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Estimation of Water Quality Index and Assessment of Toxic Metals for River Mahanadi, Odisha: [A Case Study]

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Abstract: The study was conducted to assess and ascertain thephysico-chemical properties of Mahanadi basin from water quality monitoring stations of State Pollution Control Board. It was carried out to classify the water qualityand pollution status of river Mahanadi. Twelve stations of River Mahanadi of monitoring station Cuttack were sampled for a period of one year between 2014 and 2015. Physico-chemical and biological parameters of water like pH, temperature, dissolved oxygen, BOD, turbidity, total phosphate, nitrate and E.coli were determined.

These physicochemical parameters indicates the 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 study revealed that heavy metal concentration was comparatively higher due to repeated discharge of domestic and other waste into the waters of River Mahanadi. Heavy metals were observed to follow the trend Fe>Pb>Zn>Cr>As based on their concentration detectionand water quality index was observed to be 57.1. The results indicate that the river is moderately polluted due to anthropogenic activities and macro algae can be used as an effective indicator of heavy metal pollution.

Keywords: Mahanadi River, WQI, Heavy metals, macro algae, Water pollution

I. INTRODUCTION

Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land.

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" [1]. 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 water environment quality is a very important and is a subject of major concern for economic development of any country. The water resource problems related to degradation have increasingly been serious because of rapid industrialization and urban sprawl. Anthropogenic influences such as urbanization, industrial and agricultural activities, increasing consumption of water recourses along with natural process i.e. change in precipitation inputs, erosion, effectively deteriorate surface water quality and impair their uses for drinking, industrial, agriculture, recreating and other purposes. In order to study spatial and temporal variation in surface water chemistry a regular monitoring program that will provide a representative and reliable estimation of the quality of surface water is highly essential. Thus monitoring program including frequent water samplings at many sites and determination of large number of physicochemical parameters are usually conducted resulting in a large data matrix, which needs a complex data interpretation [2].

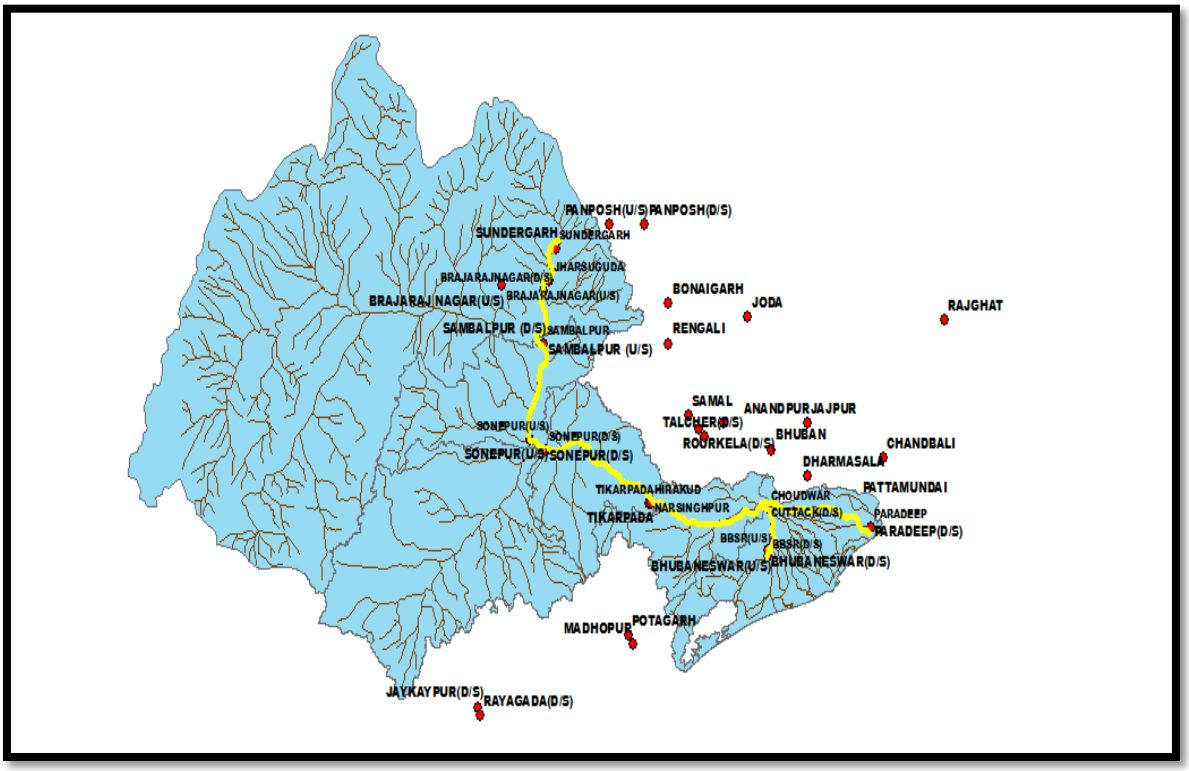
The urban aquatic ecosystem is strongly influenced by long term discharge of untreated domestic and industrial wastewater, direct solid waste dumping containing oils, plastic, grease, heavy metals, chemicals, pesticides etc. All these released pollutants have a great ecological impact on the river water quality and its surrounding food web. Thus it has become necessary to check the water quality [3]. Water quality in an aquatic ecosystem is determined by many physical, chemical and biological factors and one such method is Water Quality Index (WQI) which is basically a mathematical means of calculating a single value from multiple test results. The index result represents the level of water quality in given water body, such as lake, river or stream. Heavy metals are widespread pollutants of great environmental concern as they are non-degradable, toxic and persistent with serious ecological ramification on aquatic ecology. They accumulate in tissues of living organisms through bio-concentration and bio-magnification. Natural sources of heavy metals

