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WATER QUALITY ANALYSIS ALONG THE STRETCH OF RIVER MAHANADI, [ODISHA]

Abhijeet Das, Dr.Bhagirathi Tripathy, Dr. P.K.Pani, Dr. Tushar Kumar Nath
Department of Civil Engineering,
Indira Gandhi Institute of Technology
Sarang, Dhenkanal, Odisha

ABSTRACT
The present study was carried out to assess the water quality and pollution status of river Mahanadi. Twelve stations of River Mahanadi, Cuttack were sampled for a period of one year between September 2016 and August 2017. Physico-chemical and biological parameters of water like pH, temperature, dissolved oxygen, BOD, turbidity, total phosphate, nitrate and E.coli were determined. Macro algae samples were collected and analyzed for heavy metals like Lead, Iron, Chromium, Zinc and Arsenic using Inductively Coupled Plasma-Optical Emission Spectrometer. The study revealed that the river water was polluted with heavy metals in the trend of Fe>Pb>Zn>Cr>As and 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.

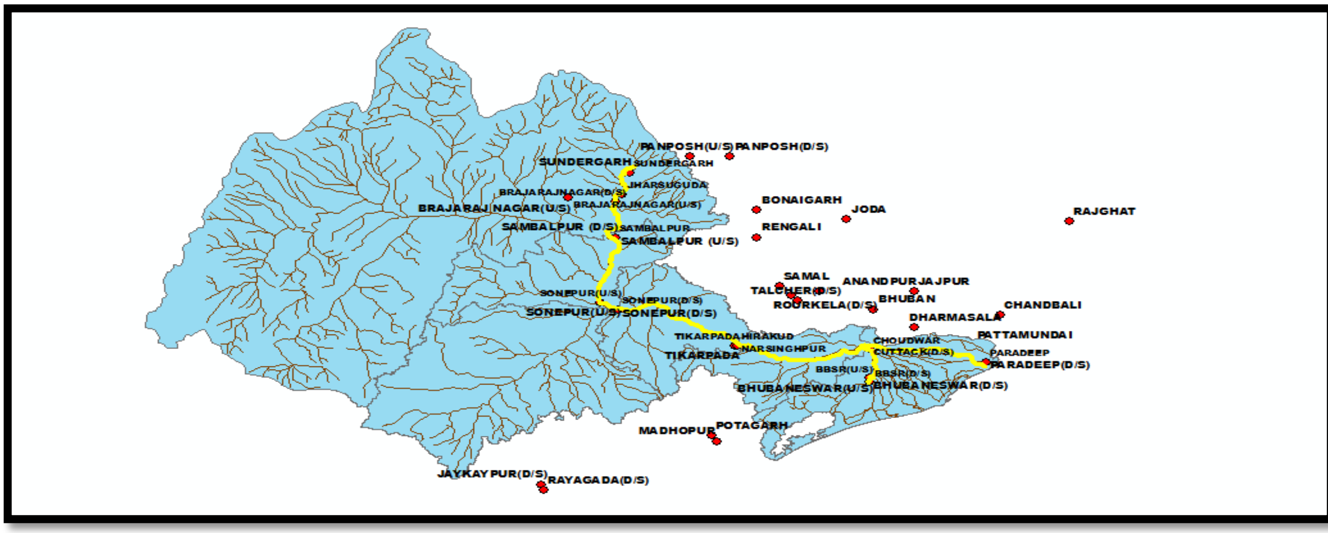
KEYWORDS: Mahanadi River, WQI, Heavy metals, macro algae, Water pollution

INTRODUCTION

Rivers are indispensible freshwater systems that are necessary for the continuation of life and contain highly crucial component of natural heritage. Rapid industrialization and modernization has led to many environmental problems which includes water pollution. 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. 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. They can be reliable indicators of metal pollution in freshwater ecosystems. Macro algae take up pollutants via their roots submerged in sediments and also absorb chemicals from the water column through their leaves. The degree of metal uptake by some plants is largely dependent on the type of metal and the plant species involved.

