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Monitoring On Surface Water Quality of Balasore District, Odisha [A Case Study]

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ABSTRACT: The present study was carried out to determine the water quality status of Subarnarekha River at Balasore region. Water samples were analyzed for physico-chemical parameters by following standard methods (APHA 1985) and the results showed their variations as follows: pH 7.3-7.8,Temperature 26.7-28.20C, Electrical Conductivity 392-514 µ mho ,Total suspended solids 118-148 mg/l, Total dissolved solids 241-285 mg/l, Alkalinity 27.3-42 mg/l, Total Hardness 64.63-114.06 mg/l, Calcium 24.6-32 mg/l, Magnesium 9.72-13.8 mg/l, Dissolved Oxygen 4.6-5.3 mg/l, Biochemical oxygen demand 1.1-3.39 mg/l, Chemical oxygen demand 53-147 mg/l, Nitrates 0.4-1.06 mg/l, Phosphates 0.86-2.4 mg/l, Sulphates 113-143 mg/l, Chlorides 26.32-36.63 mg/l, Iron 0.224-0.464 mg/l, Chromium 0.008-0.016 mg/l. The analyzedphysico-chemical parameters were almost not exceeded the maximum permissible limit of Indian standards (IS: 10500).
The water quality at Rajghat conforms to class-C inland surface water. Bio monitoring studies reveals that the river stretch at Rajghat is in a state of slight to moderate pollution. 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 quantity.After physico-chemical analysis, water quality index (WQI) was established from twelve important various physiochemical parameters by following weighted arithmetic index method. The calculated water quality index indicates that the quality of water was good and hence fit for use.

Keywords: Subarnarekha River, Balasore, Physico-chemical parameters, Water quality index. (WQI).

I. INTRODUCTION

Water quality is a complex subject, which involves physical, chemical, hydrological and biological characteristics of water and their complex and delicate relations. From the user's point of view, the term "water quality" is defined as "those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water". For example for drinking water should be pure, wholesome, and potable. Similarly, for irrigation dissolved solids and toxicants are important, for outdoor bathing pathogens are important and water quality is controlled accordingly.

The requirements for utilizing available water resources (Surface and ground) in a judicious and equitable as well as sound economic manner are outlined in the State Water Policy. Clause 7 of water Policy-2007 for the state odisha emphasizes upon monitoring of both surface and ground water quality and sharing of information among the data users group [1].

The State of Odisha is located in the southeastern part of India, between 17°31´ and 22°27´N Latitude and 81°27´ and 87°30´E Longitude with a population of 36.7 million (2001 census). The annual overall availability of surface water in odisha is about 85.89 billion cubic meters. The state has 11% of the water resources of the country. The per capita availability of water in 2001 was 2259 cubic meters. With increasing population and the consequential increase in demand for food and water and with the growth in mining and industrial activities, the demand for water from various sectors in next twenty years will have significant impact on the per capita availability of water. Further, the degradation in quality of water resources by direct and indirect human interference such as discharge of untreated/ partially treated industrial and municipal waste water will make the resource scarce. It is therefore imperative to manage this resource as rationally and efficiently as possible to make it sustainable.

State Pollution Control Board, Odisha monitors the water quality of nine rivers of Odisha under National Water Quality Monitoring Programme (NWMP) of Central Pollution Control Board (CPCB). CPCB is an apex body in the field of water quality management in India and provides technical and financial support for water quality monitoring programmes conducted by State Pollution Control Boards.

Subarnarekha basin is the smallest of the 14 major river basins of India draining an area of 19,296 square kilometres and covering hardly 0.6 percent of India's land surface, yet it is an important inter-State river flowing through one of the most important industrial belt and mineral-rich areas of India.. The river in its upper and middle reaches remains more or less as a stagnant pool, often highly charged with pollutants, particularly during dry periods as has been observed in the study based on the water quality data collected by the Bihar State Pollution Control Board (Priyadarshi, N, 1998, 2004).

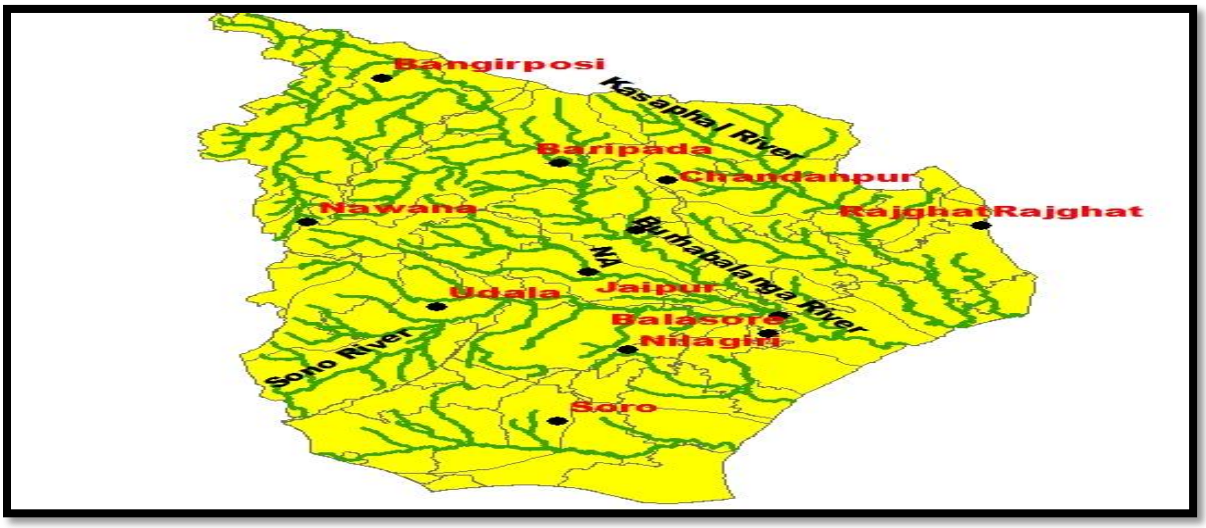
Subarnarekha is the lifeline of tribal communities and fishing communities, residing on the riverbanks and their life and livelihood is affected by the river's pollution. The basin therefore needs careful environmental management planning to protect its continued existence. A few studies have been undertaken to investigate the pollution of the Subarnarekha River towards its eastern and coastal sides (Mishra et al 1994, Senapati and Sahu, 1996; Panda et al., 2006). The water quality of Subarnarekha River in Balasore region is also in threat because Government of Odisha has proposed Subarnarekha Port or Kirtania Port near the mouth of the Subarnarekha River at Chaumukh in Balasore district of the Odisha coast [2]. The port has been awarded to Chennai-based Creative Port Development Limited (CPDL) to build and operate. If the port will come then anthropogenic activities will be increased which directly influence the water qualities of the river and the life of the people residing there to a greater extent. Hence, in present study the water quality assessment of river Subarnarekha in the coastal belt of Balasore during pre-projects period was done .This study can also be used as reference to monitor the water quality status of the Subarnarekha River during ongoing projects and post-projects scenario.

