Determination of Physicochemical and Heavy Metal Concentrations in Soil and Wellwaters Samples Around Steel Recycling Company in Osun State, Nigeria.

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Abstract- The steel industry produces various industrial processes and raw materials, resulting in effluents with high concentrations of heavy metals. These pollutants can cause environmental degradation and harm to soil quality even to the surrounding wells. Samples of soil and wellwaters around the industry were tested for physicochemical parameters and heavy metals of lead, cadmium, copper, zinc, iron, and manganese and analyzed using variance and Duncan multiple range tests at 0.05 level of significance. The physicochemical parameters of the soil and wellwaters still falls within the permissive limit of the standard limit while higher concentration of heavy metals of Zinc, Cadmium, Maganese, Iron and Lead with 413 ± 0.06, 222 ± 0.05, 894.74 ± 0.03, 1184.73 ± 0.05 and 33.4 ± 0.3 mg/ kg respectively were obtained in the soil samples and compared with the standard permissive values of the Federal Environmental Protection Agency, Nigeria and analysis of the wellwater samples revealed the presence of heavy metals in which lead had the highest concentration ranging from 0.80 ± 0.12 to 0.81 ± 0.09 mg/l in all the months examined with highest values in well six being the closest to the company. Due to the higher concentration of these heavy metals in the soil, which may have direct and indirect, short- and long-term impacts on any plants planted nearby the industry, it can be inferred from this study that the soil cannot be used for agricultural purposes and the nearby well is not too good for domestic or drinking water.

Indexed Terms- Soil, Wellwater, Heavy Metals, Steel industries

I. INTRODUCTION

Industrialization has certainly helped every nation that is expanding and progressing, but it has also had negative consequences on the environment, either directly or indirectly. Companies' effects on the environment increase as pollution sources do. The steel industry regularly releases or discharges massive amounts of untreated water into the environment for cooling or washing purposes, damaging the water and soil. This makes the steel industry one of the industries that pollutes the environment (Caneghem *et al*., 2010). The most recyclable and recycled material is steel, which is produced by chemically reducing iron ore using either a direct reduction process or an integrated steel manufacturing method. Steel has an approximate 68 percent recycling propensity (Chartterjee, 1995). The iron and steel industry recycles a large amount of waste and other resources in order to reduce the amount of raw materials required and the associated pollution.

The steel industry is seen as one of the biggest and most important economic sectors, both now and in the future. It is a resource for a nation. Iron and steel are the most widely used engineering materials for the bulk of product manufacturing, fabrication, construction, and manufacture, including cars, ships, and military gear. The iron and steel sector needs to be active and growing in order to support industrial development, improved engineering competence, and the advancement of technical skills *(Ohimain, 2013).* The steel businesses that are in operation employ more iron and steel scraps for recycling during periods of high demand for the metal, mostly from municipal solid wastes (Ohimain, 2013; Ohimain and Jenakumo, 2013). The fact that most of these companies don't have treatment facilities poses a threat because it exposes local wells and groundwater sources at risk of eventually contaminating people's bodies and causing health problems.

These steel industry wastes include large quantities of various metallic cations, including Zn+2, Cu+2, Fe+2, Mn+2, Pb+2, Ni+2, Cd+2, and others, along with a range of dissolved, unknown chemicals (Barakat, 2011). According to Hernandez et al. (2007), heavy metals can have a negative impact on the physicochemical characteristics of soil, making it unsuitable for crop development. Additionally, the metals in the soil have the potential to enter groundwater, contaminating it and preventing plant growth. In addition, possible pathways of exposure for the local populace may act as point sources of hazardous metal contamination in the soil *(Hernandez et al., 2007)*. Humans will eventually ingest the heavy metals accumulating in these plants growing in contaminated soils, either directly or indirectly, and they will enter the body through the food chain, causing a variety of physical and mental health issues (Hindwood et al., 2004).

Population growth and inappropriate industrial waste water disposal can both lead to a decline in water quality (Venkatasubramani and Meenambal, 2007). Because water is used for so many different things, including drinking, washing, bathing, and resurfacing, among many other diverse industrial uses, the significance of these water bodies has grown significantly.

Water pollution is a global problem, and as a result of the environment's ongoing and rapid degradation, which pollutes both its biotic and abiotic components, people are becoming more and more conscious of how human activity affects the environment. Wellwater with high levels of contaminants, primarily heavy metals, is unfit for drinking, irrigation, agriculture, or any other use due to a rise in biological oxygen demand and total dissolved solids (Hari *et al*., 1994).

Inappropriate handling and storage of recycled steel that is dumped on the ground exposes it to weathering and leaching processes by rain and other atmospheric influences, which can release dangerous substances like cyanides and heavy metals into subterranean water. When the effects of these pollution are greater, this can have the unintended consequence of making the water unsafe for human, recreational, and agricultural use.

