Effects Coal-based sponge iron industries on the Physico-chemical parameters of water in and around Kuarmunda area of Sundargarh District, Odisha

[a] N.R. Parida, [b]R.K.Patel, *[c]A.K. Panda

[a] *Department of chemistry, KMIPSC, Chhand, Rourkela, Odisha, India*
[b] *Department of chemistry, National Institute of Technology Rourkela, Odisha, India*
*[c] *Department of chemistry, Veer Surendra Sai University of Technology, Burla, Odisha, India*

Abstract- **Sponge iron is a rapidly growing industry in India. Undoubtedly, it has brought financial benefit to the nation; but at the same time it cause environmental pollution leading to adverse health impacts. The main reason of this problem with Indian sponge iron industry is that these are mostly coal-based units. Coal based sponge iron industries are releasing large quantities of pollutants, directly or indirectly discharged to adjoining land areas, water bodies such as stream, river, etc and also the atmosphere. Odisha is one of the major producers of sponge iron in India and thus a victim of such pollution. The present work involves the study of water qualities in and around of coal-based sponge iron industries in Kuarmunda area of Sundargarh district, Odisha. Twelve water samples from river, pond and bore wells located in and around the study area that are most likely to be affected were collected during different seasons and their physico-chemical parameter such as P^H, turbidity, electrical conductance, total solids, total dissolved solids, dissolved oxygen, biological oxygen demand, chemical oxygen demand, total alkalinity, total hardness, anions and metallic cations were analyzed as per standard procedure. A careful study of the water quality results reveals there is substantial increase in some of the water quality parameters like total dissolved solid, turbidity and few heavy metals such as Cu, Hg, Cd, and Pb with their concentration higher than the desirable limits. Among the different samples collected, the concentration of metallic impurities and total hardness is found high in samples collected during summer season as compared to rainy and winter seasons. The total dissolved solids, turbidity and electrical conductivity of the surface water is found higher during rainy season than other seasons. The surface water is found more affected than the ground water, so it must be treated suitably before it is being used for human activities.**

***Key words*- Sponge iron, environmental pollution, surface water, ground water, water qualities, physico-chemical parameter**

I. INTRODUCTION

Sponge iron is one of the major inputs to produce quality steel having considerable demand for its consumption in India. India targets to produce 110 millions tons of steel by 2020 which will require 30million ton of metallic sponge iron as compared to 13. 9 million ton produced in 2006 according to an assessment made by Ministry of Steel. Govt of India described in National Steel Policy [1]. it encourages the growth of sponge iron industry in India and abroad[2].its proposed expansion will lead to economic development on the one hand but on its contrary it will degrade the environment in the form of water pollution, air pollution, soil pollution having adverse health impact[3]. Indian sponge iron industry are mostly coal-based units because abundant availability of iron ore of all grade and non – coking coal which released large quantities of pollutants to the environment [4].Constituting a major environmental problem.

These industries are the polluting industry due to excessive emission of dust and gas to the atmosphere which contain significant amount toxic metals like of nickel, hexavalent Chromium, Cadmium, arsenic, manganese and copper etc. these pollutants eventually reach to soil and water bodies [4,5]. There is considerable amount of pollution in different stages from the raw material to disposal of final product of sponge iron of production in the shape of effluents, dust, gas and solid waste [6]. In addition the emitted coal fly ashes of the sponge iron industry are directly or indirectly mixed with water bodies which are harmful to aquatic biota [7].

The coal fly ashes, toxic compounds discharged from coal washeries and other effluents released by sponge iron industry inter mingled into the natural water of river at different points poise threat to human consumption [8].

Leaving apart river .it also contaminates the natural water sources of ponds, stream including atmosphere by heavy metals viz. Fe, Cr, Cd and Pb, toxic chemicals like oil and grease, cyanide (CN-) and other ions, produce toxic effects leading to an alteration in physico-chemical properties of water it also leads to sediment of aquatic organisms [9].

In view of large scale environmental impacts of sponge iron industry the inhabitants of these areas resist the establishment of such industry their discontentment leads to unrest even after the establishment of such industry [10].

Odisha is one of the largest producers of sponge iron in the country. Having 109 numbers operating units as a matter of fact, it causes environmental pollution by this industry [September 22, 2011 The Telegraph], Odisha claims to have a large reservoir of all grade iron ore and non-coking coal which attract the investors to establish. An estimate reveal about two lakh people are adversely affected by sponge iron industry in Odisha [11]. Most of these plants are concentrated in sundargarh districts out of these some of the sponge iron plant in kuarmunda area which discharge the effluents, solid waste and dusts that directly or indirectly affect nearby water bodies including rivers namely Sankh, Keol and Brahmani, the vital sources of drinking water for Sundargargh districts. The study is conducted in kuarmunda area to understand the basic status of sponge iron industries pollution in respect to physic-chemical properties of ground and surface water in and around kuarmunda area.

II. STUDY AREA

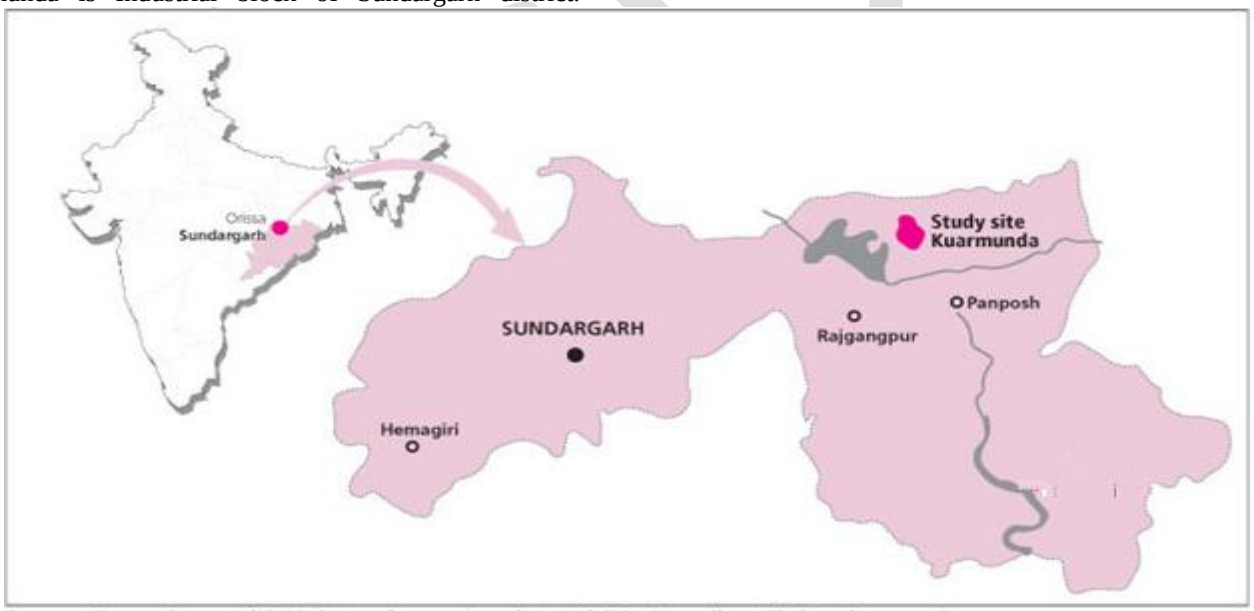
Kuarmunda area of Sundargarh district is chosen for the purpose of study because heavyconcentration of sponge irons plant and its consequent water pollution Kuarmunda is located at a distance of 12 Km.away from Rourkela City. Kuarmunda is Industrial block of Sundargarh district. Thegeographical location kuarmunda is the Latitude22º 16'25. 49"N and longitude84º 45'30.03"E. Most of the sponge iron plant in Kuarmunda is small and medium scale. One big sponge iron plant, Adhunik Metallic's Limited is located in this area

River Brahmani is originated after the confluence of Sankh and Keol rivers at Vedavyas near Rourkela, its water is predominately used for bathing, drinking and irrigation, After the establishment of sponge irons industries the water is neither fit for human consumption nor animal use[12].