include chemical weathering of minerals and soil leaching. Anthropogenic sources include industrial, domestic effluents and municipal waste water treatment plants etc. Aquatic macro algae can absorb and accumulate various metals from the aquatic environment.

II. MATERIALS AND METHODS

Study site: 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 Chattisgarh 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 Kathojodi, 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.

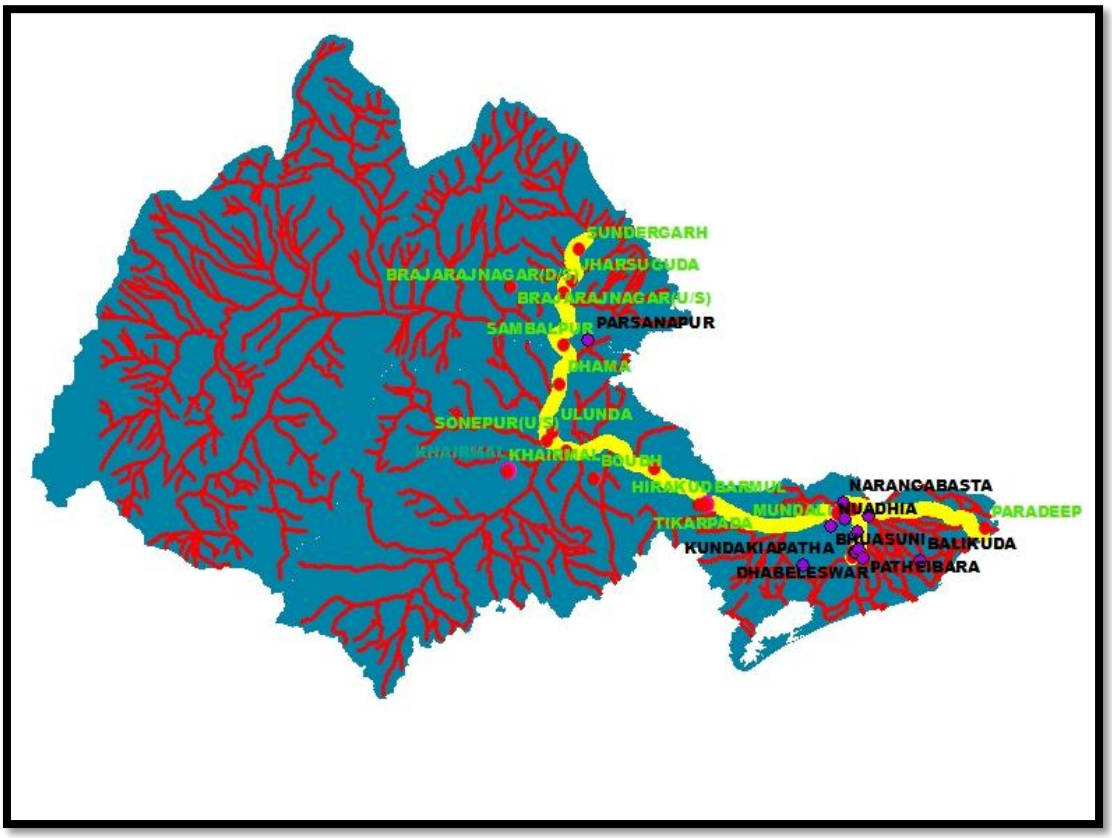
The River Mahanadi flows through the Cuttack city, Odisha and is being used as a source of drinking water, for obtaining food and bathing [4]. The river has become a dumping area for disposing all forms of waste including immersion of idols during religious ceremonies and celebrations. The study area (**Figure1,2, 3**)is located in Mahanadi River, Cuttack,and Odisha. Twelve station were selected forCollection of water samples and eight stations were sampled for heavy metal presence **(Table 1)**.



