IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 18, Issue 3 Ser. III (May – June 2019), PP 23-38
www.iosrjournals.org

Water Quality Prediction And Its Analysis On Baitarani River Basin, Odisha

Abhijeet Das [a], Dr. Bhagirathi Tripathy [b]
[a] *Guest Faculty, Civil Engineering Department, Odisha.*
[b] *Assistant Professor, Civil Engineering Department, IGIT, Sarang, Odisha.*

Abstract
The Baitarani River has experienced a general decline in water quality over the last several years due to agricultural practices, economic development, weathering of rocks, soil erosion, mining operations and other human activities in the river catchment. The spatial variation for determination of water quality index is used to find the locations of major pollutant sources that contribute to water quality depletion in the basin and also its tributaries. This study mainly conducted to assess and ascertain the physico-chemical parameters like PH, Turbidity, TDS, TSS, EC, DO, Alkalinity, BOD, TH, HCO_3^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, Cl^-, Ca^{2+}, Mg^{2+}, Na^+, K^+, *TC, FC, Fe, Cr and to classify the water quality and pollution status on this basin. These parameters indicate deterioration of water quality which is the result of various anthropogenic disturbances like industrialization, construction activities, utilization of agricultural and forest land for other developmental purposes. Other sources which contribute more or less in water quality depletion are disposal of untreated domestic and sewage effluents and different types of solid wastes directly to river. The pH, EC, TDS, TH, the major cations and anions in all samples and DO values in most of the samples were well within the BIS and WHO limits. But turbidity, TSS, total and faecal coliform units and in some cases BOD values were beyond the limits indicating contaminated water bodies. Fe and Cr contributed a lot for high value of WQI. WQI varied from 17.76 to 59.72 in the pre-monsoon season, 17.80 to 58.53 in monsoon season and 19.25 to 77.69 in the post-monsoon season. Sampling stations 1, 4 and 7 designated as excellent, 2, 3, 5, 6, 9, 10, 11, 12 and 13 designated as good in the pre-monsoon season. In monsoon season, sampling station 1 and 7 designated as excellent and 2, 3, 4, 5, 6, 9, 10, 11, 12 and 13 designated as good. In case of post-monsoon season, sampling stations 1 and 7 designated as excellent and 2, 3, 4, 5, 6, 9, 10, 11, 12 and 13 designated as good and station 8 designated as very poor because it is situated in the downstream and is thought to receive the municipal effluents. This could be attributed to improper disposal of wastes, large quantity of agricultural and urban runoff, sewage, over application of inorganic fertilizer, improper operation and maintenance of septic system. It refers to possible decline of environmental properties. This study highlights the importance of applying the water quality indices which indicate the total effect of the ecological factors on surface water quality and which gives a simple interpretation of the monitoring data to help local people in improving water quality.*

Keywords:*Water quality index (WQI), Water quality parameters, Industrialization, Municipal effluents, Construction activities.*

Date of Submission: 05-12-2018 Date of Acceptance: 18-06-2019

I. Introduction

Water is an essential component for survival of life of Earth, which contains minerals, important for human beings as well as plant and aquatic life. It is the material basis for the existence of earth creatures, and water resources are the primary condition for maintaining the sustainable development of the earth's ecological environment. The availability of water both in terms of quality and quantity is essential for the very existence of mankind. It is mainly used for drinking, bathing, fisheries and other domestic purposes. Lack of awareness and civic sense, use of inefficient methods and technology lead to more than 50% of water wastage in the domestic, agriculture & industrial sectors. With the increasing consumption of water resources, the contradiction between the supply and demand of water resources has intensified, which puts forward greater requirements for the utilization and protection of surface water resources.

The surface water quality of a region depends to a large extent on environmental factors (temperature changes, precipitation and soil erosion) and human input (discharge of municipal and industrial wastewater and over-exploitation of water resources). Among them, the discharge of urban sewage and industrial wastewater is a continuous source of pollution, so effective control of sewage discharge is of great significance to the improvement of water quality. Surface water runoff is a seasonal phenomenon that is mainly affected by the climate of the basin. In addition, seasonal changes in precipitation, surface runoff, interflow, groundwater flow, and pumping in and pumping out have a strong influence on the river flow and the subsequent pollutant concentration in the river. Therefore, correct identification of potential sources of surface water quality pollution is the basis and prerequisite for water quality management.

Considering that water pollution and irrational water use represent two risk factors to the sustainable development of human society, constant monitoring of water quality is important. Natural and anthropogenic processes determine the chemical composition of the surface water. The waters are more or less affected by pollution with organic compounds, nutrients and heavy metals, pollutants from various sources such as industrial and domestic wastewaters, which are not treated sufficiently and rainwater which runs off the agricultural land where chemical fertilizers and pesticides are used. Monitoring water quality is important, especially since Romania is a member of the European Union (EU) and must comply with the specific legislation in the field (Water Framework Directive 2000).

This study was conducted along the monitoring stations of Baitarani River. It not only plays an important role in assimilating or removing urban and industrial wastewater and farmland runoff, but is also the main inland water resources used for household, industrial, and irrigation purposes. Therefore, it is necessary to prevent and control river pollution and have reliable water quality information for effective management. Given the spatial and temporal changes in river water chemistry, regular monitoring pro-grammes are needed to reliably estimate water quality. This leads large and complex data matrices composed of a large number of physical and chemical parameters, which are often difficult to interpret, making it challenging to draw meaningful conclusions. For these reasons, this study on the BaitaraniRiverhastobedone. In this context, we took the river as the research object for the first time, set up 13 main detection sampling points along the river and detected and analyzed 22 physical and chemical parameters in water samples.

The main objectives of this study are to

- Assess thephysicochemicalpropertiesoftheriverwater.
- Determinethe water quality of the Baitarani River, through WQIanalysis,andcreateWQImapbasedonGIS,
- Discussthe suitability of the water for drinking, agricultural and industrial purposes.

II. Review Of Literature

The reduction in the quantity and quality of water resources has become a worldwide concern, including countries with great water potential, since the availability of water is one of the main factors that limits socioeconomic development.

Surface water primarily consists of the water in streams,rivers,springs,ponds,lakesandinreservoirs.Surfacewateroriginates from precipitation on watershed areas and flowsthroughstreamsandriversandsometimesdepositsinpondsand in lakes (**Manahan 2010**). This is the main source ofwater used in domestic, agricultural and industrial purposesworldwide (**Khan et al. 2015**). The rivers, among the afore-saidwaterbodies,arethemajorsourcesofwaterforhumanconsumption,irrigationandindustrialuses.Thesurface waterbeingexposedtoanthropogenicinfluencesandatmosphericdepositionofpollutantsbecomesaverysensitiveandcritical issue in many countries (**Sener et al. 2017; Kumarand Singh 2018**).

Merten & Minella (2002) observed that the water quality concept is not necessarily a state of purity of the water, but refers to chemical, physical and biological characteristics that determine its different uses.

According to **Sperling (1996)** since the process of qualifying a water resource becomes complex due to the number of parameters involved, water quality indices are proposed with the intent of summarizing the analyzed variables and expressing them in a single number with the objective of showing the temporal and spatial evolution of water quality. The search for an indicator that best characterizes a water source under study requires the use of statistical techniques.

According to **Haase et al. (1989)**, one of the methods used in the formulation of water quality indices is based on the multivariate factorial analysis technique, which was used by Carvalho et al. (2000) to evaluate a watershed water quality. The main objective of this analysis is to study the correlation structure of an initial set of “p” variables (X1, X2 ... XP), replacing it with a smaller set of hypothetical variables, which, lower in number and with a simpler structure, explain most of the variation in the original variables. This technique permits learning the behavior of data from the reduction of the parameters’ original space dimension, thus permitting the selection of the most representative variables for the water resource being analyzed, as explained by Andrade et al. (2007).

Anthropogenic influences, geochemicalfactors,chemicalcompositionofriverbasin(**Giridharanet al. 2010**) and natural processes like interaction of waterwithlithogenicstructurethroughwhichtheriverflows(**Subramani et al. 2009; Sener et al. 2017**) degrade surface waterquality making it unsuitable for drinking, industry, agricultureandotherpurposes(**Simeonovetal.2003;Sánchezetal.2007;Kazietal.2009**).

The water quality of the river is deteriorated mainly bynatural processes and through anthropogenic activities likedischarge of industrial sewage, domestic wastewater andagricultural drainage water to the river (**Singh and Kumar2017**). However, the main pollutants for river pollution aretheindustrialsewages,domesticwastewaterandagriculturaldrainage water (**Carpenter et al. 1998; Jarvie et al. 1998;Barakat et al. 2016**). Since river is the main resource offreshwatertothehumanbeingsforuseindifferentpurposes, itiswisetoprotectandcontroltheriversfrompollutionandto have reliable information on water quality for effectivemanagement. Therefore, regular monitoring and evaluationofthewaterqualityarerequiredtoprotect,controlandman-age the river water from deterioration (**Singh et al. 2005;Barakatetal.2016**).