Polluting river water and depletion of ground water in sponge irons industry clusters of kuarmunda area constitute a major concern for the inhabitants of nearby area. As a result of open dumping of raw materials and solid wastes, the nearby streams and river Brahmani get contaminated during rainy season.

In addition the fugitive emissions from the sponge iron plants viz. fly ash, coal dust and suspended particles settle on the nearby water bodies like ponds, streams and river are covered with a thick layer of dust and black sticky coat making the water unfit for human use [13,14].

So the water bodies around the factory are completely unfit for consumption and other domestic uses because of thick layer of dust and particulate matter emitted from the factory.



Source: *Himansu Patra et al, 2009, Status of sponge iron plants in Odisha, Vasundhara, Bhubaneshwar, pg. 6.*

Figure 1 Map of study area kuarmunda

III. EXPERIMENTAL

3.1 Sample locations

Kuarmunda area constitutes the universe of study. Twelve water samples were collected from different location of sponge iron plant locate in Kuarmunda area based on the hazardous ambient environment condition and the activities taking place around it. Out of 12 samples collected 3 are ground water collected from tube well, 5 are surface waters collected from pond and nallahs, 4 are from river water. Samples were collected during different seasons (summer season, rainy season, and winter season) from each location. The locations in details from which the samples have been collected are presented in table 1.

Table 1 Locations showing collection of water sample

Sample no.	Type of sample water	Location
1	Ground water	Hariharpur tube well
2	Surface water	Hariharpur pond
3	Ground water	Gobra tube well
4	Surface water	Gobra pond
5	Surface water	Adhunik and shree ganesh metallic wall side nallah
6	Ground water	Shana Kalosihiria tube well
7	Surface water	Adhunik metallic effluents discharged nallah
8	Surface water	Kalosihiria nallah
9	River water	Sankh river
10	River water	Keol river
11	River water	Brahmani river
12	River water	Brahmani river+sankh river+keol river

Sample collection was carried out as per the norms and standard laid down by central pollution control board [15].The source from where the water was collected was regular use. The water was collected after clearing the suspended and floating matter. Water for chemical examination was collected in clean white plastic leak proof bottles of 500mlor1000ml capacity. Before collection of sample, the container was rinsed with the water to be sampled more than three times. The sample was than filled completely in the container without leaving any air space.

3.2 Water quality tests

Experimental investigation and analysis were carried out as per American public health association [16].and methodology adopted for the tests are summarised in table 2. The results obtained were evaluated in accordance with the norms prescribed under 'Indian Standard Drinking Water Specification IS [17].Twenty four parameters are analysed for water samples from twelve sampling stations, during three different seasons and results are summarised in Table 1, 2, and 3. The results are graphically represented in figures 1 to 11

Table 2: Determination of Water Quality tests methods

Physico-chemical parameters	Analytical Method
P^H	P^H metry
Turbidity	Turbidimetry
Electrical Conductance (EC)	Conductometry
Dissolved Oxygen(DO)	Portable kit
Chemical Oxygen Demand (COD)	Titration
Biochemical oxygen demand(BOD)	BOD incubator
Total Solids (TS)	Gravimetric
Total Dissolved Solids (TDS)	Gravimetric
Total Alkalinity	Titration
Total Hardness	Titration
Chloride (Cl^-)	Titration
Fluoride (F^-), Nitrate (NO_3^-), Sulphate (SO_4^{2-})	Spectrophotometry
Lead (Pb^{2+}), Total Iron, Zinc (Zn^{2+}), Copper (Cu^{2+}), Cadmium (Cd^{2+}), Chromium (as Cr^{6+}), Manganese (as Mn^{2+})	Spectrophotometry

Table 3 Experimental results of water quality tests (summer season)

Sl.No	Parameters	Sample Numbers											
		1	2	3	4	5	6	7	8	9	10	11	12
1	PH	6.6	6.9	6.7	7.1	6.8	6.6	6.3	6.8	7.3	7.5	7.4	7.1
2	Turbidity	9	11	8	12	12	9	20	17	14	15	16	16
3	TDS(mg/l)	71.5	71.8	71.4	71.1	72.7	71.5	74.1	73.1	52	67	56.8	59
4	TS(mg/l)	394	377.3	394.3	377.1	391.9	394.7	409	408	466.3	412.8	310.8	462
5	Total Hardness(mg/l)	182.4	182	182.9	182.1	182.3	182.3	182.7	182.6	186.5	180.5	187.5	188.2
6	BOD(mg/l)	2	2	2	3	2.9	2.9	3.2	3.1	3.2	3.9	3.9	3.8
7	DO(mg/l)	5.2	6.4	5.3	6.4	5.4	6.4	6.4	6.4	7.4	7.8	7.6	7.1
8	EC(mho/cm)	194.2	199.1	194.1	199.5	196.4	194.3	195.8	196.7	169.1	174.9	167.5	171.2
9	COD(mg/l)	15.0	13.6	15.0	13.7	14.1	15.1	13.3	13.5	21.7	22.2	22.5	20.8
10	Total alkalinity(mg/l)	155.9	162.27	156.3	162.66	162.45	156.7	163.39	163.11	168.34	147.89	192.54	181.32
11	chloride(mg/l)	68.8	52.9	68.8	52.7	55.0	68.2	53.6	53.0	97.7	72.5	93.2	95.8
12	sulphate(mg/l)	50.29	61.35	50.78	61.33	60.87	50.65	57.79	57.33	90.43	91.02	95.62	91.35
13	fluoride(mg/l)	0.03	0.03	0.04	0.03	0.04	0.03	0.09	0.08	0,07	0.05	0.08	0.09
14	Total iron(mg/l)	0.29	0.27	0.29	0.26	0.34	0.28	0.23	0.36	0.54	0.55	0.38	0.42
15	calcium(mg/l)	126.4	126.6	126.5	126.6	126.8	126.5	126.9	127.1	134.5	126.1	135.0	135.3
16	magnesium(mg/l)	55.6	55.4	55.5	55.3	55.5	55.6	55.8	55.7	51.5	54.5	52.5	52.9
17	lead(mg/l)	1.67	1.38	1.66	1.37	2.01	1.65	2.04	2.07	2.75	2.19	2.42	2.05
18	chromium(mg/l)	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.04	0.03	0.04
19	nitrate(mg/l)	3.21	3.23	3.24	3.22	3.34	3.20	3.26	3.24	6.65	4.45	4.87	5.9
20	Zinc(mg/l)	1.15	1.92	1.4	1.91	2.29	1.3	2.41	2.43	2.76	2.31	2.55	2.52
21	manganese(mg/l)	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.06	0.06	0.04	0.04
22	mercury(mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.01	0.01
23	cadmium(mg/l)	0.02	0.02	0.02	0.02	0.03	0.02	0.08	0.07	0.08	0.07	0.08	0.09
24	copper(mg/l)	0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.05	0.1	0.04	0.08	0.09

