Indian J.L.Sci.2(2) : 27-33, 2013
ISSN : 2277-1743 (Print)
ISSN : 2278-7879 (Online)

WATER QUALITY ANALYSIS OF RIVER MAHANADI IN CUTTACK CITY, ODISHA, INDIA

SUBHASHREE PANIGRAHI[a1] AND A. K. PATRA[b]

Fishery research Laboratory ,P.G. Department of Zoology Utkal University, Bhubaneswar, India
[a]E-mail: panigrahiashok@yahoo.in
[b]E-mail: ajyapatra2@gmail.com

ABSTRACT

Water quality basing on physicochemical parameters of river Mahanadi in Cuttack District has been assessed during January 2008 and December 2009. Water samples each for three study stations were analyzed for nine physicochemical parameters namely; pH, total alkalinity, total hardness, Chloride, Calcium, Magnesium, total solids, dissolved Oxygen, BOD 5-days.. The index ranges between minimum of 50.3186, 48.0595, 50.6149 and maximum of 54.7067, 52.4681, 69.2587 at three stations respectively (upstream, Banki: S_1, Middlestream, Naraj: S_2 and downstream, Kaliaboda: S_3). These were rated poor where water quality is adverse and the conditions deviate from desirable levels.

KEYWORDS : WQI, Physicochemical Parameters, River Mahanadi

River water contains a large number of dissolved chemical components of varying magnitude. (Alemaw and Chaoka, 2003). The primary source of most dissolved ions is the mineral assemblages in rocks near the land surface but the chemical composition is likely to be greatly affected by the nature and amounts of wastes dumped into, as well as biotic and abiotic processes in the water body(APHA, 2005). However, the effect of pollutants on water composition may obscure the effect of other factors in most of the cases (Hujare, 2008; Singh et al., 2010; Sujitha et al., 2012) .

The Man and Biosphere Programme (MAB) of UNESCO has laid emphasis on the studies of impact of various human activities on water and other resources (Pradhan et al., 2009). Accurate and timely information on the quality of water is indispensable to shape a sound public policy and to implement the water quality improvement programmes efficiently (Kumar et al., 2005; Medudhula et al., 2012). Water Quality Index (WQI) is one of the most effective expression which reflects a composite influence of contributing factors on the quality of water for any water system. Thus the present study is an end over to derive a useful tool for the quick assessment of river system which is commonly used for detection and evaluation of water pollution.

MATERIALS AND METHODS

The Samples of water were collected in triplicate in plastic container during morning hours (0900h) at three study sites of Cuttack city (S_1, S_2 and S_3) and the different seasonal values (i.e., Winter, Summer & Rainy) for each parameter were calculated from monthly sample data as per the methods suggested by (APHA, 2005; Pradhan et al., 2009; Sujitha et al., 2012). The water quality index formulae had been followed as per Mishra and Mishra (1994).

Water Quality Rating And Weight Age

The quality rating 'qi' is meant for the ith parameters.

Water quality parameters (i = 1,2,3…….9) was obtained from the relation:

qi=100(Vi Vio)/(Si-Vio) …(I) (Mishra and Mishra (1994).

Where, qi = Quality rating for the ith parameters (I =1,2,3,........9)

vi = The measured valueof the ith parameter at a given sampling station,vio = The ideal value of this parameter in pure water & si = The standard permissible value for the ith parameter.

Viewed from the ideal value, that is Vio = 0 for drinking water for the most parameters, assuming the following equation in its simple form for these parameters as : qi = 100(vi/si) , …..(II)

This equation ensures that qi = 0 , when a pollutant (the ith parameter) is totally absent in the water, and qi = 100, if the value of this parameter is just equal to its permissible value Si for the drinking water. Thus, larger the value of qi, the more polluted is the water with the ith pollutant. But there are following two exceptions to the equation (II).

