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Research article

ESTIMATION OF WATER QUALITY STATUS OF KALINGA NAGAR INDUSTRIAL COMPLEX IN THE DISTRICT OF JAJPUR OF ODISHA, INDIA.

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ABSTRACT: The industries located in Kalinga Nagar industrial complex of Jajpur is using a large amount of fresh water from Kharasuan branch of Brahamani river for different purposes like cooling, washing of materials, finishing etc., and is producing a very large amount of waste water. Waste water create nuisance, degrades land , aquatic body and is responsible for water borne diseases in humans and animals as it contains heavy metals and harmful microorganisms. The present study aims at assessing the water quality status of Kalinga Nagar Industrial Complex (KNIC), an emerging steel hub in the district of Jajpur, Odisha. Waste water Samples were collected from the different places of Kalinga Nagar Industrial Complex and their Physico-chemical analysis was done by following the procedures prescribed by APHA (1995). This study identifies the potential sources of pollutants and degree of water pollution by calculating its water quality index (WQI).

Keywords: Effluent water, Physico-chemical analysis, Kalinga Nagar Industrial Complex (KNIC), Water Quality Index (WQI)

INTRODUCTION

All biological reactions occur in water and it is the integrated system of biological metabolic reactions in an aqueous solution that is essential for the maintenance of life. Most human activities involve the use of water in one way or other. It may be noted that man's early habitation and civilization sprang up along the banks of rivers. Although the surface of our planet is nearly 71% water, only 3% of it is fresh. Of these 3% about 75% is tied up in glaciers and polar icebergs, 24% in groundwater and 1% is available in the form of fresh water in rivers, lakes and ponds suitable for human consumption [1]. At present, approximately one-third of the world's people live in countries with moderate to high water stress and the worldwide freshwater consumption raised six fold between the years 1900 and 1995 more than twice the rate of population growth. Thus, many parts of the world are facing water scarcity problem due to limitation of water resources coinciding with growing population [2]. Fresh water is a finite resource, essential for agriculture, industry and even human existence, without fresh water of adequate quantity and quality, sustainable development will not be possible [3]. Rivers play a major role in assimilation or carrying off of municipal and industrial wastewater and runoff from agricultural land, the former constitutes the constant polluting source whereas the later is a seasonal phenomenon [4]. With the rapid development in agriculture, mining, urbanization, and industrialization activities, the river water contamination with hazardous waste and wastewater is becoming a common phenomenon. In India almost 70% of the water has become polluted due to the discharge of domestic sewage and industrial effluents into natural water source, such as rivers, streams as well as lakes [5].The improper management of water systems may cause serious problems in availability and quality of water [6]. Sewage contaminated storm water out-falls and the dumping of industrial waste pose a major health and environmental hazard. Since water quality and human health are closely related, water analysis before usage is of prime importance. The provision of potable water to the rural and urban population is necessary to prevent healt hazards [7]. Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards, which are designed to ensure that the water is potable and safe for drinking [8]. Potable water is defined as water that is free from diseases producing microorganisms and chemical substances deleterious to health [9].

Water can be obtained from a number of sources, among which are streams, lakes, rivers, ponds, rain, springs and wells. Unfortunately, clean, pure and safe water only exists briefly in nature and is immediately polluted by prevailing environmental factors and human activities. Water from most of the sources is therefore unfit for immediate consumption without some sort of treatment [10]. The consequences of waterborne bacteria and virus infection; Polio, Hepatitis, Cholera, Typhoid, Diarrhoea, Stomach Cramps, etc, have been well established but nitrate contamination is just as deadly. Contamination of drinking water from any source is therefore of primary importance because of the danger and risk of water borne diseases [11, 12]. The surface water is the main source of industries for waste disposal. Untreated or allegedly treated effluents have increase the level of surface water pollution up to 20 times the safe level in 22 critically polluted areas of the country. It is found that almost all rivers are polluted in most of the Stretches by some industry or the other [13, 14]. Although all the Indian industries function under the strict guidelines of the Central Pollution Control Board (CPCB) but still the situation of environmental pollution is far from satisfactory. Different norms and guidelines are given for all the industries depending upon their pollution potentials. Most of the major industries have treatment facilities for industrial effluents. But this is not the case with small scale industries, which cannot afford enormous investments in pollution control equipment as their profit margin is very slender. Consequently, the water pollution problem particularly due to toxic heavy metals has become menacing concern. As a result in India there are sufficient evidences available related with the mismanagement of industrial wastes [15-20].The day by day increasing tremendous industrial pollution in India has prompted us to carry the study of Physico-chemical properties of industrial waste water effluents from the Kalinga Nagar industrial complex, Jajpur, Odisha.