Table 4 Experimental results of water quality tests (rainy season)

Sl.No	parameters	Sample Numbers											
		1	2	3	4	5	6	7	8	9	10	11	12
1	pH	7.1	7.3	7.5	6.9	7.3	7	7.2	7.1	7.9	7.0	7.8	7.5
2	Turbidity(mg/l)	16	23	13	15	14	13	26	24	20	25	24	23
3	TDS(mg/l)	161	162	153	155	162	148	181	192	173	165	172	188
4	TS(mg/l)	173	174	162	164	174	151	199	212	202	176	186	203
5	Total Hardness(mg/l)	80	83	83	86	86	82	120	183	173	166	170	156
6	BOD(mg/l)	2	2	2	2.9	2.8	2.7	3	3	3	3.9	3.8	3.7
7	DO(mg/l)	6.9	6.8	7.0	7.5	7.2	7.3	7.8	7.8	7.5	7.9	7.3	7.6
8	EC(mho/cm)	305	312	295	307	315	302	315	322	275	315	325	332
9	COD(mg/l)	10	10	08	07	12	12	11	14	13	11	15	16
10	Total Alkalinity(mg/l)	35	30	32	33	34	42	45	40	42	73	54	63
11	Chloride(mg/l)	172	176	168	173	175	178	162	166	165	170	171	168
12	Sulphate(mg/l)	64	61	70	65	65	62	74	68	60	69	61	67
13	Fluoride(mg/l)	0.04	0.03	0.04	0.05	0.02	0.02	0.08	0.07	0.07	0.04	0.07	0.08
14	Total Iron (mg/l)	0.03	0.04	0.04	0.05	0.05	0.05	0.03	0.04	0.04	0.05	0.05	0.05

15	Calcium(mg/l)	18	20	16.5	19	20	15	22	23	22	27	24	25
16	Magnesium (mg/l)	15	15	16	16	16	17	17	18	16	19	18	19
17	Lead (mg/l)	0.021	0.021	0.021	0.021	0.021	0.021	0.31	0.051	0.061	0.041	0.061	0.041
18	Chromium(mg/l)	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.02	0.04	0.03	0.05	0.05
19	Nitrate(mg/l)	4.2	4.2	4.2	4.4	4.4	4.4	6.2	4.7	4.6	4.9	4.8	4.7
20	Zinc(mg/l)	0.013	0.012	0.003	0.03	0.03	0.04	0.033	0.022	0.043	0.035	0.036	0.043
21	manganese(mg/l)	0.01	0.02	0.01	0.03	0.02	0.02	0.07	0.05	0.04	0.04	0.03	0.03
22	mercury(mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.01	0.01
23	cadmium(mg/l)	0.01	0.02	0.01	0.02	0.02	0.01	0.05	0.04	0.06	0.06	0.05	0.07
24	copper(mg/l)	0.02	0.03	0.01	0.03	0.04	0.01	0.03	0.05	0.08	0.03	0.07	0.05

Table 5 Experimental results of water quality tests (winter season)

Sl.No	parameters	Sample Numbers											
		1	2	3	4	5	6	7	8	9	10	11	12
1	pH	6.8	7.1	7.2	7.0	7.2	6.9	6.8	7.0	7.5	7.0	7.5	7.4
2	Turbidity	10	17	9.0	10	11	9.0	21	18	15	20	19	18
3	TDS(mg/l)	140	141	130	133	141	135	171	181	150	160	170	180
4	TS(mg/l)	172	174	162	165	176	149	201	215	200	179	190	201
5	TotalHardness(mg/l)	90	94	95	98	80	84	130	180	160	155	165	150
6	BOD(mg/l)	2.1	2	2	2.5	2.6	2.5	2.9	2.9	2.9	3.4	3.5	3.5
7	DO(mg/l)	5.1	6.2	5.2	6.3	5.3	6.4	6.3	6.3	7.2	7.3	7.5	7.4
8	EC(mho/cm)	201	210	202.3	215	214	201	208.7	216	200.8	219	250.9	240
9	COD(mg/l)	12	11.6	12.2	11.8	12	12.4	11.3	11.04	20.2	21.01	20.01	19.5
10	Total Alkalinity(mg/l)	110	120	111	124	132	114	118	121	140	150	160	153
11	Chloride(mg/l)	101	120.5	110	98	102	105.7	93	97	120.3	117	119	120.8
12	Sulphate(mg/l)	60	63	60.12	64	64	65.33	70	66	80	82.34	84	83
13	Fluoride(mg/l)	0.02	0.03	0.03	0.01	0.01	0.03	0.08	0.07	0.05	0.04	0.07	0.09
14	Total Iron (mg/l)	0.27	0.25	0.28	0.25	0.32	0.27	0.31	0.32	0.45	0.46	0.31	0.35
15	Calcium (mg/l)	70.4	72.9	65	69.9	72	66	69	68	78.5	72.5	79	80.9
16	Magnesium (mg/l)	20.5	20.1	20.7	20.4	20.5	21.01	21.09	23	22.02	29.01	28.02	29.9
17	Lead (mg/l)	0.020	0.020	0.019	0.019	0.021	0.018	0.029	0.045	0.052	0.038	0.054	0.040
18	Chromium(mg/l)	0.01	0.02	0.01	0.03	0.02	0.02	0.02	0.01	0.04	0.03	0.05	0.05
19	Nitrate(mg/l)	3.11	3.22	3.10	3.24	3.33	3.11	5.1	4.6	3.8	3.6	3.7	3.8
20	Zinc(mg/l)	0.019	0.013	0.003	0.03	0.04	0.048	0.044	0.084	0.094	0.075	0.075	0.088
21	manganese(mg/l)	0.01	0.02	0.01	0.03	0.02	0.02	0.07	0.05	0.04	0.04	0.03	0.03
22	mercury(mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.01	0.01
23	cadmium(mg/l)	0.01	0.02	0.01	0.02	0.02	0.01	0.05	0.04	0.06	0.06	0.05	0.07
24	copper(mg/l)	0.02	0.03	0.01	0.03	0.04	0.01	0.03	0.05	0.08	0.03	0.07	0.05

IV. DISCUSSION

4.1 p^H

The p^H of water is important because many biological activities can occur only within a narrow range. Thus, any variation beyond an acceptable range could be fatal to a particular organism. The distribution in pH (table3,4&5 and figure 2) clearly showed that the p^H of water is not or very slightly influenced by the pollutants. The P^H values throughout the year ranged from 6.3 to 7.9, which is within the IS [17] permissible limit. Among all the samples, P^H value was higher in rainy season than the summer and winter season.