[1]Corresponding author

For pH, the ideal value is 7.0 (for neutral water) and permissible value is 8.5. Therefore, the quality rating for pH may be:

q_{ph} = 100 (vpH-7.0)/(8.5-7.0) ……..(III)

where VpH is the observed value of pH. For DO , the situation is slightly complicated , since it contrasts to other pollutants, the quality of water is enhanced if it contains more dissolved oxygen. Therefore, the quality rating q^{DO} has been calculated from the relation :

$$q^{DO} = \frac{14.6}{100\ (14.6\text{-}5.0)} \quad \frac{VDO}{(14.6\text{-}5.0)} \qquad \text{…………. (IV)}$$

Where, V^{DO}=observed value of dissolved oxygen. In equation (IV), 14.6 mg l^{-1} is the ideal value (the solubility of oxygen, mg l^{-1}) in pure (distilled) water at 0°C and 5.0 mg l^{-1} is the standard for drinking water. The equation (IV) gives q^{DO}=0 when V^{DO}=14.6 mg l^{-1} and q^{DO}= 100 when = 5.0 mg l^{-1}.

Unit weights (Wi) for various water quality parameters are assumed to be inversely proportional to the recommended standards for the corresponding parameters i.e. wi = K/si ……… (V)

Where, wi = unit weight for the ith parameter, si where (i =1,2,3 ….9) refers to water quality parameters and K = constant for proportionality which determined from the condition:

(For the sake of simplicity it is assumed K=1)

$$\sum_{i=1}^{q} w_i = 1 \qquad \text{……… (VI)}$$

The unit weights wi calculated from equation (V) and (VI) are listed in Table, 1.

Calculation of Water Quality Index (WQI) (Salve and Hiware, 2008).

The water quality index (WQI) was calculated through the sub-index (Si), corresponding to ith parameter(calculation of the quality rating qi and the unit weight Wi of the ith parameters i.e. (SI) i = qi wi ....….(VII), has to be acquired.

The overall water quality index (WQI) was then calculated by aggregating the quality ratings (or subindices) linearly. Thus, water quality index could be written as

$$WQI = \sum_{i=1}^{q} (SI)i \quad \sum_{i=1}^{q} qiwi \qquad \text{………(VIII)}$$

But according to weighted geometric mean index, the WQI is calculated as

$$WQI = \sum_{i=1}^{q} qiwi \Big/ \sum_{i=1}^{q} (SI)i \qquad \text{.........….(IX)}$$

In the present study, the calculations of WQI were made taking the data available from upstream, dam reservoir and downstream of river Mahanadi in Cuttack District.

RESULTS AND DISCUSSION

Hydogen Ion Concentration (pH)

The pH throughout the study period was fluctuated between 6.97 and 7.95. The pH of the water remained acidic during rainy season, 2009 ; alkaline winter season, 2008 and summer, 2009 in all the three stations. The value showed a trend of increasing pattern from monsoon to summer (acidic and alkaline) with little seasonal variations (Alemaw and Chaoka, 2003).

Total Alkalinity

So far the total alkalinity is concerned the phenolphthalein alkalinity was absent throughout the observations at all the three stations, whereas total alkalinity was the dominant anion and ranged between 38.0 mg l^{-1} (rainy season) and 87.25 mg l^{-1} (summer). High values of total alkalinity were reported during winter and summer. The value was comparatively low during rainy season.

Total Hardness

The total hardness of water varied from 9.83 mg l^{-1} to 30.03 mg $l^{-1}$with the minimum value in rainy, 2008 at station S_1 and maximum value during summer, 2009 at S_3. Higher values were reported during summer at all the stations. The total hardness values of the river water increased from S_1 to S_3 accompanied by increased values of chlorides (Medudhula et al., 2012).

Chloride

The variation in chloride content had a narrow range irrespective of all the seasons. Its content in water varied between 3.47 mg l^{-1} (rainy, 2009) and 8.65 mgl^{-1}(summer, 2009) against the permissible range of 250 mg l^{-1}

(Virendra et al., 2009). Its highest value was noticed during May,2009 at S_3 , while the lowest was ascertained during October 2009 at S_1. The chloride content showed an increasing trend from post Monsoon to summer. Its higher concentration was obtained along the downstream which was an indication of sewage contamination of water.