STUDY AREA

Kalinga Nagar is a major industrial area located at $20^0$57'- $21^0$3'N latitude and $85^0$59'-$86^0$5' E longitude near Duburi, a renowned mining area of Jajpur District, Odisha. The abundance of raw-materials such as iron ore, chromite, coal, dolomite, limestone, manganese and quartzite etc. at close proximity and adequate availability of infrastructure facilities have encouraged establishment of several mineral based industries (especially integrated steel plants) in Kalinga Nagar area. Kalinga Nagar Industrial Complex (KNIC) is in the process of becoming a major global hub in steel and ancillary products. It has been envisaged that by 2015, about 16 million tonnes crude steel will be produced per annum by a dozen of Mega, Large and Medium industries in the area. At present eight no. of Large and Medium industries have already started production and one Mega Plant of M/S Tata Steel with a capacity of 6 million tonnes per annum is in pipe-line.

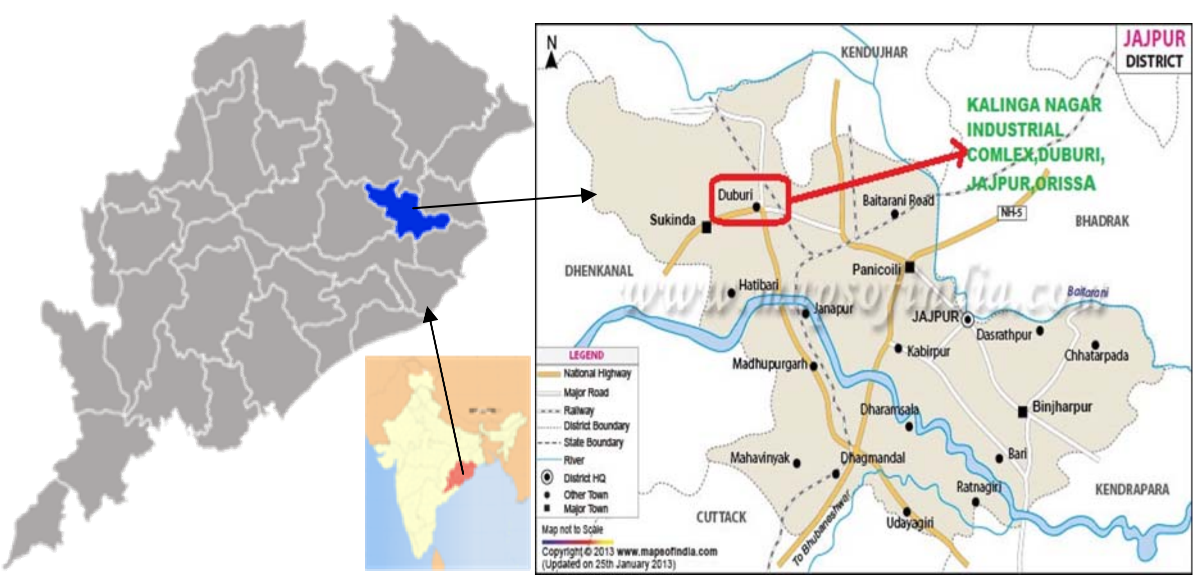

Figure-1: Map showing location of study area

Source- http://en.wikipedia.org/wiki/Jajpur_district,
http://www.mapsofindia.com/maps/orissa/districts/jajpur.htm, accessed on 12th Feb. 2013

Operation of industries in such a large scale in a cluster will have definite load on the physical, chemical and biological characteristics of the natural environment as iron and steel production involves usage of huge raw materials (approximately 3 tonne of raw materials per 1 tonne production of steel) and the manufacturing process generates a lot of waste materials [21]. Consequently, there will be considerable water pollution in pace with industrial advancement.