II. MATERIALS AND METHODS

Sample Collection and processing

Soil samples were collected at a depth of 10 cm from five different locations close to the steel recycling sector in Ikirun, Osun State, throughout the sampling months of July through December. Samples were gathered in individual polythene bags, assembled, and obtained as composite samples in triplicate. After being allowed to air dry, the soil samples were heated to 40 °C for 30 minutes in an electric oven. They were passed through 2 mm-mesh stainless steel sieves. 0.1g samples were weighed out, followed by the addition and heating of 2.0 ml of concentrated nitric acid and 5.0 ml of concentrated hydrochloric acid.

After being properly uncapped and sealed in a fume hood for two hours, the samples were allowed to cool for at least twenty-five minutes before being taken out. The digested sample was filtered through Whatman No. 41 filter paper after being properly uncapped in a fume hood. The filtrate was then collected in a 100 ml volumetric flask and adjusted to 100 ml with 0.5% HNO3.The samples that had been digested were examined for concentrations of cadmium, copper, zinc, iron, manganese, copper and lead compared with the Standards (USEPA, 2010) (Berrow and Mitchell, 1993).

Collection of Well Water Samples

Water samples from six wells dug around the industry were collected twice a month from July through December and put into sterile bottles that had been previously cleaned. The bottles were thoroughly cleansed with deionized water and then washed with 10% hydrochloric acid. The water was then used to rinse the water samples that were to be collected. The bottles were sealed once the sample water had been filled to the brim.

The concentrations of lead, manganese, copper, zinc, cadmium, and iron were then measured. Jain and Bhatia (1987) and APHA (1998) compared the quantities of these metals in the water samples to the standard permitted limits for metals in water (WHO, 2007).

Physicochemical Parameters Analysis of Wellwater Samples

In compliance with Ademoroti (2001), Nwankwoala et al. (2018), Ogundele and Olarinde (2018), and APHA (1998), the well water samples were promptly transported to the laboratory for the evaluation of physicochemical properties, including temperature, pH, total dissolved solids, conductivity, dissolved oxygen, biochemical oxygen demand, total hardness, total alkalinity, and turbidity.

Metals Evaluation in Soil and Well water

The soil samples were first allow to air dry before being cooked in an electric oven for 30 minutes to 40 °C. The sieves were made of stainless steel and had a 2 mm mesh size. Two milliliters of concentrated nitric acid and five milliliters of concentrated hydrochloric acid were added after one-gram samples had been weighed out. A hot plate was then used to cook the samples until they were completely white. Prior to being taken out, the samples were correctly sealed, kept in a fume hood for two hours, and given at least twenty-five minutes to cool.

In a fume hood, the samples were carefully opened, and Whatman No. 41 filter paper was used to filter the digested material. Following collection in a 100 ml volumetric flask, the resultant filtrates were then adjusted to another 100 ml using 0.5% HNO_3. The digested samples' levels of iron, manganese, copper, zinc, cadmium, and lead were analyzed and compared to U.S. Environmental Protection Agency (USEPA) and Federal Environmental Protection Agency, Nigeria (FEPA) standards (Berrow and Mitchell, 1993).

To reduce the pH, 50 milliliters of each well water sample were collected, filtered through Whatman filter paper, and acidified with concentrated HNO_3. 40 milliliters of the sample were then taken, and five milliliters of concentrated HNO3 were added. The mixture was then allowed to digest in a closed room for half an hour. After that, 100 milliliters of purified water were started. A Perkin Elmer 3110 atomic absorption spectrophotometer was utilized to quantify the metal concentrations in the digested samples (Morris, 2005).

III. STATISTICAL ANALYSIS

The data was subjected to statistical analysis using SPSS (Statistical Packaging for Social Sciences) version 22.0. The Duncan multiple range test and the one-way analysis of variance (ANOVA) were used to the data. The p-value was set at less than 0.5.

IV. RESULTS

Physico - Chemical Parameters of Wellwaters.

According to the months of collection, the physicochemical characteristics of Hand dug Wellwaters 1 through 6 that were gathered from the area around the industry are displayed in Table 1.