Calcium

The variation in calcium concentration in water ranged from 4.53 mg l^{-1} to 8.0 mg l^{-1}.The maximum concentration was in July'2008 at S_3 and minimum in February'2008 at S_3. The higher concentration was recorded during monsoon and lower during winter (APHA, 2005).

Magnesium

Magnesium concentration varied between (1.525 mg $l^{-1}$and 6.40 mg l^{-1}) around the year. The highest value was observed in May'2008 at S_3 while lowest in January 2009 at S1. Its higher concentration was reported during summer and lower during winter (Sujitha et al., 2012).

Total Solids

The total solids in River Mahanadi water varied from 83.625 mg $l^{-1}$to 309.75 mg l^{-1}. The total residue of water was more during monsoon and ranged up to 309.75 mg l^{-1} with the higher concentration (75%) of suspended solids consisting of silt, clay, silica and humus etc. During winter and summer, concentration of dissolved solids was reported to be more (54.0 74.0 %) in comparison to the suspended residue (Singh, 2010).

DISSOLVED OXYGEN (DO)

Dissolved oxygen content varied from 5.4 mg l^{-1} to 8.02 mg l^{-1}. Higher DO values were noted during winter. It increased appreciably in winter at all the sampling stations. It becomes low during monsoon and summer . However, the river water maintained fairly congenial levels of dissolved oxygen throughout the study periods. The seasonal mean values of water quality parameters, water quality rating & water quality index in upstream S_1, dam reservoir S_2 and downstream S_3 of river Mahanadi have reported in tables 2,3 & 4 respectively. From the seasonal study it was revealed that in the upstream the water quality index values ranged between 50.3186 to 54.7067, in dam reservoir it varied between 48.0595 to 52.4681 whereas in downstream it varied between 50.6149 to 69.2587 in different seasons of the year, which is much less than 100. During this study, it was observed that the water quality at downstream was comparatively more disturbed than the upstream as well as dam reservoir due to release of domestic sewages, washing of motor vehicles, bank side abuses by people, surface run off and agricultural tail water to river system (Pradhan et al., 2009).

Table. 1 : Water quality parameters and their assigned unit weights (wi) of river Mahanadi at study station

Parameters	Unit Weights (wi)
P^H	0.2069
total alkalinity	0.0146
total hardness	0.0058
chloride	0.0070
calcium	0.0234
magnesium	0.0352
total solids	0.0035
dissolved oxygen	0.3518
$BOD_{5\text{ - days}}$	0.3518
Σ wi	1.0000

Biological Oxygen Demand (BOD5-days)

The 5 - days biological oxygen demand indicated low values (1.39 mg l^{-1} to 3.74 mg l^{-1}) at three different stations . The highest value was reported in summer, 2009 at S_3 and lowest value during winter, 2009 at S_2. BOD 5-days value increased along the downstream at all the study sites of the river ecosystem (Jhingran, 1991; Kumar et al., 2005).

The high pH during winter and early summer in the present work might be occurred on account of photosynthesis and evaporation of water assimilation. (Hujare, 2008).The non-significant differences in dissolved oxygen at all the stations could be due to variability in physicochemical and biological factors.

The total alkalinity value of 60.0 mg l^{-1}or more indicates hard water. River Mahanadi may have little hard during winter and early summer and may be correlated with the mass use of the medium for bathing, washing with greater use of soaps and detergents. The total alkalinity depicted of high positive 'r' value with pH ($r = 0.133$;$p < 0.01$) and DO ($r = 0.148$; $p < 0.01$) as evidenced by the correlation matrix for surface water.

Table 2 : Seasonal Mean Value Of Physical Chemical Parameters,water Quality Rating & Water Quality Index Of River Mahanadi (upstream S_1) at Banki.