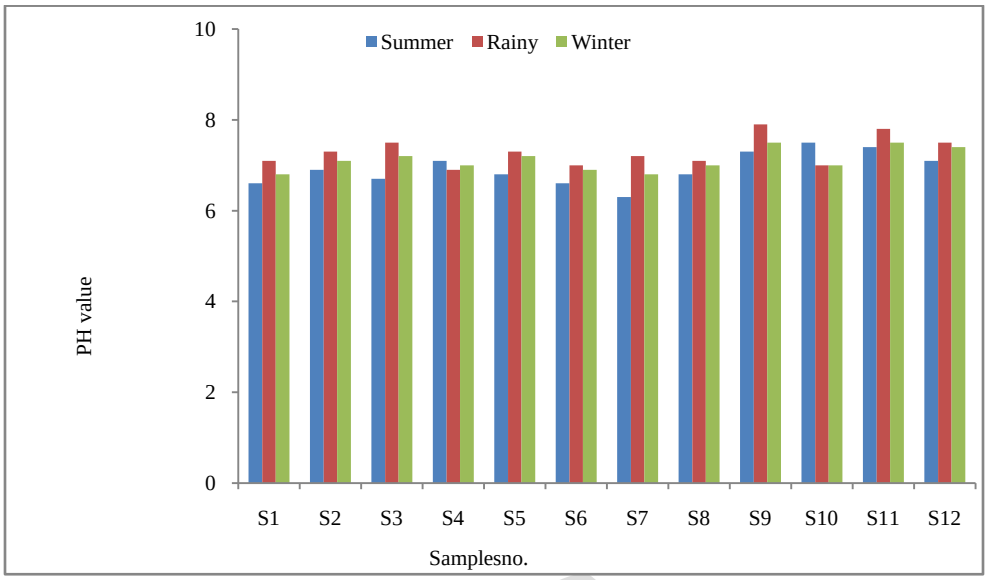


Figure 2 Variations of P^H

4.2 Turbidity

The turbidity is a major problem in the water system throughout the globe. It is observed from (table3,4&5 and figure 3) that the turbidity values range from 8 to 20 NTU during summer season, 13 to 26 NTU during rainy season and 9 to21 NTU during winter season. Majority of the water samples have higher turbidity than that of IS [17] Highest turbidity is noticed in sample S-7 i.e.26 NTU during rainy season. Turbidity was higher in rainy season than the summer and winter season. High turbidity may be due to presence of suspended matter, clay, silt, metal oxide, coal dust released in the process of manufacture of sponge iron in the nearby industry. Higher turbidity in monsoon is probably due to the more water volume flow in the rainy season and also mixing of colloidal, suspended matter and plankton through the run off sewage.

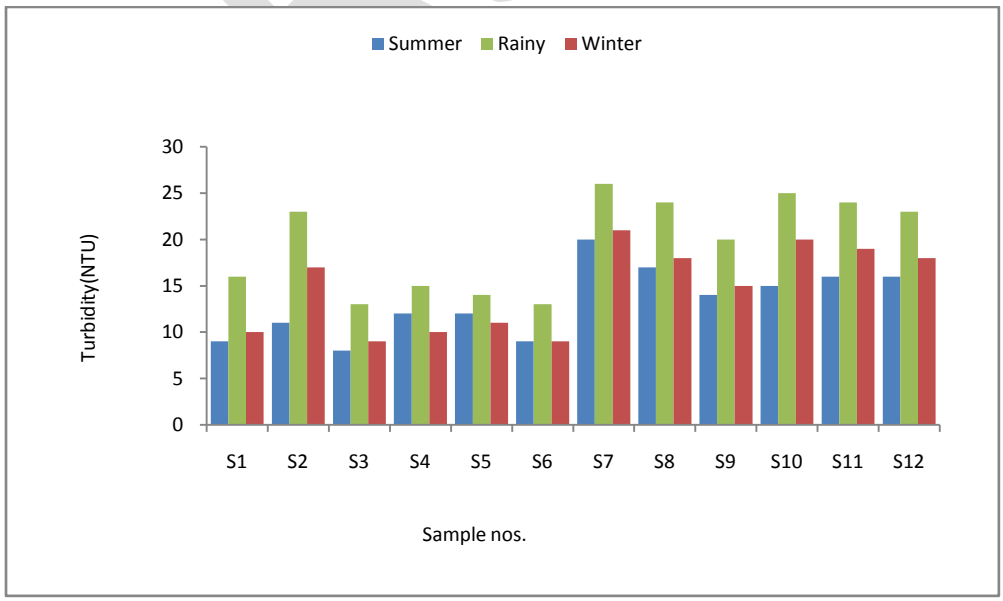


Figure 3 Variations of turbidity

4.3 Total Dissolved Solids (TDS)

Water with a high total dissolved solids indicated more soluble ionic components, which is of inferior palatability and can induce an unfavourable physicochemical reaction in the consumers. Increase in value of TDS indicated pollution by extraneous sources. The high amount of dissolved, suspended and total solids of samples adversely affects the quality of running water and it is unsuitable for irrigation and drinking purpose. Total suspended solids, that determine the depth to which photosynthetic organisms grow, or the photic zone of a lake. From (Table3,4&5 and figure 4)shows that, TDS was higher in rainy season than the summer and winter season. However the TDS value of all the water samples are within the IS[17] .

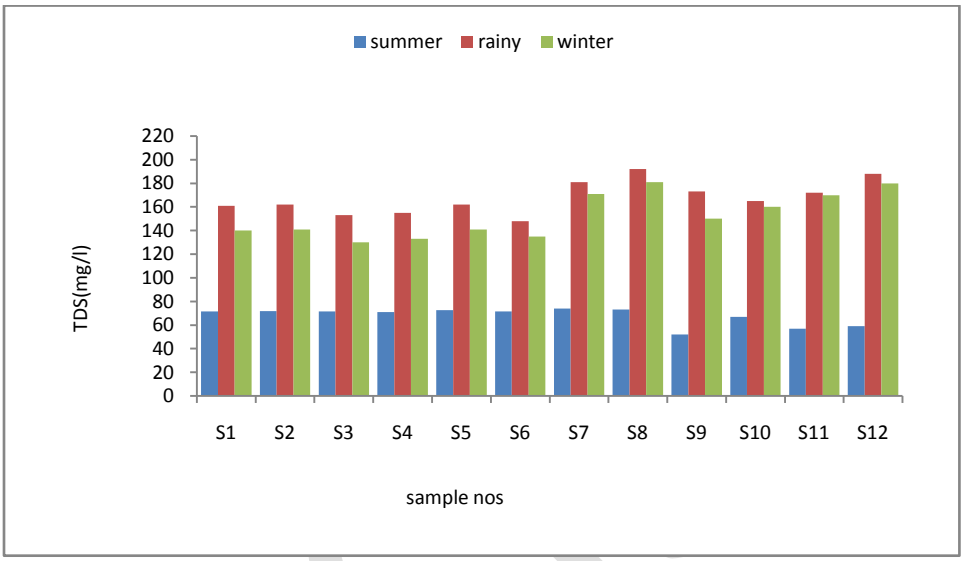


Figure 4 Variations of TDS

4.4 Total hardness

Total hardness shows the presence of soluble salts of calcium and magnesium in water. The maximum allowable limit of total hardness is 500 mg/l and the most desirable limit is 100 mg/l as per the WHO standards [18]. The IS recommended permissible limits total hardness for drinking water is 300 to 600 mg/l.Hardness below 300 mg/l is considered potable but beyond this limits cause gastro-intestinal irritation and kidney problems [19]. From (Table3,4&5 and figure 5)The total hardness values of all the water samples is found below 200mg/l, and is higher in summer season than the rainy and winter season (Figure 4).

