EFFECT OF INDUSTRIALIZATION ON WATER QUALITY OF HIRAKUD RESERVOIR

D P Satapathy[1], S Satapathy[2]

[1]*Department of Civil Engineering, CET ,Bhubaneswar, (India)*

[2]*PG Department of Zoology, Utkal University, Bhubaneswar, (India)*

ABSTRACT

In India environmental pollution is increasing day by day due to increased population, rapid urbanization, industrialization without proper management of domestic and industrial wastes. Abundant availability of fossil fuel and water in Sambalpur- Jharsuguda region have made the area suitable for mineral based industrialization. The trend of industrial growth in this region has increased exponentially in recent times and likely to continue in a more accelerated manner for coming years. The major source of water in the region is Hirakud reservoir which is the lifeline of the entire industrialization process. Injudicious and excessive use of fertilizers, discharge of untreated urban and industrial effluent in rivers and land deteriorates the surface and ground water quality. The present level of water drawl from the reservoir will increase by many folds and at the same time the reservoir water quality is also likely to be affected by contaminated runoff from its catchment area, dust fall on the reservoir and other pollutants which also increase the siltation in the reservoir. An attempt has been made to assess the water quality through development of a Water Quality Index (WQI) based on National Sanitation Foundation studies. Evaluating the quality of water can minimize contamination and prevent health hazards.

Keywords: Chemical Characteristics, Criteria Pollution Load, Hirakud Reservoir, Tributaries, Water Quality Index.

I. INTRODUCTION

Water quality refers to the characteristics of a water supply that will influence its suitability for a specific use. Quality is defined by certain physical, chemical and biological characteristics. Irrigation water quality is being evaluated based on the chemical and physical characteristics of water and only rarely are any other factors considered important [1]. Huge deposits of coal, proximity to Hirakud, one of the largest reservoirs of the country has made Sambalpur- Jharsuguda region one of the most attractive and globally most competitive destinations for mineral based industrialization. The availability of these raw materials makes this region an ideal site for production of Iron & Steel, Thermal Power and Aluminium. Industrial growth in this region has been phenomenal in recent items and likely to continue in a more accelerated manner for coming decade. The analysis of impact is based on primary data and secondary data as received from major industries available in OSPCB, Sambalpur**.** The iron and steel making capacity has increased by 2.6 times (from 2.4 MTPA to 6.152 MTPA), Thermal Power by 24 times (from 849.5 MW to 8240 MW) and Aluminium by 7 times (from 3.5 LPTA to 22.2 LPTA) within last five years and is further likely to increase. This estimate does not include ultra-mega power projects which are likely to be established in the region. All these existing and proposed industries require huge quantity of water for their process. The list of existing industries in the region is given in Table-1. Since Hirakud reservoir is a major source of water in the region having its storage capacity 5.18 km^3 which will be ultimate source to cater water requirement for existing and proposed industries including drinking purpose for Smbalpur-Jharsuguda region.

Water quality index (WQI) is valuable rating to depict the overall water quality. Evaluating the quality of water for domestic purpose especially for portable use Water Quality Index (WQI) based on chemical characteristics is found to be one of the most effective tools.Water Quality Index were formulated in many countries based on their National standards. Horton [2] proposed the first WQI to be used as a tool for assessing the overall quality of water. Crude [3] improves the understanding of water quality issues by integrating complex data and generating a score that assess the appropriateness of the quality of water for a variety of uses. Sargaonkar and Deshpande [4] defined quality in terms of its physical, chemical and biological parameters and developed an overall index of pollution for surface water based on a general classification scheme in Indian context. Boyacioglu [5] developed the Universal Water Quality Index (UWQI) to provide a simpler method for describing the quality of the surface water used for drinking water supply. Most of the WQI proposed were based on the physical, chemical and biological parameters through the hydro geology and groundwater flow influences the quality of water directly or indirectly. Access to drinking water in India has increased over the past few decades with the tremendous adverse impact of unsafe water for health [6]. Scarcity of clean and potable drinking water has emerged in recent years as one of the most serious developmental issues in many parts of West Bengal, Jharkhand, Orissa, Western Uttar Pradesh, Andhra Pradesh, Rajasthan and Punjab [7].

