International Journal of Innovative Research and Advanced Studies (IJIRAS)
Volume 5 Issue 5, May 2018

ISSN: 2394-4404

Evaluate Water Quality Index of Mahanadi River near Jagatpur Industrial Zone, Cuttack, Odisha: A Case Study

Dr. Swati Panda

Department of Zoology, Salipur Autonomous College

Abstract: ***The objective of the study was to calculate the Water Quality Index (WQI) of Mahanadi River near Jagatpur Industrial Estate in order to assess its suitability for drinking purposes. Water samples were collected from the Mahanadi River at upstream and downstream points in sterile bottles having one litre capacity. The samples were put in ice box immediately and then transported to laboratory for analysis. Samples were assessed for 8 parameters such as pH, TSS, BOD, COD, ALk, TH, DO; TC.The calculation of the WQI was done using Weighted Arithmetic Index method. The WQI was found to be 65 at U/S and 138 at D/S during April 2016-March 2017.It was clearly indicated that untreated water from Mahanadi River is of poor quality and must be treated both for drinking purposes and water related diseases.***

Keywords: Water Quality Index, Physico-chemical parameters, Solway Index

I. INTRODUCTION

The quality of water is of vital concern for mankind since it is directly linked with human welfare .But through various human activities, increasing population, urbanization and developmental activities of Cuttack city organic and inorganic substances are introduced into Mahanadi river water. As a result the pollution of water bought a veritable water crisis. Physico-chemical and biological parameter analysis of Mahanadi river water is very important for public health studies. A Water Quality Index(WQI) summerizes large amounts of water quality data into simple terms (Excellent, good, bad etc.) for public in a consistent manner (Tiwari et al,1988).A Water Quality Index provides a single number that expresses overall water quality at a certain location and time based on several water quality parameters(Singh and Singh,1994).WQI can be used as a tool in comparing the water of different sources it gives the public a general idea of possible problems with water in a particular region (Chetan et al.,1997).The calculation of WQI was done using Weighted Arithmetic Index method. It was originally proposed by Horton (1965) and developed by Brown et al.(1972).The Weighted Arithmetic Water Quality Index (WQI) in the following form

$WQI=\Sigma^{n}_{i=1}q_iw_i/\Sigma w_i$

Solway Index= $1/100\ (\Sigma^{n}_{i=1}q_iw_i)^2$

Where q_i (water Quality Rating) = $100\times Va\text{-}V_i/V_s\text{-}V_i$

V_a= Actual value present in water sample

V_i=Ideal value (0 for all parameters except p^H=7.0, DO=14.6 mg/l)

V_s=Standard value

For p^H, the ideal value is 7.0 (for pure water) and a permissible value is 8.5 (for polluted water). Therefore the quality rating for p^H is calculated from the following equation

$Q_{PH}=100[(V_{PH}\text{-}7.0)/\ (8.5\ 7.0)]$

Where V_{PH}=Observed value

For dissolved oxygen the ideal value is14.6mg/l and standard permissible value for drinking water is 5mg/l. Therefore its quality rating is calculated from the following equation

$Q_{DO}=100[(V_{DO}\text{-}14.6)/5.0\text{-}14.6)]$

Where V_{DO}=Observed value of dissolved oxygen

If quality rating q_i=0, means complete absence of pollution while $0<q_i<100$ implies that the pollutants within prescribed standard. When $q_i>100$, implies that pollutants are above standards, it indicates that the water is unsuitable for uses.(Table-1)

W_n (Unit weight) = k/S_n

Where,

$S_{n=}$ Standard permissible value of n^{th} water quality parameter

K=Constant of proportionality and it is calculated by using expression given

$K=[1/ (\Sigma\ 1/S_{n=123....n})$

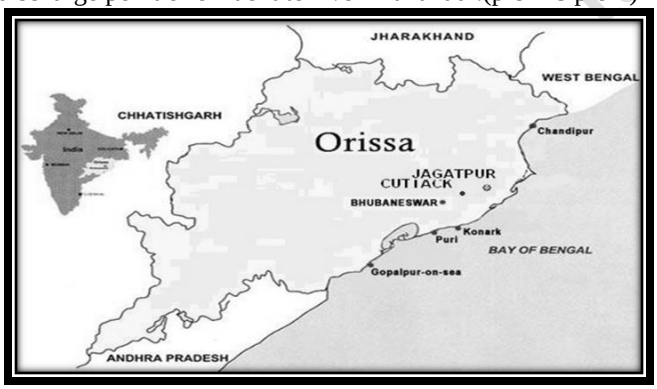
S.NO	WQI	Status	Possible Uses
1	0-25	Excellent	Drinking, Irrigation, industrial
2	25-50	Good	Domestic, irrigation and industrial
3	51-75	Fair	Irrigation and industrial
4	76-100	Poor	Irrigation
5	101-150	Very poor	Irrigation
6	Above 150	Unfit for drinking	Proper treatment before use