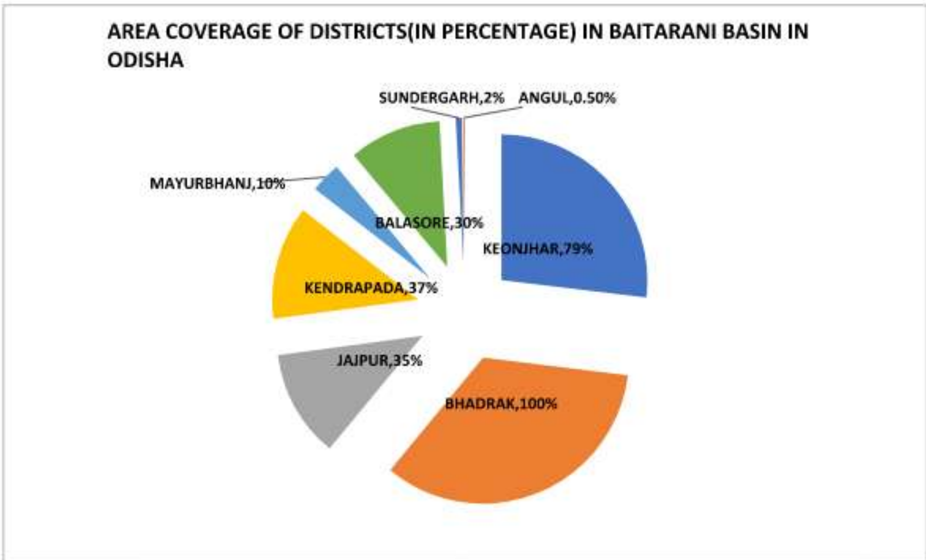
Despite being developed in technologies,agriculture is still now an important sector contributing significantly in the national economic scenario of India andprovideslifesupporttoamajorportionofpopulation(Singh1983). Agriculture needs freshwater and freshwater is scareinmanypartsofIndia,duetothedisparityofdistributionof seasonal downpour especially in the arid and semi-aridregions. Moreover, the different pollution status differentiatesthequalityofthewater,makingthequantitylimitedfor irrigation in different places in India (**Ravikumar et al.2011**).

Some physicochemical parameters, some hydrogeochemicalcalparameterscalculatedfromthewaterqualityparametersand a few graphical representations determine the suitability of the river water for agricultural uses (**Sundaray et al.2009**). Agricultural science, preferably, deals with sodiumconcentration,saltcontent,nutrientslevel,presenceoftraceelements, acidity, alkalinity and hardness of the river waterforbetterproductivity.Fertilitylossofthesoilduetosalinity variation has also become a serious problem all over theworld(**Etteiebetal.2017**).

STUDY AREA

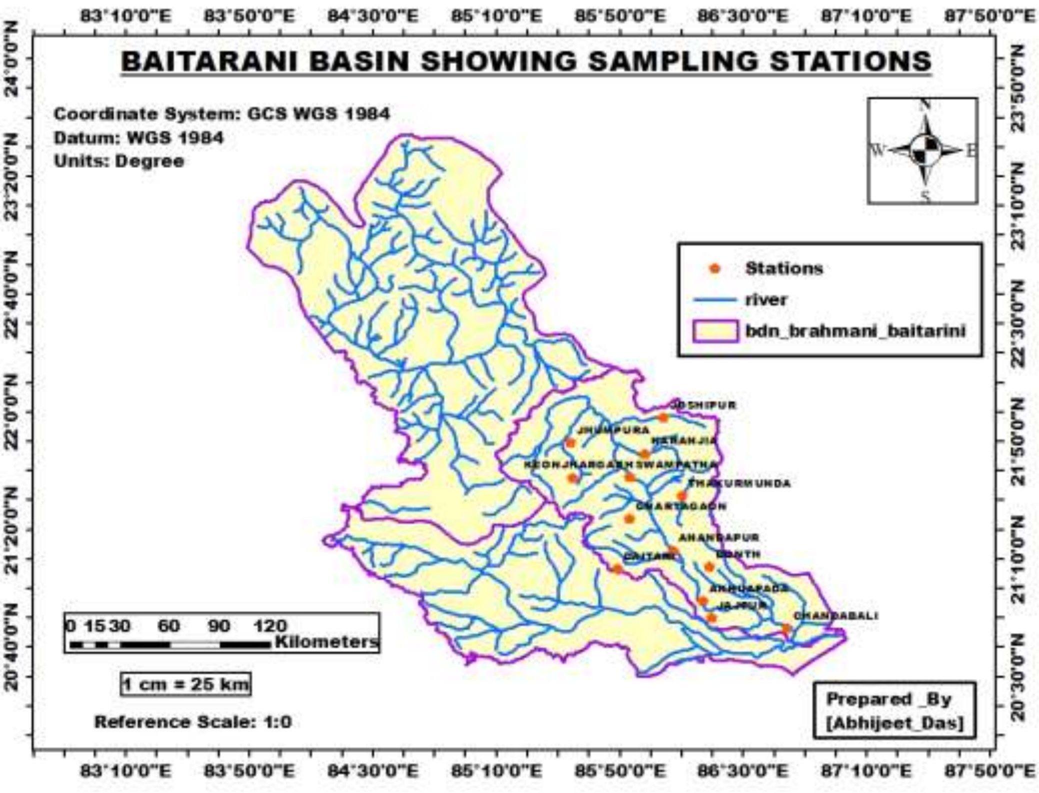
Baitarani River Basin has a total catchment area of 14,218 sq.km spreading over the two states of Odisha and Jharkhand in India. A major portion of the river basin with 13482 sq.km of catchment lies in the state of Odisha while Jharkhand have the rest of 736 sq.km. The river originates at the Gonasika / Gupta Ganga hills at 21°32’20’’ N - 85°30’48 E and starts flowing over a stone which looks like the cow’s nostril. The river at its origin has the elevation of 900 meters (3000 ft) above sea level. It originates at an elevation of 900 m above mean sea level from Guptaganga hills of Gonasika of Keonjhar district. The beginning portion of Baitarani acts as the boundary between Odisha Jharkhand states. It flows in a north-easterly direction for about 80 km and then takes a south-east 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 into the Bay of Bengal, Deo, Salandi, Kanjhari, Musal, Arredi, Siri, Kukurkata, Kusei, Gahira and Remal are major tributaries of Baitarani River.

A major portion of the basin (94.8%) lies within the state of Odisha, while a small patch of up reach (5.2%) lies in Jharkhand state. The basin covers 8 revenue districts of the state. The main urban centres in Baitarani basin are keonjhar, Joda, Jajpur, Vyasana, Bhadrak, Anandpur, Chandabali and Dhamnagar.

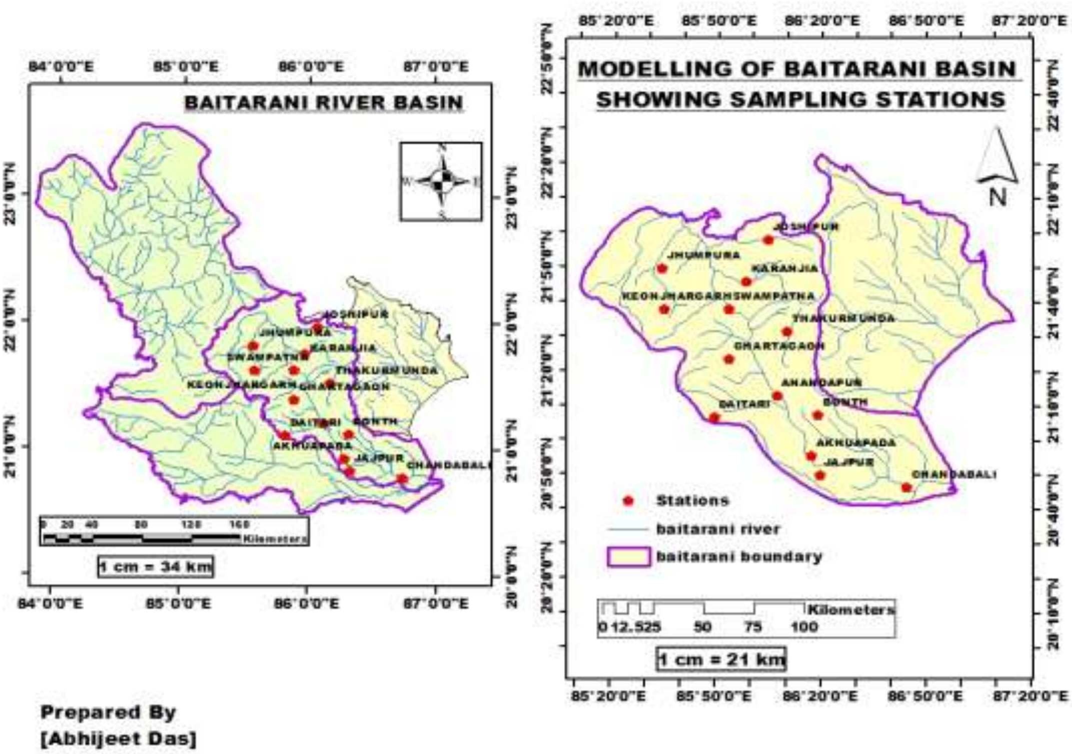


(**Figure 1.** Area coverage of districts (in percentage) in Baitarani Basin)

The below (**Figure 2, 3**) showing monitoring stations of Baitarani basin by the application of GIS Software.



(**Figure 2**. Mapping of monitoring stations of River Baitarani showing the flow path)



(**Figure 3**. Baitarani river network covering all sampling stations along the flow path)

- **SAMPLING ANALYSIS**

The water samples were collected in pre-monsoon, monsoon and post-monsoon period of 2000 - 2019 from previously selected 13 (Thirteen) sampling stations (**Table 1**) in washed polypropylene bottles (manufactured by Tar son, India). The sampling stations were selected on the basis of uniform distance, with slight deviation depending upon the geographic condition and ease of access. Coordinates of the sampling stations were recorded by Global Positioning System (GPS). Some physicochemical parameters like temperature and pH were determined in the sampling sites by laboratory mercury thermometer and pocket pH meter (HANNA, USA), respectively. The water samples were collected manually from a depth of 20 cm from the surface of the water, preferentially where the flow of the water was high, to obtain good homogenised samples (Rakotondrabe et al. 2018). After collecting the samples and making the bottles airtight, the samples were transported to the laboratory with favourable temperature (< 4°C) following the procedures described in APHA (2012).