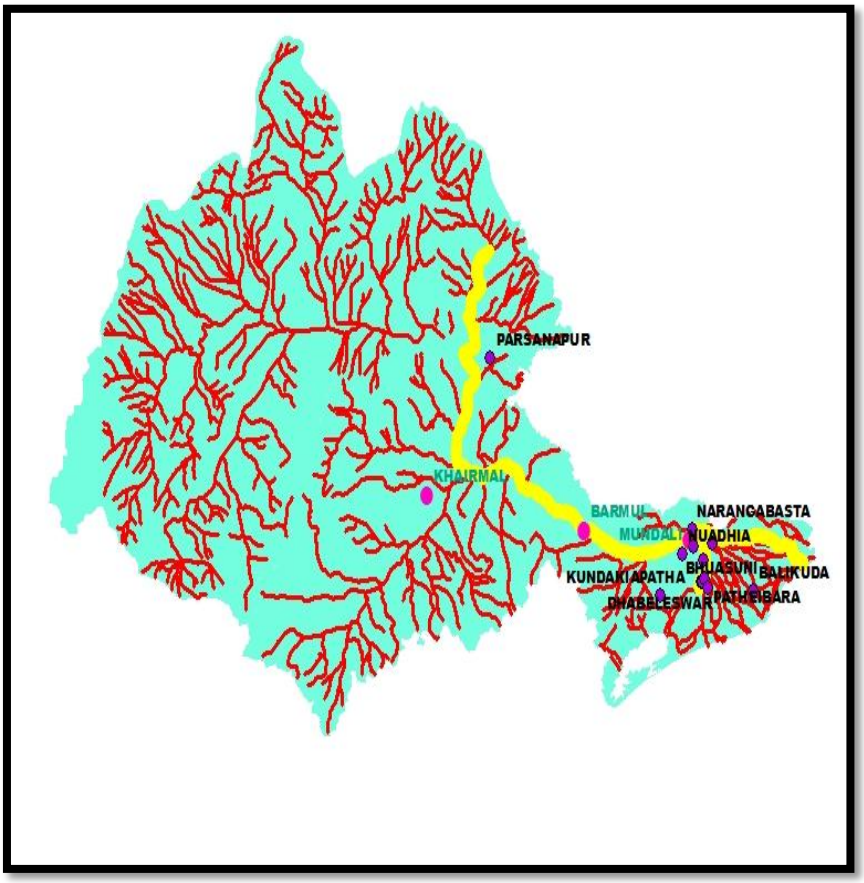
(Figure1.Monitoring stations of River Mahanadi showing the flow path)

Table1.Sampling Stations

MONITORING STATIONS	SYMBOLS	PLACES
STATION 1	S1	DHABELESWAR
STATION 2	S2	MANCHESWAR
STATION 3	S3	PARSANAPUR
STATION 4	S4	KANSARIPATHA
STATION 5	S5	KUNDAKIAPATHA
STATION 6	S6	MENDHAKIAPATHA
STATION 7	S7	DHIA SAHI, NUAPATNA
STATION 8	S8	BHUASUNI
STATION 9	S9	PATHEIBARA
STATION 10	S10	NARANGABASTA
STATION 11	S11	NUADHIA
STATION 12	S12	BALIKUDA



(Figure2.Sampling stations of River Mahanadi)



(Figure3.Plotting of monitoring stations from where the water sample has been collected)

III. SAMPLING PROCEDURE

The present study was carried out for a period of one year 2014-15. Water samples were collected from 12 different places from local stations of Mahanadi river (Table) in pre-monsoon (March-June-2014), monsoon (July-October-2014) and post monsoon (November-February-2015) periods at a regular interval of once in a month. Water samples were collected in acid- washed plastic bottles of one l tr. capacity having double stopper facilities to its full capacity without entrapping air bubbles inside. Two bottles of water was collected from each station i.e. one for analysis of physico-chemical parameters and other for heavy metals. About two ml. of concentrated HNO_3 was added to the second bottle of each station to preserve the heavy metals present in the sample [5]. Also, water Samples were collected in sterile glass bottles and were preserved in an ice bucket at 4^0C for analysis of total coliforms and faecal coliforms.

