/11	2/12

Table 3.9 Contd..

Monitoring Station		2011	2012	2013	2014	2015
Cuttack D/s (Kathajodi)	BOD	3.1 (2.4-3.9)	3.4 (1.5-4.4)	3.8 (2.5 – 4.8)	3.7 (2.1 – 5.6)	3.3 (2.1-4.7)
	F*	6/12	7/12	9/10	7/11	10/12
	TC	66083 (22000-160000)	90333 (28000-160000)	70600 (11000 – 160000)	98818 (28000 – 160000)	27108 (3300-54000)
	F*	12/12	12/12	10/10	11/11	11/12
Cuttack FD/s at Mattagajpur (Kathajodi)	BOD	5.7 (2.6-15.0)	8.2 (4.5-14.0)	12.4 (5.3 –27.5)	8.4 (1.6 –19.3)	9.7 (5.4-17.0)
	F*	9/12	12/12	10/10	9/11	12/12
	TC	40117 (8400-160000)	69333 (21000-160000)	43700 (7000 – 92000)	94273 (35000 –160000)	58583 (11000-160000)
	F*	12/12	12/12	10/10	11/11	12/12
Cuttack FD/s at Sankhatrasa (Serua)	BOD	2.2 (1.3-3.3)	2.5 (1.4-3.6)	2.8 (1.8 – 3.6)	2.7 (1.3 – 4.2)	2.1 (1.3-3.7)
	F*	2/12	3/12	3/10	4/11	1/12
	TC	5070 (940-13000)	41333 (11000-160000)	17440 (1400 – 35000)	32164 (5400 –92000)	26599 (490-92000)
	F*	3/12	12/12	9/10	11/11	11/12
Bhubaneswar FU/s (Kuakhai)	BOD	1.8 (1.0-2.4)	1.6 (0.8-2.3)	1.2 (0.6 – 1.6)	1.0 (0.4 – 1.8)	1.1 (0.5-1.9)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	938 (140-2100)	1162 (400-2400)	33678 (490 – 160000)	6241 (450 – 24000)	5552 (330-16000)
	F*	0/12	0/12	2/10	5/11	6/12
Bhubaneswar U/s (Kuakhai)	BOD	2.1 (1.6-2.8)	2.4 (1.4-3.4)	2.0 (1.4 – 3.1)	1.5 (0.7 – 2.7)	1.3 (0.7-1.9)
	F*	0/12	1/12	1/10	0/11	0/12
	TC	6392 (1700-17000)	7225 (1700-17000)	22460 (1100 – 160000)	31218 (2400 –92000)	26642 (5400-54000)
	F*	4/12	6/12	6/10	10/11	12/12
Bhubaneswar D/s (Daya)	BOD	4.0 (2.2-6.5)	4.3 (3.0-6.0)	4.2 (3.4 – 5.0)	4.4 (2.8 – 5.4)	4.3 (3.5-5.4)
	F*	3/12	11/12	10/10	10/11	12/12
	TC	26942 (7900-92000)	40783 (7000-160000)	49300 (24000 – 92000)	85727 (16000 –160000)	74908 (4900-160000)
	F*	12/12	12/12	10/10	11/11	11/12
Bhubaneswar FD/s (Daya)	BOD	3.4 (1.2-4.8)	3.1 (1.4-4.1)	3.3 (2.6 – 4.1)	3.6 (2.2 – 4.7)	3.4 (1.9-4.6)
	F*	6/12	6/11	6/10	9/11	9/12
	TC	14000 (3300-54000)	32458 (5800-160000)	32200 (16000 – 92000)	52909 (22000 – 160000)	61317 (5400-160000)
	F*	9/12	12/12	10/10	11/11	12/12
Choudwar D/s (Birupa)	BOD	1.6 (1.0-2.4)	1.6 (0.7-2.1)	1.5 (0.7 – 2.6)	1.0 (0.5 – 1.8)	1.1 (0.4-2.4)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	5445 (940-17000)	4467 (1700-9200)	27350 (3500 – 160000)	19245 (1300 – 160000)	8692 (1300-24000)
	F*	3/12	3/12	1/10	6/11	7/12

\*F : Frequency of deviation (Number of deviation/ total number of observation)

Table 3.10 Annual average and range values of Ammonical Nitrogen (mg/l)

Monitoring Station	2011			2012			2013			2014			2015		
	Amm-N	Fr. Amm-N	Total Amm-N												
	(mg/l)			(mg/l)			(mg/l)			(mg/l)			(mg/l)		
Sundargarh (lb)	0.364 (0.112-0.672)	0.157 (0.005-0.939)	0.521 (0.117-1.611)	0.154 (0.112-0.448)	0.006 (0.001-0.029)	0.160 (0.113-0.477)	0.228 (0.112-0.392)	0.012 (0-0.049)	0.240 (0.112-0.441)	0.137 (0.056-0.336)	0.005 (0-0.014)	0.142 (0.056-0.350)	0.079 (0.056-0.112)	0.003 (0.001-0.007)	0.082 (0.057-0.119)
Jharsuguda (lb)	0.462 (0.112-1.12)	0.020 (0-0.073)	0.482 (0.112-1.193)	0.224 (0.112-0.672)	0.012 (0-0.042)	0.236 (0.112-0.714)	0.227 (0.112-0.495)	0.014 (0-0.033)	0.241 (0.112-0.528)	0.117 (0.056-0.224)	0.006 (0-0.013)	0.123 (0.056-0.237)	0.065 (0.056-0.112)	0.003 (0-0.004)	0.068 (0.056-0.116)
Brajarajnaragar U/s (lb)	0.406 (0.056-0.84)	0.021 (0.001-0.07)	0.427 (0.057-0.910)	0.294 (0.112-1.340)	0.013 (0-0.107)	0.307 (0.112-1.447)	0.277 (0.112-0.605)	0.014 (0.005-0.022)	0.291 (0.117-0.627)	0.127 (0.056-0.224)	0.005 (0.001-0.011)	0.132 (0.057-0.235)	0.070 (0.056-0.112)	0.004 (0.001-0.011)	0.074 (0.057-0.123)
Brajarajnaragar D/s (lb)	0.434 (0.056-1.12)	0.023 (0.004-0.058)	0.457 (0.060-1.178)	0.294 (0.112-0.896)	0.011 (0-0.028)	0.305 (0.112-0.924)	0.300 (0.110-0.605)	0.011 (0-0.027)	0.311 (0.110-0.627)	0.137 (0.056-0.224)	0.007 (0.001-0.028)	0.144 (0.057-0.252)	0.070 (0.056-0.112)	0.004 (0.001-0.007)	0.074 (0.057-0.119)
Jharsuguda (Bheden)	0.485 (0.112-1.008)	0.022 (0.004-0.066)	0.507 (0.116-1.074)	0.219 (0.112-0.728)	0.009 (0.001-0.025)	0.228 (0.113-0.753)	0.339 (0.112-0.660)	0.016 (0-0.049)	0.355 (0.112-0.709)	0.137 (0.056-0.224)	0.007 (0.002-0.011)	0.144 (0.058-0.235)	0.079 (0.056-0.112)	0.005 (0-0.014)	0.084 (0.056-0.126)
Hirakud	0.369 (0.112-0.728)	0.020 (0.003-0.049)	0.389 (0.115-0.777)	0.275 (0.112-0.896)	0.017 (0.002-0.058)	0.292 (0.114-0.954)	0.281 (0.112-0.504)	0.017 (0.003-0.063)	0.298 (0.115-0.567)	0.117 (0.056-0.224)	0.007 (0.003-0.018)	0.124 (0.059-0.242)	0.131 (0.056-0.728)	0.006 (0-0.022)	0.137 (0.056-0.750)
Power Channel U/s	0.383 (0.112-0.952)	0.015 (0.003-0.033)	0.398 (0.115-0.985)	0.191 (0.112-0.616)	0.014 (0.001-0.049)	0.205 (0.113-0.665)	0.272 (0.112-0.550)	0.015 (0.002-0.036)	0.287 (0.114-0.586)	0.122 (0.056-0.224)	0.006 (0.002-0.021)	0.128 (0.058-0.245)	0.075 (0.056-0.112)	0.003 (0.001-0.007)	0.078 (0.057-0.119)
Power Channel D/s	0.411 (0.112-0.784)	0.020 (0.004-0.056)	0.431 (0.116-0.840)	0.285 (0.112-0.952)	0.018 (0.002-0.063)	0.303 (0.114-1.015)	0.306 (0.112-0.448)	0.019 (0.001-0.035)	0.325 (0.113-0.483)	0.127 (0.056-0.224)	0.006 (0.001-0.028)	0.133 (0.057-0.252)	0.061 (0.056-0.112)	0.003 (0.001-0.007)	0.064 (0.057-0.119)
Sambalpur U/s	0.425 (0.056-0.896)	0.017 (0.001-0.045)	0.442 (0.057-0.941)	0.200 (0.112-0.672)	0.009 (0.004-0.020)	0.209 (0.116-0.692)	0.223 (0.112-0.450)	0.016 (0.003-0.029)	0.239 (0.115-0.479)	0.117 (0.056-0.224)	0.007 (0.002-0.028)	0.124 (0.058-0.252)	0.084 (0.056-0.224)	0.004 (0-0.009)	0.088 (0.056-0.233)
Sambalpur D/s	0.518 (0.112-1.12)	0.021 (0.002-0.054)	0.539 (0.114-1.174)	0.331 (0.112-0.560)	0.019 (0.007-0.042)	0.350 (0.119-0.602)	0.273 (0.055-0.448)	0.016 (0-0.016)	0.289 (0.055-0.464)	0.122 (0.056-0.168)	0.007 (0-0.021)	0.129 (0.056-0.189)	0.135 (0.056-0.504)	0.007 (0.001-0.025)	0.142 (0.057-0.529)

Water Quality of Major Rivers of Odisha

Table 3.10 contd..

Monitoring Station	2011			2012			2013			2014			2015		
	Amm-N	Fr. Amm-N	Total Amm-N												
	(mg/l)			(mg/l)			(mg/l)			(mg/l)			(mg/l)		
Sambalpur FD/s at Shankarmath	0.443 (0.112-0.84)	0.023 (0.004-0.084)	0.466 (0.116-0.924)	0.196 (0.112-0.336)	0.011 (0.003-0.022)	0.206 (0.115-0.358)	0.239 (0.112-0.385)	0.005 (0-0.009)	0.244 (0.112-0.394)	0.122 (0.056-0.224)	0.004 (0.001-0.011)	0.126 (0.057-0.235)	0.061 (0.056-0.112)	0.003 (0.001-0.004)	0.064 (0.057-0.116)
Sambalpur FFD/s at Huma	0.397 (0.112-0.896)	0.027 (0.004-0.084)	0.424 (0.116-0.980)	0.168 (0.112-0.280)	0.010 (0-0.022)	0.178 (0.112-0.302)	0.296 (0.112-0.504)	0.015 (0-0.035)	0.315 (0.112-0.539)	0.127 (0.056-0.168)	0.009 (0.002-0.016)	0.136 (0.058-0.184)	0.075 (0.056-0.168)	0.006 (0.001-0.016)	0.081 (0.057-0.184)
Sonepur U/s	0.280 (0.112-0.616)	0.014 (0.003-0.022)	0.294 (0.115-0.638)	0.257 (0.112-0.672)	0.012 (0-0.004)	0.269 (0.112-0.676)	0.277 (0.112-0.550)	0.018 (0.003-0.036)	0.295 (0.115-0.586)	0.117 (0.056-0.168)	0.008 (0.001-0.021)	0.125 (0.057-0.189)	0.070 (0.056-0.168)	0.005 (0.001-0.016)	0.075 (0.057-0.184)
Sonepur D/s	0.401 (0.112-1.008)	0.025 (0.003-0.050)	0.426 (0.115-1.058)	0.191 (0.112-0.336)	0.016 (0.003-0.042)	0.207 (0.115-0.378)	0.273 (0.112-0.448)	0.019 (0-0.042)	0.292 (0.112-0.490)	0.107 (0.056-0.112)	0.008 (0.003-0.014)	0.115 (0.059-0.126)	0.084 (0.056-0.168)	0.007 (0.001-0.017)	0.091 (0.057-0.185)
Tikarapada	0.481 (0.112-1.904)	0.024 (0.001-0.076)	0.505 (0.113-1.980)	0.172 (0.056-0.560)	0.008 (0-0.028)	0.180 (0.056-0.588)	0.332 (0.112-0.715)	0.020 (0-0.046)	0.352 (0.112-0.761)	0.132 (0.056-0.280)	0.009 (0.001-0.027)	0.141 (0.057-0.307)	0.056 (0.056-0.056)	0.005 (0.002-0.017)	0.061 (0.058-0.073)
Narasinghpur	0.504 (0.056-1.68)	0.034 (0.002-0.109)	0.538 (0.058-1.789)	0.168 (0.112-0.448)	0.015 (0.003-0.056)	0.183 (0.115-0.504)	0.299 (0.168-0.448)	0.017 (0-0.031)	0.316 (0.168-0.479)	0.112 (0.056-0.224)	0.009 (0.002-0.015)	0.121 (0.058-0.239)	0.070 (0.056-0.112)	0.006 (0.002-0.014)	0.076 (0.058-0.126)
Munduli	0.527 (0.056-1.568)	0.028 (0.004-0.080)	0.555 (0.060-1.648)	0.215 (0.112-0.728)	0.016 (0.002-0.071)	0.231 (0.114-0.799)	0.292 (0.112-0.504)	0.009 (0-0.040)	0.301 (0.112-0.544)	0.153 (0.056-0.392)	0.009 (0.002-0.028)	0.162 (0.058-0.420)	0.070 (0.056-0.168)	0.005 (0.002-0.007)	0.075 (0.058-0.175)
Cuttack U/s	0.588 (0.056-1.568)	0.053 (0.001-0.243)	0.641 (0.057-1.811)	0.191 (0.112-0.560)	0.011 (0.006-0.027)	0.202 (0.118-0.587)	0.188 (0.028-0.280)	0.014 (0.002-0.027)	0.202 (0.030-0.307)	0.137 (0.056-0.280)	0.009 (0.001-0.027)	0.146 (0.057-0.307)	0.079 (0.056-0.112)	0.006 (0-0.014)	0.085 (0.056-0.126)
Cuttack D/s	0.425 (0.056-0.84)	0.028 (0.004-0.082)	0.453 (0.060-0.922)	0.485 (0.224-1.300)	0.034 (0-0.112)	0.519 (0.224-1.412)	0.280 (0.112-0.392)	0.017 (0-0.042)	0.297 (0.112-0.434)	0.117 (0.056-0.168)	0.006 (0.001-0.014)	0.123 (0.057-0.182)	0.075 (0.056-0.224)	0.007 (0-0.022)	0.082 (0.056-0.246)
Cuttack FDS (Mahanadi)	0.411 (0.056-1.12)	0.030 (0.006-0.090)	0.441 (0.062-1.210)	0.266 (0.112-0.504)	0.022 (0.004-0.056)	0.288 (0.112-0.560)	0.274 (0.112-0.616)	0.018 (0.004-0.049)	0.292 (0.116-0.665)	0.137 (0.056-0.224)	0.008 (0.002-0.022)	0.145 (0.058-0.246)	0.075 (0.056-0.168)	0.006 (0.001-0.016)	0.081 (0.057-0.184)

Water Quality of Major Rivers of Odisha

Table 3.10 contd..

Monitoring Station	2011			2012			2013			2014			2015		
	Amm-N	Fr. Amm-N	Total Amm-N	Amm-N	Fr. Amm-N	Total Amm-N	Amm-N	Fr. Amm-N	Total Amm-N	Amm-N	Fr. Amm-N	Total Amm-N	Amm-N	Fr. Amm-N	Total Amm-N
	(mg/l)			(mg/l)			(mg/l)			(mg/l)			(mg/l)		
Paradeep U/s	0.407 (0.056-1.065)	0.033 (0.001-0.085)	0.440 (0.057-1.150)	0.297 (0.112-0.952)	0.017 (0.001-0.045)	0.314 (0.113-0.997)	0.234 (0.112-0.440)	0.013 (0.004-0.035)	0.247 (0.116-0.475)	0.143 (0.112-0.224)	0.007 (0.002-0.018)	0.150 (0.114-0.242)	0.056 (0.056-0.056)	0.003 (0.001-0.007)	0.059 (0.057-0.063)
Paradeep D/s	0.523 (0.056-1.792)	0.034 (0.006-0.143)	0.557 (0.062-1.935)	0.318 (0.112-0.616)	0.019 (0.005-0.042)	0.337 (0.117-0.658)	0.318 (0-0.504)	0.021 (0-0.040)	0.339 (0-0.540)	0.122 (0.056-0.168)	0.005 (0.002-0.011)	0.127 (0.058-0.179)	0.056 (0.056-0.056)	0.003 (0-0.007)	0.059 (0.056-0.063)
Monmunda (Tel)	0.527 (0.056-1.12)	0.029 (0.004-0.067)	0.556 (0.060-1.187)	0.218 (0.112-0.392)	0.014 (0.001-0.033)	0.232 (0.113-0.425)	0.344 (0.112-0.605)	0.018 (0.001-0.035)	0.362 (0.113-0.640)	0.127 (0.056-0.224)	0.009 (0-0.022)	0.136 (0.056-0.246)	0.079 (0.056-0.168)	0.005 (0.002-0.011)	0.084 (0.058-0.179)
Cuttack U/s (Kathajodi)	0.448 (0.056-1.008)	0.037 (0.007-0.063)	0.485 (0.063-1.071)	0.244 (0.112-1.018)	0.018 (0.002-0.099)	0.262 (0.114-1.117)	0.498 (0.112-1.400)	0.040 (0.004-0.112)	0.538 (0.116-1.512)	0.097 (0.056-0.168)	0.006 (0.001-0.014)	0.103 (0.057-0.182)	0.079 (0.056-0.168)	0.006 (0.001-0.014)	0.085 (0.057-0.182)
Cuttack D/s (Kathajodi)	0.536 (0.112-0.952)	0.035 (0.004-0.076)	0.571 (0.116-1.028)	0.626 (0.168-1.680)	0.049 (0-0.164)	0.671 (0.168-1.844)	0.336 (0.112-0.616)	0.028 (0.005-0.060)	0.364 (0.117-0.676)	0.122 (0.056-0.336)	0.006 (0.001-0.017)	0.128 (0.056-0.353)	0.079 (0.056-0.112)	0.007 (0.002-0.014)	0.086 (0.058-0.126)
Cuttack FD/s at Mattagajpur (Kathajodi)	0.616 (0.112-1.792)	0.017 (0.002-0.063)	0.633 (0.114-1.855)	1.001 (0.224-3.940)	0.027 (0.003-0.134)	1.028 (0.227-4.074)	0.420 (0.224-0.784)	0.015 (0-0.060)	0.435 (0.224-0.844)	1.232 (0.056-10.360)	0.007 (0-0.023)	1.239 (0.056-10.383)	4.952 (0.056-16.296)	0.089 (0-0.326)	5.041 (0.056-16.622)
Cuttack FD/s at Sankhatrasa (Serua)	0.600 (0.112-1.232)	0.042 (0.009-0.099)	0.642 (0.121-1.331)	0.589 (0.112-1.800)	0.041 (0-0.176)	0.630 (0.112-1.976)	0.370 (0.168-0.784)	0.026 (0.004-0.049)	0.396 (0.172-0.833)	0.168 (0.112-0.392)	0.012 (0.001-0.049)	0.180 (0.113-0.441)	0.138 (0.035-0.504)	0.010 (0-0.028)	0.148 (0.035-0.532)
Bhubaneswar FU/s (Kuakhai)	0.387 (0.056-1.34)	0.024 (0.006-0.087)	0.407 (0.062-1.427)	0.406 (0.112-1.008)	0.019 (0.001-0.039)	0.425 (0.113-1.047)	0.368 (0.112-0.560)	0.027 (0.002-0.054)	0.395 (0.114-0.614)	0.565 (0.056-4.480)	0.041 (0.004-0.358)	0.606 (0.060-4.838)	0.061 (0.056-0.112)	0.004 (0.001-0.009)	0.065 (0.057-0.121)
Bhubaneswar U/s (Kuakhai)	0.476 (0.056-1.68)	0.017 (0.002-0.050)	0.493 (0.058-1.730)	0.435 (0.112-1.300)	0.029 (0.011-0.042)	0.464 (0.123-1.342)	0.362 (0.168-0.672)	0.015 (0.003-0.033)	0.377 (0.171-0.705)	0.519 (0.056-3.584)	0.013 (0.002-0.072)	0.532 (0.058-3.656)	0.070 (0.056-0.112)	0.005 (0.001-0.014)	0.075 (0.057-0.126)
Bhubaneswar D/s (Daya)	0.490 (0.056-0.784)	0.011 (0.002-0.025)	0.501 (0.058-0.809)	0.641 (0.280-1.700)	0.040 (0.004-0.112)	0.681 (0.284-1.812)	0.418 (0.224-0.605)	0.016 (0-0.038)	0.434 (0.224-0.643)	1.553 (0.056-7.168)	0.026 (0-0.161)	1.576 (0.056-7.229)	4.466 (0.168-12.540)	0.145 (0.004-0.633)	4.611 (0.172-3.173)

Table 3.10 contd..

Monitoring Station	2011			2012			2013			2014			2015		
	Amm-N	Fr. Amm-N	Total Amm-N	Amm-N	Fr. Amm-N	Total Amm-N	Amm-N	Fr. Amm-N	Total Amm-N	Amm-N	Fr. Amm-N	Total Amm-N	Amm-N	Fr. Amm-N	Total Amm-N
	(mg/l)			(mg/l)			(mg/l)			(mg/l)			(mg/l)		
Bhubaneswar FD/s (Daya)	0.458 (0.168-0.952)	0.016 (0.002-0.025)	0.474 (0.170-0.977)	0.322 (0.112-0.896)	0.012 (0-0.033)	0.334 (0.112-0.929)	0.401 (0.168-0.728)	0.008 (0-0.018)	0.409 (0.168-0.746)	0.972 (0.056-4.032)	0.017 (0-0.091)	0.989 (0.056-4.121)	4.055 (0.112-11.870)	0.116 (0.003-0.415)	4.171 (0.115-12.285)
Choudwar D/s (Birupa)	0.471 (0.056-1.12)	0.026 (0.001-0.085)	0.497 (0.057-1.205)	0.234 (0.112-0.728)	0.015 (0.003-0.036)	0.249 (0.115-0.764)	0.268 (0.112-0.385)	0.009 (0-0.017)	0.277 (0.112-0.402)	0.122 (0.056-0.224)	0.008 (0.001-0.021)	0.130 (0.057-0.245)	0.084 (0.056-0.168)	0.005 (0.002-0.011)	0.089 (0.058-0.179)

Note : Amm-N : Ammonical nitrogen-N

Fr. Amm-N : Free ammonia-N

Total Amm-N : (Ammonium + Ammonia)-N

Table 3.11 Seasonal average values of Electrical Conductivity (microSiemens/cm)

Monitoring Station	2011				2012				2013				2014				2015			
	W	S	M	PM																
Sundargarh (lb)	168	158	103	141	146	160	124	161	167	186	105	125	134	146	123	190	173	168	121	156
Jharsuguda (lb)	167	162	108	145	144	153	131	157	180	177	106	119	150	150	133	182	190	179	125	151
Brajarajnar U/s (lb)	186	197	105	148	147	160	135	178	171	174	118	125	168	164	129	182	196	177	133	161
Brajarajnar D/s (lb)	177	221	102	142	162	182	132	180	192	181	127	134	156	181	137	193	202	222	141	182
Jharsuguda (Bheden)	354	313	125	191	211	403	137	196	230	392	136	123	228	367	158	209	264	516	157	204
Hirakud	202	235	168	150	162	185	180	177	194	210	191	172	187	193	177	191	219	242	176	192
Power Channel U/s	202	272	176	142	177	189	159	172	214	221	184	168	187	209	184	215	235	224	178	210
Power Channel D/s	287	297	190	162	178	211	181	200	239	261	215	194	195	233	188	233	262	273	201	214
Sambalpur U/s	232	216	155	154	173	183	182	176	200	216	186	187	201	250	170	213	238	224	189	184
Sambalpur D/s	259	243	151	203	220	218	177	205	228	251	183	163	248	240	195	239	262	258	191	299

Water Quality of Major Rivers of Odisha

Table 3.11 Contd..

Monitoring Station	2011				2012				2013				2014				2015			
	W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
Sambalpur FD/s at Shankarmath	187	220	175	133	161	192	154	172	191	218	197	190	189	209	180	209	258	247	180	266
Sambalpur FD/s at Huma	204	218	164	124	155	180	167	167	192	220	192	188	192	202	173	204	234	237	177	212
Sonepur U/s	243	224	192	154	190	204	166	163	209	221	211	184	202	205	186	230	241	235	180	192
Sonepur D/s	291	258	225	192	214	206	212	197	238	237	195	246	248	208	205	246	262	248	220	225
Tikarapada	227	210	161	154	182	188	168	176	215	225	195	208	218	181	170	219	236	206	183	223
Narasinghpur	204	206	188	191	204	225	202	161	214	226	191	156	197	226	185	156	230	219	184	156
Munduli	204	225	202	161	178	181	173	187	205	226	176	191	228	196	174	210	232	214	172	207
Cuttack U/s	214	226	191	156	210	187	165	180	205	219	178	189	188	171	167	205	227	200	177	185
Cuttack D/s	197	226	185	156	172	208	161	194	212	211	189	218	261	193	174	234	239	218	205	213
Cuttack FDS (Mahanadi)	230	219	184	156	174	197	169	181	213	205	176	216	231	192	175	227	229	212	185	208
Paradeep U/s	4540	2631	191	190	3712	15535	211	332	2901	2801	187	222	11940	7254	175	1524	2708	5853	237	7135
Paradeep D/s	35455	28193	16640	11095	23220	32683	2059	10603	20512	17480	2670	219	26940	34950	434	16057	25450	11114	4852	18695
Monmunda (Tel)	239	195	156	192	215	190	179	202	206	176	173	217	216	160	172	201	202	170	184	189
Cuttack U/s (Kathajodi)	185	206	195	153	165	192	191	179	197	203	183	195	183	177	174	208	207	175	180	176
Cuttack D/s (Kathajodi)	210	206	184	190	174	261	200	203	216	215	195	216	420	232	210	263	240	248	212	266
Cuttack FD/s at Mattagajpur (Kathajodi)	705	450	255	307	580	599	389	292	607	547	346	286	464	296	243	294	592	557	462	435
Cuttack FD/s at Sankhatrasa (Serua)	212	212	201	163	176	209	190	193	215	211	188	194	326	182	222	195	237	230	208	222
Bhubaneswar FU/s (Kuakhai)	196	227	164	167	177	187	191	172	215	206	191	192	229	184	157	227	214	197	196	189
Bhubaneswar U/s (Kuakhai)	205	228	186	177	198	201	188	188	220	218	187	195	240	191	168	240	231	210	201	193
Bhubaneswar D/s (Daya)	328	275	179	205	326	231	185	242	287	287	218	231	302	273	185	259	338	338	314	310
Bhubaneswar FD/s (Daya)	327	262	219	191	318	225	194	205	285	285	221	211	372	268	173	266	326	282	298	298
Choudwar D/s (Birupa)	208	272	186	195	210	196	174	201	196	331	197	132	209	216	175	232	219	260	204	197

**Table 3.12 Annual average and Range values of Sodium Absorption Ratio (SAR) and Boron ( B)**

Monitoring Station	2011	2012	2013	2014	2015
	<b>SAR</b>				
Sundargarh (lb)	0.51 (0.30-0.69)	0.43 (0.22-0.73)	0.30 (0.08-0.46)	0.37 (0.24-0.57)	0.37 (0.26-0.56)
Jharsuguda (lb)	0.51 (0.32-0.75)	0.38 (0.20-0.59)	0.39 (0.27-0.50)	0.43 (0.25-0.61)	0.42 (0.29-1.02)
Brajaraj nagar U/s (lb)	0.54 (0.36-0.66)	0.40 (0.19-0.62)	0.38 (0.21-0.56)	0.42 (0.28-0.65)	0.38 (0.26-0.64)
Brajaraj nagar D/s (lb)	0.57 (0.32-0.69)	0.47 (0.29-0.80)	0.34 (0.13-0.51)	0.43 (0.25-0.72)	0.49 (0.23-1.34)
Jharsuguda (Bheden)	0.87 (0.28-1.70)	0.77 (0.20-1.83)	0.69 (0.21-1.40)	0.76 (0.29-1.94)	0.88 (0.27-1.96)
Hirakud	0.37 (0.25-0.52)	0.33 (0.18-0.46)	0.32 (0.08-0.53)	0.43 (0.34-0.51)	0.42 (0.22-0.87)
Power Channel U/s	0.35 (0.22-0.51)	0.32 (0.20-0.62)	0.32 (0.21-0.42)	0.38 (0.23-0.55)	0.41 (0.30-0.58)
Power Channel D/s	0.35 (0.27-0.45)	0.31 (0.21-0.41)	0.36 (0.27-0.47)	0.41 (0.29-0.51)	0.41 (0.33-0.53)
Sambalpur U/s	0.46 (0.26-0.60)	0.36 (0.23-0.46)	0.35 (0.23-0.55)	0.47 (0.32-0.65)	0.42 (0.21-0.63)
Sambalpur D/s	0.59 (0.40-0.82)	0.40 (0.23-0.71)	0.51 (0.36-0.70)	0.47 (0.27-0.64)	0.54 (0.34-0.89)
Sambalpur FD/s at Shankarmath	0.60 (0.21-1.21)	0.48 (0.24-0.82)	0.35 (0.20-0.51)	0.51 (0.34-0.82)	0.54 (0.30-1.21)
Sambalpur FD/s at Huma	0.38 (0.25-0.52)	0.37 (0.25-0.47)	0.31 (0.19-0.40)	0.42 (0.28-0.51)	0.41 (0.32-0.57)
Sonepur U/s	0.41 (0.33-0.49)	0.39 (0.18-0.55)	0.42 (0.28-0.83)	0.40 (0.31-0.51)	0.42 (0.30-0.51)
Sonepur D/s	0.43 (0.30-0.60)	0.44 (0.23-0.68)	0.31 (0.18-0.42)	0.44 (0.30-0.66)	0.46 (0.32-0.61)
Tikarapada	0.39 (0.21-0.60)	0.36 (0.12-0.55)	0.37 (0.17-0.72)	0.40 (0.24-0.65)	0.38 (0.29-0.48)
Narasinghpur	0.42 (0.32-0.49)	0.40 (0.19-0.61)	0.41 (0.22-0.84)	0.40 (0.32-0.58)	0.41 (0.28-0.80)
Munduli	0.40 (0.29-0.53)	0.38 (0.28-0.57)	0.34 (0.21-0.54)	0.42 (0.32-0.51)	0.40 (0.31-0.62)
Cuttack U/s	0.44 (0.31-0.58)	0.42 (0.28-0.86)	0.36 (0.22-0.45)	0.38 (0.27-0.49)	0.40 (0.30-0.53)
Cuttack D/s	0.42 (0.39-0.54)	0.38 (0.28-0.50)	0.39 (0.30-0.53)	0.46 (0.30-0.62)	0.37 (0.26-0.49)
Cuttack FD/s	0.42 (0.29-0.54)	0.39 (0.32-0.48)	0.35 (0.27-0.39)	0.41 (0.30-0.48)	0.41 (0.33-0.53)
Paradeep U/s	2.73 (0.40-12.92)	13.77 (0.20-31.93)	6.52 (0.18-40.93)	16.20 (0.32-47.79)	15.82 (0.31-47.53)
Paradeep D/s	32.3 (15.3-46.95)	29.58 (1.63-54.99)	22.10 (0.28-53.01)	45.89 (1.07-93.56)	38.58 (0.53-65.04)
Monmunda (Tel)	0.42 (0.21-0.65)	0.47 (0.31-1.00)	0.29 (0.16-0.59)	0.41 (0.26-0.73)	0.33 (0.22-0.45)
Cuttack U/s (Kathajodi)	0.44 (0.31-0.58)	0.37 (0.22-0.47)	0.36 (0.23-0.52)	0.47 (0.32- 1.13)	0.37 (0.25- 0.49)

Table 3.12 Contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>SAR</b>				
Cuttack D/s (Kathajodi)	0.44 (0.33-0.64)	0.42 (0.23-0.59)	0.34 (0.24-0.45)	0.68 (0.31-1.38)	0.47 (0.31-0.65)
Cuttack FD/s at Mattagajpur (Kathajodi)	1.22 (0.40-2.50)	1.51 (0.43-2.19)	1.22 (0.29-2.43)	0.99 (0.29-2.24)	1.70 (1.13-2.31)
Cuttack FD/s at Sankhatrasa (Serua)	0.40 (0.25-0.53)	0.43 (0.27-0.70)	0.41 (0.26-0.94)	0.49 (0.30-0.77)	0.53 (0.25-0.89)
Bhubaneswar FU/s (Kuakhai)	0.46 (0.36-0.59)	0.40 (0.24-0.66)	0.60 (0.26-0.48)	0.42 (0.32-0.54)	0.42 (0.30-0.52)
Bhubaneswar U/s (Kuakhai)	0.56 (0.42-0.72)	0.52 (0.25-0.86)	0.48 (0.26-0.64)	0.55 (0.31-1.09)	0.51 (0.34-0.70)
Bhubaneswar D/s (Daya)	0.81 (0.44-1.14)	0.72 (0.28-1.37)	0.74 (0.31-1.17)	0.80 (0.28-1.59)	1.39 (0.64-2.90)
Bhubaneswar FD/s (Daya)	0.87 (0.59-1.31)	0.75 (0.29-1.45)	0.76 (0.33-1.01)	0.92 (0.39-1.54)	1.20 (0.55-2.62)
Choudwar D/s (Birupa)	0.54 (0.33-1.78)	0.41 (0.21-0.73)	0.44 (0.24-0.89)	0.51 (0.22-1.34)	0.56 (0.33-2.02)
Monitoring Station	2011	2012	2013	2014	2015
	<b>B (mg/l)</b>				
Sundargarh (lb)	0.028 (0.007-0.072)	0.035 (0.007-0.095)	0.071 (0.011-0.185)	0.037 (0.003-0.105)	0.023 (0.003-0.063)
Jharsuguda (lb)	0.043 (0.008-0.106)	0.038 (0.011-0.095)	0.037 (0.003-0.109)	0.035 (0.003-0.083)	0.023 (0.003-0.063)
Brajarajnagar U/s (lb)	0.059 (0.011-0.201)	0.032 (0.007-0.064)	0.066 (0.003-0.139)	0.033 (0-0.067)	0.045 (0.003-0.179)
Brajarajnagar D/s (lb)	0.052 (0.008-0.163)	0.051 (0.011-0.136)	0.024 (0.007-0.068)	0.039 (0-0.083)	0.038 (0.003-0.112)
Jharsuguda (Bheden)	0.045 (0.011-0.132)	0.033 (0.007-0.132)	0.027 (0.003-0.041)	0.064 (0.003-0.15)	0.082 (0.009-0.273)
Hirakud	0.047 (0.008-0.114)	0.048 (0.007-0.098)	0.035 (0.007-0.154)	0.051 (0.003-0.105)	0.047 (0.003-0.158)
Power Channel U/s	0.050 (0.015-0.102)	0.056 (0.015-0.148)	0.058 (0.015-0.215)	0.037 (0.003-0.073)	0.028 (0.003-0.071)
Power Channel D/s	0.053 (0.008-0.174)	0.052 (0.023-0.102)	0.043 (0.003-0.272)	0.042 (0.003-0.096)	0.036 (0.003-0.081)
Sambalpur U/s	0.037 (0.004-0.132)	0.052 (0.019-0.117)	0.098 (0.030-0.268)	0.029 (0.003-0.096)	0.029 (0.003-0.063)
Sambalpur D/s	0.054 (0.015-0.117)	0.058 (0.026-0.098)	0.062 (0.007-0.272)	0.037 (0.003-0.077)	0.042 (0.003-0.164)
Sambalpur FD/s at Shankarmath	0.064 (0.008-0.148)	0.053 (0.025-0.079)	0.052 (0.003-0.192)	0.041 (0.003-0.141)	0.066 (0.003-0.197)
Sambalpur FFD/s at Huma	0.045 (0.008-0.095)	0.030 (0.011-0.064)	0.030 (0.003-0.079)	0.039 (0.003-0.112)	0.054 (0.003-0.221)
Sonepur U/s	0.035 (0.007-0.098)	0.053 (0.015-0.170)	0.046 (0.003-0.238)	0.076 (0.022-0.147)	0.041 (0.003-0.122)
Sonepur D/s	0.043 (0.004-0.125)	0.042 (0.004-0.096)	0.047 (0.003-0.230)	0.071 (0.022-0.205)	0.052 (0.003-0.119)

Table 3.12 Contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>B (mg/l)</b>				
Tikrapada	0.040 (0.008-0.087)	0.066 (0.019-0.117)	0.088 (0.003-0.340)	0.094 (0.003-0.359)	0.027 (0.003-0.048)
Narasinghpur	0.056 (0.004-0.102)	0.056 (0.011-0.079)	0.044 (0.007-0.151)	0.069 (0.003-0.150)	0.042 (0.016-0.112)
Munduli	0.025 (0.011-0.038)	0.044 (0.019-0.083)	0.028 (0.003-0.064)	0.050 (0.019-0.096)	0.030 (0.003-0.074)
Cuttack U/s	0.045 (0.004-0.125)	0.038 (0.004-0.094)	0.052 (0.001-0.287)	0.038 (0.003-0.121)	0.034 (0.003-0.138)
Cuttack D/s	0.036 (0.008-0.087)	0.052 (0.008-0.098)	0.073 (0.019-0.151)	0.080 (0.006-0.523)	0.043 (0.003-0.112)
Cuttack FD/s	0.066 (0.011-0.276)	0.047 (0.004-0.113)	0.067 (0.007-0.222)	0.049 (0.003-0.195)	0.043 (0.003-0.138)
Paradeep U/s	0.158 (0.019-0.466)	0.401 (0.007-1.662)	0.147 (0.022-0.382)	0.402 (0.096-1.251)	0.380 (0.003-1.171)
Paradeep D/s	0.890 (0.076-2.396)	1.102 (0.011-1.934)	0.641 (0.018-1.745)	1.108 (0.083-3.786)	1.177 (0.042-2.274)
Monmunda (Tel)	0.036 (0.008-0.132)	0.062 (0.004-0.280)	0.046 (0.007-0.268)	0.074 ( $<0.001-0.44$ )	0.045 (0.003-0.147)
Cuttack U/s (Kathajodi)	0.046 (0.007-0.163)	0.052 (0.015-0.136)	0.056 (0.007-0.204)	0.045 (0.003-0.163)	0.031 (0.010-0.077)
Cuttack D/s (Kathajodi)	0.115 (0.011-0.435)	0.063 (0.019-0.106)	0.050 (0.001-0.211)	0.101 (0.003-0.407)	0.058 (0.022-0.133)
Cuttack FD/s at Mattagajpur (Kathajodi)	0.094 (0.019-0.225)	0.084 (0.019-0.225)	0.088 (0.007-0.253)	0.164 (0.002-1.157)	0.087 (0.010-0.170)
Cuttack FD/s at Sankhatrasa (Serua)	0.062 (0.019-0.182)	0.053 (0.011-0.106)	0.061 (0.007-0.166)	0.079 (0.002-0.253)	0.030 (0.003-0.126)
Bhubaneswar FU/s (Kuakhai)	0.057 (0.008-0.341)	0.051 (0.007-0.106)	0.055 (0.019-0.098)	0.042 (0.003-0.086)	0.022 (0.003-0.061)
Bhubaneswar U/s (Kuakhai)	0.067 (0.008-0.223)	0.041 (0.007-0.091)	0.057 (0.003-0.196)	0.064 (0.006-0.154)	0.043 (0.012-0.112)
Bhubaneswar D/s (Daya)	0.062 (0.008-0.182)	0.096 (0.018-0.412)	0.061 (0.022-0.192)	0.078 (0.003-0.186)	0.050 (0.022-0.126)
Bhubaneswar FD/s (Daya)	0.048 (0.011-0.174)	0.085 (0.022-0.242)	0.068 (0.003-0.215)	0.081 (0.006-0.205)	0.045 (0.012-0.137)
Choudwar D/s (Birupa)	0.137 (0.015-0.829)	0.076 (0.015-0.216)	0.068 (0.003-0.377)	0.045 (0.006-0.112)	0.031 (0.006-0.067)

**Table 3.13 Annual average and Range values of Total Dissolved Solids (TDS) and Total Hardness (TH)**

Monitoring Station	2011	2012	2013	2014	2015
	<b>TDS (mg/l)</b>				
Sundargarh (lb)	89 (57-116)	91 (70-115)	89 (48-122)	85 (68-128)	88 (65-118)
Jharsuguda (lb)	91 (66-117)	93 (70-115)	88 (44-128)	90 (72-108)	94 (70-118)
Brajaraj nagar U/s (lb)	94 (62-128)	97 (72-123)	90 (58-115)	93 (66-109)	95 (72-116)
Brajaraj nagar D/s (lb)	95 (57-153)	101 (73-128)	95 (60-123)	100 (78-116)	108 (78-162)
Jharsuguda (Bheden)	149 (71-250)	147 (70-272)	157 (68-294)	149 (78-247)	170 (70-358)
Hirakud	113 (70-148)	111 (87-127)	114 (96-138)	109 (82-126)	118 (92-155)
Power Channel U/s	109 (75-137)	108 (87-129)	115 (96-128)	111 (85-128)	118 (90-142)
Power Channel D/s	110 (72-145)	106 (75-122)	119 (102-134)	115 (90-130)	124 (96-152)
Sambalpur U/s	120 (82-168)	109 (79-130)	118 (88-142)	114 (78-132)	117 (90-140)
Sambalpur D/s	144 (78-210)	123 (93-149)	141 (106-169)	126 (80-168)	141 (112-188)
Sambalpur FD/s at Shankarmath	129 (80-161)	125 (90-161)	124 (90-163)	132 (92-148)	139 (100-186)
Sambalpur FFD/s at Huma	110 (86-156)	113 (81-132)	117 (90-129)	121 (82-164)	120 (96-150)
Sonepur U/s	120 (83-151)	112 (81-136)	124 (101-151)	117 (80-148)	121 (90-150)
Sonepur D/s	136 (92-182)	129 (103-160)	133 (106-162)	126 (95-158)	135 (108-152)
Tikarapada	112 (76-139)	110 (79-130)	125 (98-152)	107 (78-128)	118 (96-140)
Narasinghpur	121 (86-165)	118 (89-153)	126 (90-163)	111 (82-128)	118 (102-152)
Munduli	115 (92-149)	110 (90-135)	119 (88-138)	112 (78-130)	116 (82-155)
Cuttack U/s	116 (87-171)	114 (91-150)	118 (88-149)	102 (78-125)	112 (88-148)
Cuttack D/s	119 (87-154)	116 (84-146)	118 (90-134)	116 (80-148)	125 (112-150)
Cuttack FD/s	116 (84-141)	116 (80-135)	117 (96-134)	113 (82-132)	119 (95-140)
Paradeep U/s	900 (96-3089)	4177 (96-13095)	1026 (88-5731)	3105 (82-12214)	2769 (110-8310)
Paradeep D/s	17574 (7533-30829)	13760 (429-30174)	9185 (92-26828)	16592 (102-41924)	11196 (142-23960)
Monmunda (Tel)	118 (80-166)	119 (98-140)	108 (78-142)	102 (80-124)	106 (70-121)

Table 3.13 Contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>TDS (mg/l)</b>				
Cuttack U/s (Kathajodi)	113 (87-158)	116 (84-132)	113 (82-129)	105 (76-152)	106 (82-128)
Cuttack D/s (Kathajodi)	122 (84-150)	132 (85-229)	122 (96-139)	139 (85-234)	140 (115-181)
Cuttack FD/s at Mattagajpur (Kathajodi)	245 (81-395)	285 (126-374)	269 (100-402)	186 (80-290)	301 (210-444)
Cuttack FD/s at Sankhatrasa (Serua)	119 (91-149)	119 (90-141)	121 (92-134)	120 (80-186)	127 (108-148)
Bhubaneswar FU/s (Kuakhai)	119 (82-154)	111 (92-126)	115 (98-126)	106 (80-128)	113 (90-138)
Bhubaneswar U/s (Kuakhai)	123 (104-149)	116 (100-135)	121 (90-140)	110 (82-142)	120 (105-142)
Bhubaneswar D/s (Daya)	147 (100-194)	143 (107-222)	152 (94-198)	144 (96-202)	187 (132-278)
Bhubaneswar FD/s (Daya)	151 (103-208)	135 (101-212)	152 (94-180)	139 (82-202)	165 (126-215)
Choudwar D/s (Birupa)	126 (103-173)	113 (93-136)	141 (80-362)	117 (82-148)	128 (100-218)
	<b>TH as CaCO<sub>3</sub> (mg/l)</b>				
	<b>TH as CaCO<sub>3</sub> (mg/l)</b>				
Sundargarh (Ib)	45 (22-60)	55 (28-74)	55 (30-76)	49 (30-68)	55 (32-66)
Jharsuguda (Ib)	47 (24-60)	57 (36-72)	50 (24-84)	51 (32-62)	55 (40-68)
Brajarajnagar U/s (Ib)	51 (26-72)	59 (36-80)	52 (40-72)	54 (32-76)	60 (42-74)
Brajarajnagar D/s (Ib)	51 (24-88)	62 (36-82)	54 (30-84)	55 (32-70)	64 (40-96)
Jharsuguda (Bheden)	76 (42-102)	77 (38-122)	82 (36-144)	81 (38-134)	96 (48-192)
Hirakud	67 (44-88)	75 (56-92)	75 (60-88)	75 (58-86)	82 (62-90)
Power Channel U/s	69 (48-92)	72 (64-84)	72 (62-80)	53 (38-62)	78 (50-96)
Power Channel D/s	70 (36-88)	70 (48-80)	74 (60-86)	52 (40-64)	83 (64-102)
Sambalpur U/s	70 (44-108)	72 (56-88)	76 (52-92)	72 (40-84)	78 (56-90)
Sambalpur D/s	73 (42-96)	79 (60-92)	83 (60-100)	75 (48-88)	87 (70-108)
Sambalpur FD/s at Shankarmath	72 (52-104)	81 (60-108)	81 (62-104)	81 (52-94)	90 (60-112)
Sambalpur FFD/s at Huma	69 (46-104)	76 (62-90)	77 (58-88)	79 (48-110)	82 (62-96)
Sonepur U/s	75 (58-96)	74 (56-92)	78 (58-100)	78 (50-132)	82 (60-100)
Sonepur D/s	84 (66-112)	87 (78-100)	89 (64-112)	87 (64-128)	90 (64-98)

Table 3.13 Contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>TH as CaCO<sub>3</sub> (mg/l)</b>				
Tikarapada	69 (52-92)	69 (44-80)	78 (64-88)	71 (46-88)	80 (64-100)
Narasinghpur	73 (58-100)	78 (60-98)	75 (44-94)	72 (52-86)	82 (62-94)
Munduli	71 (50-98)	71 (44-92)	76 (48-88)	70 (50-86)	80 (54-96)
Cuttack U/s	68 (40-90)	74 (58-84)	74 (58-96)	68 (42-96)	75 (56-90)
Cuttack D/s	71 (40-114)	75 (58-90)	75 (48-92)	71 (40-88)	86 (76-96)
Cuttack FD/s	71 (48-98)	79 (64-92)	76 (56-90)	71 (48-92)	82 (70-94)
Paradeep U/s	311 (54-1000)	1290 (60-7200)	173 (48-420)	452 (40-1700)	459 (76-1020)
Paradeep D/s	3447 (2400-6600)	2798 (220-6400)	1679 (52-4400)	2300 (42-5300)	1692 (84-4300)
Monmunda (Tel)	71 (40-96)	77 (64-94)	75 (56-96)	65 (36-82)	76 (40-96)
Cuttack U/s (Kathajodi)	69 (62-86)	77 (64-92)	70 (52-82)	64 (42-84)	70 (56-90)
Cuttack D/s (Kathajodi)	70 (54-94)	80 (60-96)	79 (50-98)	79 (52-116)	94 (68-128)
Cuttack FD/s at Mattagajpur (Kathajodi)	104 (52-176)	128 (76-172)	130 (72-172)	92 (46-134)	146 (100-232)
Cuttack FD/s at Sankhatrasa (Serua)	75 (58-92)	76 (56-96)	77 (62-92)	74 (46-110)	80 (66-96)
Bhubaneswar FU/s (Kuakhai)	67 (52-80)	72 (60-88)	71 (56-82)	67 (44-82)	77 (58-92)
Bhubaneswar U/s (Kuakhai)	68 (46-88)	67 (44-84)	73 (48-92)	67 (48-86)	78 (60-96)
Bhubaneswar D/s (Daya)	74 (48-100)	91 (48-264)	79 (46-100)	75 (48-90)	91 (80-122)
Bhubaneswar FD/s (Daya)	71 (46-100)	70 (48-88)	77 (46-100)	72 (46-92)	83 (74-96)
Choudwar D/s (Birupa)	71 (56-84)	76 (64-112)	90 (56-184)	75 (40-100)	84 (72-96)

Table 3.14 Annual average and Range values of Nitrate (as NO<sub>3</sub>)

Monitoring Station	2011	2012	2013	2014	2015
	<b>NO<sub>3</sub> (mg/l)</b>				
Sundargarh (lb)	0.388 (0.016-2.083)	0.362 (0.020-2.776)	0.431 (0.079-1.081)	0.526 (0.084-2.398)	0.451 (0.114-1.487)
Jharsuguda (lb)	0.340 (0.002-1.473)	0.295 (0.011-1.713)	0.283 (0.106-0.528)	0.384 (0.125-1.091)	0.775 (0.302-1.744)
Brajaraj nagar U/s (lb)	0.235 (0.004-1.102)	0.595 (0.013-1.716)	0.255 (0.016-0.489)	0.368 (0.136-0.675)	0.496 (0.103-1.433)
Brajaraj nagar D/s (lb)	0.409 (0.012-1.559)	0.613 (0.038-2.645)	0.424 (0.029-1.577)	0.535 (0.123-1.097)	1.124 (0.126-3.244)
Jharsuguda (Bheden)	0.423 (0.013-1.203)	0.373 (0.033-1.158)	0.496 (0.210-0.892)	0.528 (0.097-1.091)	0.823 (0.108-3.125)
Hirakud	0.912 (0.025-5.707)	0.734 (0.038-1.982)	0.472 (0.099-0.726)	0.531 (0.250-1.464)	0.844 (0.115-1.536)
Power Channel U/s	0.458 (0.025-2.736)	0.863 (0.051-5.432)	1.311 (0.111-8.915)	0.442 (0.072-1.523)	0.719 (0.072-2.201)
Power Channel D/s	0.682 (0.020-4.374)	0.441 (0.035-1.640)	0.398 (0.210-0.765)	0.670 (0.311-1.784)	1.444 (0.158-3.327)
Sambalpur U/s	0.155 (0.014-0.459)	0.528 (0.062-1.789)	0.447 (0.177-0.699)	0.469 (0.213-0.790)	0.860 (0.144-2.565)
Sambalpur D/s	0.499 (0.016-1.303)	0.925 (0.074-3.872)	1.001 (0.340-5.624)	0.609 (0.137-1.759)	1.738 (0.294-3.738)
Sambalpur FD/s at Shankarmath	0.706 (0.028-4.326)	0.825 (0.023-3.888)	0.608 (0.133-1.477)	0.771 (0.138-2.509)	1.719 (0.416-2.784)
Sambalpur FFD/s at Huma	0.213 (0.008-0.664)	0.670 (0.037-2.889)	0.381 (0.103-0.643)	0.395 (0.144-0.733)	1.092 (0.353-2.016)
Sonepur U/s	0.390 (0.016-1.575)	0.556 (0.111-2.096)	0.570 (0.214-0.929)	0.392 (0.143-1.080)	1.157 (0.066-3.116)
Sonepur D/s	0.336 (0.021-1.029)	0.440 (0.065-1.209)	0.565 (0.287-0.926)	0.579 (0.165-1.910)	2.000 (0.455-7.074)
Tikarapada	0.185 (0.059-0.463)	0.407 (0.032-1.464)	0.244 (0.045-0.717)	0.440 (0.108-1.279)	0.775 (0.136-2.176)
Narasingshpur	0.652 (0.129-3.564)	0.400 (0.095-1.487)	0.422 (0.145-0.950)	0.533 (0.137-1.685)	1.012 (0.082-3.463)
Munduli	0.339 (0.100-0.706)	0.336 (0.099-0.822)	0.363 (0.070-0.838)	0.515 (0.110-1.288)	0.966 (0.113-3.454)
Cuttack U/s	0.426 (0.006-1.355)	0.310 (0.045-1.100)	0.325 (0.092-1.158)	0.434 (0.047-1.670)	0.721 (0.035-1.547)
Cuttack D/s	0.582 (0.053-3.277)	0.376 (0.013-0.938)	0.251 (0.076-0.588)	0.717 (0.145-2.132)	1.943 (0.636-5.271)
Cuttack FD/s	0.334 (0.052-0.831)	0.326 (0.057-1.013)	0.406 (0.058-1.257)	0.523 (0.201-2.607)	1.316 (0.379-2.729)
Paradeep U/s	0.769 (0.198-3.171)	0.733 (0.292-1.717)	0.672 (0.206-1.634)	0.937 (0.138-3.365)	0.754 (0.199-2.201)
Paradeep D/s	1.401 (0.238-3.872)	0.847 (0.051-2.065)	0.680 (0.160-1.547)	1.299 (0.362-4.898)	1.839 (0.204-4.117)
Monmunda (Tel)	0.497 (0.040-2.597)	0.490 (0.006-2.298)	0.494 (0.027-0.746)	0.489 (0.106-2.138)	0.889 (0.108-2.408)
Cuttack U/s (Kathajodi)	0.368 (0.031-1.450)	0.257 (0.002-1.082)	0.658 (0.074-1.650)	0.661 (0.051-1.686)	0.687 (0.042-1.466)

Table 3.14 Contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>NO<sub>3</sub> (mg/l)</b>				
Cuttack D/s (Kathajodi)	0.538 (0.051-3.196)	0.556 (0.043-2.510)	0.370 (0.071-0.762)	1.902 (0.192-10.128)	2.260 (0.118-6.880)
Cuttack FD/s at Mattagajpur (Kathajodi)	5.596 (0.251-12.050)	5.528 (0.877-12.360)	4.391 (0.670-11.154)	2.416 (0.489-5.173)	3.732 (0.268-8.254)
Cuttack FD/s at Sankhatrasa (Serua)	0.456 (0.055-2.098)	0.416 (0.041-1.121)	0.481 (0.077-1.464)	0.954 (0.194-2.984)	0.996 (0.361-1.777)
Bhubaneswar FU/s (Kuakhai)	0.282 (0.012-1.085)	0.431 (0.009-1.923)	0.383 (0.038-1.410)	0.383 (0.097-1.753)	1.272 (0.076-6.336)
Bhubaneswar U/s (Kuakhai)	0.291 (0.056-7.048)	0.864 (0.231-2.337)	0.870 (0.040-2.038)	0.854 (0.053-2.597)	1.790 (0.238-4.631)
Bhubaneswar D/s (Daya)	2.975 (0.062-7.465)	2.137 (0.186-7.846)	1.829 (0.140-7.117)	2.474 (0.019-6.099)	2.880 (0.637-6.412)
Bhubaneswar FD/s (Daya)	2.621 (0.058-6.507)	2.143 (0.103-9.112)	2.455 (0.391-4.799)	2.898 (0.139-5.703)	1.869 (0.261-6.341)
Choudwar D/s (Birupa)	0.626 (0.105-1.672)	1.053 (0.081-4.869)	0.799 (0.275-1.420)	0.728 (0.120-2.601)	1.023 (0.211-2.917)

Table 3.15 Annual average and Range values of Chloride

Monitoring Station	2011	2012	2013	2014	2015
	<b>Chloride (mg/l)</b>				
Sundargarh (lb)	12.9 (4.8-19)	11.9 (5.7-19.4)	9.5 (2.9-14.8)	9.2 (4.9-15.7)	9.4 (5.9-14.7)
Jharsuguda (lb)	12.4 (7.0-20)	11.3 (6.6-18.6)	11.1 (5.8-16.7)	10.4 (5.9-14.7)	10.6 (6.9-26.4)
Brajaraj Nagar U/s (lb)	13.7 (6.8-18.7)	11.8 (6.8-19.6)	10.7 (5.8-15.7)	10.5 (5.9-16.6)	9.7 (7.8-12.7)
Brajaraj Nagar D/s (lb)	14.8 (8.8-23)	14.0 (7.6-23.1)	9.3 (4.8-15.7)	10.8 (5.9-18.6)	13.0 (5.9-37.2)
Jharsuguda (Bheden)	24.6 (8.7-54)	21.8 (6.6-66.3)	26.2 (6.7-61.9)	22.0 (6.9-56.8)	27.0 (6.9-75.3)
Hirakud	11.3 (7.6-16.4)	11.2 (7.0-13.9)	10.1 (2.8-16.4)	10.9 (7.8-13.7)	11.4 (5.9-24.5)
Power Channel U/s	11 (7-16.5)	10.8 (97.0-18.9)	10.2 (7.0-13.7)	9.8 (5.9-13.7)	10.8 (7.8-13.7)
Power Channel D/s	11 (7-16)	10.4 (7.0-13.4)	11.6 (7.7-16.7)	10.5 (7.8-13.9)	11.3 (9.8-13.7)
Sambalpur U/s	15.3 (7.0-26)	12.0 (8.0-15.8)	11.5 (6.8-20.6)	11.9 (7.8-16.6)	11.5 (5.9-15.7)
Sambalpur D/s	18 (11-28.5)	14.7 (10.6-22.2)	17.7 (8.7-30.8)	12.3 (6.9-18.6)	14.9 (9.8-27.4)
Sambalpur FD/s at Shankarmath	18.6 (7.6-33.1)	16.3 (10.0-26.6)	12.1 (7.7-16.5)	13.8 (8.3-21.5)	14.3 (7.8-33.3)
Sambalpur FFD/s at Huma	11.8 (7.6-16.3)	12.0 (8.0-15.4)	10.6 (6.6-14.8)	11.0 (6.9-14.7)	11.4 (8.8-15.6)
Sonepur U/s	13.1 (9.0-17.0)	13.7 (6.6-21.1)	13.7 (8.5-27.0)	10.5 (7.8-14.7)	11.4 (8.9-14.7)

Table 3.15 Contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>Chloride (mg/l)</b>				
Sonepur D/s	13.9 (9.6-19.6)	15.3 (8.7-26.9)	11.4 (7.5-15.4)	11.8 (7.8-19.6)	12.6 (9.8-17.6)
Tikarapada	12.1 (5.8-19.0)	11.1 (4.8-17.9)	12.3 (5.6-22.1)	10.5 (5.9-16.6)	10.1 (7.8-11.7)
Narasinghpur	12.6 (10-15.7)	13.4 (7.5-25.5)	13.2 (6.7-30.5)	10.3 (7.5-13.7)	11.4 (7.8-21.5)
Munduli	12.4 (9-17)	12.4 (8.1-20.5)	12.4 (7.5-20.2)	10.6 (7.8-13.7)	11.1 (8.8-17.6)
Cuttack U/s	13.2 (9-20)	13.4 (9.8-28.1)	11.1 (5.8-16.8)	9.8 (6.1-13.7)	10.5 (7.8-11.7)
Cuttack D/s	12.6 (9.6-17.0)	12.9 (10.0-17.3)	12.9 (7.7-19.3)	11.7 (7.8-16.6)	10.4 (7.8-12.7)
Cuttack FD/s	13.2 (8.6-20)	13.5 (10.0-16.9)	11.1 (7.7-12.8)	10.3 (7.8-13.7)	10.6 (8.8-13.7)
Paradeep U/s	355 (11.5- 1399.0)	2111.6 (6.6- 6919.2)	479.1 (5.8- 3038.0)	1567.4 (7.8- 6560.3)	1382.5 (8.8- 4696.8)
Paradeep D/s	8329 (4292.0- 16072.0)	7245.2 (96.9- 16817.5)	4749.1 (9.6- 14780.0)	8828.5 (23.5- 22505.5)	5905.4 (13.7- 12714.0)
Monmunda (Tel)	12.8 (5.6-16.0)	15.0 (9.8-32.8)	10.2 (5.6-19.6)	10.6 (6.9-19.6)	8.9 (5.9-11.7)
Cuttack U/s (Kathajodi)	13 (7.4-18.8)	12.3 (8.8-14.9)	11.4 (7.5-17.8)	11.9 (7.8-29.4)	9.9 (6.9-11.7)
Cuttack D/s (Kathajodi)	12.9 (10-16.7)	14.1 (9.8-21.8)	11.8 (7.7-16.7)	18.3 (6.9-39.1)	13.4 (8.8-20.6)
Cuttack FD/s at Mattagajpur (Kathajodi)	45.1 (10.6-99.6)	64.9 (20.5-90.1)	52.3 (10.6-98.3)	28.6 (6.9-64.6)	55.0 (37.2-70.5)
Cuttack FD/s at Sankhatrasa (Serua)	12.7 (7.9-17)	14.1 (8.6-22.6)	13.7 (7.5-27.0)	12.7 (6.9-23.5)	14.4 (7.8-23.5)
Bhubaneswar FU/s (Kuakhai)	13.4 (10-16)	12.9 (9.8-19.3)	12.0 (7.7-16.8)	10.9 (1.99-9.08)	11.0 (7.8-12.7)
Bhubaneswar U/s (Kuakhai)	16.4 (11.5-21.6)	16.6 (9.8-24.2)	16.1 (7.5-22.6)	14.3 (6.9-29.4)	13.1 (8.8-17.6)
Bhubaneswar D/s (Daya)	26.4 (12.5-38.6)	24.3 (12.5-46.3)	25.7 (9.6-46.2)	21.2 (6.9-43.1)	36.7 (17.6-64.6)
Bhubaneswar FD/s (Daya)	25.7 (18-39.2)	23.7 (11.5-46.2)	26.3 (9.6-37.4)	23.7 (8.8-41.1)	31.0 (15.7-54.8)
Choudwar D/s (Birupa)	16.4 (10-54)	12.4 (7.5-22.3)	16.4 (7.7-53.5)	13.5 (6.9-34.3)	15.5 (7.8-60.7)

Table 3.16 Annual average and Range values of Sulphate

Monitoring Station	2011	2012	2013	2014	2015
	Sulphate (mg/l)				
Sundargarh (lb)	7.2 (1.6-18.9)	6.15 (1.70-18.19)	5.92 (2.77-10.45)	4.56 (2.23-10.44)	7.9 (2.9-16.3)
Jharsuguda (lb)	6.9 (1.4-14.3)	7.96 (2.23-18.32)	5.71 (1.87-10.07)	5.53 (2.74-12.81)	12.5 (4.1-21.4)
Brajaraj nagar U/s (lb)	6.5 (1.3-17.0)	6.66 (2.23-17.13)	5.74 (3.86-7.84)	5.82 (3.73-9.07)	9.5 (5.0-17.3)
Brajaraj nagar D/s (lb)	6.1 (0.4-14.6)	7.93 (2.26-20.69)	7.05 (2.36-15.25)	5.57 (3.48-8.57)	12.3 (6.2-20.4)
Jharsuguda (Bheden)	11.7 (2-27.4)	15.97 (2.80-43.47)	22.60 (4.35-51.99)	19.24 (6.34-50.86)	23.8 (5.8-61.6)
Hirakud	7.5 (1.1-17.6)	6.93 (1.29-11.18)	7.60 (4.35-12.77)	7.18 (4.10-11.19)	13.2 (9.7-21.4)
Power Channel U/s	5.3 (0.8-11.7)	7.23 (1.29-11.78)	7.58- 6.09-9.70)	8.44 (5.97-11.44)	13.3 (8.5-26.0)
Power Channel D/s	5.9 (1.0-10.6)	8.02 (2.04-19.00)	7.43 (5.60-9.11)	9.27 (7.33-14.67)	16.2 (8.1-30.0)
Sambalpur U/s	7.1 (0.5-14)	8.36 (2.26-15.94)	8.06 (5.20-11.98)	7.06 (3.98-11.81)	7.9 (2.9-16.3)
Sambalpur D/s	9.3 (1.2-26.6)	9.97 (3.66-23.06)	10.34 (4.85-28.91)	9.87 (5.72-23.51)	7.9 (2.9-16.3)
Sambalpur FD/s at Shankarmath	8.3 (1.2-21.7)	10.26 (2.80-28.61)	8.10 (2.73-12.94)	9.41 (4.22-17.16)	13.6 (5.9-25.5)
Sambalpur FFD/s at Huma	5.7 (1.2-11.4)	8.01 (1.29-19.70)	7.55 (6.34-10.50)	7.91 (4.85-13.43)	12.7 (6.1-24.8)
Sonepur U/s	5.5 (0.6-10.1)	6.86 (2.65-15.35)	9.23 (5.47-15.05)	6.68 (1.61-13.05)	13.0 (8.2-22.8)
Sonepur D/s	7.0 (1.1-13.8)	7.59 (2.67-17.52)	10.18 (2.98-27.52)	8.23 (5.84-13.05)	13.3 (7.7-26.0)
Tikarapada	5.8 (0.9-10.6)	7.53 (3.86-14.65)	6.50 (2.23-9.07)	8.18 (5.22-14.17)	11.4 (6.7-17.7)
Narasinghpur	5.6 (1.8-10.3)	6.56 (2.80-10.00)	8.20 (2.48-15.05)	7.75 (4.35-12.18)	10.2 (4.7-18.2)
Munduli	5.1 (0.9-11.9)	6.50 (1.38-10.69)	6.70 (2.48-12.70)	7.89 (5.47-12.18)	9.9 (5.6-21.1)
Cuttack U/s	4.4 (1.0-8.6)	6.00 (1.98-10.79)	6.32 (3.35-9.21)	6.89 (2.57-12.31)	10.2 (2.4-21.5)
Cuttack D/s	6.7 (0.3-13.5)	7.39 (1.94-16.39)	7.07 (4.58-11.19)	8.03 (3.1-12.56)	13.6 (2.9-24.9)
Cuttack FD/s	5.0 (1.0-9.4)	6.32 (2.18-13.76)	7.31 (4.47-10.40)	7.50 (2.87-14.05)	11.0 (3.6-21.9)
Paradeep U/s	133.7 (1.9-736.6)	267.3 (4.9-955.4)	68.01 (3.36-210.45)	220.80 (6.46-625.10)	245.7 (11.2-808.4)
Paradeep D/s	1078 (156- 3194.2)	838.5 (85.8- 2034.7)	675.14 (6.59- 2145.47)	1022.72 (14.17- 2282.3)	855.1 (14.2- 1853.2)
Monmunda (Tel)	6.0 (1.8-14.0)	5.87 (1.08-25.05)	5.22 (2.10-12.94)	6.25 (2.36-10.07)	7.7 (2.0-14.8)
Cuttack U/s (Kathajodi)	4.5 (1.5-9.2)	5.63 (1.51-13.06)	8.17 (3.23-12.06)	6.83 (2.98-10.69)	10.6 (5.0-17.0)

Table 3.16 Contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>Sulphate (mg/l)</b>				
Cuttack D/s (Kathajodi)	5.9 (1.4-16.3)	7.91 (2.67-18.31)	10.96 (5.35-16.60)	11.26 (6.71-22.98)	15.9 (9.7-25.5)
Cuttack FD/s at Mattagajpur (Kathajodi)	16.7 (2.5-34.6)	28.88 (6.53-60.10)	28.96 (9.32-60.40)	19.77 (4.23-37.3)	41.5 (7.6-125.6)
Cuttack FD/s at Sankhatrasa (Serua)	5.6 (0.9-11.7)	6.08 (2.04-12.17)	8.79 (3.10-14.60)	7.24 (4.98-9.95)	13.2 (4.5-26.4)
Bhubaneswar FU/s (Kuakhai)	3.9 (1.0-11.0)	4.68 (0.59-11.88)	5.99 (1.49-9.90)	5.51 (1.99-9.08)	7.6 (3.9-11.1)
Bhubaneswar U/s (Kuakhai)	5.9 (1.5-24.4)	6.84 (2.57-13.96)	8.18 (1.86-10.82)	7.71 (4.85-14.42)	8.8 (4.1-12.9)
Bhubaneswar D/s (Daya)	7.9 (1.9-18)	10.75 (3.01-22.68)	13.09 (6.34-22.00)	14.24 (5.59-24.36)	19.7 (7.5-29.2)
Bhubaneswar FD/s (Daya)	4.5 (1.8-10.6)	9.05 (3.01-15.54)	9.81 (2.61-15.72)	12.33 (5.22-23.5)	12.9 (6.7-21.2)
Choudwar D/s (Birupa)	6.3 (1.1-21.4)	6.53 (1.07-14.75)	15.37 (3.37-62.30)	7.91 (4.6-16.41)	11.0 (4.7-21.8)

Table 3.17 Annual average and Range values of Fluoride

Monitoring Station	2011	2012	2013	2014	2015
	<b>Fluoride (mg/l)</b>				
Sundargarh (lb)	0.250 (0.040-0.331)	0.377 (0.241-0.748)	0.306 (0.210-0.448)	0.304 (0.230-0.380)	0.373 (0.260-0.721)
Jharsuguda (lb)	0.285 (0.067-0.593)	0.313 (0.248-0.422)	0.308 (0.175-0.496)	0.300 (0.215-0.360)	0.364 (0.260-0.655)
Brajaraj nagar U/s (lb)	0.256 (0.054-0.334)	0.304 (0.248-0.374)	0.285 (0.209-0.353)	0.304 (0.219-0.428)	0.364 (0.265-0.572)
Brajaraj nagar D/s (lb)	0.251 (0.043-0.380)	0.310 (0.221-0.383)	0.301 (0.210-0.418)	0.296 (0.226-0.388)	0.367 (0.257-0.648)
Jharsuguda (Bheden)	0.377 (0.115-0.913)	1.154 (0.283-4.420)	0.780 (0.215-1.670)	1.192 (0.283-7.610)	0.941 (0.260-3.300)
Hirakud	0.367 (0.205-0.709)	0.358 (0.262-0.441)	0.318 (0.188-0.442)	0.331 (0.242-0.408)	0.429 (0.240-0.858)
Power Channel U/s	0.270 (0.041-0.502)	0.330 (0.210-0.432)	0.281 (0.005-0.367)	0.485 (0.192-2.250)	0.409 (0.230-0.772)
Power Channel D/s	0.277 (0.042-0.455)	0.326 (0.212-0.414)	0.304 (0.226-0.359)	0.346 (0.238-0.549)	0.403 (0.230-0.750)
Sambalpur U/s	0.320 (0.046-0.665)	0.390 (0.240-0.705)	0.341 (0.157-0.442)	0.386 (0.224-0.630)	0.384 (0.230-0.692)
Sambalpur D/s	0.398 (0.233-0.610)	0.386 (0.250-0.673)	0.369 (0.230-0.572)	0.384 (0.240-0.670)	0.401 (0.180-0.659)
Sambalpur FD/s at Shankarmath	0.391 (0.191-0.753)	0.450 (0.235-0.723)	0.371 (0.167-0.515)	0.448 (0.332-0.536)	0.466 (0.250-0.676)
Sambalpur FFD/s at Huma	0.303 (0.082-0.564)	0.437 (0.245-0.790)	0.362 (0.240-0.513)	0.377 (0.251-0.451)	0.416 (0.230-0.638)
Sonepur U/s	0.079 (0.406-0.293)	0.375 (0.210-0.533)	0.335 (0.230-0.424)	0.332 (0.228-0.420)	0.407 (0.250-0.760)

Table 3.17 Contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>Fluoride (mg/l)</b>				
Sonepur D/s	0.309 (0.094-0.442)	0.406 (0.272-0.572)	0.352 (0.220-0.436)	0.384 (0.312-0.455)	0.425 (0.189-0.752)
Tikarapada	0.327 (0.198-0.601)	0.350 (0.239-0.441)	0.297 (0.179-0.372)	0.346 (0.266-0.430)	0.395 (0.291-0.680)
Narasinghpur	0.351 (0.064-0.673)	0.377 (0.250-0.674)	0.320 (0.246-0.401)	0.308 (0.215-0.443)	0.403 (0.280-0.622)
Munduli	0.313 (0.095-0.537)	0.331 (0.109-0.468)	0.329 (0.246-0.463)	0.318 (0.228-0.458)	0.407 (0.270-0.790)
Cuttack U/s	0.326 (0.106-0.549)	0.505 (0.111-1.270)	0.355 (0.250-0.483)	0.325 (0.232-0.482)	0.387 (0.298-0.536)
Cuttack D/s	0.323 (0.114-0.502)	0.353 (0.111-0.507)	0.411 (0.248-0.905)	0.330 (0.266-0.502)	0.378 (0.272-0.524)
Cuttack FD/s	0.408 (0.111-1.300)	0.342 (0.114-0.465)	0.351 (0.257-0.463)	0.323 (0.269-0.474)	0.378 (0.302-0.510)
Paradeep U/s	0.397 (0.095-1.100)	0.484 (0.208-0.969)	0.315 (0.201-0.440)	0.386 (0.237-0.485)	0.514 (0.320-0.910)
Paradeep D/s	0.604 (0.134-0.911)	0.710 (0.283-1.240)	0.549 (0.034-1.110)	0.656 (0.272-1.180)	0.652 (0.462-0.900)
Monmunda (Tel)	0.434 (0.068-1.820)	0.368 (0.267-0.445)	0.290 (0.178-0.370)	0.313 (0.256-0.370)	0.388 (0.260-0.582)
Cuttack U/s (Kathajodi)	0.318 (0.104-0.618)	0.346 (0.110-0.490)	0.324 (0.201-0.452)	0.343 (0.256-0.469)	0.384 (0.266-0.604)
Cuttack D/s (Kathajodi)	0.315 (0.109-0.486)	0.323 (0.109-0.441)	0.322 (0.157-0.452)	0.292 (0.205-0.442)	0.407 (0.262-0.543)
Cuttack FD/s at Mattagajpur (Kathajodi)	0.304 (0.081-0.512)	0.349 (0.080-0.550)	0.320 (0.165-0.445)	0.283 (0.178-0.464)	0.416 (0.300-0.555)
Cuttack FD/s at Sankhatrasa (Serua)	0.363 (0.090-0.796)	0.334 (0.090-0.507)	0.346 (0.247-0.543)	0.320 (0.243-0.464)	0.389 (0.252-0.585)
Bhubaneswar FU/s (Kuakhai)	0.278 (0.092-0.541)	0.279 (0.105-0.428)	0.288 (0.171-0.411)	0.302 (0.222-0.370)	0.378 (0.168-0.626)
Bhubaneswar U/s (Kuakhai)	0.242 (0.055-0.466)	0.293 (0.108-0.486)	0.258 (0.140-0.382)	0.288 (0.220-0.371)	0.322 (0.204-0.492)
Bhubaneswar D/s (Daya)	0.283 (0.096-0.613)	0.283 (0.177-0.441)	0.280 (0.181-0.398)	0.291 (0.201-0.421)	0.305 (0.212-0.454)
Bhubaneswar FD/s (Daya)	0.276 (0.099-0.535)	0.351 (0.180-0.990)	0.281 (0.185-0.425)	0.278 (0.199-0.424)	0.323 (0.205-0.474)
Choudwar D/s (Birupa)	0.309 (0.069-0.576)	0.372 (0.199-0.746)	0.346 (0.123-0.787)	0.305 (0.190-0.390)	0.404 (0.212-0.742)

Table 3.18 Annual average and Range values of Metals

Table 3.18 (a) Chromium (VI) and Mercury

Monitoring Station	Chromium (VI)		Mercury	
	(mg/l)			
	2014	2015	2014	2015
Sundargarh (lb)	0.015 (<0.002-0.040)	0.015 (<0.002-0.036)	0.00017 (<0.00006-0.00057)	0.00019 (<0.00006-0.00051)
Jharsuguda (lb)	0.009 (<0.002-0.031)	0.0154 (<0.002-0.033)	0.00019 (<0.00006-0.00095)	0.00033 (0.00006-0.00089)
Brajaraj Nagar U/s (lb)	0.010 (<0.002-0.035)	0.013 (<0.002-0.035)	0.00018 (<0.00006-0.00057)	0.00028 (<0.00006-0.00083)
Brajaraj Nagar D/s (lb)	0.009 (<0.002-0.031)	0.016 (<0.002-0.035)	0.00019 (<0.00006-0.00057)	0.00042 (0.00019-0.00100)
Jharsuguda (Bheden)	0.010 (<0.002-0.031)	0.011 (<0.002-0.033)	0.00031 (<0.00006-0.00095)	0.00026 (<0.00006-0.00089)
Hirakud	0.009 (<0.002-0.018)	0.008 (<0.002-0.028)	0.00012 (<0.00006-0.00051)	0.00017 (<0.00006-0.00044)
Power Channel U/s	0.010 (<0.002-0.030)	0.012 (<0.002-0.031)	0.00011 (<0.00006-0.00032)	0.00013 (<0.00006-0.00032)
Power Channel D/s	0.009 (<0.002-0.046)	0.014 (<0.002-0.033)	0.00025 (<0.00006-0.00095)	0.00022 (<0.00006-0.00095)
Sambalpur U/s	0.010 (<0.002-0.041)	0.015 (<0.002-0.031)	0.00019 (<0.00006-0.00089)	0.00013 (<0.00006-0.00070)
Sambalpur D/s	0.010 (<0.002-0.046)	0.016 (<0.002-0.036)	0.00042 (<0.00006-0.00159)	0.00027 (<0.00006-0.00076)
Sambalpur FD/s at Shankarmath	0.011 (0.002-0.025)	0.011 (<0.002-0.036)	0.00023 (<0.00006-0.00102)	0.00024 (<0.00006-0.00070)
Sambalpur FFD/s at Huma	0.010 (<0.002-0.028)	0.015 (<0.002-0.047)	0.00017 (<0.00006-0.00057)	0.00025 (0.00013-0.00076)
Sonepur U/s	0.011 (<0.002-0.028)	0.007 (<0.002-0.023)	0.00024 (<0.00006-0.00076)	0.00020 (<0.00006-0.00089)
Sonepur D/s	0.009 (<0.002-0.025)	0.011 (<0.002-0.033)	0.00027 (<0.00006-0.00083)	0.00023 (<0.00006-0.00070)
Tikarapada	0.010 (<0.002-0.027)	0.012 (<0.002-0.036)	0.00014 (<0.00006-0.00070)	0.00012 (<0.00006-0.00038)
Narasinghpur	0.015 (<0.002-0.031)	0.010 (<0.002-0.030)	0.00027 (<0.00006-0.00108)	0.00011 (<0.00006-0.00044)
Munduli	0.011 (<0.002-0.026)	0.011 (<0.002-0.025)	0.00019 (<0.00006-0.00051)	0.00011 (<0.00006-0.00044)
Cuttack U/s	0.010 (<0.002-0.023)	0.010 (<0.002-0.033)	0.00019 (<0.00006-0.00070)	0.00011 (<0.00006-0.00038)
Cuttack D/s	0.010 (<0.002-0.033)	0.011 (<0.002-0.031)	0.00027 (<0.00006-0.00095)	0.00022 (<0.00006-0.00070)
Cuttack FD/s	0.016 (<0.002-0.056)	0.010 (<0.002-0.035)	0.00025 (<0.00006-0.00101)	0.00015 (<0.00006-0.00032)
Paradeep U/s	0.015 (0.010-0.031)	0.012 (<0.002-0.028)	0.00043 (<0.00006-0.00229)	0.00016 (<0.00006-0.00057)
Paradeep D/s	0.017 (<0.002-0.060)	0.010 (<0.002-0.040)	0.00054 (<0.00006-0.00305)	0.00021 (0.00006-0.00038)
Monmunda (Tel)	0.011 (<0.002-0.036)	0.010 (<0.002-0.033)	0.00016 (<0.00006-0.00051)	0.00014 (<0.00006-0.00051)
Cuttack U/s (Kathajodi)	0.012 (<0.002-0.023)	0.014 (<0.002-0.033)	0.00036 (<0.00006-0.00120)	0.00033 (0.00006-0.00089)
Cuttack D/s (Kathajodi)	0.018 (<0.002-0.050)	0.012 (<0.002-0.036)	0.00050 (<0.00006-0.00101)	0.00035 (0.00013-0.00089)
Cuttack FD/s at Mattagajpur (Kathajodi)	0.015 (<0.002-0.035)	0.013 (<0.002-0.038)	0.00033 (<0.00006-0.00095)	0.00053 (0.00013-0.00095)

Table 3.18 (a) Chromium (VI) and Mercury contd..

Monitoring Station	Chromium (VI)		Mercury	
	(mg/l)			
	2014	2015	2014	2015
Cuttack FD/s at Sankhatrasa (Serua)	0.015 (<0.002-0.061)	0.010 (<0.002-0.033)	0.00030 (<0.00006-0.00070)	0.00025 (<0.00006-0.00057)
Bhubaneswar FU/s (Kuakhai)	0.010 (<0.002-0.028)	0.004 (<0.002-0.016)	0.00029 (<0.00006-0.00108)	0.00013 (<0.00006-0.00057)
Bhubaneswar U/s (Kuakhai)	0.014 (0.003-0.040)	0.006 (<0.002-0.021)	0.00020 (<0.00006-0.00051)	0.00015 (<0.00006-0.00064)
Bhubaneswar D/s (Daya)	0.016 (<0.002-0.042)	0.013 (<0.002-0.038)	0.00014 (<0.00006-0.00051)	0.00041 (0.00019-0.00089)
Bhubaneswar FD/s (Daya)	0.016 (<0.002-0.030)	0.008 (<0.002-0.030)	0.00016 (<0.00006-0.00051)	0.00019 (0.00006-0.00051)
Choudwar D/s (Birupa)	0.017 (<0.002-0.050)	0.006 (<0.002-0.026)	0.00021 (<0.00006-0.00044)	0.00021 (<0.00006-0.00044)

Table 3.18 (b) Total Chromium

Monitoring Station	2011	2012	2013	2014	2015
(mg/l)					
Sundargarh (lb)	0.040 (0.017-0.077)	0.020 (0.010-0.043)	0.031 (0.005-0.058)	0.035 (0.005-0.014)	0.048 (0.001-0.099)
Jharsuguda (lb)	0.065 (0.015-0.300)	0.029 (0.018-0.055)	0.033 (0.020-0.053)	0.024 (0.003-0.065)	0.047 (0.013-0.099)
Brajaraj Nagar U/s (lb)	0.39 (0.008-0.107)	0.027 (0.010-0.075)	0.025 (0.005-0.047)	0.025 (0.007-0.050)	0.038 (0.008-0.071)
Brajaraj Nagar D/s (lb)	0.046 (0.017-0.117)	0.032 (0.007-0.080)	0.026 (0.010-0.045)	0.035 (0.006-0.102)	0.049 (0.015-0.113)
Jharsuguda (Bheden)	0.032 (0.005-0.067)	0.033 (0.005-0.050)	0.028 (0.010-0.050)	0.029 (0.007-0.060)	0.039 (0.008-0.074)
Hirakud	0.045 (0.007-0.105)	0.036 (0.024-0.060)	0.048 (0.013-0.075)	0.040 (0.005-0.089)	0.030 (0.003-0.097)
Power Channel U/s	0.035 (0.005-0.067)	0.025 (0.003-0.053)	0.031 (0.007-0.055)	0.038 (0.005-0.187)	0.031 (0.008-0.076)
Power Channel D/s	0.034 (0.008-0.067)	0.030 (0.005-0.076)	0.034 (0.010-0.060)	0.054 (0.006-0.334)	0.048 (0.015-0.114)
Sambalpur U/s	0.026 (0.008-0.063)	0.028 (0.013-0.047)	0.022 (0.005-0.038)	0.024 (0.010-0.048)	0.039 (0.013-0.087)
Sambalpur D/s	0.051 (0.007-0.090)	0.033 (0.008-0.069)	0.039 (0.003-0.076)	0.024 (0.005-0.070)	0.051 (0.014-0.114)
Sambalpur FD/s at Shankarmath	0.43 (0.011-0.074)	0.028 (0.007-0.048)	0.021 (0.001-0.050)	0.037 (0.013-0.099)	0.041 (0.003-0.133)
Sambalpur FFD/s at Huma	0.026 (0.008-0.054)	0.028 (0.015-0.047)	0.026 (0.005-0.043)	0.032 (0.007-0.092)	0.036 (0.008-0.104)
Sonepur U/s	0.024 (0.005-0.052)	0.031 (0.003-0.099)	0.018 (0.005-0.035)	0.034 (0.008-0.109)	0.027 (0.007-0.076)
Sonepur D/s	0.029 (0.015-0.067)	0.037 (0.002-0.130)	0.017 (0.005-0.035)	0.020 (0.005-0.032)	0.038 (0.010-0.094)
Tikarapada	0.044 (0.011-0.077)	0.028 (0.012-0.056)	0.031 (0.007-0.047)	0.035 (0.017-0.076)	0.032 (0.008-0.076)
Narasinghpur	0.038 (0.012-0.110)	0.030 (0.007-0.087)	0.026 (0.010-0.035)	0.038 (0.012-0.072)	0.038 (0.005-0.141)
Munduli	0.040 (0.011-0.142)	0.022 (0.012-0.050)	0.022 (0.005-0.064)	0.034 (0.003-0.061)	0.043 (0.013-0.165)

Table 3.18 (b) Total Chromium contd..