MATERIALS AND METHODOLOGY

Samples collection for Effluent Water:

Waste water Samples were collected from ten sampling stations of Kalinga Nagar industrial complex which are presented in Table-1. Samples were collected in clean dry bottles of plastic (1500ml) in such a way that no bubbles were formed in the bottles. After collection the samples were analysed in the Lab of P.G Dept. of Environmental Science, F.M University, **Table-1: Sampling stations**

Station No.	Location	Type of Area
STATION 1	Jakhapura-A	Rural
STATION 2	Manapur	Industrial
STATION 3	Siaria	Industrial
STATION 4	Duburi Square	Commercial
STATION 5	Baragadia-A	Industrial
STATION 6	Baragadia-B	Industrial
STATION 7	Jakhapura-B	Rural
STATION 8	Rabana-A	Rural
STATION 9	Rabana-B	Industrial
STATION 10	Telibahali	Commercial

Method of analysis for effluent water:

The waste water samples were analyzed for 12 physicochemical parameters i.e. Temperature, Turbidity, pH, EC (Electrical conductivity), TSS (Total Suspended Solids), TDS (Total Dissolved Solids), BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), Sulphate, Nitrate, Iron and Chromium were analyzed in the laboratory by following the procedures prescribed by APHA (1995) [22] .

Balasore during 2011-12.

Calculation of Water Quality Index (WQI)

Calculating of water quality index is to turn complex water quality data into information that is understandable and useable by the public. Therefore, water Quality Index (WQI) is a very useful and efficient method that can provide a simple indicator of water quality and it is based on some very important parameters. In current study, Water Quality Index (WQI) was calculated by using the Weighted Arithmetic Index method [23]. In this method, different water quality components are multiplied by a weighting factor and are then aggregated using simple arithmetic mean.

For assessing the quality of water in this study, firstly, the quality rating scale (Qi) for each parameter was calculated by using the following equation;

- $Qi = \{[(Vactual – Videal) / (Vstandard – Videal)] * 100\}$

Where, Qi = Quality rating of ith parameter for a total of n water quality parameters

Vactual = Actual value of the water quality parameter obtained from laboratory analysis

Videal = Ideal value of that water quality parameter can be obtained from the standard Tables.

Videal for pH = 7 and for other parameters it is equalling to zero, but for DO Videal = 14.6 mg/L

Vstandard = Recommended WHO or Bureau of Indian standard of the water quality parameter.

Then, after calculating the quality rating scale (Qi), the Relative (unit) weight (Wi) was calculated by a value inversely proportional to the recommended standard (Si) for the corresponding parameter using the following expression;

$W_i = 1/S_i$

Where, Wi = Relative (unit) weight for nth parameter
Si= Standard permissible value for nth parameter
I = Proportionality constant.

That means, the Relative (unit) weight (WI) to various water Quality parameters are inversely proportional to the recommended standards for the corresponding parameters. Finally, the overall WQI was calculated by aggregating the quality rating with the unit weight linearly by using the following equation:

$WQi = \sum Q_iW_i / \sum W_i$

Where, Qi = Quality rating
Wi = Relative weight

In general, WQI is defined for a specific and intended use of water. In this study the WQI was considered for human consumption or uses and the maximum permissible WQI for the drinking water was taken as 100 score.

Chemical analysis of water gives a concept about its physical and chemical composition by some numerical values but for estimating exact quality of water, its better to depend on water quality index which gives the idea of quality of drinking water. The rating of WQI is shown below.

WQI level	Water Quality Rating
0-25	Excellent
26-60	Good
51-75	Poor
76-100	Very Poor
> 100	Unfit for Drinking Purposes.

RESULTS AND DISCUSSION

Water quality index of the present water body is established from eight important various physiochemical parameters. The mean value of various physiochemical parameters were taken for calculation of water quality index and are presented in table -3. The water quality index was found to be 155.59 which indicate that the quality of water is very poor and hence unfit for any type of use. This water quality rating study clearly shows that the water is unsuitable for the human uses. It is also observed that the pollution load is very high. The above water quality is also supported by the following physiochemical parameter variations observed in different water Samples and presented in table- 2. Temperature is one of the most important ecological features. It controls behavioural characteristics of organisms; solubility of gases and salts in water .The basis of all life functions is complicated set of biochemical reactions that are influenced by physical factors such as temperature. Disease resistance is also linked to temperature. Increase in temperature also increases the rate of microbial activity. In the present study, the temperature varies between minimum of 280C and maximum of 460C. pH is a measure of the acidity or alkalinity of water and is one of the stable measurements. pH is a simple parameter but is extremely important, since most of the chemical reactions in aquatic environment are controlled by any change in its value. Anything either highly acidic or alkaline would kill marine life. Aquatic organisms are sensitive to pH changes and biological treatment requires pH control or monitoring. The toxicity of heavy metals also gets enhanced at particular pH. Thus, pH is having primary importance in deciding the quality of waste water effluent. Water with pH value of about 10 are exceptional and may reflect contamination by strong base such as NaOH and Ca (OH) 2 .In the present study pH was ranged between 5.8-11.8. It was found that pH value of all the samples was above the permissible unit except Sample no. 3. pH value was found to be highest in Sample no. 5 and lowest in Sample no. 8 .The values of turbidity were found to be ranged from 21.3 to78.2 NTU. The turbidity value was found to be lowest in Sample no. 1 and highest in Sample no-5.