Table 1: Identification of Major Existing Industries

Industries	**Numbers**	**Capacity**
Sponge iron & steel	24	10,600 TPD and 6.152 MTPA
Smelters	3	22.2LTPA
Power plants	18	8240 MW/day
Refractory	1	400TPD
Cement	1	2.0MTPA
Area Sources		
Mines	10	23.03MTPA
Rice mills	48	912.36TPD
Stone crushers & Others	28	622 TPD
Domestics	27 villages	From census data

II.DESCRIPTION OF STUDY AREA

Hirakud dam project is built across river Mahanadi at about 15.0 kms. upstream of Sambalpur town in the state of Orissa(Fig. 1).

Salient Features

2.1 Hydrological Features

- Catchment area at Dam site – 83400 sq. km(32000 sq. miles).
- Rainfall - Original Revised

Mean Annual	1381.25 mm	10.38 mm
Max Annual	1808.73 mm	2518 mm
Min Annual	940.31 mm	607 mm
15% dependable Annual	1020 mm	816 mm
Runoff –	Original	Revised
Average Annual	6.17 M.Hect.m	3.36 M.Hect.m
Max Annual	8.62 M.Hect.m	9.09 M.Hect.m
Min Annual	2.54 M.Hect.m	1.14 M.Hect.m
15% dependable	2.64 M.Hect.m	

2.2 Reservior Data

- At top of Dam - R.L. 195.680 m
- At F.R.L/M.W.L - R.L. 192.024 m
- Dead storage Level - R.L. 179.830 m

	Original	Revised
Cross Storage Level	8136 M.Cum	7189 M.Cum
Dead storage Level	2318 M.Cum	1814 M.Cum
Live storage capacity	5818 M.Cum	5375 M.Cum
Water spread Area at F.R.L	743 sq. km.	-
Water spread area at D.S.L	274 sq. km.	-
Maximum fetch at F.R.L	83.2 km.	–

2.3 Main Dam Data

- Total length - 4840 m
- Length of concrete and masonry dam - 1148 m
- On left side - 499.9 m
- On right side - 648.6 m
- Quantity of concrete and masonry - 1.4 M.Cum
- Length of Earth Dam - 3651.5 m
- Left Earth Dam - 1353.3 m
- Right Earth Dam - 2298.2 m
- Length of right dyke - 10759 m in 1 stretch
- Length of left dyke - 9337 m in 5 gaps
- Total quantity of earth work in Dam - 18.1 million cum

Figure 1 Hirakud Reservoir`

III. RESERVOIR WATER QUANTITY

3.1. Domestic Purpose

Considering population growth and industrialization in the Sambalpur and Jharsuguda region, the water demand for domestic purpose will definitely increase. The water demand is projected as 31.9, 34.3 and 37.8 MCM for domestic purpose during 2011, 2021 & 2031 respectively. The total water requirement shall be mainly met from reservoir and partly from ground water.

3.2 Industrial Purpose

Most of the industries are catering water from the reservoir. Some of the industries are also taping groundwater for industrial purpose and domestic purpose. The Hirakud Reservoir supplies water of an about 8, 50,000 m^3/ day to major eighteen industries located in the region. Table 2 shows the water consumed by the industries from the reservoir. Further it is analyzed that for thermal power plant water requirement for the existing industries is found to be 220800 m^3/day and water requirement for CTE granted proposed industries will increase the demand to 462240 m^3/day. In case of aluminum smelters, existing industries require 12170 m^3/day of water while for proposed smelters it will increase to 64115 m^3/day of water. Presently water required by sponge iron plants is 10000 m^3/day while for the proposed industries it will increase to 85000 m^3/day. Out of water total requirement 1000 m^3/day, 500 m^3/day is required for the existing coal mines and rest 500 m^3/day will be required for the proposed coal mines. The industries like Iron & Steel, Thermal Power and Aluminium being high temperature operation, 90% would be evaporated and 10% would be discharged back as effluent from industries. Present level of water drawl has already increased many folds and is likely to increase further. The water requirement for industrial purposes is projected as 350, 382, 414 MCM during 2011, 2021 and 2031 respectively. Since the estimate is very conservative, this projected level of water drawl is estimated to go beyond against the Government plan to allocate 431.7 M m^3 per year.

