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International Journal of Current Research
Vol. 6, Issue, 06, pp.7049-7052, June, 2014

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

STUDY OF WATER QUALITY INDEX OF BRAHMANI RIVER WATER IN TALCHER-ANGUL INDUSTRIAL VICINITY, ODISHA

[1]Mishra, T. K., [2]Moharana, J. K., [3]Nanda, P. M., *[4]Garnaik, B. K.

[1]Department of Mining Engineering, Kalinga Institute of Mining Engineering & Technology, Chhendipada
[2]Department of Zoology, Talcher College (AUTO), Talcher
[3]Department of Physics, Talcher College (AUTO), Talcher
[4]P.G. Department of Chemistry, Berhampur University, Bhanja Bihar, Berhampur-7, Ganjam, Odisha (India)

ARTICLE INFO

Article History:
Received 09th March, 2014
Received in revised form
16th April, 2014
Accepted 14th May, 2014
Published online 25th June, 2014

Key words:
Water Quality Index (WQI), pH, Dissolved Oxygen, Turbidity, Total Alkalinity, Total Dissolved Solids, Total Hardness, Calcium, Magnesium, Chloride, Biochemical Oxygen Demand, Iron, Sulphate, Physico-chemical parameters.

ABSTRACT

The world's thirst for water is likely to become one of the most pressing issues of the 21st century. Rapid pace of industrialization, concurrent growth of urbanization, need and change of life style of ever expanding population have the potential to damage the environment and degrade the available surface and ground water sources. Since there has been growing concern about pollution in Angul-Talcher area due to industrial, mining and other anthropogenic activities, Central Pollution Control Board and Ministry of Environment & Forests have identified this zone as one of the hot spots in respect of pollution hazards. The present study is an attempt to provide a qualitative and quantitative status indicating the suitability of water sources for drinking purpose. The study on seasonal variations of physico-chemical characteristics along with its water quality of Brahmani river fluctuated from one season to other. Though most of the parameters varied within the recommended limit for drinking water yet BOD, COD, TDS, were recorded as some of the limiting parameters for making the source unfit for human consumption. Water Quality Index (WQI) values for river water in different seasons have been calculated to classify the sources according to pollution level and suitability for drinking water purpose.

INTRODUCTION

Talcher –Angul Industrial complex of Orissa is situated on the right bank of the river Brahmani at latitude 20^0 95 'N to 21^0 10 ' N and longitude 84^0 55' E to 85^0 28 'E ,139m above sea level (ASL), and 150 km away from Bhubaneswar, the state capital of Orissa (Climatological data of Orissa (1987-2001)) (Fig-1). This area is one of the largest coal belts of India. The majority of this area forms the plains of river Brahmani and its tributaries, like Tikira, Singida, Nandira, Lingira etc. Taking the advantages of the location, vast coal deposits, water availability and the manpower Mahanadi Coal Fields Ltd. (MCL) has developed a number of open cast and under ground mines in this industrial complex. Besides, a good number of coal based Thermal Power Plants (Talcher Super Thermal Power Project, Kaniha, Talcher Thermal Power Station, Talcher, Captive Power Plant, Nalco, Angul), several heavy industries (National Aluminimum Company, Angul, heavy Water Project, Vikrampur, Bhushan Steel and Strips Ltd, Jindal Power and Steel Ltd, Silicon steel, Nava Bharat Ferroalloys, Monet Ispat Ltd, Rungta Ltd etc), coal washeries and a large number of ancillary medium and small scale industrial Unit have come up in the area in the last few years. All these mining and industrial activities have caused significant degradation of environmental quality and now this area is considered as one among 24 most polluted areas of India. (The Sambad). The inhabitants of this area depend on the water system of river Brahmani for their day to day uses besides mining and industrial activities. The discharge of effluents (partly treated or untreated) from different industries and mines have led to depletion of water quality of the river. Such an alteration in the water quality makes the life miserable by inducing a number of water borne diseases (Sahu *et al.,* 1991). In the present work an attempt has been made to study the seasonal variations in the water quality of Bramhani water at the vicinity of Angul – Talcher industrial complex of Orissa. The water quality is monitored by studying the changes in the parameters like PH, TDS, TH, CaH, MgH, Alkalinity, DO, BOD, Iron, Cl^-, SO_4^{-2}, Turbidity etc.