Samples were collected from S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11 and S12. For analysis of hydrological parameters, surface water samples were collected from each station. Temperature was measured by thermometer (0.01°) and pH by Systronic water analyser. Collected water samples were fixed by modified Winkler's method for dissolved oxygen estimation and the remaining water samples were transferred into Tarson nutrient containers for laboratory analysis. The samples were transported under cold condition to the laboratory [6]. Dissolved Oxygen, Biological Oxygen Demand, Total Phosphate and Nitrate were determined using standard methods recommended by the American Public Health Association[3]. The macro algal samples were collected in clean bottles and 1% of formalin was added to it. The collected algal samples were washed thoroughly with distilled water and then dried at 90°C. The dried samples were crushed to powder form using mortar and pestle.

IV. RESULTS AND DISCUSSION

Dissolved oxygen concentration of river Mahanadi varied from 1.6 to 8.2 mgl^{-1}. Low levels of dissolved oxygen were observed during summer season at S4, S5, S9, S10, S11 and S12 due to manmade stressors. The water quality deteriorates on account of the increase in microbial activity as well as increase in pollutants concentration due to water evaporation during summer. Sometimes increase in algal growth also contributes towards lowering the concentration of dissolved oxygen.

Temperature was recorded between 20°C to 35°C at sampled stations. This was expected because of the relationship between dissolved oxygen and temperature. Low amount of dissolved oxygen was noticed at S10 (2.98 mg/l) which had a temperature of 33.5°C. PH varied from 7.56 to 8.3 indicating alkaline water. Dissolved oxygen is an important parameter of water quality analysis as the oxygen content of water supports both flora and fauna of aquatic ecosystem. High levels of dissolved oxygen wererecorded duringwinter season due to decrease in the microbial activity along with lowering of temperature.

Turbidity is the measurement of water clarity and high levels of turbidity indicate high concentration of particulate matter which may be the result of pollution due to human activities. Turbidity results varied from 8 NTU to 13 NTU. Nitrates are formed in water due to bacterial action and oxidation of ammonia. High nitrates in water are indicative of organic pollution [7].

Their presence indicates that the nitrogenous organic matter is undergoing oxidation. However results show very low amount present in the river. Results range from 0.28 mgl-1- 0.45 mgl-1which is far safer as compared to WHO standards. Results also indicate that the stations were not the sites of feacal matter deposition. Water quality parameters of different stations along with WQI have been mentioned in (Table 2). Arsenic concentration was recorded highest in the S8 which contained 9.1292 mg kg-1(Figure 4). Chromium concentration ranged from 2.2 mg kg-1- 16.25 mg kg-1(Figure 5) in the sampled stations. Highest amount of chromium was found at S4. Concentration of Iron ranged from 1067 mg kg-1-12936 mg kg-1(Figure 6). Lead was found highest in S5 (95.52 mg kg-1) and lowest at S6 (1.56 mg kg-1) (Figure 7). Zinc results varied from 6.092 mg kg-1to 65.67 mg kg-1(Figure 8) in the sampled macroalgal species. Highest amount of zinc was found is St-1 and lowest in S8. Results indicate that the heavy metal concentration of river water has exceeded the permissible limit values suggested by WHO 2011 which ranges from0.02mg kg-1to 0.20 mg kg-1.

However certain stations did not show any trace of arsenic and lead **(Table4)**. S3 was the most polluted station with heavy metals while S8 was the least polluted station. Biotic index was also calculated taking into account the number of May fly, Caddish fly, Clams, Dragon fly and Trichopterans. The biotic index of River Mahanadi has been calculated as 8.2 and index of 8 indicates moderate pollution which supplements the WQI of River Mahanadi. Water quality index of River Mahanadi was calculated to be 57.1**(Table 3)** which means that the water is moderately polluted **(Table5)** but can be used for irrigation purpose. Physico-chemical parameters have been found to be within the permissible range as prescribed by WHO. Studies indicate that river Mahanadi is primarily concentrated with Iron which if taken into body may cause haemo-chromatosis [8]. Excess iron quantity in water imparts an unpleasant and metallic taste to it. High amount of iron may be due to discharges from industries and factories located in

close proximity of the River. It was noticed that the quality of the river water deteriorated in summer season as compared to winter season due to increase in algal blooms, microbial activity, decrease in water table leading to concentration and upwelling of toxicants.