MATERIALS AND METHODS

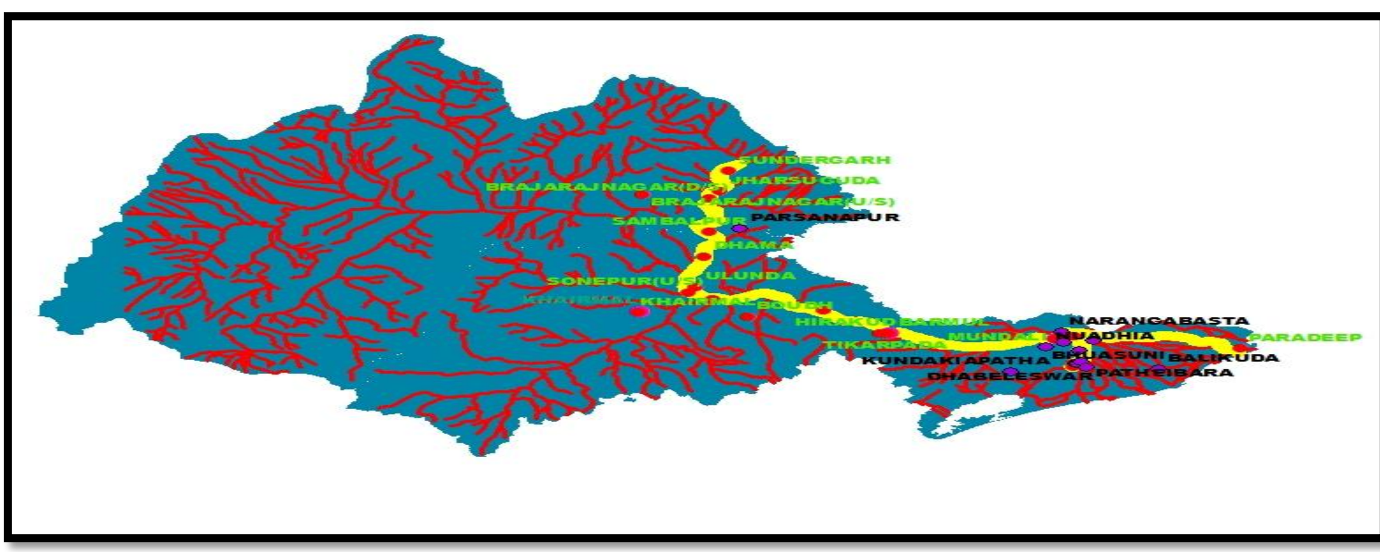
Study site: The River Mahanadi flows through the heart of Cuttack city, Odisha and is being used as a source of drinking water, for obtaining food and bathing. The river has become a dumping area for disposing all forms of waste including immersion of idols during religious ceremonies and celebrations. The study area (**Figure 1, 2, 3**) is located in Mahanadi River, Cuttack, Odisha with geographical coordinates of 85°46’21.29”E 20°28’15.81”N and 85°49’45.23”E 20°30’50.00”N. Twelve station were selected for Collection of water samples and eight stations were sampled for heavy metal presence **(Table 1)**.