Monitoring Station	2011	2012	2013	2014	2015
	(mg/l)				
Cuttack U/s	0.034 (0.012-0.085)	0.029 (0.012-0.095)	0.013 (<0.002-0.043)	0.029 (0.003-0.085)	0.029 (0.013-0.055)
Cuttack D/s	0.045 (0.020-0.104)	0.040 (0.016-0.112)	0.020 (<0.002-0.041)	0.025 (<0.002-0.055)	0.041 (0.015-0.076)
Cuttack FD/s	0.037 (0.012-0.094)	0.037 (0.015-0.135)	0.019 (0.002-0.037)	0.032 (0.003-0.116)	0.036 (0.013-0.076)
Paradeep U/s	0.043 (0.015-0.085)	0.037 (0.007-0.085)	0.025 (<0.002-0.053)	0.042 (0.026-0.122)	0.038 (0.013-0.087)
Paradeep D/s	0.047 (0.031-0.070)	0.040 (0.017-0.060)	0.024 (0.003-0.060)	0.045 (0.011-0.083)	0.046 (0.005-0.131)
Monmunda (Tel)	0.036 (0.007-0.062)	0.025 (0.005-0.050)	0.0200 (0.005-0.043)	0.049 (0.007-0.212)	0.040 (0.005-0.109)
Cuttack U/s (Kathajodi)	0.039 (0.010-0.154)	0.030 (0.015-0.085)	0.026 (<0.002-0.053)	0.035 (0.006-0.075)	0.047 (0.013-0.099)
Cuttack D/s (Kathajodi)	0.051 (0.008-0.147)	0.034 (0.010-0.075)	0.023 (0.003-0.043)	0.057 (0.003-0.121)	0.048 (0.021-0.094)
Cuttack FD/s at Mattagajpur (Kathajodi)	0.056 (0.003-0.125)	0.042 (0.010-0.061)	0.031 (0.002-0.067)	0.044 (<0.002-0.145)	0.060 (0.016-0.114)
Cuttack FD/s at Sankhatrasa (Serua)	0.039 (0.012-0.119)	0.030 (0.012-0.072)	0.024 (0.005-0.052)	0.042 (<0.002-0.148)	0.037 (0.005-0.076)
Bhubaneswar FU/s (Kuakhai)	0.032 (0.003-0.060)	0.020 (0.004-0.048)	0.022 (0.005-0.052)	0.042 (0.012-0.081)	0.025 (0.005-0.094)
Bhubaneswar U/s (Kuakhai)	0.031 (0.007-0.069)	0.023 (0.005-0.043)	0.024 (0.002-0.053)	0.042 (0.005-0.128)	0.030 (0.007-0.108)
Bhubaneswar D/s (Daya)	0.039 (0.003-0.076)	0.035 (0.010-0.067)	0.023 (0.008-0.047)	0.053 (0.013-0.130)	0.046 (0.016-0.131)
Bhubaneswar FD/s (Daya)	0.041 (0.012-0.092)	0.024 (0.013-0.040)	0.022 (0.005-0.043)	0.040 (0.018-0.083)	0.035 (0.011-0.094)
Choudwar D/s (Birupa)	0.039 (0.018-0.070)	0.041 (0.012-0.110)	0.021 (0.005-0.043)	0.034 (0.010-0.073)	0.028 (0.008-0.057)

Table 3.18 (c) Iron

Monitoring Station	2011	2012	2013	2014	2015
	(mg/l)				
Sundargarh (lb)	6.44 (.067-38.054)	6.044 (0.259-42.240)	2.635 (0.025-6.201)	1.118 (0.015-6.197)	2.087 (0.140-6.150)
Jharsuguda (lb)	2.663 (0.27-16.435)	3.093 (0.182-12.360)	2.412 (<0.005-8.167)	0.982 (0.041-6.426)	1.914 (0.170-5.890)
Brajaraj Nagar U/s (lb)	4.550 (0.014-15.629)	2.809 (0.154-8.900)	2.190 (0.047-6.369)	1.157 (0.010-7.344)	1.338 (0.030-5.630)
Brajaraj Nagar D/s (lb)	1.644 (0.504-4.397)	3.070 (0.413-12.920)	2.402 (0.102-6.524)	0.769 (0.005-4.029)	1.249 (0.117-5.580)
Jharsuguda (Bheden)	4.928 (0.220-23.789)	4.400 (0.340-11.650)	2.184 (<0.005-4.818)	1.863 (0.229-5.447)	2.383 (<0.005-7.000)
Hirakud	1.824 (0.149-6.739)	2.102 (0.139-8.390)	0.642 (<0.005-4.390)	0.492 (0.005-1.856)	0.862 (0.003-3.180)
Power Channel U/s	1.442 (0.058-7.776)	1.620 (0.173-5.875)	0.537 (<0.005-2.299)	0.691 (<0.005-3.713)	1.429 (0.230-5.460)
Power Channel D/s	3.100 (0.274-20.837)	1.575 (0.144-6.420)	0.375 (<0.005-1.650)	0.666 (0.020-3.167)	1.516 (0.090-5.150)
Sambalpur U/s	1.497 (0.130-5.563)	1.981 (0.187-8.755)	1.329 (0.101-3.576)	1.210 (0.005-5.712)	1.558 (0.143-5.530)

Table 3.18 (c) Iron contd..

Monitoring Station	2011	2012	2013	2014	2015
	(mg/l)				
Sambalpur D/s	1.534 (0.149-4.862)	1.630 (0.139-7.600)	0.691 (0.012-1.341)	0.587 (0.010-2.728)	1.320 (0.060-5.810)
Sambalpur FD/s at Shankarmath	2.309 (0.173-10.042)	1.655 (0.168-7.000)	1.368 (0.249-4.640)	0.668 (0.005-1.744)	1.485 (0.060-5.180)
Sambalpur FFD/s at Huma	2.167 (0.086-10.618)	1.630 (0.096-7.130)	0.442 (0.012-1.060)	0.771 (0.010-2.764)	1.903 (0.060-7.260)
Sonepur U/s	2.122 (0.057-10.042)	1.578 (0.158-8.800)	0.400 (0.005-1.076)	0.417 (0.020-0.938)	1.674 (0.090-6.630)
Sonepur D/s	2.338 (0.192-13.286)	1.340 (0.206-5.310)	0.429 (0.086-2.056)	0.476 (0.036-1.220)	1.778 (0.070-6.090)
Tikarapada	4.145 (0.44-14.976)	3.058 (0.154-13.421)	2.405 (<0.005-5.300)	1.438 (0.036-5.460)	2.932 (0.240-7.220)
Narasinghpur	3.010 (0.312-14.688)	1.991 (0.197-11.880)	2.675 (0.111-6.474)	2.104 (0.040-9.231)	1.825 (0.070-7.580)
Munduli	3.406 (0.090-15.360)	2.720 (0.369-13.700)	4.454 (0.144-12.980)	1.872 (0.010-6.018)	1.803 (0.030-7.210)
Cuttack U/s	3.659 (0.331-15.552)	2.853 (0.269-12.210)	1.477 (0.013-5.776)	2.317 (0.064-9.614)	2.309 (0.050-7.220)
Cuttack D/s	4.108 (0.101-21.177)	2.575 (0.269-12.610)	1.575 (0.054-5.438)	2.267 (0.010-10.557)	2.496 (<0.005-7.450)
Cuttack FD/s	3.402 (0.038-15.091)	2.887 (0.154-12.090)	2.555 (0.028-6.911)	2.125 (0.082-8.721)	2.365 (0.040-6.710)
Paradeep U/s	6.580 (0.072-41.146)	2.971 (0.142-16.400)	3.485 (0.211-8.475)	2.713 (<0.005-9.384)	1.102 (0.120-3.850)
Paradeep D/s	2.769 (0.336-8.823)	2.903 (0.130-18.500)	4.395 (0.283-10.780)	2.854 (<0.005-9.996)	1.823 (0.390-6.040)
Monmunda (Tel)	4.645 (0.269-14.246)	4.063 (0.269-14.700)	2.753 (0.144-5.947)	2.070 (0.260-6.430)	3.141 (0.020-6.760)
Cuttack U/s (Kathajodi)	4.057 (0.125-15.533)	2.397 (0.129-8.700)	1.573 (0.061-7.314)	3.147 (0.087-9.155)	1.914 (0.170-5.890)
Cuttack D/s (Kathajodi)	3.835 (0.178-13.786)	2.749 (0.475-11.770)	2.920 (0.054-9.233)	3.023 (0.230-8.339)	2.366 (<0.005-6.990)
Cuttack FD/s at Mattagajpur (Kathajodi)	5.317 (0.158-14.803)	3.052 (0.298-12.770)	2.556 (0.093-6.879)	3.001 (0.301-8.874)	2.384 (0.367-6.290)
Cuttack FD/s at Sankhatrasa (Serua)	3.430 (0.226-15.245)	2.454 (0.494-12.780)	2.154 (BDL-9.010)	1.844 (0.041-8.874)	2.736 (0.150-6.960)
Bhubaneswar FU/s (Kuakhai)	1.761 (0.053-16.474)	3.768 (0.149-21.980)	2.109 (0.095-8.844)	1.063 (0.030-7.216)	0.616 (0.010-2.260)
Bhubaneswar U/s (Kuakhai)	4.446 (0.369-29.683)	2.231 (0.310-8.830)	2.355 (0.328-12.752)	2.388 (0.010-10.532)	1.727 (0.220-6.270)
Bhubaneswar D/s (Daya)	3.922 (0.390-15.072)	6.044 (0.259-42.240)	3.981 (0.460-12.564)	2.115 (0.077-9.793)	2.173 (0.480-7.140)
Bhubaneswar FD/s (Daya)	1.664 (0.510-4.498)	4.177 (0.398-19.0)	2.932 (0.609-12.121)	2.460 (0.199-8.313)	1.600 (0.330-3.320)
Choudwar D/s (Birupa)	4.198 (0.120-16.128)	2.614 (0.302-10.500)	4.043 (0.154-12.338)	1.750 (<0.005-8.389)	1.345 (0.100-6.340)

Table 3.18 (d) Nickel

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Sundargarh (lb)	0.002 (<0.001-0.007)	0.006 (0.003-0.009)	0.002	0.003 (0.003-0.004)	0.011 (0.006-0.017)
Jharsuguda (lb)	0.003 (0.001-0.009)	0.006 (0.004-0.009)	0.002	0.003 (0.001-0.005)	0.013 (0.003-0.024)
Brajaraj Nagar U/s (lb)	0.003 (<0.001-0.010)	0.008 (0.005-0.013)	0.002	0.003 (0.002-0.004)	0.017 (0.007-0.044)
Brajaraj Nagar D/s (lb)	0.003 (<0.001-0.007)	0.008 (0.004-0.014)	0.003	0.009 (0.008-0.009)	0.014 (0.005-0.028)
Jharsuguda (Bheden)	0.003 (0.001-0.009)	0.006 (0.002-0.009)	0.002	0.026 (0.025-0.027)	0.013 (0.005-0.042)
Hirakud	0.002 (<0.001-0.006)	0.011 (0.007-0.013)	0.002	0.012 (0.011-0.012)	0.012 (0.004-0.022)
Power Channel U/s	0.003 (0.001-0.006)	0.007 (0.003-0.013)	0.002	0.009 (0.007-0.012)	0.009 (0.001-0.017)
Power Channel D/s	0.003 (0.003-0.007)	0.006 (0.002-0.011)	0.002	0.008 (<0.001-0.016)	0.014 (0.001-0.024)
Sambalpur U/s	0.003 (0.001-0.007)	0.008 (0.002-0.013)	0.003	0.011 (0.010-0.011)	0.015 (0.007-0.042)
Sambalpur D/s	0.003 (<0.001-7.2)	0.009 (0.005-0.014)	0.003	0.011 (0.007-0.015)	0.017 (0.007-0.027)
Sambalpur FD/s at Shankarmath	0.002 (0.001-0.006)	0.008 (0.004-0.013)	0.003	0.015 (0.012-0.018)	0.010 (0.003-0.047)
Sambalpur FFD/s at Huma	0.003 (0.001-0.005)	0.005 (0.004-0.007)	0.002	0.013 (0.012-0.014)	0.010 (0.005-0.022)
Sonepur U/s	0.004 (0.002-0.009)	0.006 (0.005-0.008)	0.003	0.014 (0.014-0.015)	0.009 (<0.001-0.018)
Sonepur D/s	0.004 (0.002-0.009)	0.007 (0.005-0.009)	0.004	0.013 (0.011-0.015)	0.020 (0.007-0.060)
Tikarapada	0.005 (0.001-0.023)	0.006 (0.003-0.008)	0.002	0.010 (0.008-0.012)	0.008 (0.004-0.010)
Narasinghpur	0.003 (0.001-0.007)	0.006 (0.003-0.009)	0.003	0.010 (0.008-0.012)	0.015 (0.007-0.036)
Munduli	0.004 (0.001-0.007)	0.004 (0.003-0.007)	0.003	0.012 (0.011-0.013)	0.011 (0.004-0.041)
Cuttack U/s	0.003 (<0.001-0.008)	0.005 (0.002-0.010)	0.003	0.015 (0.006-0.024)	0.007 (0.002-0.012)
Cuttack D/s	0.003 (0.001-0.007)	0.003 (0.002-0.004)	0.002	0.012 (0.007-0.017)	0.012 (0.007-0.017)
Cuttack FD/s	0.003 (0.001-0.005)	0.004 (0.002-0.006)	0.002	0.011 (0.007-0.015)	0.012 (0.007-0.020)
Paradeep U/s	0.005 (0.001-0.008)	0.006 (0.005-0.007)	0.002	0.022 (0.021-0.023)	0.020 (0.008-0.051)
Paradeep D/s	0.004 (0.001-0.006)	0.006 (0.005-0.007)	0.002	0.011 (0.009-0.012)	0.017 (0.007-0.028)
Monmunda (Tel)	0.003 (0.001-0.008)	0.006 (0.003-0.009)	0.002	0.010 (0.009-0.011)	0.012 (0.005-0.026)
Cuttack U/s (Kathajodi)	0.003 (0.001-0.006)	0.004 (0.002-0.007)	0.002	0.011 (0.002-0.020)	0.013 (0.003-0.024)
Cuttack D/s (Kathajodi)	0.004 (0.002-0.008)	0.005 (<0.001-0.0112)	0.002	0.013 (0.013-0.014)	0.017 (0.009-0.027)
Cuttack FD/s at Mattagajpur (Kathajodi)	0.005 (0.001-0.011)	0.004 (0.002-0.006)	0.002	0.009 (0.006-0.013)	0.020 (0.008-0.048)
Cuttack FD/s at Sankhatrasa (Serua)	0.003 (0.001-0.009)	0.003 (0.002-0.006)	0.002	0.012 (0.007-0.017)	0.013 (0.007-0.026)
Bhubaneswar FU/s (Kuakhai)	0.004 (0.001-0.010)	0.005 (0.002-0.009)	0.002	0.012 (0.011-0.013)	0.009 (0.001-0.017)

Table 3.18 (d) Nickel contd..

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Bhubaneswar U/s (Kuakhai)	0.003 (<0.001-0.007)	0.004 (0.002-0.006)	0.003	0.009 (0.006-0.012)	0.011 (0.007-0.017)
Bhubaneswar D/s (Daya)	0.004 (<0.001-0.010)	0.005 (0.002-0.009)	0.004	0.013 (0.007-0.018)	0.014 (0.009-0.024)
Bhubaneswar FD/s (Daya)	0.003 (0.001-0.006)	0.005 (0.002-0.007)	0.005	0.011 (0.011-0.011)	0.012 (0.006-0.024)
Choudwar D/s (Birupa)	0.004 (<0.001-0.007)	0.006 (0.004-0.008)	0.003	0.024 (0.022-0.027)	0.009 (0.003-0.024)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 3.18 (e) Copper

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Sundargarh (lb)	0.003 (0.001-0.008)	0.005 (0.004-0.006)	0.006	0.018 (0.017-0.019)	0.004 (0.002-0.009)
Jharsuguda (lb)	0.003 (0.001-0.008)	0.004 (0.002-0.005)	0.006	0.024 (0.022-0.026)	0.005 (0.002-0.010)
Brajaraj Nagar U/s (lb)	0.003 (<0.001-0.008)	0.004 (0.002-0.005)	0.005	0.016 (0.016-0.017)	0.004 (0.001-0.008)
Brajaraj Nagar D/s (lb)	0.004 (0.001-0.012)	0.003 (0.002-0.005)	0.005	0.017 (0.016-0.018)	0.005 (0.001-0.011)
Jharsuguda (Bheden)	0.004 (0.001-0.008)	0.005 (0.004-0.006)	0.006	0.019 (0.018-0.019)	0.015 (0.001-0.056)
Hirakud	0.004 (0.001-0.006)	0.002 (0.001-0.004)	0.005	0.009 (0.008-0.009)	0.008 (0.003-0.014)
Power Channel U/s	0.004 (0.001-0.006)	0.003 (0.001-0.005)	0.006	0.009 (0.009-0.010)	0.007 (0.002-0.012)
Power Channel D/s	0.004 (0.001-0.006)	0.003 (0.001-0.005)	0.008	0.008 (<0.001-0.015)	0.008 (0.001-0.013)
Sambalpur U/s	0.004 (0.002-0.005)	0.004 (0.003-0.005)	0.005	0.009 (0.008-0.011)	0.006 (0.002-0.014)
Sambalpur D/s	0.004 (<0.001-0.007)	0.006 (0.003-0.011)	0.004	0.019 (0.014-0.024)	0.007 (0.002-0.018)
Sambalpur FD/s at Shankarmath	0.004 (0.002-0.007)	0.005 (0.003-0.009)	0.003	0.016 (0.013-0.018)	0.005 (0.001-0.016)
Sambalpur FFD/s at Huma	0.004 (0.001-0.010)	0.005 (0.002-0.011)	0.007	0.014 (0.011-0.017)	0.005 (0.001-0.013)
Sonepur U/s	0.004 (0.001-0.006)	0.005 (0.001-0.009)	0.004	0.008 (0.008-0.009)	0.005 (<0.001-0.011)
Sonepur D/s	0.003 (0.001-0.005)	0.004 (0.001-0.007)	0.004	0.008 (0.007-0.008)	0.008 (0.004-0.018)
Tikarapada	0.004 (0.001-0.006)	0.003 (0.001-0.006)	0.004	0.007 (0.006-0.008)	0.003 (0.001-0.007)
Narasinghpur	0.005 (<0.001-0.009)	0.003 (<0.001-0.005)	0.004	0.004 (0.002-0.005)	0.005 (0.001-0.009)
Munduli	0.004 (0.001-0.007)	0.004 (0.002-0.006)	0.002	0.002 (0.001-0.002)	0.004 (0.001-0.010)
Cuttack U/s	0.004 (<0.001-0.007)	0.004 (0.001-0.006)	0.002	0.006 (0.005-0.006)	0.003 (0.001-0.008)

Table 3.18 (e) Copper contd..

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Cuttack D/s	0.004 (0.001-0.007)	0.004 (0.001-0.007)	0.002	0.006 (0.003-0.008)	0.005 (0.002-0.013)
Cuttack FD/s	0.004 (0.001-0.009)	0.004 (0.002-0.006)	0.002	0.009 (0.009-0.009)	0.004 (0.001-0.009)
Paradeep U/s	0.006 (0.002-0.012)	0.004 (0.002-0.008)	0.004	0.007 (0.004-0.011)	0.009 (0.004-0.013)
Paradeep D/s	0.006 (0.003-0.008)	0.004 (0.003-0.008)	0.004	0.007 (0.002-0.012)	0.013 (0.006-0.021)
Monmunda (Tel)	0.004 (0.001-0.008)	0.003 (0.001-0.006)	0.004	0.006 (0.006-0.007)	0.007 (0.002-0.014)
Cuttack U/s (Kathajodi)	0.004 (0.001-0.007)	0.004 (0.001-0.006)	0.002	0.005 (0.004-0.007)	0.005 (0.002-0.010)
Cuttack D/s (Kathajodi)	0.004 (0.003-0.005)	0.005 (0.002-0.008)	0.003	0.007 (0.006-0.009)	0.006 ( $<0.001-0.015$ )
Cuttack FD/s at Mattagajpur (Kathajodi)	0.005 (0.002-0.010)	0.005 (0.001-0.008)	0.002	0.017 (0.005-0.029)	0.011 (0.002-0.022)
Cuttack FD/s at Sankhatrasa (Serua)	0.005 (0.002-0.009)	0.005 (0.003-0.006)	0.004	0.004 (0.004-0.005)	0.005 (0.001-0.012)
Bhubaneswar FU/s (Kuakhai)	0.006 (0.001-0.019)	0.002 (0.001-0.003)	0.002	0.011 (0.006-0.016)	0.004 (0.001-0.009)
Bhubaneswar U/s (Kuakhai)	0.003 (0.001-0.006)	0.005 (0.003-0.006)	0.002	0.010 (0.008-0.012)	0.005 (0.001-0.014)
Bhubaneswar D/s (Daya)	0.004 (0.001-0.009)	0.005 (0.002-0.007)	0.002	0.012 (0.011-0.014)	0.004 ( $<0.001-0.016$ )
Bhubaneswar FD/s (Daya)	0.003 (0.002-0.005)	0.005 (0.002-0.008)	0.002	0.009 (0.008-0.011)	0.006 (0.001-0.014)
Choudwar D/s (Birupa)	0.005 (0.001-0.009)	0.005 (0.001-0.009)	0.004	0.002 (0.001-0.004)	0.004 (0.001-0.011)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 3.18 (f) Zinc

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Sundargarh (lb)	0.004 (0.002-0.009)	0.007 (0.001-0.012)	0.005	0.006 (0.004-0.008)	0.011 (0.004-0.020)
Jharsuguda (lb)	0.004 (0.001-0.014)	0.005 (0.001-0.010)	0.006	0.008 (0.008-0.009)	0.014 (0.001-0.023)
Brajaraj Nagar U/s (lb)	0.004 (0.001-0.008)	0.005 (0.001-0.011)	0.008	0.030 (0.026-0.034)	0.012 (0.006-0.022)
Brajaraj Nagar D/s (lb)	0.003 ( $<0.001-0.006$ )	0.009 (0.001-0.015)	0.009	0.038 (0.038-0.038)	0.011 (0.001-0.024)
Jharsuguda (Bheden)	0.003 (0.001-0.007)	0.004 (0.002-0.010)	0.008	0.048 (0.043-0.052)	0.010 (0.002-0.031)
Hirakud	0.004 (0.001-0.007)	0.005 (0.002-0.008)	0.006	0.005 (0.002-0.008)	0.016 (0.004-0.022)
Power Channel U/s	0.004 (0.001-0.009)	0.005 (0.001-0.008)	0.004	0.006 (0.006-0.006)	0.016 (0.004-0.020)
Power Channel D/s	0.006 (0.001-0.012)	0.004 (0.001-0.008)	0.006	0.008 (0.008-0.008)	0.023 (0.003-0.038)
Sambalpur U/s	0.003 (0.001-0.007)	0.003 (0.001-0.008)	0.006	0.007 (0.007-0.008)	0.013 (0.003-0.020)

Table 3.18 (f) Zinc contd..

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Sambalpur D/s	0.006 (0.002-0.010)	0.011 (0.002-0.032)	0.006	0.015 (0.012-0.018)	0.026 (0.005-0.056)
Sambalpur FD/s at Shankarmath	0.004 (0.002-0.008)	0.005 (0.001-0.010)	0.005	0.008 (0.008-0.008)	0.011 (0.004-0.020)
Sambalpur FFD/s at Huma	0.004 (0.002-0.008)	0.005 (0.002-0.010)	0.005	0.008 (0.008-0.008)	0.016 (0.004-0.039)
Sonepur U/s	0.005 ( $<0.001-0.009$ )	0.005 (0.001-0.008)	0.005	0.001 (0.001-0.001)	0.007 ( $<0.001-0.013$ )
Sonepur D/s	0.004 (0.001-0.007)	0.005 (0.002-0.013)	0.005	0.001 (0.001-0.001)	0.011 (0.004-0.018)
Tikarapada	0.004 (0.001-0.011)	0.003 (0.001-0.009)	0.004	0.001 (0.001-0.001)	0.009 (0.001-0.019)
Narasinghpur	0.007 (0.002-0.015)	0.005 (0.003-0.010)	0.005	0.002 (0.002-0.002)	0.007 (0.003-0.010)
Munduli	0.006 (0.001-0.011)	0.005 (0.002-0.008)	0.005	0.002 (0.002-0.002)	0.00 (0.001-0.020)
Cuttack U/s	0.005 (0.002-0.007)	0.008 (0.006-0.010)	0.004	0.004 (0.004-0.004)	0.005 (0.001-0.009)
Cuttack D/s	0.005 (0.002-0.012)	0.009 (0.003-0.019)	0.004	0.006 (0.006-0.006)	0.006 (0.001-0.013)
Cuttack FD/s	0.004 (0.002-0.011)	0.009 (0.004-0.013)	0.005	0.004 (0.004-0.004)	0.006 (0.002-0.014)
Paradeep U/s	0.006 (0.002-0.012)	0.006 (0.001-0.009)	0.009	0.012 (0.012-0.012)	0.010 (0.001-0.019)
Paradeep D/s	0.009 (0.001-0.026)	0.007 (0.002-0.012)	0.010	0.026 (0.026-0.026)	0.015 (0.008-0.023)
Monmunda (Tel)	0.004 (0.001-0.008)	0.005 (0.001-0.010)	0.005	0.002 (0.002-0.002)	0.015 (0.006-0.060)
Cuttack U/s (Kathajodi)	0.005 (0.001-0.012)	0.007 (0.003-0.013)	0.004	0.008 (0.007-0.009)	0.014 (0.001-0.023)
Cuttack D/s (Kathajodi)	0.005 (0.001-0.013)	0.013 (0.004-0.020)	0.008	0.015 (0.007-0.024)	0.010 (0.001-0.017)
Cuttack FD/s at Mattagajpur (Kathajodi)	0.007 ( $<0.001-0.018$ )	0.010 (0.003-0.022)	0.010	0.030 (0.003-0.056)	0.013 (0.003-0.028)
Cuttack FD/s at Sankhatrasa (Serua)	0.006 (0.001-0.010)	0.007 (0.002-0.011)	0.005	0.014 (0.004-0.024)	0.010 (0.001-0.028)
Bhubaneswar FU/s (Kuak hai)	0.006 (0.001-0.019)	0.008 (0.004-0.012)	0.004	0.009 (0.009-0.009)	0.005 (0.001-0.015)
Bhubaneswar U/s (Kuakhai)	0.009 (0.003-0.030)	0.011 (0.005-0.016)	0.005	0.002 (0.002-0.002)	0.008 (0.001-0.030)
Bhubaneswar D/s (Daya)	0.008 (0.002-0.017)	0.011 (0.004-0.015)	0.005	0.009 (0.009-0.009)	0.007 (0.001-0.016)
Bhubaneswar FD/s (Daya)	0.006 (0.003-0.010)	0.013 (0.005-0.030)	0.004	0.009 (0.009-0.009)	0.006 (0.001-0.016)
Choudwar D/s (Birupa)	0.006 (0.002-0.012)	0.006 (0.003-0.009)	0.006	0.012 (0.012-0.012)	0.010 (0.002-0.016)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 3.18 (g) Cadmium

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Sundargarh (lb)	0.001 (<0.001-0.003)	0.002 (0.001-0.002)	<0.001	0.0004 (0.0004-0.0004)	0.0024 (0.0007-0.0071)
Jharsuguda (lb)	0.001 (<0.001-0.003)	0.002 (0.001-0.002)	0.001	0.0008 (0.0008-0.0009)	0.0021 (0.0004-0.0060)
Brajarajnar U/s (lb)	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0010 (0.0008-0.0013)	0.0019 (0.0006-0.0047)
Brajarajnar D/s (lb)	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0008 (0.0008-0.0009)	0.0029 (0.0007-0.0081)
Jharsuguda (Bheden)	0.001 (<0.001-0.004)	0.002 (0.001-0.002)	0.001	0.0020 (0.0012-0.0028)	0.0020 (0.0007-0.0036)
Hirakud	0.002 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0009 (0.0008-0.0009)	0.0025 (0.0006-0.0066)
Power Channel U/s	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0008 (0.0008-0.0008)	0.0028 (0.0007-0.0071)
Power Channel D/s	0.001 (<0.001-0.004)	0.001 (0.001-0.008)	0.001	0.0005 (<0.0001-0.0009)	0.0034 (0.0007-0.0085)
Sambalpur U/s	0.002 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0008 (0.0008-0.0008)	0.0028 (0.0008-0.0076)
Sambalpur D/s	0.001 (<0.001-0.004)	0.002 (0.001-0.003)	0.001	0.0008 (0.0006-0.0009)	0.0035 (0.0011-0.0085)
Sambalpur FD/s at Shankarmath	0.002 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0008 (0.0007-0.0009)	0.0024 (0.0009-0.0047)
Sambalpur FFD/s at Huma	0.001 (<0.001-0.003)	0.002 (0.001-0.003)	0.001	0.0011 (0.0007-0.0015)	0.0024 (0.0009-0.0060)
Sonepur U/s	0.001 (<0.001-0.004)	0.002 (0.001-0.003)	<0.001	0.0007 (0.0007-0.0008)	0.0028 (0.0007-0.0066)
Sonepur D/s	0.001 (<0.001-0.003)	0.002 (0.001-0.003)	<0.001	0.0009 (0.0008-0.0009)	0.0036 (0.0008-0.0081)
Tikarapada	0.002 (<0.001-0.004)	0.002 (0.001-0.003)	<0.001	0.0009 (0.0008-0.0011)	0.0027 (0.0006-0.0053)
Narasinghpur	0.002 (0.001-0.004)	0.001 (0.001-0.002)	<0.001	0.0009 (0.0007-0.0010)	0.0026 (0.0004-0.0054)
Munduli	0.001 (<0.001-0.003)	0.001 (0.001-0.003)	<0.001	0.0010 (0.0006-0.0014)	0.0024 (0.0007-0.0054)
Cuttack U/s	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0007 (0.0004-0.0010)	0.0032 (0.0007-0.0067)
Cuttack D/s	0.001 (<0.001-0.003)	0.001 (0.001-0.003)	0.001	0.0032 (0.0005-0.0059)	0.0039 (0.0011-0.0076)
Cuttack FD/s	0.001 (0.001-0.003)	0.002 (0.001-0.003)	0.001	0.0008 (0.0006-0.0010)	0.0028 (0.0007-0.0059)
Paradeep U/s	0.002 (<0.001-0.003)	0.001 (0.001-0.002)	<0.001	0.0016 (0.0008-0.0023)	0.0018 (0.0005-0.0065)
Paradeep D/s	0.002 (<0.001-0.005)	0.002 (0.001-0.003)	0.001	0.0005 (0.0004-0.0006)	0.0027 (0.0011-0.0074)
Monmunda (Tel)	0.001 ((<0.001-0.003)	0.001 (0.001-0.002)	<0.001	0.0006 (0.0005-0.0006)	0.0029 (0.0003-0.0064)
Cuttack U/s (Kathajodi)	0.001 (<0.001-0.002)	0.002 (0.001-0.003)	0.001	0.0007 (0.0006-0.0007)	0.0021 (0.0004-0.0060)
Cuttack D/s (Kathajodi)	0.002 (<0.001-0.007)	0.002 (0.001-0.003)	<0.001	0.0011 (0.0008-0.0014)	0.0032 (0.0001-0.0061)
Cuttack FD/s at Mattagajpur (Kathajodi)	0.001 ((<0.001-0.006)	0.002 (0.001-0.003)	0.001	0.0011 (0.0010-0.0012)	0.0034 (0.0013-0.0072)
Cuttack FD/s at Sankhatrasa (Serua)	0.001 (<0.001-0.003)	0.002 (0.001-0.003)	<0.001	0.0007 (0.0005-0.0009)	0.0032 (0.0009-0.0072)

Table 3.18 (g) Cadmium contd..

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Bhubaneswar FU/s (Kuakhai)	0.001 (<0.001-0.004)	0.002 (0.001-0.003)	0.001	0.0010 (0.0008-0.0013)	0.0026 (0.0006-0.0061)
Bhubaneswar U/s (Kuakhai)	0.002 (0.001-0.004)	0.002 (0.001-0.003)	0.001	0.0008 (0.0008-0.0008)	0.0024 (0.0006-0.0069)
Bhubaneswar D/s (Daya)	0.002 (<0.001-0.004)	0.002 (0.001-0.003)	<0.001	0.0009 (0.0009-0.0009)	0.0037 (0.0009-0.0086)
Bhubaneswar FD/s (Daya)	0.002 (0.001-0.004)	0.001 (0.001-0.003)	<0.001	0.0010 (0.0008-0.0013)	0.0033 (0.0008-0.0077)
Choudwar D/s (Birupa)	0.002 (<0.001-0.004)	0.002 (0.001-0.003)	<0.001	0.0015 (0.0009-0.0022)	0.0033 (0.0005-0.0138)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 3.18 (h) Lead (mg/l)

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Sundargarh (lb)	0.004 (<0.001-0.007)	0.006 (0.004-0.010)	0.006	0.001 (0.001-0.002)	0.010 (0.002-0.020)
Jharsuguda (lb)	0.004 (0.002-0.008)	0.007 (0.003-0.010)	0.006	0.004 (0.003-0.005)	0.011 (0.002-0.028)
Brajaraj Nagar U/s (lb)	0.004 (0.003-0.006)	0.006 (0.004-0.008)	0.006	0.007 (0.007-0.008)	0.014 (0.006-0.024)
Brajaraj Nagar D/s (lb)	0.005 (0.002-0.009)	0.006 (0.004-0.009)	0.007	0.004 (<0.001-0.008)	0.015 (0.002-0.026)
Jharsuguda (Bheden)	0.005 (0.002-0.009)	0.005 (0.003-0.007)	0.006	0.020 (0.018-0.022)	0.011 (0.004-0.018)
Hirakud	0.005 (0.002-0.008)	0.005 (0.003-0.007)	0.008	0.005 (0.003-0.008)	0.007 (0.003-0.016)
Power Channel U/s	0.005 (0.001-0.009)	0.005 (0.003-0.012)	0.008	0.007 (0.006-0.007)	0.008 (0.001-0.015)
Power Channel D/s	0.006 (0.003-0.010)	0.005 (0.004-0.006)	0.009	0.005 (<0.001-0.009)	0.014 (0.008-0.023)
Sambalpur U/s	0.006 (0.003-0.010)	0.005 (0.003-0.008)	0.009	0.007 (0.007-0.008)	0.013 (0.005-0.024)
Sambalpur D/s	0.005 (0.002-0.009)	0.006 (0.005-0.010)	0.008	0.009 (0.007-0.011)	0.015 (0.004-0.042)
Sambalpur FD/s at Shankarmath	0.004 (0.002-0.007)	0.004 (0.003-0.007)	0.008	0.009 (0.009-0.009)	0.011 (0.003-0.023)
Sambalpur FFD/s at Huma	0.006 (0.002-0.012)	0.005 (0.004-0.007)	0.008	0.006 (0.004-0.008)	0.010 (0.004-0.022)
Sonepur U/s	0.006 (0.001-0.009)	0.006 (0.003-0.009)	0.007	0.007 (0.006-0.008)	0.011 (<0.001-0.022)
Sonepur D/s	0.005 (0.001-0.008)	0.005 (0.002-0.006)	0.007	0.008 (0.007-0.010)	0.014 (0.007-0.023)
Tikarapada	0.005 (0.002-0.008)	0.004 (0.002-0.007)	0.006	0.004 (0.003-0.005)	0.010 (0.006-0.017)
Narasinghpur	0.004 (0.001-0.009)	0.004 (0.001-0.007)	0.006	0.004 (0.002-0.005)	0.008 (0.004-0.014)
Munduli	0.005 (0.001-0.010)	0.004 (0.001-0.008)	0.003	0.008 (0.007-0.009)	0.008 (0.002-0.012)

Table 3.18 (h) Lead contd..

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Cuttack U/s	0.005 (0.003-0.009)	0.006 (0.004-0.008)	0.004	0.007 (0.005-0.009)	0.009 (0.004-0.014)
Cuttack D/s	0.006 (0.002-0.009)	0.008 (0.006-0.009)	0.006	0.006 (0.004-0.009)	0.012 (0.007-0.017)
Cuttack FD/s	0.006 (0.001-0.009)	0.007 (0.006-0.008)	0.006	0.008 (0.005-0.010)	0.009 (0.004-0.015)
Paradeep U/s	0.005 (0.001-0.007)	0.007 (0.006-0.010)	0.006	0.008 (0.007-0.008)	0.013 (0.005-0.021)
Paradeep D/s	0.007 (0.003-0.010)	0.007 (0.004-0.012)	0.006	0.004 (0.004-0.005)	0.016 (0.011-0.027)
Monmunda (Tel)	0.006 (0.002-0.012)	0.005 (0.004-0.007)	0.005	0.008 (0.008-0.008)	0.009 (0.004-0.014)
Cuttack U/s (Kathajodi)	0.006 (0.001-0.010)	0.006 (0.003-0.009)	0.003	0.004 (0.002-0.007)	0.011 (0.002-0.028)
Cuttack D/s (Kathajodi)	0.005 ( $<0.001-0.008$ )	0.007 (0.004-0.011)	0.007	0.010 (0.006-0.014)	0.011 (0.007-0.016)
Cuttack FD/s at Mattagajpur (Kathajodi)	0.005 (0.001-0.010)	0.009 (0.007-0.012)	0.009	0.008 (0.005-0.011)	0.013 (0.009-0.024)
Cuttack FD/s at Sankhatrasa (Serua)	0.006 (0.002-0.011)	0.006 (0.003-0.010)	0.008	0.010 (0.004-0.015)	0.010 (0.002-0.019)
Bhubaneswar FU/s (Kuakhai)	0.005 (0.001-0.008)	0.005 (0.005-0.006)	0.005	0.008 (0.007-0.008)	0.010 (0.009-0.015)
Bhubaneswar U/s (Kuakhai)	0.004 (0.001-0.008)	0.007 (0.005-0.012)	0.009	0.006 (0.003-0.008)	0.009 (0.004-0.013)
Bhubaneswar D/s (Daya)	0.005 (0.002-0.008)	0.007 (0.005-0.012)	0.004	0.008 ( $<0.001-0.015$ )	0.013 (0.007-0.028)
Bhubaneswar FD/s (Daya)	0.005 ( $<0.001-0.009$ )	0.005 (0.002-0.009)	0.005	0.005 (0.003-0.006)	0.009 (0.005-0.015)
Choudwar D/s (Birupa)	0.005 (0.002-0.009)	0.005 (0.002-0.008)	0.007	0.006 (0.004-0.008)	0.014 (0.005-0.025)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

**Table 3.19 Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class**

Monitoring Station	SI				
	2011	2012	2013	2014	2015
Brajrajnagar D/s (Ib)	5.7 (5.3-6.0)	5.5	5.80 (5.70-6.00)	5.80 (5.70-5.80)	5.9 (5.7-6.1)
Sambalpur D/s	5.6 (5.4-5.8)	5.4 (4.8-5.8)	5.33 (5.00-6.00)	5.51 (5.14-5.88)	4.4 (3.4-5.8)
Cuttack U/s (Mahanadi)	5.7 (5.2-6.2)	6.2 (6.0-6.4)	6.10 (5.50-6.60)	-	5.1
Cuttack D/s (Mahanadi)	5.2 (5.0-5.6)	5.6 (5.4-5.8)	5.40 (4.80-5.80)	5.50 (4.80-6.00)	5.4 (5.0-5.8)
Cuttack D/s (Kathajodi)	4.7 (4.6-5.0)	5.79 (5.75-5.83)	5.30 (5.20-5.50)	5.60 (5.00-6.00)	5.4 (5.0-5.8)
Bhubaneswar U/s (Kuakhai)	6.0 (5.1-6.6)	5.4 (4.8-6.0)	5.30 (4.80-5.80)	5.70 (5.40-6.00)	5.4 (5.2-5.6)
Bhubaneswar D/s (Daya)	5.1 (4.8-5.6)	5.3 (5.0-5.8)	5.54 (5.5-5.62)	5.40 (5.20-5.60)	5.4 (5.0-6.0)
Choudwar D/s (Birupa)	5.8 (5.5-6.0)	5.7 (5.3-6.0)	6.28 (6.00-6.75)	5.82 (5.50-6.20)	5.9 (5.8-6.0)
	DI				
Brajrajnagar D/s (Ib)	0.6 (0.6-0.7)	0.75	0.51 (0.45-0.59)	0.58 (0.52-0.61)	0.65 (0.58-0.70)
Sambalpur D/s	0.6 (0.5-0.7)	0.55 (0.30-0.83)	0.57 (0.50-0.62)	0.63 (0.52-0.75)	0.52 (0.46-0.64)
Cuttack U/s (Mahanadi)	0.53 (0.52-0.54)	0.52 (0.46-0.57)	0.63 (0.56-0.72)	-	0.69
Cuttack D/s (Mahanadi)	0.3 (0.2-0.4)	0.43 (0.30-0.55)	0.53 (0.43-0.70)	0.50 (0.30-0.80)	0.56 (0.36-0.70)
Cuttack D/s (Kathajodi)	0.4 (0.3-0.5)	0.45 (0.35-0.60)	0.64 (0.48-0.80)	0.46 (0.35-0.60)	0.48 (0.36-0.57)
Bhubaneswar U/s (Kuakhai)	0.5 (0.5-0.6)	0.64 (0.50-0.83)	0.45 (0.40-0.55)	0.50 (0.46-0.60)	0.66 (0.64-0.68)
Bhubaneswar D/s (Daya)	0.5 (0.3-0.6)	0.55 (0.46-0.66)	0.69 (0.52-0.90)	0.73 (0.65-0.85)	0.65 (0.57-0.80)
Choudwar D/s (Birupa)	0.6 (0.4-0.7)	0.49 (0.46-0.51)	0.61 (0.42-0.87)	0.76 (0.51-0.91)	0.44 (0.33-0.55)
	Biological Class				
Brajrajnagar D/s (Ib)	C	C	C	C	B-C
Sambalpur D/s	C	C	C	C	C
Cuttack U/s (Mahanadi)	B – C	B – C	B-C	-	C
Cuttack D/s (Mahanadi)	C – D	C	C	C	C
Cuttack D/s (Kathajodi)	C	C	C	C	C
Bhubaneswar U/s (Kuakhai)	B – C	C	C	C	C
Bhubaneswar D/s (Daya)	C	C	C	C	C
Choudwar D/s (Birupa)	C	C	B-C	B-C	C

Table 3.20 Annual average and Range of (Nitrite+Nitrate)- Nitrogen values

Monitoring Station	2011	2012	2013	2014	2015
	<b>(Nitrite+Nitrate)- Nitrogen (mg/l)</b>				
Sundargarh (lb)	0.388 (0.016-2.083)	0.362 (0.020-2.776)	0.431 (0.079-1.081)	0.526 (0.084-2.398)	0.451 (0.114-1.487)
Jharsuguda (lb)	0.340 (0.002-1.473)	0.295 (0.011-1.713)	0.283 (0.106-0.528)	0.384 (0.125-1.091)	0.775 (0.302-1.744)
Brajarajnaragar U/s (lb)	0.235 (0.004-1.102)	0.595 (0.013-1.716)	0.255 (0.016-0.489)	0.368 (0.136-0.675)	0.496 (0.103-1.433)
Brajarajnaragar D/s (lb)	0.409 (0.012-1.559)	0.613 (0.038-2.645)	0.424 (0.029-1.577)	0.535 (0.123-1.097)	1.124 (0.126-3.244)
Jharsuguda (Bheden)	0.423 (0.013-1.203)	0.373 (0.033-1.158)	0.496 (0.210-0.892)	0.528 (0.097-1.091)	0.823 (0.108-3.125)
Hirakud	0.912 (0.025-5.707)	0.734 (0.038-1.982)	0.472 (0.099-0.726)	0.531 (0.250-1.464)	0.844 (0.115-1.536)
Power Channel U/s	0.458 (0.025-2.736)	0.863 (0.051-5.432)	1.311 (0.111-8.915)	0.442 (0.072-1.523)	0.719 (0.072-2.201)
Power Channel D/s	0.682 (0.020-4.374)	0.441 (0.035-1.640)	0.398 (0.210-0.765)	0.670 (0.311-1.784)	1.444 (0.158-3.327)
Sambalpur U/s	0.155 (0.014-0.459)	0.528 (0.062-1.789)	0.447 (0.177-0.699)	0.469 (0.213-0.790)	0.860 (0.144-2.565)
Sambalpur D/s	0.499 (0.016-1.303)	0.925 (0.074-3.872)	1.001 (0.340-5.624)	0.609 (0.137-1.759)	1.738 (0.294-3.738)
Sambalpur FD/s at Shankarmath	0.706 (0.028-4.326)	0.825 (0.023-3.888)	0.608 (0.133-1.477)	0.771 (0.138-2.509)	1.719 (0.416-2.784)
Sambalpur FFD/s at Huma	0.213 (0.008-0.664)	0.670 (0.037-2.889)	0.381 (0.103-0.643)	0.395 (0.144-0.733)	1.092 (0.353-2.016)
Sonepur U/s	0.390 (0.016-1.575)	0.556 (0.111-2.096)	0.570 (0.214-0.929)	0.392 (0.143-1.080)	1.157 (0.066-3.116)
Sonepur D/s	0.336 (0.021-1.029)	0.440 (0.065-1.209)	0.565 (0.287-0.926)	0.579 (0.165-1.910)	2.000 (0.455-7.074)
Tikarapada	0.185 (0.059-0.463)	0.407 (0.032-1.464)	0.244 (0.045-0.717)	0.440 (0.108-1.279)	0.775 (0.136-2.176)
Narasinghpur	0.652 (0.129-3.564)	0.400 (0.095-1.487)	0.422 (0.145-0.950)	0.533 (0.137-1.685)	1.012 (0.082-3.463)
Munduli	0.339 (0.100-0.706)	0.336 (0.099-0.822)	0.363 (0.070-0.838)	0.515 (0.110-1.288)	0.966 (0.113-3.454)
Cuttack U/s	0.426 (0.006-1.355)	0.310 (0.045-1.100)	0.325 (0.092-1.158)	0.434 (0.047-1.670)	0.721 (0.035-1.547)
Cuttack D/s	0.582 (0.053-3.277)	0.376 (0.013-0.938)	0.251 (0.076-0.588)	0.717 (0.145-2.132)	1.943 (0.636-5.271)
Cuttack FD/s	0.334 (0.052-0.831)	0.326 (0.057-1.013)	0.406 (0.058-1.257)	0.523 (0.201-2.607)	1.316 (0.379-2.729)
Paradeep U/s	0.769 (0.198-3.171)	0.733 (0.292-1.717)	0.672 (0.206-1.634)	0.937 (0.138-3.365)	0.754 (0.199-2.201)
Paradeep D/s	1.401 (0.238-3.872)	0.847 (0.051-2.065)	0.680 (0.160-1.547)	1.299 (0.362-4.898)	1.839 (0.204-4.117)
Monmunda (Tel)	0.497 (0.040-2.597)	0.490 (0.006-2.298)	0.494 (0.027-0.746)	0.489 (0.106-2.138)	0.889 (0.108-2.408)
Cuttack U/s (Kathajodi)	0.368 (0.031-1.450)	0.257 (0.002-1.082)	0.658 (0.074-1.650)	0.661 (0.051-1.686)	0.687 (0.042-1.466)
Cuttack D/s (Kathajodi)	0.538 (0.051-3.196)	0.556 (0.043-2.510)	0.370 (0.071-0.762)	1.902 (0.192-10.128)	2.260 (0.118-6.880)
Cuttack FD/s at Mattagajpur (Kathajodi)	5.596 (0.251-12.050)	5.528 (0.877-12.360)	4.391 (0.670-11.154)	2.416 (0.489-5.173)	3.732 (0.268-8.254)
Cuttack FD/s at Sankhatrasa (Serua)	0.456 (0.055-2.098)	0.416 (0.041-1.121)	0.481 (0.077-1.464)	0.954 (0.194-2.984)	0.996 (0.361-1.777)

Table 3.20 Contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>(Nitrite+Nitrate)- Nitrogen (mg/l)</b>				
Bhubaneswar FU/s (Kuakhai)	0.282 (0.012-1.085)	0.431 (0.009-1.923)	0.383 (0.038-1.410)	0.383 (0.097-1.753)	1.272 (0.076-6.336)
Bhubaneswar U/s (Kuakhai)	0.291 (0.056-7.048)	0.864 (0.231-2.337)	0.870 (0.040-2.038)	0.854 (0.053-2.597)	1.790 (0.238-4.631)
Bhubaneswar D/s (Daya)	2.975 (0.062-7.465)	2.137 (0.186-7.846)	1.829 (0.140-7.117)	2.474 (0.019-6.099)	2.880 (0.637-6.412)
Bhubaneswar FD/s (Daya)	2.621 (0.058-6.507)	2.143 (0.103-9.112)	2.455 (0.391-4.799)	2.898 (0.139-5.703)	1.869 (0.261-6.341)
Choudwar D/s (Birupa)	0.626 (0.105-1.672)	1.053 (0.081-4.869)	0.799 (0.275-1.420)	0.728 (0.120-2.601)	1.023 (0.211-2.917)

Table 3.21 Annual average and Range values of Total Suspended Solids (TSS)

Monitoring Station		2011	2012	2013	2014	2015
		<b>Total Suspended Solids (TSS) (mg/l)</b>				
Sundargarh (lb)	IM	216 (3-816)	79 (12-284)	129 (26-540)	32 (3-174)	27 (4-87)
	NM	115 (3-790)	53 (12-122)	63 (26-212)	9 (3-16)	11 (4-20)
Jharsuguda (lb)	IM	118 (9-608)	70 (9-222)	67 (12-178)	25 (5-154)	22 (6-92)
	NM	50 (9-168)	54 (9-150)	47 (12-136)	10 (5-18)	11 (6-18)
Brajaraj Nagar U/s (lb)	IM	137 (17-772)	53 (15-116)	82 (14-274)	31 (7-175)	22 (4-102)
	NM	58 (17-190)	40 (15-72)	53 (14-152)	15 (7-27)	10 (4-18)
Brajaraj Nagar D/s (lb)	IM	125 (8-732)	76 (17-276)	78 (6-270)	26 (6-116)	26 (6-110)
	NM	47 (8-172)	40 (17-95)	49 (6-148)	18 (6-32)	16 (6-30)
Jharsuguda (Bheden)	IM	103 (6-438)	69 (6-180)	70 (14-138)	35 (13-108)	27 (5-60)
	NM	92 (6-438)	64 (6-180)	65 (14-138)	18 (13-30)	20 (5-40)
Hirakud	IM	51 (4-159)	30 (5-84)	34 (8-66)	14 (5-38)	15 (4-45)
	NM	35 (4-84)	19 (5-33)	33 (8-66)	13 (5-38)	8 (4-15)
Power Channel U/s	IM	43.7 (5-110)	47 (7-170)	41 (16-76)	13 (2-48)	14 (3-36)
	NM	44 (5-84)	34 (7-52)	38 (16-66)	10 (2-20)	7 (3-14)
Power Channel D/s	IM	52 (8-144)	40 (2-156)	40 (18-64)	20 (3-51)	19 (5-56)
	NM	40 (8-82)	27 (2-50)	37 (18-64)	16 (3-40)	11 (5-18)
Sambalpur U/s	IM	46 (2-96)	47 (6-172)	49 (24-116)	20 (2-114)	17 (4-75)
	NM	41 (2-72)	27 (6-50)	46 (24-116)	17 (4-40)	8 (4-16)

Table 3.21 Contd..

Monitoring Station		2011	2012	2013	2014	2015
		Total Suspended Solids (TSS) (mg/l)				
Sambalpur D/s	IM	44 (2-152)	55 (4-168)	57 (26-128)	39 (4-230)	29 (12-78)
	NM	28 (2-49)	49 (4-168)	47 (26-74)	12 (4-22)	20 (12-35)
Sambalpur FD/s at Shankarmath	IM	58 (10-134)	41 (10-80)	35 (16-72)	21 (4-50)	21 (6-70)
	NM	44 (10-69)	34 (10-52)	31 (16-60)	9 (4-15)	12 (6-20)
Sambalpur FFD/s at Huma	IM	54 (12-136)	45 (8-126)	40 (24-80)	15 (2-33)	16 (2-62)
	NM	35 (12-60)	30 (8-51)	37 (24-54)	20 (2-45)	9 (2-20)
Sonepur U/s	IM	47 (3-125)	48 (9-129)	62 (14-174)	13 (2-53)	19 (3-58)
	NM	30 (3-54)	37 (9-129)	61 (14-174)	8 (2-14)	8 (3-22)
Sonepur D/s	IM	47 (6-160)	41 (8-82)	61 (10-136)	13 (5-25)	25 (1-61)
	NM	31 (6-66)	31 (8-74)	51 (10-136)	10 (5-17)	14 (1-32)
Tikarapada	IM	82 (5-340)	58 (24-172)	73 (14-140)	28 (3-96)	28 (4-84)
	NM	49 (5-170)	50 (24-172)	60 (14-140)	19 (3-78)	11 (4-22)
Narasinghpur	IM	65 (9-252)	50 (7-128)	92 (38-290)	40 (6-119)	17 (3-56)
	NM	31 (9-78)	34 (7-116)	66 (38-112)	40 (6-29)	11 (3-35)
Munduli	IM	82 (3-332)	52 (18-192)	84 (20-196)	38 (3-114)	16 (4-45)
	NM	46 (3-110)	24 (18-38)	69 (20-172)	17 (3-76)	11 (4-37)
Cuttack U/s	IM	63 (10-384)	46 (4-132)	80 (14-316)	46 (3-195)	24 (4-81)
	NM	25 (10-42)	30 (4-66)	48 (14-80)	9 (3-14)	12 (4-38)
Cuttack D/s	IM	80 (7-500)	56 (12-158)	81 (14-284)	63 (5-281)	32 (4-145)
	NM	28 (7-66)	33 (12-78)	53 (14-82)	17 (5-30)	13 (4-32)
Cuttack FD/s	IM	61 (13-236)	49 (15-148)	82 (24-258)	51 (4-260)	34 (4-157)
	NM	38 (13-120)	34 (15-59)	55 (24-110)	12 (4-21)	13 (4-30)
Paradeep U/s	IM	74 (14-272)	89 (25-290)	164 (28-382)	96 (10-398)	25 (3-61)
	NM	41 (14-92)	72 (25-127)	121 (28-372)	40 (10-79)	21 (3-61)
Paradeep D/s	IM	122 (25-220)	159 (28-386)	214 (22-460)	181 (18-646)	42 (8-109)
	NM	112 (25-187)	136 (28-296)	202 (22-460)	107 (18-188)	37 (8-109)

Table 3.21 Contd..

Monitoring Station		2011	2012	2013	2014	2015
		Total Suspended Solids (TSS) (mg/l)				
Paradeep U/s	IM	74 (14-272)	89 (25-290)	164 (28-382)	96 (10-398)	25 (3-61)
	NM	41 (14-92)	72 (25-127)	121 (28-372)	40 (10-79)	21 (3-61)
Paradeep D/s	IM	122 (25-220)	159 (28-386)	214 (22-460)	181 (18-646)	42 (8-109)
	NM	112 (25-187)	136 (28-296)	202 (22-460)	107 (18-188)	37 (8-109)
Monmunda (Tel)	IM	167 (27-586)	122 (9-376)	128 (18-298)	63 (14-203)	27 (5-89)
	NM	91 (27-224)	88 (9-376)	93 (18-248)	53 (14-196)	12 (5-30)
Cuttack U/s (Kathajodi)	IM	80 (12-316)	65 (10-274)	86 (20-260)	81 (3-267)	25 (4-68)
	NM	49 (12-176)	24 (10-45)	59 (20-136)	41 (3-267)	14 (4-50)
Cuttack D/s (Kathajodi)	IM	73 (17-256)	56 (19-206)	87 (28-330)	85 (16-310)	22 (3-66)
	NM	46 (17-143)	35 (19-76)	55 (28-92)	59 (16-310)	14 (3-30)
Cuttack FD/s at Mattagajpur (Kathajodi)	IM	151 (25-624)	58 (22-98)	98 (32-328)	85 (30-226)	27 (7-62)
	NM	174 (25-624)	50 (22-84)	74 (32-150)	72 (30-184)	27 (7-62)
Cuttack FD/s at Sankhatrasa (Serua)	IM	82 (21-220)	49 (12-160)	83 (28-304)	40 (9-144)	26 (5-76)
	NM	57 (21-204)	29 (12-68)	53 (28-110)	32 (9-90)	14 (5-27)
Bhubaneswar FU/s (Kuakhai)	IM	35 (9-174)	83 (6-354)	51 (18-188)	34 (4-184)	20 (2-71)
	NM	23 (9-35)	34 (6-102)	35 (18-66)	9 (4-15)	9 (2-21)
Bhubaneswar U/s (Kuakhai)	IM	57 (8-280)	39 (16-138)	90 (10-486)	39 (3-190)	24 (5-74)
	NM	32 (8-49)	28 (16-44)	43 (10-72)	14 (3-36)	13 (5-30)
Bhubaneswar D/s (Daya)	IM	62 (19-224)	77 (8-318)	115 (28-466)	54 (8-274)	36 (8-100)
	NM	41 (19-62)	38 (8-89)	71 (28-122)	22 (8-38)	22 (8-42)
Bhubaneswar FD/s (Daya)	IM	44 (7-83)	71 (8-310)	85 (22-298)	43 (11-149)	34 (8-72)
	NM	40 (7-60)	40 (8-84)	55 (22-96)	26 (11-48)	24 (8-50)
Choudwar D/s (Birupa)	IM	68.2 (4-268)	58 (5-176)	95 (28-460)	45 (10-244)	18 (4-98)
	NM	68 (4-248)	45 (5-89)	59 (28-114)	22 (10-35)	6 (4-8)

Note : IM : Including Monsoon period

NM : Non-monsoon period (i.e. excluding the months July, August and September)

Table 3.22 Percentage violation and Annual Range of Fecal Coliform (FC) values

Monitoring Station	2011	2012	2013	2014	2015
	Percentage Violation from 2000 MPN/100 ml (Range of FC values in '000 MPN/100 ml)				
Sundargarh (lb)	0 (0.068-1.700)	8 (0.330-2.200)	20 (0.230-2.300)	0 (0.078-1.300)	8 (0.170-2.400)
Jharsuguda (lb)	33 (0.130-13.000)	50 (0.230-9.200)	0 (0.078-1.700)	18 (0.020-13.000)	33 (0.330-7.900)
Brajarajnaragar U/s (lb)	0 (0.110-1.400)	0 (0.230-1.700)	10 (0.330-2.400)	9 (0.020-2.400)	58 (0.460-16.000)
Brajarajnaragar D/s (lb)	8 (0.110-3.100)	33 (0.330-3.500)	30 (0.130-2.700)	18 (0.130-5.400)	75 (0.310-16.000)
Jharsuguda (Bheden)	8 (0.130-0.790)	0 (0.220-1.400)	30 (0.230-3.300)	0 (0.078-1.300)	33 (0.170-4.900)
Hirakud	8 (0.330-1.500)	0 (0.130-1.700)	10 (0.130-2.300)	18 (0.020-5.400)	17 (0.230-5.400)
Power Channel U/s	0 (0.002-0.230)	0 (0.045-0.790)	0 (0.045-0.490)	9 (0.045-2.800)	8 (0.045-3.500)
Power Channel D/s	0 (0.080-0.940)	0 (0.080-1.300)	0 (0.140-1.300)	18 (0.078-9.200)	17 (0.130-3.500)
Sambalpur U/s	17 (0.310-5.400)	25 (0.330-16.000)	90 (1.100-9.400)	64 (0.780-35.000)	67 (0.079-17.000)
Sambalpur D/s	100 (2.100-92.000)	92 (1.300-160.000)	100 (4.600-54.000)	100 (7.900-92.000)	100 (3.300-160.000)
Sambalpur FD/s at Shankarmath	92 (0.940-35.000)	100 (3.300-24.000)	30 (0.680-7.900)	54 (0.490-13.000)	100 (2.300-54.000)
Sambalpur FFD/s at Huma	42 (0.140-13.000)	75 (0.580-17.000)	30 (0.330-3.300)	9 (0.110-11.000)	42 (0.490-7.900)
Sonepur U/s	8 (0.230-2.100)	8 (0.130-2.200)	20 (0.045-3.300)	9 (0.020-2.800)	25 (0.130-16.000)
Sonepur D/s	8 (0.700-2.800)	8 (0.140-2.400)	20 (0.078-4.600)	9 (0.045-2400)	42 (0.130-16.000)
Tikarapada	33 (0.460-4.300)	17 (0.170-2.800)	10 (0.230-2.700)	27 (0.078-13.000)	27 (0.078-13.000)
Narasinghpur	0 (0.220-1.500)	50 (0.490-4.600)	30 (0.078-5.400)	18 (0.045-22.000)	50 (0.330-11.000)
Munduli	8 (0.078-2.200)	42 (0.130-5.400)	0 (0.130-1.300)	36 (0.110-7.900)	50 (0.078-16.000)
Cuttack U/s	0 (0.140-1.400)	25 (0.140-9.200)	20 (0.230-9.200)	27 (0.330-9.200)	0 (0.020-1.300)
Cuttack D/s	92 (1.100-160.000)	100 (13.000-92.000)	100 (2.400-160.000)	100 (11.000-92.000)	92 (0.780-160.000)
Cuttack FD/s	58 (0.460-92.000)	100 (5.400-35.000)	100 (7.900-35.000)	100 (4.900-54.000)	83 (0.170-54.000)
Paradeep U/s	17 (0.700-3.100)	42 (0.330-13.000)	70 (1.300-4.900)	54 (0.068-22.000)	50 (0.230-5.400)
Paradeep D/s	17 (0.080-13.000)	50 (0.790-7.000)	50 (0.045-24.000)	45 (0.002-11.000)	50 (0.130-13.000)
Monmunda (Tel)	0 (0.230-1.300)	17 (0.078-2.800)	30 (0.078-4.900)	0 (0.078-1.700)	8 (0.078-7.900)
Cuttack U/s (Kathajodi)	0 (0.110-1.200)	17 (0.170-54.000)	20 (0.330-5.400)	18 (0.490-3.500)	25 (0.045-5.400)
Cuttack D/s (Kathajodi)	100 14.000-160.000	100 14.000-92.000	100 7.000-92.000	100 13.000-160.000	92 0.780-35.000
Cuttack FD/s at Mattagajpur (Kathajodi)	92 (1.700-92.000)	100 (11.000-160.000)	100 (3.300-54.000)	100 (17.000-160.000)	100 (4.900-92.000)
Cuttack FD/s at Sankhatrasa (Serua)	42 (0.310-7.900)	100 (7.900-92.000)	90 (0.700-24.000)	91 (1.700-54.000)	92 (0.130-54.000)

Table 3.22 contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>Percentage Violation from 2000 MPN/100 ml (Range of FC values in '000 MPN/100 ml)</b>				
Bhubaneswar FU/s (Kuakhai)	0 (0.070-1.400)	0 (0.130-1.300)	30 (0.230-160.000)	27 (0.200-7.900)	25 (0.130-9.200)
Bhubaneswar U/s (Kuakhai)	58 (0.200-11.000)	67 (0.700-11.000)	60 (1.100-160.000)	91 (0.790-54.000)	92 (1.300-22.000)
Bhubaneswar D/s (Daya)	100 (4.600-54.000)	100 (4.600-54.000)	100 (13.000-54.000)	100 (9.200-160.000)	100 (1.100-160.000)
Bhubaneswar FD/s (Daya)	100 (2.300-35.000)	100 (4.300-54.000)	100 (7.900-54.000)	100 (13.000-54.000)	100 (2.200-160.000)
Choudwar D/s (Birupa)	33 (0.330-13.000)	42 (0.700-5.400)	90 (1.700-160.000)	54 (0.330-92.000)	50 (0.330-16.000)

Table 3.23 Annual average and Range values of Total Phosphate-P

Monitoring Station	2011	2012	2013	2014	2015
	<b>Total Phosphate-P (mg/l)</b>				
Sundargarh (lb)	0.060 (0.011-0.273)	0.033 (0.010-0.080)	0.079 (0.003-0.164)	0.058 (0.010-0.156)	0.090 (0.006-0.230)
Jharsuguda (lb)	0.045 (0.005-0.196)	0.038 (0.010-0.141)	0.036 (0.003-0.088)	0.075 (0.017-0.119)	0.106 (0.006-0.222)
Brajaraj Nagar U/s (lb)	0.107 (0.005-0.413)	0.035 (0.005-0.115)	0.060 (0-0.126)	0.053 (0.002-0.140)	0.110 (0.012-0.231)
Brajaraj Nagar D/s (lb)	0.033 (0.005-0.100)	0.061 (0.006-0.375)	0.057 (0.003-0.176)	0.080 (0.006-0.165)	0.199 (0.022-1.271)
Jharsuguda (Bheden)	0.027 (0.003-0.103)	0.038 (0.002-0.092)	0.064 (0.002-0.177)	0.085 (0.015-0.408)	0.148 (0.029-0.576)
Hirakud	0.044 (0.005-0.127)	0.038 (0.006-0.124)	0.099 (0.018-0.363)	0.071 (0.013-0.373)	0.078 (0.014-0.191)
Power Channel U/s	0.039 (0.013-0.089)	0.048 (0.014-0.134)	0.207 (0.003-1.430)	0.094 (0.003-0.361)	0.182 (0.018-1.430)
Power Channel D/s	0.057 (0.005-0.254)	0.052 (0.001-0.190)	0.073 (0.005-0.146)	0.117 (0.014-0.570)	0.099 (0.023-0.216)
Sambalpur U/s	0.086 (0.003-0.432)	0.032 (0.001-0.063)	0.065 (0.003-0.146)	0.054 (0.006-0.110)	0.065 (0.012-0.150)
Sambalpur D/s	0.128 (0.034-0.564)	0.063 (0.007-0.166)	0.119 (0.005-0.693)	0.122 (0.015-0.456)	0.232 (0.027-1.050)
Sambalpur FD/s at Shankarmath	0.060 (0.007-0.154)	0.054 (0.002-0.280)	0.050 (0.003-0.151)	0.060 (0.011-0.143)	0.211 (0.022-0.950)
Sambalpur FFD/s at Huma	0.067 (0.003-0.278)	0.042 (0.017-0.092)	0.069 (0.005-0.150)	0.058 (0.009-0.188)	0.108 (0.016-0.373)
Sonepur U/s	0.064 (0.003-0.226)	0.024 (0.001-0.046)	0.070 (0.003-0.210)	0.104 (0.018-0.344)	0.108 (0.033-0.337)
Sonepur D/s	0.036 (0.013-0.059)	0.041 (0.005-0.134)	0.071 (0.003-0.224)	0.094 (0.029-0.317)	0.146 (0.015-0.451)
Tikarapada	0.038 (0.013-0.059)	0.029 (0.007-0.059)	0.057 (0.010-0.210)	0.176 (0.009-0.693)	0.154 (0.035-0.612)
Narasinghpur	0.038 (0.003-0.091)	0.048 (0.007-0.110)	0.075 (0.003-0.270)	0.091 (0.022-0.358)	0.105 (0.017-0.280)
Munduli	0.043 (0.003-0.217)	0.064 (0.005-0.261)	0.090 (0.010-0.216)	0.159 (0.021-0.840)	0.179 (0.045-0.413)
Cuttack U/s	0.099 (0.009-0.469)	0.146 (0.005-1.354)	0.034 (0.006-0.078)	0.118 (0.008-0.679)	0.093 (0.015-0.223)
Cuttack D/s	0.117 (0.008-0.523)	0.226 (0.006-2.171)	0.021 (0-0.049)	0.094 (0.009-0.317)	0.079 (0.031-0.266)
Cuttack FD/s	0.097 (0.007-0.368)	0.194 (0.006-1.818)	0.069 (0.013-0.260)	0.042 (0.016-0.109)	0.208 (0.033-1.248)

Table 3.23 contd..

Monitoring Station	2011	2012	2013	2014	2015
<b>Total Phosphate-P (mg/l)</b>					
Paradeep U/s	0.047 (0.003-0.239)	0.098 (0.021-0.479)	0.078 (0-0.163)	0.072 (0.006-0.325)	0.071 (0.01-0.143)
Paradeep D/s	0.166 (0.008-0.266)	0.198 (0.080-0.445)	0.243 (0.013-0.500)	0.161 (0.006-0.599)	0.222 (0.033-1.234)
Monmunda (Tel)	0.053 (0.007-0.186)	0.071 (0.001-0.475)	0.060 (0.003-0.130)	0.073 (0.029-0.138)	0.079 (0.022-0.147)
Cuttack U/s (Kathajodi)	0.043 (0.003-0.133)	0.047 (0.004-0.146)	0.048 (0.016-0.088)	0.035 (0.012-0.073)	0.074 (0.019-0.229)
Cuttack D/s (Kathajodi)	0.052 (0.007-0.156)	0.245 (0.009-2.378)	0.060 (0.012-0.131)	0.116 (0.006-0.833)	0.190 (0.027-0.590)
Cuttack FD/s at Mattagajpur (Kathajodi)	0.606 (0.031-2.293)	1.375 (0.102-2.846)	1.186 (0.131-3.996)	0.183 (0.017-0.910)	0.327 (0.038-1.305)
Cuttack FD/s at Sankhatrasa (Serua)	0.092 (0.012-0.460)	0.257 (0.009-2.617)	0.069 (0.006-0.204)	0.096 (0.025-0.350)	0.153 (0.015-0.731)
Bhubaneswar FU/s (Kuakhai)	0.225 (0.003-2.094)	0.027 (0.005-0.076)	0.078 (0.004-0.192)	0.261 (0.007-1.950)	0.128 (0.09-0.528)
Bhubaneswar U/s (Kuakhai)	0.093 (0.005-0.380)	0.082 (0.007-0.595)	0.182 (0.008-0.804)	0.093 (0.013-0.227)	0.084 (0.019-0.232)
Bhubaneswar D/s (Daya)	0.241 (0.001-0.609)	0.231 (0.050-0.640)	0.210 (0.013-0.699)	0.212 (0.002-0.733)	0.127 (0.017-0.287)
Bhubaneswar FD/s (Daya)	0.154 (0.009-0.510)	0.199 (0.125-1.075)	0.204 (0.008-0.426)	0.227 (0.006-0.665)	0.134 (0.025-0.431)
Choudwar D/s (Birupa)	0.041 (0.008-0.118)	0.052 (0.016-0.116)	0.131 (0.003-0.426)	0.139 (0.013-0.781)	0.136 (0.027-0.864)

Table 3.24 Annual average and Range of values of Total Kjeldahl Nitrogen (TKN)

Monitoring Station	2011	2012	2013	2014	2015
<b>Total Kjeldahl Nitrogen (TKN) (mg/l)</b>					
Sundargarh (lb)	3.3 (0.8-15.7)	2.64 (1.12-7.84)	2.48 (1.12-3.40)	1.20 (0.56-1.96)	1.26 (0.84-1.68)
Jharsuguda (lb)	3.4 (0.8-10.9)	3.10 (0.84-8.40)	2.32 (1.12-4.20)	1.12 (0.28-1.96)	1.12 (0.84-1.40)
Brajaraj Nagar U/s (lb)	3.2 (0.8-9.8)	3.22 (1.12-8.40)	2.78 (1.68-4.12)	1.20 (0.28-1.68)	1.19 (0.84-1.40)
Brajaraj Nagar D/s (lb)	2.7 (0.8-8.4)	5.02 (1.68-14.28)	2.40 (1.40-3.92)	1.04 (0.28-1.68)	1.21 (0.84-1.40)
Jharsuguda (Bheden)	3.2 (1.4-10.1)	3.55 (1.12-11.76)	2.81 (1.68-3.92)	1.30 (0.56-2.24)	1.28 (1.12-1.68)
Hirakud	2.9 (0.6-6.72)	2.99 (1.12-6.72)	3.32 (1.68-6.20)	1.30 (0.28-1.96)	1.26 (0.84-1.96)
Power Channel U/s	3.6 (0.8-8.4)	3.85 (0.56-15.12)	2.67 (1.68-3.64)	1.25 (0.28-1.96)	1.24 (1.12-1.40)
Power Channel D/s	4.5 (0.6-16.2)	3.05 (0.56-9.52)	2.31 (0.80-3.08)	1.25 (0.28-1.68)	1.14 (0.84-1.40)
Sambalpur U/s	4.1 (1.4-7.84)	2.78 (1.12-9.52)	3.29 (1.12-3.10)	1.20 (0.56-1.68)	1.24 (0.84-1.68)
Sambalpur D/s	3.9 (0.8-12.3)	4.20 (1.68-8.12)	3.57 (2.24-6.20)	1.35 (0.84-1.96)	1.42 (0.84-2.52)
Sambalpur FD/s at Shankarmath	4.1 (0.6-12.6)	3.34 (1.12-7.28)	2.53 (1.68-3.60)	1.27 (0.28-1.68)	1.12 (0.84-1.40)
Sambalpur FFD/s at Huma	3.4 (1.1-8.4)	3.34 (1.12-7.28)	2.47 (1.12-5.04)	1.12 (0.28-1.68)	1.21 (0.84-1.40)

Table 3.24 contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>Total Kjeldahl Nitrogen (TKN) (mg/l)</b>				
Sonepur U/s	3.0 (1.1-6.16)	2.52 (0.56-3.92)	2.36 (0.84-3.92)	1.25 (0.28-1.68)	1.17 (0.84-1.40)
Sonepur D/s	4.3 (1.4-9.5)	2.71 (0.56-6.44)	3.01 (1.68-6.72)	1.17 (0.56-1.68)	1.26 (0.84-1.68)
Tikarapada	2.4 (0.6-7.3)	3.14 (1.12-7.28)	2.65 (1.12-4.50)	1.32 (0.28-1.96)	1.22 (0.84-1.40)
Narasinghpur	4.4 (0.6-12.04)	3.36 (1.68-9.24)	2.72 (1.12-4.40)	1.15 (0.28-1.68)	1.19 (0.84-1.68)
Munduli	4.5 (1.1-10.9)	3.22 (1.12-7.28)	2.45 (1.12-3.64)	1.27 (0.56-1.96)	1.19 (0.84-1.40)
Cuttack U/s	4.5 (1.1-15.1)	2.66 (0.56-7.28)	2.46 (1.12-3.92)	1.07 (0.56-1.96)	1.14 (0.84-1.40)
Cuttack D/s	8.4 (1.1-34.4)	5.36 (1.12-12.32)	2.87 (1.40-4.20)	1.12 (0.28-1.68)	1.17 (0.84-1.40)
Cuttack FD/s	6.4 (1.1-30.3)	3.71 (0.56-6.16)	2.80 (1.68-4.48)	1.22 (0.28-1.68)	1.05 (0.84-1.12)
Paradeep U/s	5.0 (0.6-13.44)	2.67 (0.56-6.16)	2.85 (1.40-5.04)	1.12 (0.28-1.68)	1.07 (0.84-1.40)
Paradeep D/s	3.6 (1.1-9.5)	3.45 (1.40-7.28)	3.18 (2.50-4.20)	1.04 (0.28-1.68)	1.05 (0.84-1.40)
Monmunda (Tel)	3.6 (0.6-9.0)	2.82 (1.12-6.16)	2.77 (1.40-4.20)	1.20 (0.56-1.96)	1.19 (0.84-1.40)
Cuttack U/s (Kathajodi)	5.8 (0.6-16.8)	3.95 (1.12-8.40)	4.40 (1.68-9.52)	1.02 (0.28-1.68)	1.12 (0.84-1.40)
Cuttack D/s (Kathajodi)	7.0 (0.8-39.8)	6.09 (1.68-13.44)	2.85 (1.12-4.48)	1.16 (0.28-1.84)	1.33 (1.12-1.68)
Cuttack FD/s at Mattagajpur (Kathajodi)	8.4 (1.4-35.3)	9.35 (1.12-17.92)	4.84 (2.52-12.90)	3.08 (0.56-15.4)	9.10 (2.52-25.76)
Cuttack FD/s at Sankhatrasa (Serua)	4.3 (1.1-10.1)	5.51 (2.24-9.52)	3.27 (1.68-5.04)	1.17 (0.28-1.96)	1.38 (1.12-1.68)
Bhubaneswar FU/s (Kuakhai)	8.1 (2.8-29.7)	3.03 (0.56-6.72)	4.67 (1.96-11.20)	1.76 (0.56-5.60)	1.00 (0.56-1.12)
Bhubaneswar U/s (Kuakhai)	7.8 (1.7-19.0)	6.84 (2.57-13.96)	6.44 (1.96-14.60)	1.88 (0.56-4.48)	1.21 (0.84-1.68)
Bhubaneswar D/s (Daya)	7.7 (1.1-23.2)	10.75 (3.01-22.68)	3.51 (1.40-10.80)	3.28 (0.84-9.24)	8.31 (1.68-19.60)
Bhubaneswar FD/s (Daya)	10.8 (2.8-21)	9.05 (3.01-15.54)	4.51 (1.92-11.80)	2.83 (0.84-8.40)	7.98 (1.68-19.60)
Choudwar D/s (Birupa)	4.5 (0.8-11.8)	6.53 (1.07-14.75)	3.42 (1.68-7.30)	1.12 (0.28-1.68)	1.28 (0.84-1.68)

Table 3.25 Annual average and Range of values of Chemical Oxygen Demand (COD)

Monitoring Station	2011	2012	2013	2014	2015
	<b>Chemical Oxygen Demand (COD) (mg/l)</b>				
Sundargarh (lb)	11.3 (5.8-18.3)	10.4 (6.1-16.1)	8.5 (4.1-19.8)	6.7 (3.2-11.8)	6.1 (3.0-11.8)
Jharsuguda (lb)	10.2 (7.6-15.2)	10.7 (5.8-20.1)	8.4 (6.0-10.6)	7.3 (3.3-15.8)	7.5 (4.6-15.1)
Brajarajnaragar U/s (lb)	9.7 (7.4-12.7)	9.0 (5.5-16.1)	9.5 (5.8-16.2)	6.6 (4.0-9.9)	7.0 (3.4-18.2)
Brajarajnaragar D/s (lb)	12 (5.8-18.7)	12.1 (7.8-16.1)	12.8 (7.0-18.0)	9.4 (6.1-15.8)	9.8 (5.3-21.9)
Jharsuguda (Bheden)	11.1 (1.9-18.9)	12.7 (5.7-19.6)	12.4 (8.4-15.9)	11.0 (3.9-19.3)	10.3 (4.6-15.4)
Hirakud	9.8 (5.7-18.9)	11.0 (5.7-17.3)	10.8 (5.8-16.9)	8.8 (5.7-15.8)	9.3 (3.5-13.5)
Power Channel U/s	9.1 (5.2-17.6)	10.0 (5.8-14.1)	10.2 (5.8-14.2)	6.9 (5.1-9.9)	8.9 (5.3-15.8)
Power Channel D/s	11.5 (7.5-18.7)	14.2 (8.8-18.9)	12.9 (12.1-14.9)	9.4 (6.5-11.8)	13.6 (5.3-26.1)
Sambalpur U/s	12.2 (6.0-19.6)	13.1 (7.6-18.4)	12.8 (7.0-30.9)	10.8 (8.0-13.5)	9.0 (4.6-17.4)
Sambalpur D/s	20.9 (17.5-28.2)	22.9 (14.4-32.1)	24.5 (20.7-28.8)	20.9 (13.7-32.9)	19.2 (8.6-27.5)
Sambalpur FD/s at Shankarmath	15.9 (9.6-21.9)	16.5 (1.3-28.1)	19.5 (14.2-24.1)	16.5 (7.6-31.4)	14.5 (6.1-21.7)
Sambalpur FFD/s at Huma	13.3 (9.0-21.9)	14.9 (9.8-26.1)	15.2 (9.0-22.3)	13.8 (8.5-27.2)	11.0 (4.6-18.8)
Sonepur U/s	10 (6.8-17.3)	10.7 (7.4-13.8)	10.0 (5.9-12.4)	8.8 (6.5-12.0)	9.0 (3.0-15.3)
Sonepur D/s	13 (7.7-18.9)	15.5 (8.8-19.7)	14.4 (9.5-19.6)	10.4 (6.5-14.0)	12.5 (7.6-19.2)
Tikarapada	10.9 (4.1-15.7)	11.8 (6.8-17.5)	8.3 (5.8-12.1)	7.4 (4.8-11.3)	8.7 (3.8-15.9)
Narasinghpur	9.8 (6.1-16)	10.2 (4.9-14.5)	9.9 (5.6-13.9)	7.8 (4.9-10.0)	9.2 (3.4-17.3)
Munduli	11.2 (7.6-20.2)	9.1 (4.9-16.2)	9.1 (5.8-13.1)	7.9 (5.2-14.0)	9.4 (4.6-13.8)
Cuttack U/s	10.5 (6.8-16.2)	11.6 (8.1-18.1)	8.6 (6.8-13.8)	9.1 (6.5-11.0)	9.8 (6.1-15.2)
Cuttack D/s	19.8 (12.1-25.8)	20.5 (12.1-28.6)	21.7 (12.6-28.9)	18.2 (12.7-27.6)	16.1 (9.2-27.6)
Cuttack FD/s	13.5 (8.2-19.2)	15.7 (7.4-25.6)	17.8 (10.8-25.5)	13.3 (8.0-17.7)	11.4 (5.5-18.3)
Paradeep U/s	10.1 (6.1-15.4)	13.5 (6.6-25.9)	15.6 (8.6-37.8)	14.2 (6.8-24.7)	14.3 (6.7-24.4)
Paradeep D/s	22.2 (8.8-45.4)	21.0 (12.3-31.1)	19.9 (8.7-34.4)	25.3 (10.3-45.5)	24.5 (8.3-35.2)
Monmunda (Tel)	12 (6.0-19.2)	14.0 (6.9-29.5)	10.6 (6.0-21.6)	8.8 (5.7-17.7)	10.6 (5.1-27.6)
Cuttack U/s (Kathajodi)	12 (7.7-26.2)	12.8 (9.8-28.5)	11.1 (5.4-13.8)	11.5 (6.5-18.2)	9.9 (6.1-15.8)
Cuttack D/s (Kathajodi)	22.7 (11.4-33.9)	26.0 (7.4-32.8)	29.6 (19.9-37.1)	26.3 (16.4-40.0)	21.1 (16.6-24.4)
Cuttack FD/s at Mattagajpur (Kathajodi)	39.5 (18.5-84.8)	49.4 (31.4-80.3)	51.6 (21.7-83.6)	42.2 (12.1-76.6)	55.7 (24.8-127.1)
Cuttack FD/s at Sankhatrasa (Serua)	17.7 (7.7-27.9)	20.3 (14.5-28.9)	22.7 (14.5-27.3)	20.4 (10.2-36.0)	14.4 (9.6-20.7)

Table 3.25 contd..