Table 1: WQI AND STATUS

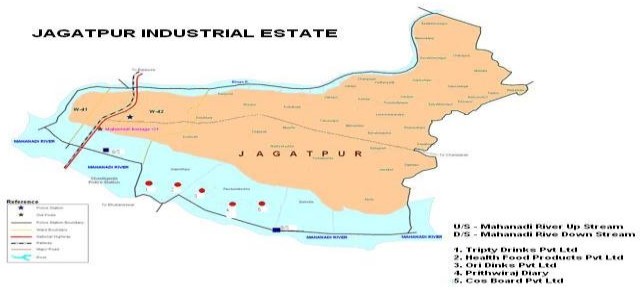
Accordingly stretch of Mahanadi near Jagatpur Industrial Estate has be choosen. In order to ascertain the quality of Mahanadi river water. The objective of the study was to calculate the Water Quality Index (WQI) of water from Mahanadi river in order to assess its suitability for drinking purposes.

II. MATERIALS AND METHOD

Two sampling points such as upstream and downstream points has been chosen to Jagatpur Industrial Estate During April 2016 to March 2017. Upstream point is near Mahanadi Barage and down stream point is 4 kilometers from the discharge point of effluent to river Mahanadi.(pic-1 &pic-2)



Picture 1: Map of Odisha



Picture 2: Mahanadi River with U/S and D/S

Grab samples were collected from U/S and D/S points of Mahanadi river in sterile bottles (1 littre) capacity in ice box immediately and then transported to laboratory for analysis of parameters like p^H, BOD, COD, TSS, Alkalinity and Total hardness (Trivedy and Goel, 1986). While DO samples were collected in DO bottles and have been fixed immediately on the spot. Similarly samples were collected separately in bacteriological bottles for Total coliform (Bhargav, 1983). The samples were analyzed immediately after collection following the standard methods for examination of water and waste water (APHA, 2000). (Table-2 & Table-3)

Sl.No	Parameters	Methods
1	pH	pH meter
2	TSS(Total Suspended Solid)	Gravimetric method
3	Total Hardness(TH)	Titration
4	Alkalinity	Titration
5	Dissolved Oxygen	Winkler's method
6	BOD(Biological Oxygen Demand)	5-days BOD Test at 20^0C
7	COD(Chemical Oxygen Demand)	Open reflux method
8	Microbial Analysis	MPN method

Table 2: Methods Of Analysis For Water Parameters

Sl. No	Parameters	Paramative	Time of Analysis
1.	pH	Not Required	Immediately
2.	Total Hardness	Not Required	
3.	Total Suspended Solid	Not Required	Immediately
4.	Alkalinity	Not Required	Immediately
5.	Biological Oxygen Demand	Refrigeration at 4^0C	6 hours
6.	Chemical Oxygen Demand	Make with H_2SO_4,to pH>2	1 day
7.	Dissolved Oxygen	Preserved with Winkler's Solution	6 hours
8.	Microbiological Examination	Preserved in ice water at 4^0C	Immediately

Table 3: Presevation Methods for Specified Parameters in Water Sample

III. RESULTS AND DISCUSSION

Table 4 and 5 below gives the monthly and average data of Mahanadi river water at U/S and D/S points during April 2016 to March 2017. Table 4 below gives Weighted Arithmetic Index of the river Mahanadi at Jagatpur Industrial Estate during 2016-2017. Table 4 gives the observed values (V_i) of the eight selected physico-chemical parameters of water samples from two sampling points i.e U/S and D/S during April 2016-MARCH 2017.