II. MATERIALS AND METHODS

SAMPLING LOCATIONS: The sampling locations were selected randomly by considering the population, location and source. Water samples were collected from the locations along the route of the Subarnarekha River basin in Balasore district. The sampling locations**(Figure1)** were Rajghat, Jamkunda, Asti, Bhusandeshwar, Chaumukh and Chaumukhmuhana which are described below (Table-1).

TABLE-1: SAMPLING LOCATIONS

SAMPLE-NO.	SAMPLING LOCATIONS	TYPE OF AREA
1	RAJGHAT	AGRICULTURAL AND FISHING AREA (LOCATED NEAR BRIDGE OF NH 60)
2	ASTI	AGRICULTURAL AND FISHING AREA
3	JAMKUNDA	AGRICULTURAL AND FISHING AREA
4	BHUSANDESHWAR	AGRICULTURAL AND FISHING AREA
5	CHAUMUKH	AGRICULTURAL AND FISHING AREA
6	CHAUMUKH MUHANA	CONFLUENCE POINT OF SUBARNAREKHA RIVER



(Figure1.Monitoring stations along the Subernarekha River)

PHYSICO-CHEMICALANALYSIS

Water samples were analysed for eighteen parameters to determine the overall quality with respect to Temperature, pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Hardness, Calcium, Magnesium Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Electrical Conductivity (EC), Chloride, Sulphate , Total Alkalinity, Chemical Oxygen Demand (COD), Fluoride, Iron, Chromium and Nitrate-Nitrogen . The water samples were analysed for various parameters in the laboratory of P.G Department of Environmental Science, Fakir Mohan University, Balasore, and Odisha during the period of March to July, 2017. In general, the standard methods recommended by APHA (1985) were adopted for determination of various physico-chemical parameters (Table 2).

TABLE-2: PHYSICO-CHEMICAL ANALYSIS OF RIVER WATER SAMPLE

S.NO	PARAMETERS	S1	S2	S3	S4	S5	S6	STANDARDIS: 10500
1	PH	7.5	7.7	7.3	7.4	7.3	7.8	6.5-8.5
2	TEMPERATURE (^{0}C)	28.2	27.4	26.7	27.1	27.8	27.3	-
3	ELECTRICAL CONDUCTIVITY(µ MHO)	485	464	392	514	427	462	-
4	TOTAL SUSPENDED SOLIDS (MG/L)	118	132	129	146	121	148	500
5	TOTAL DISSOLVED SOLIDS (MG/L)	247	276	243	241	279	285	500
6	TOTAL ALKALINITY (MG/L)	42.3	28.1	34	32.42	27.3	36	200
7	TOTAL HARDNESS (MG/L)	114.06	85.12	64.63	68.79	96.41	83.05	300
8	CALCIUM (MG/L)	26	31.47	28.46	24.6	26.42	32	75
9	MAGNESIUM (MG/L)	13.63	13.04	9.72	13.5	13.8	12.81	30
10	DISSOLVED OXYGEN (MG/L)	5.2	5.3	5.1	4.6	4.9	5.2	-
11	BIOCHEMICAL OXYGEN DEMAND (MG/L)	1.1	1.87	1.59	2.8	1.51	3.39	30
12	CHEMICAL OXYGEN DEMAND (MG/L)	53	69	74	136	122	147	250
13	NITRATES (MG/L)	0.8	0.54	1.06	0.68	0.53	0.4	45
14	PHOSPHATES (MG/L)	1.74	1.62	1.1	0.86	1.86	2.4	5
15	SULPHATES (MG/L)	134.41	132.76	113	143	131	123	150
16	CHLORIDES (MG/L)	26.32	36.63	31.24	34.1	35.1	36.12	250
17	IRON (MG/L)	0.413	0.224	0.241	0.306	0.273	0.464	0.3
18	CHROMIUM (MG/L)	0.012	0.01	0.008	0.014	0.016	0.014	0.05

WATER QUALITY INDEX

Calculating of water quality index is to turn complex water quality data into information that is understandable and useable by the public. Therefore, water Quality Index (WQI) is a very useful and efficient method which can provide a simple indicator of water quality and it is based on some very important parameters**(Table 3).** In current study, Water Quality Index (WQI) was calculated by using the Weighted Arithmetic Index method as described by Cude, C. 2001. In this model, different water quality components are multiplied by a weighting factor and are then aggregated using simple arithmetic mean.

TABLE-3: CALCULATION OF MINIMUM,MAXIMUM, MEDIAN, MEAN,S.D. AND VARIANCE

DESCRIPTIVE STATISTICS								
S.NO	**PARAMETERS**	**NO. OF SAMPLING STATIONS**	**MIN.**	**MAX.**	**MEDIAN**	**MEAN**	**S.D**	**VARIANCE**
1	**PH**	**6**	**7.3**	**7.8**	**7.45**	**7.5**	**0.21**	**0.044**
2	**TEMPERATURE**	**6**	**26.7**	**28.2**	**27.35**	**27.417**	**0.527**	**0.278**
3	**EC**	**6**	**392**	**514**	**463**	**457.333**	**42.968**	**1846.367**
4	**TSS**	**6**	**118**	**148**	**130.5**	**132.333**	**12.469**	**155.467**
5	**TDS**	**6**	**241**	**285**	**261.5**	**261.833**	**20.203**	**408.167**
6	**ALKALINITY**	**6**	**27.3**	**42.3**	**33.21**	**33.353**	**5.524**	**30.553**
7	**HARDNESS**	**6**	**64.63**	**114.06**	**84.085**	**85.343**	**18.196**	**331.096**
8	**CALCIUM**	**6**	**24.6**	**32**	**27.44**	**28.158**	**3.038**	**9.232**
9	**MAGNESIUM**	**6**	**9.72**	**13.8**	**13.27**	**12.75**	**1.53**	**2.342**
10	**DO**	**6**	**4.6**	**5.3**	**5.15**	**5.05**	**0.259**	**0.067**
11	**BOD**	**6**	**1.1**	**3.39**	**1.73**	**2.043**	**0.871**	**0.759**
12	**COD**	**6**	**53**	**147**	**98**	**100.167**	**39.585**	**1566.967**
13	**NITRATES**	**6**	**0.4**	**1.06**	**0.61**	**0.668**	**0.236**	**0.056**
14	**PHOSPHATES**	**6**	**0.86**	**2.4**	**1.68**	**1.597**	**0.552**	**0.305**
15	**SULPHATES**	**6**	**113**	**143**	**131.88**	**129.528**	**10.332**	**106.746**
16	**CHLORIDES**	**6**	**26.32**	**36.63**	**34.6**	**33.252**	**3.895**	**15.174**
17	**IRON**	**6**	**0.224**	**0.464**	**0.289**	**0.32**	**0.097**	**0.009**
18	**CHROMIUM**	**6**	**0.008**	**0.016**	**0.013**	**0.012**	**0.003**	**0**