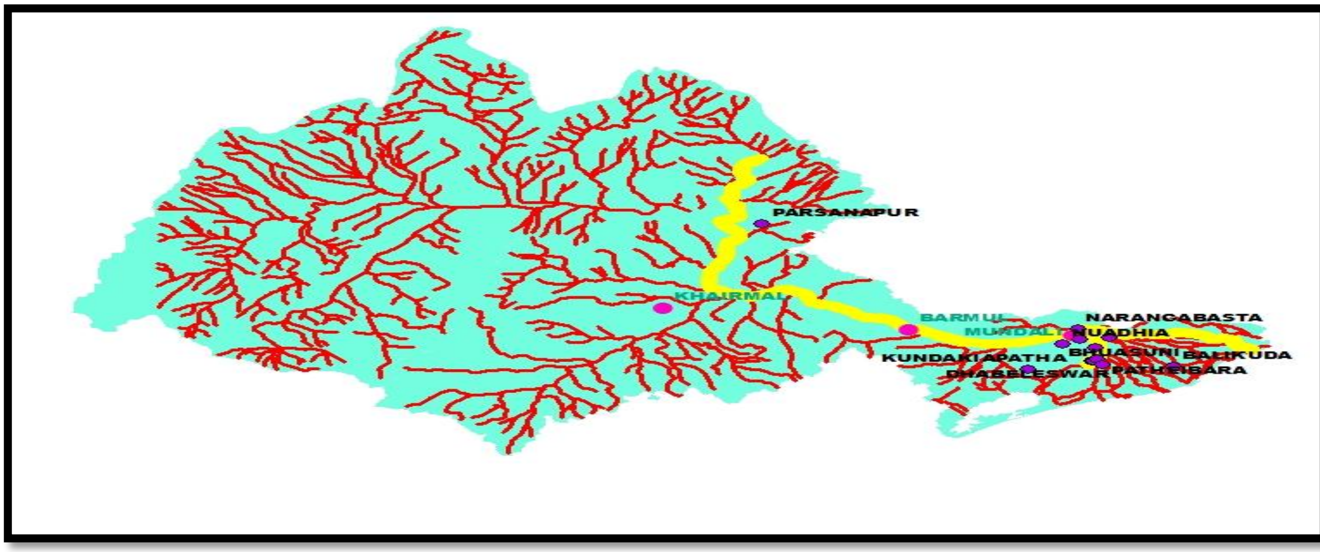
(**Figure1.**Monitoring stations of River Mahanadi showing the flow path)

Table1. <u>Sampling Stations</u>

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)

SAMPLING PROCEDURE AND SAMPLE ANALYSIS

Water samples were collected from different areas of the river once every month early morning from September 2016 to August 2017. Samples were collected from S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11 and S12. Surface water samples were collected from each station for analysis of hydrological parameters. Temperature was measured by thermometer (0.01°) and pH by Systronic water analyser. Collected surface 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. Dissolved Oxygen, Biological Oxygen Demand, Total Phosphate and Nitrate were determined using standard methods recommended by the American Public Health Association. 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. The powdered algal samples were packed in zip lock plastic pouches and the stored powdered samples were used for heavy metal analysis using Inductively Coupled Plasma-Optical Emission Spectrometer. Macro invertebrates were collected, counted and segregated for biotic index calculation.

RESULTS AND DISCUSSION

Temperature was recorded between 21°C to 34°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 34°C. PH varied from 7.5 to 8.2 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. Dissolved oxygen concentration of river Mahanadi varied from 1.8 to 8.1 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.

High levels of dissolved oxygen (7.92 mgl^{-1}, 7.98 mgl^{-1}, 8.14 mgl^{-1}, 8.16 mgl^{-1}) were recorded during Winter 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. Biological decomposition of all nitrogenous organic matters such as sewage and animal wastes contribute nitrate values in water. Their presence indicates that the nitrogenous organic matter is undergoing oxidation. However results show very low amount present in the river. Results range from 0.26 mgl^{-1}- 0.47 mgl^{-1} which is far safer as compared to WHO standards (50mgl^{-1}). 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 2.18 mg kg^{-1}- 17.03 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 (97.52 mg kg^{-1}) and lowest at S6 (1.56 mg kg^{-1}) **(Figure 7)**. Zinc results varied from 6.132 mg kg^{-1} to 67.67 mg kg^{-1} **(Figure 8)** in the sampled macro algal 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 from 0.01mg kg^{-1} to 0.10 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 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[9]. 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 detection. Studies indicate that river Mahanadi is primarily concentrated with Iron which if taken into body may cause haemo-chromatosis. 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