Month	p^H	TSS	BOD	COD	ALK	TH	DO	TC
April	8.2	3.8	1.5	3.2	103	82	7.8	3.2
May	8.1	7.7	1.7	3.4	104	80	8.0	3.3
June	8.0	8.9	2.0	3.5	112	81	8.1	3.1
July	8.3	10.4	1.8	3.1	109	80	8.2	2.9
August	8.4	43	2.8	8.2	106	75	9.0	3.2
September	8.5	45	2.6	8.5	117	76	9.1	3.2
October	8.2	48	3.0	8.3	111	75	9.2	3.3
November	8.1	50	2.5	8.4	121	78	9.5	3.2
December	7.8	12.4	2.8	12	97	85	8.2	3.5
January	7.6	12.6	2.2	13	96	84	8.4	3.6
February	7.6	13.2	1.8	14	95	83	8.7	3.6
March	7.5	13	2.1	15	95	82	8.5	3.5
Mean±Std dev	8.03±0.3	20.90±18.08	2.17 6±0.516	7.984±4.453	105.3 ±8.439	80.23 ±3.32	8.5± 0.55	3.29± 0.20
ISI(10,500-91)	6.5-8.5	500-2000	2.0	20.0	200-600	300-600	5.0	10.0

Table 4: Monthly And Yearly Average Data Of Mahanadi River (Up stream)

Month	P^H	TSS	BOD	COD	ALK	TH	DO	TC	FC
April	**8.1**	**4.5**	**2**	**6.4**	**112**	**76**	**7**	**6.5**	**6.2**
May	**8.5**	**8.6**	**2.2**	**6.3**	**114**	**77**	**7.1**	**6.7**	**6.4**
June	**8.5**	**8.8**	**2.1**	**6.8**	**115**	**75**	**7.1**	**6.2**	**6.5**
July	**8.3**	**11**	**2.5**	**6.2**	**113**	**75**	**7.2**	**6**	**6.2**
August	**8.5**	**75**	**3.2**	**9.8**	**125**	**95**	**7.5**	**6.4**	**7.2**
Sept	**8.7**	**78**	**3.3**	**10.5**	**123**	**98**	**7.3**	**6.8**	**5.6**
Oct	**8.6**	**56**	**3.1**	**10.3**	**124**	**96**	**7.4**	**7.6**	**5.9**
Nov	**8.5**	**82**	**4.3**	**10.2**	**124**	**95**	**7.4**	**7**	**5.9**
Dec	**7.8**	**24**	**3.6**	**16**	**101**	**84**	**7.5**	**7.2**	**3.5**
Jan	**7.8**	**29**	**3.8**	**17.5**	**102**	**83**	**7.6**	**7.4**	**3.6**
Feb	**7.7**	**35**	**3.7**	**18.7**	**102**	**83**	**7.6**	**7.4**	**3.7**
Mar	**7.6**	**38**	**3.5**	**19**	**99**	**84**	**7.4**	**7.2**	**3.5**
Mean	8.207	34.95	3.023	11.08	112.7	84.38	7.31	6.83	5.41
StdDevt	0.3796	28.98	0.777	4.986	9.461	8.76	0.215	0.504	1.330
ISI (10,500-91)	**6.5-8.5**	**500-2000**	**2.0**	**20.0**	**200-600**	**300-600**	**5.0**	**10.0**	**NIL**

Table 5: Monthly And Yearly Average Data Of Mahanadi River (Down stream)

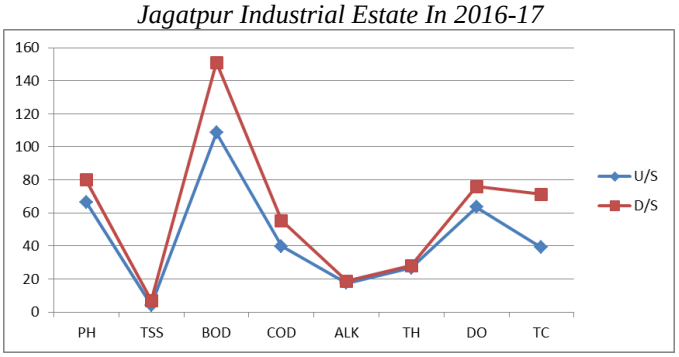
N.B:TSS,BOD,COD,ALK,TH and DO are expressed in mg/ l,TC and FC are in MPN/100ml in logarithmic form Remarks –pH-Logarithm of Hydrogen ion conc., TSS-Total Suspended Solids, BOD – Biochemical Oxygen Demand, COD-Chemical Oxygen Demand, ALK- Alkalinity, TH-Total Hardness, DO-Dissolved Oxygen, TC – Total Coli form, FC-FecalColi form

From the analytical data (Table-4 and Table-5), the various Physico-chemical parameters of Mahanadi river like p^H, BOD, COD, TSS, ALK, TH, TC are in inceasing trend at D/S point as compared to U/S points except for DO parameters. DO decreased (8.5-7.3)mg/lt. From the trend it is clearly depicted that the water quality of river Mahanadi is deteriorated at D/S point as compared to U/S point. Decreased in DO values indicate the increase in pollution load at D/S point .Water quality at D/S is not meeting the prescribed standard of drinking water quality of class-A classification of water. Mean values of different parameters are taken into consideration for the calculation of Water Quality Index (WQI).