Parameters		Water quality parameters			Water quality rating (QI)			Water quality index (WQI)		
		Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
P^H		7.95 x 9.12	7.55 x 5.66	6.97 x 0.09	72.54	42.76	0.66	15.0085 (0.0269 x 72.54)	8.8470 (0.0269 x 42.76)	0.1366 (0.0269 x 0.66)
total alkalinity	(mgl^{-1})	59.50 x 0.83	62.75 x 0.83	38.00 x 0.83	49.58	52.29	31.67	0.7239 (0.0146 x 49.58)	0.7634 (0.0146 x 52.29)	0.4624 (0.0146 x 31.67)
total hardness	(mgl^{-1})	20.66 x 0.33	26.08 x 0.33	9.83 x 0.33	6.88	8.69	3.29	0.0399 (0.0058 x 06.88)	0.0504 (0.0058 x 08.69)	0.0191 (0.0058 x 03.29)
chloride	(mgl^{-1})	4.80 x 0.40	7.15 x 0.40	3.47 x 0.40	1.92	2.85	1.39	0.0134 (0.0070 x 1.92)	0.0200 (0.0070 x 2.85)	0.0097 (0.0070 x 1.39)
calcium	(mgl^{-1})	4.53 x 1.51	5.825 x 1.38	6.91 x 1.38	6.84	8.04	9.55	0.1601 (0.0234 x 6.84)	0.1881 (0.0234 x 8.04)	0.2235 (0.0234 x 9.55)
magnesium	(mgl^{-1})	1.525 x 2.00	5.25 x 2.00	4.18 x 2.00	3.05	10.50	8.36	0.1074 (0.0352 x 3.05)	0.3696 (0.0352 x 10.50)	0.2943 (0.0352 x 8.36)
total solids	(mgl^{-1})	99.75 x 0.20	151.88 x 0.20	309.75 x 0.20	19.95	30.37	61.95	0.0698 (0.0035 x 19.95)	0.1063 (0.0035 x 30.37)	0.2168 (0.0035 x 61.95)
dissolved oxygen	(mgl^{-1})	7.3 x 8.96	6.00 x 11.82	6.45 x 13.02	65.38	70.90	83.96	23.0007 (0.3518 x 65.38)	24.9426 (0.3518 x 70.90)	29.5368 (0.3518 x 70.90)
$BOD_{5\text{-days}}$	(mgl^{-1})	2.17 x 20.00	3.73 x 20.00	2.76 x 20.00	43.4	74.60	55.20	15.2681 (0.3518 x 43.40)	19.4193 (0.3518 x 74.60)	19.4194 (0.3518 x 74.60)
$\sum$ qiwi =								54.3918	54.7067	50.3186
WQI $\sum$ qiwi /wi =								54.3918	54.7067	50.3186

Table 3 : Seasonal mean value of physical chemical parameters,water quality rating & Water quality index of river Mahanadi (middle stream S_2) at dam reservoir at Naraj

Parameters		Water quality parameters			Water quality rating (QI)			Water quality index (WQI)		
		Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
P^H		7.91 x 10.51	7.612 x 6.45	7.16 x 1.12	83.13	49.11	8.04	17.1996 (0.0269 x 83.13)	10.1609 (0.0269 x 49.11)	1.6635 (0.0269 x 8.04)
total alkalinity	(mgl^{-1})	70.95 x 0.83	69.00 x 0.83	39.25 x 0.83	58.54	57.20	32.70	0.8547 (0.0146 x 58.54)	0.8351 (0.0146 x 57.20)	0.4774 (0.0146 x 32.70)
total hardness	(mgl^{-1})	17.68 x 0.33	28.28 x 0.33	12.55 x 0.33	5.89	9.42	4.18	0.0342 (0.0058 x 05.89)	0.0546 (0.0058 x 09.42)	0.0242 (0.0058 x 04.18)
chloride	(mgl^{-1})	4.50 x 0.40	7.425 x 0.40	3.55 x 0.40	1.80	2.97	1.42	0.0126 (0.0070 x 1.80)	0.0208 (0.0070 x 2.97)	0.0099 (0.0070 x 1.42)
calcium	(mgl^{-1})	4.80 x 1.33	5.81 x 1.33	7.25 x 1.33	6.39	7.74	9.67	0.1495 (0.0234 x 6.39)	0.1811 (0.0234 x 7.74)	0.2263 (0.0234 x 9.67)
magnesium	(mgl^{-1})	1.825 x 2.00	5.50 x 2.00	4.525 x 2.00	3.65	11.00	9.05	0.1285 (0.0352 x 3.65)	0.3872 (0.0352 x 11.00)	0.3186 (0.0352 x 9.05)
total solids	(mgl^{-1})	90.00 x 0.20	193.25 x 0.20	90.00 x 0.20	18.00	38.65	18.00	0.0630 (0.0035 x 18.00)	0.1353 (0.0035 x 38.65)	0.063 (0.0035 x 18.00)
dissolved oxygen	(mgl^{-1})	8.02 x 8.59	6.36 x 10.79	6.93 x 12.45	68.92	68.65	86.30	24.2460 (0.3518 x 68.92)	24.1511 (0.3518 x 68.65)	30.3603 (0.3518 x 86.30)
BOD $_{5\text{-days}}$	(mgl^{-1})	1.39 x 20.00	2.29 x 20.00	2.12 x 20.00	27.80	45.80	42.40	9.7800 (0.3518 x 27.80)	16.1124 (0.3518 x 45.80)	14.9163 (0.3518 x 42.40)
$\sum$ qiwi =								52.4681	52.0385	48.0595
WQI $\sum$ qiwi /wi =								52.4681	52.0385	48.0595