Temperature

It was observed that the temperature changed during the month, reaching its peak point in July at 24.0 ± 0.15 mg/l and its lowest point in December at 20.2 ± 0.13 mg/l in wellwater 1, 26.71 ± 0.05 mg/l in July, and 21.0 ± 0.05 mg/l in wellwater 2. *The highest values of 24.15 ± 0.03 mg/l in the month of October and the lowest value of 20.12 ± 0.03 mg/l in the month of December in wellwater 3, highest values of 25.30 ± 0.05 mg/l in August and the lowest values of 20.12 ± 0.03 mg/l in December in wellwater 4, 26.17 ± 0.04 mg/l and 20.13 ± 0.04 mg/l in August and December in wellwater 5, highest values of 24.32 ± 0.05 mg/l in the months of July and the lowest values of 20.12 ± 0.02 mg/l and 20.15 ± 0.04 mg/l in the months of November and December in wellwater 6.*

pH

The variation of the values obtained in pH of wellwater 1in all the months were below the neutral except in the month of July and August of 7.15 ± 0.03 and 7.20 ± 0.04, pH value below the neutral in all the months except in July in wellwater 2 and 3 of 7.31 ± 0.06 and 7.02 ± 0.01, values obtained in pH of wellwater 4 and 5 were above neutral in all the months except in the month of July with 6.72 ± 0.05 and 6.85 ± 0.05 and August with 6.91 ± 0.04 and 6.63 ± 0.05 , the pH value of wellwater 6 in all the months were above the neutral with the highest value of 7.81 ± 0.03 in the month of October.

Total Dissolved Oxygen (TDS)

The variations observed for TDS in the wellwaters shows that all values obtained were below the standard limt of USEPA (2010). The highest value of 584 ± 4.33mg/l was observed in the month of August in wellwater 1, 462 ± 2.30 mg/l in the month of December in wellwater 2, 473 ± 2.15 mg/l in the month of October in wellwater 3, 440 ± 3.21 mg/l and 473 ± 3.14 mg/l in the months of November in wellwater 4 and 5 and 493 ± 2.73 mg/l in the month of December in wellwater 6.

Electrical Conductivity (EC)

The Ec values obtained in the wellwater 1 to wellwater 6 varies with high values higher than the standard limit except in the month of July for wellwater 1 with 0.20 ± 0.02 scm^{-1}, wellwater 2 with 0.30 ± 0.02scm^{-1} and wellwater 3 with 0.30 ± 0.01 scm^{-1},wellwater 4, 5 and 6 with 0.30 ± 0.02 scm^{-1}, 0.20 ± 0.03scm^{-1} and 0.21 ±0.03 scm^{-1} respectively.

Dissolved Oxygen (DO)

The DO observed in all the months were higher than the standard limit of USEPA with the highest values ranges from 4.15 ± 0.15 mg/l to 6.50 ± 0.25 mg/l in the months of December in wellwaters 2 to 5 respectively and the lowest values ranges from 2.17 ± 0.21 mg/l to 4.12 ± 0.17 mg/l in the months of July in all the wellwaters.

Biochemcal Oxygen Demand (BOD)

The values of BOD were higher than the limit in all the months with the highest values of 356 ± 0.05 mg/l, 385± 0.05 mg/l, 348 ±0.06 mg/l, 522 ± 0.06 mg/l, 531 ± 0.08 mg/l and 492 ± 0.06 mg/l in the months of December in wellwater 1 to wellwater 6 respectively.

Total Hardness

The variation of the values obtained in the hardness of the wellwaters in all the months were lower than the limit with highest values of 170 ± 0.41 mg/l, 172 ± 0.42 mg/l, 182 ± 0.44 mg/l, 184 ± 0.48 mg/l, 177± 0.37 mg/l and 172 ± 0.34 mg//l in the months of October in wellwater 1 to wellwater 6 respectively.

Alkalinity

The variation of the values obtained in Alkalinity of wellwaters in all the months were higher than the limit with the highest values of 723 ± 0.30 mg/l, 923 ± 0.37 mg/l, 682 ± 0.31 mg/l and 622 ± 0.82 mg/l in the month of October for wellwater 1,2, 3, and 5,values of 721 ± 0.22 mg/l in the month of November in wellwater 4 and values of 821 ± 0.27 mg/l in the month of December in wellwater 6 respectively.

Turbidity

In all the months for the wellwaters 1 to wellwater 6, it was observed that the turbidity were not visibly turbid.

Heavy metals in Soil and Wellwaters

Zinc (Zn)

Heavy metals were present in the soil around the industry in varying concentrations across sampling months. It was observed that the soil samples had high values of Zn (310.0 ± 0.02 mg/kg) in July, (413.3 ± 0.06 mg/kg) in August, (312.5 ± 0.03 mg/kg) in September, (319.6 ± 0.03) in October, (310.6 ± 0.05) in November and (360.8 ± 0.02) mg/kg in December, compared with FEPA standard value (300mg/kg)

The varying concentration across sampling months for Zn in the wellwater samples from the wells around the industry are shown in Table 2. All the values obtained for water samples from well were below the standard limit of WHO, (5.0) and FEPA, (1.0).

In all the months, it was observed that the values obtained for Cu were lower than the standard (70mg/kg), with the highest value of 2.28 ± 0.04 mg/kg in December, 0.26 ± 0.02 mg/kg in July,0.28 ± 0.04 mg/kg in August,1.28 ± 0.04 mg/kg in September, 1.21 ± 0.04 mg/kg in October and 1.38 ± 0.03 mg/kg in November.