For assessing the quality of water in this study, firstly, the quality rating scale (Qi) for each parameter was calculated by using the following equation;

• $\mathbf{Q_i = \{[(V_{Actual} - V_{Ideal}) / (V_{Standard} - V_{Ideal})] * 100\}}$

Where, $\mathbf{Q_i}$= Quality rating of ith parameter for a total of n water quality parameters

(V) $_{\mathbf{Actual}}$ = Actual value of the water quality parameter obtained from laboratory analysis.

(V) $_{\mathbf{Ideal}}$ = Ideal value of that water quality parameter can be obtained from the standard Tables.

(V) $_{\mathbf{Ideal}}$ for pH = 7 and for other parameters it is equalling to zero, but for DO,**(V)** $_{\mathbf{Ideal}}$ = 14.6 mg/L.

(V) $_{\mathbf{Standard}}$ = Recommended WHO standard of the water quality parameter. Then, after calculating the quality rating scale (Qi), the Relative (unit) weight (Wi) was calculated by a value inversely proportional to the recommended standard (Si) for the corresponding parameter using the following expression

$$\mathbf{W_i = 1/ S_i}$$

Where,$\mathbf{W_i}$ = Relative (unit) weight for nth parameter • $\mathbf{S_i}$= Standard permissible value for nth parameter I = Proportionality constant. That means, the Relative (unit) weight (WI) to various water Quality parameters are inversely proportional to the recommended standards for the corresponding parameters. Finally, the overall WQI was calculated by aggregating the quality rating with the unit weight linearly by using the following equation

$$\mathbf{WQi = \Sigma QiWi/ \Sigma\ Wi}$$

Where, Qi = Quality rating,Wi = Relative weight In general, **WQI** is defined for a specific and intended use of water. In this study the WQI was considered for human consumption or uses and the maximum permissible WQI for the drinking water was taken as 100 score. Chemical analysis of water gives a concept about its physical and chemical composition by some numerical values but for estimating exact quality of water, it's better to depend on water quality index which gives the idea of quality of drinking water. The rating of WQI is shown below**(Table 4)**.

Table4.RANGE AND RATING OF WATER QUALITY INDEX

WQI level	Water Quality Rating
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
> 100	Unfit for Drinking Purposes.

III. RESULTS AND DISCUSSION

WATER QUALITY TREND:

Subernarekha is an interstate river (total length 446 km) with catchment areas in Jharkhand, West Bengal and Odisha. Only a small stretch (81 km, about 18%) of its total length flows through Odisha, before falling into 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: about 22,000), which is on its bank. The waste water generated in other smaller towns and villages in the basin would not have any significant impact on the water quality of the river [3].

Though the river is expected to carry considerable pollution load from the industrial, mining and urban activities at Jharkhand and West Bengal while entering into Odisha, it seems to have gained considerable regenerative capacity. The concentrations of the metals expected from the mining activities at Jharkhand and West Bengal (e.g. iron, chromium, copper etc.) are found to be quite low to be of any environmental significance.

Water quality of the river is assessed quarterly (January, April, July and October, corresponding to winter, summer, monsoon and post monsoon seasons) at Rajghat (about 5 km downstream to Jaleswar and 60 km upstream to the confluence with sea).

Water quality at Rajghat with respect to four critical parameters such as PH, DO, BOD and TC conforms to Class-C inland surface water. BOD at Rajghat always remained within the criteria limit for Class-C inland surface water bodies [4].

Water quality index of the present water body was established from twelve important various physico-chemical parameters. WQI indicates the quality of water in terms of index number which represents overall quality of water for any intended use. The water quality index for each samples were calculated and are presented in (**Table-5, 6)**.

The values of calculated water quality index were found to be 40.14, 27.71, 25.16, 38.48, 40.27, 49.47 for the sampling sites S1, S2, S3, S4, S5 and S6 respectively which indicate that the water quality of river Subarnarekha in Balasore region is good. However, different sampling locations shows different water quality, S2 and S3 have more good water quality in comparison to S1, S4, S5 and S6. The above water quality index was also supported by the following physiochemical parameter variations observed in different water Samples and presented in **(Table- 2)**. Graphs showing values of different physicochemical parameters were presented.

TABLE-5WATER QUALITY INDEX AND DESCRIPTION OF RIVER WATER SAMPLES AT DIFFERENT SAMPLING SITES

TABLE-4 WATER QUALITY INDEX AND DESCRIPTION OF RIVER WATER SAMPLES AT DIFFERENT SAMPLING SITES			
SAMPLENO.	SAMPLING SITES	WQI	DESCRIPTION
1	RAJGHAT	40.14	GOOD
2	ASTI	27.71	GOOD
3	JAMKUNDA	25.16	EXCELLENT
4	BHUSANDESWAR	38.48	GOOD
5	CHAUMUKH	40.27	GOOD
6	CHAUMUKH MUHANA	49.47	GOOD

TABLE-6: CALCULATION OF WATER QUALITY INDEX FOR SAMPLE S1 (RAJGHAT)

TABLE-5: CALCULATION OF WATER QUALITY INDEX FOR SAMPLE S1 (RAJGHAT)						
SAMPLE 1(RAJGHAT)						
S.NO	PARAME TERS	OBSERVED VALUES	STANDARD VALUES(SI)	UNIT WEIGHT (WI)	QUALITY RATING(QI)	WIQI
1	PH	7.5	8.5	0.117	33.3333	3.9