Table 2: Quantity of Water Consumed from Hirakud Reservoir

Sl. No.	Name of Industry	Source of water	Quantity of water(m^3/day)
1	Vedanta Aluminium	Hirakud Reservoir	61920
2	Aryan Ispat & Power Ltd	Hirakud Reservoir + Ground water	15048(No breakup of groundwater and surface water is provided)
3	Shyam DRI	Hirakud Reservoir	77712
4	Action Power Ispat	-	13944
5	Eastern Steel & Power Ltd	Hirakud Reservoir	16116
6	SPS steel & Power Ltd	Hirakud Reservoir	22080
7	Sterlite Optical Tech. Ltd.	Hirakud Reservoir	324360
8	Bhushan Limited	Hirakud Reservoir	93252
9	Hindalco Industries Ltd.	Hirakud Reservoir	101555
10	MSP Metallics Ltd	Ib river	25800
11	Viraj Steel Ltd.	Hirakud Reservoir	33552
12	SMC power Co. Ltd.	Hirakud Reservoir	17040
13	Ind. Bharat Energy	Mahanadi River	63700
14	Aditya Aluminium	Hirakud Reservoir	4920
	Total		870999

IV. RESERVOIR WATER QUALITY

4.1 Wastewater Discharge into Reservoir

The region encompasses mainly three perennial rivers, namely Mahanadi river, Ib river and Bheden river. Bheden river is tributary of Ib river and Ib river is tributary of Mahanadi river which joins in the Hirakud reservoir. Twelve coal mines in the Ib valley together discharge about 14,000 cubic metre of mine discharge water per day during non-monsoon months, which increase to about 33,000 cum per day during the monsoon. Lilari Nalla carries mine discharge water to Ib river which finally meets Mahanadi river before the reservoir. The waste water of Vedanta Aluminum Ltd. flows through Kharkhari Nalla which joins Bheden river. Bhusan Steel Ltd. discharges their waste water into Bheden river. Kharjor Nalla receives the waste water of Hindalco Ind. Ltd. Which joins Mahanadi at the dam. The total wastewater generation from the existing industries is estimated to be 169280 cum/day comprising Sambalpur region of 133618 cum/day and Jharsuguda region 35662 cum/day. However, this estimate has done considering the available date from secondary sources. It is observed that no data is available regarding wastewater generation from proposed industries. However, what is more critical is the run off contamination. The runoff from various stock piles like coal, minerals, solid waste etc flows down the area and gets discharged to river Ib, Bheden and Hirakud reservoir through its feeder streams . The smelting units in this region would annually consume about 80,000tons of fluoride bearing materials. Considering 1% spillage and related loss, about 800 tones of these materials may be washed into the reservoir. Besides 3160 tons of fluoride will be emitted through stack room and pot room emission, even when it remaining with permissible limit. Similarly, 1,26,000 tons of fluoride bearing hazardous waste would be generated in this region annually, which puts the reservoir under significant risk of fluoride contamination. Fluoride level of more than 1.5 mg/l in water is known to cause fluorosis, a deadly disease for which there is no cure, if contaminated water is consumed for a prolonged period.

The water quality of the reservoir analyzed for the period 2008-2014 is presented in Table 3. The water quality of reservoir indicates that all other parameters are well within the standard.

Table 3: Water Quality of Reservoir

Water Quality Parameters	**Year**						
	2008	2009	2010	2011	2012	2013	2014
pH	7.8	7.5	7.9	7.6	7.8	8.0	7.7
DO(mg/L)	7.0	7.6	7.8	8.6	8.0	8.8	7.8
BOD(mg/L)	2.2	2.1	2.8	1.3	0.8	0.9	1.0
TC(MPN/ml)	3.55	0.84	1.4	1.75	5.4	3.3	14
TDS(mg/L)					112	98	107
SAR(mg/L)	0.37	0.59	0.6	0.47	0.51	0.84	0.29
SO_4^{-2} (mg/L)					4	5	9
Cl (mg/L)					8	3	9
F (mg/L)					0.75	0.22	0.1
TH(mg/L)					80	72	74

4.2 Dust Fall on the Reservoir

It is a fact that since the reservoir is very close to many industries and these industries emit lot of dust which is being carried by wind settle on the reservoir. To calculate the amount of dust fall on the reservoir by using air quality dispersion modeling, lot of data is required which could not collected in short time. However it is roughly estimated that the dust fall on the reservoir is about 1000 kg/ km^2. The mining activities, industrial discharge through its tributaries and dust fall in the reservoir shall increase the siltation in the reservoir.

