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RESEARCH ARTICLE

ASSESSMENT OF GROUNDWATER QUALITY IN AND AROUND PARADEEP PHOSPHATE LIMITED AT PARADEEP AREA, ODISHA, INDIA

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ABSTRACT

Groundwater is the prime source of drinking water supply for many of the Indian rural and urban habitats, like other parts of the world. Over burden of the population pressure, unplanned urbanization, unrestricted exploration and dumping of the polluted water at inappropriate place enhance the infiltration of harmful compounds to the ground water. Contamination of groundwater results in poor drinking water quality, high clean-up costs, high costs for alternative water supplies, and potential health problems .In present study, assessment of ground water quality in and around Paradeep Phosphate Limited (PPL)of Paradeep area is done.Ground water samples were collected from bore wells of different locations forcharacterise the pollutant and for assessing the level of pollution by calculating Water Quality Index (WQI). The results of the present investigation shows that ground water quality in study area is good and fit for drinking.

INTRODUCTION

Various devastating ecological and human disasters of the last four decades implicate industries as a major contribution to environmental degradation and pollution. Environmental pollution due to increase of industrial activities are one of the most significant problems of the century. Pollution in water is strictly related to human activities such as industry, agriculture, burning of fossil fuels, mining and metallurgical processes and their waste disposal (Guiliano et. al., 2007) . Ground water is frequently using as the alternative source for agricultural and industrial sector. Many regions all over the globe are heavily depending on ground water for various purposes. Over burden of the population pressure, unplanned urbanization, unrestricted exploration and dumping of the polluted water at inappropriate place enhance the infiltration of harmful compounds to the ground water (Pandey and Tiwari, 2009). There are various ways as ground water is contaminated such as use of fertilizer in farming (Altman and Parizek, 1995), seepage from effluent bearing water body (Adekunle, 2009). Most of the industries discharge their effluent without proper treatment into nearby open pits or pass them through unlined channels, resulting in the contamination of ground water (Jinwal and Dixit, 2008). The incidence of ground water pollution is highest in urban areas where large volumes of waste are concentrated and discharge into relatively small areas (Rao and Mamatha, 2004). The hydro-geochemical conditions are also responsible for causing significant variations in ground water quality (Mahanta et. al., 2004). Contamination of groundwater results in poor drinking water quality, high clean-up costs, high costs for alternative water supplies, and/or potential health problems (Adhikari et al., 2009). Rapid deterioration of groundwater quality is commonly observed in places which are densely populated, thickly industrialized and have shallow groundwater table (Patil et al., 2001). Paradip, also spelt Paradeep, is a major seaport town and a designated notified area in Jagatsinghpur district of Odisha, India. Paradip is located at 20.16°N 86.40°E. In 2009, the population of this town was estimated at 150,000 (http://en.wikipedia.org/wiki/Paradip). ParadipArea is adjoined by water bodies in three directions namely in the North, South and East. Bay of Bengal is on the South Eastern direction whereas Mahanadi river flows on the northern side and drains from west to east. Fertilizer plants of Paradeep are a major chemical fertilizer producer in India and also polluting the peripheral environment. The effluents from Paradip Phosphate Ltd (PPL), Indian Farmers and Fertilisers Cooperative (IFFCO) Ltd, SKOL Breweries, sewage from PPL Township and Paradip Port Trust (PPT) Township are discharged into AtharabankiRiver which ultimately joins the Mahanadi River near the confluence point in the Bay of Bengal (Samantray *et.al.*, 2009). Due to the discharged effluents in water bodies thereis a chance of surface water and ground water pollution in Paradeep area. In present research work an attempt is made to assess the ground water quality in and around Paradeep Phosphate Limited at Paradeep area.

MATERIALS AND METHODS

Groundwater samples were collected from four different sampling locations (Table.1) in clean plastic containers of 2 L capacity during March 2012 from bore wells located in and around Paradeep Phosphate Limited (PPL) at Paradeep area. The map of study area is given in Figure-1. The selected bore wells are both municipal and private owned and were fitted with either hand pump or electric motor and were being used to supply water for

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domestic demand. Water of the bore well was run for 2 to 3 min and the containers were rinsed with the sample water prior to collection of the sample. The samples were immediately transferred to the laboratory of P.G Dept. of Environmental Science, Fakir Mohan University and analysed for various physico-chemical parameters by following the analytical procedure of APHA (1989). Then the analysed test results were compared for Indian drinking water standards and Oregon water quality index for each sample is calculated.