***Corresponding author: Garnaik, B. K.** *P.G. Department of Chemistry, Berhampur University, Bhanja Bihar, Berhampur-7, Ganjam, Odisha (India)*

MATERIALS AND METHODS

(A) Sample Collection

Water samples of river Brahmani have been monitored at nine different stations. The choice of the stations have been mostly on the basis of major industries, Coal mines and important

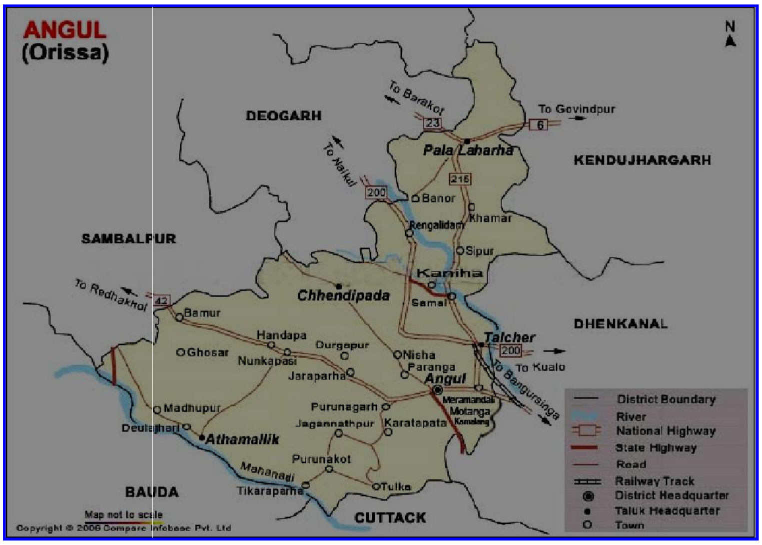

Fig 1. Map of Orissa and map of Angul- Talcher Industrial complex

Table 1. Area of study

S.No.	Sampling Spot	Major Contribution to Pollution
1.	Tikira Upstream	Industrial effluents of NTPC (Kaniha)
2.	Tikira down stream	Ash pond over flow/ leakage discharge to Tikira.
3.	Samal Barrage	Civil township, wastes discharged to river Brahmani
4.	Talcher Up stream	Contributory effect of Pollution Load from upstream mining waste, Industrial wastes & municipality wastes.
5.	Nandira Upstream	Industrial/ Mining Waste water / domestics waste water from Talcher Industrial Zone
6.	Nandira Down stream	Industrial effluents of NTPC (Talcher)
7.	Singra Jhor	Mining discharge waste water & mining waste joining this Jhor.
8.	Kamalang Down Stream	Confluence point of river Brahmani & Nandira Jhor, apparently more polluted
9.	Brahmani at Motonga	Confluence point of river Brahmani and Lingira Jhor carrying effluents of Nalco(Smelter), Bhusan Steel & Strips, Angul Municipal Waste.

township which are expected to make significant contributions to the pollution load of river Brahmani. The selected monitoring stations are mentioned in Table –1.

Water samples were collected from the said monitoring stations in clear polythene bottles at low temperature (Putting ice in box i.e. 4^0c). Generally the water samples were collected from river at a distance of 5 meters away from the bank and from a depth of about 0.25 meters. pH and DO tests were carried out immediately at the spot. After collection, the samples were brought to the laboratory on adding appropriate preservatives whenever necessary.