Monitoring Station	2011	2012	2013	2014	2015
<b>Chemical Oxygen Demand (COD) (mg/l)</b>					
Bhubaneswar FU/s (Kuakhai)	9.6 (6.0-16.3)	11.4 (7.8-16.9)	8.4 (5.4-12.8)	8.8 (4.9-20.0)	8.9 (3.7-15.4)
Bhubaneswar U/s (Kuakhai)	14.8 (7.4-23.7)	16.6 (7.4-29.0)	16.8 (10.2-25.5)	12.0 (4.9-26.7)	11.5 (3.7-19.2)
Bhubaneswar D/s (Daya)	22.6 (15.4-34.9)	33.2 (22.1-40.8)	31.0 (19.9-37.5)	29.9 (20.6-38.0)	27.0 (19.9-37.4)
Bhubaneswar FD/s (Daya)	20.7 (10.5-34.3)	26.1 (18.3-38.6)	23.3 (10.9-30.0)	24.5 (19.6-33.5)	23.5 (16.8-31.5)
Choudwar D/s (Birupa)	9.9 (6.1-21.4)	11.6 (7.4-17.6)	14.9 (7.1-22.0)	10.1 (5.7-16.2)	9.3 (1.9-19.2)

Table 3.26 Annual average and Range of values of Total Alkalinity

Monitoring Station	2011	2012	2013	2014	2015
<b>Total Alkalinity (as CaCO<sub>3</sub>) (mg/l)</b>					
Sundargarh (lb)	54 (26-76)	59 (32-76)	60 (32-80)	55 (40-68)	58 (32-76)
Jharsuguda (lb)	58 (34-80)	60 (36-76)	57 (16-88)	58 (32-72)	56 (32-76)
Brajarajnar U/s (lb)	61 (32-84)	64 (36-82)	57 (40-72)	61 (36-76)	61 (36-76)
Brajarajnar D/s (lb)	60 (26-88)	65 (32-86)	64 (36-90)	62 (40-72)	61 (36-78)
Jharsuguda (Bheden)	74 (36-100)	74 (28-120)	71 (40-112)	74 (48-116)	85 (40-148)
Hirakud	72 (42-96)	73 (52-88)	79 (64-88)	76 (56-92)	78 (56-96)
Power Channel U/s	73.5 (42-96)	71 (52-84)	79 (64-88)	75 (48-92)	81 (54-100)
Power Channel D/s	73 (42-92)	73 (44-88)	79 (62-92)	76 (52-92)	82 (58-96)
Sambalpur U/s	74 (46-106)	72 (44-92)	78 (62-92)	77 (44-90)	77 (48-100)
Sambalpur D/s	78 (38-108)	76 (48-100)	85 (58-104)	76 (40-92)	87 (62-124)
Sambalpur FD/s at Shankarmath	78 (50-112)	82 (48-116)	83 (64-108)	86 (60-104)	93 (60-120)
Sambalpur FFD/s at Huma	72 (48-100)	74 (48-98)	79 (60-88)	81 (48-120)	80 (54-96)
Sonepur U/s	79 (56-98)	74 (44-96)	78 (58-116)	80 (52-98)	81 (48-100)
Sonepur D/s	89 (70-136)	88 (64-116)	91 (64-120)	87 (60-108)	92 (60-104)
Tikarapada	73 (52-90)	75 (56-92)	85 (68-104)	73 (40-90)	82 (60-96)
Narasinghpur	76 (58-104)	79 (60-92)	80 (56-98)	72 (44-94)	81 (60-108)
Munduli	80 (62-116)	78 (56-94)	82 (54-96)	72 (48-92)	81 (48-108)
Cuttack U/s	76 (52-120)	78 (62-88)	76 (56-96)	71 (44-92)	75 (48-96)
Cuttack D/s	78 (48-128)	79 (54-96)	78 (60-92)	76 (36-96)	82 (60-98)

Table 3.26 contd..

Monitoring Station	2011	2012	2013	2014	2015
	<b>Total Alkalinity (as CaCO<sub>3</sub>) (mg/l)</b>				
Cuttack FD/s	78 (50-104)	80 (62-96)	76 (52-92)	76 (48-96)	82 (58-102)
Paradeep U/s	71 (48-104)	82 (56-100)	77 (56-88)	85 (40-140)	96 (68-116)
Paradeep D/s	96 (72-116)	110 (88-172)	85 (60-108)	91 (36-150)	119 (68-216)
Monmunda (Tel)	80 (50-120)	82 (64-100)	81 (52-112)	68 (44-92)	78 (44-96)
Cuttack U/s (Kathajodi)	70 (60-96)	80 (60-102)	73 (56-88)	69 (44-92)	72 (58-84)
Cuttack D/s (Kathajodi)	75 (58-96)	81 (56-100)	79 (56-90)	78 (48-126)	89 (68-132)
Cuttack FD/s at Mattagajpur (Kathajodi)	111 (50-188)	130 (68-248)	133 (68-228)	91 (48-124)	141 (116-200)
Cuttack FD/s at Sankhatrasa (Serua)	77 (52-100)	77 (48-92)	77 (60-88)	79 (48-134)	79 (60-92)
Bhubaneswar FU/s (Kuakhai)	80 (52-100)	76 (56-88)	76 (68-88)	71 (48-88)	79 (62-96)
Bhubaneswar U/s (Kuakhai)	72 (50-92)	71 (48-92)	73 (50-88)	68 (52-86)	78 (52-96)
Bhubaneswar D/s (Daya)	77 (52-102)	77 (44-96)	78 (52-104)	71 (44-96)	88 (68-138)
Bhubaneswar FD/s (Daya)	75 (44-104)	73 (48-92)	78 (60-88)	69 (44-98)	85 (74-104)
Choudwar D/s (Birupa)	76 (60-92)	79 (48-96)	81 (60-144)	78 (36-104)	84 (58-108)

Table 3.27 Polluted river monitoring stations in Mahanadi river systems

Sl. No.	River	Monitoring station	Annual BOD Data range (mg/l)					Range value of BOD above 3.0 mg/l in the stretch	Priority as per CPCB Criteria
			2011	2012	2013	2014	2015		
1	Mahanadi river along Sambalpur	Sambalpur U/s	(0.8-2.1)	(1.1-2.4)	(0.3-3.6)	(0.5-1.8)	(0.3-1.9)	3.1-4.9	V
2		Sambalpur D/s	(1.8-3.8)	(1.7-4.9)	(2.2-4.2)	(1.2- 3.9)	(1.8-4.1)		
3		Sambalpur FD/s at Shankarmath	(1.1-2.9)	(1.0-3.7)	(1.4-3.6)	(1.1-3.1)	(1.2-3.3)		
4	Mahanadi river along Cuttack	Cuttack D/s	(1.8-3.6)	(1.6-3.9)	(1.6-2.8)	(1.7-2.5)	(1.5-2.8)	3.6-3.9	V
5		Cuttack FD/s	(1.0-2.8)	(1.0-2.8)	(1.4-2.4)	(1.1-2.0)	(1.0-2.0)		
6	Mahanadi river at Paradeep	Paradeep D/s	(0.7-3.0)	(0.7-3.7)	(1.0-2.7)	(0.8-2.7)	(0.8-2.9)		
7	Kathajodi river along Cuttack	Kathajodi U/s	(1.1-4.1)	(1.2-3.6)	(0.4-1.8)	(0.6 -1.6)	(0.5-1.8)	3.6-27.5	II
8		Kathajodi D/s	(2.4-3.9)	(1.5-4.4)	(2.5-4.8)	(2.1- 5.6)	(2.1-4.7)		
9		Kathajodi FD/s at Mattagajpur	(2.6-15.0)	(4.5-14.0)	(5.3-27.5)	(1.6-19.3)	(5.4-17.0)		
10	Serua river along Cuttack	Sankhatrasa	(1.3-3.3)	(1.4-3.6)	(1.8- 3.6)	(1.3-4.2)	(1.3-3.7)	3.3-4.2	V
11	Kuakhai river along Bhubaneswar	Bhubaneswar FU/s	(1.0-2.4)	(0.8-2.3)	(0.6-1.6)	(0.4-1.8)	(0.5-1.9)		
12		Bhubaneswar FU/s	(1.6-2.8)	(1.4-3.4)	(1.4- 3.1)	(0.7-2.7)	(0.7-1.9)	3.1-3.4	V
13	Daya river along Bhubaneswar	Bhubaneswar D/s	(2.2-6.5)	(3.0-6.0)	(3.4-5.0)	(2.8-5.4)	(3.5-5.4)	3.4-6.5	IV
14		Bhubaneswar FD/s	(1.2-4.8)	(1.4-4.1)	(2.6-4.1)	(2.2-4.7)	(1.9-4.6)		

Table 3.28 CWQI of Mahanadi river system during 2011-2015

Monitoring station	2011	2012	2013	2014	2015
	<b>CWQI</b>				
Sundargarh (lb)	85.26	85.37	85.28	100.00	85.52
Jharsuguda (lb)	85.26	85.13	100.00	84.03	84.25
Brajarajnaragar U/s (lb)	100.00	100.00	85.49	85.33	81.25
Brajarajnaragar D/s (lb)	85.51	85.37	100.00	95.86	78.82
Jharsuguda (Bheden)	100.00	100.00	85.47	100.00	85.48
Hirakud	100.00	100.00	100.00	84.56	85.08
Sambalpur U/s	85.48	85.13	68.39	75.47	75.38
Sambalpur D/s	47.5	43.85	49.57	46.52	48.56
Sambalpur FD/s at Shankarmath	65.02	55.08	69.83	66.39	56.65
Sambalpur FFD/s at Huma	84.02	74.00	100.00	96.74	82.48
Power Channel U/s	100.00	100.00	100.00	100.00	85.52
Power Channel D/s	100.00	100.00	100.00	85.06	85.33
Sonepur U/s	100.00	100.00	100.00	85.47	85.07
Sonepur D/s	85.48	85.51	85.28	85.02	83.00
Tikarapada	85.29	85.51	85.47	85.01	82.41
Narasinghpur	100.00	85.01	84.74	68.74	83.95
Munduli	100.00	84.64	84.68	69.86	80.9
Cuttack U/s	100.00	85.12	84.21	83.65	85.52
Cuttack D/s	52.32	53.04	40.06	52.56	55.55
Cuttack FD/s	63.71	64.93	41.67	57.07	58.29
Paradeep U/s	85.5	82.97	68.90	72.74	84.00
Paradeep D/s	82.52	84.77	65.92	81.55	82.11
Monmunda (Tel)	100.00	85.51	84.80	85.51	85.39
Cuttack U/s (Kathajodi)	85.51	72.3	83.83	83.2	85.02
Cuttack D/s (Kathajodi)	43.42	40.85	40.47	39.43	50.78
Cuttack FD/s at Mattagajpur (Kathajodi)	34.71	28.62	27.97	29.86	29.45
Cuttack FD/s at Sankhatrasa (Serua)	70.2	49.49	59.36	59.17	55.91
Bhubaneswar FU/s (Kuakhai)	100.00	100.00	61.94	61.76	82.21
Bhubaneswar U/s (Kuakhai)	83.04	80.87	59.65	30.13	64.23
Bhubaneswar D/s (Daya)	50.42	36.20	42.61	33.59	32.01
Bhubaneswar FD/s (Daya)	53.63	40.56	50.03	69.87	34.1
Choudwar D/s (Birupa)	83.8	85.01	62.64	82.53	80.34

**Table 3.29 Category of water quality of Mahanadi river system during 2011-2015 based on CWQI values**

Monitoring station	2011	2012	2013	2014	2015
	<b>Category</b>				
Sundargarh (Ib)	Good	Good	Good	Excellent	Good
Jharsuguda (Ib)	Good	Good	Excellent	Good	Good
Brajarajnaragar U/s (Ib)	Excellent	Excellent	Good	Good	Good
Brajarajnaragar D/s (Ib)	Good	Good	Excellent	Excellent	Fair
Jharsuguda (Bheden)	Excellent	Excellent	Good	Excellent	Good
Hirakud	Excellent	Excellent	Excellent	Good	Good
Sambalpur U/s	Good	Good	Fair	Fair	Fair
Sambalpur D/s	Marginal	Marginal	Marginal	Marginal	Marginal
Sambalpur FD/s at Shankarmath	Fair	Marginal	Fair	Fair	Marginal
Sambalpur FFD/s at Huma	Good	Fair	Excellent	Excellent	Good
Power Channel U/s	Excellent	Excellent	Excellent	Excellent	Good
Power Channel D/s	Excellent	Excellent	Excellent	Good	Good
Sonepur U/s	Excellent	Excellent	Excellent	Good	Good
Sonepur D/s	Good	Good	Good	Good	Good
Tikarapada	Good	Good	Good	Good	Good
Narasinghpur	Excellent	Good	Good	Fair	Good
Munduli	Excellent	Good	Good	Fair	Good
Cuttack U/s	Excellent	Good	Good	Good	Good
Cuttack D/s	Marginal	Marginal	Poor	Marginal	Marginal
Cuttack FD/s	Marginal	Fair	Poor	Marginal	Marginal
Paradeep U/s	Good	Good	Fair	Fair	Good
Paradeep D/s	Good	Good	Fair	Good	Good
Monmunda (Tel)	Excellent	Good	Good	Good	Good
Cuttack U/s (Kathajodi)	Good	Fair	Good	Good	Good
Cuttack D/s (Kathajodi)	Poor	Poor	Poor	Poor	Marginal
Cuttack FD/s at Mattagajpur (Kathajodi)	Poor	Poor	Poor	Poor	Poor
Cuttack FD/s at Sankhatrasa (Serua)	Fair	Marginal	Marginal	Marginal	Marginal
Bhubaneswar FU/s (Kuakhai)	Excellent	Excellent	Fair	Fair	Good
Bhubaneswar U/s (Kuakhai)	Good	Good	Marginal	Poor	Fair
Bhubaneswar D/s (Daya)	Marginal	Poor	Poor	Poor	Poor
Bhubaneswar FD/s (Daya)	Marginal	Poor	Fair	Fair	Poor
Choudwar D/s (Birupa)	Good	Good	Fair	Good	Good

## **WATER QUALITY STATUS OF BRAHMANI RIVER SYSTEM (Sankh, Koel, Brahmani, Nandira, Kisindajhor and Kharasrota rivers)**

Water quality of Brahmani river system is monitored on the main river Brahmani, on its tributaries like Sankh, Koel, Nandira and Kisindajhor (tributary of Nandirajhor), and on its distributary Kharasrota river.

### **4.1 USE BASED WATER QUALITY STATUS**

#### **4.1.1 Water quality in respect of primary criteria**

The seasonal average values of pH, DO, BOD and TC at 26 monitoring stations on Brahmani river system pertaining to the period 2011-2015 are described in Tables 4.1 - 4.9.

**pH and DO :** As may be seen from the data, the pH and DO values show more or less a stable pattern throughout the river stretch. The seasonal average value of pH varies within the range 7.0-8.5. The water at all the monitoring station is fairly rich in oxygen. Both the parameters conform to the quality criteria for Class-A.

**BOD :** The seasonal average values of BOD at all the monitoring stations excluding Panposh D/s and Rourkela D/s generally conform to Class-C. At these two stations on Brahmani river, seasonal average values of BOD always remained above the tolerance limit of Class C (3.0 mg/l, min). The monthly BOD value at Panposh D/s and at Rourkela D/s exhibited maximum value of 6.6 mg/l and 5.3 mg/l respectively during the period 2011-2015. Frequency of deviation of monthly BOD value from the stipulated value at Panposh D/s is more than 90% of time during the period 2011-2015 and at Rourkela D/s, it is 42%-92% of the time during the entire period of study. Occasional deviations from the stipulated value are observed at Rourkela FD/s at Attaghat and Rourkela FFD/s at Biritola on Brahmani river, at Nandira D/s on Nandira jhor and in Kisindajhor.

**TC :** Total coliform count at none of the stations generally conform to Class-A or Class-B water. Water quality at Panposh D/s, Rourkela D/s and Talcher D/s do not conform to the Class-C. The magnitude and frequency of violations of TC from the stipulated value (less than 5000 MPN/100 ml) at these three stations do not warrant the water quality to be classified as Class-C. At all other stations wide fluctuations in the TC values have been observed during the study period.

The annual average and the range of BOD and TC values at all the 26 monitoring stations are given in Table 4.10. Frequency of violation of BOD and TC values from the stipulated values (3.0 mg/l and 5000 MPN/100 ml respectively) are also given in Table 4.10.

Percent violations of BOD during the study period at all stations are presented in Fig. 4.1 and Fig. 4.2. From the data and figures, the decreasing trend of frequency of deviations from the tolerance limit of BOD during the entire study period is Panposh D/s (92%), Rourkela D/s (68%), Rourkela FD/s at Attaghat (9%) and Rourkela FFD/s at Biritola (21%), Nandira D/s (23%) and Kisindajhor (16%).

Spatial variation of annual average values of BOD and TC during the period 2011-2015 in the stretches of Brahmani river system are presented in Fig. 4.3 (a) – (b) and 4.4 (a) – (b) respectively. Fig. 4.3(a) revealed that in the entire stretch of Brahmani river, water quality does not conform to Class C with respect to BOD only in the Rourkela stretch which covers four stations, that is, Panposh D/s, Rourkela D/s, Rourkela FD/s at Attghat and Rourkela FFD/s at Biritola.

**Free Ammonia** : The annual average and range values of ammonical nitrogen and free ammonia are given in Table-4.11. Free ammonia values at all stations conform to the stipulated value (1.2 mg/l, max) for Class-D inland surface water (Fish culture and wildlife propagation). No regular pattern is observed regarding the level of ammonia in the river.

**EC, SAR and B** : Seasonal average values of EC at these 26 monitoring stations are given in Table 4.12. Annual average and range value of SAR and B at these monitoring stations are given in Table 4.13. From the data, it can be seen that the EC, SAR and B values are far too low compared to the stipulated values in Table 2.4, to cause any concern to consider the suitability of the entire stretch of river water to be used for irrigation.

### 4.1.2 Water quality in respect of other parameters

**TDS and Total Hardness** : Annual average and range values of total dissolved solids (TDS) and total hardness (TH) during the period 2011- 2015 are given in Table 4.14. The entire river stretch conforms to Class-A inland surface water quality with regard to TDS and total hardness content. In terms of degree of hardness, the river water in general may be described as soft (0-60 mg/l) to moderately hard (61-120 mg/l) . However, at Nandira D/s and Kisindajhor, water quality is of moderately hard to very hard category (>180 mg/l).

**Nitrates** : Annual average and range values of nitrate during the period 2011- 2015 are given in Table 4.15. The annual average nitrate concentrations have never exceeded the stipulated value (20 mg/l) for Class-A water, though occasional deviation of monthly nitrate values from the stipulated value for Class A has been observed at Sankh U/s, Panposh U/s, Panposh D/s, Rourkela D/s, Rourkela FD/s at Attghat, Rourkela FFD/s at Biritola, Bonaigarh, Samal and Talcher FD/s. However, the monthly nitrate concentration never exceeded the stipulated limit of 50 mg/l for Class-C.

**Chloride, Sulphates and Fluorides** : Annual average and range values of chlorides, sulphates and fluorides at these monitoring stations during the period 2011-2015 are given in Table 4.16, 4.17 and 4.18 respectively. A comparison of these values with the stipulated limits for Class-A revealed that, water quality in respect of chlorides, sulphates and fluorides at all stations conform to the highest class. Occasional deviation of fluoride concentrations from the stipulated value 1.5 mg/l has been observed at Panposh D/s, Rourkela D/s, Nandira D/s and Kisindajhor.

**Heavy Metals**: Water pollution from heavy metals is expected to occur due to industrial effluents (unless some metals have geological origin). Data given in Table 4.19 (a) represent the annual average and range of concentrations of chromium (VI) and mercury during the period 2014 and 2015. Data given in Table 4.19 (b)-(h) represent the annual average and range of concentrations of total chromium, iron, nickel, copper, zinc, cadmium and lead respectively during the period 2011-2015.

From the tables it is observed that the values of these metals are well within the respective tolerance limits, even at Panposh D/s and Talcher D/s, where maximum impact of industrial effluent is expected.

#### **4.1.3 Use based classification**

From the water quality data and frequency of violation discussions made in the sec. 4.1.1 and 4.1.2, it may be reasonable to conclude that the water quality at all stations, except Panposh D/s, Rourkela D/s and Talcher D/s, can be classified as Class C/D/E. Water quality at these three stations may qualify for Class-D/E. At Panposh D/s and Rourkela D/s, the water quality downgrading parameters are both BOD and TC and at Talcher D/s, TC is the water quality downgrading parameter. Similarly at Nandira D/s and Kisindajhor do not conform to Class C with respect to both BOD and TC. An additional water quality downgrading parameters at Panposh D/s, Rourkela D/s, Nandira D/s and Kisindajhor is fluoride.

### **4.2 BIOLOGICAL ASSESSMENT OF WATER QUALITY**

The annual average and range of biomonitoring results expressed in terms of Saprobic index (SI) and Diversity index (DI) and biological class of the five monitoring stations such as Panposh U/s, Panposh D/s, Rourkela D/s, Talcher U/s and Talcher D/s during the period 2011-2015 are given in Table 4.20. Taking into consideration the observed biological indices and the BOD values (Tables 4.10), the river stretch along these monitoring stations are in a state of slight to moderate pollution (that is, B-C) as per the criteria given in Table 2.6.

### **4.3 WATER QUALITY IN TERMS OF WHOLESOMENESS**

#### **4.3.1 Wholesomeness in terms of regular parameters**

The wholesomeness of water quality at these 26 monitoring stations have been assessed with respect to general parameters specified in Table 2.7. Of the eight parameters listed in Table 2.7, results for bioassay are not available and therefore, the water quality are assessed with regard to the remaining seven parameters. Annual average and range values of (Nitrite + Nitrate)- N at the monitoring stations are given in Table 4.21. Annual average and range values of total suspended solids (TSS) including monsoon period and excluding monsoon period are given in Table 4.22. Considering pH, DO, EC, (Nitrite + Nitrate)-N values, the level of wholesomeness of the river water may be considered as “desirable”. With regard to BOD, the water level is “desirable” at all stations except at the Rourkela stretch. The level of wholesomeness at this stretch conformed to “acceptable” limit during most period of time, however, on few occasions, the water quality was below “acceptable” with respect to BOD. Water quality with regard to the parameter TSS (during non-monsoon period) is also in “acceptable” level.

However, the situation changes entirely on introduction of FC values in the above assessment. Investigation on the data given in Table 4.23 (percent violation of FC values from 2000 MPN/100 ml) shows that the water quality in the entire stretch not even “acceptable” during most part of the period under report.

#### **4.3.2 Wholesomeness in terms of special parameters**

Annual average and range values of total ammonical nitrogen ((ammonium+ammonia)-N) at all the monitoring stations are given in Table 4.11 which reveals that at most of the stations water

quality with respect to total ammoniacal nitrogen are within “acceptable” limits during the period under study. Occasional deviations from “acceptable” limit have been observed at Panposh D/s during 2011, 2014 and 2015; at Rourkela D/s during 2012, 2014 and 2015; Rourkela FD/s at Biritola during 2012; Talcher D/s during 2011 and 2015; and at Talcher FD/s during 2011.

From the annual average and range values of total phosphate-P given in Table 4.24, it is observed that the water quality at most of the stations are not within the “acceptable” limits under the period of study.

Annual average and range values of TKN during 2011-2015 are given in Table 4.25. It has been observed that annual average values of TKN at most of the monitored locations do not meet the “acceptable” limit of 3.0 mg/l during 2011 and 2012. However, during 2013, 2014 and 2015, annual average values of TKN at all stations remain within the “acceptable” limit except at Panposh D/s and Rourkela D/s, though the monthly TKN values exhibit occasional deviation from the limit at all the stations. Thus it may be concluded water quality of Brahmani river at all stations do not meet the “acceptable” limit with respect to TKN in most part of time during 2011, 2012 and 2013. However, during 2014 and 2015, excepting Panposh D/s and Rourkela D/s, water quality at other 24 stations meet “acceptable” limit.

It is seen from Table- 4.19 that the annual average as well as monthly data on concentrations of metals like total chromium, zinc, copper, nickel, lead, cadmium and mercury in the river water at all station are within the “acceptable” limits.

#### **4.4 WATER QUALITY IN TERMS OF COD AND ALKALINITY**

Annual average and range values of COD and alkalinity are given in Table-4.26 and 4.27 respectively. Both the parameters are within acceptable limits for most of the beneficial uses of water.

#### **4.5 WATER QUALITY TREND**

##### **4.5.1 Sankh River**

Water quality of this river is monitored at only one location before its confluence with Koel river at Vedvyas. As there is neither any urban centre nor any organized domestic wastewater discharge to the river, the water quality remains at the Class C level. Variation of BOD and TC is presented in Fig.4.4 (a) and (b) respectively.

##### **4.5.2 Koel River**

Water quality of this river is monitored at only one location before its confluence with Sankh river at Vedvyas. As the monitoring location is upstream to the domestic wastewater discharge points to Koel river, the water quality at the monitoring location remains at the Class C level. Variation of BOD and TC is presented in Fig.4.4 (a) and (b) respectively.

##### **4.5.3 Brahmani River**

Brahmani river is formed by the combined waters of Koel and Sankh rivers at Vedavyasa. Water quality data at Panposh U/s (Vedavyasa) generally remains at Class-C level. From the

data, it is seen that there is a deterioration of water quality at Panposh D/s and Talcher D/s. This is an expected observation, since a number of large and medium industries and mines are operating at Rourkela and Angul Talcher industrial complex and the industrial and domestic wastewater in these two areas ultimately find their way to Brahmani.

The spatial variation of water quality is in a predictable way. By the time the river reaches Bonaigarh, there is a significant improvement in water quality, which remain more or less the same up to Talcher U/s through Rengali and Samal, since there is no major urban settlements or wastewater outfalls in this stretch.

After confluence of Nandira river with Brahmani river, the water quality at Talcher D/s deteriorates both with respect to BOD and TC. Though BOD value increases in comparison to U/s stations of Talcher, still it remains within the prescribed limit of 3.0 mg/l, whereas both TC and FC counts significantly exceeds the prescribed limit. The water quality gets improved upto Dhenkanal U/s. Impact of Dhenkanal town on the water quality of Brahmani river is not that much significant irrespective of increase in TC and FC counts.

After Bhuban, there is some restoration in the water quality which continues upto Pottamundai through Dharmasala (about 108 km.). The magnitude of improvement in the water quality in this stretch, is however not the same as that in the Bonaigarh – Rengali – Samal stretch, since there is increase in the population density and intensity in agricultural activities as the river enters into the deltaic region. Fig. 4.3(a) and (b) shows the spatial variation in the water quality in respect of BOD and TC respectively, along the river stretch.

During the eighties and early nineties, water quality of the river at Rourkela and Angul-Talcher caused much concern. Presently, however, there is no indication of any severe industrial pollution in these two stretches. This could be because of some effective control measures taken by the industries and mines, subsequently. A significant step in this direction is recycling / reusing of wastewater by some of the major polluting units and reduction in the quantity of effluent generation by some large industries. Improvement in the water quality over the years is reflected in the water quality trend at Talcher D/s and the rivulet Nandira. This small tributary of Brahmani originates at Golabandha and after traveling a distance of about 39 km., joins Brahmani at Kamalnaga. Most of the major industries and mines in the Angul-Talcher area are located in the catchment of Nandira. Till late nineties, it used to receive effluent (directly or indirectly) heavily laden with suspended solids and other pollutants, from many major industries. With improved pollution control measures and recycling of wastewater, the quantum of effluent discharged to Nandira has now been reduced considerably, leading to a significant improvement in its water quality and hence at Talcher D/s.

#### 4.5.4 Kharasrota River

It originates from Brahmani river at Jenapur and after travelling a distance of 150 Km rejoins with Brahmani river before the confluence of Brahmani and Baitarani rivers at Dhamra. There are neither any major towns or urban settlements or industries located on the bank of Kharasrota river. Therefore, the water quality remains at Class-C level upto Binjharpur. However, the human activities on river water has increased significantly at Aul which is evident from the increased TC and FC count values.

#### 4.6 POLLUTED RIVER MONITORING STATIONS IN BRAHMANI RIVER SYSTEM

The monitoring stations on Brahmani river systems not meeting the tolerance limit of 3.0 mg/l for the criteria parameter BOD of Class-C are identified as polluted river monitoring stations and have been categorized into different priority classes as proposed by CPCB (Table 2.9). Comparison of BOD data obtained during the period 2011-2015 (Table 4.10) with the tolerance limits for Class-C revealed that there are six polluted river monitoring stations. The polluted monitoring locations in a continuous sequence are identified as the polluted river stretches. The list of polluted river monitoring stations with annual BOD range and priority class is given in Table 4.28. There is only one polluted river stretch, that is Rourkela stretch (19 Km) (Priority-IV) along Brahmani river. Besides this, Nandira D/s (Priority-IV) on Nandira jhor and Kisindajhor (Priority-IV) on Kisindajhor have also been identified as the polluted river monitoring stations.

#### 4.7 WATER QUALITY INDEX OF MONITORING STATIONS IN BRAHMANI RIVER SYSTEM

The Canadian Water Quality Indices (CWQI) of 26 monitoring stations on Brahmani river system are calculated for the period 2011-2015 (Table 4.29). For the CWQI evaluation, four critical variables such as pH, DO, BOD and TC are taken into consideration. Based on the CWQI values, the water quality of the monitoring stations are ranked into different categories as recommended in Table 2.10. As evident from the Table 4.30 for the CWQI ranks, water quality of Sankh river at Sankh U/s always remained in Good category during the study period. Though there is no definite source of pollution in this monitoring station, the instream activities are responsible for the occasional deviation of TC values beyond the tolerance limit and therefore lowers the water quality from Excellent to Good.

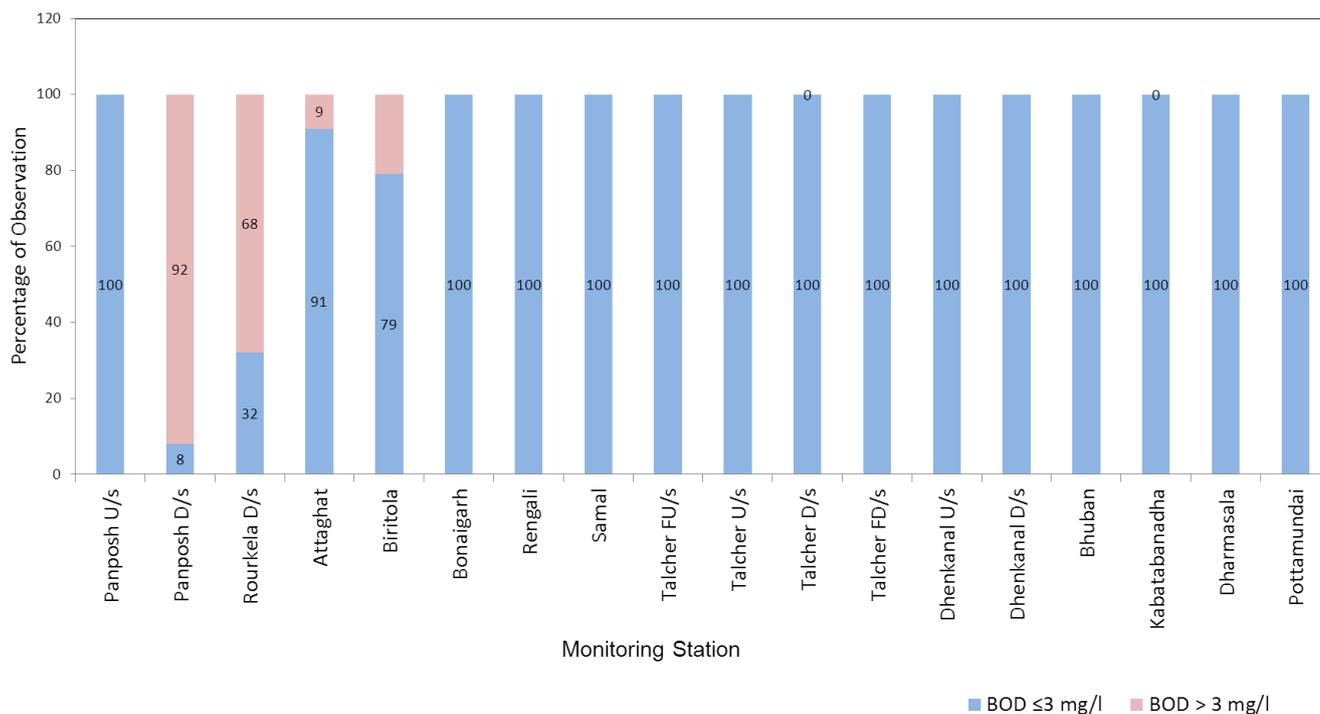
Water quality of Koel river at Koel U/s varied within Fair-Good category during the study period. The instream activities at this monitoring station are responsible for the frequent deviation of TC values beyond the tolerance limit for which the water quality is lowered.

In the Rourkela stretch of Brahmani river, water quality is within Fair-Good category at the Upstream of Rourkela city. This has been lowered to Poor-Marginal category at the downstream of the Rourkela town. However, the water quality has been improved to Fair-Good at the further downstream stations such as Attaghat and Biritola. The lowering of water quality at the downstream of Rourkela city is due to frequent observation of high values of both BOD and TC. From Bonaigarh to Talcher U/s, water quality of Brahmani river remained within Good-Excellent category, except during the year 2014 when water quality at Bonaigarh, Talcher FU/s and Talcher U/s has been lowered to Fair category. Water quality at the downstream of Talcher town remained mostly within Fair category. Similarly water quality of Brahmani river at the downstream of Dhenkanal town has also been lowered to Marginal-Fair category. In both places, TC is the major water quality deteriorating parameter.

Water quality of Brahmani river from Bhuban to Pottamundai remained within Fair – Good category.

Water quality of Kharasrota river at the three monitoring stations, namely, Khanditara, Binjharpur and Aul, remained mostly in Good category.

**Fig. 4.1 Frequency of violation of BOD in Brahmani River (2011-2015)**



**Fig.4.2 Frequency of violation of BOD in Sankh River, Koel River, Nandira Jhor, Kisinda Jhor and Kharasrota River (2011-2015)**

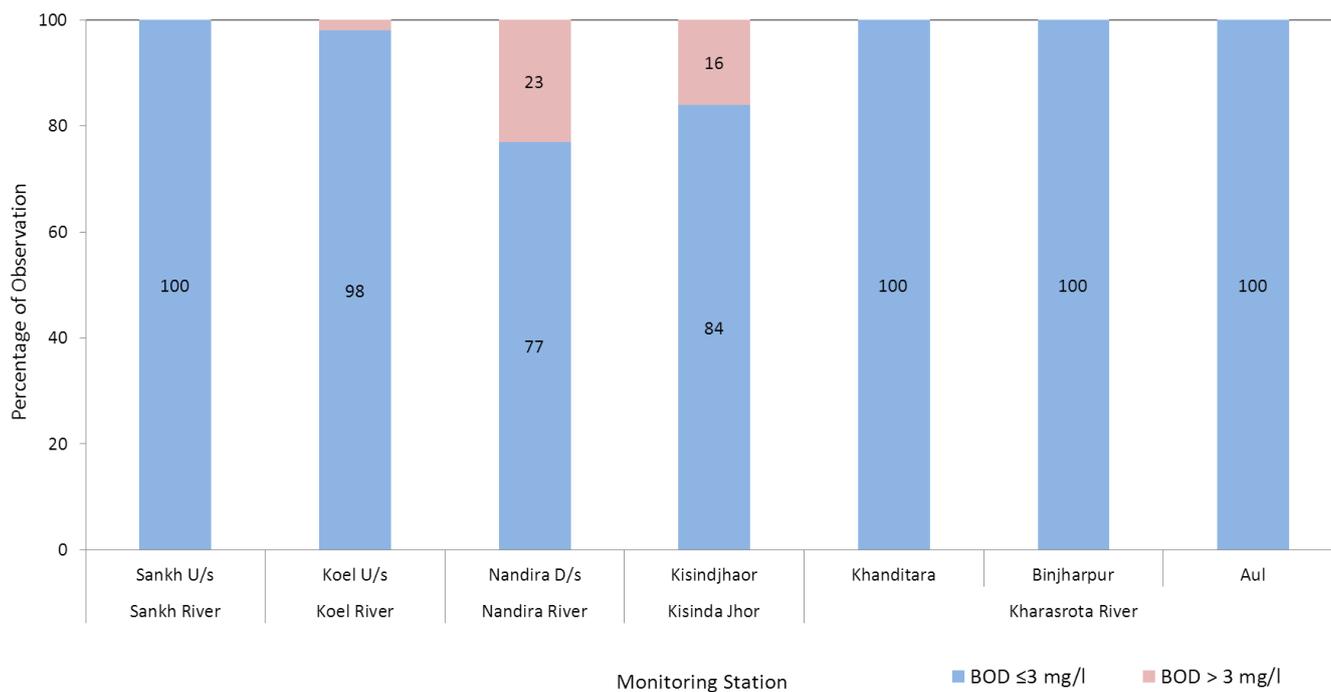


Fig.4.3 (a) Spatial variation of BOD in Brahmani River (2011-2015)

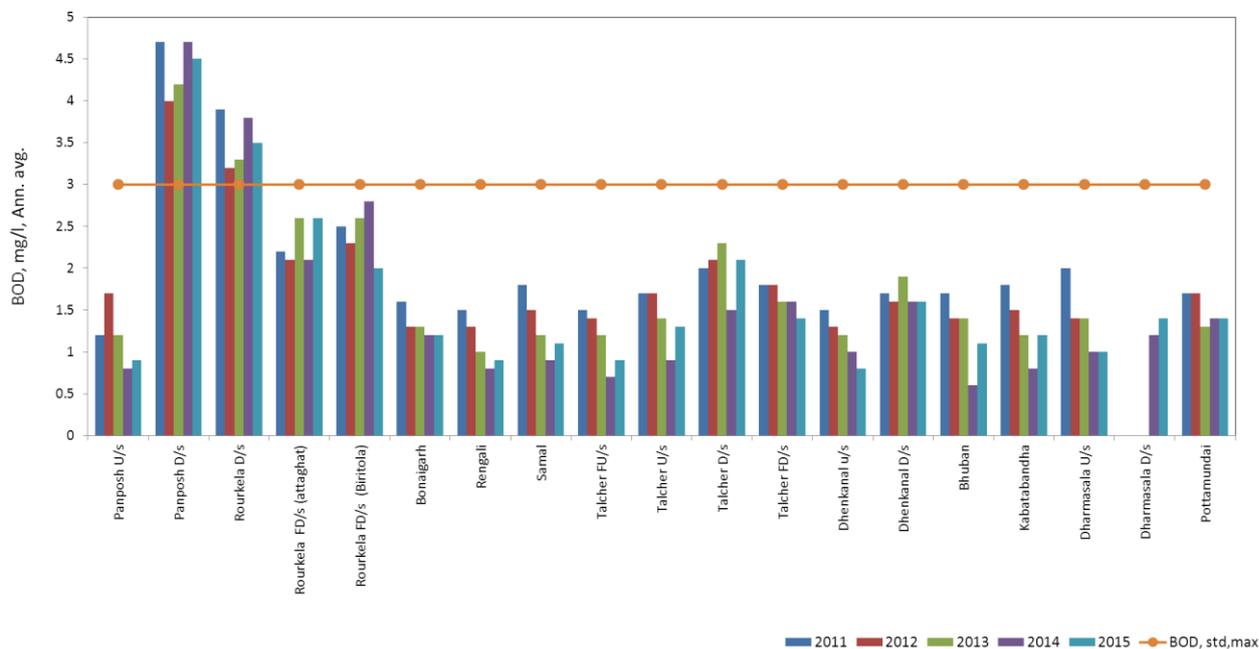
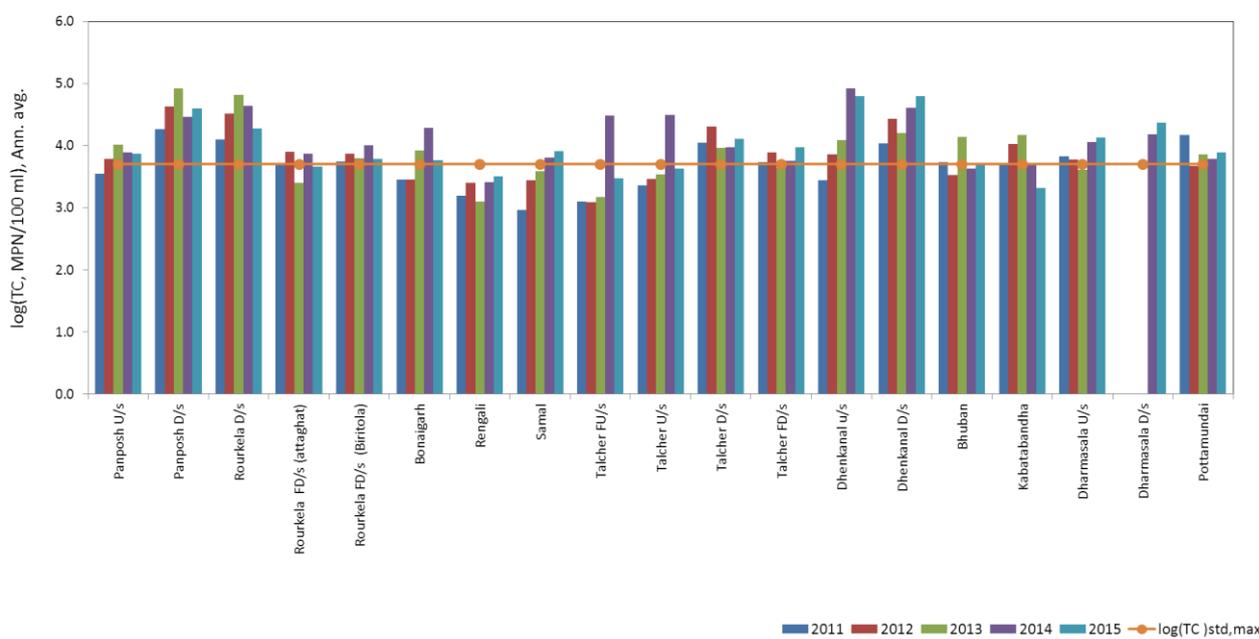
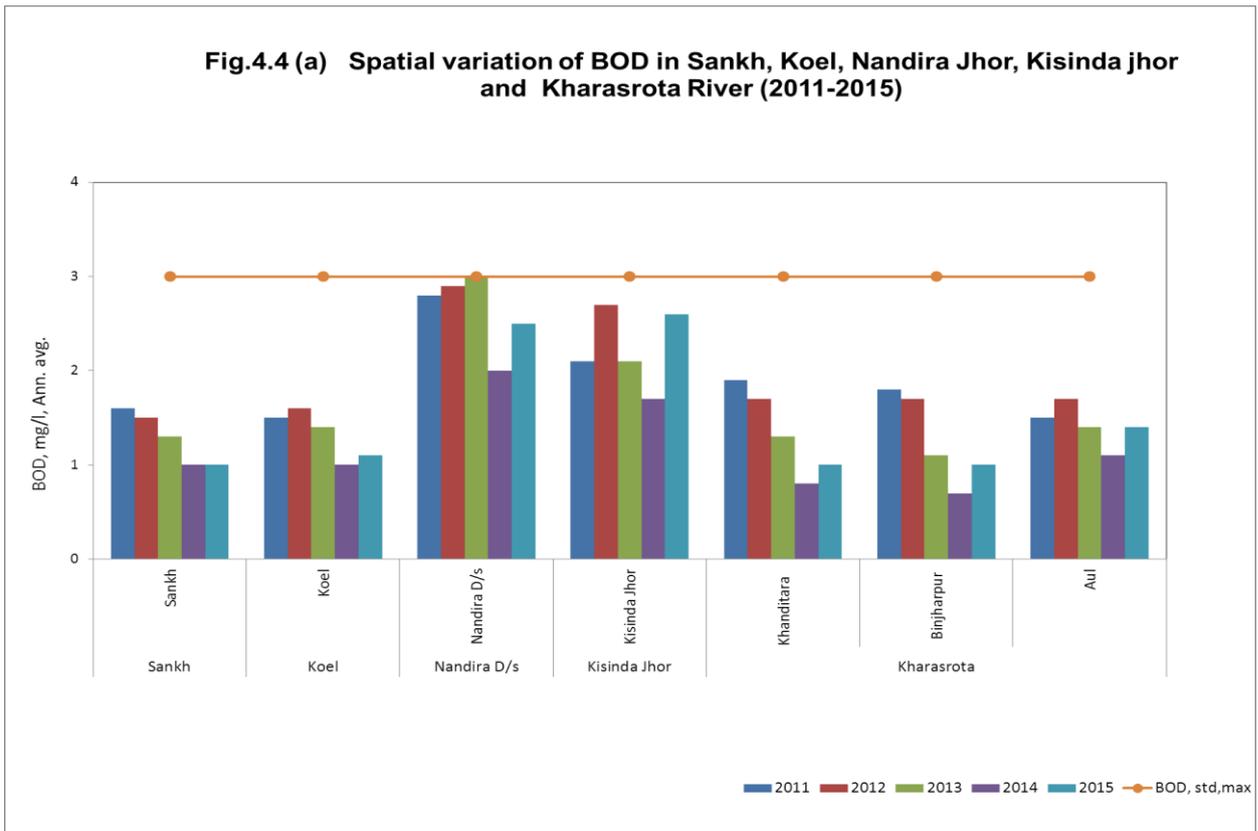


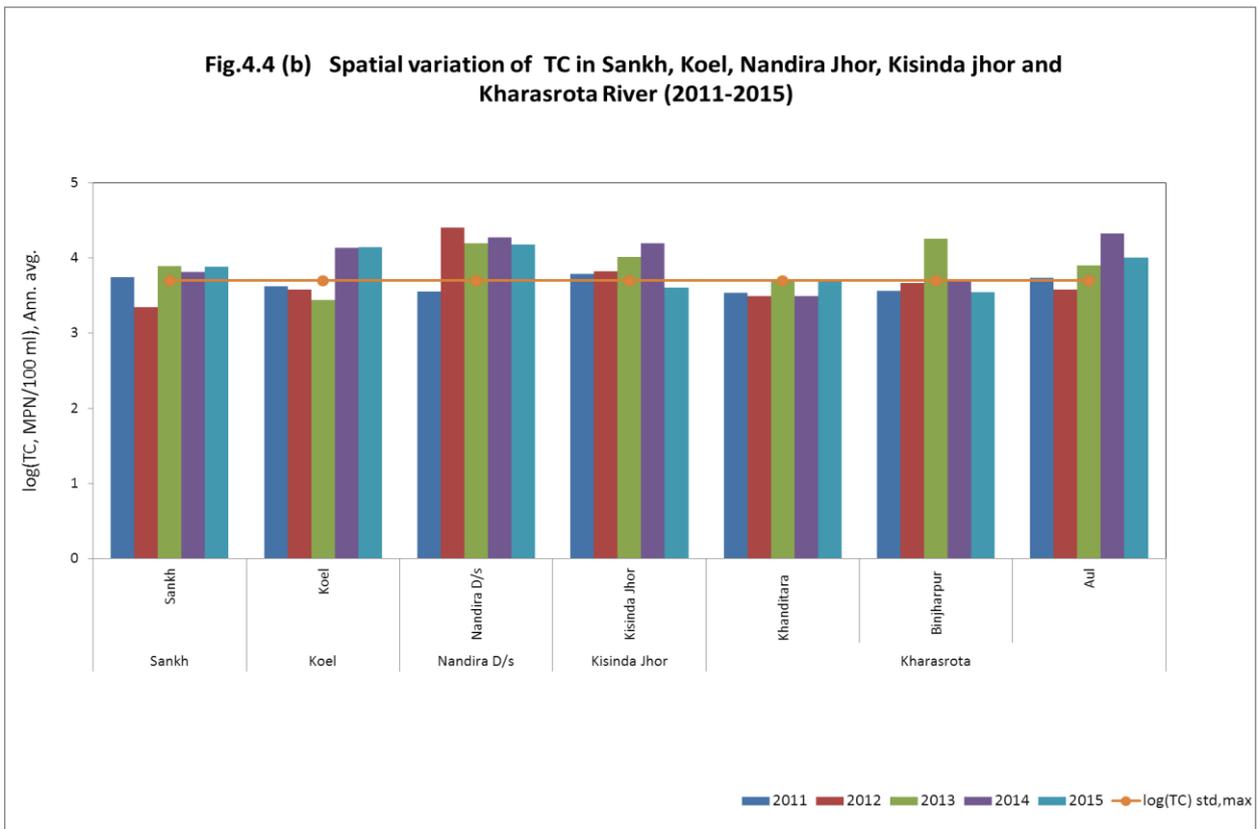
Fig.4.3 (b) Spatial variation of TC in Brahmani River (2011-2015)



**Fig.4.4 (a) Spatial variation of BOD in Sankh, Koel, Nandira Jhor, Kisinda jhor and Kharasrota River (2011-2015)**



**Fig.4.4 (b) Spatial variation of TC in Sankh, Koel, Nandira Jhor, Kisinda jhor and Kharasrota River (2011-2015)**



**Table 4.1 Seasonal average values of pH, DO, BOD and TC in Sankh river at Sankh U/s and in Koel river at Koel U/s**

Parameter	Year	Sankh U/s				Koel U/s			
		W	S	M	PM	W	S	M	PM
pH	2011	7.2	7.8	7.8	7.9	7.8	8.0	7.5	7.8
	2012	7.9	7.8	7.5	8.0	8.1	8.0	7.3	7.8
	2013	8.0	7.9	7.6	7.5	8.2	8.3	7.7	8.0
	2014	8.1	7.9	7.2	8.0	8.3	7.7	7.7	8.1
	2015	7.2	7.9	7.8	7.7	7.9	7.9	7.8	8.1
DO (mg/l)	2011	8.9	6.7	6.6	7.1	8.7	6.5	6.7	6.6
	2012	8.6	6.8	7.7	8.6	8.4	6.5	7.3	7.8
	2013	8.5	7.7	6.7	7.7	9.9	6.8	6.7	8.4
	2014	8.1	6.4	7.3	8.0	8.9	7.1	6.7	7.7
	2015	9.0	7.3	6.7	8.1	8.8	7.6	6.7	8.1
BOD (mg/l)	2011	1.1	1.9	2.0	1.5	1.1	1.2	2.4	1.7
	2012	1.4	1.5	1.6	1.0	1.6	1.8	1.6	1.5
	2013	1.5	1.7	0.6	1.1	1.7	1.8	0.9	0.5
	2014	0.5	0.7	1.6	1.0	0.8	1.1	1.4	0.5
	2015	1.3	1.0	0.8	0.6	1.1	1.4	0.9	0.7
TC ('00) (MPN/100 ml)	2011	6.30	11.60	190.13	71.38	7.10	9.55	136.67	53.56
	2012	11.27	21.75	28.63	7.95	12.13	23.75	66.67	54.50
	2013	39.00	4.98	227.67	17.00	29.00	20.75	45.33	4.90
	2014	2.30	11.63	141.33	116.50	2.30	34.55	330.00	104.50
	2015	19.77	14.70	142.67	165.00	72.67	21.75	376.67	179.50

Water Quality of Major Rivers of Odisha

**Table 4.2 Seasonal average values of pH, DO, BOD and TC in Brahmani river at Panposh U/s, Panposh D/s, Rourkela D/s, Rourkela FFDs at Attaghat and Rourkela FFDs at Biritola**

Parameter	Year	Panposh (U/s)				Panposh (D/s)				Rourkela (D/s)				Rourkela FFDs at Attaghat				Rourkela FFDs at Biritola			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	7.9	7.8	7.5	7.8	7.5	7.1	7.6	7.6	7.4	7.3	7.7	7.6	7.9	7.2	7.8	7.9	7.9	7.7	7.4	7.8
	2012	7.8	7.9	7.5	8.2	7.5	7.5	7.5	8.1	7.7	7.6	7.5	7.7	7.8	7.9	7.4	8.2	7.7	8.2	7.6	7.8
	2013	8.1	7.8	7.8	7.9	7.6	7.2	7.7	7.3	7.6	7.3	7.5	8.5	8.0	7.8	7.6	7.4	7.8	7.8	7.5	7.8
	2014	8.2	8.0	7.5	7.7	8.2	8.0	7.2	7.6	8.3	7.8	7.2	7.4	8.0	8.1	7.2	7.9	7.9	8.1	8.0	8.1
	2015	7.9	7.9	7.6	8.0	7.6	7.2	7.6	7.4	7.6	7.6	7.7	7.5	7.8	7.8	7.8	8.2	7.9	7.5	7.6	8.3
DO (mg/l)	2011	8.0	6.9	6.6	7.0	7.0	6.1	6.8	6.4	6.8	6.4	6.7	6.6	8.0	6.8	6.8	6.7	7.5	6.8	6.0	6.9
	2012	8.0	6.2	7.9	7.9	7.4	5.5	7.1	7.1	7.4	5.9	7.7	7.6	7.6	7.3	6.6	8.9	8.1	8.0	7.3	8.5
	2013	8.0	7.4	6.6	7.9	7.0	6.5	6.2	7.6	7.9	6.9	6.3	7.4	8.7	8.2	7.0	7.2	9.2	8.4	6.6	7.5
	2014	8.2	7.3	7.0	7.5	8.4	6.6	6.4	7.3	8.0	8.5	6.6	7.2	9.3	7.5	6.6	7.4	9.3	7.3	6.7	7.5
	2015	7.9	7.2	6.9	7.9	7.5	6.3	6.2	5.9	7.5	6.6	6.7	6.7	8.1	6.9	6.6	7.1	7.7	6.6	6.8	7.7
BOD (mg/l)	2011	1.3	1.1	1.5	1.2	4.3	5.8	4.1	3.8	3.8	4.9	2.9	3.1	1.9	2.7	2.2	1.7	2.4	2.7	2.5	2.2
	2012	1.6	1.9	1.5	1.6	3.6	4.3	3.9	4.0	3.0	3.3	3.2	3.5	2.0	2.3	1.8	2.2	2.2	2.4	2.3	2.2
	2013	1.9	1.5	0.6	0.6	5.2	4.6	3.1	4.2	4.1	4.0	1.8	3.1	3.1	2.8	1.9	2.0	3.5	2.8	1.6	2.7
	2014	0.5	0.9	0.9	0.6	5.5	4.8	4.1	4.7	4.8	3.9	3.2	3.9	2.9	2.0	2.0	2.3	4.5	2.6	2.3	3.4
	2015	1.1	0.9	0.6	0.8	4.8	4.6	4.0	4.6	4.0	3.3	3.0	4.0	2.9	2.2	2.5	2.9	2.7	1.8	1.8	1.7
TC ('00) (MPN/100 ml)	2011	18.00	21.75	70.67	44.56	126.00	101.00	416.67	201.56	19.50	45.75	354.00	165.33	14.00	30.35	119.00	56.67	16.00	36.25	125.00	60.33
	2012	23.33	68.25	79.00	39.00	203.33	457.50	253.33	730.00	81.00	323.50	233.33	445.00	55.33	66.50	53.00	35.00	49.00	67.50	106.33	92.00
	2013	92.00	52.00	132.00	240.00	540.00	236.33	1146.67	1600.00	920.00	213.50	956.67	920.00	136.33	11.05	47.77	7.90	33.33	78.50	77.50	3.30
	2014	49.00	53.50	142.67	39.00	280.00	272.50	413.33	230.00	220.00	205.00	540.00	975.00	3.30	25.75	169.33	86.50	24.00	43.00	230.00	88.95
	2015	63.67	81.75	80.67	79.00	110.00	485.00	353.33	600.00	149.67	117.25	203.33	335.00	17.97	26.90	99.33	40.50	49.63	22.73	113.00	49.00

Water Quality of Major Rivers of Odisha

**Table 4.3 Seasonal average values of pH, DO, BOD and TC in Brahmani river at Bonaigarh, Rengali and Samal**

Parameter	Year	Bonaigarh				Rengali				Samal			
		W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	8.0	7.9	7.7	7.9	7.7	8.1	7.4	7.8	8.0	7.8	7.6	7.7
	2012	8.0	8.2	7.2	7.7	7.4	7.9	7.8	7.3	7.6	7.6	7.9	7.9
	2013	8.0	8.0	7.6	7.8	8.0	8.2	7.6	7.7	8.2	7.9	7.7	7.7
	2014	7.7	8.1	7.5	8.0	8.1	8.1	7.5	7.7	7.8	7.6	7.3	7.8
	2015	7.9	7.8	7.6	7.6	7.8	7.8	7.8	7.7	7.5	7.8	7.3	7.3
DO (mg/l)	2011	8.4	7.7	6.8	7.4	8.5	7.4	7.3	8.0	7.8	6.8	7.6	7.5
	2012	8.2	7.9	7.8	9.9	8.1	7.9	8.0	9.4	8.0	7.6	7.4	8.0
	2013	9.1	8.0	6.8	7.7	8.0	8.0	7.8	8.4	9.1	7.7	7.0	8.4
	2014	8.9	7.4	6.8	7.2	8.5	7.9	7.1	7.6	7.9	7.6	7.5	8.0
	2015	8.7	7.4	6.7	8.2	8.3	7.2	7.0	7.8	8.2	7.9	7.3	8.0
BOD (mg/l)	2011	1.4	1.7	2.1	1.6	1.7	1.4	2.1	1.4	1.9	1.7	2.0	1.6
	2012	1.1	1.6	0.9	1.2	1.1	1.1	1.2	2.1	1.4	1.5	1.3	2.1
	2013	1.8	1.6	0.9	0.4	1.7	0.8	0.7	0.4	1.5	1.4	1.1	0.5
	2014	0.8	0.9	1.8	1.3	0.4	0.5	0.8	1.2	1.0	0.7	1.1	1.3
	2015	1.2	1.2	0.8	1.7	1.1	1.1	1.0	0.5	1.1	1.2	0.9	1.0
TC ('00) (MPN/100 ml)	2011	24.50	20.75	44.67	29.89	10.00	12.10	28.00	18.43	8.15	8.55	13.47	12.29
	2012	28.00	49.50	19.97	12.85	14.80	22.50	56.67	1.95	12.47	25.00	60.33	14.00
	2013	3.17	32.55	232.67	3.30	3.66	7.48	28.23	1.40	3.83	26.53	74.33	49.00
	2014	1.40	8.28	666.67	48.45	0.78	0.75	41.33	73.00	7.90	31.28	124.67	63.50
	2015	40.33	34.20	138.33	16.50	3.80	26.73	69.67	28.15	91.00	27.20	176.67	46.00

**Water Quality of Major Rivers of Odisha**

**Table 4.4 Seasonal average values of pH, DO, BOD and TC in Brahmani river at Talcher FU/s, Talcher U/s, Talcher D/s and Talcher FD/s**

Parameter	Year	Talcher FU/s				Talcher U/s				Talcher D/s				Talcher FDs			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	8.2	8.0	7.7	7.8	8.0	8.1	7.5	7.9	8.2	8.0	7.7	7.9	7.9	8.0	7.6	7.7
	2012	7.9	8.1	7.3	7.6	8.0	8.2	8.1	7.7	8.0	7.9	7.9	7.6	7.8	7.9	7.4	8.0
	2013	7.9	8.3	7.6	7.5	8.0	7.8	7.7	8.5	8.0	8.0	7.6	7.9	8.0	7.8	8.1	8.0
	2014	7.9	7.9	7.8	8.1	7.9	8.2	7.8	8.1	7.9	8.1	7.9	7.9	7.9	7.9	8.0	8.3
	2015	8.0	7.8	7.7	8.0	7.7	7.9	7.9	8.3	7.9	7.9	7.9	8.0	8.0	8.1	8.0	8.4
DO (mg/l)	2011	8.2	6.9	7.6	7.7	8.2	7.3	7.3	7.6	7.5	7.4	7.7	8.0	7.5	7.2	7.0	7.4
	2012	8.2	7.3	7.7	8.0	8.1	7.3	7.6	7.9	7.7	7.6	7.4	8.3	7.5	7.3	7.6	7.6
	2013	8.3	7.4	7.1	7.6	8.3	7.1	7.0	7.9	8.7	7.5	7.4	7.6	7.9	7.3	7.1	7.6
	2014	8.1	6.9	7.2	7.7	8.5	6.9	7.4	7.6	8.7	7.0	6.9	7.7	8.5	7.0	6.9	7.5
	2015	8.3	7.2	7.0	7.6	8.5	7.2	7.2	7.9	8.5	7.0	7.0	7.5	8.5	7.3	6.8	7.3
BOD (mg/l)	2011	1.5	1.4	1.5	1.7	1.7	1.7	1.7	2.0	2.3	1.8	1.8	2.0	1.9	1.5	1.8	2.0
	2012	1.3	1.7	1.5	1.5	1.3	1.6	2.2	1.6	1.8	2.0	2.5	2.3	1.8	1.8	1.9	1.6
	2013	1.4	1.5	0.7	0.8	2.0	1.2	1.4	1.1	2.5	2.3	2.1	1.8	2.0	1.5	1.6	1.6
	2014	0.8	0.8	0.6	0.5	0.8	1.1	0.8	0.7	2.7	1.5	1.6	1.1	1.8	1.0	0.9	0.9
	2015	0.9	0.9	0.9	0.6	1.8	1.4	1.1	0.8	2.4	2.5	1.6	1.6	1.9	1.4	1.4	0.8
TC ('00) (MPN/ 100 ml)	2011	8.90	12.50	15.33	13.78	16.00	17.50	28.33	30.44	24.50	59.50	251.33	139.78	11.20	29.75	128.33	61.44
	2012	11.47	8.03	26.30	4.75	23.67	13.48	49.33	44.50	94.33	297.25	233.33	150.00	47.33	135.50	69.00	39.50
	2013	9.63	16.73	14.13	17.00	18.67	23.25	60.00	22.00	56.00	52.75	143.00	170.00	36.33	31.00	49.00	79.00
	2014	14.00	13.40	1071.00	44.50	17.00	23.73	1076.00	54.00	24.00	24.00	151.00	120.00	7.90	11.80	119.00	23.00
	2015	12.67	33.73	32.00	41.50	15.00	26.23	97.67	26.00	208.00	163.25	121.33	39.00	89.97	183.75	84.67	21.45

Table 4.5 Seasonal average values of pH, DO, BOD and TC in Nandira jhor at Nandira D/s and in Kisindajhor at Kisindajhor

Parameter	Year	Nandira D/s				Kisindajhor			
		W	S	M	PM	W	S	M	PM
pH	2011	8.3	8.1	8.1	7.9	8.1	8.1	8.2	8.2
	2012	8.3	8.0	8.1	8.4	7.9	8.4	8.4	8.3
	2013	7.8	8.3	8.0	8.5	8.4	8.0	8.2	8.5
	2014	8.4	8.5	7.9	8.4	8.4	8.4	8.0	8.0
	2015	8.3	8.1	8.2	8.5	7.8	8.3	8.1	8.5
DO (mg/l)	2011	6.3	7.2	5.9	7.1	5.7	8.1	7.6	7.8
	2012	9.1	6.7	6.4	8.2	7.9	8.6	7.0	7.8
	2013	7.3	7.3	6.8	7.4	8.4	8.2	6.5	7.6
	2014	10.7	7.9	6.0	7.0	11.7	8.3	6.3	8.0
	2015	9.4	7.4	6.7	7.1	9.7	8.2	7.8	7.7
BOD (mg/l)	2011	3.7	2.7	2.5	2.7	3.5	2.0	1.3	2.1
	2012	2.5	2.7	3.5	2.5	2.2	1.6	3.9	2.1
	2013	4.0	3.2	2.6	2.7	2.1	2.5	1.7	1.8
	2014	3.3	1.9	2.3	1.1	2.0	1.2	2.0	1.8
	2015	2.7	2.5	2.4	1.5	3.1	2.9	2.6	0.6
TC ('00) (MPN/100 ml)	2011	9.00	16.43	68.33	51.44	2.35	15.55	201.67	83.89
	2012	148.67	162.75	540.00	175.00	92.33	18.33	49.83	126.00
	2013	31.50	89.25	249.67	280.00	56.00	52.73	199.67	79.00
	2014	23.00	41.23	378.00	94.50	23.00	30.50	350.00	155.00
	2015	196.00	114.50	310.33	140.00	82.97	43.33	39.00	56.00

Table 4.6 Seasonal average values of pH, DO, BOD and TC in Brahmani river at Dhenkanal U/s, Dhenkanal D/s

Parameter	Year	Dhenkanal U/s				Dhenkanal D/s			
		W	S	M	PM	W	S	M	PM
pH	2011	8.1	7.8	8.1	7.6	8.1	8.0	8.2	7.7
	2012	7.8	7.8	7.9	8.0	8.0	7.9	8.1	7.5
	2013	8.1	8.0	7.8	7.8	7.9	7.9	7.8	7.4
	2014	8.0	7.6	7.7	7.9	8.1	7.9	7.7	7.9
	2015	7.5	7.8	7.7	8.1	7.8	7.9	7.4	8.3
DO (mg/l)	2011	8.3	8.0	6.9	7.6	8.2	7.2	7.0	7.6
	2012	11.2	7.9	7.9	8.2	8.8	7.3	7.6	8.0
	2013	8.7	8.3	7.1	7.1	9.0	7.8	6.8	5.9
	2014	8.6	7.8	7.1	7.4	8.5	7.3	6.5	7.0
	2015	8.9	7.7	7.3	7.6	8.8	7.3	7.0	7.3
BOD (mg/l)	2011	0.9	1.7	1.6	1.2	1.2	1.8	2.1	1.7
	2012	1.3	1.5	1.4	1.2	1.1	1.8	1.3	1.7
	2013	1.5	1.2	1.1	0.8	2.1	2.1	1.7	0.9
	2014	0.8	1.0	0.8	1.4	1.2	1.6	1.3	1.6
	2015	1.3	0.8	1.0	0.6	2.1	1.8	1.6	1.1
TC ('00) (MPN/100 ml)	2011	17.00	23.25	36.67	35.89	60.00	47.00	234.67	164.89
	2012	56.33	57.25	130.33	29.50	73.00	452.75	174.33	316.00
	2013	23.33	28.25	316.67	7.90	38.33	30.25	466.67	130.00
	2014	33.00	295.30	1600.00	1600.00	79.00	492.50	166.67	485.00
	2015	233.00	251.33	454.67	1600.00	426.33	20.75	993.33	1600.00

Table 4.7 Seasonal average values of pH, DO, BOD and TC in Brahmani river at Bhuban and Kabatabandha

Parameter	Year	Bhuban				Kabatabandha			
		W	S	M	PM	W	S	M	PM
pH	2011	8.3	7.8	7.8	7.8	8.3	7.7	7.6	7.7
	2012	7.7	7.8	7.9	7.9	7.9	8.0	7.9	7.9
	2013	8.1	8.0	7.6	8.0	8.0	7.9	7.8	7.8
	2014	8.3	8.1	8.1	8.2	8.2	8.2	7.9	8.1
	2015	8.1	8.0	7.9	8.3	7.9	8.0	7.9	8.4
DO (mg/l)	2011	8.5	7.7	6.8	7.6	8.7	7.1	6.8	7.8
	2012	8.2	7.3	7.8	7.8	7.9	7.0	7.4	8.0
	2013	9.5	7.8	6.8	7.1	8.7	7.6	7.0	7.0
	2014	9.6	7.4	7.2	7.3	7.9	6.9	7.2	7.4
	2015	9.1	7.1	7.0	7.9	8.2	7.8	7.1	7.5
BOD (mg/l)	2011	1.4	1.8	1.9	1.8	1.3	1.8	2.0	2.0
	2012	1.3	1.2	1.6	1.7	1.3	1.6	1.2	2.1
	2013	1.6	1.4	1.3	1.2	1.2	1.2	1.2	0.8
	2014	1.1	0.4	0.4	0.9	0.6	0.3	1.0	1.0
	2015	1.0	1.3	0.7	1.2	1.5	1.8	0.8	0.6
TC ('00) (MPN/100 ml)	2011	28.50	36.25	113.33	67.44	16.00	59.75	85.00	42.67
	2012	39.33	37.95	38.30	15.50	34.67	264.75	34.63	17.00
	2013	28.00	72.50	339.33	13.00	24.67	79.50	374.33	4.90
	2014	7.80	8.55	26.33	86.50	7.80	10.28	120.67	42.00
	2015	80.00	57.98	54.33	33.00	16.87	29.55	24.67	20.50

Table 4.8 Seasonal average values of pH, DO, BOD and TC in Brahmani river at Dharmasala U/s and Dharmasala D/s

Parameter	Year	Dharmasala U/s				Dharmasala D/s			
		W	S	M	PM	W	S	M	PM
pH	2011	8.0	7.8	8.0	7.9	-	-	-	-
	2012	8.1	8.0	7.8	7.6	-	-	-	-
	2013	7.9	8.1	7.8	7.9	-	-	-	-
	2014	7.5	8.0	7.8	8.0	8.2	8.3	7.9	7.9
	2015	7.5	8.2	7.9	8.2	8.0	8.1	7.8	8.2
DO (mg/l)	2011	8.0	8.2	6.9	7.3	-	-	-	-
	2012	8.3	6.9	7.8	5.1	-	-	-	-
	2013	8.6	8.6	6.7	7.5	-	-	-	-
	2014	6.9	6.7	6.6	7.4	10.9	8.1	6.6	7.6
	2015	8.5	7.8	6.9	7.2	8.6	7.1	7.1	6.7
BOD (mg/l)	2011	2.7	1.9	2.1	1.9	-	-	-	-
	2012	1.2	1.6	1.4	1.5	-	-	-	-
	2013	1.2	1.7	1.2	1.0	-	-	-	-
	2014	1.0	0.9	1.4	0.7	1.6	1.2	1.0	1.3
	2015	1.2	1.3	0.7	0.5	1.7	1.6	0.9	0.9
TC ('00) (MPN/100 ml)	2011	24.50	64.00	107.00	84.33	-	-	-	-
	2012	31.00	68.50	116.67	14.00	-	-	-	-
	2013	26.33	30.75	68.67	22.00	-	-	-	-
	2014	540.00	88.50	84.33	28.50	33.00	260.50	157.67	62.50
	2015	191.33	89.25	165.33	94.50	127.67	97.83	588.00	112.00

Water Quality of Major Rivers of Odisha

**Table 4.9 Seasonal average values of pH, DO, BOD and TC in Brahmani river at Pottamundai and in Kharasrota river at Khanditara, Binjharpur, Aul**

Parameter	Year	Pottamundai				Khanditara				Binjharpur				Aul			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	8.2	8.0	7.7	7.9	7.5	7.8	8.0	7.9	8.1	7.7	8.1	8.1	8.1	7.7	7.4	7.6
	2012	8.2	8.0	7.5	7.6	8.1	8.1	7.3	7.8	8.1	7.6	7.6	7.9	7.9	8.0	7.9	8.2
	2013	7.9	8.1	7.8	7.6	7.9	8.2	7.9	7.9	8.2	7.9	7.8	7.6	7.8	8.2	7.9	7.8
	2014	8.2	7.8	7.6	8.0	8.0	8.2	8.1	8.2	8.0	7.7	8.1	8.0	7.9	8.0	7.6	7.8
	2015	7.5	8.2	7.9	7.7	8.0	8.2	7.9	8.2	8.0	8.3	7.5	8.3	7.6	7.8	7.8	8.1
DO (mg/l)	2011	8.7	6.7	6.0	7.6	8.9	8.0	7.3	7.6	9.3	7.8	7.0	7.8	8.6	6.3	5.9	6.9
	2012	8.5	7.4	8.1	7.9	9.8	6.9	8.0	8.4	8.6	7.3	7.7	7.8	8.0	6.9	8.1	7.4
	2013	9.5	8.1	6.1	6.1	8.9	7.1	6.7	6.7	8.9	7.4	6.6	7.0	7.9	7.1	6.5	6.1
	2014	9.3	7.7	6.9	6.9	7.9	6.7	6.8	7.9	8.3	7.0	6.9	8.1	8.3	7.3	6.6	7.3
	2015	8.8	7.4	6.5	7.4	8.7	6.8	7.0	7.2	8.5	7.2	7.1	7.3	8.0	7.5	6.2	7.6
BOD (mg/l)	2011	1.8	1.8	1.9	1.6	2.0	2.0	2.3	1.7	1.7	1.9	2.2	1.6	1.8	1.3	1.6	1.6
	2012	1.3	2.0	1.4	1.3	1.2	1.8	1.9	1.9	1.7	1.5	2.2	1.7	1.5	1.6	1.4	2.2
	2013	1.6	1.3	1.1	1.2	1.7	1.4	0.7	0.8	1.2	1.2	1.1	0.7	2.1	1.5	0.9	1.9
	2014	1.1	1.5	1.6	0.9	0.7	0.8	0.6	1.0	0.3	0.6	0.7	0.9	1.0	1.1	1.7	0.9
	2015	1.5	1.6	1.6	1.1	1.0	1.2	1.1	0.9	1.0	1.1	1.2	0.6	1.0	1.6	1.6	1.0
TC ('00) (MPN/ 100 ml)	2011	63.50	73.00	389.67	158.56	16.00	24.35	67.67	38.89	13.20	17.75	93.33	44.11	15.50	22.00	154.00	70.00
	2012	56.67	40.48	67.00	48.50	26.67	23.75	30.67	54.50	20.33	53.25	60.67	54.50	20.33	38.48	54.00	44.50
	2013	21.67	18.48	121.67	240.00	44.97	10.83	107.33	24.00	28.00	17.50	551.63	23.00	16.33	53.00	173.33	24.00
	2014	33.00	57.00	54.30	109.50	79.00	28.68	24.97	11.23	130.00	63.00	17.00	43.50	58.00	42.00	644.00	74.50
	2015	25.00	121.73	98.00	23.00	37.67	35.43	93.00	23.00	19.67	47.25	33.33	38.50	74.33	93.73	128.00	63.50

**Table 4.10 Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit**

Monitoring Stations	Parameter	2011	2012	2013	2014	2015
Sankh U/s (Sankha)	BOD	1.6 (0.7-2.8)	1.5 (0.9-2.1)	1.3 (0.3 – 2.8)	1.0 (0.3 – 2.1)	1.0 (0.3-2.5)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	5515 (630-54000)	2235 (490-5400)	7829 (220 – 54000)	6480 (230 – 24000)	7651 (330-35000)
	F*	1/12	3/12	2/10	4/11	4/12
Koel U/s (Koel)	BOD	1.5 (0.6-2.8)	1.6 (0.6-2.2)	1.4 (0.4 – 3.1)	1.0 (0.3 – 1.8)	1.1 (0.5-2.1)
	F*	0/12	0/12	1/10	0/11	0/12
	TC	4178 (580-35000)	3837 (700-9200)	2759 (490 – 7000)	13723 (230 - 92000)	13917 (1300-54000)
	F*	1/12	5/12	1/10	5/11	5/12
Panposh U/s	BOD	1.2 (0.6-1.8)	1.7 (1.0-2.2)	1.2 (0.4 – 2.5)	0.8 (0.5 – 1.4)	0.9 (0.4-1.5)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	3492 (1300-13000)	6075 (2100-16000)	10280 (1300 – 35000)	7709 (1300 – 26000)	7400 (3300-17000)
	F*	2/12	6/12	6/10	5/11	8/12
Panposh D/s	BOD	4.7 (3.0-6.6)	4.0 (2.4-5.6)	4.2 (2.1 – 5.6)	4.7 (3.4 – 5.6)	4.5 (2.6-5.3)
	F*	11/12	11/12	8/10	11/11	11/12
	TC	18450 (3500-54000)	42333 (16000-92000)	84290 (7900 – 160000)	28909 (11000 –54000)	39750 (11000-92000)
	F*	10/12	12/12	10/10	11/11	12/12
Rourkela D/s	BOD	3.9 (1.8-5.3)	3.2 (2.0-4.4)	3.3 (0.9 – 4.7)	3.8 (2.7 – 5.0)	3.5 (2.2-4.5)
	F*	9/12	5/12	6/10	8/11	11/12
	TC	12583 (1700-92000)	33025 (3900-92000)	64840 (2400 – 160000)	44091 (17000 – 160000)	18650 (7900-54000)
	F*	7/12	11/12	9/10	11/11	12/12
Rourkela FD/s at Attaghat	BOD	2.2 (1.0-3.2)	2.1 (1.3-2.6)	2.6 (1.5 – 3.6)	2.1 (1.3 – 2.9)	2.6 (1.5-4.2)
	F*	1/12	0/12	3/10	0/11	1/12
	TC	5037 (940-22000)	8033 (2500-35000)	2544 (130 – 13000)	7457 (330 – 35000)	4638 (170-17000)
	F*	3/12	8/12	1/10	4/11	2/12
Rourkela FFD/s at Biritola	BOD	2.5 (1.2-3.6)	2.3 (1.2-3.0)	2.6 (1.1 – 3.9)	2.8 (1.8 – 4.5)	2.0 (1.0-3.5)
	F*	3/12	0/12	4/10	4/11	1/12
	TC	5592 (1500-22000)	7342 (2400-13000)	6258 (330 – 24000)	10117 (790 –35000)	6148 (790-13000)
	F*	4/12	9/12	3/10	5/11	5/12
Bonai	BOD	1.6 (0.8-2.8)	1.3 (0.8-2.0)	1.3 (0.3 – 2.3)	1.2 (0.5 – 2.6)	1.2 (0.4-1.9)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	2825 (1400-5800)	2841 (130-9200)	8397 (130 – 54000)	19448 (140 – 92000)	5882 (310-22000)
	F*	1/12	1/12	4/10	4/11	4/12
Rengali	BOD	1.5 (0.6-2.8)	1.3 (1.0-2.6)	1.0 (0.4 – 2.6)	0.8 (0.3 – 1.3)	0.9 (0.5-1.3)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	1568 (630-4900)	2506 (78-9200)	1260 (78 – 7900)	2561 (45 –9200)	3239 (130-16000)
	F*	0/12	2/12	1/10	3/11	3/12

Table 4.10 contd..

Monitoring Stations	Parameter	2011	2012	2013	2014	2015
Samal	BOD	1.8 (1.1-2.5)	1.5 (1.1-2.2)	1.2 (0.5 – 2.0)	0.9 (0.4 – 2.2)	1.1 (0.4-1.7)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	924 (330-1500)	2784 (170-9200)	3879 (110 – 22000)	6482 (230 –16000)	8115 (78-24000)
	F*	0/12	3/12	2/10	6/11	5/12
Talcher FU/s	BOD	1.5 (1.1-2.0)	1.4 (0.9-2.0)	1.2 (0.4 – 2.5)	0.7 (0.2 – 1.2)	0.9 (0.4-1.4)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	1257 (700-2100)	1240 (460-5400)	1503 (210 – 4900)	30760 (460 – 160000)	2958 (790-7900)
	F*	0/12	1/12	0/10	3/11	3/12
Talcher U/s	BOD	1.7 (1.0-2.5)	1.7 (0.9-2.8)	1.4 (0.7 – 2.6)	0.9 (0.6 – 1.5)	1.3 (0.7-2.7)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	2267 (1500-4300)	2924 (790-9200)	3400 (1300 – 7900)	31472 (490 – 160000)	4266 (790-14000)
	F*	0/12	2/12	2/10	4/11	2/12
Talcher D/s	BOD	2.0 (1.0-2.4)	2.1 (1.3-2.6)	2.3 (1.4 – 3.0)	1.5 (0.6 – 2.7)	2.1 (0.8-3.4)
	F*	0/12	0/12	0/10	0/11	1/12
	TC	11075 (2100-43000)	20183 (7000-54000)	9080 (2700 – 24000)	9391 (1300 – 22000)	12900 (1300-35000)
	F*	7/12	12/12	5/10	5/11	9/12
Talcher FD/s	BOD	1.8 (1.0-2.8)	1.8 (1.2-2.3)	1.6 (0.8 – 2.8)	1.60 (0.5 – 1.8)	1.4 (0.4-2.7)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	5378 (940-21000)	7700 (1700-22000)	4420 (1300 – 7900)	5710 (230–17000)	9523 (790-54000)
	F*	3/12	5/12	3/10	3/11	6/12
Nandira D/s (Nandira)	BOD	2.8 (1.7-4.8)	2.9 (1.6-4.1)	3.0 (2.1 – 3.8)	2.0 (1.1 – 3.3)	2.5 (1.0-4.5)
	F*	3/12	5/12	3/10	1/11	1/12
	TC	3596 (580-7900)	25408 (2200-54000)	15789 (1700 – 54000)	18645 (790 – 54000)	14967 (1300-79000)
	F*	3/12	8/12	6/10	8/11	9/12
Kisindajhor (Kisindajhor)	BOD	2.1 (0.8-4.0)	2.7 (1.1-6.8)	2.1 (1.0 – 4.7)	1.7 (0.8 – 2.7)	2.6 (0.6-4.2)
	F*	1/12	2/12	2/10	0/11	4/12
	TC	6141 (140-35000)	6608 (1100-24000)	10349 (490 – 35000)	15682 (1100 – 35000)	4002 (330-9200)
	F*	2/12	5/12	8/10	7/11	3/12
Dhenkanal U/s	BOD	1.5 (0.8-2.7)	1.3 (0.8-2.0)	1.2 (0.6 – 1.7)	1.0 (0.3 – 1.8)	0.8 (0.4-1.7)
	F*	0/12	0/12	0/10	0/11	0/11
	TC	2742 (1500-5400)	7183 (2200-22000)	12280 (1300 – 54000)	84211 (920– 160000)	62618 (5400-160000)
	F*	1/12	6/12	4/10	8/11	11/11
Dhenkanal D/s	BOD	1.7 (0.8-2.8)	1.6 (0.6-2.4)	1.9 (0.9 – 2.4)	1.6 (1.1 – 2.6)	1.6 (0.8-2.9)
	F*	0/12	0/12	0/10	0/11	0/11
	TC	10817 (2600-54000)	26733 (3300-160000)	15949 (790 – 92000)	40355 (7900 – 92000)	62850 (1300-160000)
	F*	8/12	9/12	3/10	11/11	8/12
Bhuban	BOD	1.7 (1.2-2.6)	1.4 (1.0-2.0)	1.4 (0.6 – 2.2)	0.6 (0.3 – 1.4)	1.1 (0.4-1.8)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	5433 (2100-24000)	3398 (780-9400)	13920 (1300 – 92000)	4218 (230 –17000)	5008 (490-16000)
	F*	5/12	3/12	4/10	3/11	5/12

Table 4.10 contd..