Water Quality Index

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 which 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 as described by Cude, C. 2001. In this model, 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 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;

$Wi = 1/ Si$

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:

$WQi = \sum QiWi/ \sum Wi$

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, it's 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

In the present study,ground water samples were analysed and its results were compared with the standard values of Indian water quality Standards (Table-2). The description about the values of different physico-chemical parameters obtained are as follows. 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 water .In present work the pH of the water samples was observed to be basic i.e., the value varies between 6.9-7.5 which indicates that the pH value ranges in between the permissible limit. Turbidity of the water samples in between 0.3 – 0.5 NTU. The Total Dissolved Solids (TDS) values ranged between 177 mg/l to 277 mg/l. All the TDS values of water samples within the permissible limit Total hardness of the water samples were varied from 128 to 214 mg/l. Hardness is an important water quality parameter attributed due to presence of bi-carbonate, sulphate, chlorides and nitrates of calcium and magnesium. The range of calcium is 29.5 to 72.5 mg/l, which are well within the prescribed limit. The sodium ranges between 24 to 45 mg/l, which also well within the prescribed limit. The Alkalinity values ranged between 70mg/l to 280 mg/l. All the Alkalinity values of water samples in study area within the permissible limit.

Table 1 Arrangement of sampling locations

Sl. No.	Sampling number	Sampling source	Sampling location
1	GW1	Bore well near offsite	PPL
2	GW2	Test well no -1	PPL
3	GW3	Village Musadiha borewell	Village Musadiha
4	GW4	Village Jhimani borewell	Village Jhimani

The presence of fluoride in water in higher concentration cause a disease called fluorosis.In present study the fluoride concentration ranged between 0.21 to 0.28 mg/l which well within the permissible limit. The chloride content ranges from 21 to 66 mg/l which indicates that the chloride content well within the norm. Sulphate ion is one of the most important anion present in natural water produces cathartic effect on human being when it is present above permissible limit. The sulphate concentration varied from 6.13 to 9.6 mg/l which indicates that in all the sample water, the sulphate values well within the limit. Nitrates in drinking water indicate the degree of pollution of water system. The nitrates concentration in water samples varied from 0.35 to 1.18 mg/l which well within the prescribed norm. Dissolved oxygen content in water reflects the physical and biological processes prevailing in water and is influenced by aquatic vegetation. Low oxygen content in water is usually associated with organic pollution.

Table 2 Analysis report of Ground Water Quality

S.No.	PARAMETERS	UNIT	GW1	GW2	GW3	GW4	STANDARD (IS:10500)
1	Temperature	^{o}C	23	24	26	24	
2	pH	-	7.2	6.9	7.5	7.2	6.5-8.5
3	Turbidity	NTU	0.3	0.5	0.4	0.3	10
4	Dissolved Solids	Mg/l	177	207	230	277	500
5	Total hardness	Mg/l	164	128	146	214	300
6	Calcium	Mg/l	51.3	29.5	72.5	63	75
7	Sodium	Mg/l	45	24	38	35	
8	Alkalinity	Mg/l	280	70	170	90	600
9	Fluoride	Mg/l	0.22	0.21	0.28	0.21	0.6-1.2
10	Sulphate	Mg/l	9.6	9.46	6.13	7.55	150
11	Nitrate	Mg/l	0.35	0.67	1.18	0.91	45
12	Chloride	Mg/l	61	42	66	21	250
13	Dissolved Oxygen	Mg/l	3.2	5.2	4.1	5.5	
14	Iron	Mg/l	0.16	0.13	0.15	0.08	0.3
15	Lead	Mg/l	0.02	0.03	0.02	0.01	0.1
16	Zinc	Mg/l	0.07	0.13	0.11	0.09	5