Table2. Physico-chemical parameters of Mahanadi River at different stations

PHYSICO-CHEMICAL PARAMETERS OF MAHANADI RIVER AT DIFFERENT SAMPLING STATIONS													
PARAMETERS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	MEAN
PH	7.6	7.5	8	8.1	8.2	8.32	8	8	8.2	7.9	8.1	8.1	7.99
TEMPERATURE	28	31	24	25	25	25	21	25	31	34	25	25	26.583
DO	7.9	7.9	5.8	2.8	3.5	5.1	8.1	8.1	3.7	2.9	2.9	2.9	5.1633
BOD	3.2	3	0.8	0.4	0.7	1.1	4.3	4	0.4	0.4	0.4	0.4	1.5917
TOTAL PHOSPHATE	0.09	0.12	0.29	0.3	0.14	0.17	0.23	0.28	0.16	0.18	0.19	0.22	0.1975
NITRATE	0.26	0.38	0.46	0.32	0.37	0.37	0.47	0.38	0.44	0.33	0.36	0.42	0.38
TURBIDITY	8	8	9	13	10	10	9	8	11	10	11	11	9.6333
E COLI	3	3	4	4	5	5	5	6	5	3	2	4	4.0833

Table3. Calculation of Water Quality Index

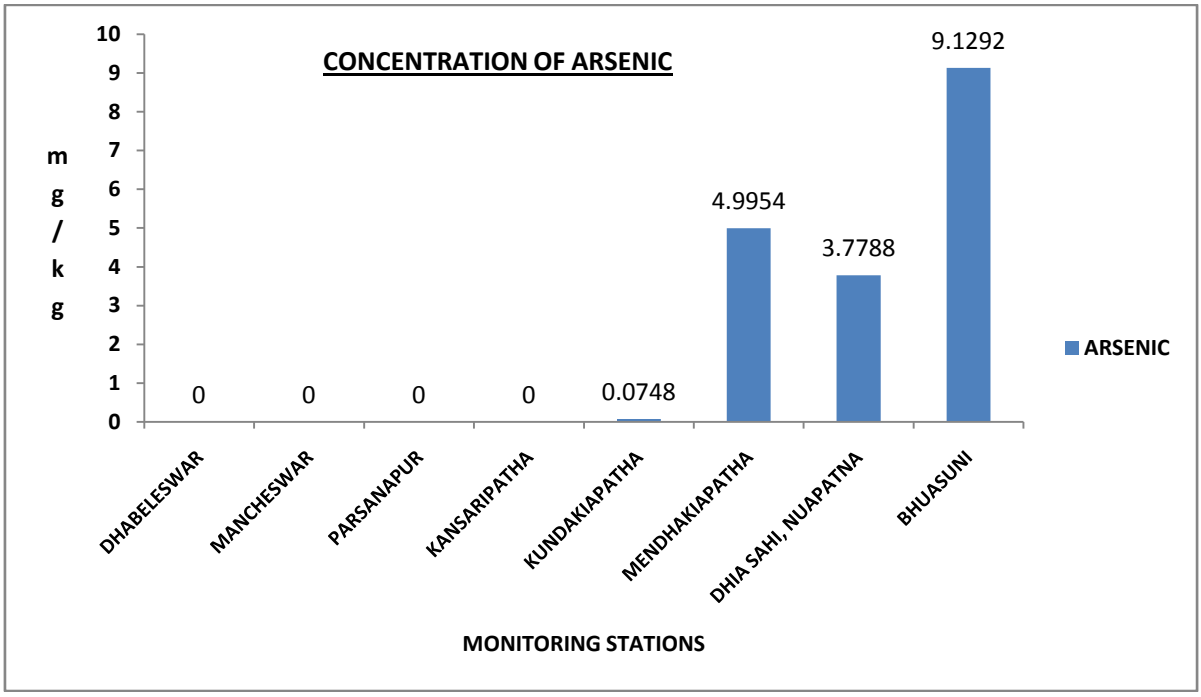
CALCULATION OF WATER QUALITY INDEX					
PARAMETERS	TEST RESULT	UNITS	Q-VALUE	WEIGHTING FACTOR	SUB TOTAL
PH	7.99	PH UNITS	85	0.12	10.2
TEMPERATURE	26.5	DEGREE CELCIUS	12	0.11	1.32
DO	5.16	MG/L	5	0.18	0.9
BOD	1.59	MG/L	85	0.12	10.2
TURBIDITY	9.6	NTU	77	0.09	6.93
TOTAL PHOSPHOROUS	0.197	MG/L	50	0.11	5.5
NITRATE	0.38	MG/L	93	0.1	9.3
E COLI	4	CFU/100ML	75	0.17	12.75
FAECAL COLIFORM	0	CFU/100ML	98	NM	NM
TOTAL				1	57.1
WATER QUALITY INDEX					57.1