In the laboratory, dissolved oxygen (DO), electrical conductivity (EC) and total dissolved solid (TDS) were determined immediately by Thermo-Scientific Orion 5 Star instrument (Thermo-Scientific Inc.). The samples were filtered with ash-less Whatman (42) 100-mm filter paper, and Na, K and Ca were determined by fame photometer (ELCO-CL361). All the reagents used for analytical purposes were of analytical grade (Merck, India) for higher accuracy and precision. Some samples were sent to water quality laboratory of Central Water Commission, Bhubaneswar for analysis of physico-chemical parameters like pH, turbidity, EC, TDS, TSS, total hardness, cations like Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, and anions like HCO_3^{-}, SO_4^{2}- , NO_3^{-}, PO_4^{3-}. Analysis of heavy metals like Fe and Cr were done by AAS (Shimadzu AA6300) and ICP-OES (PerkinElmer Optima 2100 DV) in IMMT, Bhubaneswar.

Table 1. Water Sampling Locations

SAMPLING CODES	MONITORING STATIONS
1	CHANDABALI
2	JAJPUR
3	AKHUAPADA
4	DAITARI

5	BONTH
6	ANANDAPUR
7	GHARTAGAON
8	THAKURMUNDA
9	SWAMPATNA
10	KEONJHARGARH
11	KARANJIA
12	JHUMPURA
13	JOSHIPUR

III. Materials And Methods

Water quality index (WQI) is useful in assessing the suitability of river waters for a variety of uses such as agriculture, aquaculture and domestic use. It is used to relate a group of parameters to a common scale and combining them into a single number. The water quality index (WQI) is considered as an efficient mean to reflect the water quality comprehensively, integrating the different water quality parameters into a single-valued unitless integer (Sener et al. 2017; Wang et al. 2017). The raw analytical results of various water quality parameters with different values and units are transformed into a single value by a special type of mathematical averaging function (Cude 2001).

Some researchers and some countries proposed different WQIs considering different water quality parameters, and the indices are applied worldwide. The WQI was first proposed by Horton (1965) and was used for drinking water quality analysis (Brown et al. 1970; Misaghi et al. 2017; Kumar et al. 2018). Later on, Pesce and Wunderlin (2000) also proposed a WQI method which is used by many researchers. Some WQIs proposed by some countries are National Sanitation Foundation Water Quality Index (NSFWQI) by USA, the Florida Stream Water Quality Index (FWQI), the British Columbia Water Quality Index (BCWQI) by Britain, the Canadian Water Quality index (CWQI) and the Oregon Water Quality Index (OWQI) as described by Cude (2001). WQI, here, has been calculated following the method given by Pesce and Wunderlin (2000) and is given by

$$\mathbf{WQI}_{\text{sub}} = k\frac{\sum_{i=1}^{n} C_i.P_i}{\sum_{i=1}^{n} P_i}$$

Where Ci is the normalised value assigned to each parameter and Pi is the relative weight of each parameter. k is a subjective constant and may have values ranging from 1.0 to 0.25 depending on the visual impression of river contamination of the researcher. The value 1.0 is assigned to water without apparent contamination, and 0.25 is assigned to highly contaminated water.

These parameters were compared with the standard guideline values, recommended by BIS-10500 (2012) and WHO (2006). WQI (Water quality index) was calculated (Kalavathy et al., 2011), (Reza and Singh, 2005), (Mukherjee et al., 2012),(Ravikumar et al., 2013) for pre-monsoon, monsoon and post-monsoon periods to assess the suitability of water for drinking purposes and for biotic communities (**Table 2**). For WQI calculation, total 22 parameters such as pH, turbidity, dissolved oxygen (DO), biological oxygen demand (BOD), total dissolved solids (TDS), total suspended solid (TSS), total hardness (TH), calcium (Ca) ions, magnesium (Mg) ions, total Fe, Cr, SO_4^{2-} , NO_3^- etc were considered and desirable limit of each parameter was used as per BIS standard.

Table 2. Water Quality Rating as per different Water Quality Index method

WQI LEVEL	WATER QUALITY RATING
0-25	EXCELLENT
26-50	GOOD
51-75	POOR
76-100	VERY POOR
>100	UNFIT FOR DRINKING PURPOSES

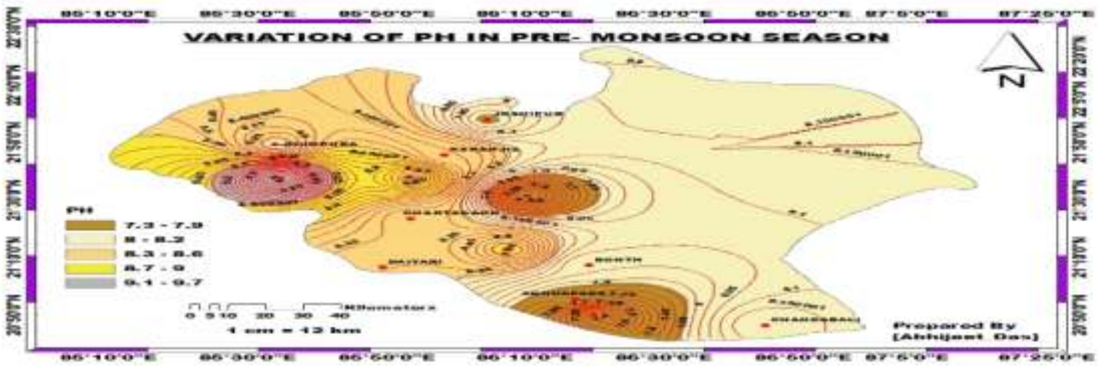
From the above table, it is clearly seen that the water quality index does not show exact degree of pollution, rather it is used to assess water quality trends for the management purpose. The WQI results represent the level of water quality in a given water basin. The computed WQI values are classified into five types, namely, excellent water (WQI<25) denotes lowest concern that generally meet state water quality standards, good water (26>WQ<50) depicts marginal concern, poor water (51<WQI<75), very poor water (76<WQI<100) both depicts moderate concern and water unsuitable for drinking (WQI>100) signifies highest concern as described by Ravikumar (2013), Mukherjee et al. (2012) and Dubey et al. (2014). Therefore, Baitarani River water ranges from “unfit for drinking” to “excellent” quality.

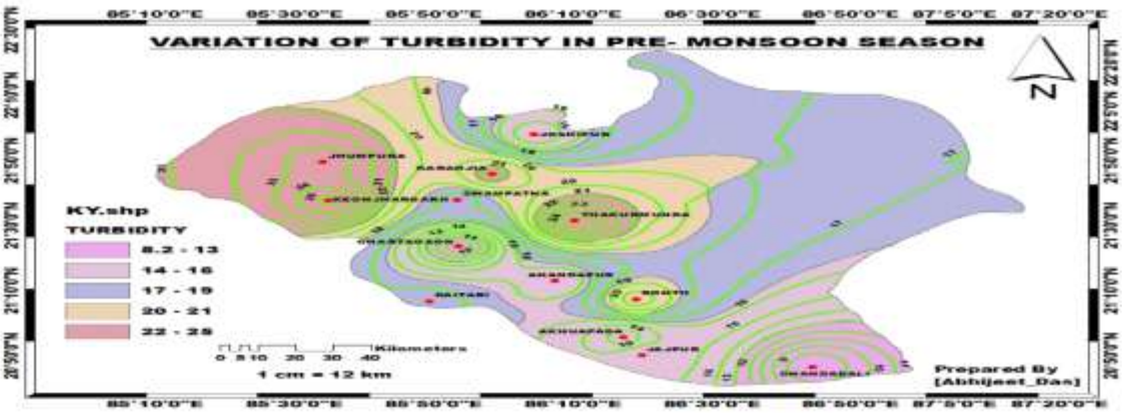
To calculate the WQI, water quality variables i.e., **PH, Turbidity, TDS, TSS, EC, DO, Alkalinity, BOD, TH, HCO_3^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, Cl^-, Ca^{2+}, Mg^{2+}, Na^+, K^+, TC, FC, Fe and Cr** were considered. The overall water quality index value for all the sampling stations is being shown in **Table 3**.

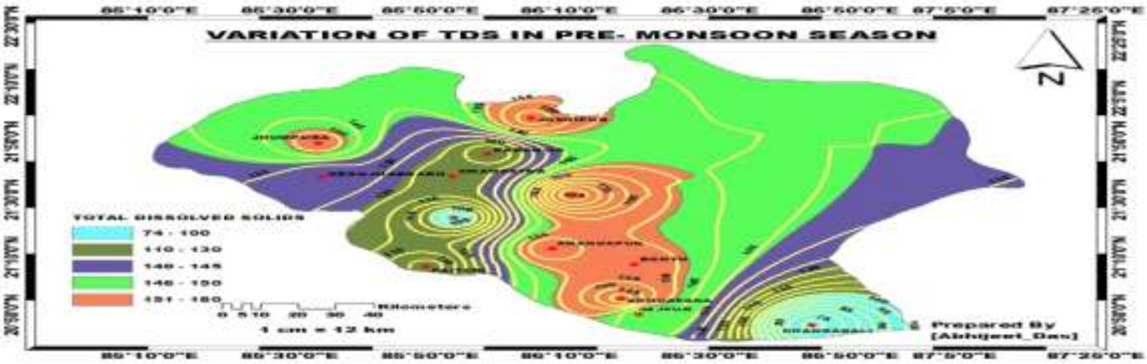
Table 3: Water quality status and WQI values at sampling stations