Table 3 Water Quality Index of different samples

S.NO.	PARAMETERS	OBSERVED VALUES			
		GW1	GW2	GW3	GW4
1	pH	7.2	6.9	7.5	7.2
2	Turbidity	0.3	0.5	0.4	0.3
3	Dissolved Solids	177	207	230	277
4	Total hardness	164	128	146	214
5	Calcium	51.3	29.5	72.5	63
6	Alkalinity	280	70	170	90
7	Sulphate	9.6	9.46	6.13	7.55
8	Nitrate	0.35	0.67	1.18	0.91
9	Chloride	61	42	66	21
10	Iron	0.16	0.13	0.15	0.08
11	Lead	0.02	0.03	0.02	0.01
12	Zinc	0.07	0.13	0.11	0.09
	WQI	27.624	32.2794	27.03595	13.9612

Table 4 Description of ground water quality at different sampling location

SAMPLING NO.	SAMPLING LOCATION	WQI	DESCRIPTION
GW1	Bore well near offsite	27.624	Good
GW2	Test well no -1	32.2794	Good
GW3	Village Musadiha borewell	27.03595	Good
GW4	Village Jhimani borewell	13.9612	Excellent

Figure 1 Map showing study area

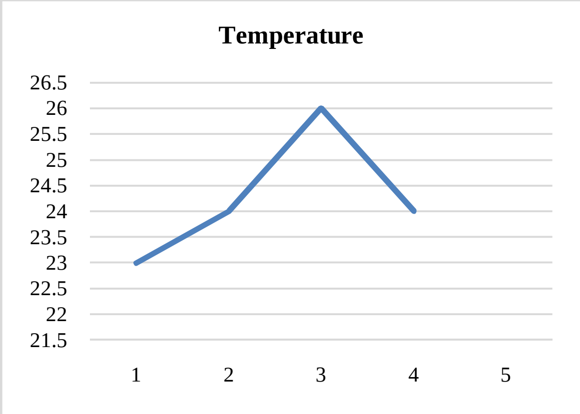

Figure 2 Variation of Temperature with Sampling Points

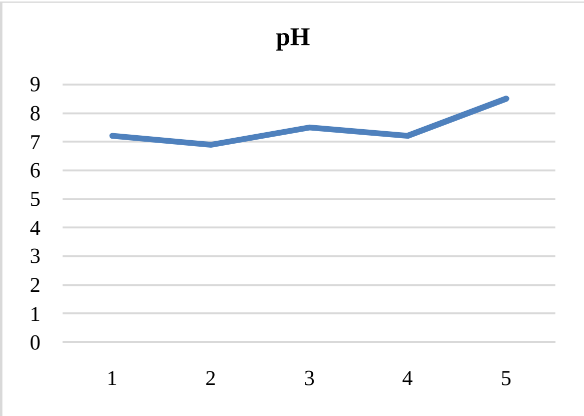

Figure 3 Variation of pH with Sampling Points

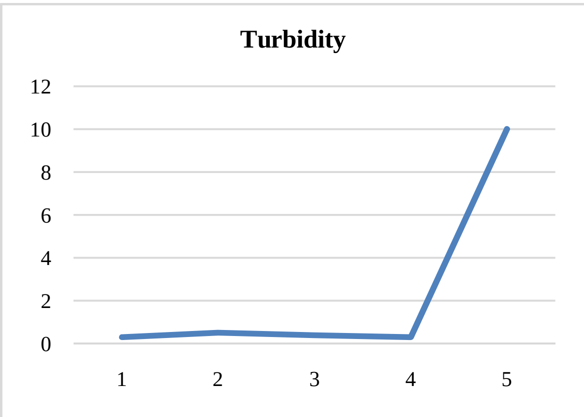

Figure 4 Variation of Turbidity with Sampling Points