The values of total suspended solid (T.S.S) were found to be ranged from 1042 to 2720 mg/l. In all the samples, T.S.S values were found to be beyond the permissible limit. T.S.S value was found lowest in Sample -2 and highest in Sample - 4. TDS content in water is a measure for salinity. A large number of salts are found dissolved in natural waters, the common ones are carbonates, bicarbonates, chlorides, sulphates, phosphates, and nitrates of calcium, magnesium, sodium, potassium, iron, and manganese, etc.

A high content of dissolved solid elements affects the density of water, influences osmoregulation of freshwater in organisms, reduces solubility of gases (like oxygen) and utility, of water for drinking, irrigational, and industrial purposes. In the present investigations the values of total dissolved solid (T.D.S) were found to be ranged from 1817 to 2861 mg/l. T.D.S value was found lowest in Sample no-2 and highest in Sample-9 .In all the samples TDS values were found beyond the permissible limit. The Chemical Oxygen Demand (COD) determination is a measure of the oxygen equivalent of that portion of the organic matter in a sample that is susceptible to oxidation by a strong chemical oxidant. During COD determination; oxygen demand value is useful in specifying toxic condition and presence of biologically resistant substances. It is an important, rapidly measured parameter for industrial waste water studies and control of waste treatments. COD test is used to measure the load of organic pollutants in the industrial waste water. The COD and BOD values both are a measure of the relative oxygen-depletion effect of a waste contaminant. Both have been widely adopted as a measure of pollution effect. COD is also one of the most common measures of pollutant organic material in water. COD is similar in function to BOD, in that both measure the amount of organic compounds in water. In the present study C.O.D values were found to be ranged from 340-547 mg/l. C.O.D value was found lowest in Sample-4 and highest in Sample no -9. In all the samples C.O.D values were found to be beyond the permissible limit. Increases in BOD can be due to heavy discharge of industrial waste water effluent, animal and crop wastes and domestic sewage. BOD values have been widely adopted as a measure of pollution effect. It is one of the most common measures of pollutant organic material in water. It indicates the amount of putrescible organic matter present in water. Sources of BOD in aquatic environment include leaves and woody debris, dead plants and animals, animal manure and industrial effluents. The B.O.D values were found to be ranged from 198 to 365 mg/l. B.O.D value was lowest in Sample no -7 and highest in Sample no-9. In all the samples B.O.D values were found beyond the permissible limit. It is important here to note that low BOD content is an indicator of good quality water, while a high BOD indicates polluted water. BOD directly affects the amount of dissolved oxygen (DO) in rivers and streams. The greater the BOD, the more rapidly Oxygen is depleted in the water. This means less Oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low DO: aquatic organisms become stressed, suffocate, and die. Sulphates occur in water due to leaching from sulphate mineral and oxidation of sulphides. Sulphates are associated generally with Calcium, Magnesium and Sodium ions. The Sulphate values were found to be ranged from 148 to 285 mg/l. The value of Sulphate was found to be lowest in Sample no.-7 and highest in Sample-6. The Sulphate value was found within the permissible limit in Sample no.-7 and beyond the permissible limit in all other samples. Nitrates in surface waters occur by the leaching of fertilizers from soil during surface run-off and nitrification of organic matter. Presence of high concentration of Nitrates is an indication of pollution. The values of Nitrate were found to be ranged from 205 to 294 mg/l. Nitrate value was found lowest in Sample no -8 and highest in Sample-9 . All the Nitrate values were found beyond the permissible limit. All organic compounds with few exceptions can be oxidized by the action of strong oxidizing agents under acidic condition. The values of chromium were found to be ranged from 0.004 to 0.021mg/l. Chromium value was found to be lowest in Sample no-10 and highest in Sample-8. The chromium value was found within the permissible limit in Sample-10 and beyond the permissible limit in all other samples. The value of iron was found to be ranged from 1.62 to 4.06 mg/l.The value of iron was found lowest in Sample-10 and highest in Sample no-5. Iron and chromium values were found to be high due the effluent discharged from steel and iron industries. In general, the results at sampling sites 1 to 10 indicated that the values of most parameters such as EC, turbidity, TDS, TSS , Sulphate, Nitrate, BOD, COD, Fe and Cr were beyond the permissible limits as prescribed by Indian standards for drinking water [IS:10500].