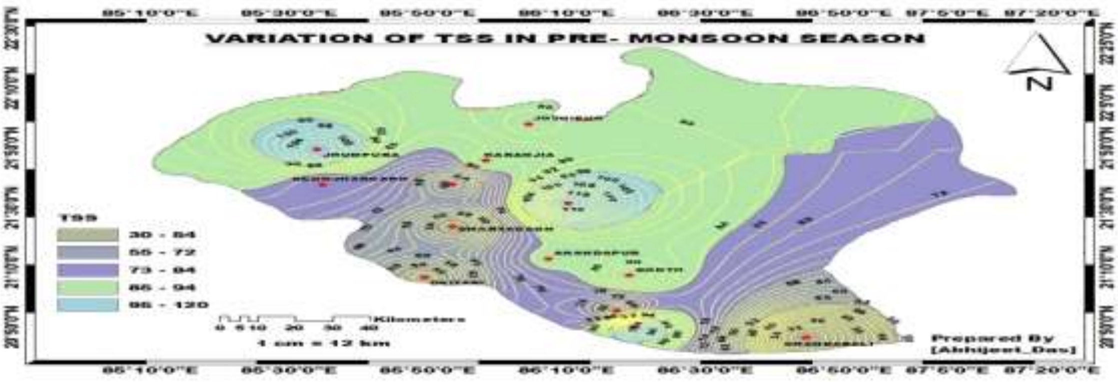
STATION NAME	WQI					
	PRE-MONSOON	DESCRIPTION	MONSOON	DESCRIPTION	POST-MONSOON	DESCRIPTION
CHANDABALI	17.76	EXCELLENT	21.62	EXCELLENT	19.25	EXCELLENT
JAJPUR	45.49	GOOD	47.10	GOOD	36.44	GOOD
AKHUAPADA	32.59	GOOD	34.65	GOOD	30.87	GOOD
DAITARI	23.94	EXCELLENT	26.03	GOOD	28.94	GOOD
BONTH	38.47	GOOD	38.59	GOOD	35.20	GOOD
ANANDAPUR	39.29	GOOD	34.86	GOOD	40.46	GOOD
GHARTAGAON	19.44	EXCELLENT	17.80	EXCELLENT	22.32	EXCELLENT
THAKURMUNDA	59.72	POOR	58.53	POOR	77.69	VERY POOR
SWAMPATNA	34.95	GOOD	28.10	GOOD	32.29	GOOD
KEONJHARGARH	39.71	GOOD	29.49	GOOD	34.70	GOOD
KARANJIA	40.00	GOOD	34.53	GOOD	36.63	GOOD
JHUMPURA	42.22	GOOD	43.26	GOOD	41.27	GOOD
JOSHIPUR	31.56	GOOD	32.57	GOOD	34.79	GOOD

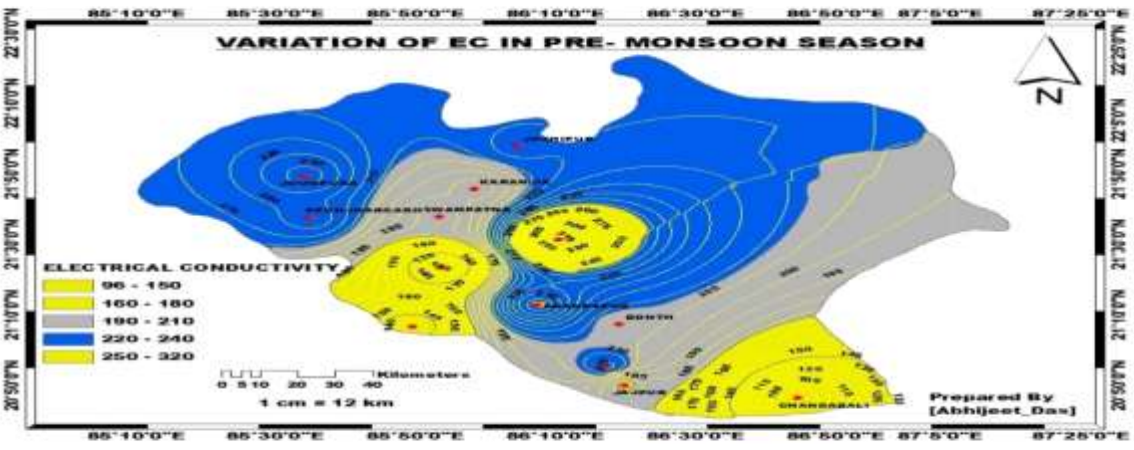
The spatial variations of different water quality parameters like PH, Turbidity, TDS, TSS, EC, DO, Alkalinity, BOD, TH, HCO_3^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, Cl^-, Ca^{2+}, Mg^{2+}, Na^+, K^+, TC, FC, Fe and Cr for pre-monsoon season over a period of 19 years are being represented in the geospatial map (**Figure 4**) which determines overall water quality status of a certain time and locations. It is used to assess water quality relative to the standard for domestic use and to provide insight into the degree to which water quality is affected by human activity. It is one of the most effective tools to provide feedback on the quality of water to the policy makers and environmentalists.

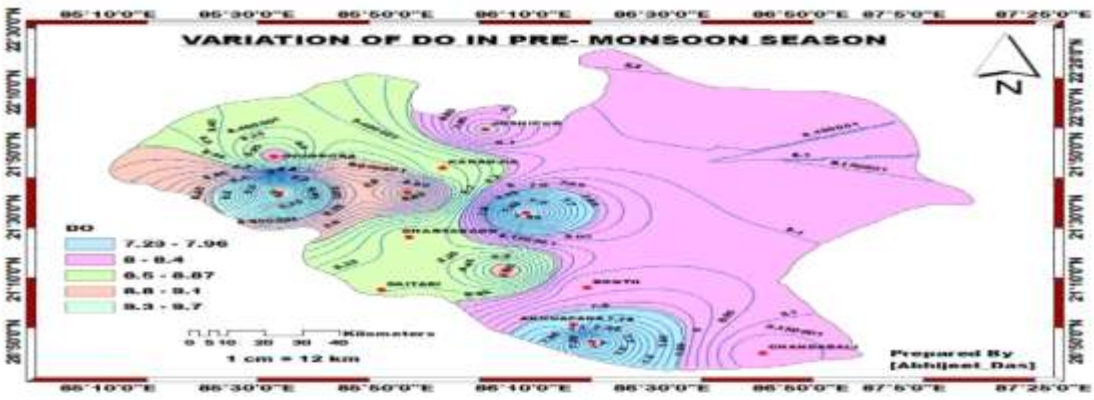


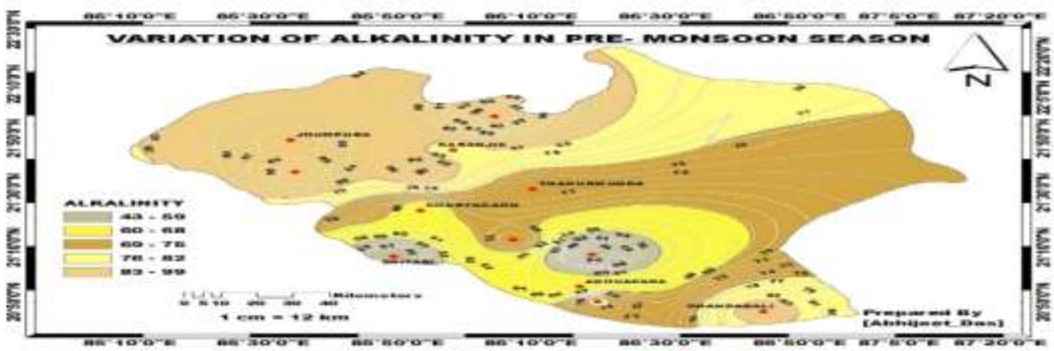

VARIATION OF TURBIDITY IN PRE- MONSOON SEASON
KY.shp
TURBIDITY
8.2 - 13
14 - 16
17 - 19
20 - 21
22 - 25
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]

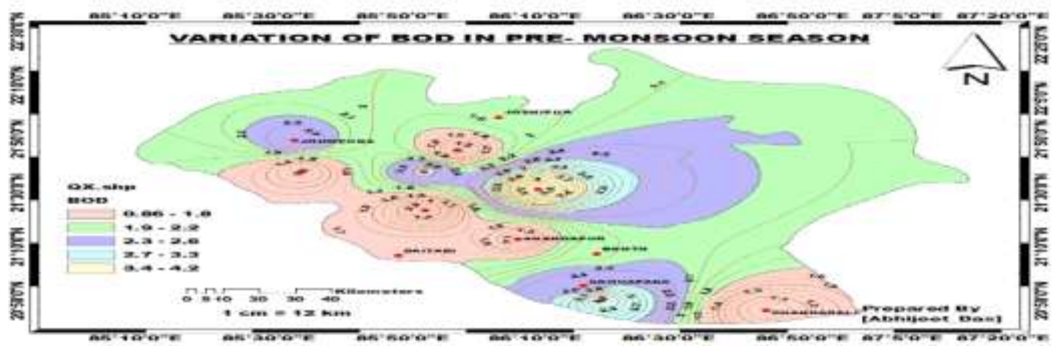

VARIATION OF TDS IN PRE- MONSOON SEASON
TOTAL DISSOLVED SOLIDS
74 - 100
110 - 130
140 - 145
146 - 150
151 - 180
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]

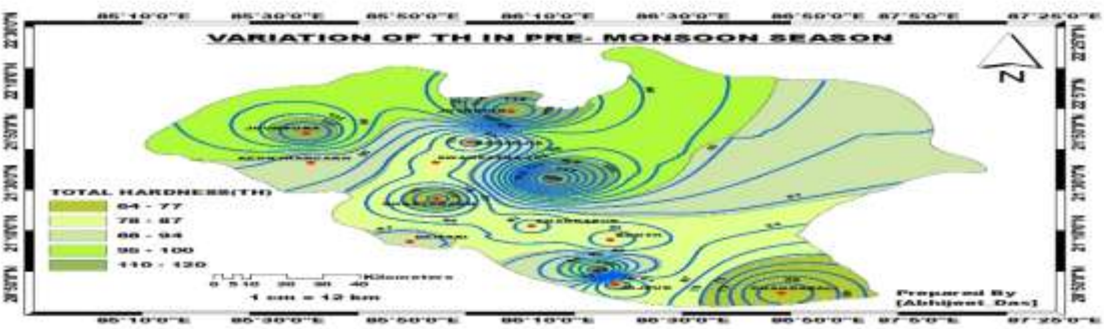

VARIATION OF TSS IN PRE- MONSOON SEASON
TSS
30 - 54
55 - 72
73 - 84
85 - 94
95 - 120
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]