Monitoring Stations	Parameter	2011	2012	2013	2014	2015
Kabatabandha	BOD	1.8 (1.0-2.6)	1.5 (0.8-2.4)	1.2 (0.7 – 1.6)	0.8 (0.2 – 1.9)	1.2 (0.5-2.6)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	5192 (1200-15000)	10574 (790-92000)	14979 (490 – 92000)	4917 (230–17000)	2073 (130-5400)
	F*	5/12	3/12	4/10	2/11	2/12
Dharmasala U/s	BOD	2.0 (1.2-2.8)	1.4 (0.6-2.0)	1.4 (0.8 - 2.2)	1.0 (0.2 – 1.8)	1.0 (0.4-1.8)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	6792 (1500-17000)	6033 (1100-28000)	4080 (1700 – 11000)	11436 (1100 –54000)	13425 (1300-35000)
	F*	12/12	12/12	12/12	12/12	12/12
Dharmasala D/s	BOD	-	-	-	1.2 (0.3 – 1.6)	1.4 (0.6-2.9)
	F*	-	-	-	0/11	0/12
	TC	-	-	-	15309 (1100-92000)	23585 (230-160000)
	F*	-	-	-	5/11	11/12
Pottamundai	BOD	1.7 (0.8-2.4)	1.7 (0.8-2.7)	1.3 (0.8 – 1.8)	1.4 (0.5 – 2.8)	1.4 (0.7-2.5)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	14717 (3500-92000)	4683 (790-9200)	7199 (790 – 24000)	6145 (490 –16000)	7691 (700-24000)
	F*	12/12	12/12	12/12	10/11	12/12
Khanditara (Kharasrota)	BOD	1.9 (1.2-2.6)	1.7 (1.0-2.8)	1.3 (0.4 – 2.0)	0.8 (0.4 – 1.3)	1.0 (0.4-1.6)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	3470 (940-14000)	3133 (1700-9200)	4892 (490 – 24000)	3137 (45 – 9400)	4964 (1700-17000)
	F*	1/12	1/12	2/10	3/11	4/12
Binjharpur (Kharasrota)	BOD	1.8 (1.0-2.5)	1.7 (1.0-2.4)	1.1 (0.6 – 1.6)	0.7 (0.3 – 1.2)	1.0 (0.4-1.8)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	3670 (940-21000)	4625 (1100-24000)	18179 (790 – 160000)	4945 (1700 – 16000)	3533 (1100-11000)
	F*	1/12	4/12	1/10	3/11	3/12
Aul (Kharasrota)	BOD	1.5 (0.8-2.6)	1.7 (1.1-2.8)	1.4 (0.5 – 2.8)	1.1 (0.6 – 2.1)	1.4 (0.4-2.1)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	5492 (1400-35000)	3816 (790-11000)	7910 (1100 – 24000)	21277 (1300 –92000)	10174 (790-24000)
	F*	2/17	3/12	5/10	8/11	9/12

\*F : Frequency of deviation (Number of deviation/ total number of observation)

Water Quality of Major Rivers of Odisha

Table 4.11 Annual average and range values of Ammonical Nitrogen (mg/l)

Monitoring Station	2011			2012			2013			2014			2015		
	Amm-N	Fr. Amm-N	Total Amm-N	Amm-N	Fr. Amm-N	Total Amm-N									
	(mg/l)			(mg/l)			(mg/l)			(mg/l)			(mg/l)		
Sankh U/s (Sankh)	0.397 (0.056-0.896)	0.017 (0.003-0.066)	0.414 (0.059-0.962)	0.331 (0.112-1.008)	0.011 (BDL-0.045)	0.345 (0.112-1.053)	0.256 (0.112-0.672)	0.010 (0.002-0.025)	0.266 (0.114-0.697)	0.163 (0.056-0.28)	0.007 (0.001-0.015)	0.170 (0.057-0.295)	0.065 (0.056-0.112)	0.003 (0-0.006)	0.068 (0.056-0.118)
Koel U/s (Koel)	0.378 (0.056-1.288)	0.024 (BDL-0.093)	0.402 (0.056-1.381)	0.243 (0.056-0.560)	0.011 (BDL-0.028)	0.254 (0.056-0.588)	0.266 (0.112-0.610)	0.014 (ND-0.040)	0.280 (0.112-0.650)	0.122 (0.056-0.224)	0.006 (0.001-0.016)	0.128 (0.057-0.240)	0.061 (0.056-0.112)	0.004 (0.001-0.007)	0.065 (0.057-0.119)
Panposh U/s	0.327 (0.056-0.952)	0.021 (0.003-0.050)	0.348 (0.059-1.002)	0.308 (0.112-0.840)	0.016 (BDL-0.055)	0.324 (0.112-0.865)	0.217 (0.112-0.392)	0.010 (0.003-0.028)	0.227 (0.115-0.420)	0.127 (0.056-0.336)	0.006 (0.001-0.027)	0.133 (0.057-0.363)	0.065 (0.056-0.112)	0.003 (0-0.006)	0.068 (0.056-0.118)
Panposh D/s	0.471 (0.056-1.456)	0.045 (0.005-0.102)	0.516 (0.061-1.558)	0.500 (0.112-1.300)	0.016 (BDL-0.049)	0.516 (0.112-1.349)	0.374 (0.220-0.610)	0.008 (ND-0.025)	0.382 (0.220-0.635)	4.373 (0.112-21.56)	0.121 (0.001-0.412)	4.394 (0.113-21.972)	4.788 (0.784-14.224)	0.096 (0-0.427)	4.884 (0.784-14.651)
Rourkela D/s	0.496 (0.056-0.896)	0.018 (0.006-0.066)	0.514 (0.062-0.962)	0.631 (0.056-2.580)	0.016 (0.003-0.055)	0.647 (0.059-2.635)	0.422 (0.22-0.952)	0.014 (ND-0.061)	0.434 (0.220-1.013)	1.563 (0.112-6.944)	0.029 (0.001-0.077)	1.592 (0.113-7.021)	2.240 (0.168-12.992)	0.049 (0-0.292)	2.289 (0.168-13.284)
Rourkela FD/s at Attaghat	0.383 (0.112-0.784)	0.016 (0.001-0.029)	0.399 (0.113-0.813)	0.261 (0.110-0.840)	0.008 (BDL-0.022)	0.269 (0.110-0.862)	0.267 (0.112-0.784)	0.009 (0.002-0.018)	0.276 (0.114-0.802)	0.163 (0.112-0.336)	0.008 (0-0.028)	0.171 (0.112-0.364)	0.287 (0.056-1.880)	0.015 (0-0.122)	0.302 (0.056-2.002)
Rourkela FFD/s at Biritola	0.397 (0.056-0.840)	0.029 (BDL-0.119)	0.426 (0.056-0.959)	0.397 (0.112-1.800)	0.014 (0.002-0.054)	0.411 (0.114-1.854)	0.246 (0.110-0.448)	0.007 (ND-0.014)	0.253 (0.110-0.462)	0.158 (0.056-0.280)	0.008 (0.004-0.014)	0.166 (0.060-0.294)	0.201 (0.056-0.896)	0.010 (0-0.031)	0.211 (0.056-0.927)
Bonaigarh	0.345 (0.056-0.560)	0.017 (0.003-0.066)	0.362 (0.059-0.626)	0.317 (0.112-0.840)	0.012 (BDL-0.031)	0.329 (0.112-0.871)	0.301 (0.112-0.610)	0.012 (0.003-0.021)	0.313 (0.115-0.631)	0.137 (0.112-0.224)	0.006 (0-0.014)	0.143 (0.112-0.238)	0.191 (0.056-1.344)	0.008 (0.001-0.054)	0.199 (0.056-1.398)
Rengali	0.327 (0.056-0.672)	0.024 (BDL-0.093)	0.351 (0.056-0.765)	0.383 (0.112-1.400)	0.013 (BDL-0.049)	0.396 (0.112-1.449)	0.240 (0.11-0.388)	0.015 (0.003-0.038)	0.255 (0.113-0.421)	0.097 (0.056-0.168)	0.005 (0.001-0.014)	0.102 (0.057-0.182)	0.079 (0.056-0.168)	0.003 (0.001-0.007)	0.082 (0.057-0.165)
Samal	0.415 (0.112-0.840)	0.019 (0.003-0.060)	0.434 (0.115-0.900)	0.331 (0.112-1.120)	0.014 (0.002-0.045)	0.345 (0.114-1.165)	0.267 (0.112-0.448)	0.012 (0.003-0.028)	0.279 (0.115-0.476)	0.132 (0.056-0.280)	0.004 (0-0.011)	0.136 (0.056-0.291)	0.079 (0.056-0.112)	0.002 (0-0.014)	0.081 (0.056-0.126)

**Water Quality of Major Rivers of Odisha**

**Table 4.11 contd..**

Monitoring Station	2011			2012			2013			2014			2015		
	Amm-N	Fr. Amm-N	Total Amm-N												
	(mg/l)			(mg/l)			(mg/l)			(mg/l)			(mg/l)		
Talcher FU/s	0.387 (0.112-0.728)	0.021 (0.002-0.054)	0.408 (0.114-0.782)	0.348 (0.112-1.460)	0.021 (BDL-0.117)	0.369 (0.112-1.577)	0.311 (0.112-0.721)	0.024 (ND-0.112)	0.335 (0.112-0.833)	0.122 (0.056-0.168)	0.005 (0.003-0.009)	0.127 (0.059-0.177)	0.065 (0.056-0.168)	0.003 (0-0.004)	0.068 (0.059-0.172)
Talcher U/s	0.467 (0.112-0.840)	0.025 (0.003-0.067)	0.492 (0.115-0.907)	0.417 (0.112-1.300)	0.034 (0.002-0.126)	0.451 (0.114-1.426)	0.300 (0.112-0.605)	0.016 (0.003-0.035)	0.316 (0.115-0.640)	0.127 (0.056-0.224)	0.007 (0.004-0.018)	0.134 (0.060-0.242)	0.163 (0.056-0.952)	0.007 (0.002-0.029)	0.170 (0.058-0.981)
Talcher D/s	0.532 (0.112-1.456)	0.030 (0.002-0.058)	0.562 (0.114-1.514)	0.342 (0.112-1.300)	0.020 (0.003-0.104)	0.362 (0.115-1.404)	0.372 (0.165-0.499)	0.019 (ND-0.049)	0.391 (0.165-0.548)	0.137 (0.056-0.224)	0.008 (0.003-0.028)	0.145 (0.059-0.252)	0.303 (0.056-2.632)	0.009 (0.001-0.053)	0.312 (0.057-2.685)
Talcher FD/s	0.541 (0.112-1.792)	0.022 (0.002-0.054)	0.563 (0.114-1.846)	0.375 (0.112-1.200)	0.019 (0-0.07)	0.394 (0.112-1.270)	0.239 (0.112-0.440)	0.014 (0.002-0.029)	0.253 (0.114-0.469)	0.148 (0.056-0.280)	0.009 (0.001-0.022)	0.157 (0.057-0.302)	0.075 (0.056-0.112)	0.006 (0.001-0.011)	0.081 (0.057-0.123)
Nandira D/s (Nandira)	0.657 (0.112-2.170)	0.055 (0.003-0.21)	0.712 (0.115-2.280)	0.587 (0.112-2.000)	0.039 (0.006-0.105)	0.626 (0.118-2.105)	0.426 (0.112-0.825)	0.029 (0.004-0.061)	0.455 (0.116-0.886)	0.127 (0.056-0.224)	0.015 (0.003-0.035)	0.142 (0.059-0.259)	0.126 (0.056-0.336)	0.013 (0.004-0.028)	0.139 (0.060-0.364)
Kisinda Jhor (Kisindajhor)	0.434 (0.112-0.728)	0.037 (0.004-0.071)	0.471 (0.116-0.799)	0.434 (0.112-1.120)	0.051 (0.007-0.174)	0.485 (0.119-1.294)	0.339 (0.112-0.499)	0.030 (0.003-0.052)	0.369 (0.115-0.551)	0.158 (0.056-0.224)	0.016 (0.002-0.037)	0.174 (0.058-0.261)	0.187 (0.056-0.504)	0.013 (0.004-0.028)	0.200 (0.060-0.532)
Dhenkanal U/s	0.420 (0.056-1.120)	0.024 (0.001-0.073)	0.464 (0.057-1.193)	0.266 (0.056-0.896)	0.010 (0.003-0.027)	0.276 (0.059-0.923)	0.245 (0.112-0.448)	0.014 (0.007-0.036)	0.259 (0.119-0.484)	0.117 (0.056-0.280)	0.007 (0-0.037)	0.124 (0.056-0.317)	0.066 (0.056-0.112)	0.003 (0-0.005)	0.069 (0.056-0.117)
Dhenkanal D/s	0.387 (0.056-1.120)	0.027 (0-0.073)	0.414 (0.056-1.193)	0.405 (0.056-0.672)	0.023 (0-0.084)	0.428 (0.056-0.756)	0.321 (0.112-0.616)	0.015 (0.001-0.049)	0.336 (0.113-0.664)	0.102 (0.056-0.168)	0.008 (0.002-0.037)	0.110 (0.058-0.205)	0.093 (0.056-0.224)	0.005 (0.001-0.021)	0.098 (0.057-0.245)
Bhuban	0.443 (0.056-1.008)	0.027 (0.003-0.105)	0.470 (0.059-1.113)	0.229 (0.112-0.672)	0.009 (0.002-0.022)	0.238 (0.114-0.694)	0.296 (0.112-0.728)	0.011 (0.005-0.025)	0.307 (0.117-0.753)	0.137 (0.056-0.224)	0.011 (0.004-0.028)	0.148 (0.060-0.252)	0.058 (0.026-0.112)	0.004 (0.001-0.009)	0.062 (0.027-0.121)
Kabatabandha	0.411 (0.056-0.952)	0.023 (0.002-0.119)	0.424 (0.058-1.071)	0.365 (0.112-0.896)	0.025 (0.003-0.112)	0.390 (0.115-1.008)	0.274 (0.112-0.504)	0.011 (0.003-0.018)	0.285 (0.115-0.522)	0.137 (0.112-0.168)	0.009 (0.005-0.021)	0.146 (0.117-0.189)	0.065 (0.056-0.112)	0.004 (0.001-0.007)	0.069 (0.057-0.119)
Dharmasala U/s	0.378 (0.112-1.008)	0.021 (0.003-0.050)	0.409 (0.115-1.058)	0.271 (0.112-0.620)	0.015 (0.001-0.050)	0.286 (0.113-0.670)	0.273 (0.112-0.444)	0.015 (0.006-0.043)	0.288 (0.118-0.487)	0.148 (0.112-0.336)	0.006 (0.002-0.011)	0.154 (0.114-0.347)	0.079 (0.056-0.224)	0.005 (0.002-0.009)	0.084 (0.058-0.233)

Water Quality of Major Rivers of Odisha

Table 4.11 contd..

Monitoring Station	2011			2012			2013			2014			2015		
	Amm-N	Fr. Amm-N	Total Amm-N												
	(mg/l)			(mg/l)			(mg/l)			(mg/l)			(mg/l)		
Dharmasala D/s	-	-	-	-	-	-	-	-	-	0.193 (0.056-1.064)	0.016 (0.001-0.104)	0.209 (0.057-1.168)	0.084 (0.056-0.168)	0.005 (0.001-0.014)	0.089 (0.057-0.182)
Pottamundai	0.658 (0.056-1.568)	0.045 (0.005-0.102)	0.703 (0.061-1.670)	0.322 (0.112-1.008)	0.021 (0-0.098)	0.343 (0.112-1.106)	0.229 (0.112-0.504)	0.012 (0.004-0.028)	0.241 (0.116-0.532)	0.122 (0.056-0.224)	0.005 (0.001-0.011)	0.127 (0.057-0.235)	0.056 (0.056-0.056)	0.003 (0.001-0.007)	0.059 (0.057-0.063)
Khanditara (Kharasrota)	0.364 (0.056-0.672)	0.018 (0.006-0.066)	0.382 (0.062-0.738)	0.289 (0.112-1.008)	0.019 (0-0.126)	0.308 (0.112-1.034)	0.295 (0.056-0.560)	0.019 (0.002-0.045)	0.314 (0.058-0.605)	0.132 (0.112-0.224)	0.009 (0.006-0.015)	0.141 (0.118-0.239)	0.065 (0.056-0.112)	0.005 (0.002-0.011)	0.070 (0.058-0.123)
Binjharpur (Kharasrota)	0.439 (0.056-1.008)	0.029 (0-0.119)	0.468 (0.056-1.127)	0.163 (0.112-0.560)	0.008 (0-0.036)	0.171 (0.112-0.596)	0.396 (0.056-1.460)	0.019 (0.001-0.044)	0.415 (0.057-1.504)	0.127 (0.112-0.224)	0.006 (0.003-0.009)	0.133 (0.115-0.233)	0.093 (0.056-0.168)	0.007 (0.001-0.014)	0.100 (0.057-0.182)
Aul (Kharasrota)	0.490 (0.112-1.680)	0.016 (0.001-0.029)	0.506 (0.113-1.709)	0.281 (0.112-1.230)	0.016 (0.003-0.080)	0.297 (0.115-1.310)	0.245 (0.112-0.448)	0.012 (0.001-0.027)	0.257 (0.113-0.475)	0.127 (0.056-0.168)	0.005 (0.001-0.011)	0.132 (0.057-0.179)	0.070 (0.056-0.112)	0.003 (0.001-0.007)	0.073 (0.056-0.119)

Note : Amm-N : Ammonical nitrogen-N

Fr. Amm-N : Free ammonia-N

Total Amm-N : (Ammonium + Ammonia)-N

**Water Quality of Major Rivers of Odisha**

**Table 4.12 Seasonal average values of Electrical Conductivity (microSiemens/cm)**

Monitoring Station	2011				2012				2013				2014				2015			
	W	S	M	PM																
Sankh U/s (Sankh)	124	139	234	149	157	138	108	191	219	155	118	108	162	149	126	180	186	155	138	135
Koel U/s (Koel)	217	210	138	128	179	216	132	182	194	219	138	136	197	255	145	210	231	218	156	176
Panposh U/s	123	149	132	140	158	138	126	187	204	193	121	123	186	141	143	191	181	149	133	160
Panposh D/s	382	347	175	244	277	311	209	305	345	349	197	220	224	333	223	301	408	308	263	331
Rourkela D/s	294	254	182	204	257	234	182	272	313	318	199	198	321	261	218	271	335	252	197	259
Rourkela FD/s at Attaghat	269	224	152	159	264	243	161	218	240	221	129	119	210	185	135	204	258	232	226	229
Rourkela FFD/s at Biritola	329	208	138	152	189	200	133	265	237	227	131	117	211	197	156	210	265	207	164	200
Bonaigarh	284	215	129	138	190	210	131	182	226	223	128	118	218	199	161	222	259	226	153	212
Rengali	168	170	122	108	124	134	150	119	173	153	124	124	110	162	149	140	150	155	151	134
Samal	263	212	128	120	132	142	147	139	130	144	177	122	138	156	155	197	173	182	147	164
Talcher FU/s	240	157	124	124	139	134	131	145	155	144	175	130	132	138	157	163	159	147	135	137
Talcher U/s	156	165	119	120	130	146	148	189	168	140	140	176	130	131	173	179	160	149	130	142
Talcher D/s	163	191	155	133	178	128	191	223	155	164	169	162	137	147	190	209	186	189	173	169
Talcher FD/s	171	179	153	129	168	148	187	195	153	147	187	267	168	150	191	207	194	168	190	192
Nandira D/s (Nandira)	482	407	456	418	453	428	406	404	471	433	439	427	493	348	390	385	422	461	447	423
Kisinda Jhor (Kisindajhor)	493	512	509	387	534	544	449	290	581	496	329	396	520	418	395	562	565	530	513	382
Dhenkanal U/s	142	172	115	105	123	159	142	160	157	138	129	178	168	204	161	199	176	150	143	155
Dhenkanal D/s	189	164	134	116	133	149	160	177	174	141	194	204	181	232	218	221	199	165	199	221
Bhuban	158	179	131	132	134	143	141	154	164	155	134	149	164	132	156	185	187	159	153	167
Kabatabandha	181	189	129	122	140	143	151	157	164	141	133	151	164	140	146	223	196	156	139	177
Dharmasala U/s	238	215	145	127	154	152	126	139	209	169	154	181	204	138	177	227	263	193	159	215
Dharmasala D/s	-	-	-	-	-	-	-	-	-	-	-	-	152	152	189	236	244	188	162	205
Pottamundai	251	196	214	188	179	233	146	193	197	215	182	197	241	173	192	209	261	253	162	210
Khanditara (Kharasrota)	181	141	118	132	133	141	121	162	160	150	130	139	168	142	159	198	182	175	150	163
Binjharpur (Kharasrota)	185	138	125	127	155	152	123	150	165	149	140	134	156	139	191	209	193	177	164	168
Aul (Kharasrota)	170	161	153	136	135	178	136	160	182	149	153	140	263	146	428	220	311	175	160	198

Table 4.13 Annual average and range values of Sodium Absorption Ratio (SAR) and Boron (B)

Monitoring Station	SAR				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	0.45 (0.31-0.99)	0.34 (0.24-0.47)	0.33 (0.25-0.44)	0.37 (0.24-0.47)	0.43 (0.30-0.63)
Koel U/s (Koel)	0.36 (0.30-0.47)	0.39 (0.25-0.78)	0.31 (0.22-0.46)	0.37 (0.20-0.49)	0.38 (0.27-0.60)
Panposh U/s	0.37 (0.21-0.62)	0.35 (0.22-0.43)	0.31 (0.12-0.52)	0.41 (0.27-0.86)	0.31 (0.21-0.49)
Panposh D/s	0.66 (0.22-0.97)	0.63 (0.24-1.48)	0.52 (0.32-0.85)	0.76 (0.24-1.21)	0.92 (0.43-1.17)
Rourkela D/s	0.66 (0.30-1.30)	0.59 (0.21-1.31)	0.50 (0.28-0.91)	0.63 (0.28-1.20)	0.61 (0.34-0.79)
Rourkela FD/s at Attaghat	0.52 (0.35-0.87)	0.67 (0.25-1.48)	0.37 (0.20-0.53)	0.42 (0.23-0.63)	0.59 (0.24-1.27)
Rourkela FFD/s at Biritola	0.49 (0.30-0.93)	0.45 (0.19-1.03)	0.38 (0.26-0.51)	0.43 (0.26-0.66)	0.50 (0.30-0.64)
Bonaigarh	0.49 (0.32-0.64)	0.44 (0.20-0.62)	0.42 (0.27-0.55)	0.56 (0.29-1.15)	0.60 (0.41-0.94)
Rengali	0.43 (0.22-0.77)	0.29 (0.16-0.44)	0.29 (0.21-0.49)	0.42 (0.20-0.70)	0.36 (0.20-0.70)
Samal	0.45 (0.25-0.65)	0.35 (0.21-0.67)	0.35 (0.21-0.54)	0.37 (0.27-0.52)	0.53 (0.33-0.92)
Talcher FU/s	0.44 (0.25-0.87)	0.29 (0.20-0.37)	0.39 (0.23-1.05)	0.36 (0.23-0.68)	0.39 (0.28-0.65)
Talcher U/s	0.41 (0.19-0.90)	0.33 (0.21-0.45)	0.37 (0.20-0.58)	0.34 (0.23-0.49)	0.32 (0.20-0.43)
Talcher D/s	0.49 (0.30-1.18)	0.38 (0.22-0.60)	0.35 (0.19-0.53)	0.40 (0.31-0.51)	0.39 (0.27-0.53)
Talcher FD/s	0.45 (0.29-0.93)	0.42 (0.20-0.57)	0.36 (0.26-0.53)	0.41 (0.31-0.56)	0.46 (0.27-0.68)
Nandira D/s (Nandira)	0.84 (0.63-1.25)	0.74 (0.36-1.28)	0.57 (0.31-0.87)	0.66 (0.31-0.95)	0.96 (0.58-1.73)
Kisinda Jhor (Kisinda Jhor)	1.15 (0.81-2.11)	0.91 (0.37-1.48)	0.82 (0.29-1.50)	1.11 (0.40-1.67)	1.53 (0.74-2.90)
Dhenkanal U/s	0.45 (0.15-1.11)	0.33 (0.19-0.76)	0.32 (0.20-0.44)	0.42 (0.28-0.74)	0.37 (0.26-0.78)
Dhenkanal D/s	0.49 (0.19-0.80)	0.35 (0.20-0.69)	0.37 (0.23-0.50)	0.64 (0.34-2.15)	0.45 (0.27-0.68)
Bhuban	0.43 (0.19-0.75)	0.33 (0.16-0.49)	0.33 (0.16-0.54)	0.33 (0.27-0.39)	0.41 (0.31-0.67)
Kabatabandha	0.43 (0.19-0.73)	0.36 (0.18-0.60)	0.37 (0.23-0.73)	0.39 (0.27-0.70)	0.40 (0.31-0.58)
Dharmasala U/s	0.44 (0.26-0.64)	0.36 (0.21-0.50)	0.41 (0.20-0.66)	0.01 (0.07-0.13)	0.54 (0.31-1.03)
Dharmasala D/s	-	-	-	0.43 (0.34-0.56)	0.41 (0.22-0.59)
Pottamundai	0.65 (0.29-2.56)	0.43 (0.22-0.59)	0.44 (0.26-0.55)	0.51 (0.33-0.65)	0.67 (0.39-1.54)
Khanditara (Kharasrota)	0.35 (0.22-0.55)	0.33 (0.22-0.43)	0.33 (0.19-0.54)	0.42 (0.33-0.68)	0.38 (0.24-0.55)
Binjharpur (Kharasrota)	0.40 (0.20-0.61)	0.34 (0.20-0.52)	0.38 (0.19-0.59)	0.40 (0.28-0.53)	0.38 (0.28-0.49)
Aul (Kharasrota)	0.42 (0.24-0.66)	0.38 (0.20-0.61)	0.48 (0.24-1.32)	0.90 (0.28-4.48)	0.79 (0.29-3.68)

Table 4.13 contd..

Monitoring Station	B (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	0.042 (0.003-0.144)	0.026 (0.003-0.076)	0.051 (0.003-0.102)	0.027 (0.003-0.064)	0.026 (0.003-0.060)
Koel U/s (Koel)	0.054 (0.004-0.261)	0.038 (0.004-0.098)	0.044 (0.004-0.094)	0.030 (0.003-0.048)	0.030 (0.003-0.064)
Panposh U/s	0.036 (0.008-0.072)	0.040 (0.011-0.098)	0.032 (0.003-0.090)	0.036 (0.003-0.147)	0.038 (0.003-0.103)
Panposh D/s	0.102 (0.023-0.231)	0.067 (0.030-0.180)	0.028 (0.003-0.064)	0.051 (0.006-0.112)	0.056 (0.003-0.125)
Rourkela D/s	0.084 (0.015-0.220)	0.045 (0.011-0.085)	0.060 (0.003-0.136)	0.054 (0.012-0.092)	0.059 (0.003-0.228)
Rourkela FD/s at Attaghat	0.064 (0.011-0.178)	0.054 (0.032-0.091)	0.050 (0.015-0.113)	0.029 (0.003-0.080)	0.034 (0.003-0.058)
Rourkela FFD/s at Biritola	0.047 (0.011-0.087)	0.041 (0.007-0.087)	0.069 (0.003-0.347)	0.040 (0.003-0.096)	0.040 (0.003-0.154)
Bonaigarh	0.036 (0.008-0.071)	0.054 (0.011-0.113)	0.088 (0.003-0.264)	0.041 (0.003-0.077)	0.042 (0.003-0.125)
Rengali	0.047 (0.007-0.136)	0.046 (0.003-0.068)	0.060 (0.007-0.238)	0.048 (0.003-0.124)	0.044 (0.006-0.093)
Samal	0.029 (0.008-0.061)	0.035 (0.004-0.087)	0.070 (0.007-0.328)	0.063 (0.003-0.136)	0.046 (0.003-0.089)
Talcher FU/s	0.151 (0.004-0.961)	0.030 (0.003-0.068)	0.053 (0.011-0.124)	0.041 (0.003-0.073)	0.024 (0.003-0.058)
Talcher U/s	0.055 (0.004-0.144)	0.033 (0.004-0.072)	0.073 (0.011-0.170)	0.060 (0.006-0.150)	0.047 (0.003-0.282)
Talcher D/s	0.112 (0.019-0.654)	0.042 (0.008-0.086)	0.101 (0.011-0.426)	0.063 (0.019-0.115)	0.075 (0.016-0.215)
Talcher FD/s	0.030 (0.004-0.091)	0.052 (0.008-0.174)	0.063 (0.003-0.408)	0.063 (0.003-0.118)	0.059 (0.003-0.164)
Nandira D/s (Nandira)	0.170 (0.011-0.454)	0.101 (0.019-0.291)	0.124 (0.015-0.340)	0.117 (0.044-0.256)	0.205 (0.096-0.370)
Kisinda Jhor (Kisinda Jhor)	0.263 (0.011-1.702)	0.085 (0.004-0.443)	0.114 (0.034-0.238)	0.147 (0.051-0.211)	0.150 (0.010-0.440)
Dhenkanal U/s	0.062 (0.007-0.182)	0.029 (0.011-0.076)	0.083 (0.022-0.154)	0.077 (0.003-0.353)	0.037 (0.006-0.071)
Dhenkanal D/s	0.043 (0.007-0.102)	0.034 (0.004-0.068)	0.098 (0.007-0.336)	0.098 (0.009-0.221)	0.045 (0.006-0.083)
Bhuban	0.060 (0.004-0.238)	0.050 (0.004-0.136)	0.064 (0.003-0.290)	0.067 (0.006-0.190)	0.069 (0.019-0.148)
Kabatabandha	0.091 (0.004-0.439)	0.042 (0.011-0.126)	0.049 (0.003-0.215)	0.082 (0.003-0.186)	0.062 (0.006-0.204)
Dharmasala U/s	0.101 (0.007-0.363)	0.044 (0.004-0.095)	0.031 (0.003-0.128)	0.070 (0.006-0.128)	0.025 (0.006-0.083)
Dharmasala D/s	-	-	-	0.076 (0.003-0.168)	0.051 (0.010-0.122)
Pottamundai	0.077 (0.011-0.212)	0.060 (0.006-0.106)	0.058 (0.007-0.117)	0.103 (0.006-0.606)	0.059 (0.003-0.239)
Khanditara (Kharasrota)	0.072 (0.007-0.458)	0.041 (0.004-0.136)	0.043 (0.007-0.071)	0.073 (0.003-0.117)	0.034 (0.003-0.093)
Binjharpur (Kharasrota)	0.059 (0.004-0.212)	0.042 (0.007-0.087)	0.062 (0.015-0.105)	0.091 (0.006-0.173)	0.046 (0.003-0.197)
Aul (Kharasrota)	0.074 (0.004-0.356)	0.045 (0.007-0.082)	0.049 (0.011-0.128)	0.052 (0.003-0.173)	0.039 (0.003-0.122)

**Table 4.14 Annual average and range values of Total Dissolved solids (TDS) and Total Hardness (TH)**

Monitoring Station	TDS (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	96 (65-205)	91 (63-123)	87 (60-137)	86 (68-115)	90 (65-122)
Koel U/s (Koel)	114 (53-232)	111 (75-155)	105 (66-147)	120 (75-216)	116 (84-148)
Panposh U/s	87 (51-143)	93 (64-119)	96 (64-127)	89 (76-112)	86 (67-118)
Panposh D/s	164 (86-219)	168 (111-222)	170 (104-225)	175 (98-240)	86 (67-118)
Rourkela D/s	142 (72-209)	149 (110-213)	153 (106-224)	151 (110-196)	145 (86-202)
Rourkela FD/s at Attaghat	125 (62-184)	140 (94-237)	109 (64-160)	106 (76-140)	119 (82-158)
Rourkela FFD/s at Biritola	123 (53-201)	120 (72-188)	111 (64-182)	111 (72-130)	135 (88-240)
Bonaigarh	119 (58-199)	112 (80-147)	109 (62-154)	113 (78-140)	122 (80-156)
Rengali	87 (57-176)	84 (56-102)	85 (62-106)	85 (64-116)	86 (70-122)
Samal	105 (56-240)	86 (70-113)	87 (60-168)	91 (74-118)	98 (80-135)
Talcher FU/s	90 (55-134)	84 (70-110)	89 (72-128)	85 (72-100)	82 (70-108)
Talcher U/s	86 (58-106)	91 (78-117)	87 (70-129)	87 (72-105)	84 (68-102)
Talcher D/s	99 (65-122)	104 (71-136)	96 (66-137)	101 (79-132)	104 (86-135)
Talcher FD/s	99 (69-129)	101 (79-131)	99 (76-145)	99 (76-128)	107 (85-138)
Nandira D/s (Nandira)	247 (101-314)	260 (195-324)	254 (216-294)	223 (87-292)	250 (165-278)
Kisinda Jhor (Kisinda Jhor)	289 (167-398)	274 (129-426)	271 (144-404)	264 (98-380)	286 (180-385)
Dhenkanal U/s	83 (54-151)	90 (73-125)	85 (64-108)	108 (76-250)	89 (74-102)
Dhenkanal D/s	93 (68-149)	94 (69-110)	100 (75-148)	127 (80-308)	114 (82-150)
Bhuban	91 (73-115)	90 (73-116)	86 (70-114)	87 (66-108)	95 (72-115)
Kabatabandha	91 (63-123)	92 (70-140)	84 (64-101)	94 (76-135)	94 (72-118)
Dharmasala U/s	108 (73-164)	93 (76-113)	103 (70-138)	101 (72-135)	116 (75-188)
Dharmasala D/s	-	-	-	105 (82-140)	111 (78-142)
Pottamundai	122 80-201	123 (88-183)	118 (88-142)	112 (77-130)	132 (86-180)
Khanditara (Kharasrota)	84 (65-108)	89 (75-122)	85 (66-102)	94 (80-115)	94 (58-120)
Binjharpur (Kharasrota)	88 (65-113)	92 (71-126)	88 (68-111)	101 (78-122)	97 (80-122)
Aul (Kharasrota)	95 (73-116)	97 (80-124)	95 (70-146)	151 (79-612)	122 (78-330)

Table 4.14 contd..

Monitoring Station	TH (as CaCO <sub>3</sub> ) (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	55 (32-80)	55 (28-82)	54 (36-94)	32 (16-56)	53 (32-72)
Koel U/s (Koel)	63 (20-108)	71 (36-104)	70 (38-100)	68 (24-96)	80 (40-108)
Panposh U/s	56 (22-112)	56 (32-82)	62 (36-90)	50 (28-68)	55 (42-68)
Panposh D/s	101 (74-128)	90 (72-120)	96 (60-140)	96 (52-136)	97 (84-116)
Rourkela D/s	77 (26-132)	83 (66-118)	86 (60-114)	86 (64-110)	85 (56-108)
Rourkela FD/s at Attaghat	68 (30-96)	77 (44-112)	67 (44-106)	63 (32-88)	74 (52-96)
Rourkela FFD/s at Biritola	71 (36-116)	71 (48-92)	68 (36-116)	65 (30-86)	80 (56-140)
Bonaigarh	62 (24-112)	69 (50-92)	66 (38-98)	62 (36-84)	71 (48-92)
Rengali	53 (34-104)	54 (28-72)	54 (34-84)	48 (38-70)	53 (35-76)
Samal	61 (30-168)	52 (44-62)	51 (36-100)	51 (34-76)	56 (44-82)
Talcher FU/s	53 (32-96)	55 (46-72)	53 (40-82)	46 (30-60)	49 (40-60)
Talcher U/s	54 (40-82)	58 (48-70)	55 (38-92)	48 (40-60)	53 (36-72)
Talcher D/s	60 (34-104)	66 (50-88)	58 (36-78)	59 (46-94)	66 (48-86)
Talcher FD/s	56 (34-78)	61 (48-70)	63 (40-98)	62 (48-98)	68 (56-104)
Nandira D/s (Nandira)	143 (52-188)	160 (100-196)	156 (118-176)	142 (52-210)	168 (146-190)
Kisinda Jhor (Kisinda Jhor)	144 (88-172)	159 (80-236)	162 (96-246)	148 (62-210)	159 (104-208)
Dhenkanal U/s	45 (34-68)	56 (48-72)	55 (34-80)	63 (44-164)	56 (48-66)
Dhenkanal D/s	50 (40-72)	58 (40-76)	63 (48-80)	73 (44-154)	73 (56-110)
Bhuban	51 (38-68)	54 (42-72)	50 (36-66)	54 (44-74)	60 (44-76)
Kabatabandha	53 (36-68)	53 (40-68)	49 (36-60)	55 (44-82)	60 (40-80)
Dharmasala U/s	63 (44-88)	58 (40-78)	60 (46-84)	62 (42-86)	71 (44-86)
Dharmasala D/s	-	-	-	61 (42-90)	71 (52-84)
Pottamundai	68 (40-96)	81 (52-130)	68 (50-82)	67 (52-88)	80 (48-92)
Khanditara (Kharasrota)	55 (36-82)	55 (36-76)	54 (36-76)	56 (44-76)	61 (36-80)
Binjharpur (Kharasrota)	55 (42-76)	60 (44-82)	53 (44-68)	57 (44-84)	65 (56-76)
Aul (Kharasrota)	60 (46-96)	62 (46-80)	52 (40-60)	56 (44-74)	65 (52-94)

Table 4.15 Annual average and range values of Nitrate (as NO<sub>3</sub>)

Monitoring Station	NO <sub>3</sub> (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	6.669 (0.085-36.291)	1.55 (0.15-7.65)	7.500 (0.927-32.825)	2.610 (0.071-15.500)	3.645 (1.041-8.720)
Koel U/s (Koel)	2.753 (0.584-12.399)	2.28 (0.19-9.39)	2.292 (0.323-6.018)	2.771 (0.660-13.658)	5.189 (0.270-18.680)
Panposh U/s	5.239 (0.210-29.934)	1.97 (0.38-10.15)	2.548 (0.623-7.002)	3.267 (0.893-20.540)	4.750 (0.771-18.640)
Panposh D/s	18.311 (0.789-43.032)	22.83 (0.79-41.62)	12.267 (0.018-37.88)	18.273 (3534-35.329)	8.774 (1.144-22.444)
Rourkela D/s	10.360 (0.185-27.769)	13.18 (1.95-28.06)	12.292 (2.171-36.619)	13.851 (1.333-32.126)	11.369 (1.058-37.444)
Rourkela FD/s at Attaghat	7.792 (0.425-25.966)	4.83 (0.2-14.33)	4.482 (0.182-8.999)	5.689 (0.655-15.372)	4.867 (1.293-23.073)
Rourkela FFD/s at Biritola	6.734 (1.346-24.841)	6.61 (1.64-13.58)	3.847 (0.948-13.255)	5.826 (2.870-13.844)	8.528 (1.023-38.754)
Bonaigarh	6.791 (0.637-19.266)	4.86 (0.89-9.18)	4.486 (1.382-10.663)	6.846 (3.470-15.566)	8.583 (0.252-42.854)
Rengali	3.760 (0.231-12.830)	1.96 (0.25-8.49)	2.207 (0.561-6.284)	3.868 (0.673-9.947)	4.267 (1.509-9.929)
Samal	2.577 (0.559-8.503)	2.02 (0.17-4.38)	2.666 (0.186-4.145)	3.930 (1.262-9.021)	5.334 (0.846-25.351)
Talcher FU/s	2.760 (0.027-15.017)	1.89 (0.46-7.13)	2.601 (0.305-9.566)	2.465 (0.611-7.577)	2.161 (0.531-4.793)
Talcher U/s	2.312 (0.162-6.810)	1.39 (0.04-3.81)	4.242 (0.221-9.991)	3.533 (0.485-10.177)	3.799 (0.965-8.220)
Talcher D/s	2.588 (0.089-12.569)	1.78 (0.06-5.09)	2.881 (0.660-2.782)	3.745 (0.424-8.937)	8.801 (4.744-16.345)
Talcher FD/s	2.458 (0.161-6.953)	4.39 (0.03-42.77)	2.224 (0.304-7.015)	2.664 (0.854-6.395)	3.674 (0.337-7.591)
Nandira D/s (Nandira)	2.954 (1.085-7.544)	2.85 (0.19-7.94)	3.078 (ND-7.396)	4.820 (0.944-14.543)	6.712 (3.175-18.317)
Kisinda Jhor (Kisinda Jhor)	4.086 (0.042-9.597)	4.80 (0.16-12.66)	5.735 (0.120-22.069)	3.519 (0.567-13.990)	6.552 (1.025-19.757)
Dhenkanal U/s	2.900 (0.106-8.640)	2.68 (0.01-10.17)	2.258 (0.354-5.855)	2.257 (0.350-7.484)	3.174 (0.457-8.335)
Dhenkanal D/s	2.993 (0.371-7.894)	1.83 (0.27-6.46)	1.824 (0.261-6.302)	1.809 (0.600-3.937)	9.355 (1.736-18.928)
Bhuban	2.870 (0.500-10.328)	3.60 (0.29-15.30)	2.514 (0.138-8.822)	1.493 (0.633-3.530)	5.115 (0.465-11.705)
Kabatabandha	4.016 (0.217-17.759)	3.96 (0.05-18.55)	2.609 (0.076-7.878)	2.114 (0.709-5.026)	5.555 (0.593-16.262)
Dharmasala U/s	4.230 (0.288-13.280)	2.57 (0.26-10.37)	3.220 (0.671-6.071)	1.581 (0.133-3.286)	5.450 (0.806-15.204)
Dharmasala D/s	-	-	-	3.073 (0.071-9.110)	8.214 (2.148-16.972)
Pottamundai	1.330 (0.311-3.741)	2.39 (0.15-10.08)	3.032 (0.337-11.120)	2.556 (1.014-4.756)	4.979 (0.106-15.105)
Khanditara (Kharasrota)	2.121 (0.134-7.560)	1.84 (0.13-7.18)	3.225 (0.345-8.363)	3.086 (0.266-6.510)	3.685 (0.164-9.929)
Binjharpur (Kharasrota)	1.787 (0.143-5.321)	4.11 (0.14-13.95)	2.592 (0.270-6.484)	2.486 (0.549-7.298)	4.138 (0.102-13.716)
Aul (Kharasrota)	2.327 (0.156-8.409)	3.94 (0.22-12.88)	2.358 (0.080-4.888)	6.784 (0.806-45.548)	3.012 (0.084-11.169)

Table 4.16 Annual average and range values of Chloride

Monitoring Station	Chloride (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	12.7 (6.6-31.9)	10.2 (7.4-12.6)	9.9 (6.6-18.7)	8.8 (5.9-11.7)	10.6 (6.9-15.7)
Koel U/s (Koel)	11.1 (5.6-19.0)	11.8 (7.7-18.3)	10.0 (5.78-14.7)	9.9 (4.9-13.7)	10.5 (7.8-16.6)
Panposh U/s	9.7 (5.7-12.5)	10.8 (8.2-16.0)	9.5 (3.9-17.7)	10.1 (6.9-20.6)	7.9 (5.9-12.7)
Panposh D/s	24.8 (6.6-40.0)	25.9 (13.5-60)	21.3 (10.1-36.3)	20.7 (6.8-33.3)	25.6 (11.7-36.2)
Rourkela D/s	19.9 (7.5-29.0)	21.3 (10.6-55.0)	19.2 (9.2-34.4)	17.6 (7.8-35.2)	16.5 (8.8-21.5)
Rourkela FD/s at Attaghat	15.9 (8.0-28.0)	22.0 (7.4-58.2)	12.4 (5.7-22.7)	10.8 (5.9-15.7)	13.1 (7.8-16.6)
Rourkela FFD/s at Biritola	15.6 (6.8-30.4)	15.6 (6.6-48.0)	12 (5.8-19.2)	11.4 (5.9-16.6)	17.0 (5.9-45.0)
Bonaigarh	14.5 (5.9-24.0)	14.1 (6.6-21.1)	14.0 (6.7-22.6)	13.9 (5.9-28.4)	16.1 (9.8-27.4)
Rengali	11.2 (6.0-24.5)	9.0 (5.2-12.4)	8.7 (5.78-14.8)	10.1 (3.9-18.6)	9.0 (5.9-19.6)
Samal	13.4 (6.6-27.4)	10.7 (5.9-17.4)	10.5 (5.78-23.14)	9.3 (6.9-12.7)	13.5 (7.8-23.5)
Talcher FU/s	12.7 (6.7-32.2)	8.9 (5.6-10.6)	10.1 (6.5-21.2)	8.7 (5.9-17.6)	9.6 (6.9-15.7)
Talcher U/s	10.4 (6.0-20.0)	10.0 (7.0-12.6)	10.2 (6.5-15.4)	8.4 (5.9-11.7)	8.1 (5.9-11.7)
Talcher D/s	12.8 (6.0-29.3)	12.3 (7.6-20.0)	9.9 (5.5-18.2)	9.8 (7.8-12.7)	10.1 (7.8-13.7)
Talcher FD/s	12.3 (8.6-22.0)	12.5 (6.6-16.7)	10.1 (7.7-12.7)	10.5 (7.8-14.67)	12.1 (7.8-16.6)
Nandira D/s (Nandira)	35.3 (27-44)	37.1 (18.3-69.8)	27.6 (19.3-35.9)	21.6 (7.8-27.4)	29.0 (21.5-45.0)
Kisinda Jhor (Kisinda Jhor)	49.9 (28-88.3)	42.3 (16.3-80.9)	41.6 (9.64-73.9)	36.9 (10.8-61.6)	51.8 (27.4-100.8)
Dhenkanal U/s	10.7 (3.6-32.0)	9.7 (5.2-20.2)	9.6 (5.78-13.49)	10.9 (6.9-23.5)	9.0 (6.8-13.7)
Dhenkanal D/s	12.2 (4.9-22.0)	11.2 (5.8-16.5)	11.3 (7.8-17.36)	17.2 (8.81-65.56)	12.1 (5.9-18.6)
Bhuban	11.5 (3.8-22.0)	10.1 (5.6-16.8)	9.4 (5.6-14.7)	8.4 (6.8-9.8)	10.3 (7.8-15.7)
Kabatabandha	11.6 (4.8-21.0)	10.3 (6.0-16.8)	10.7 (6.5-18.7)	9.2 (7.8-12.7)	10.4 (7.8-15.7)
Dharmasala U/s	13.6 (6.8-23.0)	11.2 (6.7-16.9)	12.1 (6.5-18.7)	11.2 (8.80-16.63)	14.7 (7.8-30.3)
Dharmasala D/s	-	-	-	11.5 (8.8-15.7)	11.2 (5.9-16.6)
Pottamundai	19.6 (9.6-73.3)	15.4 (7.6-22.2)	13.0 (9.0-18.7)	12.9 (7.8-16.6)	18.3 (10.8-42.1)
Khanditara (Kharasrota)	9.5 (5.8-16.0)	10.4 (6.6-14.8)	9.0 (5.5-14.8)	10. 1 (7.8-16.6)	9.9 (6.9-14.7)
Binjharpur (Kharasrota)	11.0 (5.8-15)	11.3 (7.6-16.2)	10.6 (5.5-16.7)	9.7 (7.8-11.8)	9.7 (7.8-11.7)
Aul (Kharasrota)	12.5 (6.0-18.1)	12.4 (6.6-18.7)	13.2 (6.4-39.2)	28.1 (7.8-171.2)	22.3 (7.8-119.4)

Table 4.17 Annual average and range values of Sulphate

Monitoring Station	Sulphate (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	11.8 (0.5-61.6)	5.81 (0.99-13.86)	7.8 (3.11-17.04)	8.02 (3.23-15.67)	10.7 (3.4-18.9)
Koel U/s (Koel)	8.1 (2.0-18.9)	7.17 (1.88-18.11)	5.8 (2.86-10.44)	6.87 (3.1-13.18)	9.8 (3.1-19.8)
Panposh U/s	6.1 (1.1-16.7)	6.51 (0.89-17.92)	5.8 (2.8-10.8)	7.98 (1.99-15.44)	9.8 (3.1-19.8)
Panposh D/s	33.8 (8.7-56.1)	26.82 (4.85-37.52)	31.5 (5.34-54.5)	38.10 (23.01-81.83)	40.5 (23.6-57.1)
Rourkela D/s	27.9 (8.9-56.1)	21.01 (3.27-37.62)	25.4 (6.71-47.5)	23.94 (13.43-34.00)	28.1 (13.2-45.0)
Rourkela FD/s at Attaghat	17.1 (3.2-38.8)	12.86 (6.00-25.54)	14.6 (4.6-24.5)	11.50 (6.72-21.38)	19.3 (8.3-38.8)
Rourkela FFD/s at Biritola	16.5 (2.3-38.3)	12.22 (6.03-16.33)	16.3 (2.48-32.6)	12.00 (8.08-24.62)	21.9 (11.1-39.2)
Bonaigarh	19.3 (1.6-65.3)	9.36 (2.57-17.11)	13.6 (3.98-24.25)	11.60 (5.22-17.91)	16.3 (10.0-33.6)
Rengali	8.0 (2.2-35.8)	6.69 (1.00-19.80)	6.6 (2.97-14.05)	6.16 (2.23-11.06)	10.0 (3.5-18.9)
Samal	11.2 (2.0-28.5)	6.87 (2.00-19.50)	7.7 (3.73-17.29)	8.84 (3.10-13.80)	9.8 (3.1-19.8)
Talcher FU/s	7.5 (0.8-19.8)	5.96 (0.99-15.54)	9.6 (2.99-23.48)	7.52 (2.86-13.95)	10.5 (3.7-17.2)
Talcher U/s	7.3 (2.7-15.2)	6.99 (0.79-23.56)	8.4 (4.98-13.93)	8.05 (1.74-17.16)	9.6 (3.7-18.0)
Talcher D/s	9.9 (4.0-19.1)	9.79 (1.68-30.69)	10.5 (4.48-18.24)	10.44 (3.73-19.65)	14.9 (6.5-25.5)
Talcher FD/s	9.5 (1.2-28.4)	8.76 (4.00-20.42)	10.3 (6.97-15.42)	9.56 (3.85-14.42)	13.7 (6.1-29.6)
Nandira D/s (Nandira)	46.2 (5.5-102.0)	47.38 (21.00-70.50)	42.3 (14.3-55.7)	39.20 (5.22-75.12)	54.4 (22.4-89.1)
Kisinda Jhor (Kisinda Jhor)	49.1 (9.4-87.5)	47.67 (8.34-84.55)	47.9 (10.3-91.3)	45.14 (5.72-65.04)	55.3 (16.8-94.5)
Dhenkanal U/s	7.2 (1.8-15.7)	6.75 (2.00-15.45)	8.7 (3.23-20.40)	15.28 (3.36-81.93)	10.2 (4.1-18.9)
Dhenkanal D/s	8.3 (2.3-13.3)	7.77 (3.00-14.06)	8.4 (2.24-20.52)	13.73 (3.73-71.51)	12.6 (4.2-24.6)
Bhuban	9.5 (2.6-15.9)	9.51 (2.00-26.63)	9.0 (3.85-23.63)	7.49 (2.61-14.37)	10.8 (5.30-24.1)
Kabatabandha	9.8 (2.5-19.7)	10.01 (1.00-24.25)	7.0 (3.73-11.57)	9.80 (2.11-18.9)	9.9 (5.6-18.0)
Dharmasala U/s	11.1 (3.9-24.1)	6.31 (1.88-14.95)	8.1 (1.5-18.0)	8.16 (2.36-20.77)	10.6 (4.4-42.5)
Dharmasala D/s	-	-	-	6.66 (3.10-12.31)	10.3 (4.8-18.9)
Pottamundai	8.0 (2.4-22.7)	10.18 (1.88-18.81)	10.8 (5.1-25.0)	8.17 (3.6-15.67)	9.8 (3.1-19.8)
Khanditara (Kharasrota)	9.2 (4.4-22.6)	7.94 (2.27-17.52)	7.6 (1.4-17.4)	8.24 (2.61-15.54)	9.1 (4.7-15.5)
Binjharpur (Kharasrota)	8.3 (2.8-16.7)	6.29 (1.19-14.15)	6.4 (0.5-16.1)	6.55 (3.23-11.56)	8.3 (4.8-11.4)
Aul (Kharasrota)	9.1 (3.9-18.3)	8.96 (1.48-16.03)	11.4 (5.7-25.1)	15.03 (3.48-71.14)	9.8 (3.1-19.8)

Table 4.18 Annual average and range values of Fluoride

Monitoring Station	Fluoride (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	0.301 (0.104-0.473)	0.294 (0.120-0.528)	0.302 (0.140-0.520)	0.272 (0.145-0.355)	0.386 (0.280-0.548)
Koel U/s (Koel)	0.286 (0.099-0.481)	0.313 (0.229-0.400)	0.259 (0.185-0.343)	0.291 (0.166-0.421)	0.373 (0.280-0.612)
Panposh U/s	0.272 (0.097-0.499)	0.293 (0.218-0.376)	0.284 (0.173-0.453)	0.296 (0.184-0.684)	0.343 (0.242-0.533)
Panposh D/s	1.316 (0.277-2.130)	1.137 (0.305-1.970)	1.116 (0.306-1.670)	1.123 (0.210-1.320)	1.187 (0.440-2.100)
Rourkela D/s	1.007 (0.180-1.760)	0.746 (0.310-1.690)	0.655 (0.245-1.540)	0.885 (0.218-2.150)	0.725 (0.420-1.110)
Rourkela FD/s at Attaghat	0.552 (0.103-1.390)	0.530 (0.230-1.000)	0.497 (0.165-0.980)	0.378 (0.188-0.731)	0.489 (0.370-0.730)
Rourkela FFD/s at Biritola	0.556 (0.095-1.780)	0.515 (0.235-0.949)	0.489 (0.166-0.963)	0.398 (0.190-0.751)	0.526 (0.400-0.866)
Bonaigarh	0.535 (0.101-1.300)	0.483 (0.236-0.911)	0.402 (0.093-0.909)	0.400 (0.212-0.651)	0.420 (0.220-0.797)
Rengali	0.389 (0.075-1.050)	0.277 (0.196-0.373)	0.237 (0.18-0.315)	0.290 (0.196-0.673)	0.333 (0.200-0.530)
Samal	0.361 (0.089-0.928)	0.294 (0.212-0.386)	0.345 (0.179-0.992)	0.280 (0.221-0.332)	0.344 (0.205-0.580)
Talcher FU/s	0.317 (0.174-0.668)	0.292 (0.177-0.421)	0.257 (0.153-0.338)	0.265 (0.192-0.33)	0.357 (0.270-0.540)
Talcher U/s	0.327 (0.176-1.040)	0.306 (0.205-0.450)	0.268 (0.195-0.323)	0.328 (0.235-0.920)	0.380 (248-0.580)
Talcher D/s	0.334 (0.174-0.832)	0.378 (0.288-0.510)	0.344 (0.234-0.867)	0.417 (0.237-1.36)	0.443 (0.290-0.600)
Talcher FD/s	0.496 (0.242-1.780)	0.421 (0.220-0.862)	0.329 (0.249-0.423)	0.435 (0.234-1.260)	0.467 (0.320-0.850)
Nandira D/s (Nandira)	1.249 (0.177-2.050)	1.716 (0.663-3.500)	1.577 (0.260-2.670)	1.565 (0.252-2.940)	1.898 (0.310-2.780)
Kisinda Jhor (Kisinda Jhor)	1.952 (0.591-3.720)	3.143 (0.720-8.810)	3.249 (0.193-6.52)	2.208 (0.254-3.920)	1.766 (0.310-3.600)
Dhenkanal U/s	0.348 (0.116-1.020)	0.282 (0.120-0.394)	0.319 (0.182-0.751)	0.364 (0.162-1.42)	0.376 (0.270-0.520)
Dhenkanal D/s	0.354 (0.210-0.708)	0.311 (0.113-0.480)	0.423 (0.189-1.530)	0.395 (0.194-1.700)	0.368 (0.288-0.461)
Bhuban	0.365 (0.089-1.100)	0.261 (0.072-0.383)	0.253 (0.168-0.332)	0.268 (0.175-0.405)	0.385 (0.212-0.610)
Kabatabandha	0.263 (0.093-0.397)	0.290 (0.127-0.388)	0.252 (0.165-0.321)	0.277 (0.197-0.415)	0.398 (0.202-0.600)
Dharmasala U/s	0.347 (0.135-0.965)	0.289 (0.121-0.414)	0.349 (0.206-0.736)	0.270 (0.170-0.320)	0.362 (0.203-0.525)
Dharmasala D/s	-	-	-	0.287 (0.175-0.358)	0.374 (0.252-0.541)
Pottamundai	0.252 (0.059-0.359)	0.337 (0.131-0.543)	0.417 (0.180-1.310)	0.290 (0.213-0.400)	0.390 (0.230-0.664)
Khanditara (Kharasrota)	0.250 (0.051-0.429)	0.381 (0.189-0.872)	0.266 (0.142-0.353)	0.280 (0.198-0.342)	0.362 (0.238-0.618)
Binjharpur (Kharasrota)	0.254 (0.057-0.720)	0.269 (0.133-0.498)	0.237 (0.097-0.317)	0.257 (0.136-0.310)	0.389 (0.216-0.802)
Aul (Kharasrota)	0.283 (0.065-0.616)	0.296 (0.180-0.421)	0.287 (0.198-0.381)	0.288 (0.218-0.56)	0.410 (0.230-0.612)

Table 4.19 Annual average and range values of Metals

Table 4.19 (a) Chromium (VI) and Mercury

Monitoring Station	Chromium (VI) (mg/l)		Mercury (mg/l)	
	2014	2015	2014	2015
Sankh U/s (Sankh)	0.022 (0.002-0.066)	0.012 (<0.002-0.031)	0.00019 (<0.00006-0.00083)	0.00020 (<0.00006-0.00070)
Koel U/s (Koel)	0.021 (<0.002-0.053)	0.009 (<0.002-0.025)	0.00012 (<0.00006-0.00032)	0.00028 (<0.00006-0.00095)
Panposh U/s	0.019 (<0.002-0.048)	0.009 (<0.002-0.031)	0.00023 (<0.00006-0.00083)	0.00014 (<0.00006-0.00044)
Panposh D/s	0.019 (<0.002-0.035)	0.012 (<0.002-0.033)	0.00038 (<0.00006-0.00076)	0.00033 (<0.00006-0.00089)
Rourkela D/s	0.018 (<0.002-0.038)	0.012 (<0.002-0.033)	0.00025 (<0.00006-0.00063)	0.00031 (0.00006-0.00089)
Rourkela FD/s at Attaghat	0.021 (<0.002-0.058)	0.010 (<0.002-0.033)	0.00030 (<0.00006-0.00095)	0.00020 (<0.00006-0.00089)
Rourkela FFD/s at Biritola	0.018 (0.003-0.038)	0.009 (<0.002-0.035)	0.00010 (<0.00006-0.00032)	0.00022 (<0.00006-0.00083)
Bonaigarh	0.021 (<0.002-0.058)	0.009 (<0.002-0.033)	0.00027 (<0.00006-0.00089)	0.00020 (<0.00006-0.00089)
Rengali	0.019 (<0.002-0.041)	0.010 (<0.002-0.031)	0.00013 (<0.00006-0.00032)	0.00019 (<0.00006-0.00057)
Samal	0.026 (<0.002-0.053)	0.014 (<0.002-0.033)	0.00025 (<0.00006-0.00089)	0.00018 (<0.00006-0.00070)
Talcher FU/s	0.017 (<0.002-0.043)	0.015 (<0.002-0.031)	0.00008 (<0.00006-0.00032)	0.00026 (<0.00006-0.00089)
Talcher U/s	0.025 (<0.002-0.073)	0.017 (<0.002-0.035)	0.00011 (<0.00006-0.00025)	0.00029 (<0.00006-0.00089)
Talcher D/s	0.017 (<0.002-0.058)	0.019 (<0.002-0.045)	0.00022 (<0.00006-0.00083)	0.00034 (<0.00006-0.00083)
Talcher FD/s	0.007 (<0.002-0.035)	0.016 (<0.002-0.035)	0.00025 (<0.00006-0.00083)	0.00025 (<0.00006-0.00095)
Nandira D/s (Nandira)	0.011 (<0.002-0.025)	0.011 (<0.002-0.046)	0.00023 (<0.00006-0.00095)	0.00036 (<0.00006-0.00076)
Kisinda Jhor (Kisinda Jhor)	0.012 (<0.002-0.033)	0.012 (<0.002-0.048)	0.00012 (<0.00006-0.00038)	0.00046 (0.00019-0.00089)
Dhenkanal U/s	0.008 (<0.002-0.035)	0.008 (<0.002-0.033)	0.00023 (<0.00006-0.00095)	0.00030 (<0.00006-0.00095)
Dhenkanal D/s	0.010 (<0.002-0.031)	0.012 (<0.002-0.038)	0.00019 (<0.00006-0.00044)	0.00030 (<0.00006-0.00070)
Bhuban	0.020 (<0.002-0.043)	0.018 (<0.002-0.035)	0.00015 (<0.00006-0.00051)	0.00022 (<0.00006-0.00089)
Kabatabandha	0.015 (<0.002-0.031)	0.017 (<0.002-0.038)	0.00012 (<0.00006-0.00044)	0.00023 (<0.00006-0.00089)
Dharmasala U/s	0.017 (<0.002-0.046)	0.011 (<0.002-0.041)	0.00012 (<0.00006-0.00038)	0.00022 (<0.00006-0.00083)
Dharmasala D/s	0.012 (<0.002-0.033)	0.015 (<0.002-0.043)	0.00019 (<0.00006-0.00070)	0.00026 (<0.00006-0.00089)
Pottamundai	0.008 (<0.002-0.021)	0.012 (<0.002-0.036)	0.00006 (<0.00006-0.00032)	0.00021 (<0.00006-0.00089)
Khanditara (Kharasrota)	0.011 (<0.002-0.031)	0.012 (<0.002-0.040)	0.00030 (<0.00006-0.00108)	0.00020 (<0.00006-0.00070)
Binjharpur (Kharasrota)	0.009 (<0.002-0.016)	0.012 (<0.002-0.041)	0.00020 (<0.00006-0.00051)	0.00025 (<0.00006-0.00089)
Aul (Kharasrota)	0.012 (<0.002-0.025)	0.015 (<0.002-0.036)	0.00025 (<0.00006-0.00139)	0.00021 (<0.00006-0.00089)

Table 4.19 (b) Total Chromium

Monitoring Station	Total Chromium (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	0.026 (0.005-0.062)	0.027 (0.010-0.057)	0.025 (0.010-0.038)	0.068 (0.005-0.168)	0.033 (0.012-0.077)
Koel U/s (Koel)	0.042 (0.012-0.100)	0.031 (0.012-0.095)	0.026 (0.003-0.068)	0.048 (0.080-0.108)	0.033 (0.007-0.072)
Panposh U/s	0.026 (0.002-0.065)	0.038 (0.012-0.126)	0.024 (0.005-0.043)	0.061 (0.018-0.111)	0.026 (0.004-0.057)
Panposh D/s	0.047 (0.026-0.088)	0.041 (0.017-0.078)	0.042 (0.028-0.080)	0.043 (0.025-0.077)	0.050 (0.011-0.094)
Rourkela D/s	0.043 (0.025-0.071)	0.040 (0.013-0.113)	0.033 (0.01-0.052)	0.043 (0.028-0.056)	0.039 (0.015-0.113)
Rourkela FD/s at Attaghat	0.042 (0.012-0.070)	0.034 (0.005-0.076)	0.033 (0.003-0.051)	0.052 (0.030-0.083)	0.029 (0.006-0.087)
Rourkela FFD/s at Biritola	0.060 (0.013-0.063)	0.033 (0.005-0.089)	0.023 (0.002-0.043)	0.080 (0.008-0.255)	0.027 (0.006-0.057)
Bonaigarh	0.044 (0.012-0.115)	0.031 (0.013-0.070)	0.033 (0.010-0.070)	0.047 (0.010-0.119)	0.023 (0.007-0.059)
Rengali	0.043 (0.013-0.095)	0.034 (0.013-0.070)	0.027 (0.005-0.054)	0.042 (0.005-0.065)	0.027 (0.013-0.047)
Samal	0.045 (0.013-0.114)	0.028 (0.010-0.088)	0.026 (0.005-0.052)	0.096 (0.022-0.534)	0.038 (0.011-0.094)
Talcher FU/s	0.034 (0.004-0.089)	0.032 (0.012-0.076)	0.025 (0.003-0.053)	0.059 (0.003-0.267)	0.046 (0.013-0.091)
Talcher U/s	0.041 (0.010-0.092)	0.031 (0.018-0.051)	0.026 (0.013-0.043)	0.054 (0.010-0.106)	0.049 (0.013-0.097)
Talcher D/s	0.044 (0.007-0.113)	0.041 (0.023-0.065)	0.027 (0.015-0.043)	0.056 (0.007-0.131)	0.054 (0.022-0.113)
Talcher FD/s	0.039 (0.008-0.109)	0.033 (0.018-0.056)	0.035 (0.020-0.052)	0.038 (0.003-0.105)	0.041 (0.015-0.086)
Nandira D/s (Nandira)	0.064 (0.015-0.171)	0.041 (0.017-0.070)	0.037 (0.005-0.070)	0.060 (0.005-0.140)	0.045 (0.007-0.128)
Kisinda Jhor (Kisinda Jhor)	0.057 (0.019-0.164)	0.037 (0.010-0.076)	0.031 (0.013-0.050)	0.065 (0.002-0.135)	0.045 (0.007-0.077)
Dhenkanal U/s	0.046 (0.008-0.100)	0.052 (0.010-0.077)	0.034 (0.005-0.052)	0.036 (0.016-0.067)	0.029 ( $<0.002-0.076$ )
Dhenkanal D/s	0.048 (0.018-0.086)	0.029 (0.008-0.052)	0.032 (0.008-0.053)	0.035 (0.013-0.073)	0.047 (0.013-0.094)
Bhuban	0.043 (0.015-0.107)	0.036 (0.010-0.089)	0.032 (0.005-0.060)	0.037 (0.018-0.051)	0.048 (0.013-0.086)
Kabatabandha	0.045 (0.011-0.096)	0.035 (0.015-0.070)	0.024 (0.010-0.041)	0.036 (0.010-0.112)	0.054 (0.007-0.116)
Dharmasala U/s	0.053 (0.005-0.115)	0.026 (0.007-0.044)	0.028 (0.008-0.053)	0.038 (0.008-0.068)	0.038 (0.008-0.086)
Dharmasala D/s	-	-	-	0.058 (0.015-0.292)	0.046 (0.008-0.114)
Pottamundai	0.037 (0.012-0.075)	0.027 (0.005-0.073)	0.022 (0.055-0.040)	0.035 (0.002-0.080)	0.039 (0.009-0.092)
Khanditara (Kharasrota)	0.052 (0.010-0.092)	0.025 (0.010-0.050)	0.036 (0.013-0.063)	0.062 (0.008-0.167)	0.034 (0.008-0.108)
Binjharpur (Kharasrota)	0.049 (0.018-0.072)	0.022 (0.010-0.038)	0.033 (0.005-0.052)	0.049 (0.005-0.250)	0.037 (0.011-0.094)
Aul (Kharasrota)	0.038 (0.005-0.127)	0.024 (0.010-0.038)	0.024 (0.010-0.038)	0.049 (0.003-0.114)	0.043 (0.008-0.087)

Table 4.19 (c) Iron

Monitoring Station	Iron (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	6.254 (0.206-27.994)	3.231 (0.220-15.860)	2.233 (0.068-9.673)	2.781 (0.030-9.560)	1.891 (0.100-7.190)
Koel U/s (Koel)	4.947 (0.163-20.774)	3.451 (0.206-13.920)	4.523 (0.100-12.682)	1.853 (<0.005-8.262)	2.401 (0.030-7.740)
Panposh U/s	4.606 (0.230-20.467)	2.997 (0.211-13.670)	3.210 (0.187-8.607)	2.418 (0.030-8.645)	1.902 (0.020-8.290)
Panposh D/s	7.937 (2.049-17.645)	4.241 (0.562-14.240)	7.107 (2.24-12.84)	4.251 (0.066-12.572)	4.212 (0.133-7.800)
Rourkela D/s	8.668 (0.571-23.443)	4.258 (0.341-13.670)	4.589 (1.26-8.469)	4.240 (0.570-10.302)	2.755 (0.060-6.330)
Rourkela FD/s at Attaghat	4.629 (0.029-14.169)	2.611 (0.240-13.050)	3.873 (0.25-12.837)	2.883 (0.020-10.736)	1.607 (0.050-7.390)
Rourkela FFD/s at Biritola	6.362 (0.048-23.098)	3.062 (0.150-14.410)	4.583 (0.200-13.149)	2.797 (0.015-11.858)	2.113 (0.080-6.820)
Bonaigarh	5.491 (0.086-19.469)	3.229 (0.197-13.900)	4.166 (0.115-12.837)	1.592 (0.030-9.869)	2.490 (0.080-7.170)
Rengali	2.864 (0.096-12.173)	2.001 (0.120-7.800)	1.03 (0.12-2.284)	1.254 (0.030-5.020)	1.415 (0.040-4.530)
Samal	4.734 (0.160-18.317)	2.515 (0.090-11.000)	3.949 (0.077-12.646)	1.200 (0.076-7.013)	1.940 (<0.005-7.290)
Talcher FU/s	5.151 (0.270-18.950)	3.028 (0.182-10.906)	2.620 (0.336-9.556)	1.351 (0.005-4.743)	2.000 (0.100-6.250)
Talcher U/s	5.842 (0.706-22.829)	2.953 (0.192-9.495)	3.261 (0.180-10.330)	1.946 (0.005-5.993)	2.010 (0.090-6.450)
Talcher D/s	4.405 (0.029-16.973)	3.124 (0.422-9.040)	1.974 (0.190-6.355)	1.468 (0.041-5.646)	1.888 (0.040-6.830)
Talcher FD/s	4.975 (0.320-15.876)	1.976 (0.187-7.104)	3.039 (0.300-9.662)	1.853 (<0.005-8.262)	2.272 (0.050-7.310)
Nandira D/s (Nandira)	1.787 (0.080-9.408)	1.944 (0.508-8.210)	1.185 (0.127-2.719)	0.947 (<0.005-2.647)	1.302 (0.030-4.330)
Kisinda Jhor (Kisinda Jhor)	3.193 (0.410-16.627)	2.829 (0.125-7.730)	2.370 (0.810-4.887)	1.314 (0.046-11.322)	0.879 (0.120-2.350)
Dhenkanal U/s	6.067 (0.420-18.720)	2.302 (0.230-6.900)	3.298 (0.210-8.550)	1.372 (0.005-4.710)	2.141 (<0.005-6.430)
Dhenkanal D/s	6.943 (0.500-18.988)	2.695 (0.494-7.600)	2.987 (0.180-9.185)	1.884 (0.056-6.680)	1.801 (0.060-6.070)
Bhuban	5.152 (0.398-16.896)	4.540 (0.576-13.880)	3.900 (0.590-11.326)	1.566 (0.025-6.579)	2.250 (0.260-5.890)
Kabatabandha	5.473 (0.540-18.029)	5.908 (0.274-27.700)	5.927 (0.179-12.412)	1.243 (0.061-3.770)	2.388 (0.070-7.110)
Dharmasala U/s	4.343 (0.754-14.054)	3.353 (0.254-16.000)	2.534 (0.270-4.701)	1.653 (0.060-5.666)	2.061 (0.100-7.170)
Dharmasala D/s	-	-	-	1.668 (0.138-7.579)	1.485 (0.128-6.710)
Pottamundai	4.746 (0.570-14.419)	2.808 (0.640-7.500)	2.319 (0.300-6.170)	1.601 (0.030-5.200)	1.483 (0.130-6.680)
Khanditara (Kharasrota)	5.348 (1.200-14.957)	4.641 (0.163-18.800)	4.103 (0.095-12.842)	2.189 (0.080-5.839)	1.936 (0.060-7.390)
Binjharpur (Kharasrota)	4.023 (0.450-15.590)	3.465 (0.058-10.723)	5.006 (0.350-12.577)	1.248 (0.080-6.044)	1.755 (0.340-7.320)
Aul (Kharasrota)	6.359 (0.360-23.230)	4.223 (0.466-12.580)	3.997 (0.440-10.473)	2.275 (0.120-7.900)	2.384 (0.230-7.310)

Table 4.19 (d) Nickel

Monitoring Station	Nickel (mg/l)				
	2011	2012	2013*	2014#	2015##
Sankh U/s (Sankh)	0.003 (0.001-0.007)	0.005 (0.003-0.009)	0.002	0.009 (0.008-0.009)	0.011 (0.003-0.020)
Koel U/s (Koel)	0.003 (0.001-0.006)	0.005 (0.004-0.008)	0.002	0.008 (0.007-0.008)	0.014 (0.003-0.038)
Panposh U/s	0.002 (0.001-0.004)	0.004 (0.003-0.007)	0.001	0.012 (0.011-0.013)	0.006 (0.002-0.009)
Panposh D/s	0.004 (0.001-0.008)	0.006 (0.003-0.011)	0.002	0.020 (0.016-0.025)	0.014 (0.003-0.030)
Rourkela D/s	0.003 (<0.001-0.005)	0.005 (0.003-0.007)	0.002	0.016 (0.016-0.016)	0.010 (0.001-0.027)
Rourkela FD/s at Attaghat	0.003 (0.001-0.008)	0.008 (0.003-0.028)	0.001	0.011 (0.011-0.012)	0.010 (0.002-0.026)
Rourkela FFD/s at Biritola	0.003 (0.001-0.005)	0.005 (0.004-0.007)	0.001	0.011 (0.011-0.012)	0.010 (0.002-0.020)
Bonaigarh	0.003 (0.001-0.007)	0.003 (0.001-0.007)	0.001	0.010 (0.008-0.013)	0.008 (0.001-0.024)
Rengali	0.002 (0.001-0.005)	0.003 (0.002-0.004)	0.001	0.006 (0.004-0.008)	0.015 (0.002-0.037)
Samal	0.003 (<0.001-0.010)	0.002 (0.001-0.003)	0.001	0.009 (0.009-0.010)	0.009 (0.001-0.021)
Talcher FU/s	0.003 (0.001-0.007)	0.004 (0.002-0.006)	0.001	0.016 (0.016-0.017)	0.011 (0.001-0.034)
Talcher U/s	0.004 (0.001-0.008)	0.003 (0.002-0.005)	0.002	0.015 (0.012-0.017)	0.010 (0.003-0.019)
Talcher D/s	0.004 (<0.001-0.012)	0.004 (0.002-0.007)	0.002	0.016 (0.010-0.022)	0.011 (0.003-0.023)
Talcher FD/s	0.005 (0.001-0.011)	0.003 (0.001-0.005)	0.001	0.020 (0.019-0.020)	0.012 (0.003-0.023)
Nandira D/s (Nandira)	0.005 (0.002-0.110)	0.007 (0.004-0.008)	0.002	0.031 (0.017-0.045)	0.016 (0.011-0.022)
Kisinda Jhor (Kisinda Jhor)	0.006 (0.001-0.010)	0.004 (0.001-0.007)	0.004	0.027 (0.023-0.032)	0.022 (0.008-0.047)
Dhenkanal U/s	0.003 (<0.001-0.010)	0.005 (0.002-0.008)	0.003	0.008 (0.006-0.011)	0.011 (0.003-0.018)
Dhenkanal D/s	0.003 (0.001-0.010)	0.008 (0.003-0.016)	0.003	0.016 (0.016-0.016)	0.013 (0.004-0.024)
Bhuban	0.003 (<0.001-0.007)	0.004 (0.003-0.008)	0.003	0.014 (0.012-0.016)	0.011 (0.002-0.023)
Kabatabandha	0.004 (0.001-0.008)	0.006 (0.003-0.007)	0.003	0.011 (0.009-0.014)	0.011 (0.003-0.021)
Dharmasala U/s	0.003 (0.001-0.007)	0.005 (0.004-0.006)	0.003	0.014 (0.011-0.017)	0.013 (0.007-0.019)
Dharmasala D/s	-	-	-	0.010 (0.006-0.014)	0.015 (0.001-0.024)
Pottamundai	0.004 (<0.001-0.009)	0.006 (0.003-0.010)	0.002	0.015 (0.011-0.019)	0.017 (0.002-0.049)
Khanditara (Kharasrota)	0.004 (0.002-0.008)	0.004 (0.001-0.006)	0.003	0.012 (0.012-0.012)	0.015 (0.004-0.040)
Binjharpur (Kharasrota)	0.004 0.001-0.008	0.005 (0.003-0.007)	0.002	0.012 (0.010-0.014)	0.014 (0.003-0.047)
Aul (Kharasrota)	0.004 (<0.001-0.009)	0.006 (0.003-0.009)	0.002	0.015 (0.014-0.016)	0.016 (0.006-0.028)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 4.19 (e) Copper

Monitoring Station	Copper (mg/l)				
	2011	2012	2013*	2014#	2015##
Sankh U/s (Sankh)	0.004 (0.002-0.008)	0.003 (0.002-0.004)	0.002	0.003 (0.002-0.003)	0.003 (0.001-0.008)
Koel U/s (Koel)	0.005 (0.001-0.011)	0.004 (0.002-0.006)	0.004	0.019 (0.019-0.020)	0.011 (0.001-0.028)
Panposh U/s	0.005 (0.001-0.009)	0.004 (0.003-0.005)	0.002	0.007 (0.005-0.008)	0.004 (0.001-0.011)
Panposh D/s	0.005 (0.001-0.007)	0.007 (0.005-0.013)	0.006	0.011 (0.010-0.012)	0.011 (0.002-0.037)
Rourkela D/s	0.005 ( $<0.001-0.010$ )	0.004 (0.003-0.007)	0.006	0.016 (0.015-0.018)	0.007 (0.001-0.017)
Rourkela FD/s at Attaghat	0.005 (0.002-0.010)	0.004 (0.003-0.007)	0.005	0.013 (0.013-0.014)	0.005 (0.001-0.012)
Rourkela FFD/s at Biritola	0.006 (0.003-0.010)	0.004 (0.002-0.007)	0.005	0.016 (0.015-0.017)	0.004 (0.001-0.012)
Bonaigarh	0.005 (0.003-0.010)	0.005 (0.003-0.007)	0.004	0.006 (0.003-0.008)	0.004 (0.002-0.009)
Rengali	0.003 (0.001-0.007)	0.003 (0.001-0.006)	0.003	0.005 (0.003-0.008)	0.004 (0.001-0.008)
Samal	0.004 (0.001-0.008)	0.003 (0.001-0.006)	0.002	0.004 (0.002-0.007)	0.005 (0.001-0.008)
Talcher FU/s	0.004 (0.002-0.006)	0.004 (0.002-0.006)	0.002	0.005 (0.005-0.006)	0.003 ( $<0.001-0.009$ )
Talcher U/s	0.004 (0.001-0.008)	0.004 (0.002-0.007)	0.001	0.004 (0.002-0.006)	0.004 (0.001-0.009)
Talcher D/s	0.004 (0.001-0.007)	0.005 (0.002-0.008)	0.004	0.007 (0.003-0.012)	0.005 (0.001-0.016)
Talcher FD/s	0.003 (0.001-0.006)	0.005 (0.003-0.007)	0.003	0.008 (0.003-0.014)	0.006 (0.001-0.011)
Nandira D/s (Nandira)	0.004 (0.001-0.008)	0.006 (0.004-0.008)	0.004	0.014 (0.006-0.022)	0.007 (0.001-0.016)
Kisinda Jhor (Kisinda Jhor)	0.004 (0.002-0.007)	0.005 (0.004-0.007)	0.004	0.006 (0.005-0.008)	0.008 (0.002-0.018)
Dhenkanal U/s	0.004 (0.001-0.008)	0.004 (0.002-0.005)	0.002	0.005 (0.004-0.005)	0.005 ( $<0.001-0.015$ )
Dhenkanal D/s	0.004 (0.001-0.009)	0.004 (0.003-0.006)	0.002	0.007 (0.006-0.007)	0.010 (0.001-0.040)
Bhuban	0.003 (0.001-0.006)	0.004 (0.002-0.005)	0.002	0.006 (0.005-0.007)	0.005 (0.001-0.017)
Kabatabandha	0.004 (0.001-0.009)	0.004 (0.003-0.005)	0.002	0.012 (0.009-0.015)	0.004 (0.001-0.009)
Dharmasala U/s	0.004 (0.001-0.011)	0.004 (0.003-0.004)	0.002	0.004 (0.003-0.004)	0.002 ( $<0.001-0.007$ )
Dharmasala D/s	-	-	-	0.004 (0.002-0.005)	0.004 ( $<0.001-0.008$ )
Pottamundai	0.003 ( $<0.001-0.010$ )	0.004 (0.003-0.006)	0.002	0.003 (0.003-0.004)	0.003 (0.001-0.007)
Khanditara (Kharasrota)	0.004 (0.001-0.007)	0.004 (0.002-0.005)	0.002	0.003 (0.003-0.004)	0.007 (0.001-0.028)
Binjharpur (Kharasrota)	0.004 (0.001-0.008)	0.004 (0.003-0.004)	0.003	0.004 (0.002-0.006)	0.004 (0.002-0.007)
Aul (Kharasrota)	0.004 (0.001-0.006)	0.005 (0.002-0.007)	0.004	0.029 (0.008-0.051)	0.005 (0.003-0.009)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 4.19 (f) Zinc

Monitoring Station	Zinc (mg/l)				
	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
Sankh U/s (Sankh)	0.005 (<0.001-0.010)	0.004 (0.003-0.005)	0.005	0.005 (0.002-0.008)	0.007 (0.001-0.016)
Koel U/s (Koel)	0.006 (0.001-0.015)	0.006 (0.005-0.007)	0.006	0.006 (0.001-0.012)	0.015 (0.003-0.050)
Panposh U/s	0.005 (0.001-0.009)	0.006 (0.003-0.009)	0.007	0.030 (0.024-0.036)	0.008 (0.002-0.014)
Panposh D/s	0.007 (<0.001-0.003)	0.011 (0.005-0.019)	0.015	0.172 (0.164-0.180)	0.020 (0.005-0.032)
Rourkela D/s	0.007 (0.003-0.006)	0.008 (0.002-0.013)	0.009	0.035 (0.021-0.048)	0.015 (0.003-0.023)
Rourkela FD/s at Attaghat	0.006 (<0.001-0.015)	0.004 (0.002-0.008)	0.008	0.025 (0.016-0.034)	0.011 (0.002-0.019)
Rourkela FFD/s at Biritola	0.006 (0.001-0.011)	0.010 (0.006-0.013)	0.009	0.027 (0.018-0.036)	0.012 (0.003-0.020)
Bonaigarh	0.005 (0.001-0.009)	0.006 (0.004-0.008)	0.007	0.007 (0.002-0.012)	0.012 (0.001-0.053)
Rengali	0.004 (0.001-0.011)	0.007 (0.005-0.008)	0.008	0.008 (0.001-0.014)	0.016 (0.003-0.083)
Samal	0.006 (0.001-0.012)	0.005 (0.003-0.007)	0.007	0.006 (0.001-0.011)	0.010 (0.001-0.022)
Talcher FU/s	0.005 (<0.001-0.013)	0.005 (0.002-0.009)	0.002	0.007 (0.006-0.009)	0.007 (0.001-0.023)
Talcher U/s	0.007 (0.002-0.016)	0.006 (0.001-0.010)	0.004	0.007 (0.002-0.012)	0.010 (0.002-0.026)
Talcher D/s	0.007 (0.001-0.016)	0.009 (0.002-0.012)	0.006	0.016 (0.013-0.018)	0.013 (0.002-0.030)
Talcher FD/s	0.006 (0.001-0.012)	0.007 (0.002-0.011)	0.005	0.012 (0.011-0.014)	0.012 (0.002-0.029)
Nandira D/s (Nandira)	0.005 (0.001-0.011)	0.013 (0.003-0.017)	0.008	0.032 (0.020-0.045)	0.019 (0.005-0.032)
Kisinda Jhor (Kisinda Jhor)	0.005 (0.002-0.011)	0.012 (0.002-0.022)	0.004	0.016 (0.005-0.026)	0.019 (0.003-0.032)
Dhenkanal U/s	0.005 (<0.001-0.009)	0.005 (0.001-0.008)	0.009	0.005 (0.001-0.008)	0.007 (0.002-0.013)
Dhenkanal D/s	0.008 (0.003-0.017)	0.008 (0.003-0.012)	0.011	0.014 (0.012-0.017)	0.011 (0.001-0.017)
Bhuban	0.005 (0.001-0.014)	0.005 (0.002-0.008)	0.008	0.025 (0.022-0.027)	0.013 (0.001-0.032)
Kabatabandha	0.006 (0.003-0.011)	0.007 (0.002-0.011)	0.009	0.022 (0.021-0.022)	0.011 (0.001-0.043)
Dharmasala U/s	0.006 (<0.001-0.018)	0.008 (0.003-0.013)	0.009	0.005 (0.003-0.008)	0.007 (0.001-0.014)
Dharmasala D/s	-	-	-	0.006 (0.001-0.011)	0.008 (0.001-0.015)
Pottamundai	0.007 (0.001-0.250)	0.009 (0.005-0.012)	0.011	0.005 (0.002-0.008)	0.010 (0.002-0.029)
Khanditara (Kharasrota)	0.007 (0.001-0.140)	0.006 (0.003-0.007)	0.009	0.006 (0.002-0.009)	0.014 (0.002-0.042)
Binjharpur (Kharasrota)	0.004 (0.001-0.010)	0.007 (0.002-0.015)	0.008	0.007 (0.002-0.011)	0.019 (0.004-0.089)
Aul (Kharasrota)	0.006 (0.001-0.014)	0.006 (0.004-0.008)	0.008	0.042 (0.010-0.073)	0.009 (0.002-0.019)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 4.19 (g) Cadmium