2	**BOD**	**1.1**	**30**	**0.033**	**3.66667**	**0.121**
3	**COD**	**53**	**250**	**0.004**	**21.2**	**0.0848**
4	**TDS**	**247**	**500**	**0.002**	**49.4**	**0.0988**
5	**TSS**	**118**	**100**	**0.01**	**118**	**1.18**
6	**HARDNESS**	**114.06**	**300**	**0.003**	**38.02**	**0.11406**
7	**ALKALINITY**	**42.3**	**200**	**0.005**	**21.15**	**0.10575**
8	**NITRATES**	**0.8**	**45**	**0.022**	**1.77778**	**0.03911**
9	**SULPHATES**	**134.41**	**150**	**0.006**	**89.6067**	**0.53764**
10	**CHLORIDES**	**26.32**	**250**	**0.004**	**10.528**	**0.04211**
11	**CR**	**0.012**	**0.05**	**20**	**24**	**480**
12	**FE**	**0.413**	**0.3**	**3.333**	**137.667**	**458.843**
				∑WI=23.539		**∑WIQI =945.0663**
WQI=∑WIQI / ∑ WI=945.0663/23.539=40.14						

PH: As may be seen from the data, pH remains mostly alkaline and the water is rich in oxygen. So the parameters conform to the quality criteria for Class-A.In present study (**Figure 2**), it was found that the pH value ranged between 7.3 at sampling station S5 to 7.8 at sampling station S6. All the pH values represent alkaline nature of river water samples were within the permissible limit as per **IS: 10500**.

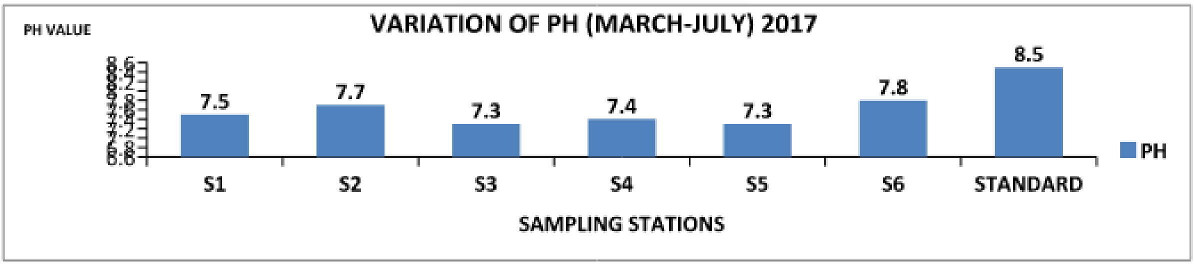


Figure 2.Variation of PH from (March-July) 2017

TEMPERATURE

Arise in temperature of the water leads to the speeding up of the chemical reactions in water, reduces the solubility of gases and amplifies the tastes and odours.At higher temperature with less dissolved gases the water becomes tasteless and even does not quench the thirst. In present study (**Figure 3**), the values of temperature were ranged between 26.70^{0}C at sampling station S3 to 28.20^{0}C at sampling stationS6.

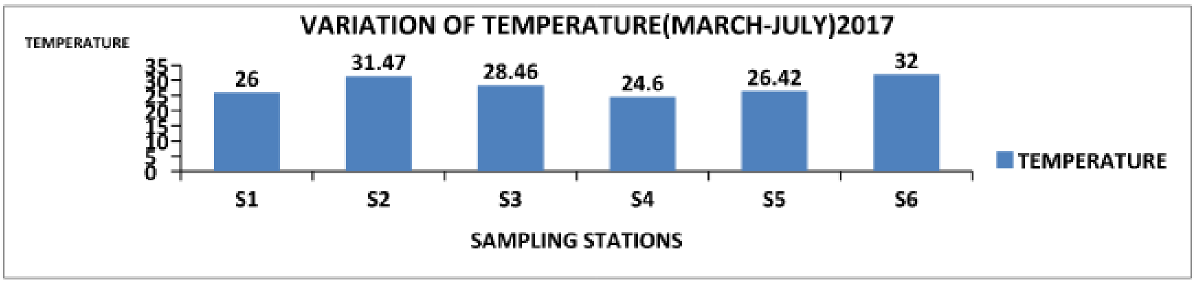


Figure 3.Variation of Temperature from (March-July) 2017

CONDUCTIVITY

As most of the salts in the water are present in the ionic forms, capable of conducting current, therefore, conductivity is a good and rapid measure of the total dissolved solids [5]. It has got no health significance as such. In present study (**Figure 4**), the values of Electrical conductivity were ranged between 392 µ mho at sampling station S3 to 514 µ mho at sampling station S4.

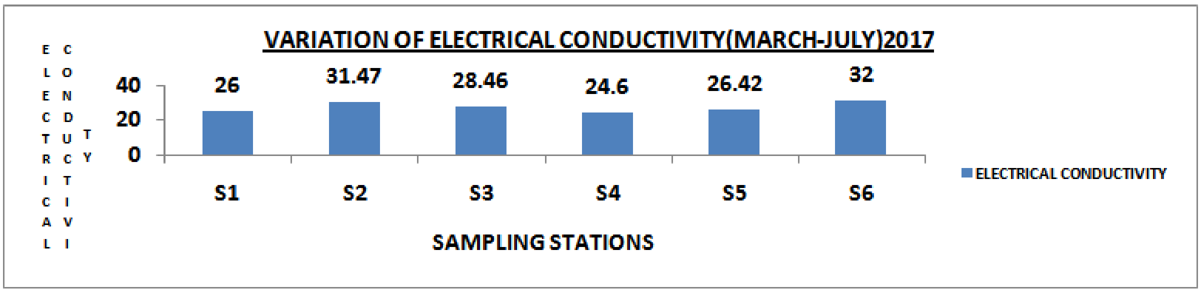


Figure 4.Variation of Electrical Conductivity from (March-July) 2017

TOTAL SUSPENDED SOLIDS

IS acceptable limit for total solids is 500 mg/L and tolerable limit is 3000 mg/L of dissolved limits. . In present study (**Figure 5**), the Total Suspended Solids (TSS) values ranged between 118 mg/l at sampling station S1 to 148 mg/l at sampling stationS6.