4.3 Water Quality Index

Water quality Index (WQI) is an excellent management and general administrative tool in communicating water quality information.It has been calculated with a primary purpose being to simplify data and information collected in respect of reservoir. The WQI was computed based on 8 selected parameters such as DO, Fecal Coliforms, pH, 5-day BOD, Nitrates, Phosphates, Temperature deviation, Turbidity and as per National Sanitation Foundation (NSF) guidelines. Although Fluoride is an important parameter for the region, it has not been taken in this selected calculation as values reported are much below the prescribed drinking water quality standards.

Table 4: Water Quality Index Calculation

Parameters	Test Results	Units	I_i	W_i	$I_i W_i$
pH	7.5	pH units	90	0.12	10.80
Change in temp	1000	degrees C	73	0.11	8.05
DO	7.7	% saturation	95	0.18	17.03
BOD	1.0	mg/L	90	0.12	10.76
Turbidity	4	NTU	45	0.09	4.09
Total Phosphorus	1	mg/L P	19	0.11	2.05
Nitrate Nitrogen	5	mg/L NO3-N	40	0.10	4.01
Fecal Coliforms	40JTU	CFU/100 mL	26	0.17	4.47
Total				**1.0**	**61.25**

To calculate the aggregate, a linear sum of sub-indices has been used which can be expressed mathematically as follows;

WQI = $\sum_{I=1}^{n} W_i I_i$

Where W_i = is the weight (in terms of importance) associated with i_{th} water quality parameter.

I_i =is the sub-index for i_{th} water quality parameter.

n= is the number of water quality parameters.

The Water Quality Index (WQI) calculation is shown in Table 4. The above method suggests that the reservoir water quality is in the range of medium water quality (71-90). The water quality index rating is as follows; 91-100: Excellent, 71-90: Good, 51-70: Medium, 26-50: Bad, 0-25 very bad.

V. CONCLUSION

The results obtained from this study clearly indicate the water is of medium quality.Considering the availability of facilities and scope available for industrialization in the Sambalpur-Jharsuguda region, it shall be largest conglomerate of smelter and power house in the world. It is unlikely that such fast paced growth would be sustained environmentally. Since all the industries located here shall depend on the Hirakud reservoir for water, the reservoir water need to be protected. During monsoon, the runoff from various stock piles like coal, minerals, solid waste etc flows down the area and gets discharged to river Ib, Bheden and Hirakud reservoir through its feeder streams. Although the water quality of the reservoir has not reached at an alarming condition, the reservoir has to be protected from discharges of its tributaries and runoffs otherwise it would affect the quality of water resources in the region. Further, there is an urgent need to protect the World Heritage Hirakud reservoir from siltation caused due to mining activities and industrial discharges. The industries must set up a “consortia’ as corporate responsibility and make a scheme for frequent dredging of the reservoir.

REFERENCES

[1] WHO (1992) International Standards for Drinking Water. World Health Organization, Geneva, Swtzerland.

[2] Horton R.K (1965) An index number system for rating water quality. Journal of the Water Pollution Control Federation 37(3): 300-306.

[3] Cude C.G (2001) Oregon water quality index a tool for evaluating water quality management effectiveness. Journal of the American Water Resource Association 37(1): 125-137.

[4] Sargaonkar A and Deshpande V (2003) Development of an overall index of pollution for surface water based on general classification scheme in Indian context. Enviornmental Monitoring and assessment 89: 43-67.

[5] Boyaciolu H (2007) Development of a water quality index based on a European classification scheme. *Water SA 33(1):*101-106.

[6] Singh A.K., Raj Beenu., Tiwari A.K., and Mahato M. K (2003) Evaluation of hydrogeochemical processes and groundwater quality in the hansi district of Bundelkhand regoon, India, Enviornmental Earth Science, 70(3): 1225-1247.

[7] Tiwari A.K. and Singh A.K. (2014) Hydrogeochemical investigation and groundwater quality assessment of Pratapgarh district, Uttar Pradesh, Journal of the Geological Society of India, 83(3): 329-343.