The variation observed in Cu in the hand dug well waters across the months were shown in table 2. All values obtained for hand dug wellwaters were below the standard (1.0mg/kg), However, no significant difference were observed in Cu in the month of July compared to months of August, September, October, November and December.

In the soil samples, Cd showed the highest value of 222 ± 0.05 mg/kg in December, the lowest value of 146 ±1.4 mg/kg in August, other values were 167 ± 1.2 mg/kg in July, 163± 0.92 mg/kg in September, 185 ±

0.98 mg/kg in October and 194 ± 0.76 mg/kg in November.

The variation observed for Cd in the hand dug well water had the highest value of 1.92a ± 0.01 mg/kg in July in well 4 were above the standard limit WHO, 0.03mg/kg and FEPA, 0.01mg/kg). Non consistent variation was obtained for Cd values in wells across the month as revealed with significant difference across the months.

It was observed that the concentration of Mg in all the soil samples were higher in all the sampling months with the highest value of 894.74 ± 0.03 mg/kg in November and lowest value of 569.22 ± 0.05 mg/kg in July compared with the standard (300mg/kg). The Mg values were 736.25 ± 0.03 mg/kg in August, 722.79 ± 0.03 mg/kg in September, 725.95 ±0.03 mg/kg in October and 765.98 ± 0.04 mg/kg in December.

The variation values observed in Mg in the hand dug well waters in all the sampling months were below the WHO standard (0.05mg/kg), The values for wellwater varied with significant differences in the months of August, October, November and December compared with no significant difference in the month of July and September.

Similarly, the concentrations of Fe in the soil samples were higher than the standard values with the highest value of 1293.22 ± 0.04 mg/kg in December and lowest value of 1143.28 ± 0.04 mg/kg in July, compared with the standard (400mg/kg). Others were 1208.23 ± 0.02 mg/kg in August, 1218.18 ± 0.04 mg/kg in September, 1205.21 ± 0.03 mg/kg in October and 1184.73 ± 0.05 mg/kg in November.

The variation observed for Fe in the well water in all values obtained were above the standard limit of WHO, (2.0 mg/kg) and FEPA, (0.3 mg/kg).

Furthermore, the concentration of Pb in the soil was higher compared with the standard value(1.6mg/kg) with the highest value of 33.4 ± 0.3 mg/kg in October, 23.5 ± 0.2 mg/kg and lowest value of 15.6 ± 0.4 mg/kg., others were 22.5 ± 0.04 mg/kg, 29.1 ± 0.2 mg/kg and 25.3 ± 0.03 mg/kg in July, August, September, November and December respectively.

The variation observed for Pb in the hand dug well water with values obtained for hand dug wellwater were above the standard of WHO, (1.0mg/kg) and FEPA,(0.05mg/kg). The highest value of 5.78a ± 0.65mg/kg was observed in well 6 in August.

Table 1 : Heavy Metals Present in the Soil around the Steel Construction industry based on the months.

	July	Aug	Sept	Oct	Nov	Dec	FEPA
Zn	310.0 ± 0.02	413.3 ± 0.06	312.5± 0.03	319.6 ±0.03	310.6 ± 0.05	360.8± 0.02	300mg/kg
Cd	167 ±1.2	146 ± 1.4	163 ± 0.92	185± 0.98	194 ± 0.76	222 ± 0.05	NOT FIXED
Mg	569.22 ±0.05	736.25 ±0.03	722.79 ±0.03	725.95 ±0.03	894.74 ±0.03	765.98 ±0.04	300mg/kg
Cu	0.26 ±0.02	0.28 ±0.04	1.28 ±0.04	1.21 ±0.04	1.38 ±0.03	2.28 ±0.04	70mg/kg
Fe	1143.28 ±0.04	1208.23 ±0.02	1218.18 ±0.04	1205.21 ±0.03	1I84 73 ±0.05	1293.22 ±0.04	400mg/kg

Pb	*23.5 ±0.2*	*15.6 ±0.4*	*22.5 ±0.4*	*33.4 ±0.3*	*29.1 ±0.2*	*25.3 ±0.03*	*1.6 mg/kg*

Table 2: Physicochemical properties of well water samples around the steel construction company