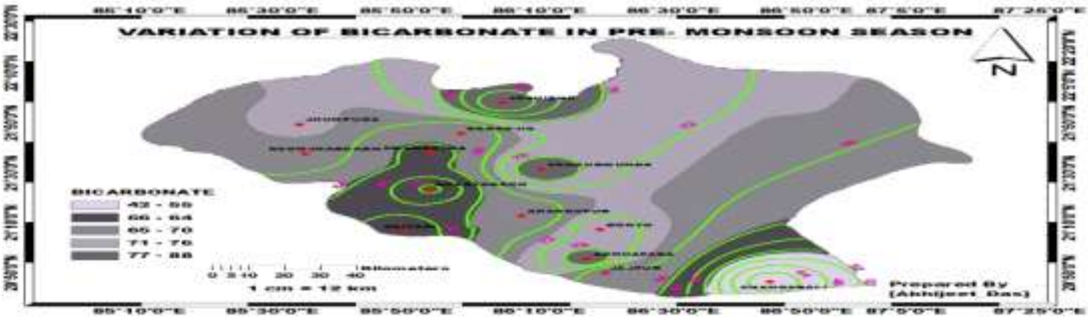

VARIATION OF EC IN PRE- MONSOON SEASON
ELECTRICAL CONDUCTIVITY
96 - 150
160 - 180
190 - 210
220 - 240
250 - 320
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]

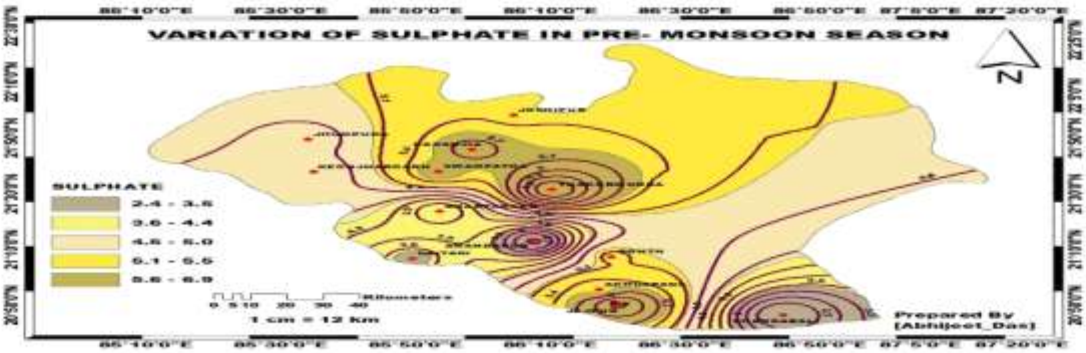

VARIATION OF DO IN PRE- MONSOON SEASON
Prepared By
[Abhijeet_Das]

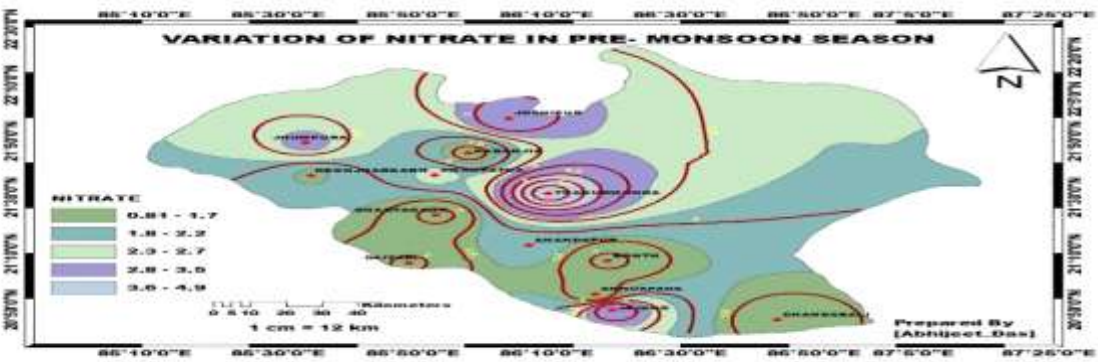

VARIATION OF ALKALINITY IN PRE- MONSOON SEASON
ALKALINITY
Prepared By
[Abhijeet_Das]

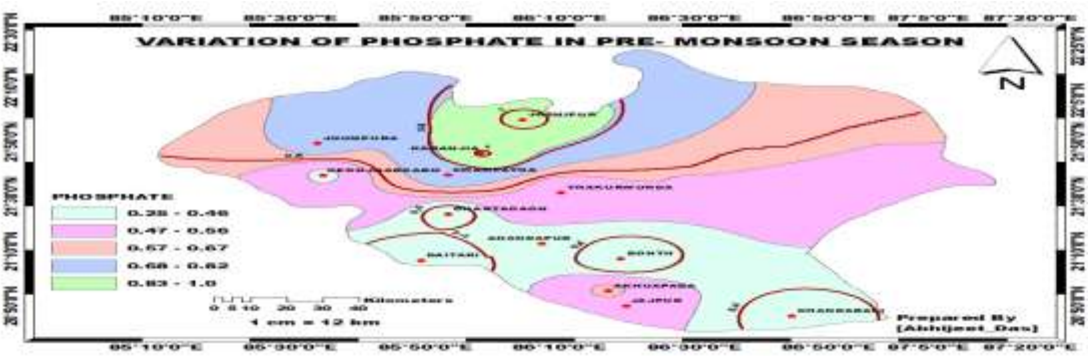

VARIATION OF BOD IN PRE- MONSOON SEASON
BOD
Prepared By
[Abhijeet_Das]

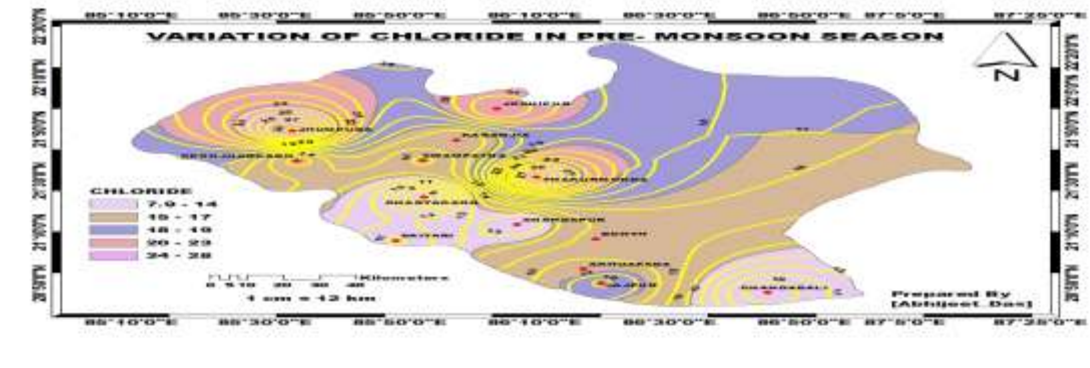

VARIATION OF TH IN PRE- MONSOON SEASON
TOTAL HARDNESS(TH)
Prepared By
[Abhijeet_Das]

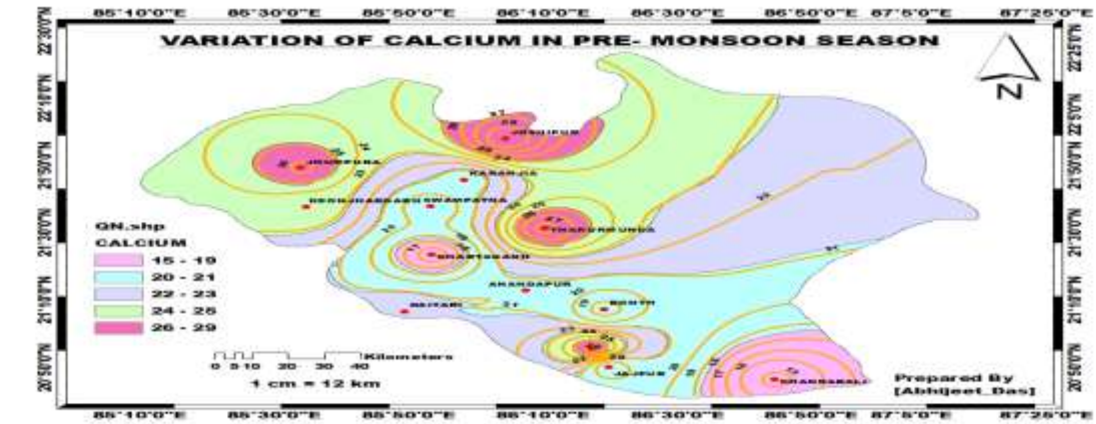

VARIATION OF BICARBONATE IN PRE- MONSOON SEASON
BICARBONATE
42 - 55
56 - 64
65 - 70
71 - 76
77 - 88
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]

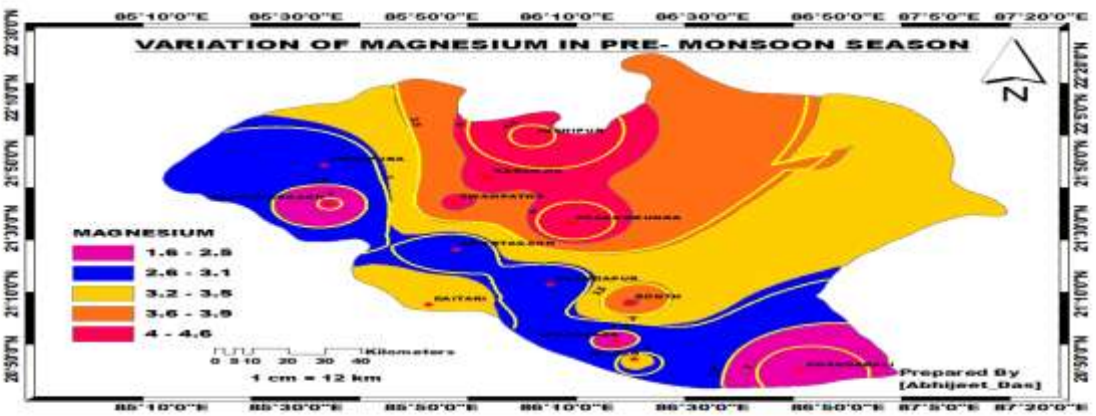

VARIATION OF SULPHATE IN PRE- MONSOON SEASON
SULPHATE
2.4 - 3.5
3.6 - 4.4
4.5 - 5.0
5.1 - 5.5
5.6 - 6.9
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]