Table4. Comparison of accumulation of heavy metals by macro-algae at different stations

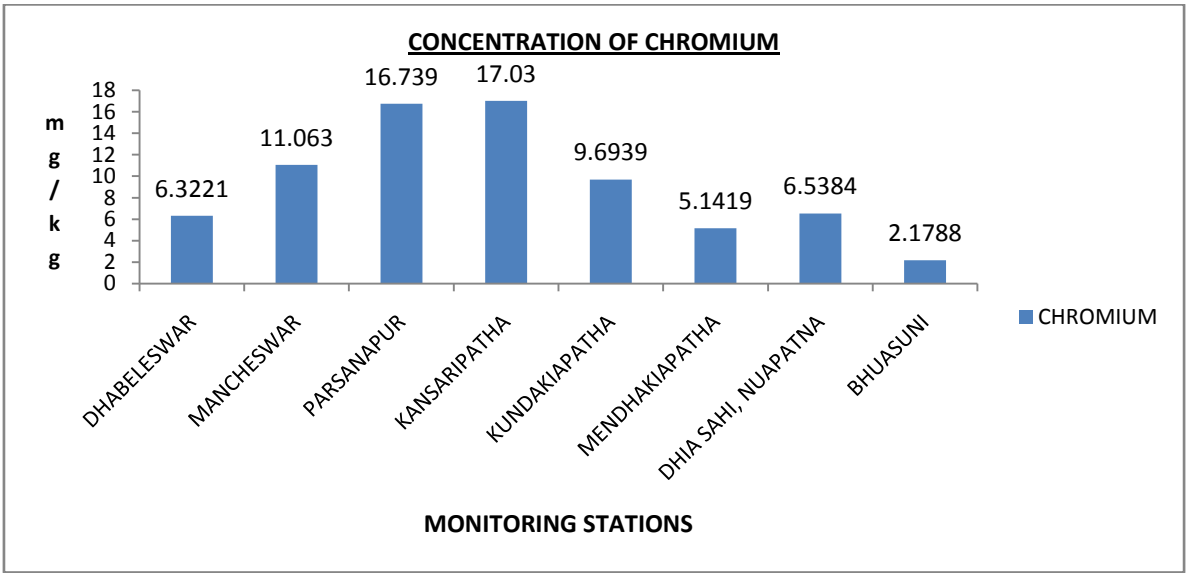
COMPARISON OF ACCUMULATION OF HEAVY METALS BY MACRO ALGAE(MG/KG) AT DIFFERENT STATIONS								
HEAVY METAL	S1	S2	S3	S4	S5	S6	S7	S8
ARSENIC	0	0	0	0	0.0748	4.9954	3.7788	9.1292
CHROMIUM(MG/KG)	6.3221	11.063	16.739	17.03	9.6939	5.1419	6.5384	2.1788
IRON(MG/KG)	3373	8871	12936	11565	5978	3884	3419	1067
LEAD(MG/KG)	2.9317	3.9655	6.8433	5.8808	97.52	1.5683	0	0
ZINC(MG/KG)	67.67	19.971	22.555	14.185	24.734	19.744	12.342	6.1322