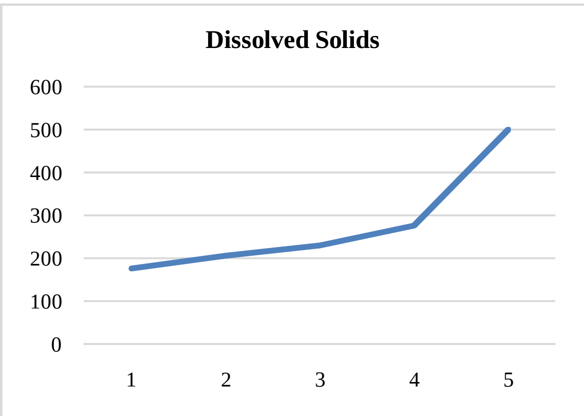

Figure 5 Variation of Dissolved solids with Sampling Points

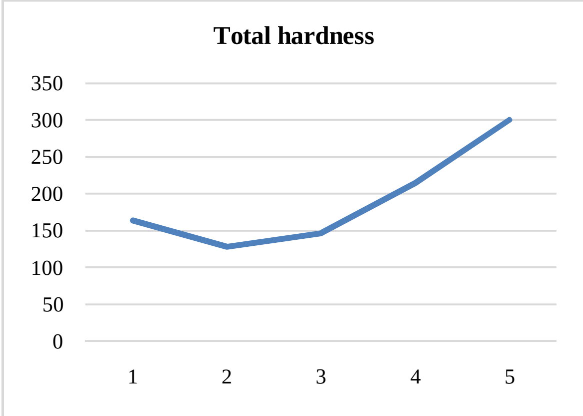

Figure 6 Variation of Total Hardness with Sampling Points

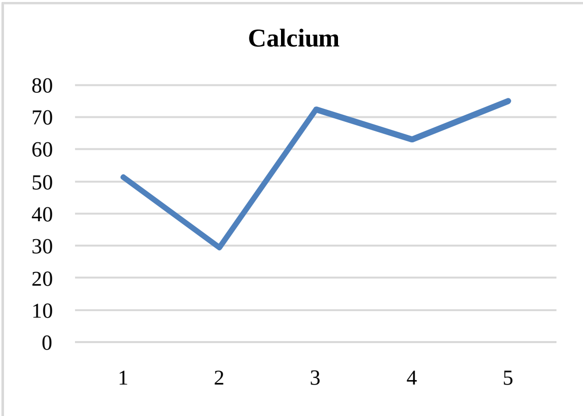

Figure 7 Variation of Calcium with Sampling Points

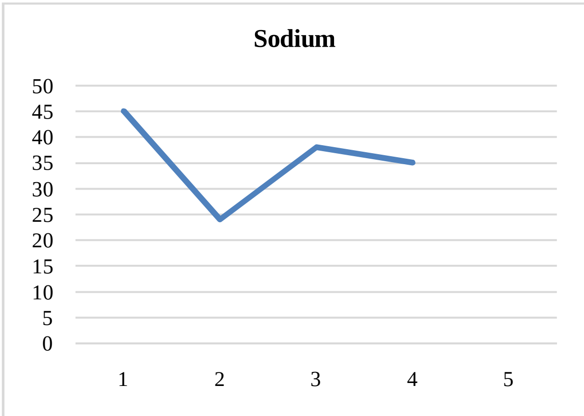

Figure 8 Variation of Sodium with Sampling Points

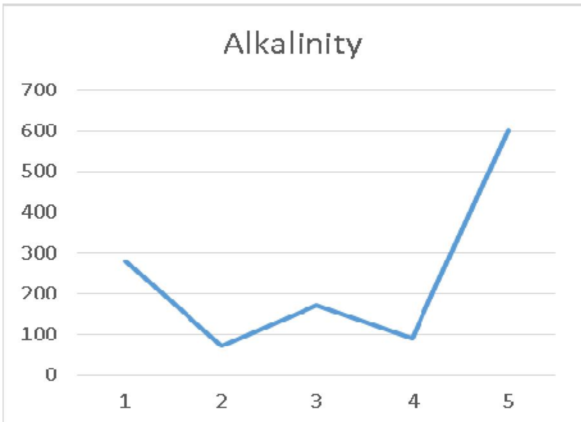

Figure 9 Variation of Alkalinity with Sampling Points

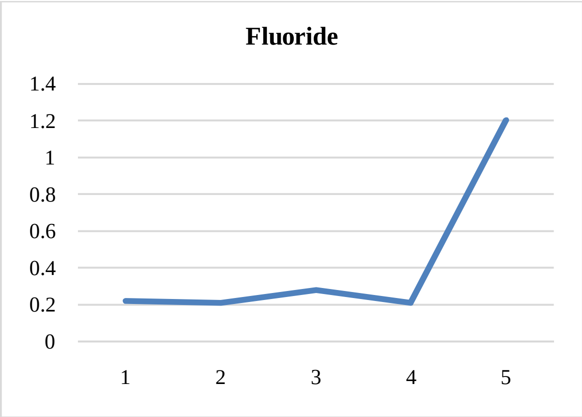

Figure 10 Variation of Fluoride with Sampling Points

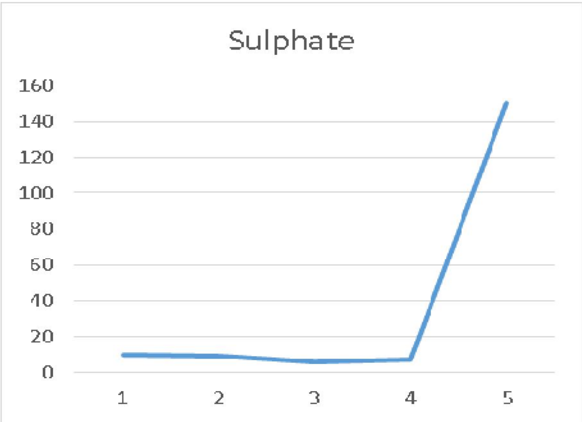

Figure 11 Variation of Sulphate with Sampling Points

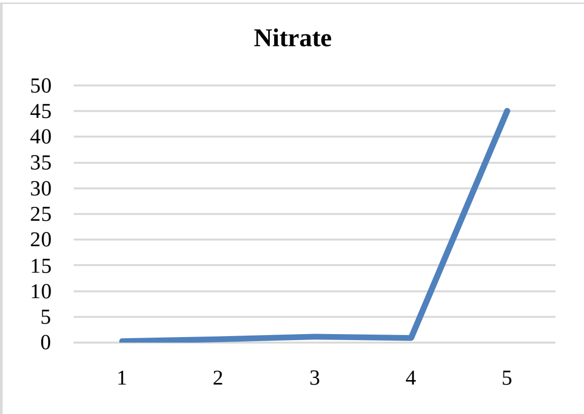

Figure 12 Variation of Nitrate with Sampling Points

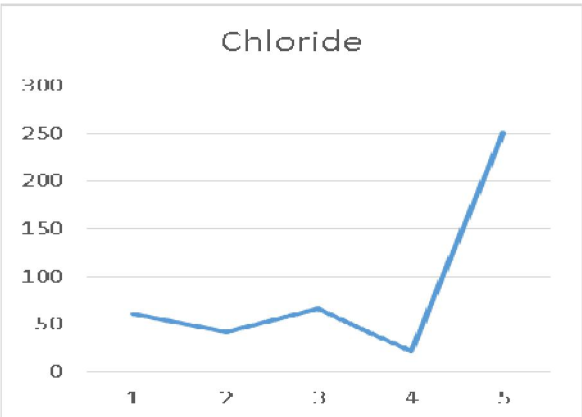

Figure 13 Variation of Chloride with Sampling Points

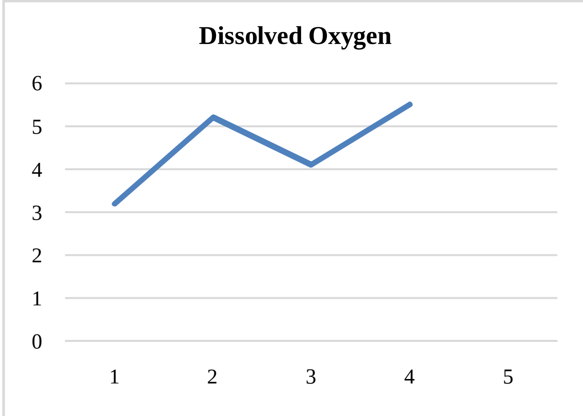

Figure 14 Variation of Dissolved Oxygen with Sampling Points

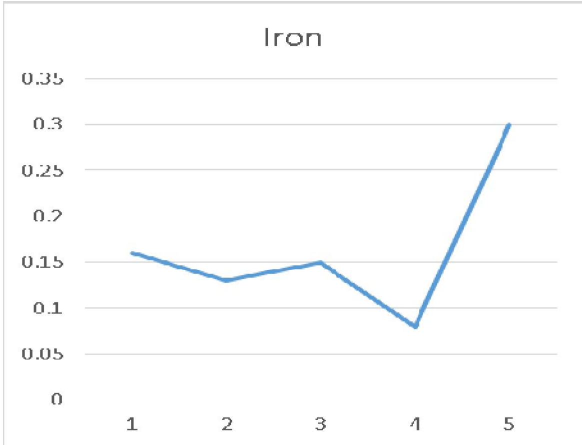