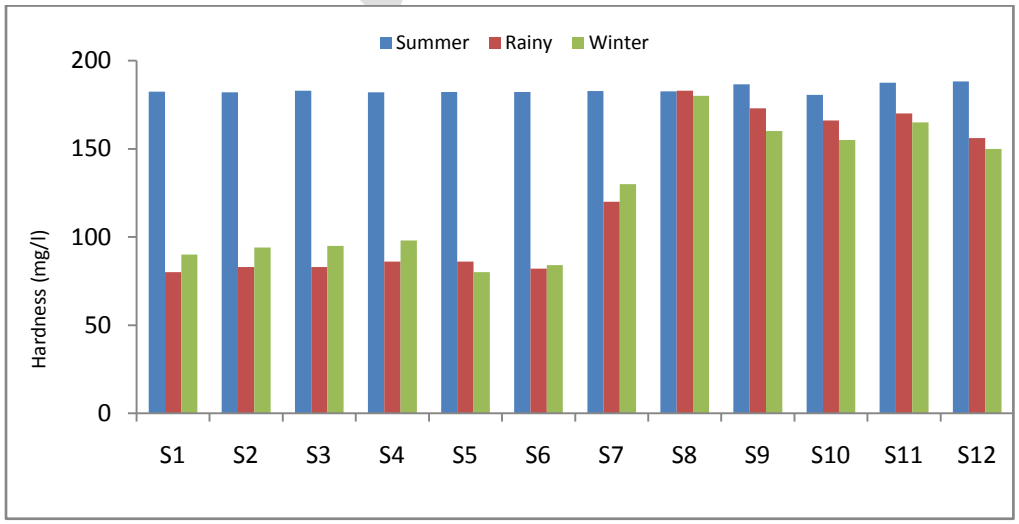


Figure 5 Variations of Total hardness

4.5 Dissolved oxygen (DO)

DO is indicative of the survivability of an aquatic system, as respiration depends purely on the amount of oxygen dissolved in the water. Optimum concentration of dissolved oxygen is essential for maintaining aesthetic qualities water as well as for supporting life. From (Table3,4&5 and figure 6) Considerably higher DO is observed in river water sample than pond water during all season and values of DO are within the IS standard[17].(Figure 5).

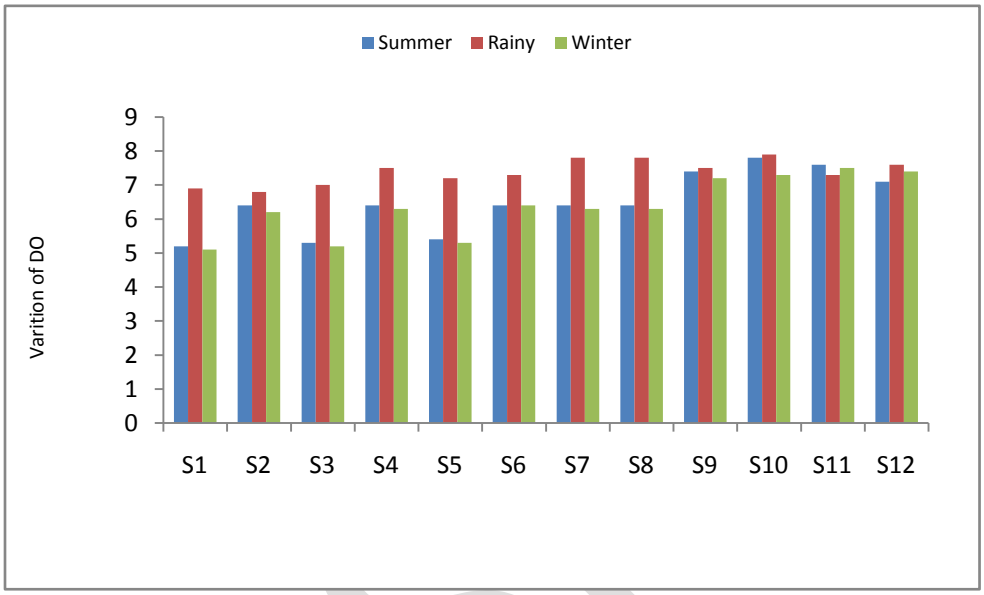


Figure 6 Variations of Dissolved oxygen (DO)

4.6 Biochemical oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

BOD is used as the index of biodegradable wastes present in water whereas COD is a measure of total oxidisable wastes present in the sample. It is observed from (tables 3, 4 and 5)that, the BOD and COD of river water samples are higher than surface water which may be due to decomposition of organic matter (sewage and dead organism) which flows through the river.

4.7 Electrical Conductivity (EC)

Electrical Conductivity is used to measure the amount of ionic impurity and ability of water to carry an electric current. Pure water is a poor conductor of electricity as it is feebly ionised. Water shows higher conductivity when dissolved salts are present and the conductivity is proportional to the amount of salts dissolved in water. Permissible limit for electrical conductivity (EC) of water is 300 µmho/cm [18]. Conductance values for the dry season are usually higher than that for the monsoon. As, conductance depends on the number of ions present in water and in dry season, the total volume of water decreases, the conductivity increases. From (Tables3, 4, 5 and figure 7), show that electrical Conductivity value of water samples range from 167.5 to199.5 µmho/cm during summer season, 275 to 332 µmho/cm during rainy season and 200.8 to250.9 µmho/cm during winter season. Electrical Conductivity was higher in rainy season than the summer and winter season. The higher electrical conductivity of water sample in rain water may be due to addition of soluble ionic impurities released from the industry through run off water and also through industrial discharge.