Well source	Physicochemical	Months					
		July	August	September	October	November	December
W1	Temp(^{0}C)	24.0 ± 0.15	23.2 ± 0.17	22.3 ± 0.13	22.3 ± 0.04	22.1 ± 0.13	20.2 ± 0.13
	pH	7.15 ± 0.03	7.20 ± 0.04	6.51 ± 0.03	6.72 ± 0.04	6.35 ± 0.04	6.90 ± 0.05
	TDS(mg/l)	450 ± 5.21	584 ± 4.33	444 ± 5.2	420 ± 0.04	468 ± 5.12	477 ± 5.14
	EC(Scm^{-1})	0.20 ± 0.02	0.60 ± 0.01	0.72 ± 0.03	0.54 ± 0.02	0.58 ± 0.05	0.60 ± 0.03
	DO(mg/l)	4.05 ± 0.15	4.32 ± 0.42	4.22 ± 0.17	4.15 ± 0.51	4.41 ± 0.32	4.50 ± 0.17
	BOD(mg/l)	255 ± 0.99	293 ± 0.86	262 ± 1.5	350 ± 1.21	292 ± 0.63	356 ± 0.05
	Hardness(mg/l)	80 ± 0.30	72 ± 0.30	92 ± 0.30	170 ± 0.41	75 ± 0.32	72 ± 0.42
	Alkanity(mg/l)	378 ± 0.24	355 ± 0.21	400 ± 0.27	723 ± 0.30	653 ± 0.31	420 ± 0.22
	Turbidity	VNT	VNT	VNT	VNT	VNT	VNT
W2	Temp(^{0}C)	26.71 ± 0.05	24.50 ± 0.03	23.55 ± 0.04	24.73 ± 0.03	22.75 ± 0.03	21.0 ± 0.5
	pH	7.31 ± 0.06	6.9 ± 20.04	6.54 ± 0.07	6.84 ± 0.03	6.72 ± 0.05	6.98 ± 0.04
	TDS(mg/l)	420 ± 1.71	463 ± 1.63	444 ± 3.20	415 ± 2.40	450 ± 3.12	462 ± 2.30
	EC(Sm^{-1})	0.30 ± 0.02	0.73 ± 0.03	0.61 ± 0.04	0.67 ± 0.03	0.63 ± 0.02	0.71 ± 0.20
	DO(mg/l)	3.55 ± 0.17	3.60 ± 0.14	3.58 ± 0.13	3.62 ± 0.12	3.17 ± 0.16	4.15 ± 0.15
	BOD(mg/l)	282 ± 0.03	270 ± 0.02	360 ± 0.03	342 ± 0.04	340 ± 0.03	385 ± 0.05
	Hardness(mg/l)	82 ± 0.27	67 ± 0.31	89 ± 0.36	172 ± 0.42	80 ± 0.38	73 ± 0.32
	Alkanity(mg/l)	325 ± 0.25	417 ± 0.41	452 ± 0.36	923 ± 0.37	756 ± 0.31	462 ± 0.25
W3	Temp(^{0}C)	21.53 ± 0.04	22.14 ± 0.03	22.51 ± 0.03	24.15 ± 0.03	21.12 ± 0.03	20.21 ± 0.03
	pH	7.02 ± 0.01	64.2 ± 0.05	6.73 ± 0.06	6.25 ± 0.01	6.30 ± 0.04	6.32 ± 0.04
	TDS(mg/l)	483 ± 2.61	447 ± 2.51	433 ± 3.10	473 ± 2.15	412 ± 3.13	452 ± 4.1
	EC(Scm^{-1})	0.30 ± 0.01	0.65 ± 0.03	0.72 ± 0.04	0.67 ± 0.02	0.70 ± 0.03	0.63 ± 0.04
	DO(mg/l)	3.2 ± 0.42	4.6 ± 0.55	4.2 ± 0.32	3.8 ± 0.25	4.7 ± 0.31	5.8 ± 0.51
	BOD(mg/l)	320 ± 0.04	312 ± 0.04	318 ± 0.03	287 ± 0.06	295 ± 0.03	348 ± 0.06
	Hardness(mg/l)	68 ± 0.52	78 ± 0.47	72 ± 0.49	182 ± 0.44	86 ± 0.37	87 ± 0.38
	Alkanity(mg/l)	412 ± 0.42	327 ± 0.36	347 ± 0.27	682 ± 0.31	733 ± 0.17	432 ± 0.27
	Turbidity	VNT	VNT	VNT	VNT	VNT	VNT