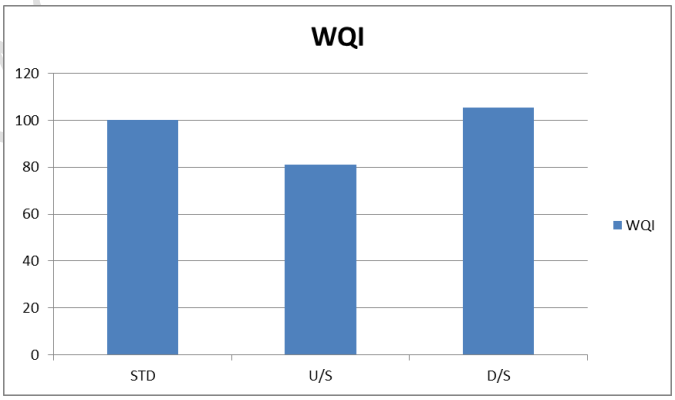
According to WHO (1993), Unit Weight (w_i) Water quality rating (q_i) and w_iq_i were depicted in the(table-6)

PARAMETERS	QUALITY RATING		UNIT WEIGHT		WQI(q_1w_1)	
	U/S	D/S	U/S	D/S	U/S	D/S
P^H	66.6	80.0	0.116	0.116	7.725	9.280
TSS	4.18	6.99	0.0019	0.0019	0.418	0.699
BOD	108.50	151.00	0.493	0.493	53.490	74.443
COD	39.90	55.40	0.049	0.049	1.955	2.714
ALKALINITY	17.55	18.78	0.0016	0.0016	0.280	0.300
TH	26.7	28.12	0.0032	0.0032	0.854	0.899
DO	63.54	76.04	0.197	0.197	12.517	14.979
TC	39.0	71.18	0.098	0.098	3.824	6.975
WEIGHTED ARITHMETIC INDEX				$\sum q_iw_i$	81.061	105.289
SOLWAY INDEX				$1/100\ (\sum q_iw_i)^2$	65.61	110.25

Table 6: Water Quality Of Index Of River Mahanadi At Jagatpur Industrial Estate In 2016-17



Graph Chart 1: Comparision Of Quality Rating Of Upstream And Downstream In 2016-2017



Graph Chart 2: Water Quality Index Of River Mahanadi During 2016-2017

The Water Quality Index (WQI) of the Mahanadi river (Graph chart-1 and graph chart-2) was then calculated using the Weighted Arithmetic Index formula as follows $WQI_A=\Sigma^8_{I=1}w_iq_i/\Sigma^8_{i=1}w_i$, 81.06/0.9603 =84.35 at U/S, Solway Index =65.61, $WQI_B=\Sigma^8_{I=}{}_1w_iq_i/\Sigma^8_{i=1}w_i$, 105.289/0.9603=109.64 at D/S, Solway Index=110.2. Before and after the industrial effluent discharged to River Mahanadi, it is found that Water Quality Index and Solway Index at U/S is 84.35 and 65.61 respectively whereas at D/S both WQI and Solway Index value is more than the prescribed standard such as 109.64 and 110.25. It is observed that WQI value is in increasing trend from upstream to downstream. The water of both the points is unsuitable for drinking purposes

IV. CONCLUSION AND RECOMMENDATIONS

The objective of the study is to calculate the Water Quality Index (WQI) of Mahanadi River in order to assess its

suitability for drinking purposes. Water Quality Index both at U/S and D/S obtained is clear indication of untreated water. It is very poor quality and must be treated before use to avoid water related diseases. It is high time to take necessary steps to curtail pollution load in river Mahanadi near Jagatpur Industrial Estate, so that the water quality of river Mahanadi would be remained within permissible limit. The industrial discharges should be released to water bodies only after their neutralization and proper treatment. We therefore strongly recommend that environmental awareness programme should be adopted among the residents of nearby villages.

ACKNOWLEDGEMENT

Dr. S.Panda is thankful to HOD Zoology Department, Salipur Autonomous College, Salipur and State Pollution Control Board, Bhubaneswar for providing laboratory facilities during the period of study.

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