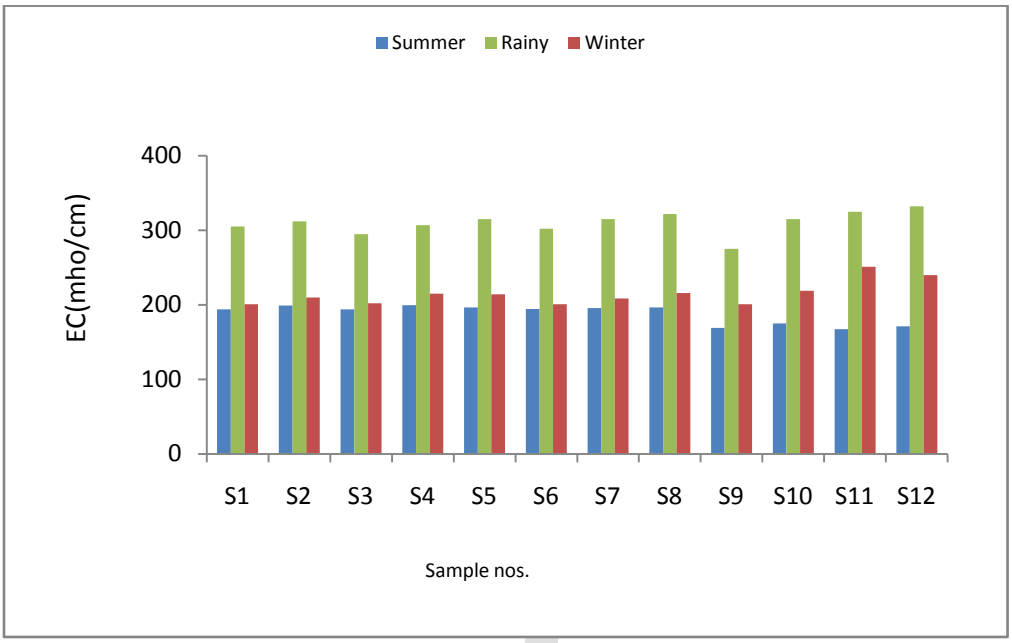


Figure 7 Variations of Electrical Conductivity (EC)

4.8 Anions (Chloride, Fluoride, sulphate and nitrate)

If the chloride content Spectrophotometry nt more can cause high blood pressure in people. Chloride in excess imparts a salty taste to water and may be laxative effect to the people. High Chloride concentration is also an indicator of large amount of organic matter [20]. Excess of fluoride not only create dental problem but also it is an endocrine disruptor that can affect your bones, brain, thyroid gland, pineal gland and even your blood sugar levels. High concentration of sulphate could cause a cathartic action on human beings and can also cause respiratory Problems. Nitrate and phosphate contamination cause Eutrophication, where algae and aquatic plant growth will consume the oxygen and increase the TSS of water, thus significantly reduce water quality [21]. Both can exist naturally in ground water but can increase dramatically due to run off from irrigated lands. From (tables 3, 4, 5) it can be concluded that the above parameters are within the IS [17], recommended permissible limits in all the twelve water samples during all the seasons. However, chloride concentration was higher in rainy season than summer and winter season, whereas the concentration of fluoride, sulphate and nitrate was higher during summer as compared to other seasons.

4.9 Metallic Impurity

Heavy metals can be very harmful to human health if found in drinking water. certain heavy metals in small quantities, are nutritionally essential for a healthy life. Some of these are referred to as the trace elements (e.g., iron, copper, manganese, and zinc). These elements, or some form of them, are commonly found naturally in foodstuffs, in fruits and vegetables, and in commercially available multivitamin products. Severe effects include reduced growth and development, cancer, organ damage, nervous system damage, and in extreme cases, death. Exposure to some metals, such as mercury and lead, may also cause development of autoimmunity, in which a person's immune system attacks its own cells. This can lead to joint diseases such as rheumatoid arthritis, and diseases of the kidneys, circulatory system, and nervous system [22]. Cadmium compounds primarily cause kidney damage but also possibly effects bone and fractures .Copper at very high levels is toxic and can cause vomiting, diarrhea, loss of strength or, for serious exposure, cirrhosis of the liver [23]. Iron is a heavy metal of concern, particularly because ingesting dietary iron supplements may acutely poison young children. Ingestion accounts for most of the toxic effects of iron because iron is absorbed rapidly in the gastrointestinal tract. The corrosive nature of iron seems to further increase the absorption [24]. It can cause a rusty red or brown stain on fixtures or laundry and/or cause your water to develop a metallic taste. The young are more prone to the toxic effects of heavy metals, as the rapidly developing body systems in the fetus, infants and young children are far more sensitive. Childhood exposure to some metals can result in learning difficulties, memory impairment, damage to the nervous system, and behavioural problems such as aggressiveness and hyperactivity. At higher doses, heavy metals can cause irreversible brain damage. Children may receive higher doses of metals from

food than adults, since they consume more food for their body weight than adults.

The concentration of different heavy metals such as iron, manganese, chromium, copper, zinc, mercury, lead, cadmium was measured in the water samples and summarised in tables (3, 4, and 5). The desirable limit of calcium in water is 75mg/l and the permissible limit is 120 mg/l. Similarly, the desirable limit for magnesium is 30mg/l and the permissible limit is 100mg/l. The concentration of calcium and magnesium was higher in summer season than rainy and winter season. In most of the water samples collected during summer season the value of calcium and magnesium is beyond the desirable limit however within the permissible limit.

Total iron concentration was higher in summer season than other seasons; however it is within the permissible limit. Most of the water samples collected during summer and winter season have iron beyond the desirable limit (Figure 8).The high rate of surface run off might be attributed to the high iron content in waters.

The concentration of heavy metals such as Manganese, chromium and zinc in all the water samples during all the seasons are within the prescribed IS standard[17].

Copper concentration was higher in summer season compared to rainy and winter season (figure 9), however it is within the IS [17]. The sample(S-9, S-11, S-12) in summer season and samples(S-9) in both rainy and summer season are beyond the desirable limit.

The concentration of Mercury in four water samples S-9 to S-12 has higher Mercury during all seasons (Figure 10).The cadmium concentration of ground water and pond water (S-1 to S-6) is low and within the range during all seasons. However the river water has higher concentration of cadmium recorded during all seasons and very high during summer season (Figure 11).

It is observed from (table 1, 2, 3 and figure 12) that the Lead values of water samples range from 1.33to2.42 mg/l during summer season, 0.021 to0.31 mg/l during rainy season and 0.018 to 0.054during winter season. Lead concentration was higher in summer season than the rainy and winter season. The Lead content of all the water samples during rainy season are within the IS[17], whereas its concentration is high and beyond the desirable limit in all the water samples of summer season and one sample(S-7) of rainy season.

The high concentration of copper, mercury, cadmium, and lead may be explained by the presence of inorganic soluble compounds of such metals in the ore used in the sponge iron extraction. Cadmium and lead may also be attributed to running of large number of heavy vehicles which uses grease, paints and batteries.