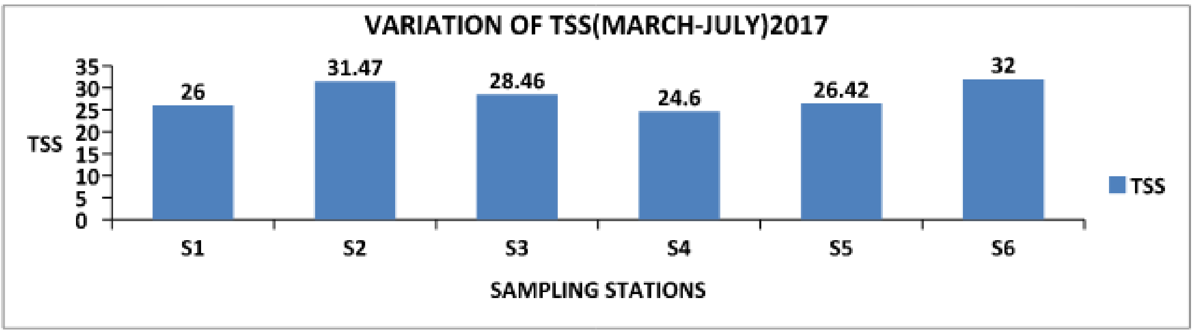


Figure 5.Variation of TSS from (March-July) 2017

TOTAL DISSOLVED SOLIDS

TDS and Total hardness are given in Table. Comparison with the required TDS concentration and hardness of different use classes (Table), it is seen that the entire river stretch conform to Class-A, except at Paradeep U/s and D/s. In terms of degree of hardness, the river water (except Paradeep) may generally be described as moderately hard (Hardness 61 to 120).

In present study (**Figure 6**), the Total Dissolved Solids (TDS) values ranged between 241 mg/l at sampling station S4 to 285 mg/l at sampling station S6. All the TDS values of river water samples were within the permissible limit as per IS: 10500.

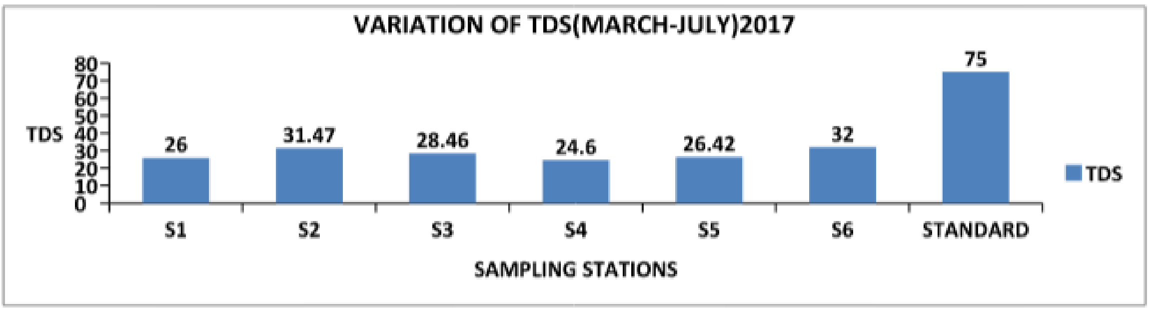


Figure 6.Variation of TDS from (March-July) 2017

ALKALINITY

Alkalinity of natural water should be more than 20 mg/l (as $CaCo_3$) for aquatic life, unless natural concentration 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) [6]. However for bottled and canned soft drink industries, the alkalinity should not exceed 85 mg/l.

In present study (**Figure 7**), the Total Alkalinity values ranged between 27.30 mg/l at sampling station S5 to 42.30 mg/l at sampling station- 1. All the Total Alkalinity values of river water samples in study area were within the permissible limit as per IS: 10500.

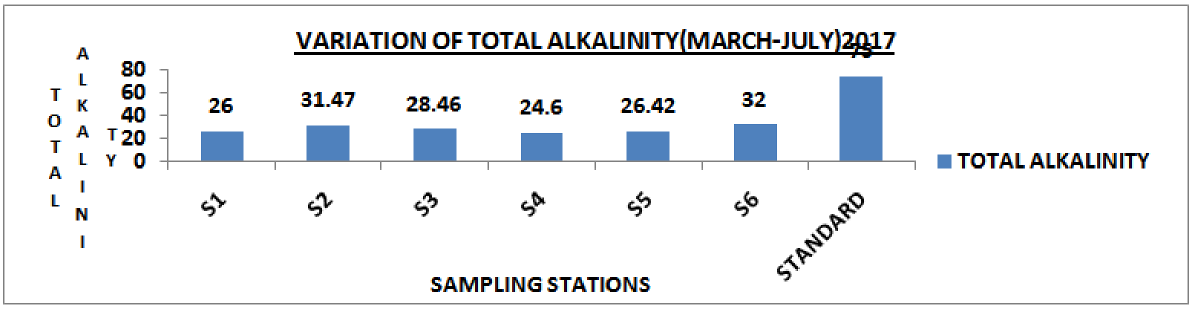


Figure 7.Variation of Total Alkalinity from (March-July) 2017

HARDNESS

The total hardness of water is defined as the sum of calcium and magnesium concentrations, both expressed as calcium carbonate, in mg/L.Based on present investigation (**Figure 8**), hardness varied from 64.63 mg/l at sampling station S3 to 114.06 mg/l at sampling station S1. The permissible limit of Hardness for drinking water is 300 mg/l (IS 10500). Hence, all the hardness values of river water samples in study area were within the permissible limit.

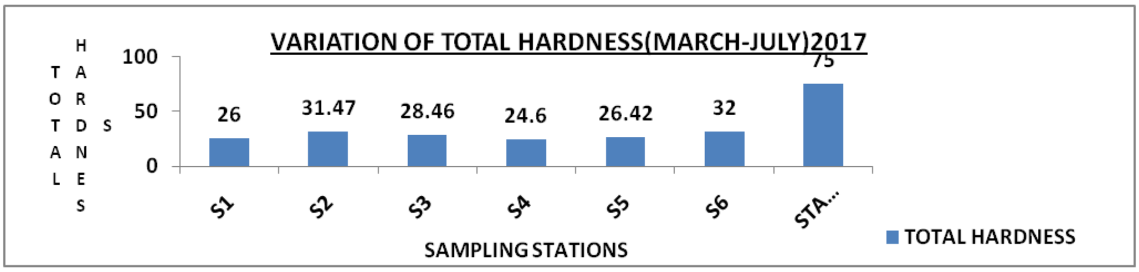


Figure 8.Variation of TH from (March-July) 2017

CALCIUM AND MAGNESIUM

The concentration of Calcium (**Figure 9**) varied from 24.60 at sampling location S4 to 32 mg/l at sampling location S6 and Magnesium (**Figure 10**) varied from 9.72 at sampling location S3 to 13.8 mg/ l at sampling location S5 respectively. All the samples were within the permissible limit i.e.75 mg/l for Calcium and 30 mg/l for Magnesium (IS: 10500).