W4	Temp(^{0}C)	24.61 ± 0.07	25.30 ± 0.05	25.10 ± 0.03	23.50 ± 0.05	24.12 ± 0.03	20.1 ± 0.03
	pH	6.72 ± 0.05	6.91 ± 0.04	7.20 ± 0.05	7.33 ± 0.01	7.14 ± 0.05	7.12 ± 0.03
	TDS(mg/l)	431 ± 2.51	416 ± 2.65	423 ± 3.17	403 ± 2.72	440 ± 3.21	412 ± 2.51
	EC(Scm^{-1})	0.63 ± 0.03	0.57 ± 0.80	0.71 ± 0.02	0.69 ± 0.04	0.64 ± 0.05	0.3 ± 00.02
	DO(mg/l)	3.4 ± 0.15	4.7 ± 0.42	5.2 ± 0.35	4.7 ± 0.17	6.-0 ± 0.19	6.2 ± 0.05
	BOD(mg/l)	500 ± 0.04	493 ± 0.05	475 ± 0.05	465 ± 0.05	475 ± 0.04	522 ± 0.06
	Hardness(mg/l)	77 ± 0.25	72 ± 0.21	91 ± 0.41	184 ± 0.48	82 ± 0.30	75 ± 0.40
	Alkanity(mg/l)	412 ± 0.32	325 ± 0.24	374 ± 0.28	658 ± 0.31	721 ± 0.22	333 ± 0.26
	Turbidity	VNT	VNT	VNT	VNT	VNT	VNT
W5	Temp(^{0}C)	22.14 ± 0.15	26.17 ± 0.04	24.52 ± 0.03	22.35 ± 0.05	23.33 ± 0.17	20.13 ± 0.04
	pH	6.85 ± 0.05	6.63 ± 0.05	7.42 ± 0.03	7.23 ± 0.04	7.41 ± 0.03	7.38 ± 0.06
	TDS(mg/l)	417 ± 2.16	433 ± 2.72	421 ± 216	435 ± 2.55	473 ± 3.14	452 ± 2.16
	EC(Scm^{-1})	0.63 ± 0.05	0.72 ± 0.04	0.68 ± 0.04	0.73 ± 0.05	0.65 ± 0.01	0.20 ± 0.03
	DO(mg/l)	2.17 ± 0.21	5.30 ± 0.32	4.60 ± 0.27	5.80 ± 0.32	6.20 ± 1.05	6.50 ± 0.25
	BOD(mg/l)	512 ± 0.05	520 ± 0.06	500 ± 0.26	496 ± 0.05	493 ± 0.05	531 ± 0.08
	Hardness(mg/l)	91 ± 0.42	86 ± 0.38	92 ± 0.31	177 ± 0.37	82 ± 0.32	79 ± 0.41
	Alkanity(mg/l)	382 ± 0.52	355 ± 0.61	457 ± 0.58	622 ± 0.82	582 ± 0.73	721 ± 0.64
	Turbidity	VNT	VNT	VNT	VNT	VNT	VNT
W6	Temp(^{0}C)	24.32 ± 0.05	23.6 ± 0.02	24.63 ± 0.02	22.17 ± 0.12	20.12 ± 0.02	20.15 ± 20.15
	Ph	7.22 ± 0.04	7.53 ± 0.03	7.32 ± 0.30	7.81 ± 0.03	7.65 ± 0.03	7.31 ± 0.05
	TDS(mg/l)	463 ± 3.13	452 ± 2.72	447 ± 3.21	465 ± 2.75	483 ± 3.52	493 ± 2.73
	EC(Scm^{-1})	0.60 ± 0.05	0.71 ± 0.02	0.63 ± 0.05	0.63 ± 0.04	0.30 ± 0.01	0.21 ± 0.03
	DO(mg/l)	4.12 ± 0.17	4.35 ± 1.15	5.35 ± 0.26	5.22 ± 0.23	5.15 ± 0.188	6.15 ± 0.42
	BOD(mg/l)	422 ± 0.06	417 ± 0.07	425 ± 0.06	450 ± 0.06	462 ± 0.06	492 ± 0.06
	Hardness(mg/l)	81 ± 0.34	68 ± 0.30	87 ± 0.30	172 ± 0.34	82 ± 0.42	75 ± 0.23
	Alkanity(mg/l)	327 ± 0.4	422 ± 0.32	382 ± 0.41	312 ± 0.35	425 ± 0.25	821 ± 0.27
	Turbidity	VNT	VNT	VNT	VNT	VNT	VNT

Table 3: Mean levels of heavy metals in well water samples around the steel construction company