Monitoring Station	Cadmium (mg/l)				
	2011	2012	2013*	2014#	2015##
Sankh U/s (Sankh)	0.001 (<0.001-0.002)	0.001 (<0.001-0.002)	<0.001	0.0011 (0.0008-0.0014)	0.0019 (0.0004-0.0049)
Koel U/s (Koel)	0.001 (<0.001-0.003)	0.002 (<0.001L-0.003)	<0.001	0.0011 (0.0009-0.0011)	0.0034 (0.0005-0.0089)
Panposh U/s	0.001 (<0.001-0.004)	0.002 (0.001-0.003)	<0.001	0.0010 (0.0009-0.0012)	0.0029 (0.0004-0.0079)
Panposh D/s	0.001 (<0.001-0.003)	0.002 (0.001-0.002)	0.001	0.0010 (0.0007-0.0013)	0.0032 (0.0010-0.0066)
Rourkela D/s	0.001 (<0.001-0.003)	0.002 (0.001-0.003)	0.001	0.0009 (0.0006-0.0011)	0.0029 (0.0008-0.0051)
Rourkela FD/s at Attaghat	0.001 (<0.001-0.002)	0.002 (0.001-0.003)	0.001	0.0007 (0.0006-0.0009)	0.0023 (0.0006-0.0044)
Rourkela FFD/s at Biritola	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0006 (0.0002-0.0011)	0.0028 (0.0009-0.0055)
Bonaigarh	0.001 (<0.001-0.003)	0.002 (0.001-0.002)	<0.001	0.0010 (0.0007-0.0013)	0.0034 (0.0007-0.0105)
Rengali	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0007 (0.0004-0.0011)	0.0032 (0.0005-0.0086)
Samal	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	<0.001	0.0007 (0.0004-0.0011)	0.0034 (0.0007-0.0088)
Talcher FU/s	0.001 (<0.001-0.004)	0.001 (0.001-0.002)	<0.001	0.0011 (0.0011-0.0012)	0.0019 (0.0007-0.0046)
Talcher U/s	0.001 (<0.001-0.004)	0.001 (0.001-0.002)	0.001	0.0008 (0.0004-0.0012)	0.0019 (0.0005-0.0048)
Talcher D/s	0.002 (<0.001-0.006)	0.002 (0.001-0.003)	0.001	0.0009 (0.0004-0.0014)	0.0025 (0.0011-0.0084)
Talcher FD/s	0.001 (<0.001-0.004)	0.001 (0.001-0.002)	0.001	0.0011 (0.0010-0.0011)	0.0022 (0.0011-0.0054)
Nandira D/s (Nandira)	0.001 (<0.001-0.005)	0.002 (0.001-0.003)	0.001	0.0019 (0.0018-0.0020)	0.0045 (0.0011-0.0104)
Kisinda Jhor (Kisinda Jhor)	0.001 (<0.001-0.004)	0.002 (0.001-0.003)	0.001	0.0021 (0.0021-0.0021)	0.0049 (0.0007-0.0109)
Dhenkanal U/s	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0008 (0.0008-0.0009)	0.0029 (0.0005-0.0076)
Dhenkanal D/s	0.001 (<0.001-0.003)	0.003 (0.001-0.008)	0.001	0.0011 (0.0011-0.0012)	0.0037 (0.0006-0.0083)
Bhuban	0.001 (<0.001-0.003)	0.001 (0.001-0.003)	<0.001	0.0011 (0.0010-0.0011)	0.0015 (0.0007-0.0044)
Kabatabandha	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	<0.001	0.0016 (0.0014-0.0018)	0.0015 (0.0004-0.0036)
Dharmasala U/s	0.001 (<0.001-0.002)	0.002 (0.001-0.002)	<0.001	0.0011 (0.0009-0.0012)	0.0032 (0.0006-0.0141)
Dharmasala D/s	-	-	-	0.0010 (0.0008-0.0012)	0.0034 (0.0006-0.0146)
Pottamundai	0.002 (<0.001-0.004)	0.002 (0.001-0.003)	0.001	0.0011 (0.0008-0.0014)	0.0016 (0.0006-0.0048)
Khanditara (Kharasrota)	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	<0.001	0.0011 (0.0009-0.0013)	0.0017 (0.0007-0.0041)
Binjharpur (Kharasrota)	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	<0.001	0.006 (0.006-0.006)	0.0031 (0.0007-0.0158)
Aul (Kharasrota)	0.002 (<0.001-0.007)	0.002 (0.001-0.003)	<0.001	0.0013 (0.0011-0.0014)	0.0030 (0.0007-0.0116)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 4.19 (h) Lead

Monitoring Station	Lead (mg/l)				
	2011	2012	2013*	2014#	2015##
Sankh U/s (Sankh)	0.004 (0.001-0.010)	0.003 (0.001-0.008)	0.005	0.011 (0.008-0.014)	0.009 (0.003-0.013)
Koel U/s (Koel)	0.004 (<0.001-0.010)	0.005 (0.003-0.007)	0.005	0.006 (0.003-0.009)	0.014 (0.004-0.026)
Panposh U/s	0.004 (0.002-0.007)	0.005 (0.001-0.008)	0.002	0.007 (0.006-0.008)	0.007 (0.003-0.014)
Panposh D/s	0.006 (<0.001-0.012)	0.009 (0.008-0.010)	0.01	0.007 (0.002-0.012)	0.013 (0.006-0.021)
Rourkela D/s	0.005 (0.001-0.008)	0.007 (0.006-0.009)	0.008	0.009 (0.005-0.012)	0.009 (0.002-0.013)
Rourkela FD/s at Attaghat	0.006 (0.001-0.010)	0.005 (0.004-0.007)	0.008	0.004 (0.001-0.008)	0.008 (0.003-0.012)
Rourkela FFD/s at Biritola	0.005 (0.001-0.009)	0.006 (0.005-0.007)	0.008	0.006 (0.005-0.008)	0.009 (0.005-0.013)
Bonaigarh	0.005 (0.002-0.009)	0.005 (0.004-0.006)	0.005	0.007 (0.006-0.009)	0.010 (0.002-0.025)
Rengali	0.003 (0.001-0.010)	0.005 (0.004-0.005)	0.004	0.008 (0.005-0.011)	0.007 (0.003-0.010)
Samal	0.003 (<0.001-0.009)	0.004 (0.003-0.007)	0.004	0.011 (0.011-0.011)	0.008 (0.002-0.019)
Talcher FU/s	0.005 (0.001-0.010)	0.004 (0.001-0.008)	0.008	0.027 (0.009-0.044)	0.005 (<0.001-0.012)
Talcher U/s	0.004 (<0.001-0.009)	0.004 (0.003-0.006)	0.019	0.010 (0.007-0.012)	0.007 (0.002-0.025)
Talcher D/s	0.005 (0.001-0.011)	0.020 (0.006-0.048)	0.013	0.018 (0.012-0.024)	0.009 (0.004-0.015)
Talcher FD/s	0.003 (<0.001-0.007)	0.007 (0.004-0.015)	0.012	0.010 (0.009-0.012)	0.007 (0.003-0.011)
Nandira D/s (Nandira)	0.008 (0.002-0.130)	0.021 (0.014-0.026)	0.009	0.028 (0.014-0.042)	0.014 (0.009-0.020)
Kisinda Jhor (Kisinda Jhor)	0.005 (0.002-0.011)	0.013 (0.008-0.019)	0.003	0.036 (0.025-0.048)	0.017 (0.009-0.023)
Dhenkanal U/s	0.004 (0.001-0.008)	0.005 (0.003-0.009)	0.013	0.004 (0.001-0.008)	0.012 (0.003-0.028)
Dhenkanal D/s	0.004 (<0.001-0.007)	0.007 (0.004-0.009)	0.015	0.011 (0.006-0.016)	0.011 (0.003-0.022)
Bhuban	0.005 (<0.001-0.008)	0.004 (0.001-0.007)	0.01	0.013 (0.011-0.016)	0.006 (0.002-0.015)
Kabatabandha	0.005 (0.001-0.078)	0.005 (0.002-0.009)	0.008	0.008 (0.006-0.009)	0.007 (0.002-0.029)
Dharmasala U/s	0.003 (<0.001-0.007)	0.003 (0.002-0.004)	0.006	0.008 (0.008-0.008)	0.009 (0.004-0.019)
Dharmasala D/s	-	-	-	0.006 (0.005-0.007)	0.010 (0.006-0.018)
Pottamundai	0.004 (<0.001-0.007)	0.005 (0.003-0.007)	0.008	0.011 (0.008-0.013)	0.011 (0.004-0.035)
Khanditara (Kharasrota)	0.004 (0.001-0.008)	0.004 (0.003-0.006)	0.005	0.009 (0.008-0.009)	0.008 (0.001-0.017)
Binjharpur (Kharasrota)	0.005 (0.002-0.009)	0.007 (0.004-0.009)	0.006	0.009 (0.005-0.012)	0.008 (0.002-0.019)
Aul (Kharasrota)	0.004 (0.001-0.008)	0.005 (0.003-0.008)	0.007	0.012 (0.009-0.014)	0.010 (0.002-0.036)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 4.20 Annual average and Range of Saprobic index (SI) , Diversity Index (DI) and Biological Class

Monitoring station	SI				
	2011	2012	2013	2014	2015
Panposh U/s	4.7 (4.0-5.4)	5.5 (4.8-6.0)	5.94 (5.84-6.00)	5.77	6.1 (5.8-6.4)
Panposh D/s	5.1 (5.0-5.2)	5.5 (5.3-5.7)	5.37 (5.14-5.83)	5.59 (5.25-5.80)	5.1 (4.8-5.6)
Rourkela D/s	5.8	-	5.30 (5.20-5.60)	5.63 (5.57-5.83)	5.7 (5.6-5.8)
Talcher U/s	5.7 (5.6-5.8)	5.7 (4.8-6.4)	5.60 (5.30-5.80)	-	6.2 (6.2-6.3)
Talcher D/s	4.9 (4.6-5.3)	5.5 (5.0-6.0)	5.20 (5.5-6.0)	5.40 (4.57-5.80)	5.3 (4.7-5.7)
	DI				
	2011	2012	2013	2014	2015
Panposh U/s	0.6 (0.3-0.8)	0.69 (0.60-0.83)	0.63 (0.48-0.90)	0.67	0.58 (0.46-0.70)
Panposh D/s	0.5 (0.3-0.8)	0.49 (0.38-0.60)	0.63 (0.51-0.77)	0.53 (0.45-0.75)	0.54 (0.36-0.75)
Rourkela D/s	0.3	-	0.46 (0.36-0.66)	0.55 (0.50-0.66)	0.66 (0.58-0.80)
Talcher U/s	0.5 (0.3-0.7)	0.56 (0.45-0.72)	0.60 (0.56-0.63)	-	0.64 (0.57-0.71)
Talcher D/s	0.5 (0.5-0.6)	0.62 (0.44-0.84)	0.50 (0.45-0.55)	0.67 (0.56-0.80)	0.65 (0.51-0.73)
	Biological Class				
	2011	2012	2013	2014	2015
Panposh U/s	C	C	C	C	B-C
Panposh D/s	C	C	C	C	C
Rourkela D/s	C	-	C	C	C
Talcher U/s	C	B-C	C	-	B
Talcher D/s	C	C	C	C	C

Table 4.21 Annual average and Range of (Nitrite+Nitrate)-Nitrogen values

Monitoring Station	(Nitrite+Nitrate)-Nitrogen (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	1.506 (0.019-8.195)	0.351 (0.033-1.728)	1.694 (0.209-7.412)	0.589 (0.016-3.500)	0.823 (0.235-1.969)
Koel U/s (Koel)	0.622 (0.132-2.800)	0.516 (0.042-2.120)	0.518 (0.073-1.359)	0.626 (0.149-3.084)	1.172 (0.061-4.218)
Panposh U/s	1.183 (0.047-6.759)	0.445 (0.085-2.293)	0.575 (0.141-1.581)	0.738 (0.202-4.638)	1.126 (0.174-4.209)
Panposh D/s	4.135 (0.178-9.717)	5.155 (0.179-9.397)	2.770 (0.004-8.554)	4.126 (0.798-7.978)	1.781 (0.258-5.068)
Rourkela D/s	2.339 (0.042-6.270)	2.976 (0.441- 6.336)	2.776 (0.490-8.269)	3.128 (0.301-7.254)	2.300 (0.239-8.455)
Rourkela FD/s at Attaghat	1.760 (0.096-5.863)	1.091 (0.045-3.235)	1.012 (0.041-2.032)	1.285 (0.148-3.471)	1.478 (0.231-8.751)
Rourkela FFD/s at Biritola	1.521 (0.304-5.609)	1.491 (0.369-3.065)	0.869 (0.214-2.993)	1.315 (0.648-3.126)	0.725 (0.292-1.049)
Bonaigarh	1.534 (0.144-4.350)	1.097 (0.202-2.073)	1.013 (0.312-2.408)	1.546 (0.783-3.515)	2.088 (0.057-9.677)
Rengali	0.849 (0.052-2.897)	0.444 (0.057-1.917)	0.498 (0.127-1.419)	0.873 (0.152-2.246)	0.988 (0.341-2.242)
Samal	0.582 (0.126-1.920)	0.457 (0.039-0.989)	0.602 (0.042-0.936)	0.887 (0.285-2.037)	1.252 (0.191-5.724)
Talcher FU/s	0.623 (0.006-3.391)	0.426 (0.104-1.609)	0.587 (0.069-2.160)	0.557 (0.138-1.711)	0.518 (0.120-1.082)
Talcher U/s	0.522 (0.037-1.538)	0.314 (0.009-0.860)	0.958 (0.050-2.256)	0.798 (0.110-2.298)	0.846 (0.218-1.856)
Talcher D/s	0.584 (0.020-2.838)	0.402 (0.014-1.149)	0.650 (0.149-1.983)	0.846 (0.096-2.018)	2.019 (1.071-3.691)
Talcher FD/s	0.555 (0.036-1.570)	0.991 (0.007-9.656)	0.502 (0.069-1.584)	0.602 (0.193-1.444)	0.759 (0.076-1.714)
Nandira D/s (Nandira)	0.667 (0.245-1.704)	0.643 (0.044-1.793)	0.772 (0.039-1.670)	1.088 (0.213-3.284)	1.521 (0.717-4.136)
Kisinda Jhor (Kisinda Jhor)	0.923 (0.010-2.167)	1.083 (0.037-2.858)	1.295 (0.027-4.983)	0.795 (0.128-3.159)	1.479 (0.232-4.461)
Dhenkanal U/s	0.655 (0.024-1.951)	0.604 (0.003-2.295)	0.510 (0.080-1.322)	0.510 (0.079-1.690)	0.747 (0.103-1.882)
Dhenkanal D/s	0.676 (0.084-1.782)	0.422 (0.061-1.458)	0.412 (0.059-1.423)	0.408 (0.135-0.889)	2.234 (0.392-4.274)
Bhuban	0.648 (0.113-2.332)	0.813 (0.066-3.454)	0.568 (0.031-1.992)	0.337 (0.143-0.797)	1.155 (0.105-2.643)
Kabatabandha	0.907 (0.049-4.010)	0.894 (0.012-4.188)	0.589 (0.017-1.779)	0.477 (0.160-1.135)	1.254 (0.134-3.672)
Dharmasala U/s	0.955 (0.065-2.999)	0.581 (0.059-2.341)	0.727 (0.151-1.371)	0.357 (0.030-0.742)	1.231 (0.182-3.433)
Dharmasala D/s	-	-	-	0.694 (0.016-2.057)	1.960 (0.485-3.832)
Pottamundai	0.300 (0.070-0.845)	0.540 (0.033-2.277)	0.685 (0.076-2.511)	0.577 (0.229-1.074)	1.159 (0.024-3.411)
Khanditara (Kharasrota)	0.479 (0.030-1.707)	0.415 (0.029-1.621)	0.728 (0.078-1.888)	0.697 (0.060-1.470)	0.832 (0.037-2.242)
Binjharpur (Kharasrota)	0.404 (0.392-1.201)	0.929 (0.032-3.150)	0.585 (0.061-1.464)	0.561 (0.124-1.648)	0.934 (0.023-3.097)
Aul (Kharasrota)	0.526 (0.035-1.899)	0.890 (0.051-2.907)	0.533 (0.018-1.104)	1.532 (0.182-10.285)	0.680 (0.019-2.522)

Table 4.22 Annual average and Range of Total Suspended Solids (mg/l)

Monitoring Station		TSS				
		2011	2012	2013	2014	2015
Sankh U/s (Sankha)	IM	185 (5-1374)	63 (6-286)	97 (26-242)	77 (8-557)	24 (4-134)
	NM	173 (5-1374)	25 (6-39)	74 (26-138)	15 (8-25)	13 (4-24)
Koel U/s (Koel)	IM	176 (3-940)	73 (16-310)	99 (10-336)	132 (8-948)	24 (3-146)
	NM	136 (3-940)	25 (16-39)	57 (10-122)	13 (8-22)	8 (3-10)
Panposh U/s	IM	193 (2-1330)	67 (15-174)	73 (20-166)	30 (5-83)	18 (2-80)
	NM	181 (2-1330)	40 (15-86)	54 (20-112)	11 (5-14)	6 (2-10)
Panposh D/s	IM	270 (23-1318)	101 (27-372)	113 (22-366)	154 (23-1035)	47 (14-160)
	NM	198 (23-1318)	62 (27-89)	68 (22-366)	41 (23-68)	34 (14-70)
Rourkela D/s	IM	262 (21-1174)	92 (26-414)	100 (34-356)	131 (15-761)	39 (12-120)
	NM	172 (21-1174)	54 (26-112)	69 (34-112)	43 (15-136)	25 (12-54)
Rourkela FD/s at Attaghat	IM	193 (3-1142)	84 (14-348)	94 (16-274)	117 (8-885)	27 (6-120)
	NM	166 (3-1142)	40 (14-68)	59 (16-132)	18 (8-42)	14 (6-22)
Rourkela FD/s at Biritola	IM	280 (5-1966)	89 (18-380)	101 (14-276)	96 (10-722)	29 (10-110)
	NM	252 (5-1966)	39 (18-78)	67 (14-100)	20 (10-40)	12 (10-24)
Bonaigarh	IM	232 (6-1850)	61 (8-144)	133 (20-438)	109 (5-891)	33 (4-130)
	NM	229 (6-1850)	43 (8-78)	68 (20-160)	11 (5-20)	13 (4-20)
Rengali	IM	75 (10-316)	43 (8-74)	75 (18-300)	25 (6-64)	15 (2-39)
	NM	26 (10-62)	37 (8-66)	49 (18-130)	16 (6-50)	12 (2-39)
Samal	IM	107 (3-356)	69 (6-278)	111 (30-328)	28 (3-85)	22 (3-80)
	NM	36 (9-88)	38 (6-68)	73 (30-196)	16 (3-42)	10 (3-28)
Talcher FU/s	IM	166 (9-1232)	72 (16-238)	84 (26-256)	32 (3-76)	29 (4-85)
	NM	48 (9-188)	54 (16-238)	71 (26-256)	18 (3-40)	15 (4-80)
Talcher U/s	IM	126 (18-788)	67 (10-182)	81 (20-180)	36 (3-73)	25 (3-87)
	NM	45 (18-138)	58 (10-182)	56 (20-80)	26 (3-72)	8 (3-15)
Talcher D/s	IM	114 (11-544)	63 (12-136)	62 (28-160)	36 (4-78)	30 (12-90)
	NM	52 (11-210)	49 (12-135)	50 (28-84)	26 (4-78)	15 (12-22)
Talcher FD/s	IM	92 (7-308)	63 (12-150)	105 (18-422)	39 (4-85)	25 (4-82)
	NM	50 (7-145)	51 (12-150)	102 (18-422)	25 (4-60)	11 (4-20)

Table 4.22 contd..

Monitoring Station		TSS				
		2011	2012	2013	2014	2015
Nandira D/s (Nandira)	IM	34 (12-65)	58 (19-148)	55 (26-98)	71 (4-293)	38 (10-92)
	NM	30 (12-49)	61 (19-148)	51 (26-98)	41 (4-102)	31 (10-91)
Kisinda Jhor (Kisindajhor)	IM	76 (17-332)	93 (18-210)	70 (10-174)	26 (5-92)	33 (4-115)
	NM	83 (17-332)	76 (18-187)	76 (10-174)	32 (5-92)	21 (4-36)
Dhenkanal U/s	IM	139 (9-400)	63 (14-109)	145 (52-584)	25 (6-72)	24 (7-65)
	NM	73 (9-180)	64 (14-109)	78 (52-110)	22 (6-22)	13 (7-22)
Dhenkanal D/s	IM	126 (14-346)	58 (9-130)	136 (34-536)	35 (2-95)	29 (6-75)
	NM	96 (14-346)	52 (9-130)	77 (34-132)	24 (2-82)	18 (6-27)
Bhuban	IM	94 (12-268)	120 (38-250)	93 (18-248)	73 (6-73)	31 (6-85)
	NM	52 (12-151)	93 (38-216)	79 (18-116)	33 (6-71)	15 (6-36)
Kabatabandha	IM	120 (11-328)	108 (16-414)	90 (20-224)	37 (6-114)	30 (3-88)
	NM	75 (11-283)	112 (16-414)	51 (20-80)	22 (6-60)	11 (3-30)
Dharmasala U/s	IM	83 (23-196)	70 (13-234)	216 (4-1244)	24 (6-56)	27 (3-102)
	NM	58 (23-115)	37 (13-109)	67 (4-1224)	13 (6-20)	11 (3-25)
Dharmasala D/s	IM	-	-	-	22 (6-44)	30 (5-118)
	NM	-	-	-	16 (6-33)	13 (5-30)
Pottamundai	IM	105 (29-272)	78 (27-164)	103 (34-454)	26 (4-77)	15 (3-56)
	NM	65 (29-121)	60 (27-131)	54 (34-82)	18 (4-60)	10 (3-20)
Khanditara (Kharasrota)	IM	96 (19-338)	75 (13-200)	142 (16-468)	31 (8-68)	22 (3-87)
	NM	47 (19-79)	43 (13-138)	73 (16-205)	21 (8-31)	10 (3-16)
Binjharpur (Kharasrota)	IM	95 (18-372)	63 (19-206)	124 (14-458)	34 (8-76)	25 (6-111)
	NM	46 (18-95)	33 (19-108)	63 (14-207)	22 (8-38)	10 (6-23)
Aul (Kharasrota)	IM	103 (9-336)	87 (24-220)	98 (22-256)	44 (12-108)	25 (5-98)
	NM	45 (9-102)	58 (24-150)	51 (22-68)	31 (12-108)	10 (5-23)

**Note :** IM : Including monsoon period

NM : Non-monsoon period (i.e. excluding the months July, August and September)

Table 4.23 Percentage violation and annual range of Fecal Coliform (FC) values

Monitoring Station	Percentage Violation from 2000 MPN/100 ml (Range of FC values in '000 MPN/100 ml)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	8 (0.210-24.000)	17 (0.210-3.500)	20 (0.078-17.000)	18 (0.078-13.000)	42 (0.110-13.000)
Koel U/s (Koel)	17 (0.230-17.000)	42 (0.230-3.500)	10 (0.170-4.900)	45 (0.130-35.000)	42 (0.330-24.000)
Panposh U/s	17 (0.790-7.900)	50 (1.300-9.200)	90 (0.490-13.000)	9 (0.790-13.000)	75 (1.100-11.000)
Panposh D/s	92 (1.700-35.000)	100 (7.900-54.000)	100 (2.700-92.000)	100 (7.000-35.000)	100 (4.600-54.000)
Rourkela D/s	58 (0.940-35.000)	100 (2.200-54.000)	90 (0.790-92.000)	100 (7.000-92.000)	100 (3.300-22.000)
Rourkela FD/s at Attaghat	50 (0.330-13.000)	82 (1.300-13.000)	10 (0.078-7.900)	36 (0.130-16.000)	50 (0.330-4.900)
Rourkela FFD/s at Biritola	42 (0.790-13.000)	92 (0.790-7.900)	20 (0.130-17.000)	64 (0.230-11.000)	50 (0.078-7.900)
Bonaigarh	17 (0.790-3.100)	17 (0.045-5.400)	40 (0.045-22.000)	36 (0.045-24.000)	33 (0.130-13.000)
Rengali	8 (0.210-2.300)	8 (0.020-2.400)	0 (0.045-1.100)	18 (0.020-3.500)	8 (0.020-9.200)
Samal	0 (0.170-0.940)	25 (0.045-5.400)	20 (0.045-7.900)	46 (0.045-5.400)	58 (0.020-13.000)
Talcher FU/s	0 (0.230-1.500)	8 (0.170-2.400)	10 (0.170-2.300)	27 (0.110-3.500)	25 (0.130-4.600)
Talcher U/s	8 (0.790-2.200)	17 (0.330-3.500)	20 (0.780-4.900)	27 (0.230-35.000)	25 (0.330-9.400)
Talcher D/s	75 (1.100-28.000)	100 (3.300-24.000)	80 (1.100-7.900)	45 (0.490-14.000)	67 (0.490-24.000)
Talcher FD/s	42 (0.460-14.000)	75 (0.700-11.000)	60 (0.780-4.900)	27 (0.078-7.000)	42 (0.330-24.000)
Nandira D/s (Nandira)	42 (0.210-4.300)	75 (1.400-35.000)	33 (0.490-24.000)	64 (0.140-35.000)	83 (0.330-49.000)
Kisinda Jhor (Kisinda Jhor)	17 (0.080-22.000)	42 (0.780-1.300)	70 (0.280-17.000)	73 (0.490-24.000)	33 (0.130-4.900)
Dhenkanal U/s	25 (0.840-2.800)	58 (0.700-14.000)	40 (0.790-24.000)	82 (0.450-92.000)	91 (1.700-160.000)
Dhenkanal D/s	75 (1.400-35.000)	92 (1.700-92.000)	50 (0.220-54.000)	100 (0.5300-54.000)	67 (0.490-92.000)
Bhuban	50 (1.100-13.000)	25 (0.330-7.000)	80 (0.490-54.000)	18 (0.078-4.900)	42 (0.078-16.000)
Kabatabandha	50 (0.840-8.400)	33 (0.230-54.000)	50 (0.330-35.000)	27 (0.078-7.900)	25 (0.020-2.400)
Dharmasala U/s	58 (0.940-11.000)	42 (0.460-17.000)	30 (0.700-7.900)	55 (0.700-35.000)	92 (0.790-17.000)
Dharmasala D/s	-	-	-	64 (0.490-54.000)	83 (0.078-92.000)
Pottamundai	83 (1.700-35.000)	67 (0.490-5.400)	40 (0.490-7.900)	45 (0.230-9.200)	58 (0.230-16.000)
Khanditara (Kharasrota)	25 (0.490-9.400)	25 (0.790-5.400)	20 (0.330-7.900)	27 (0.130-3.300)	33 (0.078-7.900)
Binjharpur (Kharasrota)	17 (0.330-14.000)	25 (0.490-11.000)	20 (0.330-92.000)	18 (0.490-9.200)	25 (0.330-9.200)
Aul (Kharasrota)	25 (0.700-24.000)	42 (0.220-7.000)	60 (0.330-13.000)	45 (0.330-54.000)	25 (0.230-11.000)

Table 4.24 Annual average and Range values of Total Phosphate-P

Monitoring Station	Total Phosphate-P (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	0.052 (0.001-0.130)	0.048 (0.002-0.153)	0.081 (0.008-0.179)	0.284 (0.005-2.220)	0.128 (0.018-0.488)
Koel U/s (Koel)	0.042 (0.005-0.130)	0.057 (0.009-0.168)	0.050 (0.010-0.128)	0.138 (0.022-0.923)	0.150 (0.006-0.590)
Panposh U/s	0.165 (0.007-1.345)	0.032 (0.006-0.100)	0.100 (0.036-0.168)	0.108 (0.017-0.310)	0.071 (0.004-0.335)
Panposh D/s	0.067 (0.005-0.153)	0.078 (0.019-0.260)	0.159 (0.040-0.842)	0.140 (0.006-0.717)	0.136 (0.019-0.509)
Rourkela D/s	0.094 (0.003-0.556)	0.123 (0.016-0.720)	0.071 (0.018-0.170)	0.217 (0.014-1.765)	0.111 (0.013-0.453)
Rourkela FD/s at Attaghat	0.046 (0.008-0.164)	0.084 (0.023-0.490)	0.074 (0.010-0.192)	0.152 (0.022-1.025)	0.081 (0.011-0.231)
Rourkela FFD/s at Biritola	0.099 (0.004-0.722)	0.091 (0.005-0.413)	0.089 (ND-0.336)	0.182 (0.005-1.231)	0.075 (0.011-0.192)
Bonaigarh	0.127 (0.003-0.846)	0.045 (0.003-0.237)	0.058 (0.020-0.099)	0.234 (0.006-1.036)	0.095 (0.027-0.410)
Rengali	0.048 (0.009-0.104)	0.069 (0.002-0.447)	0.090 (0-0.371)	0.367 (0.007-0.959)	0.141 (0.024-0.600)
Samal	0.090 (0.019-0.399)	0.037 (0.004-0.092)	0.062 (0.003-0.160)	0.087 (0.018-0.192)	0.108 (0.038-0.414)
Talcher FU/s	0.042 (0.005-0.126)	0.095 (0.008-0.774)	0.047 (0.003-0.150)	0.246 (0.011-2.287)	0.200 (0.016-1.273)
Talcher U/s	0.057 (0.007-0.185)	0.044 (0.004-0.178)	0.047 (0.005-0.109)	0.144 (0.015-1.053)	0.090 (0.009-0.227)
Talcher D/s	0.066 (0.013-0.297)	0.047 (0.011-0.126)	0.038 (0.003-0.133)	0.058 (0.009-0.319)	0.096 (0.011-0.231)
Talcher FD/s	0.079 (0.004-0.326)	0.043 (0.005-0.163)	0.030 (0.001-0.077)	0.238 (0.009-1.210)	0.082 (0.035-0.202)
Nandira D/s (Nandira)	0.081 (0.003-0.176)	0.078 (0.014-0.259)	0.063 (0.006-0.168)	0.220 (0.025-1.040)	0.062 (0.023-0.094)
Kisinda Jhor (Kisinda Jhor)	0.084 (0.023-0.149)	0.111 (0.023-0.319)	0.150 (0.012-0.366)	0.321 (0.019-2.444)	0.050 (0.012-0.115)
Dhenkanal U/s	0.112 (0.004-0.684)	0.044 (0.011-0.176)	0.080 (0.005-0.177)	0.063 (0.008-0.146)	0.073 (0.012-0.231)
Dhenkanal D/s	0.171 (0.004-0.788)	0.058 (0.017-0.116)	0.055 (0.010-0.243)	0.072 (0.009-0.234)	0.107 (0.033-0.214)
Bhuban	0.082 (0.008-0.242)	0.066 (0.006-0.389)	0.048 (0.003-0.123)	0.082 (0.030-0.175)	0.193 (0.009-1.212)
Kabatabandha	0.044 (0.005-0.114)	0.061 (0.005-0.285)	0.051 (0.001-0.123)	0.118 (0.008-0.529)	0.085 (0.005-0.220)
Dharmasala U/s	0.043 (0.001-0.092)	0.037 (0.006-0.074)	0.138 (0.008-0.571)	0.080 (0.011-0.150)	0.152 (0.004-0.731)
Dharmasala D/s	-	-	-	0.053 (0.023-0.097)	0.185 (0.027-0.743)
Pottamundai	0.039 (0.005-0.113)	0.050 (0.007-0.298)	0.054 (0.012-0.122)	0.116 (0.020-0.420)	0.266 (0.045-1.096)
Khanditara (Kharasrota)	0.041 (0.005-0.137)	0.038 (0.003-0.166)	0.076 (0.008-0.214)	0.089 (0.025-0.224)	0.049 (0.001-0.121)
Binjharpur (Kharasrota)	0.055 (0.003-0.193)	0.056 (0.008-0.270)	0.099 (0.002-0.532)	0.047 (0.008-0.091)	0.097 (0.003-0.542)
Aul (Kharasrota)	0.078 (0.006-0.216)	0.047 (0.003-0.154)	0.073 (0.011-0.126)	0.128 (0.018-0.320)	0.160 (0.036-0.667)

Table 4.25 Annual average and Range values of Total Kjeldahl Nitrogen (TKN)

Monitoring Station	TKN (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	4.8 (1.1-13.4)	3.45 (1.12-13.44)	2.54 (1.12-4.48)	1.30 (0.84-0.68)	1.12 (0.84-1.40)
Koel U/s (Koel)	5.6 (0.6-13.4)	3.81 (1.12-8.12)	2.45 (1.12-4.67)	1.12 (0.56-1.96)	1.21 (0.84-1.40)
Panposh U/s	3.5 (1.1-10.1)	3.73 (0.56-10.64)	2.54 (0.013-6.20)	1.30 (0.84-1.96)	1.19 (0.84-1.40)
Panposh D/s	4.2 (1.1-12.3)	3.90 (1.12-8.96)	2.870 (0.038-6.400)	7.46 (1.12-27.44)	8.89 (3.08-23.52)
Rourkela D/s	6.0 (1.7-21.8)	4.81 (1.40-12.88)	2.763 (0.048-5.300)	3.79 (1.12-13.72)	4.76 (1.40-21.84)
Rourkela FD/s at Attaghat	6.1 (0.8-23.0)	4.34 (1.12-8.40)	2.63 (0.05-5.04)	1.30 (0.84-1.68)	1.56 (1.12-2.24)
Rourkela FFD/s at Biritola	4.0 (1.1-11.2)	3.73 (1.68-6.72)	2.401 (0.030-4.200)	1.35 (0.84-1.68)	1.52 (1.12-1.96)
Bonaigarh	4.1 (1.1-14.6)	3.17 (0.56-6.72)	2.98 (1.68-6.05)	1.32 (0.56-1.68)	1.28 (0.84-2.52)
Rengali	5.0 (1.1-16.2)	2.85 (1.12-6.72)	2.73 (1.68-3.92)	1.15 (0.28-1.68)	1.10 (0.84-1.68)
Samal	4.9 (0.8-20.7)	3.27 (1.12-6.72)	2.98 (1.68-4.50)	1.22 (1.12-1.068)	1.24 (0.84-1.40)
Talcher FU/s	4.2 (1.1-9.0)	4.67 (1.12-25.76)	2.56 (1.12-4.80)	1.15 (0.56-1.40)	1.14 (0.84-1.40)
Talcher U/s	6.9 (1.1-22.4)	2.82 (1.12-5.32)	2.73 (1.4-5.04)	1.25 (0.28-1.68)	1.19 (0.84-2.24)
Talcher D/s	6.3 (1.1-29.1)	5.02 (1.40-22.96)	3.32 (1.96-5.60)	1.22 (0.28-1.68)	1.49 (0.84-4.20)
Talcher FD/s	3.6 (1.1-14.8)	3.90 (1.40-8.96)	3.01 (0.84-7.30)	1.27 (0.28-2.24)	1.28 (1.12-1.68)
Nandira D/s (Nandira)	4.4 (2.2-7.3)	4.63 (1.68-8.96)	2.91 (2.47-3.36)	1.25 (0.56-1.96)	1.54 (1.12-2.52)
Kisinda Jhor (Kisinda Jhor)	3.4 (1.1-7.8)	4.18 (0.84-8.96)	2.95 (1.96-4.50)	1.45 (0.56-1.96)	1.63 (1.12-2.24)
Dhenkanal U/s	4.1 (0.6-11.2)	6.93 (1.40-55.44)	2.78 (1.40-4.98)	1.09 (0.56-1.40)	1.17 (0.84-1.40)
Dhenkanal D/s	3.6 (0.6-11.8)	4.32 (1.20-8.96)	2.77 (1.94-3.92)	1.12 (0.28-1.68)	1.14 (0.84-1.68)
Bhuban	3.2 (0.8-9.2)	2.54 (1.12-4.48)	3.16 (1.4-5.04)	1.20 (0.56-1.96)	1.14 (0.56-1.68)
Kabatabandha	3.4 (1.1-8.1)	2.83 (1.40-3.92)	2.79 (1.96-4.48)	1.17 (0.28-1.96)	1.19 (0.84-1.40)
Dharmasala U/s	3.3 (0.8-6.7)	3.50 (1.40-8.40)	2.95 (1.96-3.92)	1.35 (1.12-1.96)	1.21 (0.84-1.68)
Dharmasala D/s	-	-	-	1.27 (0.28-2.24)	1.19 (0.84-1.68)
Pottamundai	3.4 (1.1-8.9)	3.48 (1.40-7.84)	2.14 (1.12-4.2)	0.99 (0.28-1.68)	1.12 (0.84-1.40)
Khanditara (Kharasrota)	3.7 (0.6-9.0)	2.94 (1.12-5.32)	2.64 (0.84-4.67)	1.20 (0.56-1.68)	1.26 (1.12-1.40)
Binjharpur (Kharasrota)	2.7 (1.1-7.6)	2.64 (1.12-5.60)	2.58 (0.82-4.95)	1.17 (0.28-1.96)	1.21 (0.84-1.40)
Aul (Kharasrota)	3.5 (0.6-7.3)	3.36 (1.12-8.40)	2.75 (1.1-5.04)	1.04 (0.28-1.68)	1.17 (0.84-1.40)

Table 4.26 Annual average and Range values of Chemical Oxygen Demand (COD)

Monitoring Station	COD (mg/l)				
	2011	2012	2013	2014	2015
Sankh	10.1 (5.2-16.2)	11.5 (7.8-22.2)	11.4 (5.2-20.0)	9.1 (3.9-13.6)	8.1 (3.8-15.8)
Koel	11.5 (6.1-25.6)	13.6 (5.2-25.3)	12.9 (5.6-28.0)	8.7 (3.8-12.1)	8.8 (3.9-13.1)
Panposh U/s	10.7 (4.7-20.5)	11.6 (6.1-19.7)	10 (5.6-16.9)	10.5 (3.8-18.7)	7.6 (3.8-11.8)
Panposh D/s	33.3 (19.5-44.8)	33.0 (12.1-49.7)	31.1 (15.2-45.5)	36.0 (23.1-53.1)	29.8 (19.6-43.3)
Rourkela D/s	25.9 (9.4-41.1)	27.0 (10.1-43.1)	26.8 (13.5-40.3)	31.2 (19.3-45.3)	24.8 (15.8-43.8)
Rourkela FD/s at Attaghat	16.0 (7.6-27.7)	18.2 (8.1-29.8)	20.8 (10.3-30.9)	19.8 (11.5-27.7)	14.9 (7.7-37.4)
Rourkela FD/s at Biritola	17.4 (6.3-31.5)	19.7 (6.1-33.1)	21.5 (8.4-37.6)	24.0 (11.5-42.2)	17.4 (11.1-25.6)
Bonaigarh	10.6 (6.3-17.1)	10.5 (5.2-17.7)	10.4 (4.2-16.9)	10.9 (3.3-23.4)	9.3 (5.1-17.8)
Rengali	10.4 (4.3-15.4)	9.0 (4.9-15.8)	8.9 (5.6-12.7)	9.0 (3.9-13.6)	8.2 (3.7-19.8)
Samal	10.4 (6.3-16.2)	10.2 (6.1-15.8)	10.5 (5.6-16.2)	10.1 (4.9-19.4)	10.2 (3.1-19.8)
Talcher FU/s	9.4 (6.1-15.4)	10.5 (6.6-14.8)	9.5 (3.52-15.2)	7.5 (3.7-14.6)	5.7 (2.0-9.5)
Talcher U/s	12.5 (6.0-20.2)	12.3 (6.9-16.4)	11.1 (5.5-20.1)	9.2 (4.9-16.3)	9.8 (5.2-21.7)
Talcher D/s	15.5 (7.9-21.5)	16.9 (5.9-22.4)	20.5 (12.8-30.0)	13.6 (5.6-24.0)	7.6 (3.8-11.8)
Talcher FD/s	10.8 (3.1-14.1)	13.4 (6.6-18.9)	14.0 (9.2-19.7)	10.4 (3.7-18.0)	10.8 (3.7-23.6)
Nandira D/s	19.5 (12.2-26.9)	26.3 (15.8-39.6)	24.7 (15.3-35.5)	17.6 (9.3-36.0)	19.0 (11.1-37.4)
Kisinda Jhor	19.5 (7.9-37.8)	25.5 (13.8-55.8)	17.9 (8.81-42.0)	14.0 (8.2-26.0)	20.8 (7.8-47.3)
Dhenkanal u/s	9.7 (6.8-14.5)	9.1 (4.0-11.5)	9.0 (7.0-12.3)	10.3 (5.4-14.9)	7.4 (3.9-15.0)
Dhenkanal D/s	12.1 (8.0-18.4)	13.0 (4.0-20.6)	15.6 (9.7-20.9)	14.6 (7.7-21.9)	11.4 (7.6-21.0)
Bhuban	10.4 (6.8-15.7)	11.0 (5.9-23.0)	10.5 (2.9-17.4)	7.5 (4.9-9.5)	9.2 (5.2-12.9)
Kabatabandha	11.6 (7.6-19.0)	10.7 (6.9-19.7)	9.2 (2.9-15.7)	8.8 (3.7-18.6)	10.1 (5.2-18.5)
Dharmasala U/s	10.6 (7.6-16.2)	9.1 (4.9-15.2)	10.1 (7.8-12.0)	10.0 (5.4-24.7)	7.7 (5.3-11.7)
Dharmasala D/s	-	-	-	11.3 (8.1-19.7)	10.6 (6.0-17.6)
Pottamundai	10.8 (5.9-14.9)	12.3 (7.8-18.1)	10.8 (6.9-15.1)	16.5 (6.0-52.5)	11.6 (9.2-15.2)
Khanditara	10.2 (7.6-16.2)	10.1 (4.9-16.1)	9.3 (7.1-16)	8.6 (5.1-18.7)	8.8 (3.8-16.0)
Binjharpur	11.1 (7.6-21.1)	10.4 (5.3-14.1)	8.7 (5.6-12.7)	6.7 (3.8-9.7)	7.9 (3.8-14.4)
Aul	11 (6.0-16.3)	13.2 (7.4-20.9)	11.2 (3.5-18.0)	10.7 (6.5-17.7)	11.3 (4.6-17.6)

Table 4.27 Annual average and Range values of Total Alkalinity

Monitoring Station	Total Alkalinity (as CaCO <sub>3</sub> ) (mg/l)				
	2011	2012	2013	2014	2015
Sankh U/s (Sankh)	53 (34-88)	60 (32-80)	56 (36-98)	49 (24-72)	54 (28-76)
Koel U/s (Koel)	67 (26-104)	79 (36-120)	76 (40-112)	70 (24-104)	81 (36-116)
Panposh U/s	59 (22-120)	63 (32-80)	66 (36-94)	53 (36-88)	55 (24-72)
Panposh D/s	62 (20-88)	71 (44-108)	74 (50-112)	70 (28-106)	70 (52-92)
Rourkela D/s	56 (16-84)	71 (44-128)	69 (42-96)	68 (48-88)	68 (48-88)
Rourkela FD/s at Attaghat	59 (16-86)	80 (46-136)	64 (36-92)	65 (28-90)	65 (44-92)
Rourkela FFD/s at Biritola	65 (24-128)	69 (36-84)	61 (32-90)	66 (44-96)	68 (42-140)
Bonaigarh	59 (28-86)	70 (44-84)	60 (40-80)	61 (32-84)	65 (40-80)
Rengali	54 (30-86)	56 (36-76)	52 (40-72)	50 (36-76)	52 (40-80)
Samal	58 (32-148)	52 (38-72)	52 (40-96)	53 (36-82)	55 (44-80)
Talcher FU/s	57 (32-108)	54 (44-64)	52 (40-82)	52 (40-72)	46 (32-60)
Talcher U/s	52 (32-78)	59 (44-78)	55 (32-102)	52 (44-68)	51 (32-68)
Talcher D/s	56 (36-76)	63 (52-88)	58 (34-76)	59 (44-80)	61 (44-76)
Talcher FD/s	57 (40-72)	61 (50-72)	64 (36-104)	61 (46-80)	63 (52-92)
Nandira D/s (Nandira)	109 (52-162)	124 (90-168)	136 (116-170)	118 (48-152)	128 (72-180)
Kisinda Jhor (Kisinda Jhor)	116 (82-164)	119 (70-168)	114 (56-144)	122 (64-198)	117 (72-148)
Dhenkanal U/s	47 (28-68)	56 (48-64)	54 (40-76)	57 (44-88)	55 (40-68)
Dhenkanal D/s	54 (36-92)	60 (50-70)	58 (44-76)	69 (44-92)	73 (54-108)
Bhuban	53 (36-68)	55 (36-72)	52 (38-72)	54 (44-72)	59 (38-80)
Kabatabandha	51 (26-74)	53 (40-72)	52 (40-68)	55 (40-80)	57 (36-70)
Dharmasala U/s	60 (36-88)	62 (44-84)	61 (42-88)	63 (48-104)	73 (44-92)
Dharmasala D/s	-	-	-	64 (44-96)	73 (44-96)
Pottamundai	70 (46-104)	77 (44-148)	72 (54-88)	67 (44-94)	78 (48-104)
Khanditara (Kharasrota)	54 (34-78)	58 (36-88)	55 (42-72)	55 (44-76)	60 (37-76)
Binjharpur (Kharasrota)	54 (36-76)	61 (44-88)	54 (40-64)	63 (46-82)	64 (46-80)
Aul (Kharasrota)	58 (40-90)	60 (40-82)	51 (40-62)	70 (40-200)	64 (44-78)

**Table 4.28 Polluted River Monitoring Stations in Brahmani River System**

Sl. No.	River	Monitoring station	Annual BOD Data range (mg/l)					Range value of BOD above 3.0 mg/l in the stretch	Priority as per CPCB Criteria
			2011	2012	2013	2014	2015		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	Brahmani river along Rourkela	Panposh D/s	( 3.0-6.6)	(2.4-5.6)	(2.1-5.6)	(3.4-5.6)	(2.6-5.3)	3.2-6.6	IV
2		Rourkela D/s	( 1.8-5.3)	(2.0-4.4)	(0.9-4.7)	(2.7-5.0)	(2.2-4.5)		
3		Rourkela FD/s at Attaghat	( 1.0-3.2)	(1.3-2.6)	(1.5-3.6)	(1.3-2.9)	(1.5-4.2)		
4		Rourkela FFD/s at Biritola	( 1.2-3.6)	(1.2-3.0)	(1.1-3.9)	(1.8-4.5)	(1.0-3.5)		
5	Nandira jhor	Nandira D/s	(1.7-4.8)	(1.6-4.1)	(2.1-3.8)	(1.1-3.3)	(1.0-4.5)	3.3-4.8	IV
6	Kisindajhor	Kisindajhor	(0.8-4.0)	(1.1-6.8)	(1.0-4.7)	(0.8-2.7)	(0.6-4.2)	4.0-6.8	IV

Table 4.29 CWQI of Brahmani river system during 2011-2015

Monitoring Station	2011	2012	2013	2014	2015
	CWQI				
Sankh U/s (Sankh)	82.51	85.12	80.48	81.82	81.49
Koel U/s (Koel)	84.16	84.20	70.98	74.68	74.87
Panposh U/s	85.24	82.89	78.32	81.94	81.34
Panposh D/s	53.64	44.70	39.52	47.50	45.11
Rourkela D/s	60.04	51.38	43.48	45.68	53.16
Rourkela FD/s at Attaghat	70.3	80.53	70.43	81.60	70.18
Rourkela FFD/s at Biritola	69.11	80.16	67.87	76.18	69.56
Bonaigarh	85.36	85.48	79.44	69.20	82.84
Rengali	100.00	85.33	85.47	84.98	84.88
Samal	100.00	85.08	84.60	81.71	81.20
Talcher FU/s	100.00	85.52	100.00	63.18	85.03
Talcher U/s	100.00	85.48	85.19	62.84	84.82
Talcher D/s	77.79	67.79	80.59	79.39	68.72
Talcher FD/s	84.39	82.09	84.80	83.43	78.93
Nandira D/s (Nandira)	83.63	55.22	62.50	60.45	63.26
Kisinda Jhor (Kisinda Jhor)	69.21	68.87	64.84	72.86	81.77
Dhenkanal U/s	85.52	83.20	77.66	50.51	52.52
Dhenkanal D/s	77.67	66.33	73.16	57.85	53.55
Bhuban	84.14	85.26	75.18	84.63	83.85
Kabatabandha	84.02	78.08	74.00	84.27	85.37
Dharmasala U/s	82.11	83.45	85.08	77.05	73.71
Dharmasala D/s	-	-	-	73.70	66.03
Pottamundai	73.66	61.58	82.02	84.13	60.46
Khanditara (Kharasrota)	85.37	85.48	84.10	84.91	83.99
Binjharpur (Kharasrota)	85.07	84.38	70.91	81.91	85.11
Aul (Kharasrota)	83.92	85.18	81.04	70.20	80.24

**Table 4.30 Category of water quality of Brahmani river system during 2011-2015 based on CWQI values**

Monitoring Station	2011	2012	2013	2014	2015
	Category				
Sankh U/s (Sankh)	Good	Good	Good	Good	Good
Koel U/s (Koel)	Good	Good	Fair	Fair	Fair
Panposh U/s	Good	Good	Fair	Good	Good
Panposh D/s	Marginal	Marginal	Poor	Marginal	Marginal
Rourkela D/s	Marginal	Marginal	Poor	Marginal	Marginal
Rourkela FD/s at Attaghat	Fair	Good	Fair	Good	Fair
Rourkela FFD/s at Biritola	Fair	Good	Fair	Fair	Fair
Bonaigarh	Good	Good	Fair	Fair	Good
Rengali	Excellent	Good	Good	Good	Good
Samal	Excellent	Good	Good	Good	Good
Talcher FU/s	Excellent	Good	Excellent	Fair	Good
Talcher U/s	Excellent	Good	Good	Fair	Good
Talcher D/s	Fair	Fair	Good	Fair	Fair
Talcher FD/s	Good	Good	Good	Good	Fair
Nandira D/s (Nandira)	Good	Marginal	Fair	Fair	Fair
Kisinda Jhor (Kisinda Jhor)	Fair	Fair	Fair	Fair	Good
Dhenkanal U/s	Good	Good	Fair	Fair	Marginal
Dhenkanal D/s	Fair	Fair	Fair	Marginal	Marginal
Bhuban	Good	Good	Fair	Good	Good
Kabatabandha	Good	Fair	Fair	Good	Good
Dharmasala U/s	Good	Good	Good	Fair	Fair
Dharmasala D/s	-	-	-	Fair	Fair
Pottamundai	Fair	Fair	Good	Good	Fair
Khanditara (Kharasrota)	Good	Good	Good	Good	Good
Binjharpur (Kharasrota)	Good	Good	Fair	Good	Good
Aul (Kharasrota)	Good	Good	Good	Fair	Good

**CHAPTER-V****WATER QUALITY STATUS OF BAITARANI RIVER BASIN  
(Baitarani, Kusei, Salandi and Dhamra Rivers)**

Water quality of Baitarani river system is monitored on the main river Baitarani starting from Joda upto its tidal limit at Dhamra (after confluence of Brahmani river), on its tributaries like Kusei and Salandi rivers.

**5.1 USE BASED WATER QUALITY STATUS****5.1.1 Water quality in respect of primary criteria**

The seasonal average values of pH, DO, BOD and TC in Baitarani river at Joda, Anandpur, Jajpur and Chandbali U/s, in Kusei river at Deogaon, in Dhamra river at Dhamra pertaining to the period 2011-2015 are described in Tables 5.1 – 5.2. The seasonal average values of pH, DO, BOD and TC in Baitarani river at Chandbali D/s, in Salandi river at Bhadrak U/s and Bhadrak D/s pertaining to the period 2014-2015 are described in Tables 5.2 – 5.3.

**pH and DO :** As may be seen from the data, the pH and DO values in Baitarani river show more or less a stable pattern throughout the river stretch. The seasonal average value of pH varies within the range 7.0-8.5. The water at all the monitoring station is fairly rich in oxygen. Both the parameters at all the nine stations conform to the quality criteria for Class-A.

**BOD :** The seasonal average values of BOD at all the monitoring stations excluding Bhadrak D/s on one occasion (winter, 2014) generally conform to Class-C. The monthly BOD values at these nine stations also conform to Class-C except on one occasion at Jajpur (September, 2011) and twice at Bhadrak D/s (February and May, 2014).

**TC :** Total coliform count at none of the stations generally conform to Class-A or Class-B water. The magnitudes and frequency of violations of TC from the stipulated value (less than 5000 MPN/100 ml) at all the nine stations do not warrant the water quality to be classified as Class-C. Wide fluctuations in the TC values have been observed during the study period.

The annual average and range of BOD and TC values at all the 9 monitoring stations are given in Table 5.4. Frequency of violation of BOD and TC values from the stipulated values (3.0 mg/l and 5000 MPN/100 ml respectively) are also given in Table 5.4.

Percent violations of BOD during the study period at all stations are presented in Fig. 5.1 . From the data and figures, it is evident that BOD at Jajpur is violated only 2% of total observations, while at Bhadrak D/s, BOD is violated 9% of time of total observations.

Spatial variation of annual average values of BOD and TC during the period 2011-2015 in the stretches of Baitarani river system are presented in Fig. 5.2 and 5.3 respectively. Fig. 5.2 revealed that, annual average of BOD conforms to Class-C at all the monitoring stations. Whereas, the annual average of TC violated the tolerance limit for Class-C at all stations always except at Joda during 2011.

**Free Ammonia** : The annual average and range values of ammonical nitrogen and free ammonia are given in Table 5.5. Free ammonia values at all stations conform to the stipulated value (1.2 mg/l, max) for Class-D inland surface water (Fish culture and wildlife propagation). A decreasing pattern in ammonical nitrogen values over the years at all the stations has been observed. However, no such regular pattern is observed in free ammonia values as free ammonia concentration is dependent upon both pH and ammonical nitrogen.

**EC, SAR, B** : Seasonal average values of EC at the 9 monitoring stations are given in Table 5.6. It is quite evident from the data that EC values for Joda, Anandpur, Jajpur, Deogaon, Bhadrak U/s and Bhadrak D/s satisfy the requirements for Class D/E. EC values at Chandbali U/s, D/s and Dhamra exhibit a wide range of fluctuation because of tidal influence on the river as these three monitoring stations are close to the muhan of the rivers.

Annual average and range value of SAR and B values at these monitoring stations are given in Table 5.7. SAR and B values at Joda, Anandpur, Jajpur, Deogaon, Bhadrak U/s and Bhadrak D/s are far too low compared to the stipulated values in Table 2.4 to cause any concern for suitability of the river water to be used for irrigation. Very high and fluctuating values of SAR at Chandbali U/s Chandbali D/s and Dhamra are due to tidal effect, which makes the river water at these stations unsuitable for irrigation.

### 5.1.2 Water quality in respect of other parameters

**TDS and Total Hardness** : Annual average and range values of total dissolved solids (TDS) and total hardness (TH) during the period 2011- 2015 are given in Table 5.8. TDS and total hardness values at Joda, Anandpur, Jajpur, Deogaon, Bhadrak U/s and Bhadrak D/s conform to Class-A . In terms of degree of hardness, the river water at these six monitoring stations vary from soft (0-60 mg/l) to moderately hard (61-120 mg/l) category . High values of TDS and TH observed at Chandbali U/s, D/s and Dhamra are evidently due to tidal impact.

**Nitrates** : Annual average and range values of nitrate during the period 2011- 2015 are given in Table 5.9. The annual average of nitrate concentrations have never exceeded the stipulated value (20 mg/l) for Class-A water, though occasional deviation of monthly nitrate values from the stipulated value for Class-A has been observed in Baitarani river at Joda (2012), Kusei river at Deogaon (2012) and Dhamra river at Dhamra (2015). However, the monthly nitrate concentration never exceeded the stipulated limit of 50 mg/l for Class-C.

**Chloride, Sulphates and Fluorides** : Annual average and range values of for chlorides, sulphates and fluorides at these monitoring stations during the period 2011-2015 are given in Table 5.10. A comparison of these values with the stipulated limits for Class-A revealed that, water quality in respect of chlorides, sulphates and fluorides at Joda, Anandpur, Jajpur and Deogaon conform to the highest class. Chloride values are too high at Chandbali U/s and D/s and Dhamra , on some occasions and the water quality do not conform to Class-E for irrigation. Excepting few occasions, sulphate content at Dhamra has always exceeded the limit even for irrigation water (1000 mg/l). High values of chloride and sulphate at Chandbali U/s and D/s and Dhamra are due to tidal impacts on the rivers. Fluoride concentrations at these three monitoring stations remained well within the tolerance limit of 1.5 mg/l.

**Heavy Metals:** Data given in Table 5.11 (a) represent the annual average and range of concentrations of chromium (VI) and mercury during the period 2014 and 2015. Data given in Table 5.11 (b)-(h) represent the annual average and range of concentrations of total chromium, iron, nickel, copper, zinc, cadmium and lead respectively during the period 2011-2015. From the tables it is observed that the values of these metals are well within the respective tolerance limits, except a very high values of iron in Baitarani river at Joda and in Kusei river at Deogaon during monsoon period of 2012.

### **5.1.3 Use based classification :**

From the water quality data and frequency of violation discussions made in the sec. 5.1.1 and 5.1.2, it may be reasonable to conclude that the water quality at Joda, Anandpur, Jajpur, Deogaon, Bhadrak U/s and Bhadrak D/s qualify for Class-D/E. TC is the water quality downgrading parameter at these stations. Water quality at Chandbali and Dhamra does not qualify even for Class-E because of tidal impact.

## **5.2 BIOLOGICAL ASSESSMENT OF WATER QUALITY**

As Board has not established any biomonitoring stations in this basin, biological assessment of the river stretch could not be carried out.

## **5.3 WATER QUALITY IN TERMS OF WHOLESOMENESS**

### **5.3.1 Wholesomeness in terms of regular parameters**

The wholesomeness of water quality at these 9 monitoring stations have been assessed with respect to general parameters specified in Table 2.7. Of the eight parameters listed in Table 2.7, results for bioassay are not available and therefore, the water quality are assessed with regard to the remaining seven parameters. Annual average and range values of (Nitrite + Nitrate)- N at the monitoring stations are given in Table 5.12. Annual average and range values of total suspended solids (TSS) including monsoon period and excluding monsoon period are given in Table 5.13. Considering pH, DO, EC, (Nitrite + Nitrate)-N values, the level of wholesomeness of the river water may be considered as "excellent" except at Deogaon during 2012 when the water quality is of "desirable" level. With regard to BOD, the water level at all stations mostly remained at "desirable" level. However, water quality with regard to the parameter TSS (during non-monsoon period) was not in "acceptable" level.

However, the situation changes entirely on introduction of FC values in the above assessment. Investigation on the data given in Table 5.14 (percent violation of FC values from 2000 MPN/100 ml) shows that the water quality in the entire stretch not even "acceptable" during most part of the period under report.

### **5.3.2 Wholesomeness in terms of special parameters**

Annual average and range values of total ammonical nitrogen ((ammonium+ammonia)-N) at all the monitoring stations are given in Table 5.5 which reveals that water quality at all stations with respect to total ammonical nitrogen during most period of 2011, 2012 and 2013 were in acceptable level, but during 2014 and 2015 were in "Excellent" level.

From the annual average and range values of total phosphate-P given in Table 5.15, it is observed that the water quality at most of the stations are not within the acceptable limits under the period of study.

Annual average and range values of TKN values during 2011-2015 are given in Table 5.16. It has been observed that annual average values of TKN at most of the monitored locations do not meet the acceptable limit of 3.0 mg/l during 2011 and 2012 and 2013. However, during 2014 and 2015, annual average values of TKN as well as the monthly TKN values at all stations remain within the “Desirable” limit.

It is seen from Table 5.11 that the annual average as well as monthly data on concentrations of metals like total chromium, zinc, copper, nickel, lead, cadmium and mercury in the river water at all station are within the “acceptable” limits.

#### **5.4 WATER QUALITY IN TERMS OF COD AND ALKALINITY**

Annual average and range values of COD and total alkalinity values are given in Table 5.17 and 5.18 respectively. Values of COD and alkalinity at Joda, Anandpur, Jajpur, Deogaon, Bhadrak U/s and Bhadrak D/s conform to the acceptable limit for most of the beneficial uses of water. However, due to tidal impact, COD values at Chandbali U/s, D/s and Dhamra most of the time exhibited high values.

#### **5.5 WATER QUALITY TREND**

##### **5.5.1 Baitarani River**

There are no large towns or highly water polluting industries on the bank of Baitarani river. Joda was the centre of major iron ore mining activities till 2012 after which the mining activities has been decreased significantly. Anandpur and Jajpur are sub-division and district headquarters respectively. Jajpur is an important religious place for Hindus. Nevertheless, all the three towns are small in terms of population (less than 40,000) and as such the pollution load is not very high. This is reflected in the quality of water at these three places, particularly during recent years. Excluding the coliform values, the water qualities at these stations very nearly conform to Class B/C. With the inclusion of TC, the water quality does not conform to Class-C. Such deterioration in water quality may be attributed to the instream activities on the river.

As the river enters its tidal zone at Chandbali, there is significant deterioration in the water quality due to tidal effect (higher EC, Chlorides, sulfate, SAR values) which makes the water unsuitable for most of the beneficial uses of the water.

##### **5.5.2 Kusei River**

Kusei river is a small river (catchment area : 870 sq km) flowing through the Daitari mining area and has its confluence with Baitarani river near Anandpur. Water quality of this river at Deogaon does not conform to Class-C with respect to TC.

##### **5.5.3 Salandi river**

Salandi river originates from the Maghasani hills of Similpal hilla range in Odisha. It passes through Mayurbhanj, Keonjhar and Bhadrak district. It has a total length of 144 km and has a catchment area of 1793 sq km. The river joins Baitarani river at Tinitar near Aradi in Bhadrak district. The river water quality has been monitored at the upstream and downstream of Bhadrak town. Though the criteria pollutant BOD conforms to the tolerance limit of Class-C, water quality at this station do not Conform to Class-C with respect to another criteria pollutant, TC.

#### 5.5.4 Dhamra River

After confluence of Baitarani river with Brahmani river, the river till its outfall into Bay of Bengal is known as Dhamra river. Water quality of Dhamra river is greatly influenced by the tidal effect and the water becomes unsuitable for almost all beneficial uses of inland surface water.

Spatial variation of BOD and TC in the abovementioned four rivers are shown in Fig. 5.2 and 5.3.

### 5.6 POLLUTED RIVER MONITORING STATIONS IN BAITARANI RIVER SYSTEM

The monitoring stations of rivers in Baitarani river systems not meeting the tolerance limit of 3.0 mg/l for the criteria parameter BOD of Class-C are identified as polluted river monitoring stations and have been categorized into different priority classes as proposed by CPCB (Table 2.9). Comparison of BOD data obtained during the period 2011-2015 (Table 5.4) with the tolerance limits for Class-C revealed that there are two polluted river monitoring stations. The list of polluted river monitoring stations with annual BOD range and priority class is given in Table 5.19. Jajpur (Priority-V) on Baitarani river and Bhadrak D/s (Priority-V) on Salandi river have been identified as the polluted river monitoring stations.

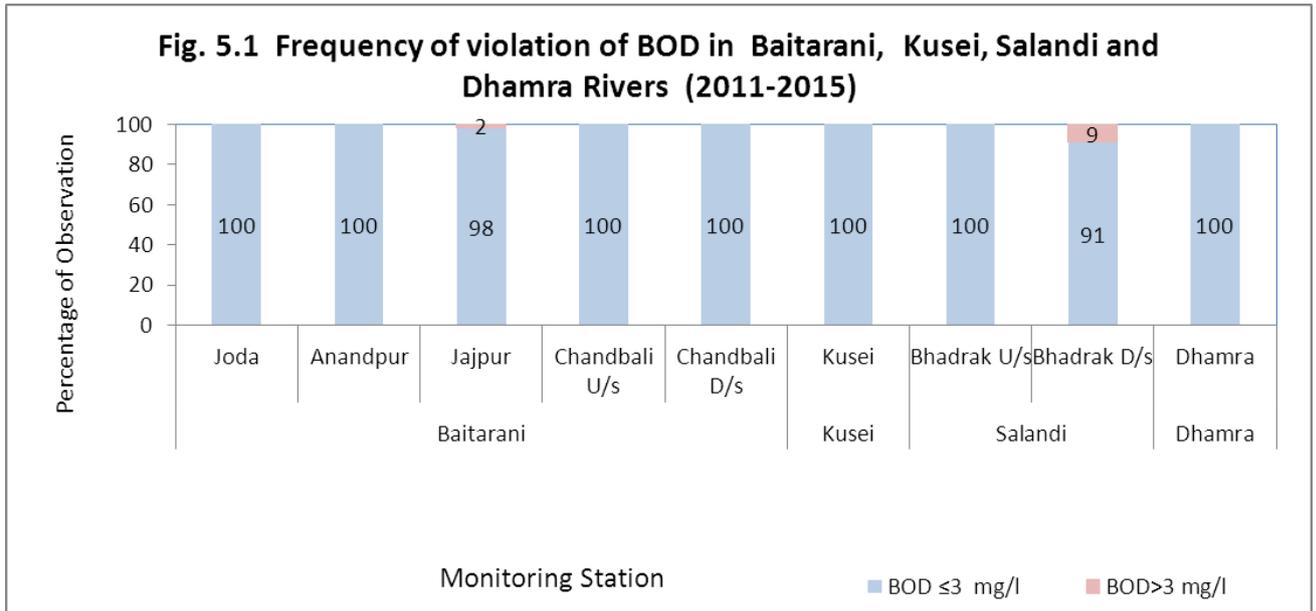
### 5.7 WATER QUALITY INDEX OF MONITORING STATIONS IN BAITARANI RIVER SYSTEM

The Canadian Water Quality Indices (CWQI) of 9 monitoring stations on Baitarani river system are calculated for the period 2011-2015 (Table 5.20). For the CWQI evaluation, four critical variables such as pH, DO, BOD and TC are taken into consideration. Based on the CWQI values, the water quality of the monitoring stations are ranked into five categories as recommended in Table 2.10. As evident from the Table 5.21 for the CWQI ranks, water quality of Baitarani river at Joda remained within Fair-Good category during the study period. Water quality varied within Fair-Excellent at Anandpur, within Fair-Good at Jajpur. Investigation into the CWQI score values, it has been observed that frequency of deviation of TC values as well as magnitude of deviation from the tolerance limit is the contributing factor towards the lowering of the water quality. Though there is no definite source of pollution in these monitoring stations, the instream activities are responsible for the occasional deviation of TC values beyond the tolerance limits.

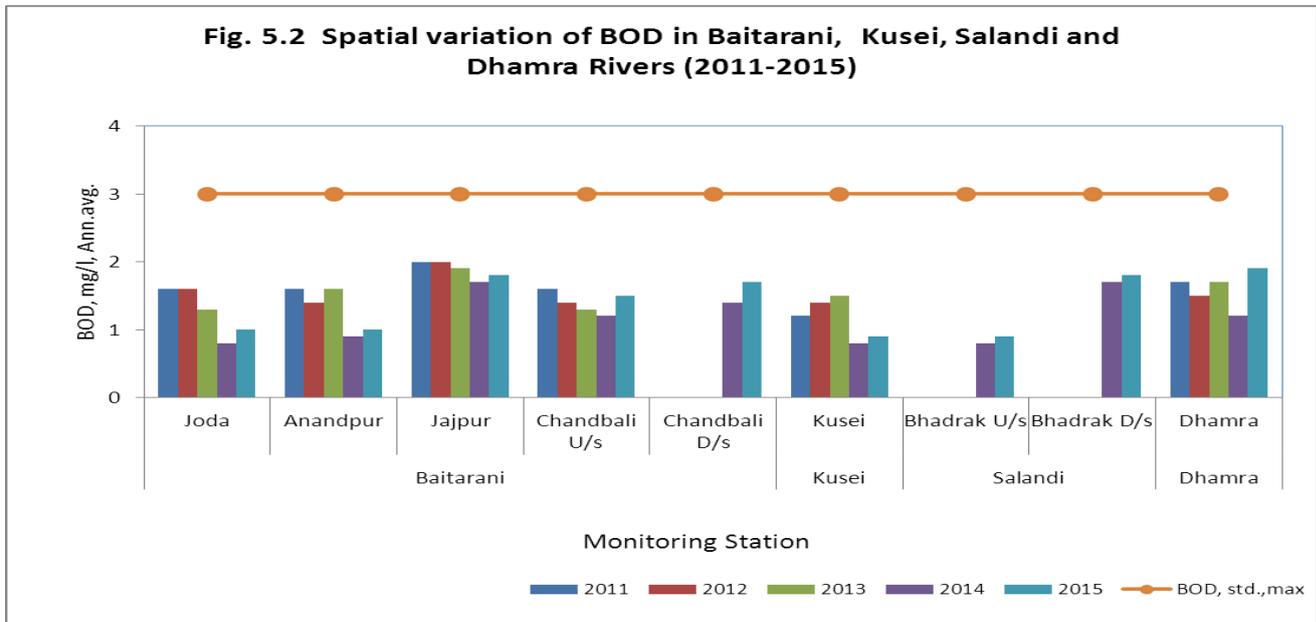
The CWQI score at Chandbali U/s, Chandbali D/s and Dhamra calculated using pH, DO, BOD and TC as variables, remained within Marginal-Fair during the study period. However, as these three stations are very close to the mouth of the river, the major water quality determining parameters in such cases are EC, chloride, sulfate, calcium, magnesium, sodium and potassium. Therefore, recalculation of CWQI score considering EC, SAR (calculated from calcium, magnesium and sodium), chloride, sulfate, TDS and boron as the variables and comparing them with the respective tolerance limits for irrigation water quality, it has been observed that water quality at Chandbali U/s varied within Poor-Fair category (CWQI Score : 42.96-66.67), at Chandbali D/s varied within Poor-Marginal category (CWQI Score : 38.24-56.50) and at Dhamra remained at Poor category (CWQI Score : 13.76-19.40). The water quality downgrading parameters are EC, SAR, chloride, sulfate and TDS which owes its origin from the tidal effect.

Water quality of Kusei river at Deogaon was in Marginal category. Water quality of Salandi river at the upstream of Bhadrak town was in Fair category, whereas water quality at downstream of the town was in Marginal category. TC was the water quality downgrading parameter in Kusei river at Deogaon and in Salandi river along Bhadrak town.

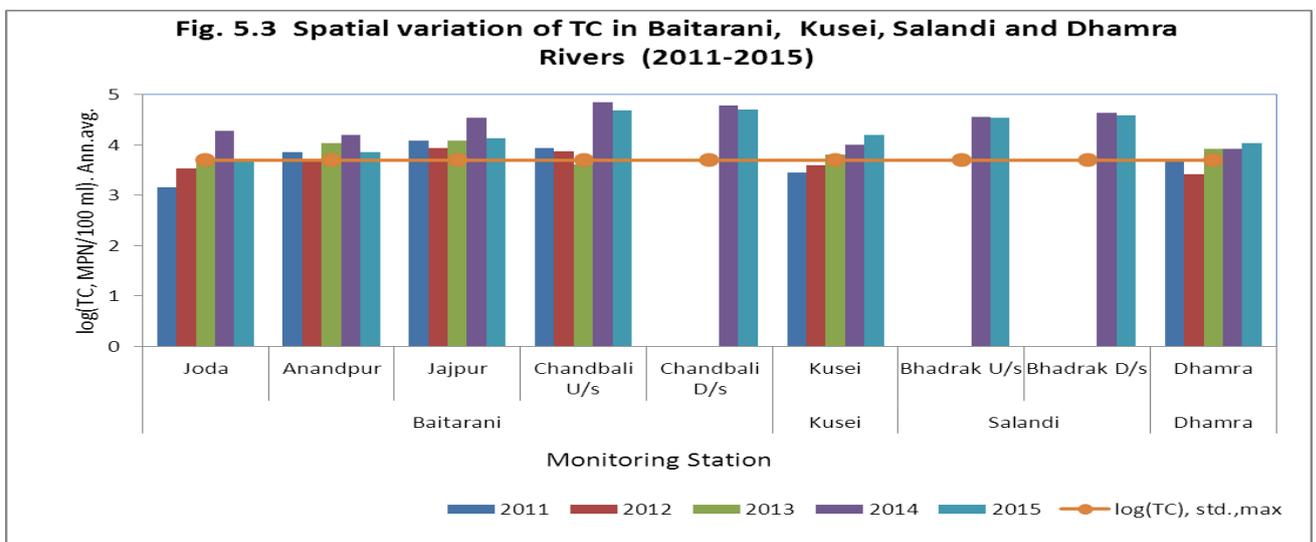
**Fig. 5.1 Frequency of violation of BOD in Baitarani, Kusei, Salandi and Dhamra Rivers (2011-2015)**



**Fig. 5.2 Spatial variation of BOD in Baitarani, Kusei, Salandi and Dhamra Rivers (2011-2015)**



**Fig. 5.3 Spatial variation of TC in Baitarani, Kusei, Salandi and Dhamra Rivers (2011-2015)**



Water Quality of Major Rivers of Odisha

Table 5.1 Seasonal average values of pH, DO, BOD and TC in Baitarani river at Joda, Anandpur, Jajpur, Chandbali U/s

Parameter	Year	Joda				Anandpur				Jajpur				Chandbali U/s			
		W	S	M	PM	W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	7.7	7.6	7.4	7.8	7.9	7.8	7.5	7.9	8.0	8.0	8.1	8.0	7.9	7.6	7.7	7.9
	2012	7.9	7.7	7.5	7.9	7.9	8.0	7.5	7.5	8.2	7.7	7.3	7.8	7.9	7.7	7.8	7.8
	2013	7.5	7.7	7.4	7.7	8.2	8.0	7.4	8.0	8.1	8.2	7.6	8.0	8.2	7.9	7.7	7.4
	2014	7.7	8.0	7.2	8.2	7.6	8.1	7.0	8.0	7.6	8.3	7.6	8.0	7.7	7.8	7.5	8.0
	2015	7.7	7.8	7.9	7.7	7.9	7.9	7.9	8.0	8.0	8.3	7.8	8.3	7.5	7.9	7.8	7.7
DO (mg/l)	2011	9.5	7.5	6.2	7.2	9.0	7.0	6.1	6.9	10.6	7.1	6.9	8.1	9.4	6.4	5.6	6.3
	2012	8.7	6.7	7.6	8.5	8.2	6.7	8.7	7.9	9.0	6.6	8.0	6.0	8.0	6.5	8.0	7.7
	2013	8.3	7.4	6.9	7.9	8.0	6.8	6.9	7.5	8.1	7.2	6.9	7.0	7.5	6.8	6.1	4.5
	2014	8.5	7.0	7.2	7.8	9.0	6.9	7.2	8.2	8.2	6.9	6.8	8.3	7.1	6.4	5.9	6.6
	2015	8.6	6.9	6.5	8.3	8.8	7.2	6.2	7.7	8.3	7.1	7.2	7.5	7.6	6.8	6.0	6.1
BOD (mg/l)	2011	1.6	2.1	1.3	1.0	1.7	1.9	1.8	1.2	2.3	2.3	2.6	1.3	1.4	2.0	2.5	1.2
	2012	1.4	1.5	1.8	1.3	1.1	1.4	1.7	1.1	1.8	1.9	2.1	2.0	1.2	2.1	0.6	1.4
	2013	2.1	1.6	0.6	0.6	1.9	1.9	1.1	1.1	2.3	2.1	1.7	1.5	1.9	1.2	1.0	0.9
	2014	0.5	0.6	1.2	1.0	0.7	0.7	1.3	1.0	1.3	1.8	1.6	1.7	1.8	0.9	1.2	1.1
	2015	0.8	1.1	1.2	0.6	0.9	1.1	1.4	0.6	2.5	1.9	1.9	0.9	1.6	1.8	1.5	0.9
TC ('00) (MPN/ 100 ml)	2011	9.00	19.23	17.00	9.50	19.00	43.75	112.00	38.00	26.00	56.00	206.50	67.50	37.50	72.75	286.50	26.50
	2012	12.13	27.50	66.67	12.45	133.00	56.50	68.67	16.50	63.00	107.25	95.33	107.00	22.00	86.75	110.33	54.00
	2013	47.67	54.83	49.30	11.00	47.67	69.75	234.33	2.30	31.67	81.75	254.67	70.00	47.67	29.85	55.00	35.00
	2014	49.00	13.20	625.00	64.00	130.00	43.23	201.00	410.00	240.00	163.00	114.67	1260.00	1600.00	535.00	413.33	920.00
	2015	9.60	31.40	100.33	19.50	19.97	64.23	123.00	85.50	46.67	126.00	210.00	147.00	856.33	154.50	540.00	920.00

Water Quality of Major Rivers of Odisha

**Table 5.2** Seasonal average values of pH, DO, BOD and TC in Baitarani river at Chandbali D/s, in Kusei river at Deogaon and in Dhamra river at Dhamra

Parameter	Year	Chandbali D/s				Deogaon				Dhamra			
		W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	-	-	-	-	8.2	8.0	7.8	8.2	7.9	7.7	7.5	7.4
	2012	-	-	-	-	8.2	8.2	7.9	8.1	7.9	7.8	7.2	8.0
	2013	-	-	-	-	8.4	7.9	8.0	8.1	7.7	7.6	7.5	7.4
	2014	7.8	7.7	7.5	7.8	8.0	8.2	7.9	8.1	7.8	8.0	7.7	7.9
	2015	7.7	7.9	7.3	7.8	8.3	8.1	8.0	8.3	7.9	7.9	7.9	7.9
DO (mg/l)	2011	-	-	-	-	8.9	7.5	6.0	7.1	7.6	6.2	5.8	6.3
	2012	-	-	-	-	9.1	7.1	8.2	8.8	7.6	6.2	7.4	7.5
	2013	-	-	-	-	8.2	7.3	6.4	7.3	7.7	6.0	5.7	5.1
	2014	7.0	6.1	5.8	6.4	8.2	6.7	6.9	8.2	6.5	5.8	5.4	6.2
	2015	7.2	7.2	5.8	6.1	9.0	7.1	6.5	8.4	6.7	6.2	5.5	5.6
BOD (mg/l)	2011	-	-	-	-	1.3	1.3	1.1	1.4	2.3	1.3	1.2	2.5
	2012	-	-	-	-	0.9	1.5	1.8	1.5	1.8	2.2	0.8	1.0
	2013	-	-	-	-	1.7	2.1	0.9	0.4	2.1	1.8	0.9	2.4
	2014	2.0	1.3	1.1	1.5	0.5	0.5	1.2	1.2	1.7	1.0	1.2	0.9
	2015	1.8	1.5	2.1	1.5	0.8	0.9	1.1	0.9	2.4	2.2	1.6	1.5
TC ('00) (MPN/ 100 ml)	2011	-	-	-	-	31.20	30.50	39.00	12.20	12.70	8.53	174.67	4.70
	2012	-	-	-	-	14.10	27.33	92.00	24.00	14.57	6.88	60.33	26.20
	2013	-	-	-	-	17.10	93.00	79.33	3.30	48.00	16.23	167.33	160.00
	2014	240.00	550.00	893.33	295.00	24.00	48.33	203.33	120.00	35.00	44.06	160.00	97.50
	2015	866.33	331.00	730.00	410.00	60.33	159.00	230.00	202.00	95.67	54.75	160.00	97.50

**Table 5.3 Seasonal average values of pH, DO, BOD and TC in Salandi river at Bhadrak U/s and Bhadrak D/s**

Parameter	Year	Bhadrak U/s				Bhadrak D/s			
		W	S	M	PM	W	S	M	PM
pH	2014	7.0	8.1	7.6	7.7	8.3	8.3	7.4	7.5
	2015	7.5	8.1	7.9	8.3	7.9	8.0	7.9	8.3
DO (mg/l)	2014	8.5	7.4	6.7	8.1	10.3	8.0	6.6	7.6
	2015	8.2	7.0	5.8	7.4	8.9	6.6	5.5	6.6
BOD (mg/l)	2014	1.0	0.7	0.8	0.9	3.6	1.5	1.4	1.9
	2015	1.4	0.9	1.1	0.4	2.4	2.3	1.7	0.9
TC ('00) (MPN/ 100 ml)	2014	240.00	335.25	719.00	125.00	33.00	259.00	920.00	445.00
	2015	880.00	127.25	253.33	285.00	200.00	182.50	413.33	350.00

**Table 5.4 Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit**

Monitoring Stations	Parameter	2011	2012	2013	2014	2015
Joda	BOD	1.6 (0.5-2.5)	1.6 (0.9-2.2)	1.3 (0.2 – 2.4)	0.8 (0.4 – 1.8)	1.0 (0.4-2.7)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	1472 (700-4300)	3428 (790-9200)	4672 (330 – 11000)	19206 (790– 92000)	4713 (170-13000)
	F*	0/12	4/12	5/10	4/11	5/12
Anandpur	BOD	1.6 (0.6-2.4)	1.4 (0.8-2.0)	1.6 (0.6 – 2.2)	0.9 (0.2 – 1.8)	1.0 (0.2-2.2)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	7209 (1700-28000)	5158 (1100-9200)	10923 (230 – 54000)	16008 (790 – 54000)	7257 (790-16000)
	F*	5/12	5/12	6/10	6/11	7/12
Jajpur	BOD	2.0 (1.2-3.2)	2.0 (1.3-2.8)	1.9 (1.2 – 2.4)	1.7 (0.8 – 3.0)	1.8 (0.5-2.9)
	F*	1/12	0/12	0/10	0/11	0/12
	TC	12133 (2400-54000)	8692 (1700-17000)	12390 (2400 – 54000)	34364 (2400 – 160000)	13783 (1100-54000)
	F*	7/12	9/12	8/10	9/11	10/12
Chandbali U/s	BOD	1.6 (0.6-2.8)	1.4 (0.3-2.3)	1.3 (0.8 - 2.2)	1.2 (0.3 - 2.0)	1.5 (0.8-2.5)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	8858 (1700-54000)	7408 (2100-16000)	4084 (940 – 9200)	70364 (16000 – 160000)	49142 (4900-160000)
	F*	5/12	10/12	3/10	11/11	11/12

Monitoring Stations	Parameter	2011	2012	2013	2014	2015
Chandbali D/s	BOD	-	-	-	1.4 (0.6 - 2.5)	1.7 (0.9-2.4)
	F*	-	-	-	0/11	0/12
	TC	-	-	-	60273 (16000 – 160000)	51853 (7900-160000)
	F*	-	-	-	11/12	12/12
Deogaon (Kusei)	BOD	1.2 (0.7-1.8)	1.4 (0.6-2.5)	1.5 (0.4 – 2.8)	0.8 (0.4 – 1.5)	0.9 (0.5-1.5)
	F*	0/11	0/11	0/10	0/11	0/12
	TC	2798 (840-5400)	3942 (630-9200)	6583 (330 – 24000)	10021 (330 – 28000)	15817 (2200-35000)
	F*	1/11	4/11	4/10	6/11	9/12
Bhadrak U/s (Salandi)	BOD	-	-	-	0.8 (0.2 – 1.4)	0.9 (0.3-1.8)
	F*	-	-	-	0/11	0/12
	TC	-	-	-	36700 (1700 – 160000)	34492 (1700-160000)
	F*	-	-	-	8/11	11/12
Bhadrak D/s (Salandi)	BOD	-	-	-	1.7 (0.2 – 3.6)	1.8 (0.9-2.9)
	F*	-	-	-	2/11	0/12
	TC	-	-	-	43718 (3300 – 160000)	38917 (16000-160000)
	F*	-	-	-	10/11	12/12
Dhamra (Dhamra)	BOD	1.7 (0.3-3.0)	1.5 (0.6-2.7)	1.7 (0.6 – 2.8)	1.2 (0.7 – 2.1)	1.9 (0.9-2.7)
	F*	0/12	0/12	0/10	0/11	0/12
	TC	5174 (470-28000)	2597 (230-9200)	8359 (790 – 24000)	8375 (45 – 16000)	10883 (1300-16000)
	F*	2/12	2/12	5/10	5/12	9/12

\*F : Frequency of deviation (No of deviation/no. of observation)

Table 5.5 Annual average and range values of Ammonical Nitrogen

Monitoring Station	2011		
	Ammonical Nitrogen	Free Ammonia-N	(Ammonium+Ammonia)-Nitrogen
Joda	0.420 (0.056-1.064)	0.013 (0-0.043)	0.433 (0.056-1.107)
Anandpur	0.442 (0.056-0.896)	0.021 (0.002-0.036)	0.463 (0.058-0.932)
Jajpur	0.331 (0.056-0.728)	0.021 (0.004-0.058)	0.353 (0.060-0.786)
Chandbali U/s	0.606 (0.056-1.456)	0.027 (0.004-0.133)	0.633 (0.060-1.589)
Chandbali D/s	-	-	-
Deogaon (Kusei)	0.428 (0.056-0.896)	0.032 (0.006-0.076)	0.460 (0.062-0.972)
Bhadrak U/s (Salandi)	-	-	-
Bhadrak D/s (Salandi)	-	-	-
Dhamra (Dhamra)	0.541 (0.056-1.344)	0.017 (0.002-0.040)	0.558 (0.058-1.384)
	2012		
	Ammonical Nitrogen	Free ammonia -N	(Ammonium+Ammonia)-Nitrogen
Joda	0.350 (0.112-1.064)	0.013 (0.002-0.043)	0.363 (0.114-01.107)
Anandpur	0.415 (0.112-1.008)	0.016 (0.005-0.036)	0.431 (0.117-1.044)
Jajpur	0.285 (0.112-1.120)	0.010 (0.001-0.026)	0.295 (0.113-1.146)
Chandbali U/s	0.476 (0.112-1.120)	0.021 (0.003-0.051)	0.497 (0.115-1.171)
Chandbali D/s	-	-	-
Deogaon (Kusei)	0.249 (0.112-0.896)	0.016 (0-0.056)	0.265 (0.112-0.952)
Bhadrak U/s (Salandi)	-	-	-
Bhadrak D/s (Salandi)	-	-	-
Dhamra (Dhamra)	0.341 (0.112-0.840)	0.012 (0.001-0.029)	0.353 (0.113-0.869)
	2013		
	Ammonical Nitrogen	Free Ammonia-N	(Ammonium+Ammonia)-Nitrogen
Joda	0.296 (0.112-0.560)	0.006 (0-0.017)	0.302 (00112-0.577)
Anandpur	0.295 (0.112-0.721)	0.014 (0.002-0.027)	0.309 (0.114-748)
Jajpur	0.217 (0.112-0.336)	0.010 (0-0.017)	0.227 (00112-0.353)
Chandbali U/s	0.335 (0.112-0.616)	0.013 (0-0.038)	0.348 (0.112-0.654)
Chandbali D/s	-	-	-

Table 5.5 contd..