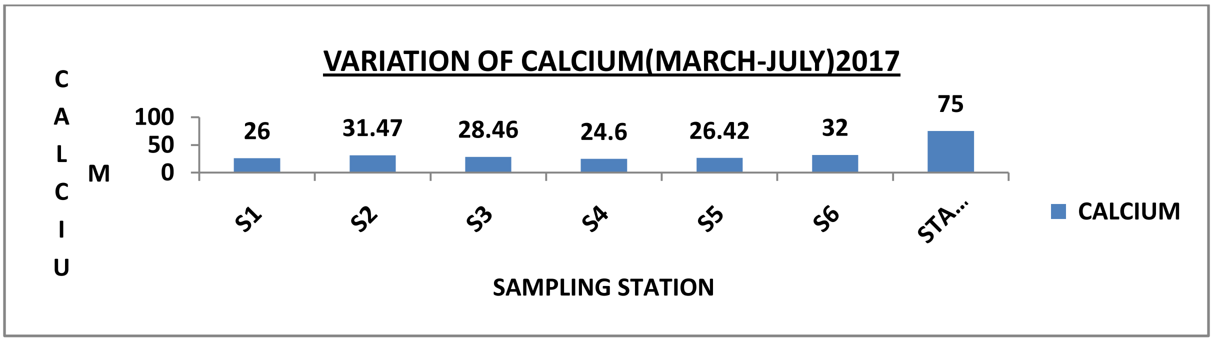


Figure 9.Variation of Calcium from (March-July) 2017

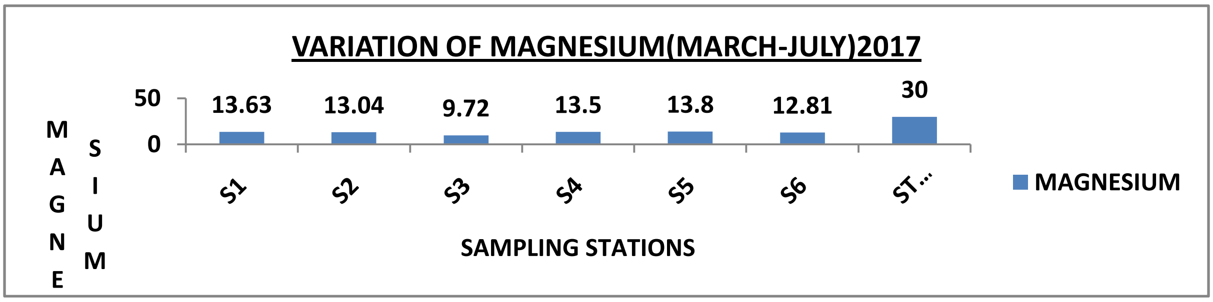


Figure 10.Variation of Magnesium from (March-July) 2017

DISSOLVED OXYGEN

Low oxygen content in water is usually associated with organic pollution. The fluctuations in Oxygen content depend on factors such as Temperature, de-compositional activities, photosynthesis and the level of aeration. In present investigation (**Figure 11**), DO was ranged from 4.60 mg/l at sampling station S4 to 5.30 mg/l at sampling station S2 in the study area, where as the prescribed limit for DO is 5.0 mg/l.

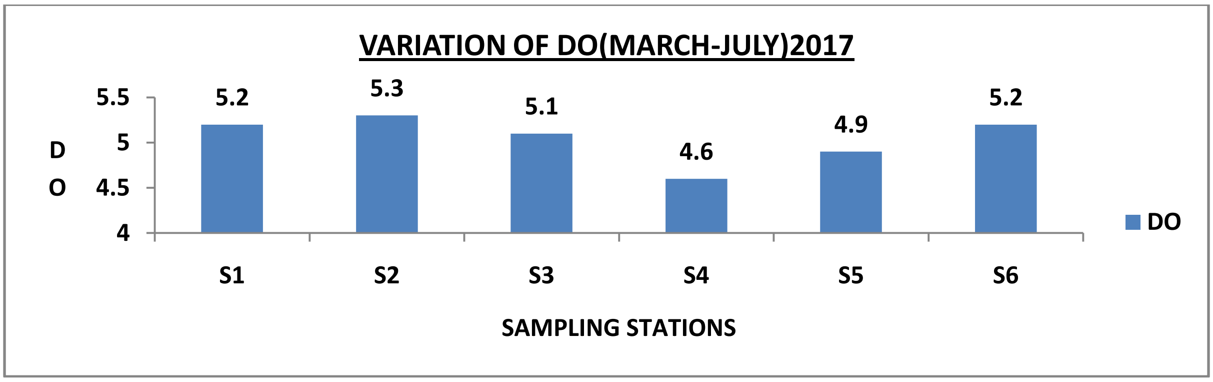


Figure 11.Variation of DO from (March-July) 2017

BIOCHEMICAL OXYGEN DEMAND

Except a few occasional deviations of small magnitudes from the stipulated value of 3 mg/l, the BOD at all the sampling stations generally conform to Class-B water quality.In present investigation (**Figure 12**), BOD was ranged from 1.10 mg/l at sampling station-1 to 3.39 mg/l at sampling station S6 in the study area;whereas the prescribed limit for BOD is 30 mg/l (IS 10500). Hence all the BOD values of river water samples were within the permissible limit.

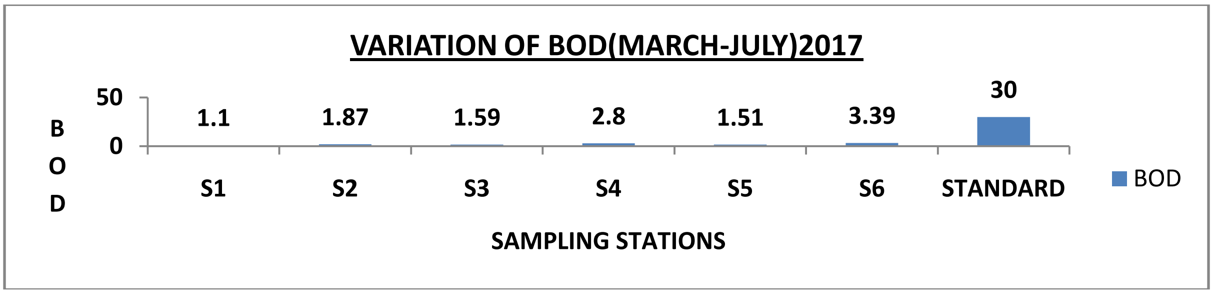


Figure 12.Variation of BOD from (March-July) 2017

CHEMICAL OXYGEN DEMAND

Chemical Oxygen Demand (COD) test is important, rapidly measured parameters as a means of measuring organic strength for streams and polluted water bodies. In present investigation (**Figure 13**), COD was ranged from 53 mg/l at sampling station S1 to 147 mg/l at sampling station S6 in the study area;whereas the prescribed limit for COD is 250 mg/l (IS 10500). Hence, all the COD values of river water samples were within the permissible limit.