Heavy Metal	Well Sample	Months					
		July	August	September	October	November	December
Zn	W1	0.54b ± 0.02	0.44c ± 0.00	0.63bc ± 0.01	0.57cd ± 0.0	0.03b ± 0.14	0.33a ± 0.01
	W2	0.64 ± 0.03	0.56bc ± 0.04	0.58c ± 0.00	0.74ab ± 0.01	0.62a ± 0.00	0.60a ± 0.01
	W3	0.54b ± 0.01	0.63ab ± 0.00	0.80a ± 0.03	0.69b ± 0.01	0.54ab ± 0.01	0.44bc ± 0.00
	W4	0.78b ± 0.02	0.78a ± 0.01	0.78*a* ± 0.01	0.75*ab* ± 0.02	0.45ab ± 0.00	0.45bc ± 0.00
	W5	0.60b ± 0.04	0.61ab ± 0.00	0.68b ± 0.01	0.66bc ± 0.00	0.64a ± 0.00	0.36cd ± 0.02
	W6	0.81 ± 0.99	0.66ab ± 0.06	0.56c ± 0.00	0.55d ± 0.00	0.45a ± 0.00	0.50ab ± 0.04
Cd	W1	1.30ab ± 0.01	1.25c ± 0.00	0.63c ± 0.01	0.73c ± 0.01	0.47c ± 0.03	0.45c ± 0.03
	W2	1.46ab ± 0.06	1.25c ± 0.00	0.58c*d* ± 0.00	1.20b ± 0.34	0.72c ± 0.35	1.15b ± 0.14
	W3	0.73b ± 0.01	0.61d ± 0.00	0.77a ± 0.00	1.41b ± 0.01	0.33c ± 0.05	0.32c ± 0.00
	W4	1.92a ± 0.01	1.56a ± 0.02	0.78*a* ± 0.01	1.49*b* ± 0.23	0.61c ± 0.32	1.10b ± 0.09
	W5	1.49ab ± 0.05	1.42b ± 0.00	0.68b ± 0.01	1.15bc ± 0.07	0.64c ± 0.27	0.66bc ± 0.38
	W6	1.34ab ± 0.01	1.49ab ± 0.07	0.56d ± 0.00	1.47b ± 0.13	1.58b ± 0.05	1.12b ± 0.23
Mg	W1	0.03 ± 0.01	0.04ab ± 0.00	0.05 ± 0.00	0.04b ± 0.00	0.04b ± 0.00	0.03bc ± 0.00
	W2	0.04 ± 0.00	0.04ab ± 0.00	0.04 ± 0.01	0.04b ± 0.00	0.047b ± 0.00	0.04b ± 0.01
	W3	0.05 ± 0.00	0.05ab ± 0.00	0.05 ± 0.00	0.04b ± 0.00	0.05b ± 0.00	0.32c ± 0.00
	W4	1.92a ± 0.01	1.56a ± 0.02	0.78*a* ± 0.01	1.49*b* ± 0.23	0.61c ± 0.32	0.04a ± 0.00
	W5	0.05 ± 0.00	0.04ab ± 0.00	0.05 ± 0.00	0.05ab ± 0.01	0.04b ± 0.01	0.036b ± 0.00
	W6	0.04 ± 0.00	0.04b ± 0.00	0.04 ± 0.00	0.05a ± 0.00	0.04b ± 0.00	0.04b ± 0.01
Cu	W1	0.04 ± 0.00	0.05b ± 0.00	0.05*b* ± 0.00	0.05ab ± 0.01	0.02c ± 0.01	0.03b ± 0.00
	W2	0.04 ± 0.01	0.05b ± 0.00	0.04*b* ± 0.01	0.04b ± 0.03	0.04bc ± 0.00	0.04b ± 0.00
	W3	0.03 ± 0.01	0.03b ± 0.00	0.04b ± 0.00	0.04b ± 0.03	s0.04ab ± 0.00	0.04ab ± 0.01
	W4	1.92a ± 0.01	1.56a ± 0.02	0.78*a* ± 0.01	1.49*b* ± 0.23	0.61c ± 0.32	0.04a ± 0.00

	W5	0.03 ± 0.01	0.04b ± 0.00	0.04b ± 0.00	0.03b ± 0.01	0.04ab ± 0.00	0.03b ± 0.00
	W6	0.05 ± 0.00	0.04b ± 0.00	0.04*b* ± 0.01	0.05a*b* ± 0.02	0.04ab ± 0.00	0.04b ± 0.01
Fe	W1	1.20c ± 0.09	0.04d ± 0.00	0.44cd ± 0.07	1.39b ± 0.03	1.53b ± 0.047	1.42b ± 0.25
	W2	1.30bc ± 0.05	0.04d ± 0.00	0.34d ± 0.015	1.12b ± 0.09	1.69b ± 0.31	0.99b ± 0.18
	W3	1.19c ± 0.06	0.04d ± 0.00	0.40cd ± 0.03	1.26b ± 0.14	0.97b ± 0.11	1.01b ± 0.12
Pb	W4	1.10c ± 0.03	0.04d ± 0.00	0.48cd ± 0.04	1.07*b* ± 0.04	2.27b ± 0.66	1.04b ± 0.03
	W5	1.33bc ± 0.15	1.72c ± 0.33	1.04c ± 0.00	1.55b ± 0.48	2.30b ± 0.59	1.48b ± 0.21
	W6	1.76b ± 0.05	4.09a ± 0.42	1.06b ± 0.43	4.38a ± 0.34	4.35a ± 0.34	1.33b ± 0.14
	W1	1.35c ± 0.06	0.80d ± 0.12	1.15c ± 0.10	1.60b ± 0.14	1.27b ± 0.08	1.08c ± 0.08
	W2	1.48c ± 0.25	1.55cd ± 0.29	0.04c ± 0.01	1.38b ± 0.23	1.51b ± 0.10	1.31b*c* ± 0.05
	W3	1.41c ± 0.18	1.34cd ± 0.23	1.02c ± 0.33	1.57b ± 0.09	1.01b ± 0.17	1.28bc ± 0.033
	W4	1.43c ± 0.02	1.57cd ± 0.17	1.56c ± 0.09	1.57*b* ± 0.09	1.20b ± 0.10	1.40b ± 0.35
	W5	1.80c ± 0.18	2.34c ± 0.60	1.74c ± 0.13	1.18b ± 0.28	1.34b ± 0.19	1.27bc ± 0.11
	W6	4.38b ± 0.45	5.78b ± 0.65	4.84b ± 1.15	2.98a ± 0.38	1.4b ± 0.23	1.24bc ± 0.13