Figure 15 Variation of Iron with Sampling Points

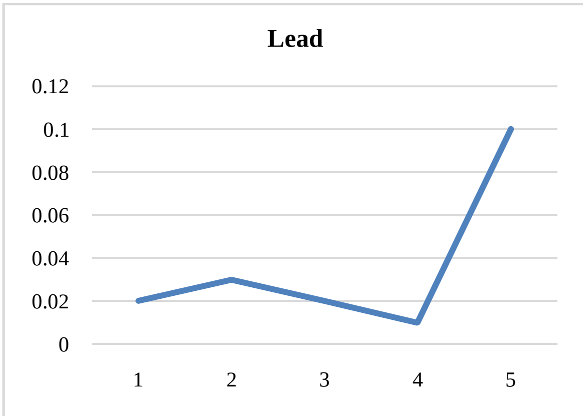

Figure 16 Variation of Lead with Sampling Points

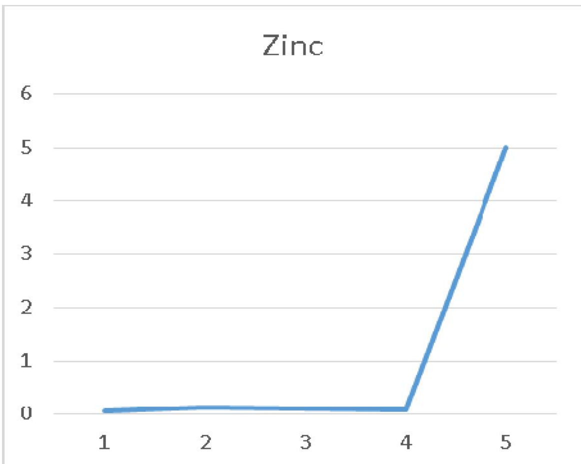

Figure 17 Variation of Zinc with Sampling Points

Based on present investigation, dissolved oxygen content ranges between 3.2 to 5.5 mg/l which well within the prescribed limit. The Concentration of iron, ranges between 0.08 to 0.16 mg/l. Iron in excess of 0.3 mg/l creates problem in staining of cloths and utensils. Also higher concentration is not suitable for food, beverages, dying, bleaching and so many items. In present investigation, Lead ranged from 0.01 to 0.03 mg/l and Zinc is ranged from 0.07 to 0.13. All the Lead and Zinc values of water samples within the permissible limit. The variations observed in all the parameters are graphically presented in Figure-2 to17. Water quality index (WQI) of the present water samples arealso established from twelve important various physiochemical parameters and are presented in Table-3. The water quality index for sample no- 1,2,3,4 are found to be 27.62, 32.27, 27.03 and 13.96 respectively which indicates the good ground water quality (Table-4) in and around Paradeep Phosphate limited of Paradeep area. In present research work it is also found that sampling station-4 (Village Jhimani) has the best ground water quality in comparison to other sampling locations.

CONCLUSION

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 .From the present research study, it was concluded that the physicochemical parameters of ground water quality in and around Paradeep Phosphate Limited at Paradeep area, Odisha are within the safe limits of Indian standard for drinking waterquality (IS: 10500) but the toxic level of harmful materialscan mix up with the ground water if no precautionary measures were taken for effective treatment of the industrial effluents. Water Quality Index (WQI) of different sampling locations also shows that the ground water quality in and around Paradeep Phosphate Limited at Paradeep, odishais good and fit for drinking.

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