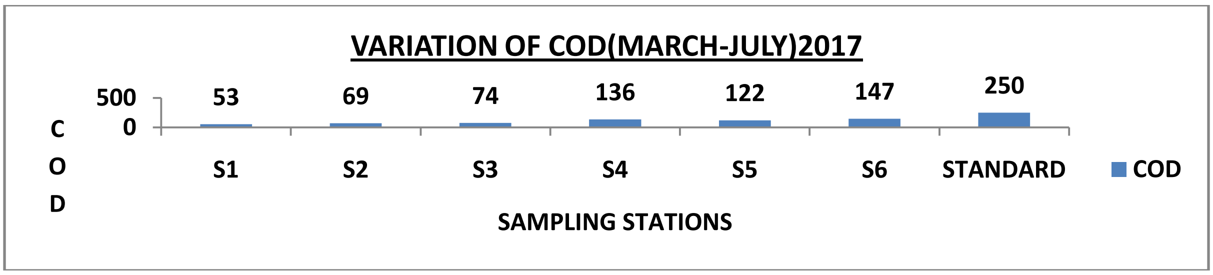


Figure 13.Variation of COD from (March-July) 2017

NITRATES

Presence of high concentration of nitrates is an indication of pollution. Concentrations of nitrates above 45 mg/L cause a disease methemoglobinemia. In present investigation (**Figure 14**), Nitrate was ranged from 0.40 mg/l at sampling station S6 to 1.06 mg/l at sampling station S3 in the study area;whereas the prescribed limit for Nitrate is 45 mg/l (IS 10500). Hence all the Nitrate values of river water samples were within the permissible limit [7].

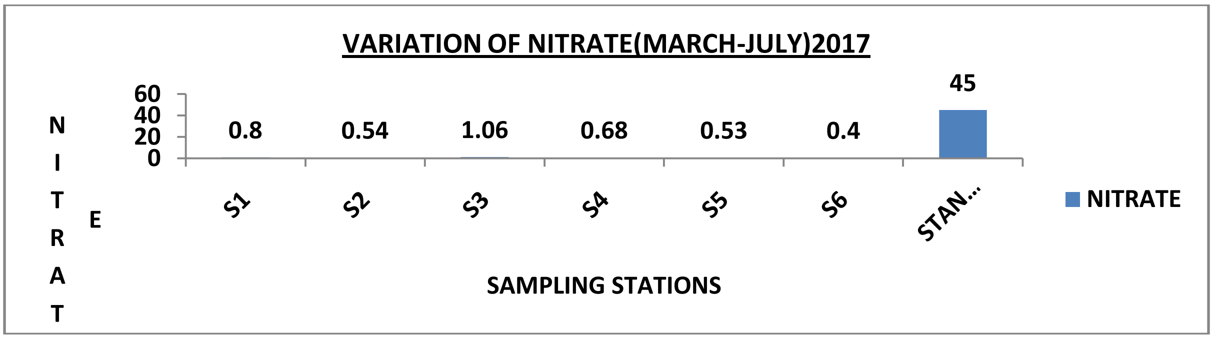


Figure 14.Variation of Nitrate from (March-July) 2017

PHOSPHATES

The presence of phosphate in large quantities in fresh waters indicates pollution through sewage and industrial wastes. It promotes growth of nuisance causing micro-organisms. Though phosphate possesses problems in surface waters, its presence is necessary for biological degradation of wastewaters. Phosphorus is an essential nutrient for the growth of organisms and helps for the primary productivity of a body of water [8]. In present investigation (**Figure 15**), phosphate was ranged from 0.86 mg/l at sampling station S4 to 2.40 mg/l at sampling station S6 in the study area;whereas the prescribed limit for phosphate is 5 mg/l (IS 10500). Hence all the phosphate values of river water samples were within the permissible limit.

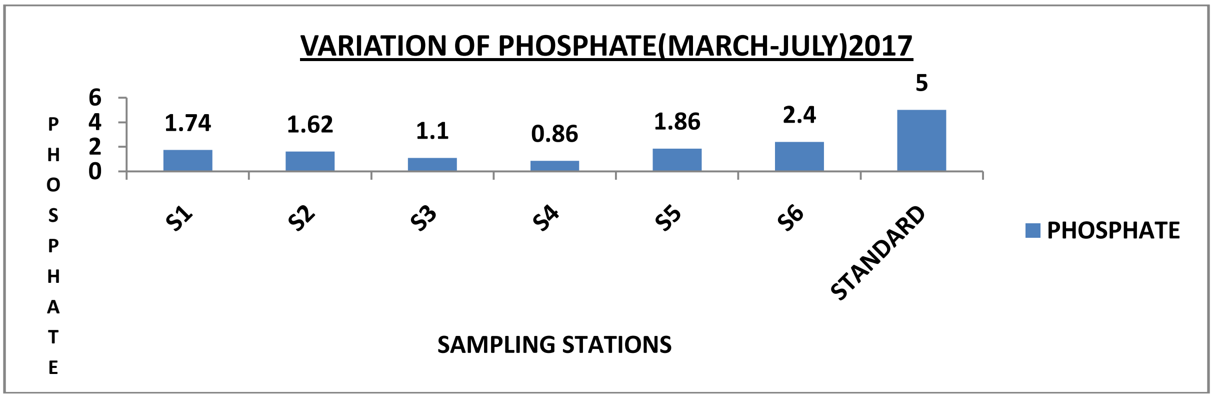


Figure 15.Variation of Phosphate from (March-July) 2017

SULPHATES

Sulphates occur in water due to leaching from sulphate mineral and oxidation of sulphides. Sulphates are associated generally with calcium, magnesium and sodium ions. Sulphate in drinking water causes a laxative effect. The prescribed limit of sulphate for drinking water is 150 mg/l (IS 10500). In present investigation (**Figure 16**), Sulphate was ranged from 113 mg/l at sampling station S3 to 143 mg/l at sampling station S4 in the study area. Hence all the sulphate values of river water samples were within the permissible limit.