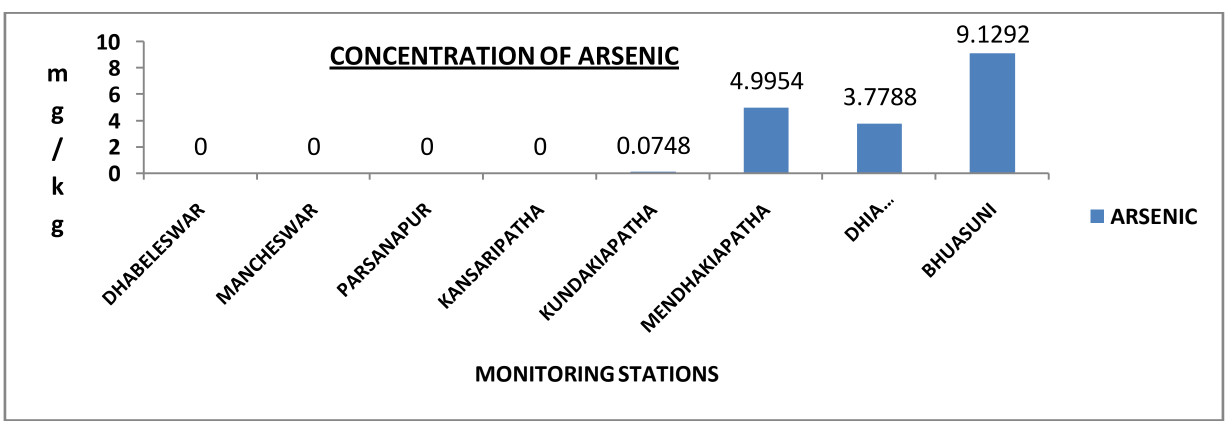
CALCULATION OF WATER QUALITY INDEX					
PARAMETERS	TEST RESULT	UNITS	Q-VALUE	WEIGHTING FACTOR	SUB TOTAL
PH	7.99	PH UNITS	85	0.12	10.2
TEMPERATURE	26.5	DEGREE CELCIUS	12	0.11	1.32
DO	5.16	MG/L	5	0.18	0.9
BOD	1.59	MG/L	85	0.12	10.2
TURBIDITY	9.6	NTU	77	0.09	6.93
TOTAL PHOSPHOROUS	0.197	MG/L	50	0.11	5.5
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

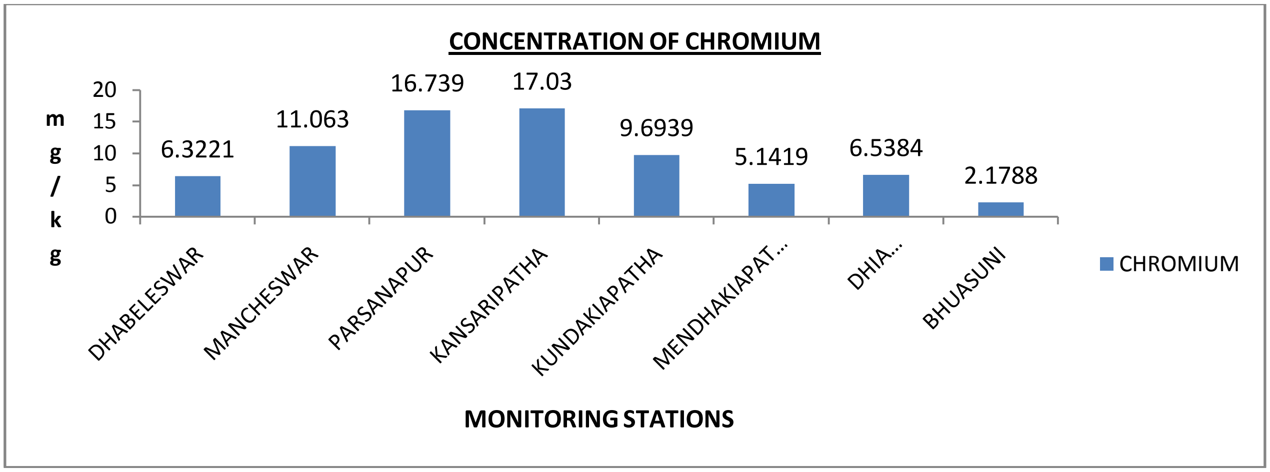
COMPARISON OF ACCUMULATION OF HEAVY METALS BY MACRO ALGAE(MG/KG) AT DIFFERENT STATIONS								
HEAVY METAL	S1	S2	S3	S4	S5	S6	S7	S8
ARSENIC	0	0	0	0	0.0748	4.9954	3.7788	9.1292
CHROMIUM(MG/KG)	6.3221	11.063	16.739	17.03	9.6939	5.1419	6.5384	2.1788
IRON(MG/KG)	3373	8871	12936	11565	5978	3884	3419	1067
LEAD(MG/KG)	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