Table 4 : Seasonal mean value of physical chemical parameters,water quality rating & Water quality index of river Mahanadi (down stream S_3) at Kaliaboda

Parameters		Water quality parameters			Water quality rating (QI)			Water quality index (WQI)		
		Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
P^H		7.88 x 7.60	7.50 x 4.77	6.97 x 0.47	59.85	35.81	3.29	12.3830 (0.0269 x 59.85)	7.4091 (0.0269 x 35.81)	0.6807 (0.0269 x 03.29)
Total alkalinity	(mgl^{-1})	82.25 x 0.83	87.25x 0.83	57.75 x 0.83	68.54	72.71	48.13	1.0007 (0.0146 x 68.54)	1.0616 (0.0146 x 72.71)	0.7027 (0.0146 x 48.13)
Total hardness	(mgl^{-1})	23.86 x 0.33	30.03 x 0.33	17.09 x 0.33	7.88	10.01	5.70	0.0457 (0.0058 x 07.88)	0.0581 (0.0058 x 10.01)	0.0331 (0.0058 x 05.70)
Chloride	(mgl^{-1})	5.85x 0.40	8.65 x 0.40	4.30 x 0.40	2.33	3.46	1.72	0.0163 (0.0070 x 2.33)	0.0242 (0.0070 x 03.46)	0.012 (0.0070 x 1.72)
Calcium	(mgl^{-1})	4.66 x 1.33	6.33 x 1.33	8.00 x1.33	6.21	8.44	10.66	0.1453 (0.0234 x 6.21)	0.1975 (0.0234 x 08.44)	0.2494 (0.0234 x 10.66)
Magnesium	(mgl^{-1})	1.77 x 254.94	6.40 x 2.00	4.975 x 2.00	451.25	12.80	9.95	15.8840 (0.0352 x 451.25)	0.4506 (0.0352 x 12.80)	0.3502 (0.0352 x 09.95)
Total solids	(mgl^{-1})	83.625x 0.20	177.50 x 0.20	301.00 x 0.20	16.72	35.50	60.20	0.0585 (0.0035 x 16.72)	0.1243 (0.0035 x 35.50)	0.2107 (0.0035 x 60.20)
Dissolved oxygen	(mgl^{-1})	7.05 x 9.86	5.40 x 13.13	6.15 x13.88	69.52	70.88	82.31	24.4571 (0.3518 x 69.52)	24.9356 (0.3518 x 70.88)	28.9567 (0.3518 x 82.31)
$BOD_{5\text{-days}}$	(mgl^{-1})	2.17 x 20.00	3.74 x 20.00	2.76 x 20.00	43.40	74.80	55.20	15.2681 (0.3518 x 43.40)	26.3146 (0.3518 x 74.80)	19.4194 (0.3518 x 55.20)
$\sum$ qiwi =								69.2587	60.5756	50.6149
WQI $\sum$ qiwi /wi =								69.2587	60.5756	50.6149

Calcium level within 10.0 mg l^{-1} is an index of medium productivity. In the present study, the higher rainfall in the first year (2008), has not only caused a higher rate of inflow, but also an increase in the level of nutrients like Calcium, Nitrogen and Phosphate. However, the sedimentary rock strata form almost the entire source of calcium in the medium.