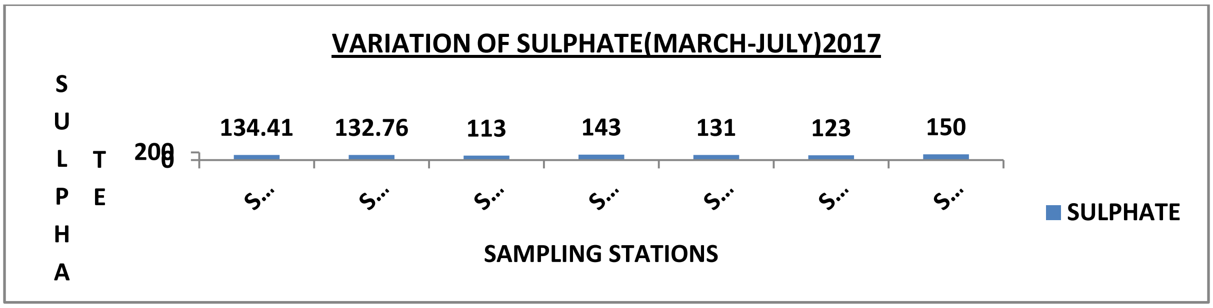


Figure 16.Variation of Sulphate from (March-July) 2017

CHLORIDES

Chloride ion may be present in combination with one or more of the cations of calcium, magnesium, iron and sodium. Chlorides of these minerals are present in water because of their high solubility in water. Thus, excessive presence of chloride in water indicates sewage pollution. The prescribed limit of chloride for drinking water is 250 mg/l (IS 10500). In present investigation (**Figure 17**), Chloride was ranged from 26.32 mg/l at sampling station S1 to 36.63 mg/l at sampling station S2 in the study area. Hence all the Chloride values of river water samples were within the permissible limit.

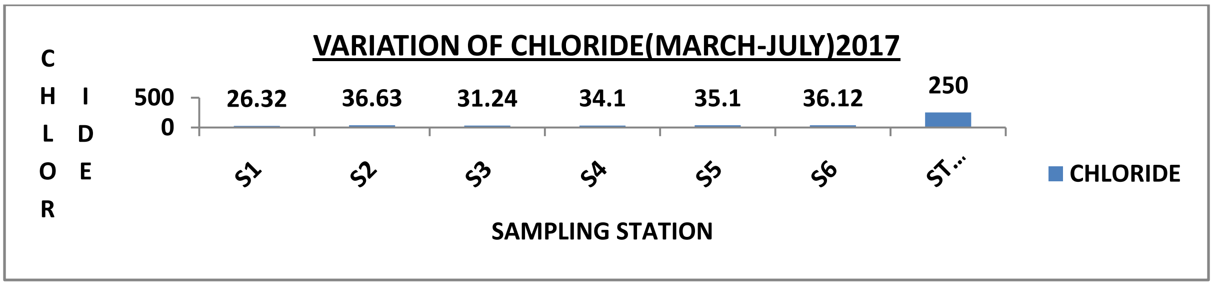


Figure 17.Variation of Chloride from (March-July) 2017

IRON

Iron can impart bad taste to the water, causes discolouration in clothes and incrustations in water mains. The permissible value of Iron for drinking water is 0.3 to 1.0 mg/l (IS 10500). In present investigation (**Figure 18**), Iron was ranged from 0.224 mg/l at sampling station S2 to 0.464 mg/l at sampling station S6 in the study area. Hence all the Iron values of river water samples were within the permissible limit.

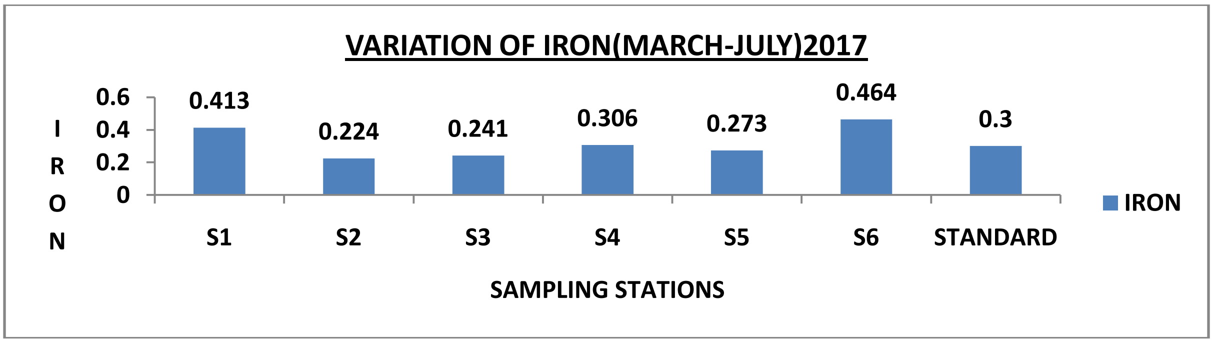


Figure 18.Variation of Fe from (March-July) 2017

CHROMIUM

Chromium may exist in water supplies in both the hexavalent and the trivalent state although the trivalent form rarely occurs in potable water. In present investigation (**Figure 19**), hexavalent Chromium was ranged from 0.008 mg/l at sampling station S3 to 0.016 mg/l at sampling station S5 in the study area, where as the prescribed limit for hexavalent Chromium is 0.05 mg/l (IS 10500). Hence, all the hexavalent Chromium values of river water samples were withinthepermissiblelimit.

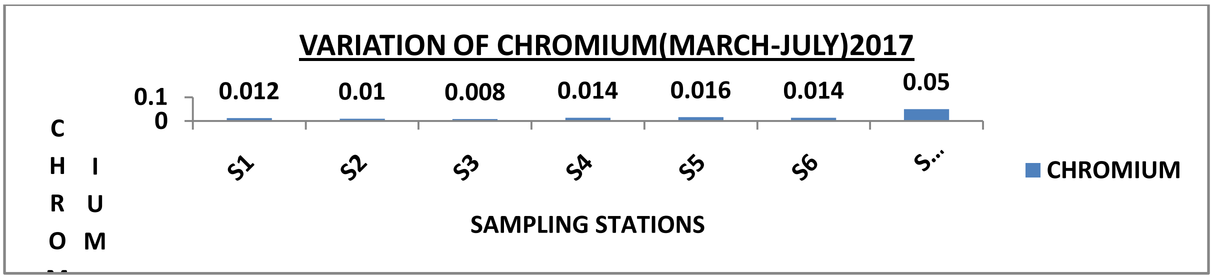


Figure 19.Variation of Chromium from (March-July) 2017

IV. CONCLUSION

The water quality at Rajghat conforms to class-C inland surface water. Biomonitoring studies reveals that the river stretch at Rajghat is in a state of slight to moderate pollution. 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 quantity [9].

The physico-chemical analysis and Water Quality Index (WQI) indicates that the water quality of Subarnarekha River is good in the coastal belt of Balasore. Though it is expected to carry some pollution load from the industrial, mining and urban activities of Jharkhand and West Bengal, the river has considerable re - generating capacity. There should be proper environmental management to protect the existence of Subarnarekha River.

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