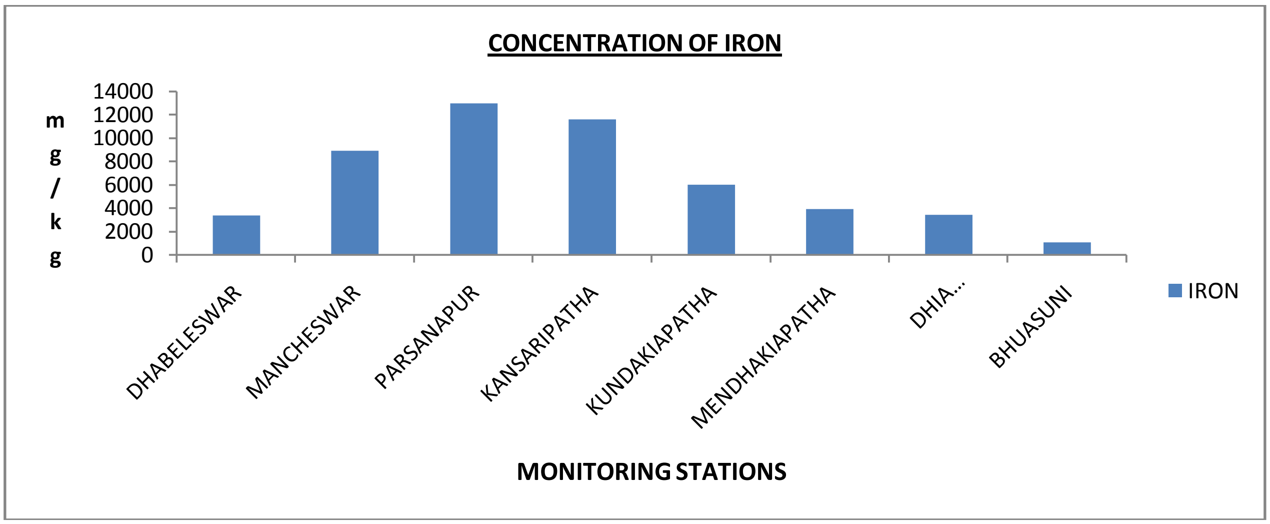
WATER QUALITY INDEX RANGE	WATER QUALITY RATING
90-100	EXCELLENT
70-89	GOOD
50-69	MEDIUM
25-49	BAD
0-24	VERY BAD