	2014		
	Ammonical Nitrogen	Free Ammonia-N	(Ammonium+Ammonia)-Nitrogen
Deogaon (Kusei)	0.208 (0.056-0.392)	0.011 (0.003-0.018)	0.219 (0.059-0.410)
Bhadrak U/s (Salandi)	-	-	-
Bhadrak D/s (Salandi)	-	-	-
Dhamra (Dhamra)	0.208 (0.056-0.392)	0.011 (0.003-0.018)	0.219 (0.059-0.410)
	2014		
	Ammonical Nitrogen	Free Ammonia-N	(Ammonium+Ammonia)-Nitrogen
Joda	0.127 (0.056-0.224)	0.007 (0-0.028)	0.134 (0.056-0.0252)
Anandpur	0.122 (0.056-0.224)	0.005 (0-0.011)	0.127 (0.056-0.235)
Jajpur	0.137 (0.056-0.224)	0.009 (0.001-0.022)	0.146 (0.057-0.246)
Chandbali U/s	0.127 (0.056-0.224)	0.004 (0.002-0.008)	0.131 (0.058-0.232)
Chandbali D/s	0.122 (0.056-0.224)	0.004 (0.001-0.010)	0.126 (0.057-0.234)
Deogaon (Kusei)	0.137 (0.112-0.224)	0.010 (0.003-0.016)	0.147 (0.115-0.240)
Bhadrak U/s (Salandi)	0.137 (0.112-0.168)	0.005 (0-0.016)	0.142 (0.112-0.184)
Bhadrak D/s (Salandi)	0.168 (0.056-0.336)	0.012 (0-0.035)	0.180 (0.056-0.371)
Dhamra (Dhamra)	0.122 (0.056-0.280)	0.005 (0.001-0.010)	0.127 (0.057-0.238)
	2015		
	Ammonical Nitrogen	Free Ammonia-N	(Ammonium+Ammonia)-Nitrogen
Joda	0.070 (0.056-0.112)	0.002 (0.001-0.004)	0.072 (0.057-0.116)
Anandpur	0.070 (0.056-0.112)	0.003 (0.002-0.005)	0.073 (0.058-0.117)
Jajpur	0.089 (0.056-0.112)	0.007 (0.001-0.014)	0.096 (0.057-0.126)
Chandbali U/s	0.103 (0.056-0.224)	0.004 (0.001-0.007)	0.107 (0.057-0.231)
Chandbali D/s	0.149 (0.056-0.728)	0.004 (0-0.011)	0.153 (0.056-0.739)
Deogaon (Kusei)	0.065 (0.056-0.112)	0.005 (0.002-0.011)	0.070 (0.058-0.123)
Bhadrak U/s (Salandi)	0.079 (0.056-0.224)	0.004 (0.002-0.009)	0.083 (0.058-0.233)
Bhadrak D/s (Salandi)	0.112 (0.056-0.280)	0.005 (0.001-0.011)	0.117 (0.057-0.391)
Dhamra (Dhamra)	0.089 (0.056-0.112)	0.007 (0.002-0.014)	0.096 (0.058-0.126)

**Table 5.6 Seasonal average values of Electrical Conductivity (microSiemens/cm)**

Year	Season	Joda	Anandpur	Jajpur	Chandbali U/s	Chandbali D/s	Deogaon (Kusei)	Bhadrak U/s (Salandi)	Bhadrak D/s (Salandi)	Dhamra (Dhamra)
2011	W	193	178	286	12173	-	316	-	-	29020
	S	159	173	189	8981	-	238	-	-	24633
	M	162	142	160	3646	-	214	-	-	12831
	PM	105	158	149	4891	-	209	-	-	16955
2012	W	112	157	141	402	-	250	-	-	26007
	S	145	159	239	12343	-	246	-	-	34773
	M	111	134	128	394	-	201	-	-	3602
	PM	139	153	173	295	-	254	-	-	4504
2013	W	131	162	190	3186	-	269	-	-	28080
	S	144	178	189	5932	-	261	-	-	33953
	M	93	105	115	198	-	217	-	-	5244
	PM	103	146	105	111	-	187	-	-	380
2014	W	125	147	163	3277	3170	277	124	157	34780
	S	173	162	198	5229	6247	243	124	159	26198
	M	117	145	143	186	251	185	126	144	3961
	PM	167	224	189	202	237	258	194	184	9140
2015	W	152	170	175	7109	7052	292	164	177	29127
	S	141	168	183	12293	11912	270	140	166	32293
	M	121	153	154	199	231	182	156	173	7408
	PM	121	168	171	2716	2647	216	137	150	10685

Table 5.7 Annual average and range values of Sodium Absorption Ratio (SAR) and Boron

Monitoring Station	SAR				
	2011	2012	2013	2014	2015
Joda	0.46 (0.17-0.89)	0.31 (0.15-0.64)	0.35 (0.22-0.51)	0.32 (0.19-0.46)	0.35 (0.20-0.52)
Anandpur	0.41 (0.18-0.55)	0.36 (0.24-0.56)	0.36 (0.19-0.63)	0.40 (0.29-0.75)	0.38 (0.26-0.52)
Jajpur	0.43 (0.27-0.58)	0.49 (0.21-1.69)	0.46 (0.22-1.27)	0.44 (0.30-1.06)	0.40 (0.33-0.49)
Chandbali U/s	23.90 (0.61-57.92)	7.68 (0.33-29.88)	16.66 (0.47-72.12)	12.82 (0.46-40.02)	19.16 (0.68-48.68)
Chandbali D/s	-	-	-	13.61 (0.41-43.37)	18.07 (0.62-46.63)
Deogaon (Kusei)	0.51 (0.28-0.84)	0.44 (0.24-0.65)	0.35 (0.23-0.58)	0.43 (0.31-0.63)	0.49 (0.25-0.98)
Bhadrak U/s (Salandi)	-	-	-	0.53 (0.29-1.24)	48.63 (1.05-75.33)
Bhadrak D/s (Salandi)	-	-	-	0.65 (0.34-1.54)	0.43 (0.28-0.73)
Dhamra (Dhamra)	33.19 (0.96-51.93)	28.18 (0.70-56.26)	42.91 (2.87-90.56)	41.19 (1.22-83.82)	0.48 (0.28-0.83)
	B (mg/l)				
	2011	2012	2013	2014	2015
Joda	0.036 (0.011-0.095)	0.028 (0.007-0.053)	0.138 (0.003-1.004)	0.066 (0.003-0.234)	0.012 (0.003-0.038)
Anandpur	0.044 (0.011-0.098)	0.022 (0.004-0.048)	0.020 (0.003-0.079)	0.055 (0.016-0.109)	0.041 (0.003-0.098)
Jajpur	0.050 (0.008-0.155)	0.050 (0.004-0.121)	0.049 (0.011-0.091)	0.094 (0.012-0.256)	0.031 (0.003-0.080)
Chandbali U/s	0.523 (0.034-1.419)	0.705 (0.053-2.350)	0.219 (0.007-0.893)	0.276 (0.010-0.632)	0.536 (0.010-1.958)
Chandbali D/s	-	-	-	0.278 (0.009-0.860)	0.620 (0.042-2.185)
Deogaon (Kusei)	0.093 (0.004-0.446)	0.040 (0.004-0.076)	0.040 (0.011-0.068)	0.049 (0.012-0.137)	0.037 (0.003-0.130)
Bhadrak U/s (Salandi)	-	-	-	0.083 (0.006-0.215)	0.039 (0.003-0.084)
Bhadrak D/s (Salandi)	-	-	-	0.083 (0.003-0.165)	0.055 (0.006-0.161)
Dhamra (Dhamra)	1.163 (0.026-1.790)	1.076 (0.083-3.320)	1.011 (0.120-2.213)	0.949 (0.080-2.779)	1.461 (0.016-3.918)

**Table 5.8 Annual average and range values of Total Dissolved Solids (TDS) and Total Hardness (TH )**

Monitoring Station	TDS (mg/l)				
	2011	2012	2013	2014	2015
Joda	95 (58-168)	76 (61-101)	74 (48-107)	85 (56-147)	78 (62-108)
Anandpur	99 (54-157)	94 (66-133)	89 (54-113)	97 (78-140)	93 (78-104)
Jajpur	106 (57-162)	109 (74-248)	96 (64-141)	102 (68-132)	99 (72-125)
Chandbali U/s	5384 (130-11966)	3297 (165-14087)	2216 (72-6318)	1725 (88-5616)	4729 (106-13010)
Chandbali D/s	-	-	-	2027 (102-6536)	4722 (118-13390)
Deogaon (Kusei)	151 (124-200)	143 (114-174)	139 (90-189)	135 (84-178)	137 (84-178)
Bhadrak U/s (Salandi)	-	-	-	86 (60-122)	88 (70-129)
Bhadrak D/s (Salandi)	-	-	-	98 (68-182)	99 (84-136)
Dhamra (Dhamra)	15336 (131-26727)	14120 (632-30238)	17046 (260-39861)	14190 (144-29156)	17122 (130-28390)
	TH (as CaCO <sub>3</sub> ) (mg/l)				
	2011	2012	2013	2014	2015
Joda	57 (28-96)	48 (28-64)	43 (20-62)	47 (16-102)	46 (32-60)
Anandpur	64 (28-112)	59 (36-94)	52 (20-72)	56 (32-100)	59 (44-72)
Jajpur	63 (40-106)	64 (44-84)	56 (28-84)	59 (36-76)	65 (44-78)
Chandbali U/s	838 (66-1800)	902 (60-3000)	295 (40-600)	249 (44-660)	878 (48-2350)
Chandbali D/s	-	-	-	292 (40-920)	926 (52-2400)
Deogaon (Kusei)	96 (72-136)	95 (80-120)	90 (56-120)	95 (44-132)	96 (52-128)
Bhadrak U/s (Salandi)	-	-	-	52 (32-86)	56 (38-96)
Bhadrak D/s (Salandi)	-	-	-	54 (30-100)	60 (46-80)
Dhamra (Dhamra)	3056 (70-5000)	2863 (350-5800)	2671 (68-5800)	2090 (54-4700)	2680 (60-5000)

Table 5.9 Annual average and range values of Nitrate (as NO<sub>3</sub>)

Monitoring Station	2011	2012	2013	2014	2015
	NO <sub>3</sub> (mg/l)				
Joda	4.132 (0.177-17.612)	4.66 (0.31-25.88)	5.655 (1.342-16.917)	3.616 (0.226-16.474)	3.678 (0.362-10.252)
Anandpur	1.745 (0.093-5.797)	2.72 (0.22-10.75)	4.226 (0.362-14.109)	2.809 (0.128-15.496)	5.328 (1.092-8.820)
Jajpur	3.724 (0.275-11.125)	4.50 (0.31-19.94)	2.253 (0.276-6.235)	3.475 (0.226-15.018)	5.607 (0.186-17.129)
Chandbali U/s	3.286 (0.097-8.427)	3.81 (0.55-9.50)	4.145 (2.388-9.397)	4.196 (0.385-17.125)	3.444 (0.580-7.859)
Chandbali D/s	-	-	-	5.418 (0.908-20.358)	5.640 (0.753-12.011)
Deogaon (Kusei)	1.205 (0.297-5.682)	4.37 (0.14-33.82)	3.313 (0.261-11.953)	2.511 (0.556-12.055)	4.764 (1.523-10.066)
Bhadrak U/s (Salandi)	-	-	-	1.605 (0.314-3.853)	3.564 (0.678-6.878)
Bhadrak D/s (Salandi)	-	-	-	3.379 (0.700-10.248)	7.404 (2.582-15.297)
Dhamra (Dhamra)	5.837 (0.934-12.457)	3.54 (0.23-8.57)	4.470 (1.448-13.237)	3.315 (1.497-8.060)	8.210 (0.793-31.487)

Table 5.10 Annual average and range values of Chloride, Sulphate and Fluoride

Monitoring Station	2011	2012	2013	2014	2015
	Chloride (mg/l)				
Joda	12.2 (5.0-28.4)	8.6 (4.6-16.0)	9.6 (5.8-15.7)	8.0 (4.9-13.7)	8.72 (4.89-13.69)
Anandpur	12.0 (5.9-16.7)	10.1 (6.6-15.0)	10.0 (5.5-19.7)	9.9 (7.8-15.7)	9.62 (7.80-13.69)
Jajpur	12.7 (6.8-19.6)	14.1 (7.1-49.0)	12.7 (4.7-35.6)	11.1 (6.9-24.5)	10.60 (8.80-13.69)
Chandbali U/s	2713.4 (16.3-5997.0)	1761.9 (15.4-7919.2)	1540.4 (9.4-6870.0)	853.7 (11.7-3035.0)	2414.2 (8.0-7145.2)
Chandbali D/s	-	-	-	987.9 (10.8-3524)	2369.5 (15.65-7047.4)
Deogaon (Kusei)	18.0 (9.7-29.0)	16.0 (11.5-24.4)	12.7 (7.4-24.6)	12.1 (8.2-17.6)	13.78 (6.84-27.40)
Bhadrak U/s (Salandi)	-	-	-	12.8 (7.8-27.4)	11.25 (7.83-21.53)
Bhadrak D/s (Salandi)	-	-	-	16.6 (7.8-40.8)	12.79 (8.80-17.61)
Dhamra (Dhamra)	8076.5 (31.7-14000.0)	7824.1 (82.5-16650.0)	9090.6 (94.3-21150.0)	7494.3 (33.3-15466.8)	9295.3 (29.4-15677.5)

Table 5.10 contd..

Monitoring Station	2011	2012	2013	2014	2015
<b>Sulphate (mg/l)</b>					
Joda	8.4 (0.8-27.7)	4.90 (0.99-9.0)	5.64 (0.99-10.82)	6.41 (2.86-13.93)	9.8 (2.5-17.7)
Anandpur	4.4 (1.0-10.4)	6.62 (1.38-17.82)	5.4 (1.4-19.0)	8.82 (1.24-23.25)	9.2 (3.5-21.4)
Jajpur	6.83 (1.51-9.89)	8.64 (0.79-21.88)	6.40 (1.50-17.71)	7.54 (2.39-13.93)	9.6 (4.0-16.9)
Chandbali U/s	285.3 (6.0-1199.0)	151.8 (10.89-574.2)	163.1 (7.3-957.7)	86.84 (9.57-251.85)	388.3 (10.3-883.1)
Chandbali D/s	-	-	-	100.78 (10.94-279.84)	329 (12.0-907.9)
Deogaon (Kusei)	3.60 (0.97-8.49)	6.77 (2.17-14.85)	6.3 (0.5-20.6)	6.29 (2.73-10.57)	10.5 (3.4-20.2)
Bhadrak U/s (Salandi)	-	-	-	4.7 (0.9-9.0)	6.6 (3.2-12.4)
Bhadrak D/s (Salandi)	-	-	-	6.1 (2.9-10.0)	8.8 (4.1-14.9)
Dhamra (Dhamra)	663.5 (12.8-2602.2)	841.3 (210.7-2940.1)	912.2 (24.8-2226.3)	867.30 (17.96-1789.78)	911.3 (17.9-1530.0)
<b>Fluoride (mg/l)</b>					
Monitoring Station	2011	2012	2013	2014	2015
Joda	0.247 (0.049-0.654)	0.180 (0.111-0.244)	0.288 (0.101-0.972)	0.188 (0.105-0.314)	0.304 (0.180-0.514)
Anandpur	0.234 (0.088-0.518)	0.201 (0.140-0.295)	0.182 (0.105-0.263)	0.194 (0.126-0.292)	0.307 (0.180-0.509)
Jajpur	0.198 (0.043-0.330)	0.233 (0.126-0.414)	0.312 (0.110-1.310)	0.205 (0.131-0.312)	0.368 (0.225-0.720)
Chandbali U/s	0.243 (0.076-0.498)	0.319 (0.142-0.525)	0.294 (0.137-0.565)	0.248 (0.165-0.334)	0.391 (0.230-0.617)
Chandbali D/s	-	-	-	0.240 (0.147-0.351)	0.392 (0.248-0.566)
Deogaon (Kusei)	0.272 (0.093-0.598)	0.268 (0.187-0.373)	0.250 (0.147-0.357)	0.238 (0.152-0.335)	0.337 (0.219-0.530)
Bhadrak U/s (Salandi)	-	-	-	0.186 (0.112-0.302)	0.340 (0.150-0.600)
Bhadrak D/s (Salandi)	-	-	-	0.172 (0.103-0.288)	0.301 (0.140-0.532)
Dhamra (Dhamra)	0.427 (0.105-0.741)	0.555 (0.202-0.969)	0.509 (0.152-0.813)	0.483 (0.166-0.711)	0.512 (0.250-0.740)

Table 5.11 Annual average and range values of Metals

Table 5.11 (a) Chromium (VI) and Mercury

Monitoring Station	2014	2015	2014	2015
	Chromium (VI) (mg/l)		Mercury (mg/l)	
Joda	0.020 (<0.002-0.051)	0.015 (<0.002-0.036)	0.00010 (<0.00006-0.00060)	0.00016 (<0.00006-0.00070)
Anandpur	0.019 (<0.002-0.043)	0.013 (<0.002-0.030)	0.00026 (<0.00006-0.00133)	0.00024 (<0.00006-0.00100)
Jajpur	0.013 (0.003-0.028)	0.013 (<0.002-0.035)	0.00026 (<0.00006-0.00102)	0.00039 (0.00013-0.00095)
Chandbali U/s	0.022 (0.003-0.067)	0.019 (<0.002-0.037)	0.00012 (<0.00006-0.00076)	0.00025 (<0.00006-0.00083)
Chandbali D/s	0.018 (<0.002-0.033)	0.021 (<0.002-0.040)	0.00021 (<0.00006-0.00090)	0.00024 (0.00006-0.00076)
Deogaon (Kusei)	0.016 (<0.002-0.047)	0.013 (<0.002-0.033)	0.00040 (<0.00006-0.00257)	0.00013 (<0.00006-0.00051)
Bhadrak U/s (Salandi)	0.011 (<0.002-0.036)	0.010 (<0.002-0.031)	0.00010 (<0.00006-0.00038)	0.00023 (<0.00006-0.00089)
Bhadrak D/s (Salandi)	0.017 (<0.002-0.056)	0.014 (<0.002-0.038)	0.00020 (<0.00006-0.00051)	0.00038 (0.00013-0.00095)
Dhamra (Dhamra)	0.020 (<0.002-0.043)	0.014 (<0.002-0.043)	0.00010 (<0.00006-0.00025)	0.00030 (<0.00006-0.00095)

Table 5.11 (b)

Monitoring Station	2011	2012	2013	2014	2015
	Total Chromium (mg/l)				
Joda	0.043 (0.010-0.070)	0.043 (0.023-0.060)	0.041 (0.006-0.068)	0.055 (0.020-0.113)	0.043 (0.008-0.081)
Anandpur	0.035 (0.015-0.063)	0.023 (0.015-0.028)	0.030 (0.010-0.053)	0.084 (0.005-0.288)	0.047 (0.013-0.113)
Jajpur	0.039 (0.005-0.068)	0.032 (0.018-0.065)	0.028 (0.005-0.060)	0.048 (0.010-0.145)	0.049 (0.007-0.131)
Chandbali U/s	0.041 (0.009-0.105)	0.043 (0.018-0.085)	0.027 (0.002-0.050)	0.084 (0.023-0.242)	0.054 (0.013-0.094)
Chandbali D/s	-	-	-	0.086 (0.021-0.202)	0.054 (0.015-0.097)
Deogaon (Kusei)	0.294 (0.010-0.052)	0.024 (0.012-0.052)	0.023 (0.003-0.040)	0.038 (0.010-0.058)	0.043 (0.011-0.077)
Bhadrak U/s (Salandi)	-	-	-	0.030 (0.006-0.057)	0.038 (0.011-0.087)
Bhadrak D/s (Salandi)	-	-	-	0.063 (0.013-0.188)	0.049 (0.015-0.126)
Dhamra (Dhamra)	0.051 (0.009-0.101)	0.041 (0.007-0.088)	0.028 (0.007-0.048)	0.056 (0.025-0.126)	0.043 (0.011-0.094)

Table 5.11 (c) Iron

Monitoring Station	2011	2012	2013	2014	2015
	Iron (mg/l)				
Joda	6.953 (0.139-18.990)	12.752 (0.586-93.600)	5.842 (0.514-18.200)	3.699 (<0.005-11.580)	3.081 (0.280-8.620)
Anandpur	4.636 (0.307-15.418)	4.739 (0.570-15.700)	5.057 (0.498-13.160)	2.644 (0.010-8.720)	1.949 (0.050-8.080)
Jajpur	5.996 (0.180-14.746)	4.759 (0.125-14.340)	4.835 (0.402-12.810)	2.266 (0.090-9.792)	2.728 (0.160-7.06)
Chandbali U/s	10.861 (2.070-19.500)	8.945 (0.394-19.910)	7.661 (1.970-12.158)	5.125 (0.051-15.606)	5.373 (1.340-9.100)
Chandbali D/s	-	-	-	8.609 (0.061-15.989)	4.102 (0.209-9.840)
Deogaon (Kusei)	4.003 (0.200-13.805)	14.088 (0.180-102.220)	3.469 (0.340-9.397)	1.978 (<0.005-9.460)	2.452 (0.160-7.650)
Bhadrak U/s (Salandi)	-	-	-	0.759 (0.010-4.830)	1.192 (0.180-6.550)
Bhadrak D/s (Salandi)	-	-	-	2.215 (0.102-7.478)	1.186 (0.020-6.020)
Dhamra (Dhamra)	11.735 (2.183-19.565)	7.442 (1.490-17.200)	7.123 (BDL-15.996)	6.167 (0.464-18.003)	4.096 (0.390-7.470)

Table 5.11 (d) Nickel

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	Nickel (mg/l)				
Joda	0.003 (<0.001-0.007)	0.006 (0.005-0.010)	0.002	0.005 (0.001-0.008)	0.014 (0.004-0.031)
Anandpur	0.004 (0.001-0.010)	0.005 (0.003-0.008)	0.002	0.012 (0.007-0.018)	0.013 (0.004-0.022)
Jajpur	0.004 (0.001-0.008)	0.004 (0.002-0.008)	0.002	0.014 (0.012-0.015)	0.011 (0.002-0.020)
Chandbali U/s	0.004 (0.001-0.009)	0.005 (0.004-0.009)	0.003	0.065 (0.046-0.084)	0.026 (0.005-0.082)
Chandbali D/s	-	-	-	0.061 (0.042-0.080)	0.026 (0.006-0.088)
Deogaon (Kusei)	0.004 (<0.001-0.009)	0.006 (0.002-0.013)	0.002	0.012 (0.014-0.012)	0.010 (0.002-0.021)
Bhadrak U/s (Salandi)	-	-	-	0.013 (0.011-0.015)	0.013 (0.006-0.061)
Bhadrak D/s (Salandi)	-	-	-	0.014 (0.011-0.018)	0.016 (0.005-0.049)
Dhamra (Dhamra)	0.007 (0.001-0.023)	0.006 (0.004-0.009)	0.003	0.010 (0.008-0.012)	0.030 (0.009-0.085)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 5.11 (e) Copper

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	Copper (mg/l)				
Joda	0.005 (0.001-0.009)	0.004 (0.003-0.006)	0.002	0.005 (0.003-0.007)	0.006 (0.002-0.010)
Anandpur	0.004 (<0.001-0.007)	0.004 (0.003-0.004)	0.002	0.007 (0.003-0.011)	0.007 (0.001-0.014)
Jajpur	0.004 (<0.001-0.008)	0.004 (0.001-0.006)	0.003	0.008 (0.004-0.012)	0.005 (0.002-0.013)
Chandbali U/s	0.004 (0.001-0.007)	0.003 (0.001-0.006)	0.002	0.010 (0.009-0.011)	0.01 (0.002-0.028)
Chandbali D/s	-	-	-	0.009 (0.008-0.011)	0.010 (0.002-0.028)
Deogaon (Kusei)	0.004 (0.001-0.006)	0.005 (0.001-0.007)	0.002	0.006 (0.005-0.008)	0.004 (0.001-0.013)
Bhadrak U/s (Salandi)	-	-	-	0.005 (0.002-0.008)	0.005 (0.001-0.013)
Bhadrak D/s (Salandi)	-	-	-	0.028 (0.025-0.032)	0.006 (0.001-0.015)
Dhamra (Dhamra)	0.006 (0.001-0.009)	0.006 (0.002-0.010)	0.002	0.006 (0.006-0.011)	0.013 (0.001-0.030)

Table 5.11 (f) Zinc

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	Zinc (mg/l)				
Joda	0.005 (0.001-0.018)	0.003 (0.001-0.004)	0.008	0.006 (0.003-0.008)	0.016 (0.003-0.048)
Anandpur	0.006 (0.001-0.014)	0.005 (0.001-0.006)	0.008	0.006 (0.004-0.008)	0.014 (0.002-0.023)
Jajpur	0.005 (0.001-0.011)	0.007 (0.002-0.016)	0.008	0.004 (0.003-0.006)	0.013 (0.001-0.024)
Chandbali U/s	0.006 (0.001-0.016)	0.007 (0.005-0.009)	0.007	0.013 (0.012-0.014)	0.033 (0.003-0.195)
Chandbali D/s	-	-	-	0.011 (0.010-0.012)	0.033 (0.003-0.201)
Deogaon (Kusei)	0.004 (0.001-0.006)	0.006 (0.002-0.010)	0.007	0.012 (0.011-0.012)	0.012 (0.002-0.038)
Bhadrak U/s (Salandi)	-	-	-	0.012 (0.012-0.012)	0.009 (0.001-0.022)
Bhadrak D/s (Salandi)	-	-	-	0.016 (0.016-0.016)	0.020 (0.008-0.058)
Dhamra (Dhamra)	0.008 (0.003-0.017)	0.007 (0.004-0.008)	0.008	0.049 (0.046-0.052)	0.036 (0.007-0.214)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 5.11 (g) Cadmium

Monitoring Station	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	Cadmium (mg/l)				
Joda	0.001 (<0.001-0.002)	0.001 (0.001-0.002)	< 0.001	0.0007 (0.0005-0.0008)	0.0027 (0.0006-0.0078)
Anandpur	0.001 (0.001-0.003)	0.001 (0.001-0.002)	<0.001	0.0007 (0.0007-0.0008)	0.0028 (0.0003-0.0064)
Jajpur	0.001 (<0.001-0.003)	0.001 (0.001-0.002)	0.001	0.0010 (0.0008-0.0013)	0.0029 (0.0010-0.0051)
Chandbali U/s	0.002 (0.001-0.007)	0.002 (0.001-0.003)	0.001	0.0034 (0.0005-0.0063)	0.0034 (0.0007-0.0116)
Chandbali D/s	-	-	-	0.0033 (0.0005-0.0060)	0.0044 (0.0008-0.0154)
Deogaon (Kusei)	0.002 (0.001-0.004)	0.001 (0.001-0.002)	<0.001	0.0018 (0.0016-0.0020)	0.0030 (0.0006-0.0074)
Bhadrak U/s (Salandi)	-	-	-	0.0008 (0.0008-0.0008)	0.0018 (0.0008-0.0035)
Bhadrak D/s (Salandi)	-	-	-	0.0029 (0.0012-0.0046)	0.0024 (0.0009-0.0043)
Dhamra (Dhamra)	0.002 (<0.001-0.004)	0.002 (0.001-0.004)	0.001	0.0008 (0.0006-0.0011)	0.0061 (0.0007-0.0293)

Table 5.11 (h) Lead

Monitoring Station	2011	2012	2013	2014	2015
	Lead (mg/l)				
Joda	0.005 (0.001-0.009)	0.005 (0.004-0.008)	0.003	0.013 (0.011-0.014)	0.008 (0.004-0.014)
Anandpur	0.004 (0.001-0.007)	0.004 (0.003-0.006)	0.004	0.009 (0.008-0.009)	0.009 (0.003-0.014)
Jajpur	0.004 (0.001-0.009)	0.004 (0.002-0.008)	0.003	0.002 (0.001-0.004)	0.007 (0.002-0.015)
Chandbali U/s	0.005 (0.002-0.010)	0.005 (0.004-0.008)	0.008	0.030 (0.025-0.036)	0.015 (0.002-0.040)
Chandbali D/s	-	-	-	0.033 (0.028-0.038)	0.016 (0.004-0.029)
Deogaon (Kusei)	0.005 (0.001-0.009)	0.005 (0.003-0.008)	0.002	0.011 (0.010-0.012)	0.009 (0.003-0.019)
Bhadrak U/s (Salandi)	-	-	-	0.006 (0.005-0.008)	0.007 (0.001-0.020)
Bhadrak D/s (Salandi)	-	-	-	0.011 (0.009-0.012)	0.008 (0.002-0.022)
Dhamra (Dhamra)	0.005 (0.001-0.008)	0.007 (0.004-0.008)	0.009	0.005 (0.004-0.007)	0.014 (0.004-0.046)

\* Data for the period February, 2013

# Data for the period February and March, 2014

## Data for the period April-December, 2015

Table 5.12 Annual average and range values of (Nitrite+Nitrate)- Nitrogen

Monitoring Station	2011	2012	2013	2014	2015
	(Nitrite+Nitrate)- Nitrogen (mg/l)				
Joda	0.933 (0.040-3.977)	1.052 (0.069-5.844)	1.277 (0.303-3.820)	0.817 (0.051-3.720)	0.830 (0.082-2.315)
Anandpur	0.394 (0.021-1.309)	0.618 (0.050-2.426)	0.954 (0.082-3.186)	0.634 (0.029-3.499)	1.203 (0.247-1.992)
Jajpur	0.841 (0.062-2.512)	1.015 (0.069-4.503)	0.509 (0.062-1.408)	0.785 (0.051-3.391)	1.266 (0.042-3.868)
Chandbali U/s	0.742 (0.022-1.903)	0.861 (0.123-2.146)	0.936 (0.539-2.122)	0.947 (0.087-3.867)	0.778 (0.131-1.775)
Chandbali D/s	-	-	-	1.224 (0.205-4.597)	1.274 (0.170-2.712)
Deogaon (Kusei)	0.272 (0.067-1.283)	0.987 (0.031-7.635)	0.748 (0.059-2.699)	0.567 (0.126-2.722)	1.076 (0.344-2.273)
Bhadrak U/s (Salandi)	-	-	-	0.362 (0.071-0.870)	0.805 (0.153-1.553)
Bhadrak D/s (Salandi)	-	-	-	0.763 (0.158-2.314)	1.672 (0.583-3.454)
Dhamra (Dhamra)	1.318 (0.211-2.813)	0.799 (0.052-1.934)	1.009 (0.327-2.989)	0.749 (0.338-1.820)	1.854 (0.179-7.110)

Table 5.13 Annual average and range values of Total suspended solids (TSS)

Monitoring Station		2011	2012	2013	2014	2015
		TSS (mg/l)				
Joda	IM	192 (13-804)	182 (16-1020)	186 (22-1252)	14 (8-724)	38 (6-111)
	NM	81 (13-214)	40 (16-1020)	225 (22-1252)	93 (8-199)	21 (6-80)
Anandpur	IM	88 (5-261)	106 (5-402)	101 (8-424)	124 (10-864)	29 (4-80)
	NM	87 (5-261)	53 (5-128)	96 (8-424)	27 (10-73)	16 (4-50)
Jajpur	IM	153 (31-564)	101 (23-298)	134 (28-416)	59 (8-371)	23 (6-85)
	NM	62 (31-217)	60 (23-140)	89 (28-276)	20 (8-43)	12 (6-25)
Chandbali U/s	IM	272 (72-642)	239 (60-812)	151 (38-364)	234 (45-926)	150 (38-759)
	NM	301 (72-642)	224 (60-812)	145 (38-364)	279 (45-926)	177 (38-759)
Chandbali D/s	IM	-	-	-	260 (56-988)	167 (45-679)
	NM	-	-	-	302 (56-988)	189 (45-679)
Deogaon (Kusei)	IM	121 (11-628)	55 (11-144)	148 (28-596)	61 (10-210)	32 (8-110)
	NM	43 (11-99)	35 (11-56)	129 (28-596)	42 (10-210)	16 (8-30)

Monitoring Station		2011	2012	2013	2014	2015
		TSS (mg/l)				
Bhadrak U/s (Salandi)	IM	-	-	-	36 (5-147)	21 (8-80)
	NM	-	-	-	36 (5-147)	13 (8-20)
Bhadrak D/s (Salandi)	IM	-	-	-	39 (12-182)	31 (12-87)
	NM	-	-	-	39 (12-182)	21 (12-30)
Dhamra (Dhamra)	IM	513 (178-1704)	295 (114-842)	276 (56-620)	216 (60-651)	117 (30-490)
	NM	590 (178-1704)	313 (114-842)	258 (56-504)	240 (60-651)	85 (30-173)

**Note :** IM : Including monsoon period

NM : Non-monsoon period (i.e. excluding the months July, August and September)

**Table 5.14 Percentage violation and Annual range of Fecal coliform (FC) values**

Monitoring Station	2011	2012	2013	2014	2015
	Percentage Violation from 2000 MPN/100 ml (Range of FC values in '000 MPN/100 ml)				
Joda	8 (0.230-2.200)	42 (0.330-3.500)	45 (0.130-4.900)	36 (0.220-35.000)	42 (0.078-4.900)
Anandpur	50 (1.100-17.000)	50 (0.490-5.400)	64 (0.078-35.000)	45 (0.220-24.000)	58 (0.330-16.000)
Jajpur	90 (1.200-24.000)	75 (0.700-11.000)	82 (1.300-17.000)	82 (0.790-54.000)	75 (0.330-35.000)
Chandbali U/s	50 (0.940-17.000)	67 (1.100-9.200)	27 (0.400-3.500)	100 (2.200-160.000)	92 (1.700-54.000)
Chandbali D/s	-	-	-	100 (2.300-160.000)	100 (2.200-160.000)
Deogaon (Kusei)	17 (0.230-2.300)	33 (0.210-5.400)	54 (0.130-7.900)	54 (0.130-17.000)	67 (0.490-24.000)
Bhadrak U/s (Salandi)	-	-	-	72 (0.790-160.000)	92 (0.230-54.000)
Bhadrak D/s (Salandi)	-	-	-	100 (3.500-160.000)	100 (4.900-160.000)
Dhamra (Dhamra)	17 (0.140-14.000)	25 (0.130-2.800)	45 (0.170-16.000)	54 (0.045-16.000)	75 (0.330-16.000)

**Table 5.15 Annual average and range values of Total Phosphate-P**

Monitoring Station	2011	2012	2013	2014	2015
	Total Phosphate-P (mg/l)				
Joda	0.086 (0.003-0.418)	0.125 (0.003-0.645)	0.159 (0.008-0.460)	0.045 (0.011-0.147)	0.121 (0.011-0.427)
Anandpur	0.051 (0.004-0.108)	0.071 (0.012-0.201)	0.096 (0.020-0.283)	0.239 (0.021-1.702)	0.178 (0.027-0.916)
Jajpur	0.029 (0.005-0.064)	0.042 (0.005-0.163)	0.134 (0.008-0.576)	0.071 (0.009-0.138)	0.072 (0.008-0.231)
Chandbali U/s	0.060 (0.002-0.146)	0.070 (0.003-0.214)	0.087 (0.009-0.310)	0.051 (0.009-0.164)	0.144 (0.023-0.734)
Chandbali D/s	-	-	-	0.043 (0.007-0.087)	0.187 (0.017-0.922)
Deogaon (Kusei)	0.065 (0.001-0.297)	0.057 (0.007-0.158)	0.075 (0.003-0.210)	0.180 (0.006-1.571)	0.120 (0.015-0.803)
Bhadrak U/s (Salandi)	-	-	-	0.081 (0.004-0.387)	0.113 (0.012-0.781)
Bhadrak D/s (Salandi)	-	-	-	0.105 (0.009-0.396)	0.155 (0.018-1.078)
Dhamra (Dhamra)	0.071 (0.005-0.161)	0.049 (0.006-0.092)	0.100 (0.037-0.190)	0.058 (0.007-0.116)	0.048 (0.029-0.075)

**Table 5.16 Annual average and range values of Total Kjeldahl Nitrogen (TKN)**

Monitoring Station	2011	2012	2013	2014	2015
	TKN (mg/l)				
Joda	4.2 (0.8-14.0)	3.42 (1.68-7.00)	2.87 (1.66-5.60)	1.171 (0.56-1.680)	1.21 (0.84-1.68)
Anandpur	4.2 (1.1-17.6)	6.96 (1.68-38.08)	3.82 (2.24-7.00)	1.20 (0.56-1.96)	1.17 (0.84-1.40)
Jajpur	3.5 (0.8-11.5)	4.43 (1.40-9.52)	2.28 (0.82-3.90)	1.25 (0.28-1.96)	1.35 (1.12-1.68)
Chandbali U/s	4.4 (1.4-16.5)	6.43 (1.96-14.56)	3.28 (1.12-6.20)	1.30 (0.56-1.96)	1.38 (0.84-1.96)
Chandbali D/s	-	-	-	1.35 (0.84-1.68)	1.47 (0.84-2.24)
Deogaon (Kusei)	2.9 (1.1-7.0)	3.61 (1.12-5.88)	2.62 (1.68-5.60)	1.27 (0.56-1.68)	1.17 (0.84-1.68)
Bhadrak U/s (Salandi)	-	-	-	1.27 (0.84-1.68)	1.17 (0.84-1.68)
Bhadrak D/s (Salandi)	-	-	-	1.48 (0.84-1.96)	1.42 (0.84-1.96)
Dhamra (Dhamra)	3.5 (1.7-7.8)	2.99 (1.68-7.84)	2.69 (0.56-5.04)	1.20 (0.84-1.68)	1.31 (0.84-1.68)

**Table 5.17 Annual average and range values of Chemical Oxygen Demand (COD)**

Monitoring Station	2011	2012	2013	2014	2015
	COD (mg/l)				
Joda	10.8 (4.1-16.2)	9.9 (6.9-16.4)	11.1 (2.0-18.9)	8.6 (3.8-20.9)	8.4 (2.0-18.5)
Anandpur	12.8 (6.1-24.2)	9.5 (7.4-13.6)	11.8 (2.2-19.8)	8.8 (1.9-15.2)	8.8 (2.0-17.8)
Jajpur	14.7 (6.8-24.5)	11.8 (7.1-20.8)	13.3 (2.1-22.0)	15.5 (7.6-28.3)	14.5 (9.2-23.5)
Chandbali U/s	19.4 (6.3-29.7)	16.5 (7.8-23.7)	14.8 (1.6-24.6)	16.9 (4.9-39.6)	23.7 (5.2-78.8)
Chandbali D/s	-	-	-	23.0 (10.2-43.6)	25.4 (12.2-59.1)
Deogaon (Kusei)	10.0 (6.0-17.8)	9.6 (5.9-13.6)	10.1 (1.5-26.0)	8.6 (3.3-17.2)	7.7 (4.1-15.8)
Bhadrak U/s (Salandi)	-	-	-	9.3 (4.8-19.8)	7.7 (5.7-9.8)
Bhadrak D/s (Salandi)	-	-	-	13.9 (6.5-25.7)	19.9 (9.9-76.8)
Dhamra (Dhamra)	30.5 (6.1-69.0)	20.8 (7.8-45.0)	22.5 (1.7-39.8)	28.4 (8.6-62.4)	29.2 (11.4-72.0)

**Table 5.18 Annual average and range values of Total Alkalinity**

Monitoring Station	2011	2012	2013	2014	2015
	Total Alkalinity (as CaCO <sub>3</sub> ) (mg/l)				
Joda	59 (28-106)	49 (28-68)	43 (16-68)	54 (22-120)	44 (24-60)
Anandpur	71 (30-118)	64 (36-100)	56 (28-70)	60 (20-96)	59 (40-70)
Jajpur	76 (36-140)	65 (40-102)	58 (32-80)	59 (24-76)	62 (36-86)
Chandbali U/s	84 (44-112)	85 (68-112)	64 (26-92)	69 (28-176)	88 (44-192)
Chandbali D/s	-	-	-	71 (36-176)	91 (54-198)
Deogaon (Kusei)	106 (76-160)	104 (80-130)	99 (56-124)	97 (48-144)	93 (48-140)
Bhadrak U/s (Salandi)	-	-	-	53 (36-88)	57 (40-104)
Bhadrak D/s (Salandi)	-	-	-	57 (20-96)	60 (32-100)
Dhamra (Dhamra)	88 (54-124)	107 (60-148)	81 (48-112)	88 (48-196)	106 (52-196)

**Table 5.19 : Polluted river monitoring stations in Baitarani river system**

Sl. No.	River	Monitoring station	Annual BOD Data Range (mg/l)						
			Annual BOD Data range (mg/l)					Range value of BOD above 3.0 mg/l in the stretch	Priority as per CPCB Criteria
			2011	2012	2013	2014	2015		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	Baitarani	Jajpur	(1.2-3.2)	1.3-2.8	1.2-2.4	0.8-3.0	0.5-2.9	3.2	V
2	Salandi	Bhadrak D/s	-	-	-	(0.2-3.6)	(0.9-2.9)	3.6	V

**Table 5.20 : CWQI of Baitarani river system**

Monitoring station	CWQI				
	2011	2012	2013	2014	2015
Joda	85.52	84.64	81.71	83.56	72.25
Anandpur	100	84.73	83.48	70.23	83.62
Jajpur	89.08	83.92	75.61	72.41	81.33
Chandbali U/s	65.52	79.38	74.85	60.72	73.73
Chandbali D/s	80.1	79.89	84.93	51.30	55.70
Deogaon (Kusei)	-	-	-	53.03	54.68
Bhadrak U/s (Salandi)	-	-	-	66.12	60.30
Bhadrak D/s (Salandi)	-	-	-	49.65	58.34
Dhamra (Dhamra)	83.2	83.33	80.11	81.10	77.12

**Table 5.21 : Category of water quality of Baitarani river system based on CWQI values**

Monitoring station	Category of water quality				
	2011	2012	2013	2014	2015
Joda	Good	Good	Good	Good	Fair
Anandpur	Excellent	Good	Good	Fair	Good
Jajpur	Very Good	Good	Fair	Fair	Good
Chandbali U/s	Fair	Fair	Fair	Fair	Fair
Chandbali D/s	Good	Fair	Good	Marginal	Marginal
Deogaon (Kusei)	-	-	-	Marginal	Marginal
Bhadrak U/s (Salandi)	-	-	-	Fair	Fair
Bhadrak D/s (Salandi)	-	-	-	Marginal	Marginal
Dhamra (Dhamra)	Good	Good	Good	Good	Fair

**CHAPTER - VI****WATER QUALITY STATUS OF RUSHIKULYA RIVER**

Water quality of Rushikulya river is monitored at two locations – Madhopur and Potagada, in the last 7.0 km stretch of the river, before it falls into Bay of Bengal, primarily to assess the impact of a chloroalkali industry. Madhopur is at the upstream, while Potagarh is about 1.0 km downstream to the industry at a distance of 2.0 km from the mouth. The water intake points of two towns, Chhatrapur (district headquarter) and Ganjam is located at Madhopur. The distance between the two sampling stations is about 5.0 km.

**6.1 USE BASED WATER QUALITY STATUS****6.1.1 Water quality in respect of primary criteria**

The seasonal average values of pH, DO, BOD and TC at Madhopur and Potagada pertaining to the period 2011-2015 are described in Tables 6.1.

**pH and DO :** pH and DO values at both the stations conform to the water quality criteria for the highest class, i.e., Class-A. Seasonal average values of pH at Madhopur remained in the range 7.6- 8.4 and at Potagarh remained in the range 7.8 – 8.3. Most of the time water at both the stations is observed to be oxygen rich.

**BOD :** The seasonal average values of BOD at both the stations during the period 2011-2015 remained within 3.0 mg/l and thus meet Class-B water quality.

**TC :** Water quality with respect to TC at Madhopur and Potagarh do not conform to Class -A or Class- B. Seasonal average of TC values at Madhopur conform to Class-C only 55 % of time of observation. Whereas, at Potagarh, only 10 % of observation of seasonal average values do not conform to Class-C. TC counts at Potagada is significantly less in comparison to that in Madhopur.

The annual average and the range of BOD and TC values at the two monitoring stations are given in Table 6.2. Frequency of deviation of BOD and TC values from the stipulated values (3.0 mg/l and 5000 MPN/100 ml respectively) are also given in Table 6.2. Percent violations of BOD during the study period at the two stations are presented in Fig. 6.1. From the data and figures, it is evident that monthly BOD value is violated only 2 % of time (May, 2013) at Madhopur and 4% of time (January and September, 2011) at Potagarh under the period of study.

Spatial variation of BOD and TC values at these two stations are depicted in Fig. 6.2 and Fig. 6.3 respectively.

**Free Ammonia** : The annual average and range values of ammonical nitrogen and free ammonia are given in Table 6.3. Free ammonia values at the two stations conform to the stipulated value (1.2 mg/l, max) for Class-D inland surface water (Fish culture and wildlife propagation). Ammonical nitrogen values at both monitoring stations exhibit a decreasing pattern over the years.

**EC, SAR and B** : Seasonal average values of EC at the two monitoring stations are given in Table 6.4. From the data it is observed that the seasonal average values of EC at Madhopur varied within 212 - 407 microSiemens/cm during the study period excepting in one case when average value of 9538 microSiemens/cm was observed. At Potagarh, the seasonal average values vary widely from 241 microSiemens/cm to 48760 microSiemens/cm during the study period. Such wide range of fluctuation in EC values at Potagarh may be attributed to the tidal impact as Potagarh is very close to the river mouth. The same cause is also responsible for wide fluctuation in EC values at Madhopur during few occasions.

Annual average and range values of SAR and B at these monitoring stations are given in Table 6.5. From the data, it can be seen that the values of SAR and boron at Madhopur always remained within the tolerance limit (except on two occasions for SAR during 2013), whereas at Potagarh, frequent deviations from the tolerance limit are observed. SAR and B values at Madhopur are generally far too low compared to the stipulated values in Table 2.4, to cause any concern for its suitability for irrigation purposes. High and fluctuating values of EC and SAR at Potagada may be ascribed to tidal effect.

### **6.1.2 Water quality in respect of other parameters**

**TDS and Total Hardness** : Annual average and range values of TDS and total hardness are given in Table 6.6. The river water quality at Madhopur conforms to the Class-A quality criteria with respect to TDS (except on two occasions i.e. May and June, 2013) and total hardness (except one occasion (June, 2013)). Based on hardness values, the water quality at Madhopur can be categorized as soft to hard category. High values at Potagada are evidently due to tidal impact and makes it unfit to be classified as Class-E.

**Nitrates** : Annual average and range values of Nitrate are presented in Table 6.7. Nitrate concentrations at both the sampling stations conform to Class-A criteria of 20 mg/l except on one occasion at Potagarh during June, 2015, during which the nitrate value conformed to Class C

**Chloride, Sulphates and Fluorides** : The annual average and range values of chloride, sulphate and fluoride at Madhopur and Potagarh are given in Table 6.8. Comparison with the prescribed standards (Table 2.5) reveal that while the chloride, sulphate and fluoride values at Madhopur conform to the highest class (Class-A) (except for one occasion at Madhopur), the values for chloride and sulfate are often too high at Potagarh to be even fit for Class-E water quality for irrigation. A comparatively higher fluoride value at Potagada than at Madhopur also reflects the impact of tidal water.

**Heavy Metals:** Data given in Table 6.9 represent the annual average and range of concentration of chromium (VI) and mercury during the period 2014 and 2015 and annual average and range of concentrations of total chromium, iron, nickel, copper, zinc, cadmium and lead during the period 2011-2015. From the table it is observed that the values of these metals are well within the respective tolerance limit.

### 6.1.3 Use based classification

From the foregoing section, it may be concluded that the water quality at Madhopur do not conform to Class-C with respect to TC. Water quality at Potagarh is not qualifying the tolerance limits for Class- E because of tidal effect.

## 6.2 BIOLOGICAL ASSESSMENT OF WATER QUALITY

The annual average and range of biomonitoring results expressed in terms of Saprobic index (SI) and Diversity index (DI) and biological class of Rushikulya river at Potagarh during the period 2011-2015 are given in Table 6.10. Taking into consideration the observed biological indices and the BOD values (Table 6.2), the river stretch at is observed to be in a state of slight to moderate pollution (that is, B-C) during 2011, 2013 and in a state of slight pollution (B) during 2012, 2014 and 2015.

## 6.3 WATER QUALITY IN TERMS OF WHOLESOMENESS

### 6.3.1 Wholesomeness in terms of regular parameters

The wholesomeness of water quality at these two monitoring stations have been assessed with respect to general parameters specified in Table 2.7. Of the eight parameters listed in Table 2.7, results for bioassay are not available and therefore, the water quality are assessed with regard to the remaining seven parameters. Annual average and range values of (Nitrite + Nitrate)- N at the monitoring stations are given in Table 6.11. Annual average and range values of total suspended solids (TSS) including monsoon period and during non-monsoon period are given in Table 6.12. Considering pH, DO, BOD, EC, (Nitrite + Nitrate)-N values, the level of wholesomeness of the river water may be considered as “desirable” at Madhopur. However, TSS values (during non- monsoon period) most of the time exceeded the stipulated limit even for “acceptable” level. Similarly, data given in Table 6.13 (% violation of FC values from 2000 MPN/100 ml) show that the water quality generally deteriorates from “desirable” category to below “acceptable” category during most part of the period under study.

At Potagada, water quality is below “acceptable” with respect to the parameters like EC, TSS and FC during most part of the study.

### 6.3.2 Wholesomeness in terms of special parameters

Annual average and range values of total ammonical nitrogen ((ammonium+ammonia)-N) at the monitoring stations are given in Table 6.3.

Water quality with respect to total ammonical nitrogen at Madhopur was observed to be in “excellent” level during the study period except on three occasions during 2011 (January, March and September) and on one occasion during 2012 (April).

Water quality with respect to total ammonical nitrogen at Potagarh mostly remained in “desirable” level during 2011, in “excellent” level during 2012 -2015 except on one occasion (May, 2012).

Annual average and range values of total phosphate-P at the monitoring stations are given in Table 6.14 which reveals that water quality at both the stations mostly remained in “desirable level under the period of study.

Annual average and range values of TKN values are given in Table 6.15. Annual average values of TKN and frequency of deviation of monthly TKN values from the stipulated values for acceptable limit during the period 2011-2013 indicate that water quality with respect to TKN was below “acceptable” level at both stations. However, during 2014 and 2015, water quality with respect to TKN has been upgraded to “desirable” level.

It is seen from Table 6.9 that the annual average as well as monthly data on concentrations of metals like total chromium, zinc, copper, nickel, lead, cadmium and mercury in the river water at all station are within the “acceptable” limits.

#### **6.4 WATER QUALITY IN TERMS OF COD AND ALKALINITY**

Annual average and range values of COD and alkalinity are given in Table 6.16. COD and alkalinity values (excepting few occasions for COD) at Madhopur are within acceptable limits for most of the beneficial uses of water. However at Potagada, most of the time higher COD values are observed which may be ascribed to the tidal effect on the river.

#### **6.5 WATER QUALITY TREND**

Water quality of the river at Madhopur do not conform to Class-C which may be due to instream activities on the river. As the river enters its tidal zone at Potagada, there is significant deterioration in the water quality due to sea-river interaction which is clearly evident from higher EC, SAR, Chloride and Sulphate values. At Potagada, the water becomes unsuitable for most of the designated uses of inland surface water.

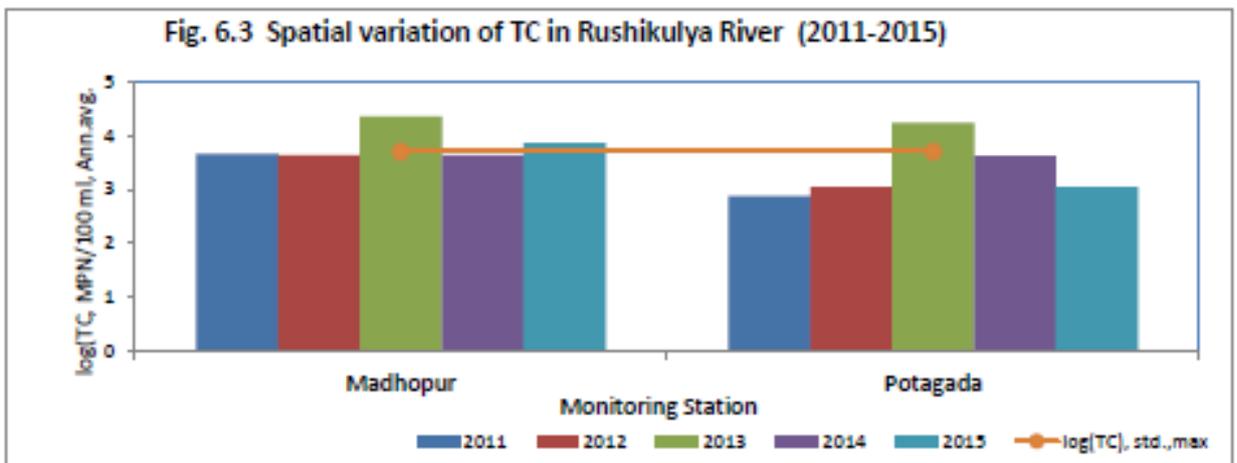
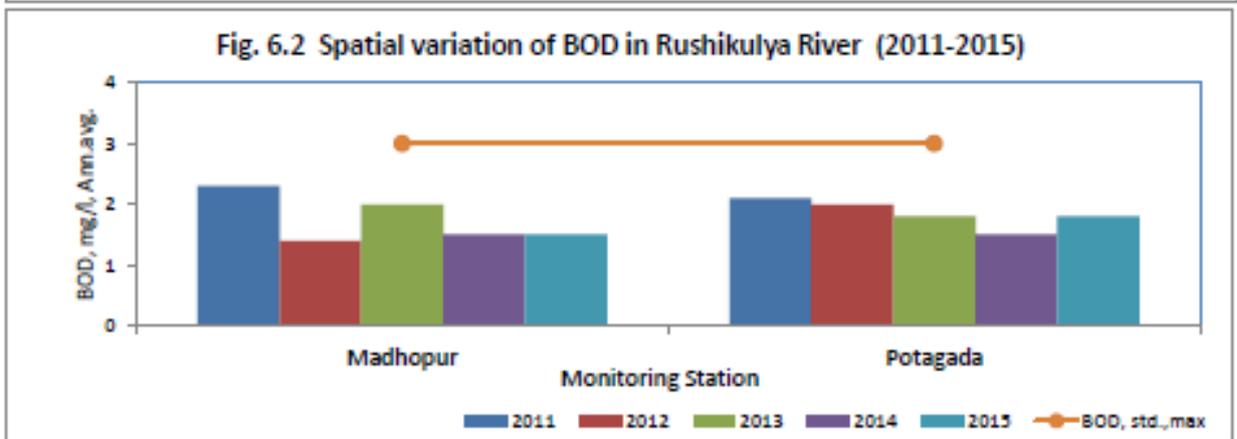
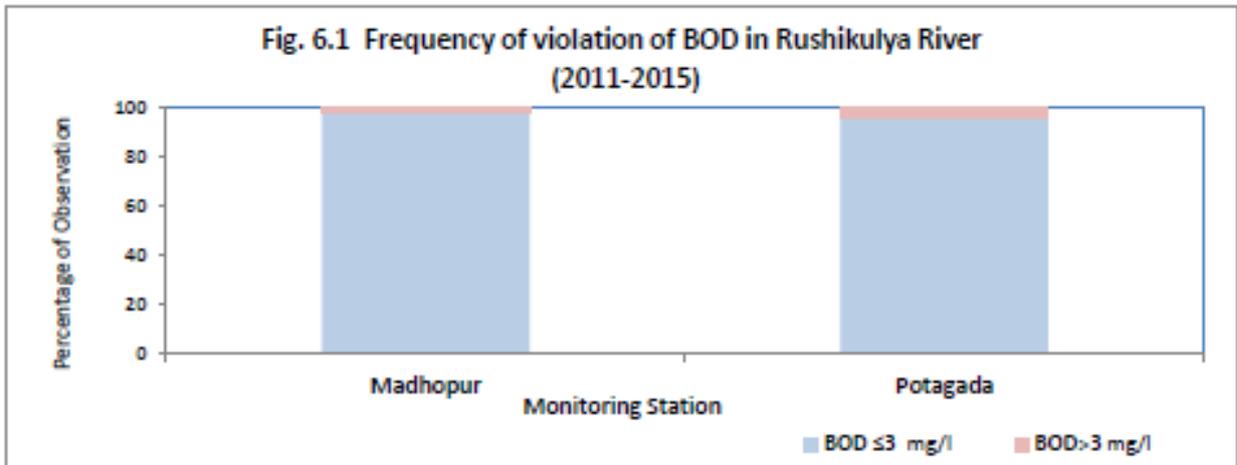
#### **6.6 POLLUTED RIVER MONITORING STATIONS IN RUSHIKULYA RIVER**

Comparison of BOD data obtained during the period 2011-2015 (Table 6.2) with the tolerance limits for Class-C revealed that both the stations can be identified as the polluted river monitoring stations under Priority-V category. As the polluted monitoring locations in a continuous sequence are identified as the polluted river stretches, the stretch from Madhopur-Potagada (5 Km) may be identified as the polluted river monitoring stretch. The list of polluted river monitoring stations with annual BOD range and priority class is given in Table 6.17.

## 6.7 WATER QUALITY INDEX OF MONITORING STATIONS IN RUSHIKULYA RIVER

The Canadian Water Quality Indices (CWQI) of the two monitoring stations on Rushikulya river system are calculated for the period 2011-2015 (Table 6.18). For the CWQI evaluation, four critical variables such as pH, DO, BOD and TC are taken into consideration. Based on the CWQI values, the water quality of the monitoring stations are ranked into different categories as recommended in Table 2.10. As evident from the Table 6.18 for the CWQI ranks, water quality of Rushikulya river at Madhopur remained within Marginal - Good category during the study period. The instream activities are responsible for the occasional deviation of TC values beyond the tolerance limit which lowers the water quality at the monitoring station.

The CWQI score at Potagada calculated using pH, DO, BOD and TC as variables, varied from Fair to Excellent. However, as this station is very close to the mouth of the river, the major water quality determining parameters in such cases are EC, chloride, sulfate, calcium, magnesium, sodium and potassium. Therefore, recalculation of CWQI score considering EC, SAR (calculated from calcium, magnesium, sodium and potassium), chloride, sulfate, TDS and boron as the variables and comparing them with the respective tolerance limits for irrigation water quality, it has been observed that water quality at Potagada remained at Poor category (CWQI Score : 14.94-27.24). The water quality downgrading parameters are EC, SAR, chloride, sulfate, TDS and Boron which owes its origin from the tidal effect.



**Table 6.1 Seasonal average values of pH, DO, BOD and TC in Rushikulya river at Madhopur and Potagada**

Parameter	Year	Madhopur				Potagada			
		W	S	M	PM	W	S	M	PM
pH	2011	8.2	7.8	8.1	8.1	7.9	7.9	8.1	8.0
	2012	8.3	8.3	8.1	8.4	7.7	7.9	8.1	8.3
	2013	8.3	8.2	8.2	7.6	7.8	7.9	8.2	7.9
	2014	8.3	8.3	7.8	7.5	7.9	7.9	7.8	7.8
	2015	8.3	8.3	8.0	8.2	8.3	8.0	8.1	8.2
DO (mg/l)	2011	9.1	8.1	6.5	8.4	8.3	8.1	6.8	8.4
	2012	9.5	7.3	7.7	8.7	9.4	7.2	8.1	8.8
	2013	8.1	6.9	6.6	5.6	8.0	6.9	6.8	6.2
	2014	8.2	7.4	6.3	7.7	7.3	6.2	6.4	7.1
	2015	8.4	7.6	7.1	7.5	7.6	8.0	7.6	8.0
BOD (mg/l)	2011	2.6	2.6	1.9	1.8	2.9	2.0	1.8	1.9
	2012	2.0	1.5	1.5	1.2	2.2	2.1	2.0	1.1
	2013	1.3	2.6	1.4	2.6	2.1	1.6	1.9	2.0
	2014	1.4	1.7	1.6	1.0	1.9	1.7	1.4	1.1
	2015	1.5	1.4	1.9	0.8	1.4	1.9	2.1	0.8
TC ('00) (MPN/100 ml)	2011	16.50	23.83	107.33	31.50	2.45	4.70	10.07	12.70
	2012	47.67	27.33	53.00	25.00	5.83	2.80	24.10	19.50
	2013	79.33	21.83	139.67	1600.00	3.63	1.58	37.67	1600.00
	2014	22.00	24.38	53.33	86.50	2.30	1.92	49.57	126.00
	2015	20.63	29.50	146.67	74.50	18.52	1.33	17.97	9.35

**Table 6.2 Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit**

Monitoring Stations	Parameter	2011	2012	2013	2014	2015
Madhopur	BOD	2.3 (1.0-3.0)	1.4 (0.8-2.2)	2.0 (1.0 – 3.6)	1.5 (0.6 – 2.1)	1.5 (0.7-2.4)
	F*	0/12	0/12	1/10	0/11	0/12
	TC	4569 (130-24000)	4319 (330-9200)	22523 (790 – 160000)	4314 (170 – 9400)	7308 (490-17000)
	F*	1/12	6/12	5/10	5/11	6/12
Potagada	BOD	2.1 (1.0-3.3)	2.0 (1.0-2.8)	1.8 (0.9 -2.7)	1.5 (0.8 -2.2)	1.8 (0.8-2.8)
	F*	2/12	0/12	0/10	0/11	0/12
	TC	739 (120-2200)	1116 (68-3500)	17269 (130 – 160000)	4224 (68 – 16000)	1112 (2-5400)
	F*	0/12	0/12	2/10	5/11	1/12

\*F : Frequency of deviation (No of deviation/no. of observation)

Table 6.3 Annual average and Range values of Ammonical Nitrogen

Monitoring Stations	2011		
	Ammonical Nitrogen (mg/l)	Free Ammonia-N (mg/l)	(Ammonium+Ammonia)-Nitrogen (mg/l)
Madhopur	0.466 (0.112-1.230)	0.033 (0.004-0.098)	0.499 (0.116-1.328)
Potagada	0.490 (0.112-0.896)	0.028 (0.008-0.087)	0.518 (0.120-0.983)
<b>2012</b>			
	Ammonical Nitrogen (mg/l)	Free Ammonia-N (mg/l)	(Ammonium+Ammonia)-Nitrogen (mg/l)
Madhopur	0.274 (0.112-0.784)	0.029 (0.004-0.076)	0.303 (0.116-0.860)
Potagada	0.378 (0.112-1.456)	0.021 (BDL-0.058)	0.399 (0.112-1.514)
<b>2013</b>			
	Ammonical Nitrogen (mg/l)	Free Ammonia-N (mg/l)	(Ammonium+Ammonia)-Nitrogen (mg/l)
Madhopur	0.252 (0.112-0.504)	0.019 (0.005-0.038)	0.271 (0.117-0.542)
Potagada	0.252 (0.168-0.504)	0.014 (0.004-0.014)	0.266 (0.172-0.518)
<b>2014</b>			
	Ammonical Nitrogen (mg/l)	Free Ammonia-N (mg/l)	(Ammonium+Ammonia)-Nitrogen (mg/l)
Madhopur	0.132 (0.056-0.224)	0.009 (0-0.021)	0.141 (0.056-0.235)
Potagada	0.127 (0.056-0.168)	0.005 (0.003-0.009)	0.132 (0.059-0.177)
<b>2015</b>			
	Ammonical Nitrogen (mg/l)	Free Ammonia-N (mg/l)	(Ammonium+Ammonia)-Nitrogen (mg/l)
Madhopur	0.061 (0.056-0.112)	0.006 (0.001-0.014)	0.067 (0.057-0.126)
Potagada	0.075 (0.056-0.280)	0.005 (0.002-0.018)	0.080 (0.058-0.298)

Table 6.4 Seasonal average values of Electrical Conductivity (microSiemens/cm)

Monitoring station	Year	W	S	M	PM
Madhopur	2011	323	312	307	233
	2012	322	404	227	255
	2013	291	9538	212	223
	2014	347	310	233	324
	2015	320	358	224	334
Potagada	2011	14115	16365	5046	16654
	2012	23727	29779	9376	1428
	2013	37949	48760	684	241
	2014	36410	44528	15731	3945
	2015	23330	38973	667	5983

Table 6.5 Annual average and Range values of SAR and Boron

Monitoring Stations	SAR				
	2011	2012	2013	2014	2015
Madhopur	0.67 (0.45-1.29)	0.74 (0.28-2.67)	10.12 (0.23-65.45)	0.65 (0.42-1.27)	0.85 (0.41-2.47)
Potagada	23.15 (0.95-45.32)	26.86 (0.35-66.79)	39.59 (0.87-74.16)	46.05 (1.48-94.45)	47.2 (0.46-104.47)
	B(mg/l)				
Madhopur	0.120 (0.026-0.367)	0.116 (0.026-0.447)	0.309 (0.041-1.809)	0.093 (0.006-0.397)	0.059 (0.010-0.204)
Potagada	0.737 (0.064-1.824)	1.065 (0.125-2.831)	1.880 (0.071-3.513)	1.297 (0.016-3.186)	1.845 (0.010-4.339)

Table 6.6 Annual average and Range values of Total Dissolved Solids (TDS) and Total Hardness (TH)

Monitoring Stations	TDS (mg/l)				
	2011	2012	2013	2014	2015
Madhopur	171 (136-247)	186 (123-418)	2718 (76-13874)	168 (115-216)	180 (115-280)
Potagada	8979 (161-19204)	14380 (188-38831)	21341 (151-44815)	20764 (230-42856)	18054 (157-32960)
	TH (as CaCO <sub>3</sub> ) (mg/l)				
Madhopur	95 (72-132)	103 (74-140)	375 (32-2000)	102 (48-134)	114 (76-150)
Potagada	2082 (88-3800)	2928 (660-6600)	3388 (68-6800)	2756 (112-5050)	2660 (110-6000)

Table 6.7 Annual average and Range values of Nitrate (as NO<sub>3</sub>) (mg/l)

Monitoring station	2011	2012	2013	2014	2015
	NO <sub>3</sub> (mg/l)				
Madhopur	1.953 (0.062-9.672)	3.16 (0.20-12.54)	4.933 (0.401-13.494)	3.087 (0.638-9.938)	5.006 (0.204-13.423)
Potagada	2.555 (0.549-4.849)	4.03 (2.17-10.47)	6.698 (1.320-17.261)	4.288 (0.325-8.043)	6.329 (0.391-26.128)

Table 6.8 Annual average and Range values Chloride, Sulphate and Fluoride

Monitoring Stations	Chloride (mg/l)				
	2011	2012	2013	2014	2015
Madhopur	24.3 (15.0-42.1)	30.2 (10.3-118.4)	1457.3 (7.7-7690.0)	19.6 (10.8-38.2)	25.84 (9.78-76.32)
Potagada	4815 (32.7-10500)	7211.7 (17.3-19887)	11550.9 (24.5-23384)	11178 (45-23875)	10033.7 (13.7-19080.8)
	Sulphate (mg/l)				
Madhopur	4.64 (1.18-9.79)	13.9 (3.5-29.0)	89.6 (1.1-521.6)	9.7 (4.7-16.3)	12.1 (4.2-24.3)
Potagada	518 (7.5-1134.4)	1235.0 (34.6-2435.6)	1129.9 (11.8-3016.1)	1203 (19.4-2711)	768.6 (21.8-1660.4)
	Fluoride (mg/l)				
Madhopur	0.383 (0.088-0.837)	0.370 (0.287-0.502)	0.333 (0.128-0.499)	0.271 (0.033-0.426)	0.483 (0.217-0.900)
Potagada	0.509 (0.217-1.000)	0.719 (0.302-0.988)	0.556 (0.172-0.922)	0.604 (0.198-1.010)	0.634 (0.320-0.990)

Table 6.9 Annual average and Range values of Metals

Parameter	Madhopur				
	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Chromium (VI)	-	-	-	0.016 (<0.002-0.045)	0.013 (<0.002-0.033)
Chromium (Total)	0.040 (0.007-0.084)	0.031 (0.012-0.053)	0.025 (0.005-0.048)	0.048 (0.018-0.082)	0.042 (0.015-0.087)
Iron	3.117 (0.182-14.266)	3.01 (0.51-12.37)	3.394 (0.387-12.625)	2.310 (0.127-7.956)	2.292 (0.070-6.810)
Nickel	0.003 (0.001-0.008)	0.006 (0.004-0.012)	0.002	0.007 (0.007-0.007)	0.011 (0.004-0.017)
Copper	0.004 (0.001-0.009)	0.002 (0.001-0.004)	0.004	0.019 (0.016-0.021)	0.005 (0.001-0.013)
Zinc	0.007 (<0.001-0.018)	0.012 (0.002-0.032)	0.006	0.013 (0.012-0.014)	0.009 (0.001-0.025)
Cadmium	0.002 (<0.001-0.004)	0.002 (0.001-0.003)	0.001	0.0030 (0.0020-0.0039)	0.0034 (0.0004-0.0080)
Mercury	-	-	-	0.00020 (<0.00006-0.00076)	0.00032 (0.00006-0.00089)
Lead	0.005 (0.001-0.009)	0.006 (0.004-0.008)	0.007	0.008 (0.007-0.008)	0.011 (0.005-0.017)
	<b>Potagada</b>				
Parameter	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Chromium (VI)	-	-	-	0.012 (<0.002-0.030)	0.009 (<0.002-0.023)
Chromium (Total)	0.058 (0.005-0.187)	0.038 (0.017-0.089)	0.028 (0.005-0.070)	0.057 (0.008-0.145)	0.042 (0.011-0.094)
Iron	3.777 (0.480-16.608)	2.85 (0.44-10.84)	2.337 (0.216-6.339)	1.569 (0.117-6.400)	2.654 (0.110-7.140)
Nickel	0.005 (0.001-0.010)	0.007 (0.002-0.010)	0.004	0.015 (0.011-0.018)	0.027 (0.007-0.070)
Copper	0.006 (0.001-0.013)	0.005 (0.003-0.006)	0.004	0.005 (0.003-0.008)	0.014 (0.002-0.046)
Zinc	0.008 (0.001-0.017)	0.008 (0.006-0.010)	0.007	0.026 (0.024-0.028)	0.021 (0.006-0.085)
Cadmium	0.003 (0.001-0.007)	0.001 (0.001-0.002)	0.001	0.001 (0.0008-0.0012)	0.0089 (0.0004-0.0436)
Mercury	-	-	-	0.00020 (<0.00006-0.00051)	0.00028 (<0.00006-0.00070)
Lead	0.007 (0.003-0.010)	0.006 (0.005-0.009)	0.009	0.004 (0.001-0.006)	0.018 (0.006-0.052)

\* Data for the period February, 2013 for parameters like nickel, copper, zinc, cadmium and lead

# Data for the period February and March, 2014 for parameters like nickel, copper, zinc, cadmium and lead

## Data for the period April-December, 2015 for parameters like nickel, copper, zinc, cadmium and lead

**Table 6.10 Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class**

Monitoring Stations	SI-Range				
	2011	2012	2013	2014	2015
Potagada	6.0 (5.6-6.8)	6.3 (6.0-6.5)	6.13 (5.50-6.75)	6.17 (6.10-6.20)	6.26 (6.2-6.3)
	DI-Range				
Potagada	0.5 (0.4-0.6)	0.65 (0.44-0.85)	0.55 (0.52-0.57)	0.69 (0.43-0.87)	0.52 (0.50-0.54)
	Biological Class				
Potagada	B – C	B	B-C	B	B

**Table 6.11 Annual average and Range values of (Nitrite+Nitrate)-Nitrogen**

Monitoring Stations	(Nitrite + Nitrate)- Nitrogen (mg/l)				
	2011	2012	2013	2014	2015
Madhopur	0.441 (0.014-2.184)	0.713 (0.045-2.832)	1.114 (0.090-3.047)	0.635 (0.141-2.046)	1.147 (0.046-3.031)
Potagada	0.577 (0.124-1.095)	0.910 (0.490-2.364)	1.512 (0.298-3.898)	0.883 (0.067-1.656)	1.437 (0.086-5.900)

**Table 6.12 Annual average and Range values of Total Suspended Solids (TSS)**

Monitoring Stations		TSS (mg/l)				
		2011	2012	2013	2014	2015
Madhopur	IM	87 (12-188)	114 (32-356)	186 (34-596)	63 (8-180)	35 (8-88)
	NM	67 (12-147)	69 (32-113)	186 (34-596)	34 (8-86)	20 (8-82)
Potagada	IM	127 (33-340)	194 (47-456)	294 (50-1044)	127 (8-356)	47 (10-128)
	NM	94 (33-167)	188 (47-456)	353 (50-1044)	126 (8-356)	36 (10-128)

Note : IM : Including Monsoon period

NM : Non-monsoon period (i.e. excluding the months July, August and September)

**Table 6.13 Percentage violation and Range of Fecal coliform values**

Monitoring Stations	Percentage Violation from 2000 MPN/100 ml (Range of FC values in '000 MPN/100 ml)				
	2011	2012	2013	2014	2015
Madhopur	25 (0.078-13.000)	42 (0.230-2.800)	45 (0.490-160.000)	18 (0.045-5.400)	42 (0.130-16.000)
Potagada	0 (0.070-1.100)	17 (0.020-2.400)	27 (0.045-92.000)	36 (0.020-5.400)	17 (Absent-2.400)

**Table 6.14 Annual average and Range values of Total Phosphate-P**

Monitoring Stations	Total Phosphate-P (mg/l)				
	2011	2012	2013	2014	2015
Madhopur	0.094 (0.010-0.416)	0.051 (0.003-0.122)	0.057 (0.005-0.155)	0.066 (0.004-0.235)	0.104 (0.007-0.370)
Potagada	0.059 (0.005-0.357)	0.081 (0.003-0.224)	0.052 (0.016-0.129)	0.163 (0.001-0.873)	0.105 (0.032-0.344)

**Table 6.15 Annual average and Range values of Total Kjeldahl Nitrogen(TKN)**

	Total Kjeldahl Nitrogen (TKN) (mg/l)				
	2011	2012	2013	2014	2015
Madhopur	5.5 (1.7-25.2)	3.78 (1.68-7.28)	3.17 (2.52-4.20)	1.22 (0.28-1.68)	1.14 (0.84-1.40)
Potagada	3.6 (1.1-5.6)	3.87 (1.12-8.12)	2.78 (1.96-3.40)	1.27 (0.56-1.68)	1.19 (0.84-1.40)

**Table 6.16 Chemical Oxygen Demand (COD) and Total Alkalinity**

Monitoring Stations	COD (mg/l)				
	2011	2012	2013	2014	2015
Madhopur	19.7 (8.1-29.9)	13.2 (4.7-20.6)	19.0 (7.8-34.9)	13.5 (6.5-30.6)	10.8 (5.7-14.8)
Potagada	22 (12-34)	20.1 (9.3-29.4)	26.7 (14.5-46.1)	25.9 (8.6-63.3)	22.1 (10.4-34.5)
Total Alkalinity (as CaCO <sub>3</sub> ) (mg/l)					
	2011	2012	2013	2014	2015
Madhopur	111 (78-152)	108 (62-138)	101 (32-128)	114 (68-152)	116 (80-152)
Potagada	119 (88-156)	112 (76-124)	110 (80-124)	108 (92-132)	129 (96-172)

**Table 6.17 Polluted river monitoring stations in Rushikulya river**

Sl. No.	River	Monitoring station	Annual BOD Data range (mg/l)					Range value of BOD above 3.0 mg/l in the stretch	Priority as per CPCB Criteria
			2011	2012	2013	2014	2015		
1	Rushikulya	Madhopur	(1.0-3.0)	(0.8-2.2)	(1.0-3.6)	(0.6-2.1)	(0.7-2.4)	3.3-3.6	V
2		Potagarh	(1.0-3.3)	(1.0-2.8)	(0.9-2.7)	(0.8-2.2)	(0.8-2.8)		

**Table 6.18 CWQI of Rushikulya river and category of water quality based on CWQI values**

Monitoring station	2011	2012	2013	2014	2015
	<b>CWQI</b>				
Madhopur	84.75	83.69	58.90	83.75	81.72
Potagad	85.37	100	70.78	83.42	85.52
	<b>Category</b>				
Madhopur	Good	Good	Marginal	Good	Good
Potagad	Good	Excellent	Fair	Good	Good

**CHAPTER - VII**

**WATER QUALITY STATUS OF NAGAVALI RIVER**

Water quality of the interstate river Nagavali is monitored at three locations- Penta U/s, Jaykaypur D/s and Rayagada D/s. The primary objective of choosing these stations is to assess the impact of a large pulp and paper mill (M/s J.K. paper Mills Limited) at Jaykaypur and the impact of the Rayagada town at the further downstream.

**7.1 USE BASED WATER QUALITY STATUS**

**7.1.1 Water quality in respect of primary criteria**

Seasonal average values of pH, DO, BOD and TC at three monitoring stations pertaining to the period 2011-2015 are described in Table 7.1.

**pH and DO :** As may be seen from the data, the pH and DO values show more or less a stable pattern throughout the river stretch. The seasonal average value of pH varies within the range 7.8-8.3. The water at all the monitoring station is fairly saturated with oxygen. Both the parameters conform to the quality criteria for Class-A.

**BOD :** The seasonal average values of BOD at Penta U/s conform to Class-A except on one occasion (winter, 2013). At Jaykaypur D/s, the seasonal average values of BOD do not conform to Class-C at 20% of time of total observations. At Rayagada D/s, BOD average values conformed to Class-C.

**TC :** Total coliform count at none of the stations generally conform to Class-A or Class-B water. The magnitudes and frequency of violations of TC from the stipulated value (less than 5000 MPN/100 ml) at these three stations do not warrant the water quality to be classified as Class-C. Wide fluctuations in the TC values have been observed during the study period.

The annual average and the range of BOD and TC values at three monitoring stations are given in Table 7.2. Frequency of violation of BOD and TC values from the stipulated values (3.0 mg/l and 5000 MPN/100 ml respectively) are also given in Table 7.2. The monthly BOD values at Penta U/s mostly remained within the tolerance limit for Class-A with occasional deviations. Whereas at Jaykaypur D/s and Rayagada D/s, monthly BOD values generally conform to Class-C.

Percent violations of BOD during the study period at three monitoring stations are presented in Fig. 7.1. Frequency of deviation of monthly BOD values from the stipulated value for Class C at Jaykaypur D/s was 24% of total observation during the period 2011-2015 and at Rayagada D/s, it is only 3% of total observation during the the entire period of study.

**Free Ammonia :** The annual average and range values of ammonical nitrogen and free ammonia are given in Table 7.3. Free ammonia values at all stations conform to the stipulated value (1.2 mg/l, max) for Class-D inland surface water (Fish culture and wildlife propagation). No regular pattern is observed regarding the level of ammonia in the river.

**EC, SAR and B :** Seasonal average values of EC at these three monitoring stations are given in Table 7.4. Seasonal averages of EC at Penta U/s remained within 146-272 microSiemens/ cm, at Jaykaypur D/s within 158-360 microSiemens/ cm and Rayagada D/s within 148-384 microSiemens/ cm. Annual average and range value of SAR values ranged within 0.18-0.99 in the river stretch from Penta U/s to Rayagada D/s during the study period. SAR and B values at these monitoring stations are given in Table 7.5. From the data, it can be seen that the EC, SAR and B values are far too low compared to the stipulated values in Table 2.4, to cause any concern to consider the suitability of the entire stretch of river water to be used for irrigation.

### **7.1.2 Water Quality in respect of Other Parameters**

**TDS and Total Hardness :** Annual average and range values of total dissolved solids (TDS) and total hardness (TH) during the period 2011- 2015 are given in Table 7.6. The entire river stretch conforms to Class-A inland surface water quality with regard to TDS and total hardness content. In terms of degree of hardness, the river water in general may be described as moderately hard (61-120 mg/l) - hard (121-180 mg/l).