(B) Physico-chemical analysis

Procedures as laid down in (APHA-2005) (American Public Health Association-2005; Trivedi and Goel 1984) have been followed for the analysis of different parameters such as pH, Dissolved Oxygen, Turbidity, Total Alkalinity, Total Dissolved Solids, Total Hardness, Calcium, Magnesium, Chloride, Biochemical Oxygen Demand, Iron & Sulphate of the water samples. An average of three observations in a season with respect to each monitoring station and parameters have been determined and results were compared with the Indian standards (IS0:10500); (ISO:10500, Drinking water specification1992 (reaffirmed 1993)) for portable water.

Water Quality Index (WQI)

Water quality index (WQI) is commonly used for the detection and evaluation of water pollution and may be defined as "a rating, reflecting the composite influence of different quality parameters on the overall quality of water". The indices are broadly characterized into two parts: the physico-chemical indices and the biological indices. The physico-chemical indices are based on the values of various physico-chemical parameters in a water sample, while biological indices are derived from the biological information and are calculated using the species composition of the sample, the diversity of species, their distribution pattern, the presence or absence of the indicator species or groups etc. (Trivedy and Goel 1984). Here attempt has been made to calculate the water quality index of Talcher-Angul industrial complex on the basis of Harkins (1974), Lohani (1981) and subsequently modified by Tiwari *et al.* (1986) based on physico-chemical data. For the purpose of present investigation, twelve water quality parameters have been selected. These twelve parameters are pH, Dissolved Oxygen, Turbidity, Total Dissolved Solids, Hardness, Calcium, Magnesium, Chloride, Bio-chemical Oxygen Demand, Iron and Sulphate.

Table 2. Drinking water standards and unit weights

Water Quality Parameters	Standards	Recommending Agency	Unit Weight
pH	7.0-8.5	ICMR	0.0354
Dissolved Oxygen	5.0 mg/l	EEC	0.0496
Turbidity	10 NTU	ISI	0.0248
Total Alkalinity	120 mg/l	USPHS	0.0020
Total Dissolved Solids	500 mg/l	ICMR	0.0004
Total Hardness	300 mg/l	ICMR	0.0008
Calcium	75 mg/l	ICMR	0.0033
Magnesium	50 mg/l	ICMR	0.0049
Chloride	250 mg/l	ISI	0.0009
Biochemical Oxygen Demand	5.0 mg/l	WHO	0.0496
Iron	0.3 mg/l	ISI	0.8276
Sulphate	200 mg/l	ICMR	0.0012

Quality rating and weightage

In the formulation of water quality index, the importance of various parameters depends on the intended use of water; here water quality parameters are studied from the point of view of suitability for human consumption. The 'standards' (permissible values of various pollutants) for the drinking water, recommended by the Indian Council of Medical Research (ICMR) and unit weights are given in the above Table-2. When the ICMR standards are not available, the standards of United States Public Health Services (USPHS), World Health Organization (WHO), Indian Standards Institution (ISI) and European Economic Community (EEC) have been quoted.

The quality rating q_i for the i^{th} water quality parameters (i = 1,2,3--12) was obtained from the relation

$q_i = 100\ (v_i / S_i)$ --------------------(1)

Where v_i = value of the i^{th} parameter at a given sampling station and S_i = Standard permissible value of i^{th} parameter. This equation ensures that q_i = 0 when a pollutant (the i^{th} parameter) is absent in the water, while q_i = 100 if the value of this parameter is just equal to its permissible value for drinking water. Thus the larger the value of q_i the more polluted is the water with the i^{th} pollutant.

However, quality ratings for pH and DO require special handling. The range of pH for the drinking water is 7.0 to 8.5. Therefore, the quality rating for pH may be

$q_{pH} = 100[(v_{pH} - 7.0)/ (8.5 - 7.0)]$ ----------------------------(2)

Where v_{pH} = value of pH ~ 7, it means the numerical difference between v_{pH} and 7.0, ignoring algebraic sign. Equation (2) ensures the q_{pH} = 0 for pH = 7.0.