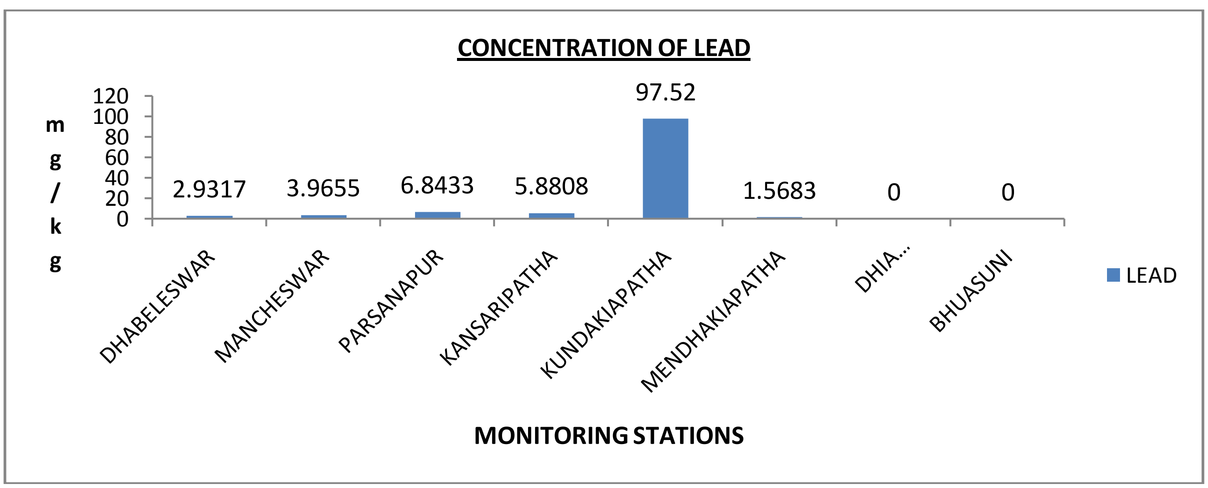
(**Figure4.** Comparative Graph of Arsenic Content in Collected Macro-algae from Different stations)



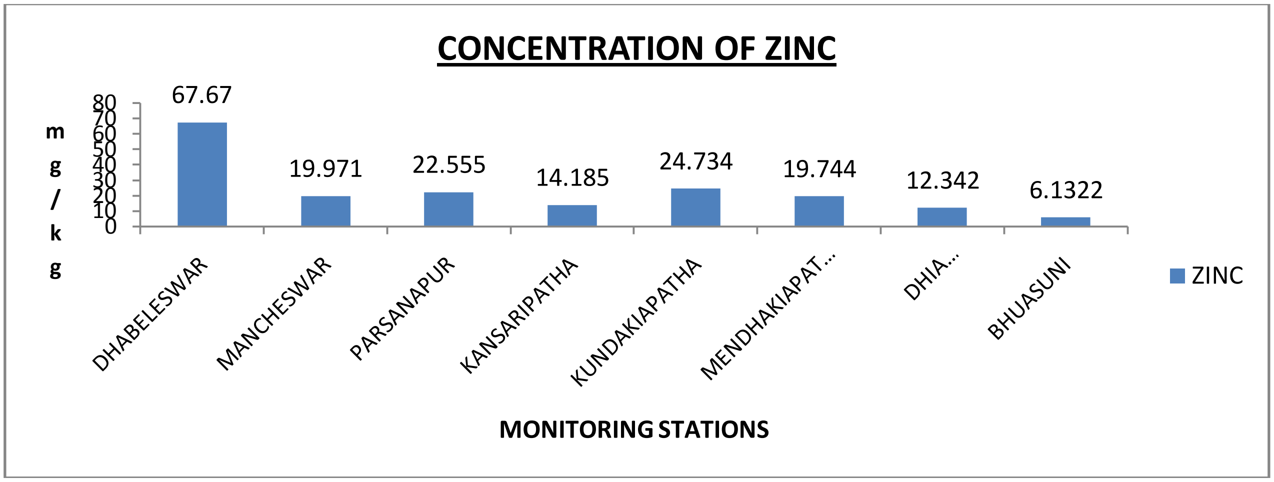
(**Figure5.** Comparative Graph of Chromium Content in Collected Macro-algae from Different stations)



(**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)

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. 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. 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.

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