Table5. Classification of water quality index range and water quality rating

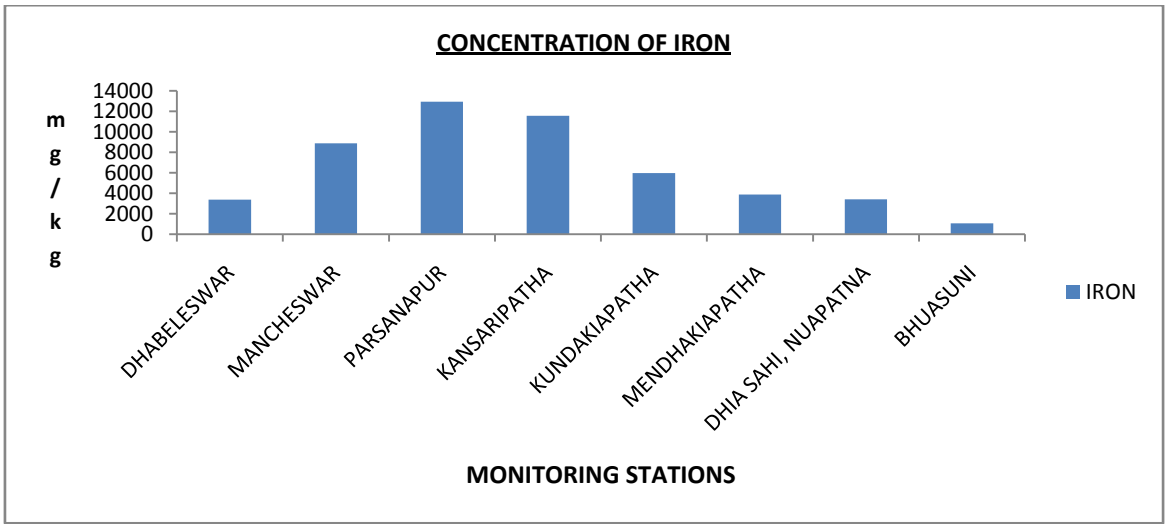
WATER QUALITY INDEX RANGE	WATER QUALITY RATING
90-100	EXCELLENT
70-89	GOOD
50-69	MEDIUM
25-49	BAD
0-24	VERY BAD



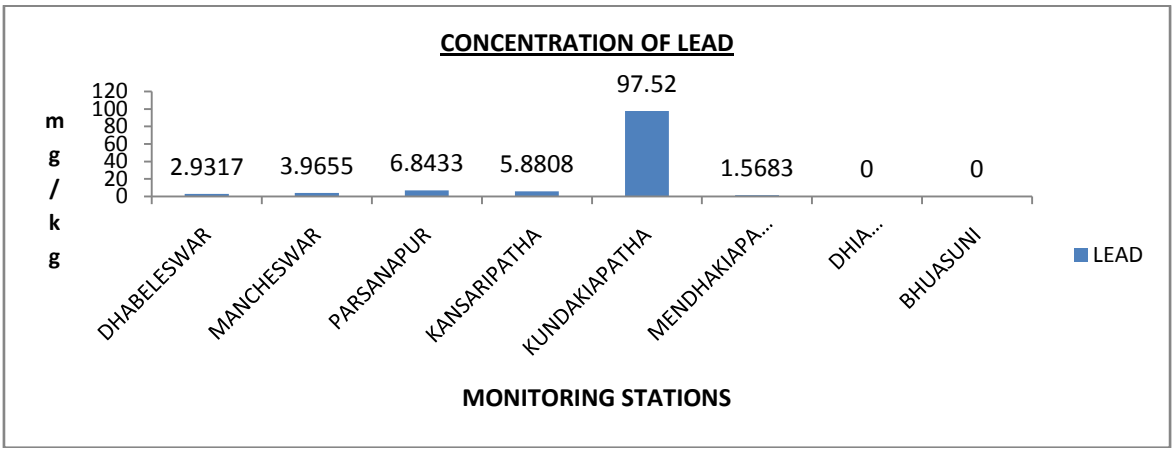
(Figure4.Comparative Graph of Arsenic Content in Collected Macro-algae from Different stations)