In contrast to other pollutants, the case of DO is slightly complicated because the quality of water is enhanced if it contains more DO. Therefore, the quality rating q_{DO} has been calculated from the relation

$q_{DO} = 100[(14.6 - v_{DO})/(14.6 - 5)]$-----------------------------(3)

Where v_{DO} = value of DO.

In equation (3), 14.6 is the solubility of oxygen (mg/l) in distilled water at $0^{o}C$ and 5.0 mg/l is the standard for drinking water. Equation (3) gives q_{DO} = 0 when DO = 14.6 mg/l and q_{DO} = 100 when v_{DO} = 5.0 mg/l.

The more harmful a given pollutant is, the smaller is its permissible value for drinking water. So the 'weights' for various water quality parameters are assumed to be inversely proportional to the recommended standards for the corresponding parameters i.e.

$$W_i = \frac{k}{S_i} \quad \text{------------------(4)}$$

Where W_i = unit weight for the i_{th} parameter (i = 1, 2, 3 ----12), k = constant of proportionality which is determined from the condition and k =1 for shake of simplicity.

$$\sum_{i=1}^{12} W_i = 1 \quad \text{-------------------- (5)}$$

The unit weights W_i calculated from equation (4) and (5) are listed in Table 2.

Calculation of WQI

To calculate the Water Quality Index, first the sub index $(SI)_i$ corresponding the i^{th} parameter was calculated. These are given by the product of the quality rating q_i and the unit weight W_i of the i^{th} parameter i.e.

$(SI)_i = q_i \times W_i$ -----------------------(6)

The overall Water Quality Index was then calculated by aggregating this subindices (SI) linearly. Thus Water Quality Index could be written as

$$WQI=\left[\sum_{i=1}^{12} q_i W_i \Big/ \sum_{i=1}^{12} W_i\right] \text{--------------------(7), Which gives}$$

$$WQI=\sum_{i=1}^{12} q_i W_i \quad \text{------- (8a), Since } \sum W_i=1 \text{-----(8b)}$$

By using these formulae we have developed a program in Turbo C++ to calculate WQI which has been given below.

Table 3. Water quality index of the River water of various study areas of TALCHER-ANGUL industrial complex

LOCATION	WQI OF THE YEAR 2012-13		
	Winter	Summer	Rainy
Tikira Up Stream	124	119	163
Tikira Down Stream	24	25	55
Samal Barrage	279	267	390
Talcher Up Stream	282	292	323
Nandira Up Stream	28	30	57
Nandira Down Stream	29	29	60
Singira Jora	292	283	359
Kamalamga Down Stream	391	376	442
Brahmani at Motonga	402	377	451

RESULTS AND DISCUSSION

Water samples from the periphery of Angul-Talcher were collected from river water sources on seasonal basis for comparison of water quality. The WQI values within 26-50 are taken as good for domestic purposes and under this category Tikira Downstream is coming. The WQI values of Nandira Upstream/Downstream are within 51-75, which is taken as poor quality for human consumption. Similarly WQI value 76-100 are taken as very poor for human consumption and WQI having value more than 100 has been taken as unsuitable for drinking and river water of Tikira Upstream, Singira jora, Samal barrage, Talcher Upstream, Kamalanga Downstream, and Brahmani at Motonga are coming under this category.

Conclusion

The analytical data from nine stations along the course of Brahmani river from Tikira to Motonga through Talcher – Angul industrial area, reveals that the water quality is poor in nature throughout the year. Though the concentrations of various parameters are above the desirable limits of drinking water specifications, the river water is not at all fit to use. Thus, to carry to aware every individual and their participations to protect human health and for sustainable development, it recommends an extensive study/studies of river water use of Brahmani at the peripheral area of Talcher –Angul industrial complex.

Acknowledgement

Two of the authors (P.M.Nanda and B.K.Garnaik) are thankful to University- grant- commission for financial assistance.

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