**Nitrates :** Annual average and range values of nitrate during the period 2011- 2015 are given in Table 7.7. The annual average nitrate concentrations have never exceeded the stipulated value (20 mg/l) for Class-A water, though occasional deviation of monthly nitrate values from the stipulated value for Class- A has been observed at Jaykaypur D/s. However, the monthly nitrate concentration never exceeded the stipulated limit of 50 mg/l for Class-C.

**Chloride, Sulphates and Fluorides :** Annual average and range values of chlorides, sulphates and fluorides during the period 2011-2015 are given in Table 7.8. A comparison of these values with the stipulated limits for Class-A revealed that, water quality in respect of chlorides, sulphates and fluorides at all stations conform to the highest class.

**Heavy Metals:** Data given in Table 7.9 represent the annual average and range of concentration of chromium (VI) and mercury during the period 2014 and 2015 and annual average and range of concentrations of total chromium, iron, nickel, copper, zinc, cadmium and lead during the period 2011-2015. From the tables it is observed that the values of these metals are well within the respective tolerance limits.

### 7.1.3 Use based classification

From the discussions in the sec. 7.1.1 and 7.1.2, it may be reasonable to conclude that the water quality at all the three stations do not conform to Class-C. TC is the major violating parameter at Penta U/s, whereas both BOD and TC are the violating parameters at Jaykaypur D/s and Rayagada D/s.

## 7.2 BIOLOGICAL ASSESSMENT OF WATER QUALITY

The annual average and range of biomonitoring results expressed in terms of Saprobic index (SI) and Diversity index (DI) and biological class of the three monitoring stations during the period 2011-2015 are given in Table 7.10. Taking into consideration the observed biological indices and the BOD values (Tables 7.2), the river stretch along these monitoring stations are in a state of slight pollution to moderate pollution (that is, B-C) during the study period excepting on occasion at Rayagada D/s when the biological Class was heavy pollution (D) category (during April, 2013).

## 7.3 WATER QUALITY IN TERMS OF WHOLESOMENESS

### 7.3.1 Wholesomeness in terms of regular parameters

The wholesomeness of water quality at the three monitoring stations have been assessed with respect to general parameters specified in Table 2.7. Of the eight parameters listed in Table 2.7, results for bioassay are not available and therefore, the water quality are assessed with regard to the remaining seven parameters. Annual average and range values of (Nitrite + Nitrate)- N at the monitoring stations are given in Table 7.11. Annual average and range values of total suspended solids (TSS) including monsoon period and excluding monsoon period are given in Table 7.12

Considering pH, DO, EC values, the level of wholesomeness of the river water may be considered as “excellent”. With regard to BOD, the water level is “desirable” at all stations except at Jaykaypur D/s and Rayagada D/s on few occasions. The level of wholesomeness at these two stations is “acceptable”. Water quality with regard to the parameter (Nitrite + Nitrate)- N was excellent at Rayagada D/s during the period of study. Water quality with respect to (Nitrite + Nitrate)- N did not conform the excellent level for 2 % of total observations at Jaykaypur D/s and for 4 % of total observations at Rayagada D/s, wherein the water quality conformed to “desirable” level.

Water quality with regard to the TSS (during non-monsoon period) at all the three stations is in “acceptable” level during most period under study.

However, the situation changes entirely on introduction of FC values in the above assessment. Investigation on the data given in Table 7.13 (percent violation of FC values from 2000 MPN/100 ml) shows that the water quality in the entire stretch was not even “acceptable” during most part of the period under report.

### 7.3.2 Wholesomeness in terms of special parameters

Annual average and range values of total ammonical nitrogen ((ammonium+ammonia)-N) at all the monitoring stations are given in Table 7.3 which reveals that at most of the stations water quality with respect to total ammonical nitrogen are within acceptable limits during the period under study.

From the annual average and range values of total phosphate-P given in Table 7.14, it is observed that the water quality at the monitoring stations are not within the acceptable limits for most of the time under the period of study.

Annual average and range values of TKN values during 2011-2015 are given in Table 7.15. It has been observed that annual average values of TKN at the three stations do not meet the “acceptable” limit of 3.0 mg/l during most time of 2011, 2012 and 2013. However, during 2014 and 2015, TKN values remained within the “desirable” limit. .

It is seen from Table 7.9 that the annual average as well as monthly data on concentrations of metals like total chromium, zinc, copper, nickel, lead, cadmium and mercury in the river water at all station are within the “acceptable” limits.

## 7.4 WATER QUALITY IN TERMS OF COD AND ALKALINITY

Annual average and range values of COD and alkalinity values are given in Table 7.16. COD at Jaykaypur D/s is comparatively higher than that at Penta U/s possibly due to the industrial activity at Jaykaypur. Both the parameters are within acceptable limit (except for COD on some occasions) for most of the beneficial uses of water.

## 7.5 WATER QUALITY TREND

Keeping in view the lean flow in the Nagavali river during most part of the year, instream use by the riparian population along the bank, the State Pollution Control Board, Odisha has instructed M/s J.K. Paper Mill to discharge the treated effluent after meeting the prescribed standards to the river only in the night time. With this arrangement, the river water quality remains more or less acceptable (except for occasional higher BOD values and coliform count) for most beneficial uses. To further improve the situation and to completely stop discharge of the paper mill effluent to the river, steps are being taken by the Industry to divert the effluent water for irrigation. There is a general improvement in the water quality at Rayagada D/s with respect to BOD. However, TC is still the major pollutant at all the three stretches which may also be ascribed to the instream uses of the river water.

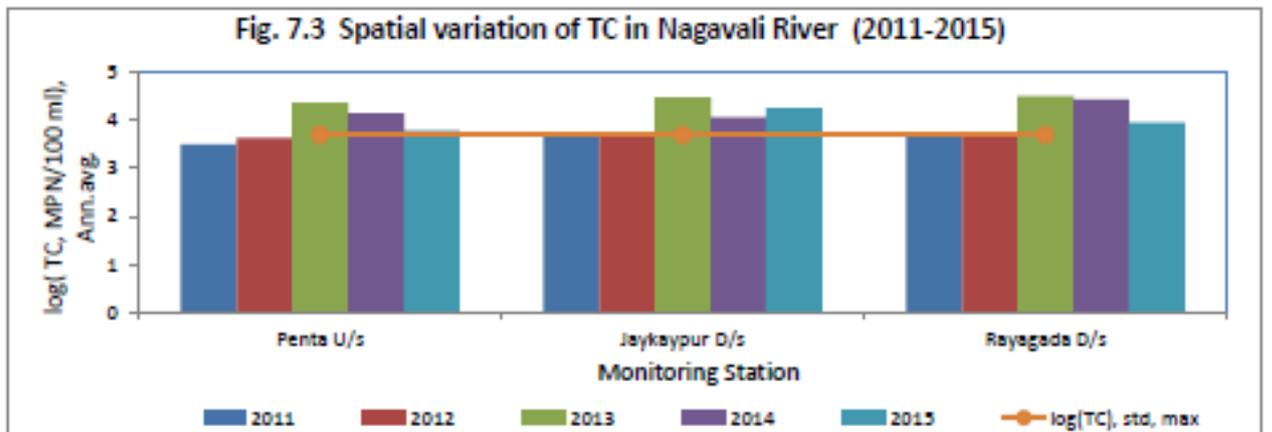
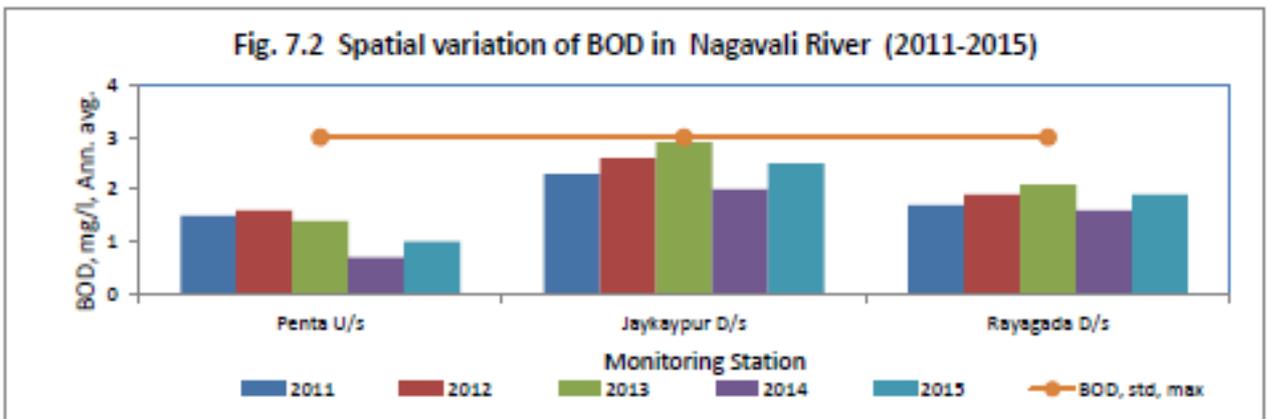
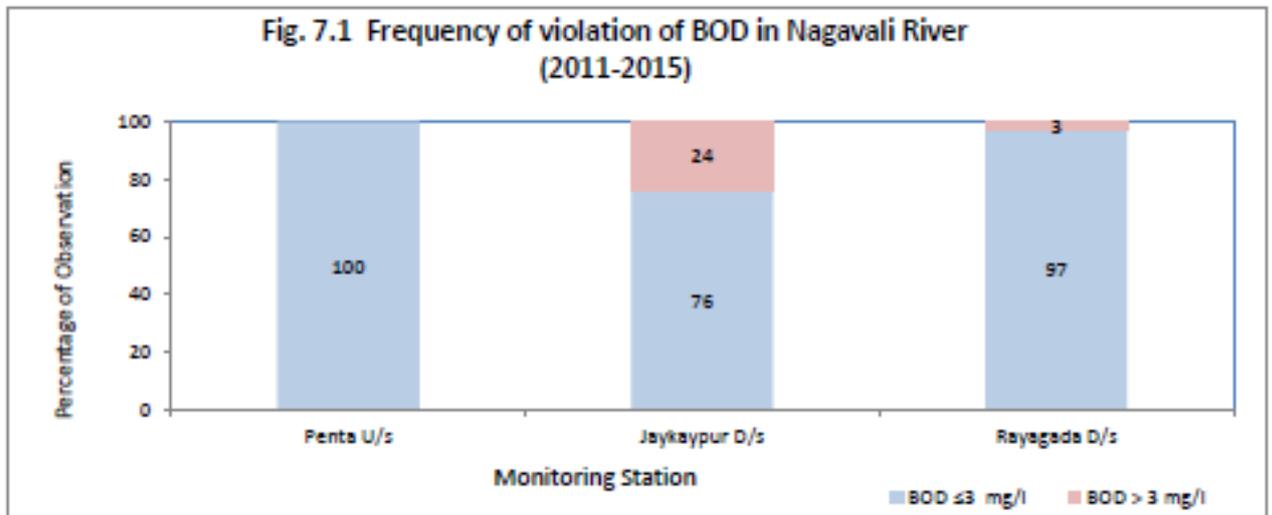
Spatial variation of BOD and TC values in the river during the period under study are depicted in Fig. 7.2 and 7.3 respectively.

## 7.6 POLLUTED RIVER MONITORING STATIONS IN NAGAVALI RIVER

The monitoring stations of Nagavali river not meeting the tolerance limit of 3.0 mg/l for the criteria parameter BOD of Class-C are identified as polluted river monitoring stations and have been categorized into different priority classes as proposed by CPCB (Table 2.9). Comparison of BOD data obtained during the period 2011-2015 (Table 7.2) with the tolerance limits for Class C revealed that there are two polluted river monitoring stations. The polluted monitoring locations in a continuous sequence are identified as the polluted river stretches. The list of polluted river monitoring stations with annual BOD range and priority class is given in Table 7.17. The river stretch from Jaykaypur D/s to Rayagada D/s (11 km ) has been identified as the polluted river stretch under priority-V category.

## 7.7 WATER QUALITY INDEX OF MONITORING STATIONS IN NAGAVALI RIVER

The Canadian Water Quality Indices (CWQI) of three monitoring stations on Nagavali river are calculated for the period 2011-2015 (Table 7.18). For the CWQI evaluation, four critical variables such as pH, DO, BOD and TC are taken into consideration. Based on the CWQI values, the water quality of the monitoring stations are ranked into different categories as recommended in Table 2.10. As evident from the Table 7.18 for the CWQI ranks, water quality of Nagavali river at Penta U/s remained in Fair-Good category during the study period. Whereas, the water quality at the downstream of Jaykaypur and Rayagada are in Marginal-Fair category. Occasional deviation of TC values beyond the tolerance limit and BOD lowers the water quality at the downstream stations.



Water Quality of Major Rivers of Odisha

**Table 7.1 Seasonal average values of pH, DO, BOD and TC in Nagavali river at Penta U/s, Jaykaypur D/s and Rayagada D/s**

Parameter	Year	Penta U/s				Jaykaypur D/s				Rayagada D/s			
		W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	8.0	8.1	7.8	7.8	7.8	7.9	7.7	7.8	8.0	8.1	8.1	8.0
	2012	8.1	7.9	8.2	8.0	8.0	7.9	8.1	8.3	8.2	7.9	8.1	8.3
	2013	8.0	8.1	7.8	7.9	8.2	7.9	7.9	7.9	8.0	7.8	8.0	8.0
	2014	8.0	8.1	7.9	7.8	7.7	7.8	7.8	7.8	8.1	8.3	7.8	8.0
	2015	7.8	7.9	7.8	8.3	7.8	7.9	7.5	8.2	7.9	8.0	7.8	8.3
DO (mg/l)	2011	7.7	7.6	7.1	7.3	7.1	7.2	6.9	7.0	7.7	7.4	6.9	7.0
	2012	7.5	7.2	7.2	7.6	6.5	7.0	6.8	7.0	6.8	7.1	7.1	7.7
	2013	7.1	7.3	7.9	7.6	7.0	7.2	7.4	7.5	7.5	7.4	7.9	7.8
	2014	7.1	7.1	7.5	7.8	7.2	7.0	7.6	7.3	7.5	7.2	7.7	7.6
	2015	7.1	7.6	7.3	6.9	7.8	7.3	7.2	6.8	7.6	7.7	7.3	7.2
BOD (mg/l)	2011	1.3	1.3	1.9	1.8	3.1	1.9	2.7	2.3	2.1	1.3	2.1	1.3
	2012	1.4	1.7	1.9	1.3	2.3	2.4	3.1	2.1	1.8	2.2	1.8	1.7
	2013	2.1	1.4	1.1	1.3	3.2	3.6	2.6	1.8	2.3	2.3	2.1	1.6
	2014	0.8	0.6	1.0	0.5	2.2	2.5	1.6	2.0	1.6	1.3	1.8	1.3
	2015	1.1	1.1	0.7	1.2	2.7	3.0	2.3	1.9	2.2	2.3	1.5	2.1
TC ('00) (MPN/ 100 ml)	2011	18.00	21.50	70.33	14.50	29.50	36.75	110.00	73.38	24.50	36.25	111.00	19.50
	2012	27.00	62.48	46.63	22.00	48.33	76.00	46.00	26.00	31.33	59.08	61.00	18.50
	2013	27.00	24.75	724.33	374.54	18.00	47.75	830.00	335.00	35.33	35.50	956.67	200.00
	2014	2.30	33.75	389.67	89.50	3.30	111.50	163.33	137.42	7.90	36.98	706.67	355.00
	2015	29.63	78.75	99.33	35.00	96.67	82.00	436.67	66.50	70.67	75.00	169.33	51.50

**Table 7.2 Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit**

Parameter	2011	2012	2013	2014	2015
<b>Penta U/s</b>					
BOD	1.5 (0.7-2.2)	1.6 (1.1-2.6)	1.4 (0.3 – 2.3)	0.7 (0.5 – 1.2)	1.0 (0.6-1.6)
F*	0/12	0/12	0/11	0/11	0/12
TC	3185 (1100-9400)	4348 (790-11000)	23191 (1700 – 160000)	13948 (230 - 92000)	6316 (490-22000)
F*	2/12	3/12	4/11	5/11	5/12
<b>Jaykaypur D/s</b>					
BOD	2.3 (0.8-3.7)	2.6 (1.6-3.9)	2.9 (1.2 – 4.9)	2.0 (1.1 – 3.0)	2.5 (1.8-3.3)
F*	2/12	4/12	5/11	0/11	3/12
TC	5442 (1700-13000)	5142 (1300-11000)	30836 (1700 – 160000)	11657 (330 – 24000)	18308 (2200-92000)
F*	6/12	5/12	6/11	7/11	7/12
<b>Rayagada D/s</b>					
BOD	1.7 (0.8-2.7)	1.9 (1.4-3.4)	2.1 (1.3 – 2.9)	1.6 (0.7 – 3.2)	1.9 (0.5-2.8)
F*	0/12	1/12	0/11	1/11	0/12
TC	4950 (1200-15000)	4586 (230-13000)	31727 (1300 – 160000)	27635 (790 – 160000)	9200 (1300-35000)
F*	3/12	4/12	7/11	7/11	7/12

F\* : Frequency of deviation (No. of deviation/ No. of Observation)

**Table 7.3 Values of Ammonical Nitrogen (mg/l)**

Monitoring Stations	2011		
	Ammonical Nitrogen	Free ammonia-N	(Ammonium+Ammonia)-N
Penta U/s	0.374 (0.056-0.784)	0.023 (0.001-0.060)	0.397 (0.057-0.844)
Jaykaypur D/s	0.536 (0.056-1.060)	0.020 (0.002-0.060)	0.556 (0.058-1.120)
Rayagada D/s	0.513 (0.056-1.170)	0.033 (0.003-0.094)	0.546 (0.059-1.264)
	2012		
	Ammonical Nitrogen	Free ammonia-N	(Ammonium+Ammonia)-N
Penta U/s	0.257 (0.112-0.900)	0.021 (0.004-0.113)	0.278 (0.116-1.013)
Jaykaypur D/s	0.313 (0.112-0.730)	0.026 (0.006-0.071)	0.339 (0.118-0.801)
Rayagada D/s	0.258 (0.056-0.560)	0.021 (0.004-0.064)	0.279 (0.060-0.624)

Table 7.3 Contd..

Monitoring Stations	2013		
	Ammonical Nitrogen	Free ammonia-N	(Ammonium+Ammonia)-N
Penta U/s	0.229 (<0.056-0.112)	0.012 (0-0.033)	0.241 (BDL-0.145)
Jaykaypur D/s	0.372 (0.224-0.560)	0.016 (0-0.032)	0.388 (0.224-0.592)
Rayagada D/s	0.267 (0.168-0.440)	0.012 (0-0.029)	0.279 (0.168-0.469)
Monitoring Stations	2014		
	Ammonical Nitrogen	Free ammonia-N	(Ammonium+Ammonia)-N
Penta U/s	0.122 (0.112-0.224)	0.006 (0.002-0.011)	0.128 (0.114-0.235)
Jaykaypur D/s	0.107 (0.056-0.168)	0.005 (0.001-0.021)	0.112 (0.057-0.189)
Rayagada D/s	0.127 (0.056-0.224)	0.009 (0.002-0.021)	0.136 (0.058-0.245)
	2015		
	Ammonical Nitrogen	Free ammonia-N	(Ammonium+Ammonia)-N
Penta U/s	0.061 (0.056-0.112)	0.003 (0.001-0.011)	0.064 (0.057-0.123)
Jaykaypur D/s	0.056 (0.056-0.056)	0.002 (0.001-0.004)	0.058 (0.057-0.060)
Rayagada D/s	0.056 (0.056-0.056)	0.003 (0.001-0.007)	0.059 (0.057-0.063)

Table 7.4 Seasonal average values of Electrical Conductivity (microSiemens/ cm)

Year	Penta U/s			
	W	S	M	PM
2011	237	205	182	180
2012	269	250	177	208
2013	272	198	146	172
2014	202	202	160	236
2015	209	177	180	197
Jaykaypur D/s				
2011	304	360	195	277
2012	267	288	219	234
2013	305	254	158	218
2014	307	296	181	239
2015	240	264	185	267
Rayagada D/s				
2011	281	296	214	254
2012	384	255	214	219
2013	247	235	148	223
2014	327	272	196	243
2015	279	276	237	246

Table 7.5 Annual average and Range values of SAR and B

Monitoring station	2011	2012	2013	2014	2015
	<b>SAR</b>				
Penta U/s	0.43 (0.28-0.76)	0.54 (0.18-1.39)	0.31 (0.16-0.53)	0.37 (0.25-0.51)	0.34 (0.21-0.50)
Jaykaypur D/s	0.55 (0.36-0.77)	0.57 (0.32-0.94)	0.40 (0.20-0.65)	0.54 (0.31-0.97)	0.51 (0.33-0.77)
Rayagada D/s	0.47 (0.35-0.70)	0.49 (0.33-0.65)	0.36 (0.22-0.56)	0.48 (0.27-0.89)	0.60 (0.36-0.99)
	<b>B (mg/l)</b>				
Penta U/s	0.054 (0.011-0.140)	0.043 (0.015-0.083)	0.083 (0.011-0.226)	0.064 (0.022-0.134)	0.034 (0.006-0.109)
Jaykaypur D/s	0.040 (0.008-0.087)	0.040 (0.007-0.079)	0.075 (0.007-0.147)	0.070 (0.006-0.131)	0.049 (0.010-0.197)
Rayagada D/s	0.041 (0.007-0.110)	0.048 (0.004-0.091)	0.072 (0.003-0.207)	0.064 (0.003-0.118)	0.039 (0.003-0.102)

Table 7.6 Annual average and Range values of TDS and Total Hardness (TH)

Monitoring station	2011	2012	2013	2014	2015
	<b>TDS (mg/l)</b>				
Penta U/s	119 (99-138)	135 (98-112)	119 (77-173)	114 (78-135)	106 (80-120)
Jaykaypur D/s	165 (105-248)	156 (117-225)	137 (92-175)	148 (82-196)	140 (98-202)
Rayagada D/s	148 (110-206)	181 (100-616)	126 (86-172)	146 (104-186)	149 (122-172)
	<b>TH (as CaCO<sub>3</sub>) (mg/l)</b>				
Penta U/s	75 (54-92)	79 (26-112)	78 (52-112)	74 (44-96)	76 (54-98)
Jaykaypur D/s	101 (68-152)	98 (78-134)	87 (56-120)	87 (42-116)	92 (70-136)
Rayagada D/s	93 (60-120)	99 (54-168)	76 (52-94)	91 (66-108)	100 (72-124)

Table 7.7 Annual average and Range values of Nitrate (as NO<sub>3</sub>)

Monitoring station	2011	2012	2013	2014	2015
	<b>NO<sub>3</sub> (mg/l)</b>				
Penta U/s	3.844 (0.164-30.309)	2.94 (0.26-6.53)	4.288 (1.333-8.083)	2.790 (0.706-7.502)	5.062 (0.771-15.093)
Jaykaypur D/s	7.675 (0.921-33.338)	4.90 (0.36-16.75)	4.525 (0.385-15.717)	4.664 (1.521-9.393)	8.905 (0.793-36.040)
Rayagada D/s	2.670 (0.159-10.797)	6.34 (0.36-15.72)	4.889 (0.397-10.478)	3.943 (1.692-5.992)	5.058 (1.621-17.018)

Table 7.8 Annual average and Range values of Chloride, Sulphate and Fluoride

Monitoring Station	2011	2012	2013	2014	2015
<b>Chloride (mg/l)</b>					
Penta U/s	13.4 (9.6-18.0)	17.9 (6.1-26.7)	11.2 (5.5-22.6)	9.2 (6.9-11.7)	8.72 (5.87-11.74)
Jaykaypur D/s	19.4 (12.5-33.0)	21.5 (12.7-35.7)	14.9 (5.8-26.7)	14.9 (7.8-27.4)	13.7 (8.80-20.55)
Rayagada D/s	16.2 (11.5-22.1)	18.9 (12.5-25.9)	11.5 (5.8-21.6)	13.5 (7.8-22.5)	16.80 (9.78-24.50)
<b>Sulphate (mg/l)</b>					
Penta U/s	5.07 (0.65-12.69)	6.54 (1.08-16.73)	7.37 (2.50-14.40)	6.27 (0.74-10.60)	7.0 (3.3-12.9)
Jaykaypur D/s	10.98 (2.47-22.47)	10.60 (4.55-21.78)	11.71 (2.36-32.98)	13.76 (4.47-27.74)	15.7 (8.2-26.4)
Rayagada D/s	7.8 (2.7-18.7)	9.33 (1.28-18.91)	9.30 (2.26-22.69)	12.76 (5.26-20.40)	18.8 (8.6-27.4)
<b>Fluoride (mg/l)</b>					
Penta U/s	0.235 (0.122-0.311)	0.251 (0.198-0.343)	0.224 (0.176-0.284)	0.225 (0.147-0.361)	0.307 (0.164-0.490)
Jaykaypur D/s	0.250 (0.196-0.322)	0.210 (0.200-0.228)	0.221 (0.162-0.311)	0.243 (0.159-0.356)	0.294 (0.170-0.414)
Rayagada D/s	0.264 (0.088-0.565)	0.201 (0.176-0.224)	0.221 (0.135-0.285)	0.240 (0.172-0.347)	0.299 (0.175-0.420)

Table 7.9 Annual average and Range values of Metals

Parameter	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
<b>Penta U/s</b>					
Chromium (VI)	-	-	-	0.015 (<0.002-0.043)	0.012 (<0.002-0.033)
Chromium (Total)	0.035 (0.012 -0.104)	0.018 (0.005-0.034)	0.026 (0.008-0.050)	0.059 (0.012-0.123)	0.037 (0.008-0.077)
Iron	7.482 (0.696-20.750)	4.379 (0.782-10.157)	5.407 (0.800-12.757)	3.489 (0.010-8.874)	2.780 (0.460-6.500)
Nickel	0.004 (0.001-0.009)	0.006 (0.004-0.007)	0.001	0.011 (0.011-0.012)	0.013 (0.007-0.026)
Copper	0.005 (0.001-0.009)	0.003 (0.001-0.004)	0.002	0.008 (0.006-0.010)	0.005 (0.002-0.011)
Zinc	0.007 (0.002-0.012)	0.006 (0.004-0.008)	0.008	0.028 (0.024-0.032)	0.006 (0.003-0.012)
Cadmium	0.001 (<0.001-0.003)	0.002 (0.001-0.003)	0.001	0.0008 (0.0006-0.00010)	0.0018 (0.0004-0.0035)
Mercury	-	-	-	0.00008 (<0.00006-0.00032)	0.00010 (<0.00006-0.00076)
Lead	0.004 (<0.001-0.008)	0.005 (0.004-0.008)	0.007	0.007 (0.006-0.008)	0.008 (0.003-0.012)

\* Data for the period February, 2013 for parameters like nickel, copper, zinc, cadmium and lead

# Data for the period February and March, 2014 for parameters like nickel, copper, zinc, cadmium and lead

## Data for the period April-December, 2015 for parameters like nickel, copper, zinc, cadmium and lead

Table 7.9 Contd..

Parameter	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
<b>Jaykaypur D/s</b>					
Chromium (VI)	-	-	-	0.015 (<0.002-0.041)	0.015 (<0.002-0.033)
Chromium (Total)	57.6 (18.0-101.0)	0.024 (0.010-0.046)	0.027 (0.007-0.038)	0.055 (0.036-0.114)	0.130 (0.011-0.958)
Iron	6.851 (0.067-23.650)	4.424 (0.586-9.400)	4.360 (0.700-13.149)	3.351 (0.041-10.124)	3.793 (1.170-7.210)
Nickel	0.005 (0.001-0.012)	0.006 (0.003-0.008)	0.001	0.017 (0.015-0.018)	0.018 (0.009-0.030)
Copper	0.005 (0.002-0.010)	0.005 (0.001-0.008)	0.003	0.010 (0.009-0.012)	0.007 (0.002-0.012)
Zinc	0.007 (<0.001-0.012)	0.010 (0.003-0.019)	0.009	0.027 (0.026-0.028)	0.011 (0.002-0.024)
Cadmium	0.002 (<0.001-0.004)	0.002 (0.001-0.003)	0.006	0.0009 (0.0009-0.0009)	0.0028 (0.0010-0.0061)
Mercury	-	-	-	0.00013 (<0.00006-0.00038)	0.00030 (<0.00006-0.00089)
Lead	0.006 (0.001-0.009)	0.009 (0.008-0.010)	0.009	0.011 (0.010-0.012)	0.012 (0.006-0.022)
<b>Rayagada D/s</b>					
Parameter	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
Chromium (VI)	-	-	-	0.011 (<0.002-0.040)	0.018 (<0.002-0.036)
Chromium (Total)	0.053 (0.026-0.157)	0.02 (0.010-0.048)	0.028 (0.010-0.070)	0.080 (0.016-0.322)	0.058 (0.023-0.150)
Iron	5.264 (0.706-12.970)	8.424 (0.750-53.280)	5.805 (0.475-13.646)	4.148 (0.036-10.379)	4.598 (0.790-7.630)
Nickel	0.004 (<0.001-0.011)	0.004 (0.001-0.006)	0.001	0.015 (0.014-0.016)	0.019 (0.007-0.030)
Copper	0.003 (<0.001-0.008)	0.004 (0.002-0.005)	0.003	0.008 (0.008-0.009)	0.006 (0.002-0.010)
Zinc	0.006 (0.001-0.010)	0.009 (0.003-0.013)	0.009*	0.029 (0.014-0.042)	0.009 (0.003-0.019)
Cadmium	0.002 (<0.001-0.003)	0.002 (0.001-0.002)	0.006	0.0007 (0.0007-0.0008)	0.0022 (0.0009-0.0054)
Mercury	-	-	-	0.00013 (<0.00006-0.00032)	0.00020 (<0.00006-0.00064)
Lead	0.005 (0.002-0.010)	0.009 (0.008-0.010)	0.007	0.004 (0.001-0.008)	0.008 (0.006-0.014)

\* Data for the period February, 2013 for parameters like nickel, copper, zinc, cadmium and lead

# Data for the period February and March, 2014 for parameters like nickel, copper, zinc, cadmium and lead

## Data for the period April-December, 2015 for parameters like nickel, copper, zinc, cadmium and lead

**Table 7.10 Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class**

Monitoring station	SI				
	2011	2012	2013	2014	2015
Penta U/s	6.1 (5.1-7.0)	5.5 (4.5-6.3)	5.43 (4.40-6.10)	6.10 (5.50-6.80)	6.1 (5.8-6.3)
Jaykaypur D/s	5.5 (5.3-6.0)	5.8 (5.5-6.4)	5.27 (4.70-6.10)	5.69 (5.33-6.00)	5.05 (5.5-5.5)
Rayagada D/s	5.9 (5.6-6.1)	6.0 (5.3-6.8)	5.05 (4.00-6.16)	5.57 (5.50-5.60)	5.5 (5.3-5.8)
	DI				
	2011	2012	2013	2014	2015
Penta U/s	0.6 (0.5-0.8)	0.76 (0.74-0.78)	0.55 (0.48-0.67)	0.68 (0.50-0.83)	0.63 (0.53-0.72)
Jaykaypur D/s	0.6 (0.5-0.7)	0.68 (0.56-0.83)	0.73 (0.65-0.88)	0.84 (0.80-0.87)	0.52 (0.50-0.53)
Rayagada D/s	0.6 (0.3-0.8)	0.63 (0.58-0.72)	0.44 (0.32-0.56)	0.81 (0.75-0.90)	0.67 (0.61-0.70)
	Biological Class				
	Penta U/s	B – C	B – C	B-C	B-C
Jaykaypur D/s	C	B – C	B-C	C	C
Rayagada D/s	B – C	B – C	B-D	C	C

**Table 7.11 Annual average and Range values of (Nitrite+Nitrate)-Nitrogen**

Monitoring Station	(Nitrite + Nitrate)- Nitrogen, mg/l				
	2011	2012	2013	2014	2015
Penta U/s	0.877 (0.037-6.844)	0.664 (0.059-1.475)	0.968 (0.301-1.825)	0.630 (0.169- 1.694)	1.143 (0.174-3.408)
Jaykaypur D/s	1.733 (0.208-7.528)	1.106 (0.081- 3.782)	1.022 (0.087-3.549)	1.053 (0.343-2.121)	2.011 (0.179-8.138)
Rayagada D/s	0.603 (0.036-2.438)	1.432 (0.081-3.550)	1.104 (0.090-2.366)	0.890 (0.382-1.353)	1.142 (0.366-3.843)

**Table 7.12 Annual average and Range values of Total Suspended Solids (TSS)**

Monitoring Station		TSS, mg/l				
		2011	2012	2013	2014	2015
Penta U/s	IM	162 (12-778)	120 (37-330)	218 (28-1080)	76 (14-304)	39 (10-107)
	NM	137 (12-778)	74 (37-158)	99 (28-250)	29 (14-74)	23 (10- 48)
Jaykaypur D/s	IM	247 (24-1472)	123 (29-382)	507 (20-2324)	104 (20-349)	55 (19-116)
	NM	249 (24-1472)	76 (29-200)	199 (20-976)	37 (20-80)	40 (19-76)
Rayagada D/s	IM	175 (14-680)	118 (42-354)	329 (24-1624)	99 (12-357)	52 (15-116)
	NM	149 (14-680)	126 (42-126)	281 (24-1624)	39 (12-82)	35 (15-50)

Note : IM : Including Monsoon period

NM : Non-monsoon period (i.e. excluding the months July, August and September)

Table 7.13 Percentage violation and Annual range of Fecal coliform values

Monitoring Station	Percentage Violation from 2000 MPN/100 ml (Range of FC values in '000 MPN/100 ml)				
	2011	2012	2013	2014	2015
Penta U/s	25 (0.700-4.300)	58 (0.490-7.000)	25 (0.790-92.000)	42 (0.130-24.000)	42 (0.130-7.900)
Jaykaypur D/s	33 (0.780-7.900)	58 (0.460-7.900)	50 (0.790-35.000)	58 (0.110-160.000)	75 (0.700-54.000)
Rayagada D/s	33 (0.630-9.400)	25 (0.130-7.900)	50 (0.330-54.000)	58 (0.110-35.000)	67 (0.490-14.000)

Table 7.14 Annual average and Range values of Total Phosphate-P (mg/l)

Monitoring Station	2011	2012	2013	2014	2015
	Total Phosphate-P (mg/l)				
Penta U/s	0.220 (0.005-1.251)	0.061 (0.007-0.240)	0.136 (0.006-0.803)	0.064 (0.015-0.175)	0.086 (0.037-0.310)
Jaykaypur D/s	0.088 (0.005-0.241)	0.056 (0.011-0.032)	0.124 (0.005-0.553)	0.229 (0.009-1.475)	0.113 (0.037-0.553)
Rayagada D/s	0.208 (0.030-0.675)	0.100 (0.029-0.537)	0.114 (0.003-0.323)	0.185 (0.022-1.312)	0.074 (0.015-0.159)

Table 7.15 Annual average and Range values of Total Kjeldahl Nitrogen (TKN)

Monitoring Stations	2011	2012	2013	2014	2015
	TKN (mg/l)				
Penta U/s	2.66 (0.84-4.76)	2.21 (1.12-3.36)	2.48 (1.67-4.43)	1.04 (0.28-1.68)	1.12 (0.84-1.40)
Jaykaypur D/s	2.7 (0.6-10.6)	3.17 (0.84-7.84)	2.81 (1.68-3.92)	1.07 (0.56-1.96)	1.14 (0.84-1.40)
Rayagada D/s	3.5 (0.3-11.2)	3.25 (1.40-6.72)	2.84 (1.40-4.71)	1.09 (0.56-1.68)	1.05 (0.84-1.40)

Table 7.16 Annual average and Range values of Chemical Oxygen Demand (COD) and Total Alkalinity

Monitoring Stations	COD (mg/l)				
	2011	2012	2013	2014	2015
Penta U/s	11.4 (6.0-20.5)	10.8 (7.4-19.2)	11.7 (4.1-20.9)	8.2 (4.0-13.8)	9.4 (3.8-17.7)
Jaykaypur D/s	20.1 (9.3-30.5)	22.1 (13.8-30.9)	22.7 (6.9-36.6)	18.7 (8.0-29.5)	18.2 (11.9-27.6)
Rayagada D/s	14.9 (8.0-22.9)	15.8 (10.3-29.0)	17.1 (9.8-23.8)	15.1 (6.6-23.6)	15.3 (5.9-28.6)
Total Alkalinity (as CaCO <sub>3</sub> ) (mg/l)					
	2011	2012	2013	2014	2015
Penta U/s	80 (56-100)	83 (28-112)	82 (48-108)	82 (44-108)	77 (48-100)
Jaykaypur D/s	102 (66-166)	95 (64-132)	89 (60-125)	92 (48-118)	90 (64-142)
Rayagada D/s	99.7 (66-128)	89 (64-108)	86 (58-112)	93 (54-110)	95 (68-116)

**Table 7.17 Polluted river monitoring stations in Nagavali river**

Sl. No.	River	Monitoring station	Annual BOD Data range (mg/l)					Range value of BOD above 3.0 mg/l in the stretch	Priority as per CPCB Criteria
			2011	2012	2013	2014	2015		
1	Nagavali	Jaykaypur D/s	(0.8-3.7)	(1.6-3.9)	(1.2-4.9)	(1.1-3.0)	(1.8-3.3)	3.3-4.9	V
2		Rayagada D/s	(0.8-2.7)	(1.4-3.4)	(1.3-2.9)	(0.7-3.2)	(0.5-2.8)		

**Table 7.18 CWQI of Nagavali river during 2011-2015 and category of water quality based on CWQI values**

Monitoring station	2011	2012	2013	2014	2015
	<b>CWQI</b>				
Penta U/s	85.22	84.77	67.52	75.04	83.29
Jaykaypur D/s	69.23	68.92	53.64	76.43	59.67
Rayagada D/s	70.43	70.33	62.33	56.34	79.93
	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>
<b>Category</b>					
Penta U/s	Good	Good	Fair	Fair	Good
Jaykaypur D/s	Fair	Fair	Marginal	Fair	Marginal
Rayagada D/s	Fair	Fair	Fair	Marginal	Good

**CHAPTER - VIII**

**WATER QUALITY STATUS OF SUBARNAREKHA RIVER**

Water quality of Subarnarekha river is assessed at only one monitoring station, Rajghat, which is about 5 km downstream of Jaleswar town and 60 km upstream to the confluence of the Subarnarekha river with the sea.

**8.1 USE BASED WATER QUALITY STATUS**

**8.1.1 Water quality in respect of primary criteria**

Seasonal average values of pH, DO, BOD and TC at the monitoring station pertaining to the period 2011-2015 are given in Table 8.1.

**pH and DO** : pH varies within the range 7.6-8.3 and conforms to the tolerance limit of Class-A. The water at the monitoring station is fairly rich in oxygen and also conform to the quality criteria for Class-A with respect to DO.

**BOD** : The seasonal average values of BOD at the monitoring station varies within 0.6-2.0 mg/l. and thereby conform to Class-C during the entire study period.

**TC** : Total coliform count at Rajghat does not conform to Class-A or Class-B water. The magnitudes and frequency of violations of TC from the stipulated value (less than 5000 MPN/100 ml) at this station do not warrant the water quality to be classified as Class-C. Wide fluctuations in the TC values have been observed during the study period.

The annual average and the range of BOD and TC values at Rajghat are given in Table 8.2. Frequency of violation of BOD and TC values from the stipulated values (3.0 mg/l and 5000 MPN/100 ml respectively) are also given in Table 8.2. Monthly average BOD values at Rajghat always conformed to Class-C.

Percent violations of BOD at Rajghat during the study period are presented in Fig. 8.1 Variation of annual average values of BOD and TC during the period 2011-2015 at the monitoring station is presented in Fig. 8.2 and 8.3 respectively. Fig. 8.3 revealed that annual average of TC at Rajghat exceeded the tolerance limit during the study period except during 2015.

**Free Ammonia** : The annual average and range values of ammonical nitrogen and free ammonia are given in Table 8.3. Observance of free ammonia values in the range 0 - 0.073 mg/l during the study period indicates that water quality at Rajghat conform to Class-D (Fish culture and wildlife propagation). No regular pattern is observed regarding the level of ammonia in the river over the years.

**EC, SAR and B** : Seasonal average values of EC at Rajghat are given in Table 8.4. Annual average and range values of SAR and B are given in Table 8.5. From the data, it can be seen that

the EC, SAR and B values are far too low compared to the stipulated values in Table 2.4, to cause any concern to consider the suitability of the entire stretch of river water to be used for irrigation.

### 8.1.2 Water quality in respect of other parameters

**TDS and Total Hardness :** Annual average and range values of total dissolved solids (TDS) and total hardness (TH) during the period 2011- 2015 are given in Table 8.6. The entire river stretch conforms to Class-A inland surface water quality with regard to TDS and total hardness content. In terms of degree of hardness, the river water in general may be described as soft (0-60 mg/l) to moderately hard (61-120 mg/l) .

**Nitrates :** Annual average and range values of nitrate during the period 2011- 2015 are given in Table 8.7. The annual average nitrate concentrations have never exceeded the stipulated value (20 mg/l) for Class-A water.

**Chloride, Sulphates and Fluorides :** Annual average and range values of for chlorides, sulphates and fluorides are given in Table 8.8. A comparison of these values with the stipulated limits for Class-A revealed that, water quality in respect of chlorides, sulphates and fluorides at all stations conform to the highest class.

**Heavy Metals:** Data given in Table 8.9 represent the annual average and range of concentration of chromium (VI) and mercury during the period 2014 and 2015 and annual average and range of concentrations of total chromium, iron, nickel, copper, zinc, cadmium and lead respectively during the period 2011-2015. From the table it is observed that the values of these metals are well within the respective tolerance limits.

### 8.1.3 Use Based Classification

From the discussions in the forgoing sections, it may be concluded that water quality of Subarnarekha river at Rajghat do not conform to Class-C during the study period. The water quality downgrading period during the entire study period is TC.

## 8.2 BIOLOGICAL ASSESSMENT OF WATER QUALITY

The annual average and range of biomonitoring results expressed in terms of Saprobic index (SI) and Diversity index (DI) and biological class at Rajghat during the period 2011-2015 are given in Table 8.10. Taking into consideration the observed biological indices and the BOD values (Tables 8.2), the water quality at Rajghat is in a state of slight to moderate pollution (that is, B-C) as per the criteria given in Table 2.6.

## 8.3 WATER QUALITY IN TERMS OF WHOLESOMENESS

### 8.3.1 Wholesomeness in terms of regular parameters

The wholesomeness of water quality at Rajghat has been assessed with respect to general parameters specified in Table 2.7. Of the eight parameters listed in Table 2.7, results for bioassay

are not available and therefore, the water quality are assessed with regard to the remaining seven parameters. Annual average and range values of (Nitrite + Nitrate)- N and total suspended solids (including monsoon period and excluding monsoon period ) are given in Table 8.11. Considering pH, DO, EC, (Nitrite + Nitrate)-N values, the level of wholesomeness of the river water may be considered as “excellent”. However, with regard to BOD, the water level is “desirable” Further, introduction of FC values (Percent violation of FC values from 2000 MPN/100 ml given in Table 8.12) in the above assessment revealed that the water quality of Subarnarekha river at Rajghat was not “acceptable” during most part of the period under report.

### **8.3.2 Wholesomeness in terms of special parameters**

Annual average and range values of total ammonical nitrogen ((ammonium+ammonia)-N) at all the monitoring stations are given in Table 8.3 water quality with respect to total ammonical was “desirable” during 2011 and 2013 and the quality was “excellent” during 2012, 2014 and 2015. Deviations from the desirable limit during 2011 was observed only once.

From the annual average and range values of total phosphate-P given in Table 8.13, it is observed that the water quality at the station was “acceptable” except only on two occasions in the entire period of study.

Annual average and range values of TKN during 2011-2015 are given in Table 8.14 which indicated that water quality with respect to TKN was not “acceptable” most part of the period from 2011 to 2013. However, TKN was within acceptable limit during 2014 and 2015.

It is seen from Table 8.9 that the annual average as well as monthly data on concentrations of metals like total chromium, zinc, copper, nickel, lead, cadmium and mercury in the river water at all station are within the “acceptable” limits.

## **8.4 WATER QUALITY IN TERMS OF COD AND ALKALINITY**

Both COD and alkalinity values at Rajghat (Table 8.15) meet the tolerance limit conforming to the criteria for most of the beneficial uses of the river water.

## **8.5 WATER QUALITY TREND**

Subarnarekha is an interstate river (total length 446 kms) with catchment areas in Jharkhand, West Bengal and Odisha. Only a small stretch (81 kms, about 18%) of its total length flows through Odisha, before falling into the Bay of Bengal at Bhogarai Block of Balasore district.

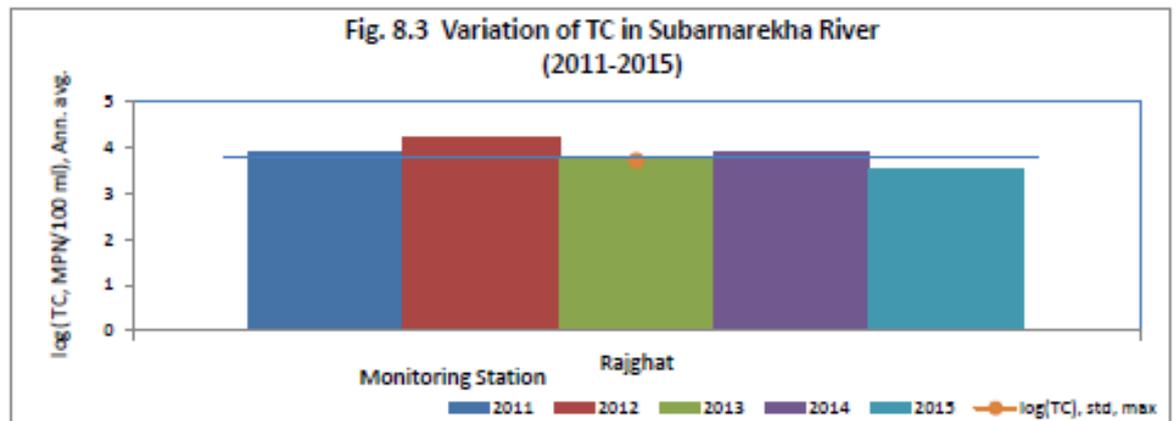
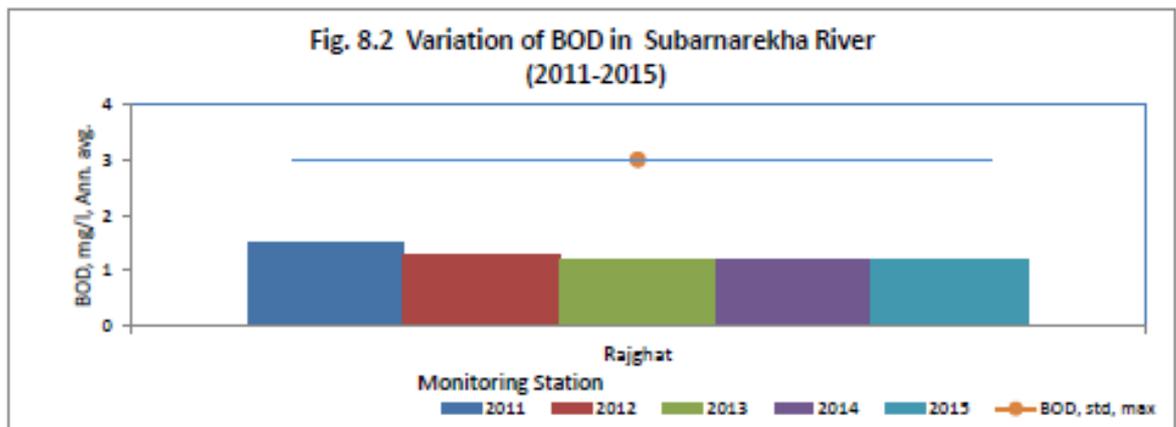
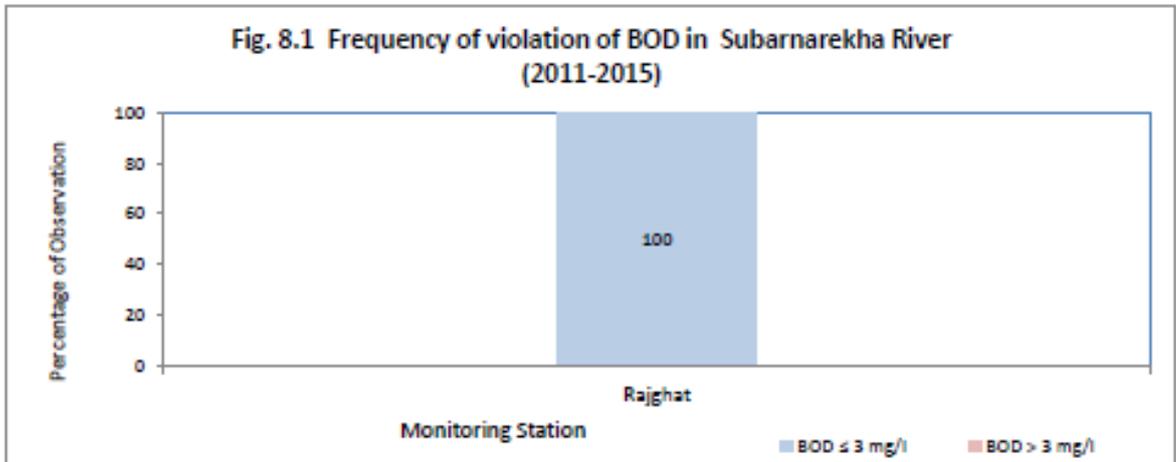
In the Odisha portion of the basin, industrial and mining activities are almost non-existent. There is only one Class-II town in the basin (Jaleswar, population: 25,747, 2011 census), which is on its bank. The wastewater generated in other smaller towns and villages in the basin would not have any significant impact on the water quality of the river. However, the instream activities on the river has resulted increased TC and FC counts for which the river water quality did not conform to Class-C during the study period. .

### **8.6 POLLUTED RIVER MONITORING STATIONS IN SUBARNAREKHA RIVER**

The criteria parameter BOD at Rajghat on Subarnarekha river was meeting the tolerance limit of 3.0 mg/l of Class-C during the period 2011-2015 and hence is not categorized as a polluted river monitoring station with respect to BOD.

### **8.7 WATER QUALITY INDEX OF MONITORING STATIONS IN SUBARNAREKHA RIVER**

The Canadian Water Quality Indices (CWQI) at Rajghat on Subarnarekha river are calculated for the period 2011-2015 (Table 8.16). For the CWQI evaluation, four critical variables such as pH, DO, BOD and TC are taken into consideration. Based on the CWQI values, the water quality of the monitoring stations are ranked into different categories as recommended in Table 2.10. As evident from the Table 8.16 for the CWQI ranks, water quality of Subarnarekha river at Rajghat always remained in Good category with CWQI score in the range 81.83 – 85.33.



**Table 8.1 Seasonal average of pH, DO, BOD and TC values in Subarnarekha river at Rajghat**

Parameter	Year	Rajghat			
		W	S	M	PM
pH	2011	7.9	8.1	8.0	7.8
	2012	7.9	8.0	8.1	8.0
	2013	8.3	8.2	7.6	8.0
	2014	8.0	7.9	7.7	8.2
	2015	7.9	8.1	8.1	8.3
DO (mg/l)	2011	7.7	7.7	7.5	8.0
	2012	7.6	7.8	7.4	7.9
	2013	8.0	8.0	7.0	7.1
	2014	7.4	8.0	8.1	8.0
	2015	7.8	7.6	7.3	8.0
BOD (mg/l)	2011	1.0	1.7	1.7	1.6
	2012	1.4	1.4	1.5	1.1
	2013	1.1	1.3	1.1	1.2
	2014	0.8	1.3	0.8	2.0
	2015	0.6	1.3	1.7	0.6
TC ('00) (MPN/100 ml)	2011	14.50	37.75	207.33	23.00
	2012	22.33	346.00	91.33	72.50
	2013	63.67	34.50	84.33	58.95
	2014	33.00	121.00	50.67	23.00
	2015	30.77	47.23	33.67	32.50

**Table 8.2 Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit at Rajghat**

Parameter	2011	2012	2013	2014	2015
BOD	1.5 (0.8-2.0)	1.3 (0.4-2.1)	1.2 (0.6 - 1.8)	1.2 (0.4 – 2.9)	1.2 (0.4-2.8)
F*	0/12	0/12	0/12	0/12	0/12
TC	7300 (1200-43000)	15758 (1700-92000)	5917 (790 – 13000)	7218 (2200 – 17000)	3252 (230-9200)
F*	3/12	6/12	6/12	4/12	3/12

\*F : Frequency of deviation (No of deviation/no. of observation)

**Table 8.3 Annual average and range values of Ammonical Nitrogen**

Monitoring Stations	Year	Ammonical Nitrogen	Free ammonia-Nitrogen	(Ammonium+Ammonia) Nitrogen
		(mg/l)		
Rajghat	2011	0.457 (0.056-1.120)	0.028 (0.003-0.073)	0.485 (0.059-1.193)
	2012	0.156 (0.112-0.336)	0.013 (0.002-0.036)	0.169 (0.114-0.372)
	2013	0.285 (0.050-0.672)	0.013 (0-0.044)	0.298 (0.050-0.716)
	2014	0.132 (0.112-0.224)	0.006 (0.003-0.014)	0.138 (0.115-0.238)
	2015	0.056 (0.056-0.056)	0.005 (0.001-0.007)	0.061 (0.057-0.063)

**Table 8.4 Seasonal average values of Electrical Conductivity (microSiemens/cm)**

Monitoring station	Year	W	S	M	PM
Rajghat	2011	362	270	153	225
	2012	274	241	171	238
	2013	286	299	154	182
	2014	280	289	148	282
	2015	332	291	191	272

**Table 8.5 Annual average and range values of SAR and B values**

Monitoring station	2011	2012	2013	2014	2015
Rajghat	<b>SAR</b>				
	0.69 (0.37-1.13)	0.65 (0.35-0.95)	0.56 (0.23-0.92)	0.66 (0.28-1.09)	0.85 (0.39-2.04)
	<b>B (mg/l)</b>				
	0.096 (0.011-0.409)	0.082 (0.030-0.148)	0.069 (0.003-0.347)	0.091 (0.022-0.184)	0.068 (0.003-0.274)

**Table 8.6 Annual average and range values of TDS and Total Hardness (TH)**

Monitoring station	2011	2012	2013	2014	2015
Rajghat	<b>TDS (mg/l)</b>				
	146 (80-259)	145 (98-184)	140 (72-207)	141 (78-178)	154 (96-255)
	<b>TH (as CaCO<sub>3</sub>), (mg/l)</b>				
	78 (46-116)	79 (60-96)	77 (40-106)	79 (40-102)	91 (64-124)

**Table 8.7 Annual average and range values of Nitrate (as NO<sub>3</sub>) (mg/l)**

Monitoring Stations	2011	2012	2013	2014	2015
Rajghat	<b>NO<sub>3</sub> (mg/l)</b>				
	1.094 (0.177-4.229)	2.11 (0.18-6.36)	0.644 (0.177-3.328)	3.986 (0.476-10.965)	3.313 (0.496-10.062)

Table 8.8 Annual average and range values of Chloride, Sulphate and Fluoride

Monitoring Station	2011	2012	2013	2014	2015
Rajghat	<b>Chloride (mg/l)</b>				
	28.1 (9.7-94.9)	22.5 (10.5-31.1)	20.3 (7.5-37.2)	19.1 (6.9-29.4)	24.9 (9.8-65.6)
	<b>Sulphate (mg/l)</b>				
	14.31 (0.32-34.73)	15.4 (5.1-20.8)	14 (2.98-26.04)	18.2 (10.2-28.2)	16.7 (3.8-27.6)
	<b>Fluoride (mg/l)</b>				
0.362 (0.213-0.859)	0.470 (0.239-0.860)	0.307 (0.186-0.709)	0.479 (0.233-0.652)	0.519 (0.290-0.700)	

Table 8.9 Annual average and range values of Metals (mg/l)

Parameter	Rajghat				
	2011	2012	2013	2014	2015
Chromium (VI)	-	-	-	0.017 (<0.002-0.040)	0.012 (<0.002-0.033)
Chromium (Total)	0.037 (0.010-0.082)	0.025 (0.013-0.048)	0.025 (0.009-0.047)	0.059 (0.010-0.164)	0.049 (0.018-0.143)
Iron	4.478 (0.077-15.380)	3.07 (0.21-12.72)	2.475 (0.212-5.941)	1.470 (<0.005-7.727)	1.351 (0.0280-6.220)
Nickel	0.004 (<0.001-0.011)	0.005 (0.002-0.009)	0.003	0.024 (0.022-0.027)	0.009 (0.003-0.015)
Copper	0.005 (0.001-0.009)	0.003 (0.002-0.005)	0.005	0.002 (0.001-0.004)	0.005 (0.002-0.008)
Zinc	0.005 (<0.001-0.010)	0.005 (0.002-0.008)	0.006	0.017 (0.016-0.018)	0.011 (0.003-0.018)
Cadmium	0.002 (<0.001-0.004)	0.002 (0.001-0.003)	<0.001	0.0011 (0.0009-0.0013)	0.0024 (0.0005-0.0047)
Mercury	-	-	-	0.00032 (<0.00006-0.00102)	0.00015 (<0.00006-0.00076)
Lead	0.006 (0.002-0.011)	0.02 (0.004-0.074)	0.005	0.005 (0.004-0.006)	0.007 (0.005-0.011)

\* Data for the period February, 2013 for parameters like nickel, copper, zinc, cadmium and lead

# Data for the period February and March, 2014 for parameters like nickel, copper, zinc, cadmium and lead

## Data for the period April-December, 2015 for parameters like nickel, copper, zinc, cadmium and lead

Table 8.10 Annual average and range values of SI and DI and Biological class

Monitoring station	2011	2012	2013	2014	2015
Rajghat	<b>SI-Range</b>				
	5.1 (4.4-5.5)	6.12 (5.8-6.57)	5.83 (5.50-6.10)	5.98 (5.75-6.40)	6.1 (5.9-6.4)
	<b>DI-Range</b>				
	0.6 (0.5-0.7)	0.66 (0.48-0.79)	0.71 (0.50-0.86)	0.71 (0.53-0.80)	0.73 (0.60-0.90)
<b>Biological Class</b>					
B – C	B – C	B-C	B-C	B-C	

**Table 8.11 Annual average and range values of (Nitrite+Nitrate)-Nitrogen and Total Suspended Solids (TSS)**

Monitoring Station	2011	2012	2013	2014	2015
Rajghat	<b>(Nitrite + Nitrate)- Nitrogen, (mg/l)</b>				
	0.247 (0.040-0.955)	0.476 (0.041-1.436)	0.145 (0.040-0.751)	0.900 (0.107-2.476)	0.748 (0.112-2.272)
	<b>TSS (Including Monsoon period) (mg/l)</b>				
	98 (8-376)	74 (9-222)	111 (8-308)	46 (6-166)	19 (4-56)
	<b>TSS (Non-monsoon period), (mg/l)</b>				
	33 (8-62)	47 (9-111)	71 (8-124)	19 (6-52)	14 (4-46)

**Table 8.12 Percentage violation and Annual range of Fecal coliform values**

Monitoring Station	Percentage Violation of FC values (Range of FC values in '000 MPN/100 ml)				
	2011	2012	2013	2014	2015
Rajghat	25 (0.460-15.000)	50 (1.100-54.000)	33 (0.220-4.900)	42 (0.490-11.000)	25 (0.078-3.500)

**Table 8.13 Total Phosphate-P (mg/l)**

Monitoring Station	2011	2012	2013	2014	2015
Rajghat	0.037 (0.001-0.178)	0.053 (0.004-0.158)	0.061 (0.005-0.245)	0.172 (0.014-1.187)	0.116 (0.027-0.435)

**Table 8.14 Total Kjeldahl Nitrogen (TKN) (mg/l)**

Monitoring Station	2011	2012	2013	2014	2015
Rajghat	6.3 (1.7-29.4)	3.08 (1.58-5.04)	2.63 (1.68-4.95)	1.30 (0.28-2.80)	1.17 (0.84-1.40)

**Table 8.15 Chemical Oxygen Demand (COD) (mg/l) and Total Alkalinity**

Monitoring Station	2011	2012	2013	2014	2015
Rajghat	<b>COD, mg/l</b>				
	9.9 (3.8-17.1)	12.3 (4.4-18.1)	12.5 (7.2-20.9)	11.0 (6.5-23.8)	9.1 (5.1-17.5)
	<b>Total Alkalinity (as CaCO<sub>3</sub>) (mg/l)</b>				
	78 (40-112)	76 (44-102)	73 (48-92)	74 (44-102)	84 (58-112)

**Table 8.16 CWQI of Subarnarekha river and Category of water quality based on CWQI Values**

Monitoring Station	2011	2012	2013	2014	2015
Rajghat	<b>CWQI</b>				
	81.83	85.33	83.16	82.12	85.08
	<b>Category</b>				
	Good	Good	Good	Good	Good

**CHAPTER-IX****WATER QUALITY STATUS OF BUDHABALANGA RIVER**

Water quality of Budhabalanga river is monitored at the downstream of Baripada town, upstream and downstream of Balasore town to assess the impact of Baripada and Balasore towns respectively.

**9.1 USE BASED WATER QUALITY STATUS****9.1.1 Water quality in respect of Primary Criteria**

Seasonal average values of four critical parameters such as pH, DO, BOD and TC at these three stations pertaining to the period 2011 – 2015 are given in Table 9.1.

**pH and DO** : As may be seen from the data, the seasonal average of pH values vary within 7.6-8.3 at the three stations during the period of study. Both pH and DO values conform to Class-A.

**BOD** : The seasonal average values of BOD at all the monitoring stations excluding on one occasion at Balasore D/s (Summer, 2013) , conform to Class-C.

**TC** : The seasonal average values of TC at all the monitoring stations do not conform to Class C limit excepting very few occasions at Balasore U/s. The magnitudes and frequency of violations of TC from the stipulated value (less than 5000 MPN/100 ml) at these three stations do not warrant the water quality to be classified as Class-C. Wide fluctuations in the TC values have been observed during the study period.

The annual average and the range of BOD and TC values at three monitoring stations are given in Table 9.2. Frequency of deviation of BOD and TC values from the stipulated values (3.0 mg/l and 5000 MPN/100 ml respectively) are also given in Table 9.2. BOD at Baripada D/s and Balasore U/s conformed to Class-C tolerance limit during the study period. However, at Balasore D/s, deviation in monthly BOD values from the tolerance limit for Class-C has been observed for 10 % of total observations. Frequency of violation of BOD values at the three stations during the period under study is presented in Fig. 9.1. Spatial variations of annual average values of BOD and TC along the river stretch are depicted in Fig. 9.2 & 9.3 respectively.

**Free Ammonia** :The annual average and range values of ammonical nitrogen and free ammonia are given in Table 9.3. Free ammonia values at all stations conform to the stipulated value (1.2 mg/l, max) for Class-D inland surface water (Fish culture and wildlife propagation). No regular pattern is observed regarding the level of ammonia in the river.

**EC, SAR and B :** Seasonal average values of EC at these three monitoring stations are given in Table 9.4. Annual average and range value of SAR and B values at these monitoring stations are given in Table 9.5. From the data, it can be seen that the except very few occasions at Balasore D/s, EC, SAR and B values are far too low compared to the stipulated values in Table 2.4, to cause any concern to consider the suitability of the entire stretch of river water to be used for irrigation.

### 9.1.2 Water quality in respect of Other Parameters

**TDS and Total Hardness :** Annual average and range values of total dissolved solids (TDS) and total hardness (TH) during the period 2011- 2015 are given in Table 9.6. The entire river stretch conforms to Class-A inland surface water quality with regard to TDS and total hardness content. In terms of degree of hardness, the river water in general may be described as soft (0-60 mg/l) to moderately hard (61-120 mg/l) with a very few exceptions at Balasore D/s.

**Nitrates :** Annual average and range values of nitrate during the period 2011- 2015 are given in Table 9.7. The annual average nitrate concentrations have never exceeded the stipulated value (20 mg/l) for Class-A water, though a single deviation of monthly nitrate value from the stipulated value for Class-A has been observed at Baripada D/s (August, 2015) However, the monthly nitrate concentration never exceeded the stipulated limit of 50 mg/l for Class-C.

**Chloride, Sulphates and Fluorides :** Annual average and range values of chloride, sulphate and fluoride at these monitoring stations during the period 2011-2015 are given in Table 9.8. A comparison of these values with the stipulated limits for Class-A revealed that, water quality in respect of chloride, sulphate and fluoride at all stations conform to the highest class. Occasional deviation of chloride and sulphate concentrations from the stipulated value has been observed at Balasore D/s.

**Heavy Metals:** Data given in Table 9.9 represent the annual average and range of concentration of chromium (VI) and mercury during the period 2014 and 2015 and annual average and range of concentrations of total chromium, iron, nickel, copper, zinc, cadmium and lead respectively during the period 2011-2015. From the table it is observed that the values of these metals are well within the respective tolerance limits.

### 9.1.2 Use based classification

From the water quality data and frequency of violation discussions made in the sec. 9.1.1 and 9.1.2, it may be reasonable to conclude that the water quality at all stations do not conform to Class-C. At Baripada D/s and Balasore U/s, the water quality downgrading parameter is TC while at Balasore D/s, the water quality downgrading parameter are both BOD and TC.

## 9.2 BIOLOGICAL ASSESSMENT OF WATER QUALITY

The annual average and range of biomonitoring results expressed in terms of Saprobic index (SI) and Diversity index (DI) and biological class of the three monitoring stations during the period 2011-2015 are given in Table 9.10. Taking into consideration the observed biological

indices and the BOD values (Tables 9.2), the river stretch along these monitoring stations are generally in a state of slight to moderate pollution (that is, B-C) as per the criteria given in Table 2.6.

### **9.3 WATER QUALITY IN TERMS OF WHOLESOMENESS**

#### **9.3.1 Wholesomeness in terms of regular parameters**

The wholesomeness of water quality at the three monitoring stations have been assessed with respect to general parameters specified in Table 2.7. Of the eight parameters listed in Table 2.7, results for bioassay are not available and therefore, the water quality are assessed with regard to the remaining seven parameters. Annual average and range values of (Nitrite + Nitrate)- N at the monitoring stations are given in Table 9.11. Annual average and range values of total suspended solids (TSS) including monsoon period and excluding monsoon period are given in Table 9.12. Considering pH, DO, EC, (Nitrite + Nitrate)-N values, the level of wholesomeness of the river water may be considered as “excellent”. With regard to BOD, the water level is “desirable” at all stations except on few occasions at Balasore D/s where the level of wholesomeness is “acceptable” (10% of total observation). Water quality with regard to the TSS (during non-monsoon period) at all the three stations is in “acceptable” level during most period under study.

However, the situation changes entirely on introduction of FC values in the above assessment. Investigation on the data given in Table 9.13 (percent violation of FC values from 2000 MPN/100 ml) shows that the water quality in the entire stretch was not even “acceptable” during most part of the period under report.

#### **9.3.2 Wholesomeness in terms of special parameters**

Annual average and range values of total ammonical nitrogen ((ammonium+ammonia)-N) at all the monitoring stations are given in Table 9.3 which reveals that at all the three stations water quality with respect to total ammonical nitrogen are mostly within “desirable” limits during the period under study. Occasional deviations from “desirable” limit have been observed at Balasore D/s during Feb, 2011 and July, 2012.

From the annual average and range values of total phosphate-P and total Kjeldahl nitrogen given in Table 9.14, it is observed that the water quality at most of the stations are not within the acceptable limits for total phosphates-P under the period of study. Further, annual average values of TKN at the monitored locations generally do not meet the acceptable limit of 3.0 mg/l during the study period except during 2015.

It is seen from Table 9.9 that the annual average as well as monthly data on concentrations of metals like total chromium, zinc, copper, nickel, lead, cadmium and mercury in the river water at all station are within the “acceptable” limits.

#### **9.4 WATER QUALITY IN TERMS OF COD AND ALKALINITY**

Annual average and range values of COD and alkalinity values are given in Table 9.15. Both the parameters are mostly within acceptable limits for most of the beneficial uses of water.

#### **9.5 WATER QUALITY TREND**

Budhabalanga is an interstate river (total length 198.75 kms) with catchment areas in Odisha and West Bengal. Most part of the river (length :175 km) flows in Odisha with a basin catchment of 6354 sqkm in Mayurbhanj and Balasore districts. In the Odisha portion of the basin, industrial and mining activities are not that much significant. There are only two Class-II towns in the basin (Baripada and Balasore, population: about 1.5 lakhs) on its bank. The wastewater generated in other smaller towns and villages in the basin would not have any significant impact on the water quality of the river.

The river after flowing the relatively undisturbed areas from its origin in Similipal biosphere reserve and traversing a distance of 89 km enters Baripada town. Water quality of the river at downstream of Baripada city does not conform to Class-C with respect to TC. From Baripada, the river flows again through an undisturbed stretch upto Balasore U/s (153 km stretch). Wastewater of Balasore town (treated industrial and untreated domestic) are discharged to Sone river which ultimately outfalls into Budhabalanga river. Water quality of the river at the upstream of Balasore town does not conform to Class-C with respect to TC, whereas at downstream of Balasore town, water quality does not conform to Class C with respect to both BOD and TC.

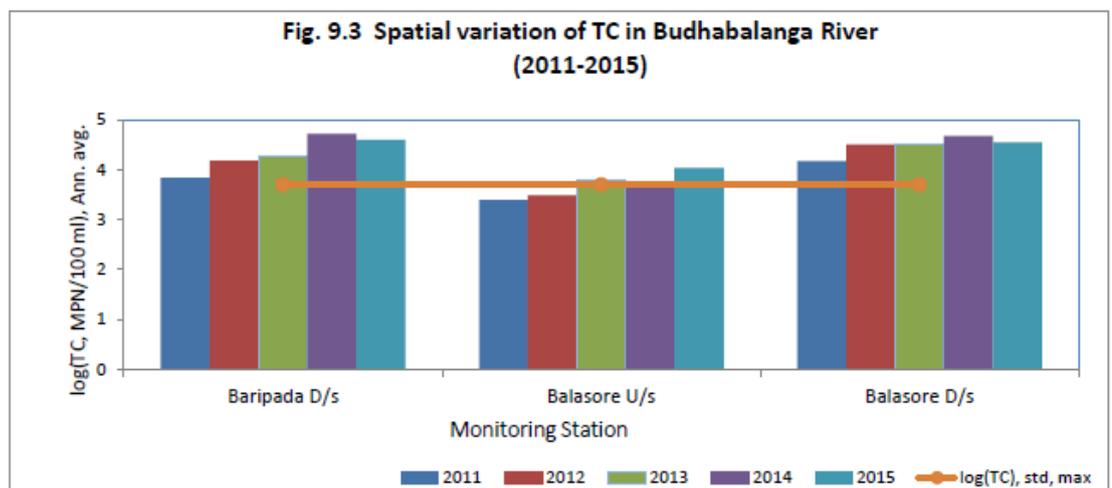
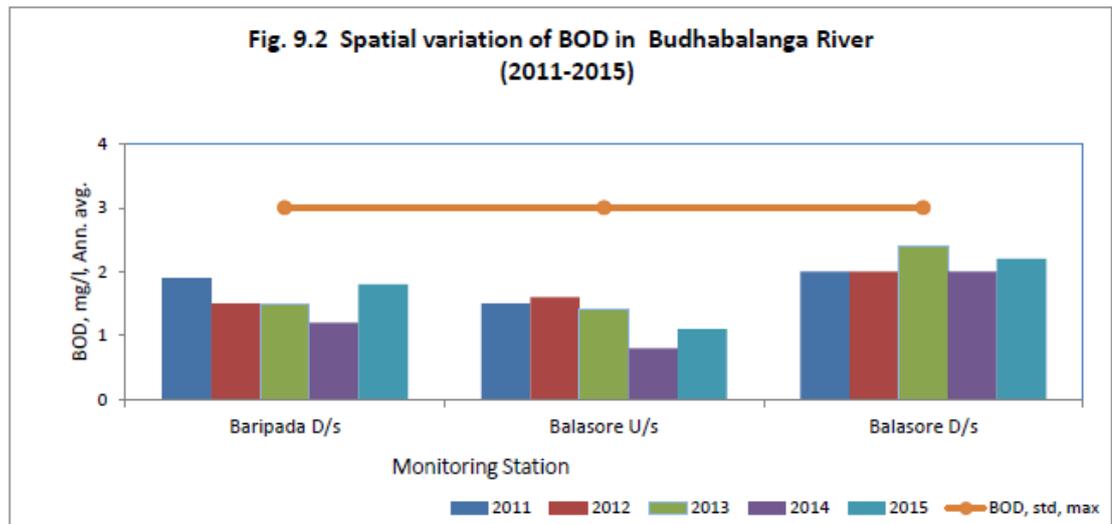
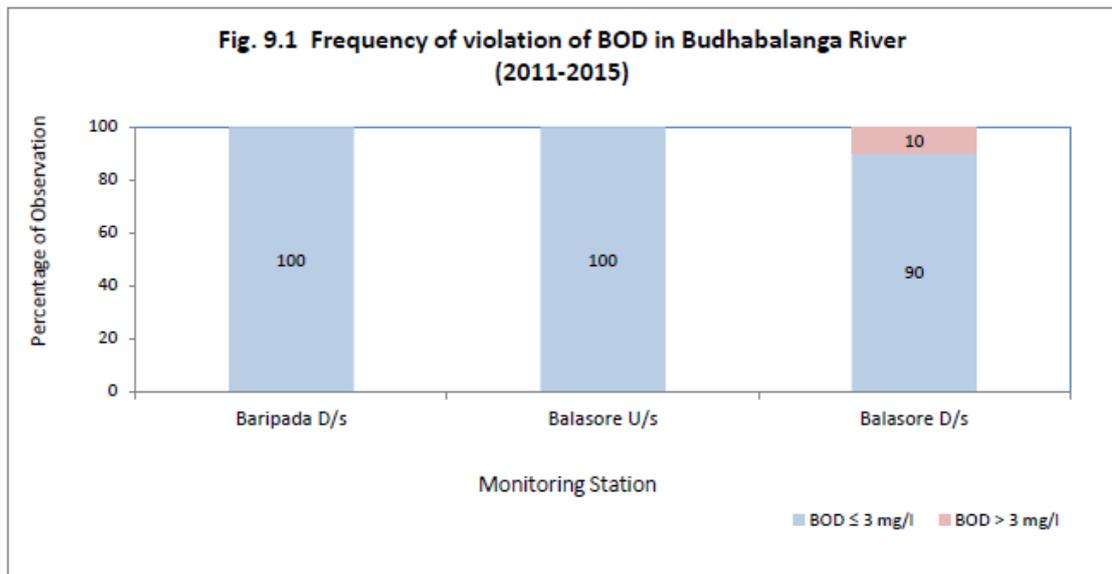
#### **9.6 POLLUTED RIVER MONITORING STATIONS IN BUDHABALANGA RIVER**

The monitoring stations on Budhabalanga river not meeting the tolerance limit of 3.0 mg/l for the criteria parameter BOD of Class-C are identified as polluted river monitoring stations and have been categorized into different priority classes as proposed by CPCB (Table 2.9). Comparison of BOD data obtained during the period 2011-2015 (Table 9.2 with the tolerance limits for Class-C revealed that there is only one polluted river monitoring station, that is, Balasore D/s. Annual BOD range at the polluted river monitoring station and priority class is given in Table 9.16.

#### **9.7 WATER QUALITY INDEX OF MONITORING STATIONS IN BUDHABALANGA RIVER**

The Canadian Water Quality Indices (CWQI) of three monitoring stations on Budhabalanga river system are calculated for the period 2011-2015 and given in Table 9.17. For the CWQI evaluation, four critical variables such as pH, DO, BOD and TC are taken into consideration. Based on the CWQI values, the water quality of the monitoring stations are ranked into different categories as recommended in Table 2.10. As evident from the Table 9.17 for the CWQI ranks, water quality of Budhabalanga river at Baripada D/s varied within Marginal- Good. Water quality of Balasore U/s remained within Fair-Good category. Whereas, water quality at Balasore D/s has been lowered to Marginal- Fair category.

The instream activities as well as discharge of untreated wastewater into the river water are responsible for the occasional deviation of BOD and TC values beyond the tolerance limit which ultimately lowers the water quality at these stations.



**Table 9.1** Sesaonal average values of pH, DO, BOD and TC in Budhabalanga river at Baripada D/s, Balasore U/s and Balasore D/s

Parameter	Year	Baripada D/s				Balasore U/s				Balasore D/s			
		W	S	M	PM	W	S	M	PM	W	S	M	PM
pH	2011	8.1	8.1	8.0	7.8	7.9	7.8	7.9	8.1	7.8	7.9	8.0	8.0
	2012	7.9	7.9	7.9	7.9	8.3	8.1	7.9	7.7	8.2	8.0	7.9	7.9
	2013	8.3	8.0	7.5	7.7	7.8	8.3	7.7	7.5	8.3	7.7	7.5	7.5
	2014	8.1	8.1	7.6	8.1	7.8	8.0	7.6	7.9	8.0	8.1	7.6	7.7
	2015	7.9	8.0	7.9	7.8	8.1	7.8	7.8	8.3	7.9	7.8	7.8	7.9
DO (mg/l)	2011	7.8	7.5	7.3	7.4	7.8	7.6	7.8	7.6	7.4	7.4	7.1	7.3
	2012	8.5	7.7	7.7	7.5	7.9	8.1	7.8	7.6	8.5	7.6	7.6	7.2
	2013	8.0	7.4	7.2	7.7	7.9	7.8	7.2	7.4	7.5	7.9	7.1	7.4
	2014	7.4	7.6	7.8	7.9	8.0	7.7	7.7	7.6	7.6	7.5	7.8	7.3
	2015	7.7	7.6	7.1	7.3	7.7	7.3	7.2	7.1	7.5	7.2	6.9	7.5
BOD (mg/l)	2011	2.6	1.9	1.9	1.7	1.2	1.6	1.7	1.6	1.8	2.1	2.0	2.4
	2012	1.7	1.6	1.1	1.4	1.3	1.7	1.8	1.5	1.6	1.9	2.0	2.4
	2013	1.2	2.1	1.3	0.9	1.6	1.8	1.1	0.7	2.3	3.4	1.7	1.8
	2014	1.3	1.5	1.2	0.7	0.8	0.7	1.0	0.6	1.1	2.2	2.2	1.8
	2015	1.7	2.1	1.5	2.2	1.3	1.2	0.9	0.7	2.0	2.4	2.5	1.6
TC ('00) (MPN/100 ml)	2011	19.50	33.50	176.33	33.50	7.60	16.85	52.00	19.50	21.50	50.25	151.00	75.00
	2012	60.67	205.75	149.67	150.00	18.00	21.98	56.00	28.00	388.00	334.50	330.00	175.00
	2013	66.33	108.50	396.67	140.00	89.33	26.00	86.33	35.50	620.67	229.50	390.00	250.00
	2014	220.00	262.50	1020.00	445.00	33.00	32.00	91.00	18.50	240.00	260.00	660.00	730.00
	2015	440.00	212.50	766.67	195.00	73.00	92.50	214.33	57.00	603.33	325.00	345.67	250.00

**Table 9.2 Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit**

Monitoring Stations	Parameter	2011	2012	2013	2014	2015
Baripada D/s	BOD	1.9 (1.1-2.8)	1.5 (0.8-1.8)	1.5 (0.8 – 2.5)	1.2 (0.6 – 2.7)	1.8 (0.9-2.7)
	F*	0/12	0/12	0/11	0/11	0/12
	TC	6858 (1300-35000)	15083 (5800-54000)	18118 (2200 – 54000)	52200 (13000 – 160000)	39417 (13000-160000)
	F*	4/12	12/12	8/11	11/11	12/12
Balasore U/s	BOD	1.5 (1.0-2.2)	1.6 (0.7-3.0)	1.4 (0.5 – 2.6)	0.8 (0.4 – 1.9)	1.1 (0.5-1.9)
	F*	0/12	0/12	0/12	0/12	0/12
	TC	2455 (580-13000)	3049 (790-9200)	6227 (1100 – 24000)	4710 (1300 – 17000)	10792 (3500-54000)
	F*	1/12	2/12	4/11	3/11	3/12
Balasore D/s	BOD	2.0 (1.6-2.4)	2.0 (1.3-2.8)	2.4 (1.5 – 3.6)	2.0 (1.1 – 3.2)	2.2 (0.8-3.4)
	F*	0/12	0/12	3/11	1/11	2/12
	TC	14725 (2100-92000)	32017 (8400-92000)	32091 (2200 – 92000)	47200 (16000 – 160000)	34642 (5400-92000)
	F*	7/12	12/12	10/11	11/11	9/12

\*F : Frequency of deviation (Number of deviation/ total number of observation)

**Table 9.3 Annual average and range values of Ammonical Nitrogen**

Monitoring Station	Ammonical Nitrogen	Free ammonia-Nitrogen	(Ammonium + ammonia)- Nitrogen
	(mg/l)		
	2011		
Baripada D/s	0.439 (0.112-0.840)	0.029 (0.005-0.082)	0.468 (0.117-0.922)
Balasore U/s	0.481 (0.056-0.952)	0.020 (0.006-0.047)	0.501 (0.062-0.999)
Balasore D/s	0.527 (0.056-1.288)	0.027 (0.004-0.076)	0.554 (0.060-1.364)
	2012		
Baripada D/s	0.280 (<0.056-0.560)	0.016 (0-0.056)	0.296 (<0.056-0.616)
Balasore U/s	0.210 (0.112-0.448)	0.018 (0.001-0.085)	0.228 (0.113-0.535)
Balasore D/s	0.253 (0.112-1.176)	0.011 (0-0.028)	0.264 (0.112-1.204)
	2013		
Baripada D/s	0.341 (0.112-0.550)	0.016 (0-0.036)	0.357 (0.112-0.586)
Balasore U/s	0.250 (0.112-0.560)	0.011 (0.002-0.026)	0.261 (0.114-0.586)
Balasore D/s	0.261 (0.056-0.495)	0.011 (0.001-0.039)	0.272 (0.057-0.534)

Table 9.3 contd..