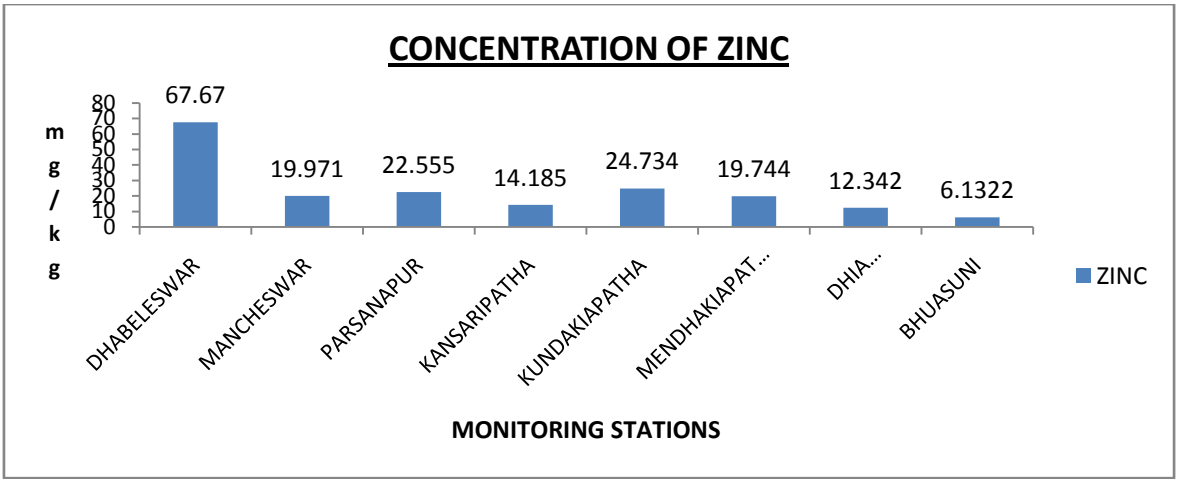
(Figure5.Comparative Graph of Chromium Content in Collected Macro-algae from Different stations)



(Figure6.Comparative Graph of Iron Content in Collected Macro-algae from Different stations)



(Figure7.Comparative Graph of Lead Content in Collected Macro-algae from Different stations)



(Figure8.Comparative Graph of Zinc Content in Collected Macro-algae from Different stations)

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 freshwater resources to safeguard public health·River Mahanadi is the lifeline of Cuttack city, Odisha. Hence long term monitoring programme inclusive of in-situ analysis at regular intervals is required to understand the complex cycle of physico-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 study area cannot be used for public consumption without any treatment though all samples are of good quality for irrigation purpose on the basis of physico-chemical parameter values.

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/river catchment and to control and monitor human activities along with public awareness to ensure its minimal negative effect on the water body [9]. Deforestation should be strictly enforced to check the massive soil erosion. The present baseline information of the physico-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 Index provides precise information which in turn can help in classifying fresh water bodies based on sub component of WQI. Aquatic plants are used for phyto-remediation of heavy metals worldwide [10]. This is due to the fact that roots are very effective in removing heavy metals because of its absorbing power. Thus Water Quality Index and plants can be used as important bio-indicators of water pollution.

REFERENCES

[1]. M. K. Akkaraboyina, B. S. N. Raju; Assessment of Water Quality Index of River Godavari at Rajahmundry.Universal Journal of Environmental Research and Technology, 2012, 2: 161-167.
[2]. A.N. Amadi; Quality Assessment of Aba River Using Heavy Metal PollutionIndex.American Journal of Environmental Engineering.2012, 2: 45-49.
[3]. APHA, Standard Methods for the Examination of Water and Wastewater. 16th ed. pp1268. New York, USA: American Public Health Association; 1985.
[4]. M. Dubey, N. C. Ujjania; Water Quality and Pollution Status of Tapi River, Gujarat, India. International Journal of Pure and Applied Zoology, 2013, 1: 261-266.
[5]. AGor, A. Shah; Water Quality Index of Mahi River, Vadodara, Gujarat.International Journal of Engineering Development and Research, 2014, 2: 3214-3219.
[6]. K. Mophin-Kani, A. G. Murugesan; Evaluation and Classification of Water Quality of Perennial River Tamirabarani through Aggregation of Water Quality Index. International Journal of Environmental Protection, 2011, 1: 24-33.
[7]. J. I. K Nirmal, H. Soni, R. N. Kumar, I. Bhatt; Macrophytes in Phytoremediation of Heavy Metal Contaminated Water and Sediments in Pariyej Community Reserve, Gujarat, India. Turkish Journal of Fisheries and Aquatic Sciences, 2008, 8: 193-200.
[8]. E. Skorbilowicz; Aquatic Plants as Bioindicators of contamination of upper Narew River and some of its tributaries with Heavy Metals. Environment Protection Engineering, 2009, 35: 65-77.
[9]. World Health Organisation (WHO) - Guidelines for Drinking water Quality. FourthEdition. World Health Organisation; 2011.
[10]. M. Ying; Monitoring of Heavy Metals in the Bottelary River Using *Typha capensis* and *Phragmites australis*.- M.Sc Mini–thesis, Department of Biodiversity and Conservation Biology, University of the Western Cape. 2005.

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