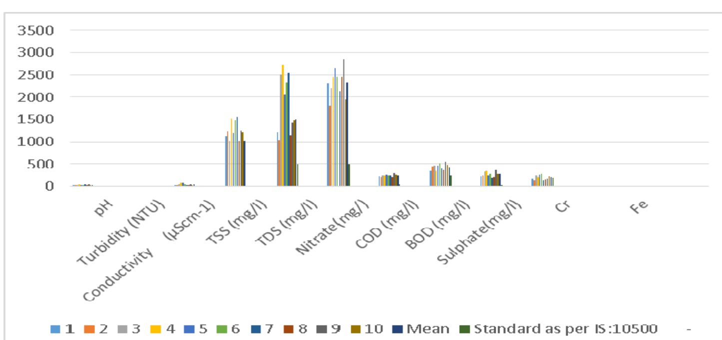

Figure-2: Graph showing Physico-chemical Parameters of industrial effluent

Table-2: Physico-chemical parameters of effluent water

Parameters	1	2	3	4	5	6	7	8	9	10	Mean	Standard as per IS:10500
Temperature(^{0}C)	34	30	32	42	33	28	37	35	46	33.4	35.04	-
pH	8.8	8.8	8.4	10.5	11.8	9.5	6.3	5.8	9.4	8.9	8.82	6.5 to 8.5
Turbidity (NTU)	21.3	22	52	74.5	78.2	52.35	31.01	35.64	47.65	35.15	44.98	5
Conductivity (µScm^{-1})	1123	1240	1021	1534	1183	1477	1562	1023	1254	1204	1262.1	-
TSS (mg/l)	1210	1042	2512	2720	2061	2345	2547	1148	1425	1477	1848.7	500
TDS (mg/l)	2321	1817	2207	2451	2655	2457	2136	2454	2861	1943	2330.2	500
Nitrate(mg/)	223	211	252	241	262	254	248	205	294	265	245.5	45
COD (mg/l)	346	452	466	340	464	512	412	365	547	487	439.1	-
BOD (mg/l)	224	246	329	346	245	276	198	215	365	286	273	-
Sulphate(mg/l)	172	154	252	215	264	285	148	162	176	224	205.2	200
Chromium as Cr^{6+}	0.012	0.018	0.007	0.008	0.014	0.016	0.006	0.021	0.007	0.004	0.0113	0.05
Fe (Iron)	3.28	3.37	2.70	2.19	4.06	3.41	3.32	1.86	2.54	1.62	2.835	0.3

Table-3: Calculation of Water Quality Index

S.no	parameters	Observed values (Mean Values)	Standard values (S_i)	Unit weight (w_i)	Quality rating (Q_i)	W_iQ_i
1.	pH	8.82	8.5	0.11764	103.764	12.2067
2.	BOD	273	30	0.03333	910	30.3303
3.	TDS	2330.2	500	0.002	466.04	0.93208
4.	TSS	1848.7	500	0.002	369.74	0.73948
5.	Nitrate	245.5	45	0.02222	545.55	12.12212
6.	Sulphate	205.2	200	0.005	102.6	0.513
7.	Cr	0.0113	0.05	20	22.6	452
8.	Fe	2.835	0.3	3.3333	945	3149.9685
				∑Wi=23.51549		∑QiWi=3658.81218
WQI = ∑QiWi/∑Wi = 3658.81218/23.51549=155.59						

CONCLUSION AND RECOMMENDATION

Thus in the present study, calculating of Water Quality Index (WQI) shows that the water quality status of Kalinga Nagar Industrial Complex is very poor and unfit for any human use. The major source of surface and ground water pollution is injudicious discharge of untreated industrial effluents directly into the surface water bodies resulting in serious surface and ground water pollution. This loss of water quality is causing health hazards and death of human beings, livestock and death of aquatic lives, crop failure and loss of aesthetics. This problem is aggravated by lack of awareness, lack of wastewater treatment facilities, lack of financial resources and the ineffective environmental laws. Hence, the author suggests that the water must be treated properly before it is discharged and used for human activities.

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