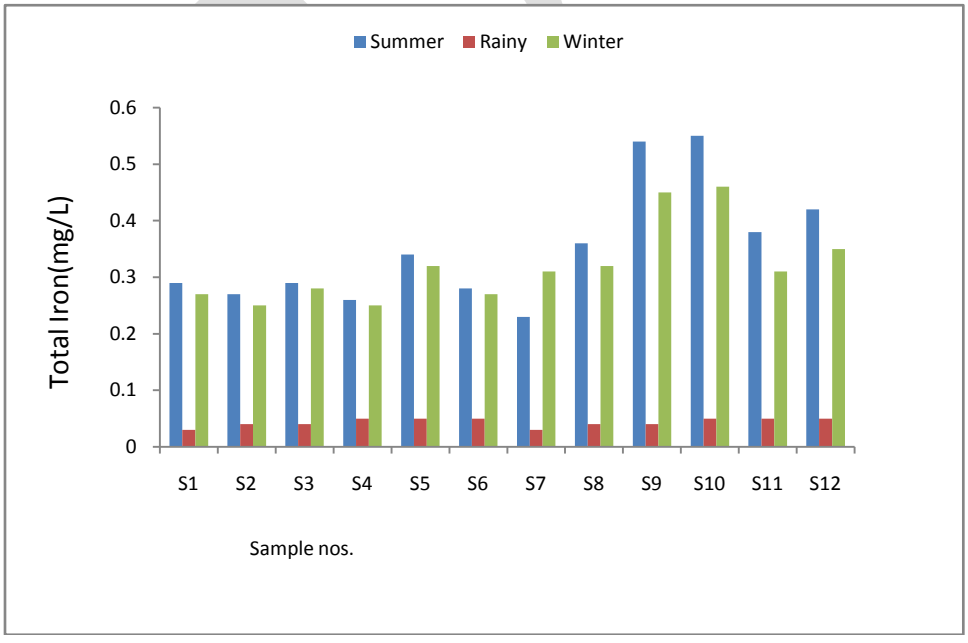


Figure 8 Variations of Total iron (mg/l)

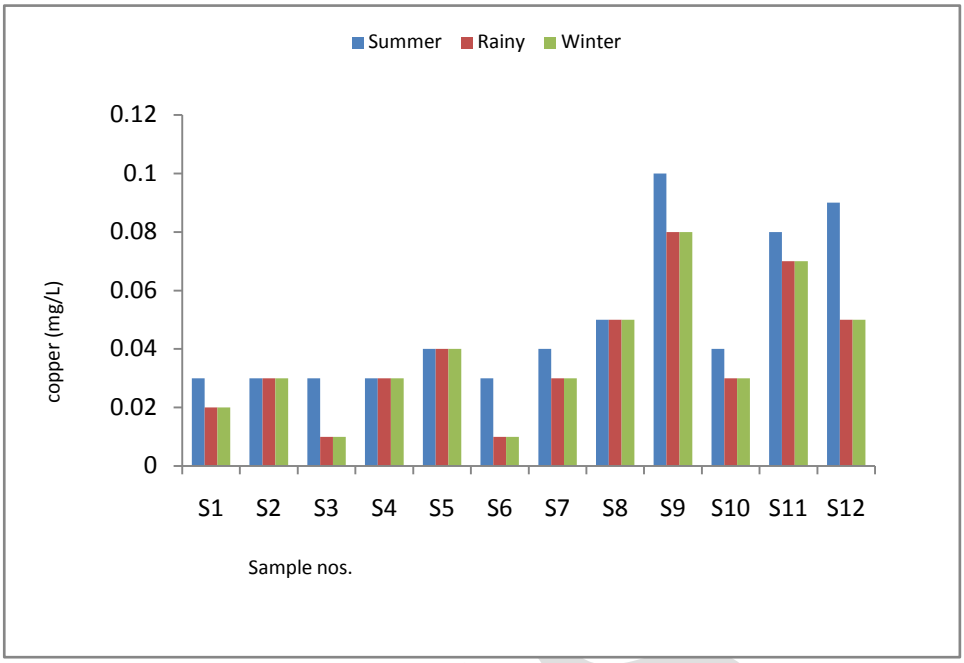


Figure 9 Variations of copper (mg/l)

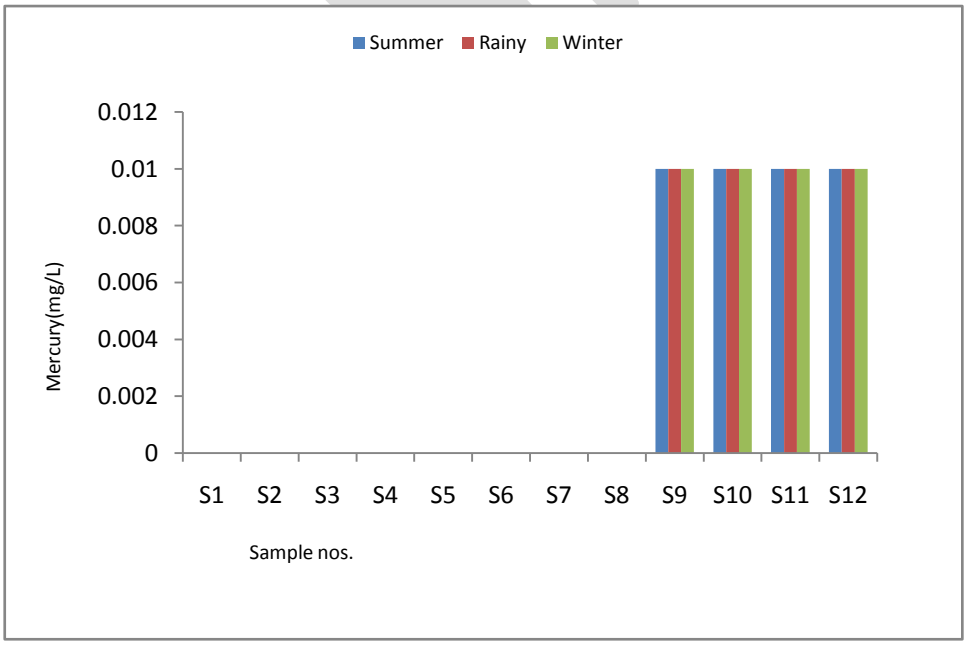


Figure 10 Variations of Mercury (mg/l)

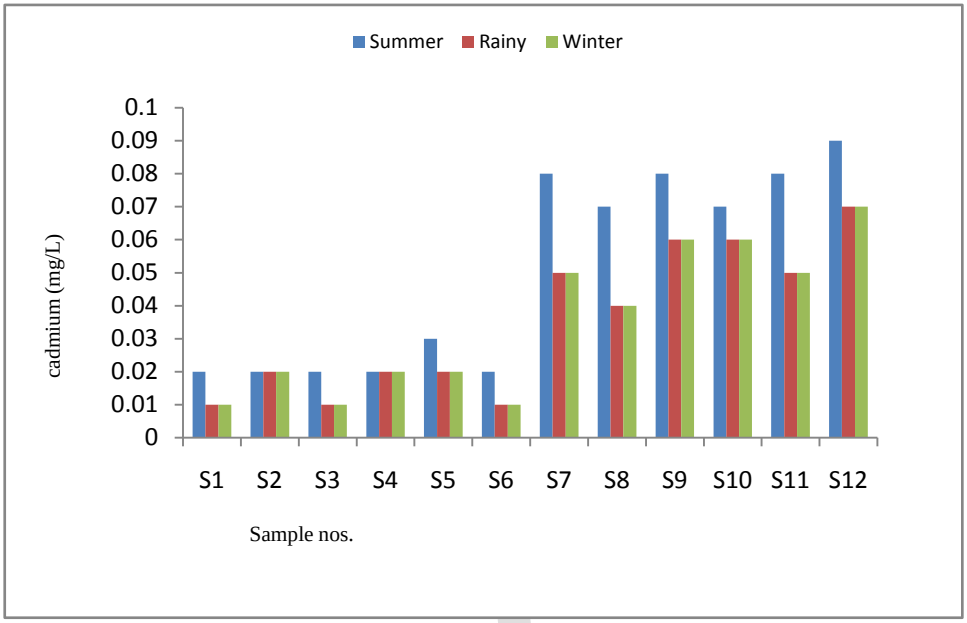


Figure 11 Variations of Cadmium (mg/l)