Monitoring Station	Ammonical Nitrogen	Free ammonia-Nitrogen	(Ammonium + ammonia)- Nitrogen
	(mg/l)		
	2014		
Baripada D/s	0.140 (0.056-0.336)	0.008 (0.001-0.018)	0.148 (0.057-0.354)
Balasore U/s	0.129 (0.056-0.224)	0.005 (0.001-0.013)	0.134 (0.057-0.237)
Balasore D/s	0.134 (0.112-0.224)	0.006 (0.001-0.014)	0.140 (0.113-0.238)
2015			
Baripada D/s	0.065 (0.056-0.112)	0.004 (0.001-0.009)	0.069 (0.057-0.121)
Balasore U/s	0.056 (0.056-0.056)	0.003 (0.001-0.007)	0.059 (0.057-0.063)
Balasore D/s	0.065 (0.056-0.168)	0.002 (0.001-0.007)	0.067 (0.057-1.687)

Table 9.4 Seasonal average values of Electrical Conductivity (microSiemens/cm)

Monitoring station	Year	W	S	M	PM
Baripada D/s	2011	331	236	128	163
	2012	217	259	162	190
	2013	256	382	145	166
	2014	229	269	156	263
	2015	295	259	189	509
Balasore U/s	2011	286	212	148	171
	2012	222	261	150	200
	2013	260	320	122	160
	2014	225	200	136	251
	2015	237	231	193	232
Balasore D/s	2011	440	260	202	186
	2012	263	455	241	218
	2013	363	16572	198	194
	2014	208	489	174	286
	2015	3378	2744	233	370

**Table 9.5 Annual average and range values of SAR and B**

Monitoring station	2011	2012	2013	2014	2015
	SAR				
Baripada D/s	0.54 (0.42-0.67)	0.48 (0.30-0.69)	0.51 (0.25-0.97)	0.45 (0.33-0.57)	0.51 (0.32-0.73)
Balasore U/s	0.51 (0.15-0.72)	0.53 (0.23-0.99)	0.53 (0.24-1.03)	0.49 (0.25-1.07)	0.54 (0.27-1.08)
Balasore D/s	0.69 (0.43-0.92)	1.05 (0.44-2.85)	14.67 (0.18-56.10)	3.11 (0.23-14.93)	7.19 (0.49-36.66)
	B (mg/l)				
Baripada D/s	0.077 (0.007-0.231)	0.054 (0.015-0.087)	0.057 (0.003-0.109)	0.071 (0.009-0.181)	0.044 (0.003-0.133)
Balasore U/s	0.064 (0.004-0.212)	0.061 (0.013-0.113)	0.065 (0.011-0.272)	0.047 (0.009-0.099)	0.033 (0.006-0.074)
Balasore D/s	0.053 (0.011-0.114)	0.171 (0.023-1.347)	0.201 (0.018-0.776)	0.059 (0.006-0.112)	0.146 (0.019-1.008)

**Table 9.6 Annual average and range values of TDS and Total Hardness**

Monitoring station	2011	2012	2013	2014	2015
	TDS (mg/l)				
Baripada D/s	120 (71-180)	133 (83-185)	156 (82-247)	138 (88-270)	138 (94-196)
Balasore U/s	117 (64-173)	133 (70-199)	137 (68-203)	114 (75-166)	125 (70-152)
Balasore D/s	150 (90-278)	193 (118-388)	4555 (84-21122)	353 (67-1710)	1215 (122-6610)
	TH (as CaCO <sub>3</sub> ) (mg/l)				
Baripada D/s	71 (34-120)	86 (52-104)	91 (48-144)	83 (40-106)	92 (60-118)
Balasore U/s	71.2 (28-124)	87 (52-114)	80 (36-124)	68 (40-92)	80 (40-104)
Balasore D/s	76 (50-120)	103 (78-148)	594 (48-2700)	99 (40-250)	235 (52-840)

**Table 9.7 Annual average and range values of Nitrate (as NO<sub>3</sub>) (mg/l)**

Monitoring Station	2011	2012	2013	2014	2015
	NO <sub>3</sub> (mg/l)				
Baripada D/s	1.678 (0.372 -3.866)	1.50 (0.04-6.48)	1.743 (0.602-4.065)	3.524 (0.648-7.936)	6.1919 (1.089-20.415)
Balasore U/s	1.714 (0.182-4.048)	1.74 (0.13-7.46)	1.969 (0.589-9.557)	3.655 (0.354-17.648)	2.682 (0.368-7.002)
Balasore D/s	2.737 (0.018-12.644)	3.12 (0.10-8.86)	5.974 (0.655-12.110)	3.066 (0.208-6.943)	5.622 (1.563-10.714)

**Table 9.8 Annual average and range values of Chloride, Sulphate and Fluoride**

Monitoring station	2011	2012	2013	2014	2015
	<b>Chloride (mg/l)</b>				
Baripada D/s	17.0 (10.6-33.1)	16.8 (9.6-24.2)	21.4 (7.7-42.3)	19.3 (7.8-81.2)	14.83 (8.80-22.50)
Balasore U/s	14.8 (5.0-26.0)	18.4 (6.8-34.3)	19.6 (6.7-37.1)	13.1 (5.9-27.4)	14.35 (6.84-24.46)
Balasore D/s	25.7 (13.0-84.9)	42.5 (14.2-134.5)	2333 (7.7-11250.0)	131.2 (5.9-782.8)	593.9 (11.74-3571.5)
<b>Sulphate (mg/l)</b>					
Baripada D/s	9.32 (0.22-22.69)	6.28 (2.11-11.88)	6.59 (2.24-16.92)	9.70 (4.48-20.40)	16.4 (5.2-48.8)
Balasore U/s	7.7 (1.3-21.9)	10.19 (1.34-23.47)	12.46 (2.49-29.85)	8.72 (5.97-17.04)	14.5 (7.8-24.6)
Balasore D/s	11.2 (1.5-31.9)	17.31 (4.21-40.89)	198.54 (3.23-828.60)	33.66 (3.10-182.25)	78.4 (11.4-359.4)
<b>Fluoride (mg/l)</b>					
Baripada D/s	0.339 (0.164-0.653)	0.212 (0.135-0.310)	0.161 (0.082-0.246)	0.201 (0.152-0.233)	0.314 (0.160-0.500)
Balasore U/s	0.293 (0.161-0.515)	0.213 (0.154-0.303)	0.195 (0.110-0.361)	0.205 (0.146-0.276)	0.331 (0.130-0.470)
Balasore D/s	0.258 (0.169-0.603)	0.241 (0.171-0.317)	0.329 (0.113-0.642)	0.200 (0.153-0.236)	0.324 (0.190-0.500)

**Table 9.9 Annual average and range values of Metals**

Parameter	Baripada D/s				
	2011	2012	2013*	2014#	2015##
<b>(mg/l)</b>					
Chromium (VI)	-	-	-	0.013 (<0.002-0.048)	0.014 (0.002-0.038)
Chromium (Total)	0.046 (0.005-0.154)	0.019 (0.010-0.038)	0.047 (0.008-0.250)	0.042 (0.018-0.092)	0.042 (0.011-0.114)
Iron	4.126 (0.260-14.822)	2.364 (0.264-6.400)	3.218 (0.132-12.736)	1.669 (<0.005-8.007)	1.671 (0.260-5.330)
Nickel	0.004 (0.001-0.010)	0.002 (0.001-0.004)	0.002	0.026 (0.020-0.032)	0.011 (0.002-0.019)
Copper	0.004 (0.002-0.008)	0.004 (0.002-0.005)	0.003	0.005 (0.002-0.008)	0.008 (0.002-0.029)
Zinc	0.006 (<0.001-0.012)	0.004 (0.001-0.005)	0.009	0.030 (0.028-0.032)	0.016 (0.008-0.025)
Cadmium	0.001 (<0.001-0.004)	0.001 (0.001-0.002)	0.001	0.0017 (0.0012-0.0021)	0.0026 (0.0007-0.0053)
Mercury	-	-	-	0.00028 (<0.00006-0.00095)	0.00021 (<0.00006-0.00083)
Lead	0.005 (0.001-0.009)	0.007 (0.003-0.010)	0.007	0.006 (0.004-0.008)	0.011 (0.002-0.043)

\* Data for the period February, 2013 for parameters like nickel, copper, zinc, cadmium and lead

# Data for the period February and March, 2014 for parameters like nickel, copper, zinc, cadmium and lead

## Data for the period April-December, 2015 for parameters like nickel, copper, zinc, cadmium and lead

Table 9.9 contd..

Parameter	Balasore U/s				
	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Chromium (VI)	-	-	-	0.018 (<0.002-0.033)	0.014 (<0.002-0.033)
Chromium (Total)	0.033 (0.011-0.085)	0.026 (0.020-0.042)	0.036 (0.005-0.180)	0.065 (0.035-0.113)	0.040 (0.008-0.094)
Iron	5.104 (0.158-15.090)	2.475 (0.302-7.900)	5.529 (0.240-11.918)	2.185 (<0.005-8.833)	2.998 (0.076-7.530)
Nickel	0.004 (<0.001-0.010)	0.003 (0.001-0.006)	0.003	0.017 (0.016-0.018)	0.014 (0.004-0.029)
Copper	0.005 (0.002-0.017)	0.004 (0.001-0.006)	0.003	0.009 (0.004-0.013)	0.005 (0.003-0.006)
Zinc	0.004 (<0.001-0.011)	0.004 (0.001-0.006)	0.007	0.026 (0.025-0.026)	0.013 (0.003-0.018)
Cadmium	0.001 (<0.001-0.003)	0.001 (<0.001-0.002)	0.001	0.0022 (0.0014-0.0031)	0.0022 (0.0006-0.0059)
Mercury	-	-	-	0.00019 (<0.00006-0.00076)	0.00005 (<0.00006-0.00019)
Lead	0.004 (0.001-0.009)	0.007 (0.003-0.012)	0.004	0.008 (0.007-0.008)	0.006 (0.002-0.017)
	Balasore D/s				
	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
Chromium (VI)	-	-	-	0.018 (<0.002-0.048)	0.018 (<0.002-0.046)
Chromium (Total)	0.04 (0.005-0.117)	0.029 (0.012-0.060)	0.015 (0.005-0.033)	0.045 (0.014-0.097)	0.074 (0.015-0.173)
Iron	5.399 (0.658-13.940)	6.796 (0.720-45.120)	7.059 (0.651-12.951)	1.062 (0.056-2.188)	3.520 (0.092-7.210)
Nickel	0.004 (<0.001-0.010)	0.004 (0.002-0.006)	0.002	0.026 (0.026-0.026)	0.016 (0.003-0.035)
Copper	0.005 (0.001-0.008)	0.005 (0.004-0.006)	0.004	0.007 (0.003-0.012)	0.005 (0.002-0.009)
Zinc	0.005 (0.001-0.015)	0.006 (0.002-0.008)	0.009	0.038 (0.034-0.042)	0.019 (0.007-0.026)
Cadmium	0.001 (<0.001-0.004)	0.001 (0.001-0.003)	0.001	0.0018 (0.0018-0.0019)	0.0028 (0.0007-0.0071)
Mercury	-	-	-	0.00031 (<0.00006-0.00076)	0.00007 (<0.00006-0.00025)
Lead	0.009 (0.003-0.040)	0.006 (0.001-0.009)	0.009	0.007 (0.001-0.012)	0.009 (0.004-0.028)

\* Data for the period February, 2013 for parameters like nickel, copper, zinc, cadmium and lead

# Data for the period February and March, 2014 for parameters like nickel, copper, zinc, cadmium and lead

## Data for the period April-December, 2015 for parameters like nickel, copper, zinc, cadmium and lead

**Table 9.10 Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class**

Monitoring station	SI				
	2011	2012	2013	2014	2015
Baripada D/s	5.6 (5.3-5.8)	5.9 (5.7-6.0)	5.87 (5.60-6.20)	5.49 (5.25-5.72)	5.5 (5.4-5.8)
Balasore U/s	5.4 (4.6-5.8)	6.2 (6.0-6.50)	6.20 (6.00-6.40)	5.83 (5.20-6.30)	5.9 (5.4-6.3)
Balaosre D/s	5.1 (4.8-5.4)	5.7 (5.3-6.0)	5.78 (5.25-6.50)	5.49 (5.10-5.87)	5.8 (5.6-6.0)
	DI				
Baripada D/s	0.6 (0.5-0.7)	0.75 (0.67 -0.81)	0.80 (0.78-0.83)	0.69 (0.62-0.75)	0.62 (0.50-0.79)
Balasore U/s	0.5 (0.4-0.7)	0.68 (0.44-0.95)	0.70 (0.63-0.84)	0.73 (0.60-0.80)	0.77 (0.69-0.83)
Balaosre D/s	0.7 (0.6-0.7)	0.57 (0.50-0.62)	0.79 (0.54-0.94)	0.76 (0.71-0.80)	0.67 (0.53-0.80)
	Biological Class				
Baripada D/s	C	B – C	B-C	C	C
Balasore U/s	C	B – C	B-C	B-C	B-C
Balaosre D/s	C	B – C	B-C	C	C

**Table 9.11 Annual average and Range values of (Nitrite+Nitrate)-Nitrogen**

Monitoring Station	2011	2012	2013	2014	2015
	(Nitrite + Nitrate)- Nitrogen (mg/l)				
Baripada D/s	0.379 (0.084-0.873)	0.339 (0.009-1.463)	0.394 (0.136-0.918)	0.796 (0.146-1.792)	1.398 (0.246-4.610)
Balasore U/s	0.387 (0.041-0.914)	0.393 (0.029-1.685)	0.445 (0.133-2.158)	0.825 (0.080-3.985)	0.606 (0.083-1.581)
Balasore D/s	0.618 (0.004-2.855)	0.705 (0.023-2.001)	1.349 (0.148-2.735)	0.692 (0.047-1.568)	1.269 (0.353-1.269)

**Table 9.12 Annual average and Range values of Total Suspended Solids (TSS )**

Monitoring Station		2011	2012	2013	2014	2015
		TSS (mg/l)				
Baripada D/s	IM	79 (7-220)	57 (14-146)	97 (20-212)	42 (10-114)	19 (5-30)
	NM	61 (7-220)	42 (14-89)	77 (20-114)	35 (10-114)	20 (5-30)
Balasore U/s	IM	94 (29-190)	58 (12-116)	109 (20-276)	50 (8-100)	29 (6-62)
	NM	76 (29-190)	42 (12-116)	77 (20-168)	41 (8-100)	24 (6-50)
Balasore D/s	IM	118 (39-272)	124 (21-560)	95 (8-316)	47 (6-89)	48 (26-92)
	NM	111 (39-272)	120 (21-560)	84 (8-168)	40 (6-89)	44 (26-92)

Note : IM : Including Monsoon period

NM : Non-monsoon period (i.e. excluding the months July, August and September)

**Table 9.13 Percentage violation and Annual range of Fecal coliform values**

Monitoring Station	Percentage Violation of FC values (Range of FC values in '000 MPN/100 ml)				
	2011	2012	2013	2014	2015
Baripada D/s	42 (0.580-17.000)	100 (2.100-35.000)	67 (0.490-24.000)	100 (4.900-92.000)	100 (7.900-92.000)
Balaosre U/s	8 (0.130-7.900)	8 (0.330-2400)	54 (0.490-13.000)	25 (0.130-7.900)	67 (1.300-35.000)
Balaosre D/s	67 (1.100-35.000)	100 (3.100-35.000)	91 (1.100-54.000)	100 (11.000-54.000)	100 (3.300-54.000)

**Table 9.14 Annual average and range of Total Phosphate-P and Total Kjeldahl Nitrogen (TKN)**

Monitoring Station	2011	2012	2013	2014	2015
	<b>Total Phosphate-P (mg/l)</b>				
Baripada D/s	0.068 (0.001-0.175)	0.044 (0.001-0.149)	0.142 (0.002-0.488)	0.087 (0.011-0.164)	0.154 (0.034-0.531)
Balasore U/s	0.062 (0.009-0.275)	0.033 (0.001-0.059)	0.068 (0.006-0.230)	0.139 (0.014-0.369)	0.145 (0.006-0.460)
Balasore D/s	0.225 (0.021-1.600)	0.100 (0.030-0.187)	0.157 (0.017-0.453)	0.088 (0.007-0.235)	0.168 (0.039-0.625)
<b>TKN (mg/l)</b>					
Baripada D/s	4.5 (1.7-14.6)	3.41 (1.12-5.88)	2.79 (1.38-5.04)	1.55 (0.28-3.36)	1.17 (0.84-1.40)
Balasore U/s	4.3 (0.8-18.2)	3.41 (1.68-8.40)	2.64 (1.68-3.40)	1.20 (0.28-2.24)	1.12 (0.84-1.40)
Balasore D/s	3.9 (0.8-15.6)	4.17 (1.12-9.52)	2.69 (1.68-3.92)	1.43 (0.56-3.36)	1.14 (0.84-1.40)

**Table 9.15 Chemical Oxygen Demand (COD) and Total Alkalinity**

Monitoring Station	2011	2012	2013	2014	2015
	<b>COD (mg/l)</b>				
Baripada D/s	9.8 (6.1-16.0)	9.7 (5.6-14.5)	11.8 (4.2-19.0)	10.5 (4.9-22.6)	12.9 (6.7-21.8)
Balasore U/s	9.2 (6.1-17.1)	11.9 (7.1-19.9)	10.3 (7.0-14.1)	8.2 (5.1-12.1)	8.9 (5.1-15.8)
Balasore D/s	12.0 (8.0-20.6)	17.4 (6.9-24.4)	19.0 (8.3-30.8)	14.8 (7.9-25.6)	16.1 (10.2-23.1)
<b>Total Alkalinity (as CaCO<sub>3</sub>) (mg/l)</b>					
Baripada D/s	76 (28-118)	98 (60-112)	99 (38-156)	87 (48-116)	88 (60-112)
Balasore U/s	78 (28-136)	84 (48-108)	78 (40-112)	71 (36-102)	81 (40-104)
Balasore D/s	81 (42-112)	91 (72-112)	92 (44-128)	81 (44-148)	103 (44-84)

**Table 9.16 Polluted river monitoring station in Budhabalanga river**

Sl. No.	River	Monitoring station	Annual BOD Data range (mg/l)					Range value of BOD above 3.0 mg/l in the stretch	Priority as per CPCB Criteria
			2011	2012	2013	2014	2015		
1	Budhabalanga	Balasore D/s	(1.6-2.4)	(1.3-2.8)	(1.5-3.6)	(1.1-3.2)	(0.8-3.4)	3.2-3.6	V

**Table 9.17 CWQI of Budhabalanga river and category of water quality based on CWQI values**

Monitoring station	2011	2012	2013	2014	2015
	<b>CWQI</b>				
Baripada D/s	82.54	71.87	70.46	55.38	58.34
Balasore U/s	85.39	85.33	80.86	84.45	77.52
Balasore D/s	73.92	61.04	52.22	47.96	51.79
	<b>Category</b>				
Baripada D/s	Good	Fair	Fair	Marginal	Marginal
Balasore U/s	Good	Good	Good	Good	Fair
Balasore D/s	Fair	Fair	Marginal	Marginal	Marginal

**CHAPTER - X****WATER QUALITY STATUS OF KOLAB RIVER SYSTEM**

Water quality of Kerandi river (a major tributary of Kolab river in Odisha part) is monitored at only one station, Sunabeda, which is near the water intake points of HAL and NALCO refinery and downstream of Sunabeda town to assess the impact of Sunabeda township.

**10.1 USE BASED WATER QUALITY STATUS****10.1.1 Water quality in respect of primary criteria**

The seasonal average values of pH, DO, BOD, TC and EC at the monitoring stations pertaining to the period 2011-2015 are described in Tables 10.1.

**pH and DO** : As may be seen from the data, the pH and DO values show more or less a stable pattern over the years at the monitoring station. The seasonal average value of pH varies within the range 7.0-8.0. The water at the monitoring station is fairly rich in oxygen. Both the parameters conform to the quality criteria for Class-A.

**BOD** : The seasonal average values of BOD at the monitoring station conform to Class-A during the period 2011-2015.

**TC** : Seasonal average values of TC at Sunabeda do not conform to Class-A or Class-B. During winter and post-monsoon season of the period under study, water quality with respect to TC conformed to Class-C whereas, during summer and monsoon period, TC values exhibit a wide range of fluctuation and the magnitude of deviation warrants the water quality not to qualify for Class-C.

The annual average and the range of BOD and TC values at the monitoring station are given in Table 10.2. Frequency of deviation of BOD and TC values from the stipulated values (3.0 mg/l and 5000 MPN/100 ml respectively) are also given in Table 10.2. Percent violations of BOD during the study period at Sunabeda are presented in Fig. 10.1 which indicates that the monthly BOD values at Sunabeda always conformed to Class-C. Frequency of deviation of monthly TC values from the stipulated value (5000 MPN/100 ml) is more than 28% of time during the period 2011-2015.

Spatial variation of annual average values of BOD and TC during the period 2011- 2015 are presented in Fig. 10.2 and 10.3 respectively. From the figures, it is evident that the annual average BOD values always conformed to Class A. However, the annual average of TC values during 2012, 2013 and 2014 did not meet the stipulated limit even for Class C though during 2011 and 2015, it was within the stipulated limit for Class C.

**Free Ammonia** : The annual average and range values of ammonical nitrogen and free ammonia are given in Table 10.3. Free ammonia values conform to the stipulated value (1.2 mg/l, max) for

Class-D inland surface water (Fish culture and wildlife propagation). No regular pattern is observed regarding the level of ammonia in the river.

**EC, SAR and B** : Seasonal average values of EC always remained within the stipulated limit for Class-D and E. Annual average and range values of SAR and B are given in Table 10.4. From the data, it can be seen that EC, SAR and B values are far too low compared to the stipulated values in Table 2.4, to cause any concern over its suitability for irrigation purposes.

### **10.1.2 Water quality in respect of other parameters**

**TDS and Total Hardness** : Annual average and range values of total dissolved solids (TDS) and total hardness (TH) during the period 2011- 2015 are given in Table 10.5. Water quality at the monitoring station conforms to Class-A with regard to TDS and total hardness content. In terms of degree of hardness, the river water may be described as soft (0-60 mg/l) with a very few exceptions in moderately hard (61-120 mg/l) category during the period of study.

**Nitrates** : Annual average and range values of nitrate during the period 2011- 2015 are given in Table 10.6. The annual average nitrate concentrations have never exceeded the stipulated value (20 mg/l) for Class-A water, though deviation of monthly nitrate values from the stipulated value for Class A has been observed only twice (April, 2012 and March, 2014) during the entire study period. However, the monthly nitrate concentration never exceeded the stipulated limit of 50 mg/l for Class-C.

**Chloride, Sulphates and Fluorides** : Annual average and range values of chloride, sulphate and fluoride at the monitoring station during the period 2011-2015 are given in Table 10.7. A comparison of these values with the stipulated limits for Class-A revealed that, water quality in respect of chloride, sulphate and fluoride at the station conform to the highest class.

**Heavy Metals**: Data given in Table 10.8 represent the annual average and range of concentration of chromium (VI) and mercury during the period 2014 and 2015 and annual average and range of concentrations of total chromium, iron, nickel, copper, zinc, cadmium and lead respectively during the period 2011-2015. From the table it is observed that the values of these metals are well within the respective tolerance limits.

### **10.1.3 Use Based Classification**

From the discussions made in Sec.10.1.1 and 10.1.2, it may be concluded that water quality of Kerandi river do not conform to Class-C with respect to the parameter TC.

## **10.2 BIOLOGICAL ASSESSMENT OF WATER QUALITY**

The annual average and range of biomonitoring results expressed in terms of Saprobic index (SI) and Diversity index (DI) and biological class of the the monitoring station during the period 2011-2015 are given in Table 10.9. Taking into consideration the observed biological indices and the BOD values (Tables 10.2), the river stretch along these monitoring stations are in a state of slight to moderate pollution (that is, B-C) as per the criteria given in Table 2.6.

### 10.3 WATER QUALITY IN TERMS OF WHOLESOMENESS

#### 10.3.1 Wholesomeness in terms of regular parameters

The wholesomeness of water quality at the monitoring station has been assessed with respect to general parameters specified in Table 2.7. Of the eight parameters listed in Table 2.7, results for bioassay are not available and therefore, the water quality are assessed with regard to the remaining seven parameters. Annual average and range values of (Nitrite + Nitrate)- N at the monitoring stations are given in Table 10.10. Annual average and range values of total suspended solids (TSS) including monsoon period and excluding monsoon period are given in Table 10.11. Considering pH, DO, EC, (Nitrite + Nitrate)-N values, the level of wholesomeness of the river water may be considered as “excellent”. With regard to BOD, the water level is “excellent” during most period of time. However, TSS (during non-monsoon period) and FC values (Table 10.12) exceeded the stipulated limit for “acceptable” level in most of the time period under report.

#### 10.3.2 Wholesomeness in terms of special parameters

Annual average and range values of total ammonical nitrogen ((ammonium+ammonia)-N) at all the monitoring stations are given in Table 10.3 which reveals that water quality with respect to total ammonical nitrogen are mostly within “excellent” limits during the period under study. Occasional deviations from “excellent” limit have been observed during March, 2012 and January-April, 2012.

From the annual average and range values of total phosphate-P and total Kjeldahl nitrogen given in Table 10.13, it is observed that the water quality at Sunabeda is within the acceptable limits for total phosphates-P under the period of study except on two occasions i.e. April of 2012 and 2015. Annual average values of TKN at the monitored locations remained within the acceptable limit of 3.0 mg/l during the study period though only 12% observation has been made for exceedence of monthly TKN values from the limit for “acceptable” during the entire study period.

It is seen from Table 10.8 that the annual average as well as monthly data on concentrations of metals like total chromium, zinc, copper, nickel, lead, cadmium and mercury in the river water at all station are within the “acceptable” limits.

### 10.4 WATER QUALITY IN TERMS OF COD AND ALKALINITY

Annual average and range values of COD and alkalinity values are given in Table 10.14. Both COD and alkalinity values at Sunabeda meet the tolerance limit conforming to the most of beneficial uses of the river water.

### 10.5 WATER QUALITY TREND

Kolab river is an interstate river with catchment areas in Odisha and Andhra Pradesh. The main water source of Upper Kolab Reservoir near Jeypore of Koraput district is Kolab river. Kerandi river, the major tributary of Kolab river has its origin from Mali Parbat situated near Paikajhola Gram

Panchayat in Pottangi block of Koraput district. Only two large scale industries like Hindustan Aeronautics Limited (HAL) at Sunabeda and NALCO refinery at Damanjodi exists on the either side of its bank. Small towns like Sunabeda, Semiliguda with a total population of neary 1 lakhs exists on its bank. Water quality monitoring of Kerandi river reveals no significant impact of industrial activities and domestic activites on the water quality at Sunabeda. However, instream activities on the river has increased the total coliform counts for which the water quality do not conform to Class C with respect to TC.

#### **10.6 POLLUTED RIVER MONITORING STATIONS IN KOLAB RIVER SYSTEM**

The criteria parameter BOD at Sunabeda, the only monitoring station on Kerandi river was meeting the tolerance limit of 3.0 mg/l of Class -C during the period 2011-2015 and hence is not categorized as a polluted river monitoring station with respect to BOD.

#### **8.7 WATER QUALITY INDEX OF MONITORING STATIONS IN KOLAB RIVER SYSTEM**

The Canadian Water Quality Indices (CWQI) at Sunabeda on Kerandi river are calculated for the period 2011-2015 using four critical variables such as pH, DO, BOD and TC and are given in Table 10.15. Based on the CWQI values, the water quality at Sunabeda is ranked as Fair during 2013 and 2014 and as Good during 2011, 2012 and 2015.

Fig. 10.1 Frequency of violation of BOD in Kerandi River (2011-2015)

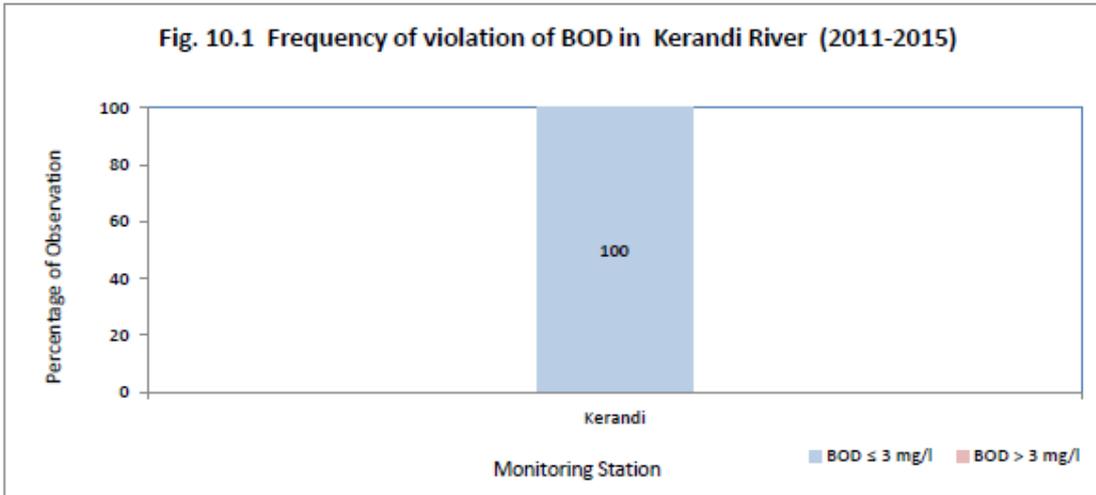


Fig. 10.2 Variation of BOD in Kerandi River (2011-2015)

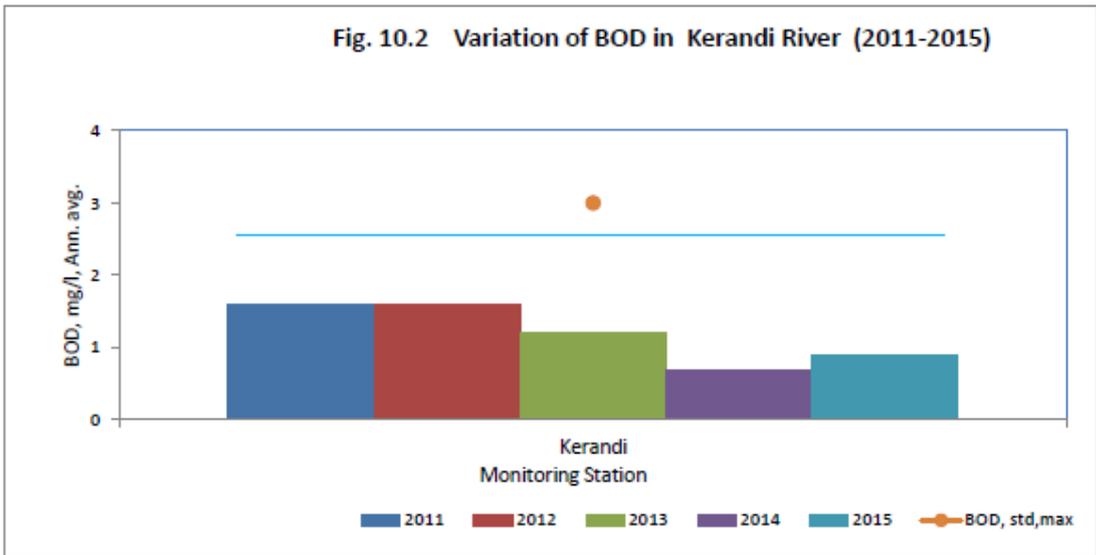
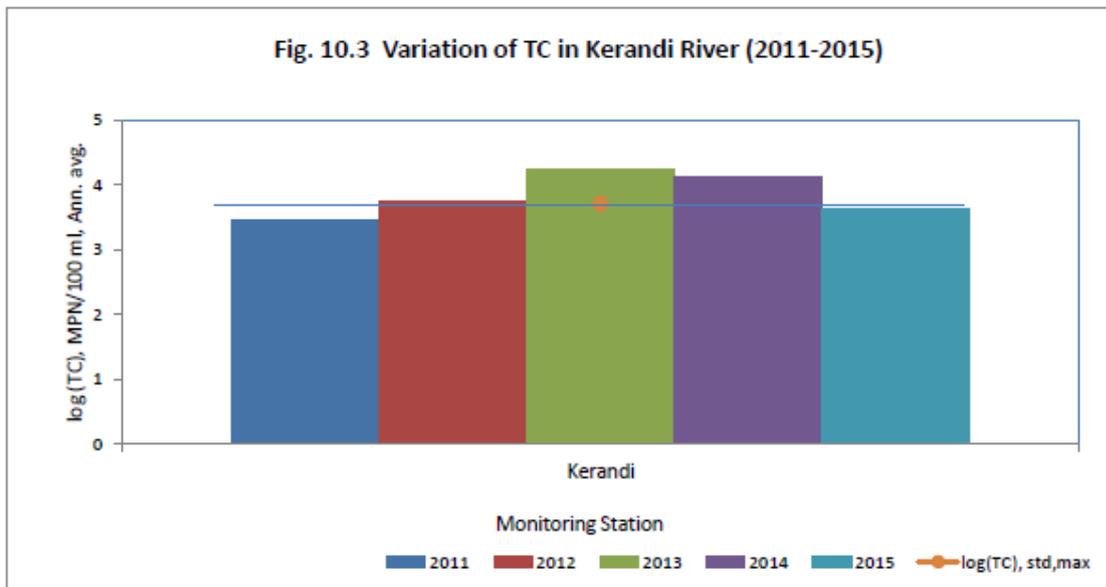


Fig. 10.3 Variation of TC in Kerandi River (2011-2015)



**Table 10.1 Seasonal average values of pH, DO, BOD, TC and EC in Kerandi river at Sunabeda**

Parameter	Year	Sunabeda			
		W	S	M	PM
pH	2011	7.8	7.4	8.0	7.4
	2012	8.0	7.3	7.4	7.8
	2013	7.7	7.6	7.4	7.5
	2014	7.3	7.4	7.0	7.1
	2015	7.3	7.6	6.9	7.7
DO (mg/l)	2011	7.0	7.1	7.2	6.8
	2012	7.1	6.9	6.6	7.1
	2013	7.2	7.2	7.4	7.7
	2014	7.5	7.0	7.4	7.4
	2015	7.3	7.6	6.9	7.7
BOD (mg/l)	2011	0.9	1.3	2.0	1.9
	2012	2.1	1.5	1.5	1.7
	2013	1.6	1.4	0.9	0.7
	2014	0.9	0.7	0.8	0.6
	2015	0.5	1.0	1.3	0.8
TC ('00) (MPN/100 ml)	2011	14.00	13.93	67.00	13.50
	2012	9.13	72.00	91.00	26.00
	2013	27.00	12.83	586.33	23.00
	2014	24.00	63.00	344.00	24.00
	2015	25.00	44.35	64.33	46.00
EC (microSiemens/cm)	2011	93	83	146	117
	2012	119	103	95	132
	2013	98	81	69	88
	2014	65	112	91	109
	2015	95	88	93	93

**Table 10.2 Annual average and range values of BOD and Total Coliform and frequency of deviation from criteria limit**

Monitoring Station	Parameter	2011	2012	2013	2014	2015
Sunabeda	BOD( mg/l)	1.6 (0.9-2.5)	1.6 (1.0-2.4)	1.2 (0.4 – 1.9)	0.7 (0.2-1.4)	0.9 (0.4-1.7)
	F*	0/12	0/12	0/11	0/11	0/12
	TC (MPN/100ml)	2743 (400-15000)	5395 (940-17000)	17512 (930 – 160000)	12772 (1300-92000)	4162 (460-16000)
	F*	1/12	4/12	2/11	5/11	4/12

\*F : Frequency of deviation (Number of deviation/ total number of observation)

**Table 10.3 Annual average and range values of Ammonical Nitrogen**

Monitoring Station	Year	Ammonical Nitrogen (mg/l)	Free ammonia-Nitrogen (mg/l)	(Ammonium+ ammonia) – Nitrogen (mg/l)
Sunabeda	2011	0.290 (0.056-0.896)	0.009 (0.001-0.031)	0.299 (0.057-0.927)
	2012	0.234 (0.112-0.840)	0.005 (0-0.013)	0.239 (0.112-0.853)
	2013	0.160 (0.056-0.330)	0.003 (0-0.007)	0.163 (0.056-0.337)
	2014	0.112 (0.056-0.168)	0.001 (0-0.003)	0.113 (0.056-0.171)
	2015	0.065 (0.056-0.168)	0.001 (0-0.004)	0.066 (0.056-0.172)

**Table 10.4 Annual average and range values of SAR and B**

Monitoring Station	Parameter	2011	2012	2013	2014	2015
Sunabeda	SAR	0.47 (0.20-0.71)	0.37 (0.22-0.53)	0.38 (0.23-0.52)	0.36 (0.20-0.46)	0.33 (0.23-0.48)
	B (mg/l)	0.048 (0.004-0.151)	0.040 (0.004-0.125)	0.072 (0.003-0.230)	0.058 (0.012-0.134)	0.011 (0.003-0.025)

**Table 10.5 Annual average and range values of TDS and Total Hardness**

Monitoring Station	Parameter	2011	2012	2013	2014	2015
Sunabeda	TDS (mg/l)	69 (43-99)	67 (44-93)	49 (32-63)	57 (40-100)	53 (44-62)
	TH (as CaCO <sub>3</sub> ) (mg/l)	43 (20-58)	43 (28-76)	32 (16-84)	30 (16-68)	30 (18-38)

**Table 10.6 Annual average and range values of Nitrate (as NO<sub>3</sub>)**

Monitoring Station	2011	2012	2013	2014	2015
Sunabeda	<b>Nitrate (as NO<sub>3</sub>) (mg/l)</b>				
	2.941 (0.106-17.023)	6.08 (1.19-22.09)	2.975 (0.115-9.765)	6.979 (0.868-37.412)	2.821 (0.429-7.578)

Table 10.7 Annual average and range values of Chloride, Sulphate and Fluoride

Monitoring Station	Parameter	2011	2012	2013	2014	2015
Sunabeda	Chloride (mg/l)	10.0 (5.0-13.5)	9.1 (4.6-12.6)	8.4 (4.6-13.7)	8.0 (5.9-9.8)	7.6 (5.9-10.8)
	Sulphate (mg/l)	5.61 (0.32-18.39)	6.7 (0.9-24.3)	5.86 (1.49-11.81)	5.5 (3.1-11.2)	6.7 (3.0-18.8)
	Fluoride (mg/l)	0.165 (0.095-0.247)	0.149 (0.092-0.289)	0.206 (0.084-0.777)	0.154 (0.078-0.315)	0.254 (0.120-0.392)

Table 10.8 Annual average and range values of Metals

Monitoring Station	Parameter	Sunabeda				
		2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
		(mg/l)				
Sunabeda	Chromium (VI)	-	-	-	0.014 (<0.002-0.033)	0.015 (0.000-0.042)
	Chromium (Total)	0.041 (0.005-0.110)	0.020 (0.007-0.048)	0.026 (0.002-0.060)	0.046 (0.005-0.078)	0.043 (0.013-0.087)
	Iron	2.805 (0.580-13.133)	6.88 (1.20-24.42)	3.752 (0.710-12.921)	2.828 (0.051-10.175)	3.033 (0.710-7.780)
	Nickel	0.002 (0.001-0.004)	0.005 (0.002-0.007)	0.002	0.011 (0.011-0.012)	0.012 (0.003-0.027)
	Copper	0.004 (0.002-0.007)	0.004 (0.002-0.007)	0.003	0.005 (0.004-0.006)	0.006 (0.001-0.011)
	Zinc	0.005 (0.001-0.012)	0.004 (0.002-0.008)	0.004	0.010 (0.008-0.012)	0.010 (0.003-0.015)
	Cadmium	0.002 (<0.001-0.004)	0.002 (0.001-0.003)	0.001	0.0009 (0.0008-0.0009)	0.0021 (0.0004-0.0050)
	Mercury	-	-	-	0.00015 (<0.00006-0.00083)	0.00015 (<0.00006-0.00070)
	Lead	0.004 (0.002-0.009)	0.006 (0.004-0.008)	0.006	0.006 (0.003-0.009)	0.010 (0.002-0.018)

\* Data for the period February, 2013 for parameters like nickel, copper, zinc, cadmium and lead

# Data for the period February and March, 2014 for parameters like nickel, copper, zinc, cadmium and lead

## Data for the period April-December, 2015 for parameters like nickel, copper, zinc, cadmium and lead

**Table 10.9 Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class**

Monitoring station	SI-Range				
	2011	2012	2013	2014	2015
Sunabeda	5.8 (5.1-6.5)	5.7 (5.5-5.8)	6.05 (5.30-6.75)	6.00 (5.60-6.40)	6.1 (5.8-6.4)
	DI-Range				
	0.5 (0.4-0.7)	0.58 (0.40-0.75)	0.59 (0.46-0.75)	0.70 (0.58-0.81)	0.67 (0.63-0.71)
	Biological Class				
	B – C	C	B-C	B-C	B-C

**Table 10.10 Annual average and range values of Nitrite+Nitrate)-Nitrogen**

Monitoring Station	2011	2012	2013	2014	2015
	(Nitrite + Nitrate)- Nitrogen (mg/l)				
Sunabeda	0.664 (0.024-3.844)	1.373 (0.269-4.988)	0.672 (0.026-2.205)	1.576 (0.196-8.448)	0.637 (0.097-1.711)

**Table 10.11 Annual average and range values Total Suspended Solids (TSS)**

Monitoring Station		2011	2012	2013	2014	2015
		TSS (mg/l)				
Sunabeda	IM	89 (5-296)	121 (20-344)	211 (28-1596)	60 (10-334)	29 (6-60)
	NM	63 (5-140)	108 (20-344)	72 (28-240)	32 (10-105)	22 (6-50)

Note : IM : Including Monsoon period

NM : Non-monsoon period (i.e. excluding the months July, August and September)

**Table 10.12 Percentage violation and Annual range of Fecal coliform values**

Monitoring Station	Percentage Violation of FC values (Range of FC values in '000 MPN/100 ml)				
	2011	2012	2013	2014	2015
Sunabeda	8 (0.170-4.300)	42 (0.460-11.000)	25 (0.330-160.000)	33 (0.330-35.000)	33 (0.130-16.000)

**Table 10.13 Annual average and range values Total Phosphate-P and Total Kjeldahl Nitrogen (TKN)**

Monitoring Station	Parameter	2011	2012	2013	2014	2015
Sunabeda	Total Phosphate-P (mg/l)	0.079 (0.011-0.305)	0.088 (0.012-0.392)	0.075 (0.006-0.299)	0.056 (0.011-0.242)	0.148 (0.036-0.803)
	TKN (mg/l)	2.70 (0.84-8.40)	2.0 (0.12-4.48)	1.68 (1.10-3.10)	1.27 (0.56-2.52)	1.14 (0.84-1.40)

**Table 10.14 Annual average and range values Chemical Oxygen Demand (COD) and Total Alkalinity**

Monitoring Station	Parameter	2011	2012	2013	2014	2015
Sunabeda	COD (mg/l)	13.4 (8.2-20.9)	11.9 (5.8-23.6)	13.0 (6.9-26.0)	8.4 (3.3-19.7)	9.1 (5.3-15.8)
	Total Alkalinity as CaCO <sub>3</sub> (mg/l)	40 (24-70)	38 (24-76)	29 (12-104)	29 (19-72)	26 (16-34)

**Table 10.15 CWQI of Kolab river system and category of water quality based on CWQI values**

Monitoring Station	2011	2012	2013	2014	2015
	<b>CWQI</b>				
Sunabeda	85.29	83.60	71.53	76.10	84.21
<b>Category</b>					
	Good	Good	Fair	Fair	Good

**CHAPTER – XI****WATER QUALITY STATUS OF VANSADHARA RIVER SYSTEM**

Water quality of Vansadhara river is monitored at two stations, such as, downstream of Muniguda town and downstream of Gunupur town.

**11.1 USE BASED WATER QUALITY STATUS****11.1.1 Water quality in respect of primary criteria**

The seasonal average values of pH, DO, BOD, TC and EC at the two monitoring stations on Vansadhara river pertaining to the period 2011-2015 are described in Tables 11.1.

**pH and DO** : As may be seen from the data, the pH and DO values show more or less a stable pattern over the years at the monitoring stations. The seasonal average values of pH vary within the range 7.5-8.3 at Muniguda and within the range 7.0-8.3 at Gunupur. The water at both the monitoring stations is fairly rich in oxygen. Both the parameters conform to the quality criteria for Class-A.

**BOD** : The seasonal average values of BOD at the monitoring station conform to Class-A during the period 2011-2015 except on two occasions at Gunupur (Winter, 2012 and Winter, 2013). However, BOD at both the stations always conformed to Class-C.

**TC** : Seasonal average values of TC at Muniguda and Gunupur generally do not conform to Class-A or Class-B. However, the average values conform to Class-C for 80% of total observations at Muniguda and for 55% of total observations at Gunupur.

The annual average and the range of BOD and TC values at the monitoring stations are given in Table 11.2. Frequency of deviation of BOD and TC values from the stipulated values (3.0 mg/l and 5000 MPN/100 ml respectively) are also given in Table 11.2. Percent violations of BOD during the study period are presented in Fig. 11.1 which indicates that BOD values at both the stations conformed to Class-C during the study period. Frequency and magnitude of deviation of monthly TC values from the stipulated value for Class-C revealed that water quality conformed to Class-C during 2011 and 2012 but did not conform to Class-C during 2013, 2014 and 2015.

Spatial variation of annual average values of BOD and TC during the period 2011- 2015 are presented in Fig. 11.2 and 11.3 respectively. From the figures, it is evident that the annual average BOD values always conformed to Class-A. However, the annual average of TC values

during 2013, 2014 and 2015 did not meet the stipulated limit even for Class-C though during 2011 and 2012, it was within the stipulated limit for Class-C.

**Free Ammonia** : The annual average and range values of ammonical nitrogen and free ammonia are given in Table 11.3. Free ammonia values at all stations conform to the stipulated value (1.2 mg/l, max) for Class-D inland surface water (Fish culture and wildlife propagation). No regular pattern is observed regarding the level of ammonia in the river.

**EC, SAR and B** : Seasonal average values of EC always remained within the stipulated limit for Class-D and E. Annual average and range values of SAR and B are given in Table 11.4. From the data, it can be seen that EC, SAR and B values are far too low compared to the stipulated values in Table 2.4, to cause any concern over its suitability for irrigation purposes.

### 11.1.2 Water quality in respect of Other Parameters

**TDS and Total Hardness** : Annual average and range values of total dissolved solids (TDS) and total hardness (TH) during the period 2011- 2015 are given in Table 11.5. Water quality at the monitoring stations conformed to Class-A with regard to TDS and total hardness content. In terms of degree of hardness, the river water may be described as soft (0-60 mg/l) with a very few exceptions in moderately hard (61-120 mg/l) category during the period of study.

**Nitrates** : Annual average and range values of nitrate during the period 2011- 2015 are given in Table 11.6. The annual average nitrate concentrations have never exceeded the stipulated value (20 mg/l) for Class-A water.

**Chloride, Sulphates and Fluorides** : Annual average and range values of chloride, sulphate and fluoride at the monitoring stations during the period 2011-2015 are given in Table 11.7. A comparison of these values with the stipulated limits for Class-A revealed that, water quality in respect of chloride, sulphate and fluoride at all stations conform to the highest class.

**Heavy Metals**: Data given in Table 11.8 represent the annual average and range of concentration of chromium (VI) and mercury during the period 2014 and 2015 and annual average and range of concentrations of total chromium, iron, nickel, copper, zinc, cadmium and lead respectively during the period 2011-2015. From the table it is observed that the values of these metals are well within the respective tolerance limits.

### 11.1.3 Use based classification

From the discussions made in Sec.11.1.1 and 11.1.2, it may be concluded that water quality of Vansadhara river at Munigida and Gunupur conform to Class-C during 2011, 2012.

However, due to increased TC values, water quality of the river at both the stations did not conform to Class-C.

## 11.2 BIOLOGICAL ASSESSMENT OF WATER QUALITY

The annual average and range of biomonitoring results expressed in terms of Saprobic index (SI) and Diversity index (DI) and biological class of Vansadhara river at both the monitoring stations during the period 2011-2015 are given in Table 11.9. Taking into consideration the observed biological indices and the BOD values (Tables 11.2), the river stretch along these monitoring stations are in a state of slight to moderate pollution (that is, B-C) as per the criteria given in Table 2.6.

## 11.3 WATER QUALITY IN TERMS OF WHOLESOMENESS

### 11.3.1 Wholesomeness in terms of regular parameters

The wholesomeness of water quality at the monitoring stations has been assessed with respect to general parameters specified in Table 2.7. Of the eight parameters listed in Table 2.7, results for bioassay are not available and therefore, the water quality are assessed with regard to the remaining seven parameters. Annual average and range values of (Nitrite + Nitrate)-N at the monitoring stations are given in Table 11.10. Annual average and range values of total suspended solids (TSS) including monsoon period and excluding monsoon period are also given in Table 11.11. Considering pH, DO, EC, (Nitrite + Nitrate)-N values, the level of wholesomeness of the river water may be considered as “excellent”. With regard to BOD, the water level is “excellent” during most period of time. However, water quality with regard to the TSS (during non-monsoon period) and FC values (Table 11.12) most of the time exceeded the stipulated limit for “acceptable” level.

### 11.3.2 Wholesomeness in terms of special parameters

Annual average and range values of total ammonical nitrogen ((ammonium+ammonia)-N) at all the monitoring stations are given in Table 11.3 which reveals that water quality with respect to total ammonical nitrogen are mostly within “desirable” limits during the period under study.

From the annual average and range values of total phosphate-P and total Kjeldahl nitrogen are given in Table 11.13. It is observed that the water quality at both the stations conformed to “desirable” level during the study period, except 2 % of time at Muniguda and 9% of time at Gunupur. TKN values at the monitored locations did not meet the acceptable limit of 3.0 mg/l in most part of the study during 2011-2013.

It is seen from Table 11.8 that the annual average as well as monthly data on concentrations of metals like total chromium, zinc, copper, nickel, lead, cadmium and mercury in the river water at all station are within the “acceptable” limits.

#### **11.4 WATER QUALITY IN TERMS OF COD AND ALKALINITY**

Annual average and range values of COD and alkalinity values are given in Table 11.14. Both COD and alkalinity values at both the stations meet the tolerance limit conforming to the most of beneficial uses of the river water.

#### **11.5 WATER QUALITY TREND**

Vansadhara river is an interstate river with catchment areas in Odisha and Andhra Pradesh. The river flows mainly through hilly areas in Odisha and enters Andhra Pradesh at Kashinagar. Only one major industry, i.e. M/s Vedanta Alumina Limited, at Lanjigarh exists on its bank. Small towns like Muniguda and Gunupur exists on its bank.

Water quality monitoring of Vansadhara river reveals no significant impact of industrial activities and domestic activities on the water quality at Muniguda and Gunupur. However, instream activities on the river has increased the total coliform counts for which the water quality do not conform to Class-C with respect to TC during 2013, 2014 and 2015.

#### **11.6 POLLUTED RIVER MONITORING STATIONS IN VANSADHARA RIVER**

The criteria parameter BOD at Muniguda and Gunupur, the two monitoring stations on Vansadhara river was meeting the tolerance limit of 3.0 mg/l of Class C during the period 2011-2015 and hence there are no polluted river monitoring station in Vansadhara river with respect to BOD.

#### **11.7 WATER QUALITY INDEX OF MONITORING STATIONS IN VANSADHARA RIVER**

The Canadian Water Quality Indices (CWQI) at Muniguda and Gunupur are calculated for the period 2011-2015 (Table 11.15) using four critical variables such as pH, DO, BOD and TC. Based on the CWQI values, the water quality at Muniguda is ranked as Good-Excellent whereas, water quality at Gunupur has been ranked as Fair-Good during the study period.

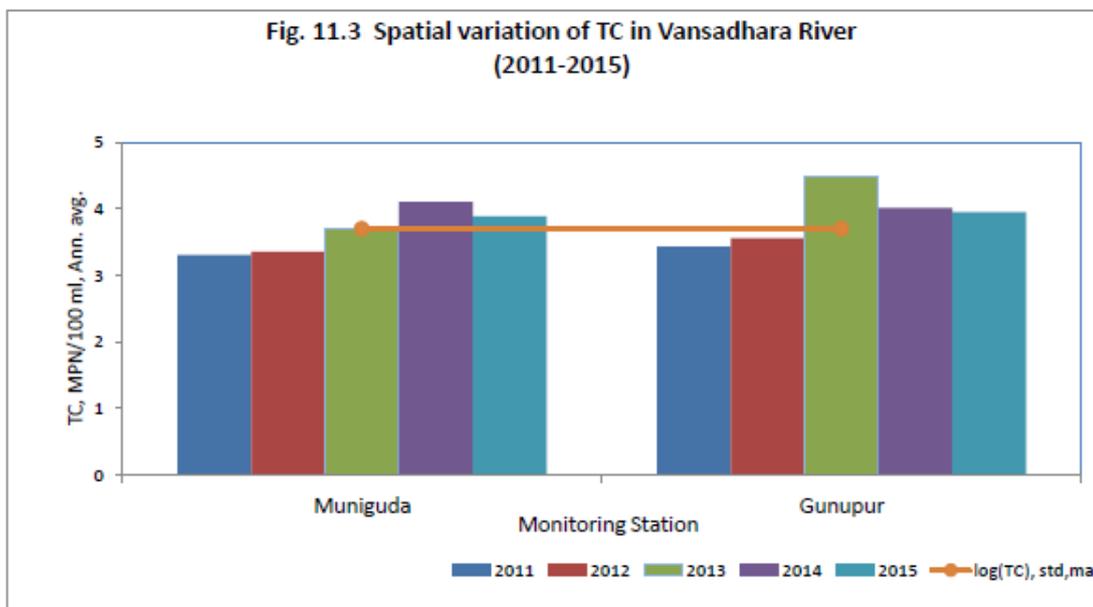
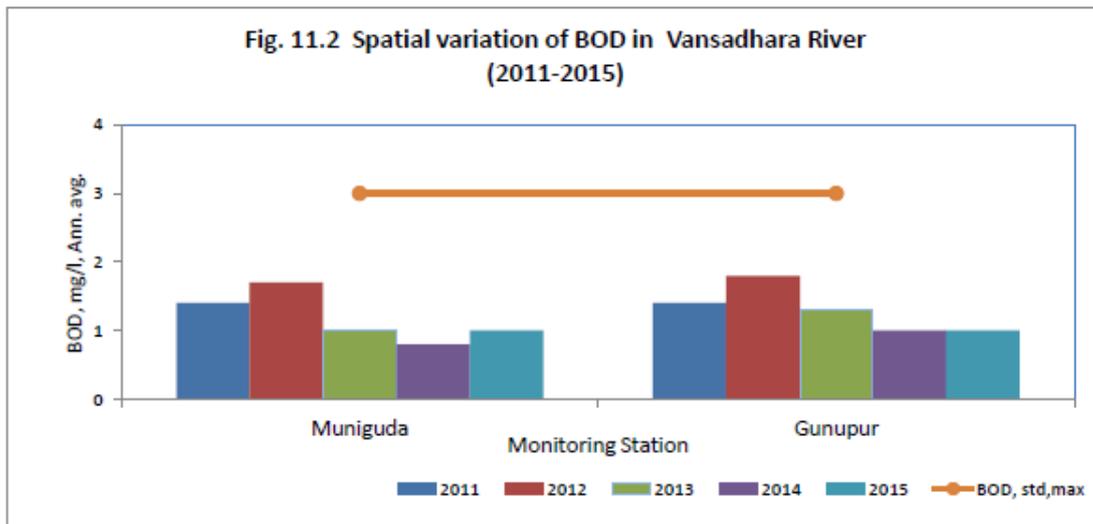
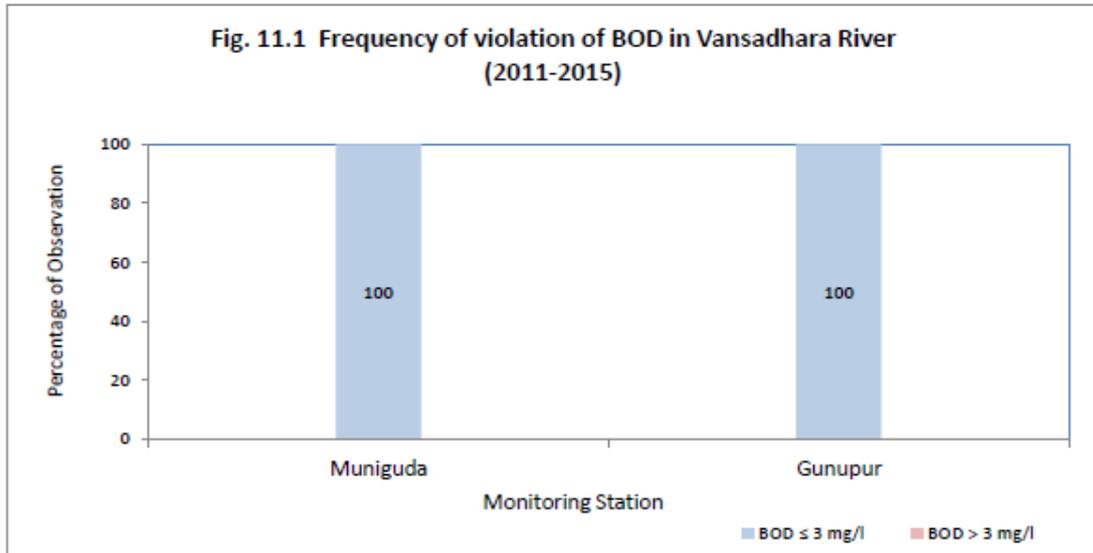


Table 11.1 Seasonal average values of pH, DO, BOD TC in Vansadhara river at Muniguda and Gunupur

Parameter	Year	Muniguda				Gunupur			
		W	S	M	PM	W	S	M	PM
pH	2011	8.2	7.8	8.1	7.9	8.0	8.1	7.8	8.1
	2012	8.2	8.3	7.7	8.1	8.2	8.1	8.2	7.0
	2013	7.5	8.0	8.0	7.9	8.1	7.7	8.1	8.0
	2014	8.2	8.1	7.7	7.9	8.1	7.9	7.8	7.8
	2015	8.0	8.1	7.8	8.3	8.1	7.9	7.6	8.3
DO (mg/l)	2011	7.6	7.5	7.2	6.7	7.4	7.6	7.3	6.8
	2012	7.2	7.1	7.1	7.5	7.1	7.0	6.8	7.2
	2013	7.2	7.1	7.3	7.8	7.2	7.0	7.2	7.8
	2014	7.3	7.1	7.7	7.8	7.5	7.0	7.7	8.0
	2015	7.5	7.6	7.4	6.8	7.5	7.6	7.2	6.9
BOD (mg/l)	2011	0.8	0.9	2.0	1.8	0.8	1.1	1.8	1.7
	2012	1.6	1.7	1.8	1.7	2.1	1.9	2.0	1.1
	2013	1.7	1.2	0.7	1.3	2.2	1.5	1.0	0.5
	2014	0.6	0.6	1.3	0.4	1.2	1.3	1.2	0.4
	2015	0.8	1.2	0.9	1.2	1.2	1.3	0.9	0.5
TC ('00) (MPN/100 ml)	2011	27.00	8.58	44.10	8.90	14.00	13.15	67.00	9.00
	2012	19.13	28.75	24.30	11.00	26.00	40.25	62.00	8.65
	2013	15.33	14.95	146.67	16.00	19.80	8.43	1093.00	33.00
	2014	1.70	19.48	393.33	57.00	3.30	14.98	186.33	240.00
	2015	13.07	23.50	240.00	22.00	21.67	52.50	185.00	79.00
Cond., $\mu\text{S/cm}$	2011	183	207	185	182	239	249	178	187
	2012	194	194	172	175	216	281	166	168
	2013	223	271	171	165	232	228	169	143
	2014	166	182	140	179	206	214	161	194
	2015	198	187	169	188	237	220	144	179

**Table 11.2 Annual average and range values of BOD (mg/l) and Total Coliform (MPN/100 ml) and frequency of deviation from criteria limit**

Monitoring Station	Parameter	2011	2012	2013	2014	2015
Muniguda	BOD	1.4 (0.6-2.8)	1.7 (1.2-2.1)	1.0 (0.4-2.0)	0.8 (0.4-2.0)	1.0 (0.2-2.3)
	F*	0/12	0/12	0/11	0/11	0/12
	TC	1998 (400-7900)	2249 (490-4700)	5153 (790- 24000)	12742 (170-92000)	7693 (330-35000)
	F*	1/12	0/12	3/11	4/11	4/12
Gunupur	BOD	1.4 (0.8-2.4)	1.8 (0.9-2.9)	1.3 (0.3-2.3)	1.0 (0.3-2.2)	1.0 (0.4-2.7)
	F*	0/12	0/12	0/11	0/11	0/12
	TC	2724 (460-9400)	3648 (790-9200)	31170 (490- 160000)	10275 (330-35000)	8917 (1300-28000)
	F*	2/12	2/12	3/11	5/11	6/12

\*F : Frequency of deviation (Number of deviation/ total number of observation)

**Table 11.3 Annual average and Range Values of Ammonical Nitrogen**

Monitoring Stations	Ammonical Nitrogen	Free ammonia-Nitrogen	(Ammonium + ammonia)- Nitrogen
	<b>(mg/l)</b>		
	<b>2011</b>		
Muniguda	0.208 (0.056-0.728)	0.016 0.003-0.049	0.224 (0.059-0.777)
Gunupur	0.278 (0.056-0.672)	0.016 0.005-0.047	0.294 (0.061-0.719)
	<b>2012</b>		
Muniguda	0.215 (0.112-0.730)	0.015 (0-0.058)	0.230 (0.112-0.788)
Gunupur	0.178 (0.112-0.336)	0.010 (0-0.033)	0.188 (0.112-0.369)
	<b>2013</b>		
Muniguda	0.261 (0.112-0.550)	0.016 (0-0.069)	0.277 (0.128-0.619)
Gunupur	0.317 (0.112-0.666)	0.018 (0-0.053)	0.335 (0.112-0.719)
	<b>2014</b>		
Muniguda	0.122 (0.056-0.224)	0.008 (0.002-0.028)	0.130 (0.058-0.0252)
Gunupur	0.122 (0.056-0.168)	0.006 (0.002-0.021)	0.128 (0.058-0.0189)
	<b>2015</b>		
Muniguda	0.061 (0.056-0.112)	0.004 (0.001-0.009)	0.065 (0.057-0.121)
Gunupur	0.061 (0.056-0.112)	0.004 (0.0-0.009)	0.065 (0.056-0.121)

Table 11.4 Annual average and Range Values of SAR and B

Monitoring station	SAR				
	2011	2012	2013	2014	2015
Muniguda	0.42 (0.06-0.86)	0.41 (0.22-1.19)	0.40 (0.22-0.63)	0.35 (0.25-0.51)	0.38 (0.30-0.52)
Gunupur	0.34 (0.03-0.66)	0.39 (0.20-0.67)	0.34 (0.22-0.45)	0.37 (0.25-0.52)	0.36 (0.22-0.47)
	B (mg/l)				
Muniguda	0.049 (0.004-0.174)	0.044 (0.011-0.128)	0.062 (0.003-0.158)	0.078 (0.006-0.231)	0.030 (0.006-0.071)
Gunupur	0.090 (0.008-0.242)	0.040 (0.004-0.098)	0.070 (0.007-0.366)	0.065 (0.009-0.205)	0.047 (0.01-0.138)

Table 11.5 Annual average and Range Values of TDS and Total Hardness

Monitoring station	2011	2012	2013	2014	2015
	TDS				
Muniguda	118 (102-149)	114 (94-137)	125 (87-189)	97 (72-122)	105 (88-118)
Gunupur	153 (103-388)	131 (88-230)	118 (72-197)	110 (88-134)	113 (76-158)
	Total Hardness (mg/l)				
Muniguda	79 (64 – 88)	78 (66-110)	76 (48-124)	62 (36-86)	70 (52-78)
Gunupur	77.5 (58-120)	86 (48-156)	74 (42-120)	72 (40-86)	76 (48-116)

Table 11.6 Annual average and Range Values of Nitrate (as NO<sub>3</sub>)

Monitoring Station	2011	2012	2013	2014	2015
	NO <sub>3</sub> (mg/l)				
Muniguda	2.44 (0.044-16.275)	1.56 (0.38-3.93)	3.154 (0.093-18.348)	2.992 (0.877-15.270)	4.148 (0.553-7.591)
Gunupur	2.321 (0.079-13.002)	4.76 (0.18-18.57)	3.348 (0.748-14.610)	4.559 (0.522-19.596)	5.146 (0.850-9.854)

Table 11.7 Annual average and Range Values of Chloride, Sulphate and Fluoride

Monitoring station	2011	2012	2013	2014	2015
<b>Chloride (mg/l)</b>					
Muniguda	12.4 (6.8 – 18.7)	13.6 (7.8-35.4)	12.9 (6.8-27.2)	8.98 (5.88-12.72)	10.03 (7.82-13.7)
Gunupur	13.0 (8.8-22)	13.9 (8.6-32.3)	10.9 (5.6-20.7)	9.70 (6.86-12.72)	9.62 (5.87-13.69)
<b>Sulphate (mg/l)</b>					
Muniguda	4.68 (0.65-10.11)	5.4 (0.9-14.4)	5.54 (0-21.34)	5.49 (0.37-14.42)	7.2 (3.5-14.3)
Gunupur	10.3 (2.04-39.8)	6.5 (0.9-17.9)	6.2 (1.6-21.3)	7.8 (1.0-15.5)	10.5 (1.9-21.1)
<b>Fluoride (mg/l)</b>					
Muniguda	0.24 (0.19-0.346)	0.255 (0.142-0.313)	0.210 (0.142 -0.263)	0.247 (0.160-0.432)	0.446 (0.180-1.100)
Gunupur	0.246 (0.194-0.352)	0.251 (0.154-0.363)	0.247 (0.137-0.398)	0.252 (0.161-0.405)	0.301 (0.180-0.408)

Table 11.8 Annual average and Range Values of Metals (mg/l)

Parameter	Muniguda				
	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
<b>(mg/l)</b>					
Chromium (VI)	-	-	-	0.016 (<0.002-0.033)	0.016 (<0.002-0.040)
Chromium (Total)	0.024 (0.002-0.065)	0.023 (0.017-0.032)	0.049 (0.006-0.270)	0.050 (0.022-0.090)	0.053 (0.008-0.131)
Iron	5.639 (0.283-18.182)	1.82 (0.35-5.00)	3.524 (0.288-8.952)	3.022 (0.082-7.574)	2.333 (0.030-6.880)
Nickel	0.003 (0.001-0.007)	0.010 (0.003-0.023)	0.002	0.015 (0.014-0.017)	0.012 (0.004-0.023)
Copper	0.004 (0.001-0.008)	0.004 (0.002-0.006)	0.001	0.008 (0.008-0.008)	0.005 (0.001-0.008)
Zinc	0.006 (0.002-0.010)	0.004 (0.002-0.007)	0.008	0.015 (0.012-0.018)	0.009 (0.002-0.017)
Cadmium	0.002 (<0.001-0.004)	0.002 (0.001-0.003)	0.001	0.0010 (0.0009-0.0016)	0.0021 (0.0004-0.0056)
Mercury	-	-	-	0.0003 (<0.00006-0.00070)	0.00016 (<0.00006-0.00057)
Lead	0.005 (0.002-0.010)	0.007 (0.003-0.008)	0.005	0.007 (0.007-0.008)	0.009 (0.002-0.017)

\* Data for the period February, 2013 for parameters like nickel, copper, zinc, cadmium and lead

# Data for the period February and March, 2014 for parameters like nickel, copper, zinc, cadmium and lead

## Data for the period April-December, 2015 for parameters like nickel, copper, zinc, cadmium and lead

Table 11.8 contd..

Parameter	Gunupur				
	2011	2012	2013*	2014 <sup>#</sup>	2015 <sup>##</sup>
	(mg/l)				
Chromium (VI)	-	-	-	0.019 (0.002-0.048)	0.017 (<0.002-0.036)
Chromium (Total)	0.035 (0.006-0.142)	0.024 (0.012-0.034)	0.029 (0.003-0.067)	0.075 (0.005-0.217)	0.059 (0.007-0.146)
Iron	6.085 (0.340-19.219)	5.36 (0.50-32.0)	4.871 (0.460-12.593)	3.824 (0.541-8.600)	3.477 (0.120-6.870)
Nickel	0.003 (0.001-0.005)	0.007 (0.002-0.010)	0.002	0.019 (0.018-0.019)	0.015 (0.004-0.029)
Copper	0.005 (<0.001-0.008)	0.004 (0.001-0.006)	0.002	0.007 (0.006-0.008)	0.008 (<0.001-0.018)
Zinc	0.005 (0.001-0.012)	0.006 (0.002-0.011)	0.009	0.019 (0.014-0.024)	0.009 (0.001-0.016)
Cadmium	0.002 (<0.001-0.004)	0.002 (<0.001-0.003)	0.001	0.0013 (0.0012-0.0014)	0.0029 (0.0004-0.0058)
Mercury	-	-	-	0.0002 (<0.00006-0.00038)	0.00022 (<0.00006-0.00057)
Lead	0.004 (0.002-0.008)	0.007 (0.002-0.010)	0.008	0.011 (0.009-0.012)	0.013 (0.002-0.034)

\* Data for the period February, 2013 for parameters like nickel, copper, zinc, cadmium and lead

# Data for the period February and March, 2014 for parameters like nickel, copper, zinc, cadmium and lead

## Data for the period April-December, 2015 for parameters like nickel, copper, zinc, cadmium and lead

Table 11.9 Annual average and Range of Saprobic Index (SI) , Diversity Index (DI) values (DI) and Biological Class

Monitoring station	SI-Range				
	2011	2012	2013	2014	2015
Muniguda	6.2 (6.0-6.5)	6.2 (5.8-6.6)	6.32 (6.20-6.50)	6.21 (6.00-6.42)	6.3 (6.2-6.5)
Gunupur	6.2 (6.0-6.5)	5.83 (5.8-6.0)	6.03 (5.80-6.20)	5.60 (5.60-5.60)	6.2 (5.8-6.6)
	DI-Range				
Muniguda	0.4 (0.2-0.6)	0.75 (0.58-0.85)	0.58 (0.52-0.65)	0.57 (0.47-0.66)	0.62 (0.52-0.83)
Gunupur	0.6 (0.4-0.8)	0.56 (0.41-0.63)	0.75 (0.63-0.88)	0.49 (0.40-0.57)	0.55 (0.40-0.70)
	Biological Class				
Muniguda	B – C	B	B	B-C	B
Gunupur	B – C	C	B-C	C	B-C

Table 11.10 Annual average and Range Values of (Nitrite+Nitrate)-Nitrogen

Monitoring station	2011	2012	2013	2014	2015
	<b>(Nitrite+Nitrate)-Nitrogen (mg/l)</b>				
Muniguda	0.551 (0.010- 3.675)	0.353 (0.086- 0.887)	0.700 (0.021- 4.143)	0.676 (0.198- 3.448)	0.937 (0.125- 1.714)
Gunupur	0.524 (0.018- 2.936)	1.075 (0.040 - 4.192)	0.738 (0.169- 3.299)	1.029 (0.118- 4.425)	1.162 (0.192- 2.225)

Table 11.11 Annual average and Range Values of Total Suspended Solids (TSS)

Monitoring station		TSS (mg/l)				
		2011	2012	2013	2014	2015
Muniguda	IM	148 (10 -1172)	59 (24-152)	120 (24-334)	105 (8-511)	35 (4-122)
	NM	40 (10-110)	43 (24-86)	105 (24-200)	23 (8-50)	21 (4-62)
Gunupur	IM	337 (18-2328)	165 (28-592)	111 (8-368)	81 (6-377)	41 (6- 87)
	NM	92 (18-260)	100 (28-368)	110 (8-368)	46 (6-120)	30 (6-85)

Note : IM : Including Monsoon period

NM : Non-monsoon period (i.e. excluding the months July, August and September)

Table 11.12 Annual Range Values and Percentage violation of Fecal coliform

Monitoring Station	Percentage Violation of FC values (Range of FC values in '000 MPN/100 ml)				
	2011	2012	2013	2014	2015
Muniguda	17 (0.170- 2.300)	25 (0.093- 2.700)	18 (0.230- 7.900)	36 (0.068- 24.000)	33 (0.130- 17.000)
Gunupur	17 (0.110- 4.900)	33 (0.330- 3.300)	45 (0.170- 160.000)	64 (0.130- 13.000)	58 (0.330- 17.000)

**Table 11.13 Annual average and Range Values of Total Phosphate-P and Total Kjeldahl Nitrogen (TKN)**

Monitoring station	2011	2012	2013	2014	2015
	<b>Total Phosphate-P (mg/l)</b>				
Muniguda	0.064 (0.008-0.181)	0.045 (0.008-0.095)	0.150 (0.020-0.388)	0.084 (0.006-0.359)	0.128 (0.045-0.299)
Gunupur	0.066 (0.021-0.111)	0.072 (BDL-0.319)	0.130 (0.021-0.344)	0.159 (0.009-0.552)	0.120 (0.019-0.344)
	<b>TKN (mg/l)</b>				
Muniguda	4.4 (0.6-12.3)	3.06 (1.12-8.96)	2.46 (1.68-3.10)	1.12 (0.56-1.68)	1.10 (0.84-1.68)
Gunupur	3.4 (0.84-10.36)	3.57 (1.12-14.0)	2.48 (0.84-3.92)	1.04 (0.28-1.40)	1.12 (0.84-1.40)

**Table 11.14 Annual average and Range Values of Chemical Oxygen Demand (COD) and Total Alkalinity**

Monitoring station	2011	2012	2013	2014	2015
	<b>COD (mg/l)</b>				
Muniguda	9.5 (5.7-20.8)	11.2 (6.0-26.9)	11.5 (7.3-22.0)	10.0 (4.0-21.7)	11.1 (3.8-36.6)
Gunupur	11.8 (6.2-19.5)	13.6 (6.0-24.1)	13.3 (5.5-22.0)	14.1 (4.0-26.0)	11.4 (5.4-21.7)
	<b>Total Alkalinity (as CaCO<sub>3</sub>) (mg/l)</b>				
Muniguda	84 (72 – 100)	84 (60-124)	87 (36-138)	67 (32-90)	75 (48-88)
Gunupur	83 (56-152)	91 (54-156)	81 (44-140)	76 (48-92)	78 (32-124)

**Table 11.15 CWQI of Vansadhara river and category of water quality based on CWQI values**

Monitoring station	2011	2012	2013	2014	2015
	<b>CWQI</b>				
Muniguda	85.48	100.00	83.60	84.64	81.14
Gunupur	85.21	85.29	62.94	78.00	79.63
	<b>Category</b>				
Muniguda	Good	Excellent	Good	Good	Good
Gunupur	Good	Good	Fair	Fair	Fair

**CONCLUSION**

Water quality assessment of Mahanadi river system, Brahmani river system, Baitarani river system, Rushikulya river, Nagavali river, Subarnarekha river, Budhabalanga river, Kolab river system and Vansadhara river during the period 2011-2015 are discussed in Chapters III-XI. Water quality assessment are done on the basis of use based classification, biological assessment and wholesomeness. From the discussions, it is observed that water quality of the rivers at all the monitoring stations conformed to Class-D (Fish Culture and wild life propagation). Except the monitoring stations located close to muhans of the rivers, like Paradeep U/s, Paradeep D/s on Mahanadi river, Chandbali U/s and Chandbali D/s on Baitarani river, Dhamra on Dhamra river and Potagarh on Rushikulya river, all other stations conformed to the quality requirements for Class-E (Irrigation water quality).

No station conformed to Class-A (drinking water source without conventional treatment but after disinfection) because of high total coliform bacterial counts. Similarly, most of the monitoring stations do not conform to the quality requirements for Class-B (bathing water quality) with respect to coliform bacteria (both total and fecal coliform) counts.

Water quality of most of the monitoring stations do not conform to Class-C (drinking water source after conventional treatment and after disinfection) with respect to BOD or TC or both. Water quality of the rivers at the downstream of major urban local bodies or towns do not meet the tolerance limit for Class-C with respect to both BOD and TC. Such downstream stations identified are at Sambalpur and Cuttack on Mahanadi river, Cuttack on Kathajodi river, Bhubaneswar on Daya river, Rourkela on Brahmani river, Jeykaypur and Rayagada on Nagavali river, Madhopur and Potagarh on Rushikulya river; and Balasore on Budhabalanga river. Water quality at other stations also deteriorated due to high coliform bacteria which may be attributed to the instream activities on the river. Wide fluctuation in TC values has been observed at all locations during the study period. The magnitude and frequency of violations of TC from the stipulated value (less than 5000 MPN/100 ml) at most of the stations are far too large for the water quality to be classified as Class-C.

Number of stations non-conforming to the desired Class i.e. Class-C with respect to BOD alone, TC alone or BOD and TC both during the period 2011-2015 is given in Table 12.1. For assessment of non-conformance with respect to TC, criteria as given in IS : 2296-1982 which states that “TC values with more than 5% of samples show more than 20,000 MPN/100 ml and more than 20% of the samples show more than 5000 MPN/100 ml (Ref : IS 2296-1982 foot note)” are taken into consideration. It is evident from the table that number of stations non-conforming with respect to both BOD and TC remains fairly constant during the period of study, whereas, the number of non-conforming stations with respect to TC exhibits an increasing trend over the period. The number for

**Table 12.1 Water quality Trend of Major River System of Odisha w.r.t. Critical Parameter BOD and TC from 2011 - 2015**

Sl. No.	Name of the River System	No. of Stations	No. of Non-Conforming Station w.r.t. BOD & TC					No. of Non-Conforming Station w.r.t. BOD alone					No. of Non-Conforming Station w.r.t. TC alone				
			2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
1	Mahanadi	32	7	11	9	7	7	1	--	--	--	-	7	7	13	16	19
2	Brahmani *	25	6	4	6	4	7	--	--	1	--	-	11	16	16	21	17
3	Baitarani *	6	1	--	--	1	-	--	--	--	--	-	3	5	6	8	9
4	Rushikulya	2	--	--	1		-	1	--	--	--	-	1	1	1	2	1
5	Nagavali	3	1	2	1	1	1	--	--	--	--		1	1	2	2	2
6	Subernarekha	1	--	--	--		-	--	--	--	--		1	1	1	1	1
7	Budhabalanga	3	--	--	1	1	1	--	--	--	--		2	2	2	2	2
8	Kolab (Kerandi)	1	--	--	--		-	--	--	--	--		--	1	1	1	1
9	Vansadhara	2	--	--	--		-	--	--	--	--	-	--	--	2	2	2
<b>Total</b>		<b>75</b>	<b>15</b>	<b>17</b>	<b>18</b>	<b>14</b>	<b>16</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>26</b>	<b>34</b>	<b>44</b>	<b>55</b>	<b>54</b>

Since 2014, total number of stations has been increased from 75 to 79. No. of stations in Brahmani river system and Baitarani river system has been changed from 25 to 26 and 6 to 9 respectively

TC non-conformance has been increased from 34 % during 2011 to 68% during 2015. Out of 79 stations, on an average, 16 stations are not meeting the tolerance limit with respect to both BOD and TC. Only very few stations are conforming to Class-C with respect to both BOD and TC.

Occasional deviation of fluoride concentration from the tolerance limit of 1.5 mg/l has been observed at Jharsuguda on Bheden river, Rourkela D/s on Brahmani river, Nandira D/s on Nandira Jhor and Kisindajhor. All other parameters remained within the tolerance limits specified for highest desired Class.

Biomonitoring studies conducted on the river stretches at 24 stations revealed that river segment at these stations have moderate biodiversity with the biological class remained in slight-moderate pollution category.

In terms of wholesomeness, water quality at most of the stations meet the “acceptable” level with respect to most of the general and special parameters listed under Table 2.7 and Table 2.8 described in Chapter-II. However, the water quality falls below “acceptable” level with respect to BOD at Cuttack D/s and Cuttack FD/s at Mattagajpur on Kathajodi river, Bhubaneswar D/s on Daya river and Rourkela D/s on Brahmani river. In addition to these four stations, water quality at other stations also do not meet the “acceptable” level with respect to fecal coliform counts, suspended solids during non-monsoon period, total Kjeldahl nitrogen. Water quality at some stations also do not meet the “acceptable” level with respect to phosphate and nitrate. Water quality at the monitoring stations on river muhan areas fall below “acceptable” limit with respect to parameters like conductivity.

Water quality index (WQI), a numerical value between 0 to 100, is used to indicate the overall water quality of a water body. The value is derived from the integration of certain physico-chemical and biological constituents of water which have significant impact on the beneficial uses of the water body. Canadian Council of Ministers of the Environment (CCME) developed the water quality index (CWQI) which has been used by environmental authorities in several nations to assess water quality of rivers and other aquatic resources. The CWQI is derived from a number of use-based variables and has the advantage of considering the number as well as type of physico-chemical and biological variables depending upon the overall use of the water segment. In this report, CWQI of the water quality monitoring stations are evaluated using the criteria pollutants such as pH, DO, BOD and TC and corresponding tolerance limits for Class-C surface water bodies. However, at the muhans of the rivers with the sea, due to tidal influence of the sea, water quality of the river is significantly changed and therefore, CWQI at such stations are calculated using the parameters like electrical conductivity, chloride, sulfate, sodium absorption ratio, boron, total dissolved solids and the corresponding tolerance limits for irrigation water quality.

Water quality index at the downstream stations such as Cuttack D/s and Cuttack FD/sat Mattagajpur on Kathajodi river, Bhubaneswar D/s on Daya river and Rourkela D/s on Brahmani river remained within Poor-Marginal category. Water quality deteriorating parameters in these stations are BOD and TC with occasionally DO.

Water quality index at other downstream stations remained in Fair-Good category. Water quality deteriorating parameters in these stations are TC. Frequency of deviation of TC values as well as magnitude of deviation from the tolerance limits prescribed for Class-C are the main cause of water quality deterioration at rest other stations, where the water quality index remained in Good-Excellent category.

The above water quality assessment made during the period 2011-2015 indicate that the organic and bacterial contamination are continued to be critical in water bodies. This may be attributed to the discharge of partially treated or untreated domestic wastewater from the urban areas or due to instream activities, absence of environmental flow in the rivers for dilution purposes and insanitary conditions of the monitoring locations. Therefore, the oxygen demand and bacterial population at most of the monitoring stations exhibit wide range of fluctuations.

The natural water bodies are used for various uses such as drinking water source; religious bathing; propagation of wild life and fisheries; irrigation, industrial cooling and controlled waste disposal. As the standards for surface water quality for various uses specify, the surface water is not recommended to use directly for drinking purposes unless treated and disinfected by an organized water supply system. However for religious bathing, public are advised to use specified stretches of the rivers. The critical parameters for maintenance of water quality with respect to public health are coliform group of bacteria and organic matter. Thus the organic matter in terms of Biochemical Oxygen Demand is the most critical parameter representing municipal sewage pollution. The organised water supplies with high organic matter in surface water may cause formation of chlorinated compounds during the disinfection process using chlorine. The presence of high organic matter from municipal origin also account for higher number of coliform group of bacteria including fecal coliforms. Therefore the need for water quality management in river is broadly concentrated on control of organic matter (in terms of BOD) by providing infrastructure for sewage treatment as first priority. Based on BOD concentrations, CPCB has categorised the river stretches under five priorities. Monitoring locations with BOD concentration exceeding 30 mg/l has been categorized as Priority-I. Monitoring locations with BOD concentrations in the range 20-30 mg/l, 10-20 mg/l, 6-10 mg/l and 3-6 mg/l are categorized as Priority-II, Priority-III, Priority-IV and Priority-V respectively.

Water quality monitoring during the years 2011-2015 provided information on river stretches/ stations having higher concentration of BOD and identified as polluted under

different categories. Out of 79 monitoring stations, 27 polluted monitoring stations have been identified, of which, one is in Priority-II category, two in Priority-IV category and others are in Priority-V category. Polluted monitoring stations occurred in a continuous sequence are termed as Polluted river stretch. In Mahanadi river system, there are five polluted river stretches, such as Sambalpur stretch (3 km) (Priority- V) and Cuttack stretch (15 km) (Priority-V) on Mahanadi river, Cuttack stretch (19 km) (Priority -II) on Kathajodi river, Cuttack stretch (4 km) (Priority- V) on Serua river and Bhubaneswar stretch (30 Km) (Priority-IV) on Daya river. In Brahmani river system, only one polluted river stretch, that is Rourkela stretch (19 Km) (Priority-IV) along Brahmani river has been identified. Similarly, Madhopur- Potagada stretch (5 Km) in Rushikulya river, Jaykaypur D/s to Rayagada D/s stretch (11 km ) on Nagavali river have been identified as polluted river stretches under Priority-V category.

Besides these, Paradeep D/s (Priority-V) on Mahanadi river, Bhubaneswar U/s (Priority-V) on Kuakhai river, Nandira D/s (Priority-IV) on Nandira jhor, Kisindajhor (Priority-IV) on Kisindajhor, Jajpur (Priority-V) on Baitarani river, Bhadrak D/s (Priority-V) on Salandi river and Balaosre D/s (Priority-V) on Budhabalanga river have been identified as polluted river monitoring stations.

As the deterioration of water quality affects the public health, aquatic ecosystem and hampers it's designated best uses, corrective actions are to be taken to prevent and control of water pollution.





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