Magnesium hardness increases in summer whereas calcium hardness decreases (Virendra et al., 2003). It might be due to higher carbon dioxide concentration in water, the insoluble magnesium carbonate was converted to soluble bicarbonate. The same possibly does not occur with calcium carbonate because of its lower solubility. Magnesium compounds are in general more soluble than the calcium salts. In the investigation it has been found that the magnesium concentration is within the permissible range i.e. within 15.0 mg l^{-1}.

In the present study the results of analysis of variance for biological oxygen demand between sampling stations are highly significant. BOD 5-days value of Indian standard limit for river is 20.0 mg l^{-1}. But when its value exceeds 30.0 mg l^{-1}, the water becomes polluted and it shows the nature of eutrophication. However, BOD 5-days value of river Mahanadi at study stations remains within the range 1.39 mg l^{-1} to 3.74 mg l^{-1} unaffected by the seasonal trend and as such the river water might be suitable for domestic use.

ACKNOWLEDGEMENT

The authors are grateful to Head of the Department of Zoology, Utkal University for providing necessary laboratory facilities.

REFERENCES

Alemaw B.F. and Chaoka T.R., 2003. A continental scale water balance model. A GIS approach for Southern Africa. Physics and Chemistry of the Earth, **28**: 957-966.

APHA, 2005. Standard methods for examination of water and waste water. 21st Edn., American Public Health Association. Washington D.C., USA.

Hujare M. S., 2008. Seasonal variation of physicochemical parameters in the perennial tank of Talsande, Maharastra. Ecotoxicol. Environ. Monit., **18**(3): 233-242.

Jhingran V.G., 1991. Fish and Fisheries of India. Revised and enlarged Third Edition. Hindustan Publishing Corporation (India), Delhi :727.

Kumar Rakesh, R.D. Singh and K.D. Sharma, 2005.Water Resources of India, Current Science, **89**(5): 794-811.

Medudhula. Thirupathaiah, Ch. Samatha and Chintha Sammaiah, 2012. Analysis of water quality using Physicochemical parameters in lower manair reservoir of Karinagar district, Andhra Pradesh International Journal of Environmental Sciences, **3**(1): 172-180.

Mishra R.K. and Mishra V.N., 1994. A critical appraisal of the Ganga water quality at Varanasi. International Conference on Recent Trends in water Pollution and Research, Dhobi, Jaunpur :19-21.

Pradhan U.K., Shirodkar P.V. and Sahu B.K., 2009. Physicochemical evalution of its seasonal changes using chemometric techniques, Current Science, **96**(9), 1203-1209.

Salve V. B. and Hiware C. J., 2008. Study on water quality of Wanparakalpa reservoir Nagpur, Near Parli Vaijnath, District Beed. Marathwada region, J. Aqua. Biol., **21**(2): 113-117.

Singh M.R., Gupta Asha and Beeteswari K.H., 2010. Physicochemical properties of water samples from Manipur river system, India. J.Appl. Sci. Environ. Manage, **14**(4): 85- 89.

Sujitha P. C., Mitra Dev D., Sowmya P. K. and Mini Priya R., 2012. Physicochemical parameters of Karamana river water in Trivandrum district, Kerala, India. International journal of Environmental Sciences **2**(3) : 1417-1434.

Virendra M., S. D. Pande, V.K.Gaur and K.Gopal., 2003. Fate of contaminated Sediments in Ecological Decline of Indian Rivers. In: River Pollution in India, Gopal, K. and A.K. Agarval (Eds.). APH Pub. Co., New Delhi, India : 23-36.