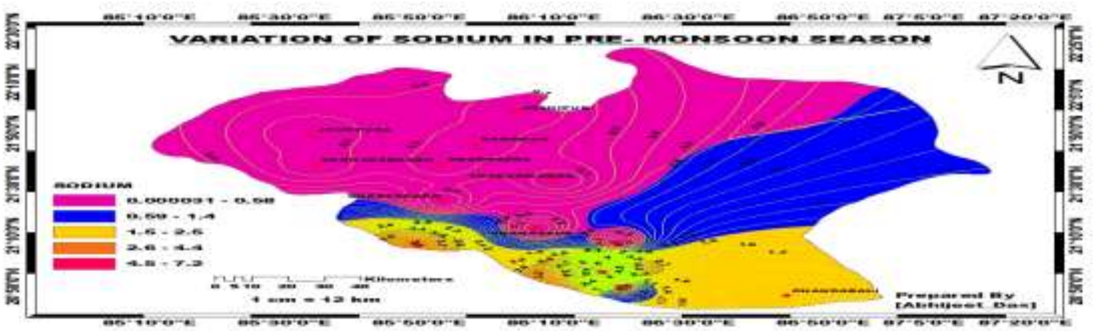

VARIATION OF NITRATE IN PRE- MONSOON SEASON
NITRATE
0.81 - 1.7
1.8 - 2.2
2.3 - 2.7
2.8 - 3.5
3.6 - 4.9
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]

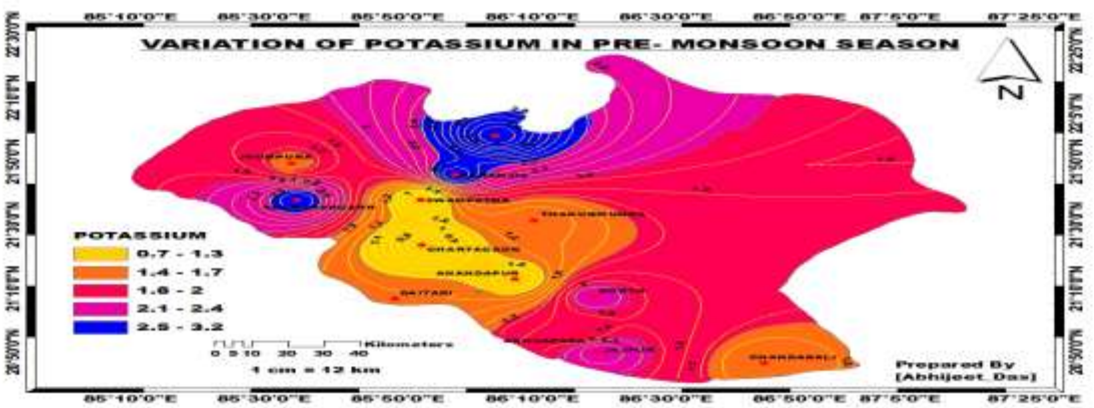

VARIATION OF PHOSPHATE IN PRE- MONSOON SEASON
PHOSPHATE
0.35 - 0.46
0.47 - 0.56
0.57 - 0.67
0.68 - 0.82
0.83 - 1.0
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]

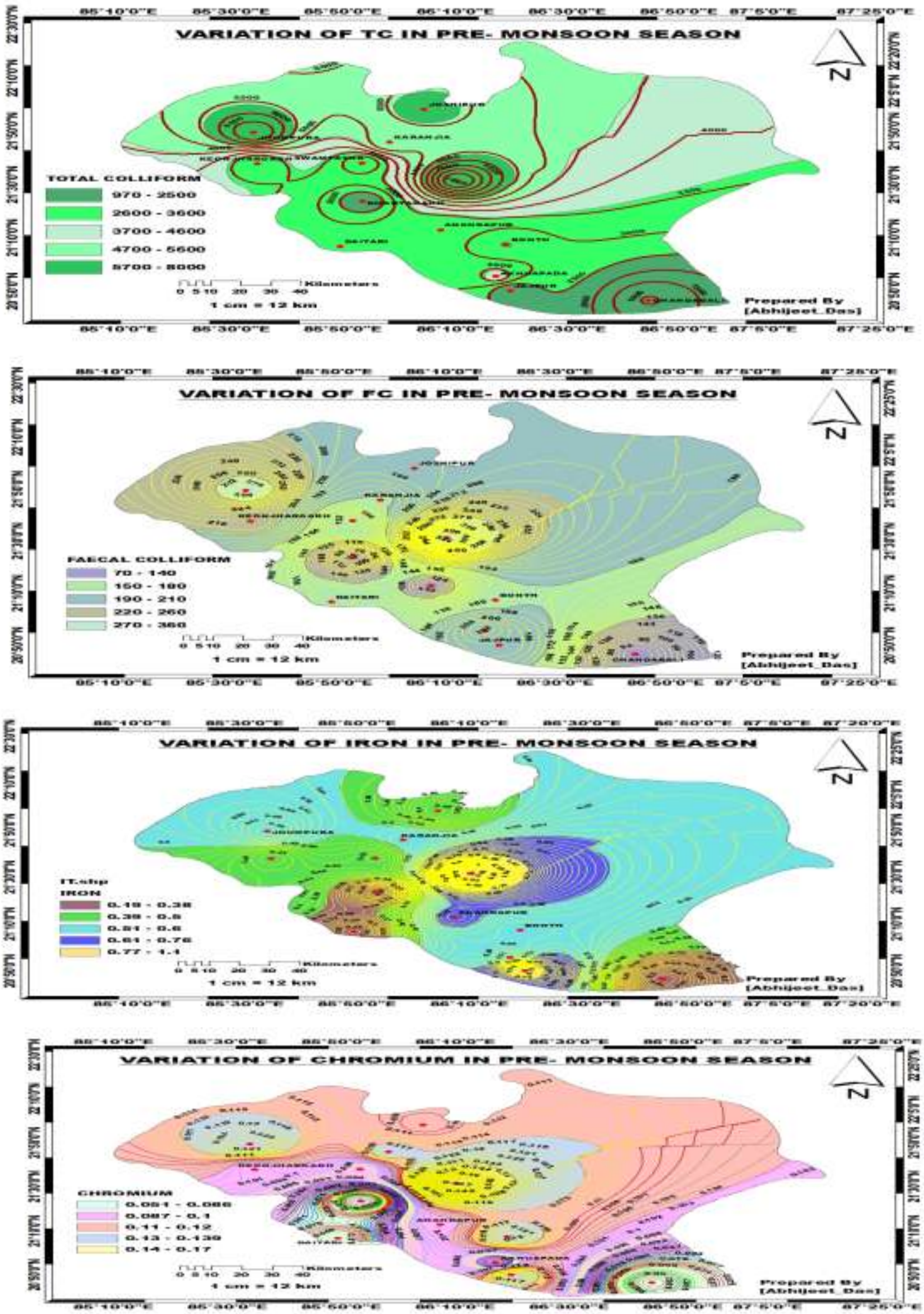

VARIATION OF CHLORIDE IN PRE- MONSOON SEASON
CHLORIDE
7.9 - 14
15 - 17
18 - 19
20 - 23
24 - 28
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]


VARIATION OF CALCIUM IN PRE- MONSOON SEASON
QN.shp
CALCIUM
15 - 19
20 - 21
22 - 23
24 - 25
26 - 29
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]


VARIATION OF MAGNESIUM IN PRE- MONSOON SEASON
MAGNESIUM
1.6 - 2.5
2.6 - 3.1
3.2 - 3.5
3.6 - 3.9
4 - 4.6
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]


VARIATION OF SODIUM IN PRE- MONSOON SEASON
SODIUM
0.000031 - 0.58
0.59 - 1.4
1.5 - 2.5
2.6 - 4.4
4.5 - 7.3
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]


VARIATION OF POTASSIUM IN PRE- MONSOON SEASON
POTASSIUM
0.7 - 1.3
1.4 - 1.7
1.8 - 2
2.1 - 2.4
2.5 - 3.2
Kilometers
1 cm = 12 km
Prepared By
[Abhijeet_Das]



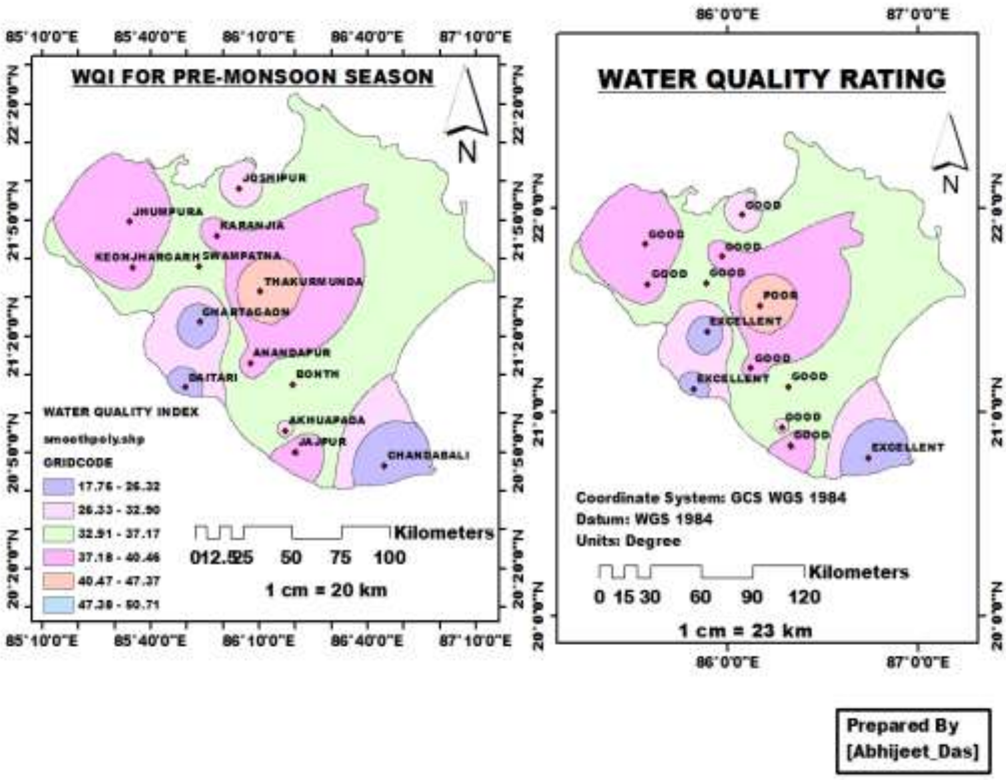
(**Figure 4**. Spatial variations of water quality parameters (using GIS) for pre-monsoon season)