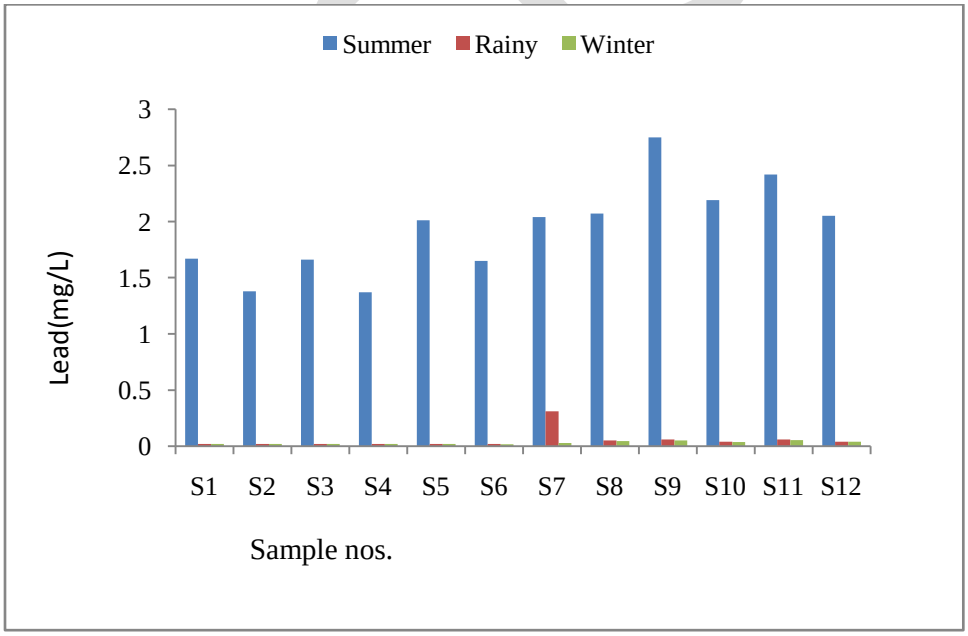


Figure 12 Variations of Lead (mg/l)

V. CONCLUSION

The present work concludes that the wastes from the sponge industry significantly affect the physiochemical properties of water leading to water pollution. From present investigations we concluded that the quality of most of the surface water samples under study was not suitable for drinking and other domestic purposes. The results from the present study clearly pointed out that surface waters contain high levels of turbidity, TDS, TS, heavy metal impurities which are not within the desirable limits given by IS. Therefore, it is recommended that water from these sources

are to be used for drinking purpose only after pre-treatment like filtering, boiling, reverse osmosis and electro dialysis.

REFERENCES

[1]. S . Battacharjee. Sponge iron industry; current scenario. In: Research papers. Available via DIALOG.http://www.steelworld.com/report0707.pdf(2007)

[2]. P. S. Rao, A. Kumar, M.. F. Ansari, P. Pipalatakar and T. Chakraborti, Bull. Environ. Contam. Toxicol. 82,255(2009).

[3]. D. Douchanov, J. Environ. Prot. Ecol. 3(1), 92-100(2002)

[4]. H. Patra ,B. Sahoo and B. Mishra.Status of sponge iron plants in Odisha,Vasundhara,Bhubaneshwar,14-20.(2009); available at: http://vasundharaodisha.org/Research%20Reports/Status%20of%20sponge%20iron%20plant%20in%20Orissa.pdf

[5]. S. Sahoo, S. K. Pattanayak, J. R. Sethi, K. Haripal and A. R. Panda, International Journal of scientific research. 2, 206(2013).

[6]. A. Bandopadhayay, M. G. Goswami and S. Kumar, 'Improvement of environmental performance of integrated steel sector through process integration and optimization measures and innovative waste management practices'. Int. Symposium Environ, Management Metallurgical Industries, 249 (2005); available at: eprints.nmlindia.org/2491/1/Amitava_Bandho..PDF

[7]. H. B. Sahu, J. Patra and R.K Patel, Asian J. Water Environ. Pollut. 10, 43(2013)

[8]. U.S. Banerjee and S. Gupta, J. Environ. Res. Develop., 6 (3A), JAN-MARCH (2012).

[9]. A. Giorgi and L . Malacalza, Environ. Monit Assess. 75(2), 107-119(2002).

[10]. Centre for Science and Environment (CSE), New Delhi, (2011); available at: http://www.cseindia.org/content/cse-releases-study-sponge-iron-sector-odisha

[11]. M. Asher and R. Mumtaz, Info pack on sponge iron industry issues & campaign, (NCAS)National Centre for Advocacy Studies, Pune, 79(2007)

[12]. Orissa: Stop poisoning Brahmani water: M. Nayak, July 25,(2010); available at: http://orissadiary.com/printStory.asp?id=20092

[13]. Sponge iron industry the regulatory challenge center for science and environment (CSE); available at : www.cseindia.org/userfiles/sponge_iron_layout.pdf .38(2011).

[14]. Statesman News Service Rourkela, mining and industrialization update, Orissa environmental information on industries and mining in Orissa, 3(2008); available at: http://vasundharaodisha.org/mining%20and%20industrialisation%20update%20april-may.pdf

[15]. Central pollution control board (CPCB).Water quality in India, status and trend (2003).

[16]. American Public Health Association (APHA), Standards methods for examination of water and wastewater, 16th ed. (Baltimore, Maryland, USA, 1985)

[17]. Indian Standard Specification for Drinking Water; IS: 10500, (1992).

[18]. WHO (World Health Organization), Guidelines for drinking water quality, 3rd ed.Recommendations, vol. 1. WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland (2008)

[19]. ICMR, Manual of Standards of Quality of Drinking Water Supplies, Indian Council of Medical Research, New Delhi (1975)

[20]. G. Yadav, Geobios. 29, 197 (2002)

[21]. P. C. Sujitha, D .D. Mitra, P.K. Sowmya and P. R. Mini, International Journal of Environmental Sciences . 2, 1417 (2012).

[22]. T. Imo, F. Latū, V. Vaurasi, J. Yoshida, P. Amosa and M. A. Sheikh . International Journal of Environmental Science and Development, 5,517(2014).

[23]. Deepali and N. Jos , Glob. J. Mul. App. Sci. 2 (2),36-40(2014)

[24]. J. baby, J. S. raj , E.T. biby, P. sankarganesh , M.V. jeevitha, S.U.ajisha and S. S. rajan, Int. J. Biol. Chem. Sci. 4(4), 939-952(2010).