Repeat the above procedure for both monsoon and post- monsoon seasons to detect the spatial variations in different water quality parameters in order to monitor at regular intervals to understand the complex cycle of physio-chemical factors and their role in regulating the quality of water. It encourages to minimize the incidence of pollution related problems and to protect the valuable fresh water resources to safeguard public health

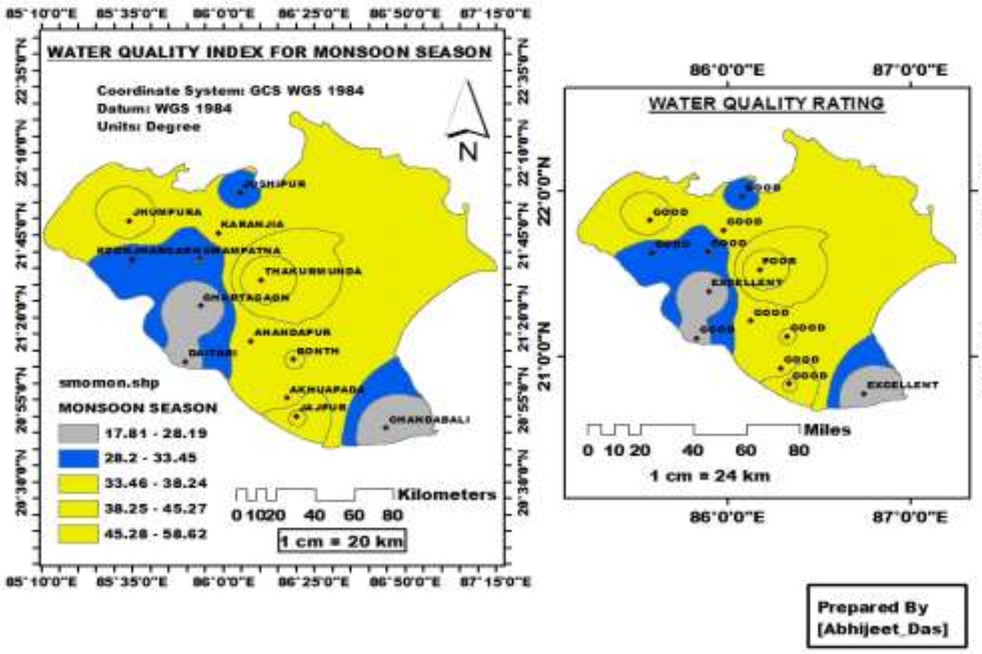
IV. Results And Discussion

In this study, water quality of Baitarani River water was calculated for each sampling stations and for three seasons i.e., Pre-monsoon, Monsoon and Post-monsoon over a period of 19 years (2000-2019). There was a little difference between parameter values measured in this study for the sampling stations as a result of the similar atmospheric conditions and source of water, yet there were significant differences according to the season.

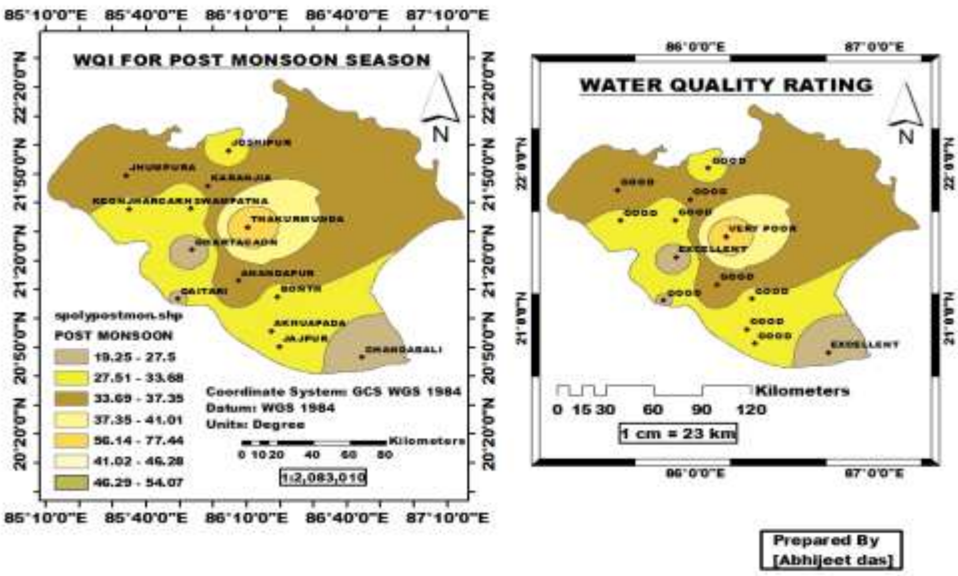
The exact variations of the WQI of all the seasons i.e., pre-monsoon, monsoon and post monsoon) are shown in the geospatial map in (**Figure 5, 6 and 7)** respectively.



(**Figure 5**. Spatial variations of water quality index (WQI) for Pre-monsoon season)



(**Figure 6**. Spatial variations of water quality index (WQI) for Monsoon season)



(**Figure 7**. Spatial variations of water quality index (WQI) for Post-monsoon season)

From the overall analysis of three different seasons i.e., (pre-monsoon, monsoon and post-monsoon), the WQI varied from 17.76 to 59.72 in the pre-monsoon season, 17.80 to 58.53 in monsoon season and 19.25 to 77.69 in the post-monsoon season. Sampling stations 1, 4 and 7 designated as excellent, 2, 3, 5, 6, 9,10, 11, 12 and 13 designated as good in the pre-monsoon season. In monsoon season, sampling station 1 and 7 designated as excellent and 2, 3, 4, 5, 6, 9, 10, 11, 12 and 13 designated as good. In case of post-monsoon season, sampling stations 1 and 7 designated as excellent and 2, 3, 4, 5, 6, 9, 10, 11, 12 and 13 designated as good and station 8 designated as very poor because it is situated in the downstream and is thought to receive the municipal effluents. The water looks like municipal drain water. In this case water here is almost static and pollutants did not get disperse. Good status of water quality signifies high number of fecal coliforms, high values of turbidity and presence of dissolved salts and that reflected in the values of their WQI. This could be attributed to improper disposal of wastes, large quantity of agricultural and urban runoff, sewage, over application of inorganic fertilizer, improper operation and maintenance of septic system. It refers to possible decline of environmental properties. A small difference between values in different seasons could be attributed to discharge of pollutants to a water resource system from domestic sewers, water discharges, industrial waste discharges, agricultural runoff and other sources which can have significant effects of both short term and long-term duration on the quality of a river system.

The evaluation of the ecological status of surface water courses (rivers), existing within hydrographical system has revealed the fact that most rivers have been found in good ecological status. Concerning the evaluation of the chemical status, one could notice that most rivers have been found in good chemical status and only one of them have been characterized by a very poor chemical status. Regarding the surface water courses that are heavily modified (rivers), which exist within this basin, it has been found that most of the water courses have had a good ecological potential, the difference being represented by the water courses that have had an excellent ecological potential, and from a chemical status point of view, more than half had a good chemical status and less than half have had a bad ecological status. In the same period, the evaluation of the ecological potential of the surface reservoirs existing within the basin analysed has revealed the fact that all these have had a marginal ecological potential and that all have been found in a good chemical status.The values of the water quality index correspond to poor class which are influenced by the nutrients, respectively, by the high values of nitrates as a result of the agricultural practices, municipal and industrial wastewaters, manure from farms and so on. It is influenced by many factors including the quantitative variation of biogenic and organic substances. All biogenic elements within the water bodies are the result of the decomposition process of the organic substances therefore the regime of the biogenic elements depend directly on the vital activity of the organisms from the rivers. Moreover, this river is characterized by the presence of several impurities in natural state with a composition which depends on the types of soils from the reception basin, waste water spills from different kind of users and the dissolving capacity of the gases in the atmosphere.

The reduction of WQI value downstream is an indication of various pollutants entering the waterway because of different anthropogenic and natural factors like the release of untreated local sewage and spill over water from horticultural areas and the decrease in river water levels that promotes drainage from the ground water into the waterway. There are large yearly fluctuations in the river water level in the dry seasons (summer and autumn), water comes from the reservoirs full of organic materials, plankton algae and plants with dark green colour, reducing in PH and oxygen, raising turbidity, total dissolved solids and affecting the overall water quality. The river can't self-purify because of the low level of water and shortage caused by limited rains, the many dams which had been built and the poor planning with the old methods used in irrigation.

At the downstream, the water quality status is deteriorated according to the average annual, maximum annual and minimum annual values of the water quality index and also doe to the result of human activity and demographic characteristic on one side and urbanization and industrialization on the other side. Discharging of untreated waste waters from industry, households and pollution from agriculture (sewage water) are the main causes of pollution on surface water resources and ground water in this region. The human stress is induced by the total number of inhabitants and the urban inhabitants from cities by the organic loading that they generate through the industrial activities, land use and animal husbandry in animal farming complexes and finally through the degree of improvement of the hydrographical network, as a result of human activity. At the monitoring stations situated downstream of the waste water discharge high values of nitrogen compounds have been identified, more exactly of the nitrate, nitrite and ammonium ions, which influence the quality of the watercourses. The waters at the exit point are much polluted because the rivers quality state suffers a slight depreciation downstream thanks to effects of the urban sewage, of the urban wastewaters, of the agricultural wastes, and of the natural causes such as erosion in the hydrographical basins of these main rivers.

Water pollution by nitrates reaches high levels due to the introduction of intensive farming methods, with increased use of chemical fertilizers and higher concentrations of animals in smaller areas especially in animal farming complexes. In this basin, the values of these parameters vary from one monitoring station to another due to the hydrological regime of the surface water but also to the origin and the behaviour of the physical, chemical and biological parameters. The anthropogenic factor has an important role in the formation and influence of leakage water processes on the rivers of this hydrographical system. It has mostly influenced by the water discharge, by achieving several types of hydraulic structures, among which the most important are the regulation of maximum discharges on the main rivers and the most important tributaries, the performance of flood mitigation works, and river bed regulation, damming works on the most important rivers and tributaries, within the proximity of the most important localities.

Quantitatively, the post-monsoon water quality is slightly better, because a part of the pollutants is diluted and washed away with heavy rain water. The exact variations of the WQI of all the seasons i.e., (pre-monsoon, monsoon and post monsoon) are shown in the geospatial map. However, ecological parameters and the WQI calculated give us some idea of the overall pollution in Baitarani River. We can conclude that from this that the Baitarani River was slightly polluted in study area, therefore water is not suitable for direct public usage at all the seasons, in view of the high counts of both fecal coliform which is monitored only in the sections where the water is targeted for the potable use and turbidity. Besides, all the other water quality parameters were within the limits set out by world health organization standards for drinking water. Overall, we need fast measures to avoid further deterioration of the river water quality and we need correct treatment for Baitarani water to supply health drinking water.

V. Conclusion

Water quality monitoring is one of the highest priorities in environmental protection policy to control and minimize the incidence of pollution related problems and to protect the valuable fresh water resources to safeguard public health. It provides monitoring programme inclusive of in-situ analysis at regular intervals is required to understand the complex cycle of physio-chemical factors and their role in regulating the quality of water. The overall study of water quality clearly indicates that the water sources of the concerned study area cannot be used for public consumption without any treatment through all samples are of good quality for irrigation purpose on the basis of physio-chemical parameter values.

On the basis of the present study of various physio-chemical parameters, it was found that though the cations and anions along with pH are within the BIS and WHO standard limits for almost all samples in Baitarani River, some of the samples is fit for direct human consumption with respect to water quality index. Maximum sampling stations are contaminated with high total coliform including faecal coliform bacteria. Water is slightly acidic at some stations, particularly in post-monsoon period and alkaline in most of the stations in monsoon and pre-monsoon period. Comparatively low DO and high BOD values along with high turbidity and TSS, high values of Fe and Cr indicate poor quality of water. WQI reveals that degradation of water quality is due to high concentrations of Fe and Cr. BOD, TSS, turbidity and coliform counts (CFU/100ml) as well as iron and chromium are relatively higher. This may be due to low volume of water, low flow condition, dense population in the catchment area and flowing of streams in the close proximity of various iron and manganese mines. The sources of contamination are domestic sewage, disposal of garbage, soil erosion, mines run off and anthropogenic activities with extensive recreational use of the streams and the river.

Lack of sanitary awareness mostly open defecation among the local people is one of the most important factors for the degradation of water quality in this area. Therefore, there is a need for proper management to check the disposal of wastes into the streams and river catchment and to control and monitor human activities along with the public awareness to ensure its minimal negative effect on the water body. Deforestation should be strictly enforced to check the massive soil erosion. The present baseline information of the physio-chemical parameters of water samples would form a useful tool for further ecological and environmental assessment and monitoring of these water ecosystems, leading to the safe survival of the inhabitants in the study area.

Water quality in the upstream sections has been in a better condition than the downstream river sections. There has been significant deterioration in values of the most important water quality parameters (DO, PH, BOD, temperature, N-NO_2, Slurry) downstream of the rivers, which indicates that the local pollutants may be contributing incrementally to the degradation of river quality.

This study mainly focuses on water resources management and shows the need to enforce the existing international bilateral agreements and to implement this European directive in order to improve the water quality and quality received by the downstream of a shared watershed. According to the Water Framework Directive requirement, knowledge of anthropogenic pressure formed on water resources is highly imperative, in order to identify the quality of water bodies and ultimately for adopting appropriate measures to protect and conserve the water in this region.

References

[1]. Abdul HM, Jaward A, Bahram KM, Abass JK (2010) Evaluating raw and treated water quality of Tigris River within Baghdad by index analysis. J Water Resour Prot 2:629–635

[2]. Ameen SMM, Wilde SA, Kabir MZ, Akon E, Chowdhury KR, Khan MSH (2007) Paleoproterozoic granitoids in the basement of Bangladesh: a piece of the Indian shield or an exotic fragment of the Gondwana jigsaw? Gondwana Res 12:380–387. https:// doi.org/10.1016/j.gr.2007.02.001

[3]. APHA (2012) Standard methods for the examination of water and wastewater, 22nd edn. American Public Health Association, American Water Works Association, Water Environment Federation, Washington

[4]. Arumugam K, Elangovan K (2009) Hydrochemical characteristics and groundwater quality assessment in Tirupur Region, Coimbatore District, Tamil Nadu, India. Environ Geol 58:1509–1520. https://doi.org/10.1007/s00254-008-1652-y

[5]. Ayers RS, Westcot DW (1976) Water quality for agriculture. FAO irrigation and drainage. Paper no. (29), rev. (1). U.N. Food and Agriculture Organization, Rome

[6]. Banerjee T (1955) Progress report for 1955–1956 feld season (Continuation of geological mapping in Sikkim and Kalimpong hills). Geological Survey of India. F. no. 398(10)

[7]. Barakat A, Baghdadi ME, Rais J, Aghezzaf B, Slassi MM (2016) Assessment of spatial and seasonal water quality variation of Oum Er Rbia River (Morocco) using multivariat statistical techniques. Int Soil Water Conserv Res. https://doi. org/10.1016/j.iswcr.2016.11.002
[8]. Carpenter S, Caraco NF, Correll DL, Howarth RW, Sharpley AN, Smith VH (1998) Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecol Appl 8(3):559–568
[9]. Etteieb S, Cherif S, Tarhouni J (2017) Hydrochemical assessment of water quality for irrigation: a case study of the Medjerda River in Tunisia. Appl Water Sci 7:469–480. https://doi.org/10.1007/ s13201-015-0265-3
[10]. Giridharan L, Venugopal T, Jayaprakash M (2010) Identifcation and evaluation of hydrogeochemical processes on river Cooum, South India. Environ Monit Assess 162:277–289
[11]. Jarvie HP, Whitton BA, Neal C (1998) Nitrogen and phosphorus in east coast British rivers: speciation, sources and biological signifcance. Sci Total Environ 210(211):79–109
[12]. Kannel PR, Lee S, Lee YS, Kanel SR, Khan SP (2007) Application of water quality indexes and dissolved oxygen as indicators for river water classifcation and urban impact assessment. Environ Monit Assess 132:93–110
[13]. Kazi T, Arain MB, Jamali MK, Jalbani N, Afridi HI, Sarfraz RA, Baig JA, Shah AQ (2009) Assessment of water quality of polluted lake using multivariate statistical techniques: a case study. Ecotoxicol Environ Saf 72:301–309
[14]. Kumar B, Singh UK (2018) Source apportionment of heavy metals and their ecological risk in a tropical river basin system. Environ Sci Pollut Res. https://doi.org/10.1007/s11356-018-2480-6
[15]. Kumar B, Singh UK, Ojha SN (2018) Evaluation of geochemical data of Yamuna River using WQI and multivariate statistical analyses: a case study. Int J River Basin Manag. https://doi. org/10.1080/15715124.2018.1437743
[16]. Manahan SE (2010) Environmental chemistry, 9th edn. CRC Press, Boca Raton, p 52
[17]. Sener S, Sener E, Davraz A (2017) Evaluation of water quality using water quality index (WQI) method and GIS in Aksu River (SW-Turkey). Sci Total Environ 584–585:131–144. https://doi. org/10.1016/j.scitotenv.2017.01.102
[18]. Subramani T, Rajmohan N, Elango L (2009) Groundwater geochemistry and identification of hydrogeochemical processes in a hard rock region, Southern India. Environ Monit Assess 162(1–4):123–137
[19]. Sánchez E, Colmenarejo MF, Vicente J, Rubio A, García MG, Travieso L, Borja R (2007) Use of the water quality index and dissolved oxygen defcit as simple indicators of basins pollution. Ecol Indic 7:315–328
[20]. Sener S, Sener E, Davraz A (2017) Evaluation of water quality using water quality index (WQI) method and GIS in Aksu River (SW-Turkey). Sci Total Environ 584–585:131–144. https://doi. org/10.1016/j.scitotenv.2017.01.102
[21]. Simeonov V, Stratis JA, Samara C, Zachariadis G, Voutsa D, Anthemidis A, Sofoniou M, Kouimtzis T (2003) Assessment of the surface water quality in Northern Greece. Water Res 37:4119–4124 Singh H (1983) Crop production in India. Agric Situat India. 38:635–63
[22]. Singh UK, Kumar B (2017) Pathways of heavy metals contamination and associated human health risk in Ajay River basin, India. Chemosphere 174:183–199. https://doi.org/10.1016/j.chemospher e.2017.01.103