V. DISCUSSION

Water that is closer to neutral in pH will be more corrosive, and the closer it is to neutral, the more aquatic life it threatens. The hand-dug wells' water had an alkaline tendency. According to Khan et al. (2011), the increased chemical interaction that causes buffering and the release of more alkaline ions (bicarbonate and carbonate ions) or salts into the well water may be the cause of the alkaline condition of wellwaters.

High EC water may alter the structure of the soil, making it unsuitable for home or agricultural irrigation. Salinity hazards are these detrimental impacts, which have been shown to have a significant impact on agricultural output and plant growth (Berrow and Mitchel, 1993; Alkorta et al., 2004).

The breaking down considering the amount of organic matter that washes into a body of water determines its oxygen content, measurements of dissolved oxygen are frequently used to assess the biochemistry of wells. Both recharge and airflow through unsaturated material above the water table provide oxygen to groundwater. When employed for aquatic species, a high dissolved oxygen value might cause eutrophication (Dalal et al., 2013).

Any material that has the capacity to transport an electric current is said to be electrically conductible, and samples containing dissolved solids like calcium, magnesium, and sodium do so. According to Jonathan and Chinhanga (2010), conductivity has no direct effect on human health, but it can reduce the wellwater's aesthetic value by imparting a mineral taste. Conductivity needs to be checked for agricultural applications, and high conductivity wellwater can corrode metal equipment surfaces throughout the year.

Though the physical and chemical parameters of the wellwater were still within the acceptable range, they were too close to it. In December, the hardness of the water was higher in wells, indicating that it needed to be properly treated before drinking or using for household purposes. Hardness is a result of impurities in the water, and whether it is high or low, it affects people differently and makes it unfit for use in homes. Hard water damages delicate machinery and degrades the quality, stability, and glossiness of the finished product, making it unsuitable for use in industry and agriculture as well as home tasks like cooking, washing, and bathing as reported by Navneet *et al*., 2010, while the physico chemical parameters of the wellwater varies in values in the months in relations to the level of production processes involved in the company.

The most significant natural resource for life's survival has always been soil; yet, industrialization has had an impact on the quality of soil nutrients. According to studies by Liu et al. (2004) and Berrow and Mitchel (1993), soil samples from the steel industry have short- and long-term, direct, and indirect effects on any plant growing nearby due to the industry's discharges. According to Karczewska et al. (2001), the current study revealed greater concentrations of all assessed heavy metals (Zn, Cd, Mg, Cu, Fe, and Pb) than FEPA standard values during the sample months. These findings could imply that the heavy metals are biaccumulated in the plants.

According to Liu et al. (2004), there is a good chance that elevated levels of Cd and Zn will negatively impact the surrounding vegetation. Therefore, complex soil contamination by heavy metals will be a major environmental issue if manufacturing operations continue and acid deposition is not controlled in the future.

According to Angima (2010), there has been a lot of focus on the rise in lead levels in soil because lead is rather common due to its historical use and is known to have harmful health effects. Based on this investigation, it was concluded that every metal taken into consideration was beyond the Federal Environmental Protection Agency's standard standards. This means that the soil surrounding the corporation is not appropriate for agricultural use, as recommended by Stehouwer and Macneal (1999).

The findings of Yoon *et al*. (2006) reported that there is evidence that heavy metals accumulate in crops grown on polluted soil, with soil ingestion and plant bioaccumulation being the greatest health risk. Because children are more likely than adults to absorb soil directly, soils with high percentages of heavy metals, as found in this study, provide a larger health risk to them. This has been noted by Hamel *et al*. (2010) and Nwankwoala *et al*. (2018).

Liu et al., (2004) reported that increase in Cd and Zn which might probably lead to serious harmful effects on local vegetation. Therefore, if production activities continue and acid deposition is not under control in the future, complex contamination of soil by heavy metal will be a serious environmental problem.

Angima (2010) reported that there has been a lot of attention paid to increase of lead levels in soil because it is well-known to cause adverse health effects and is relatively widespread as a result of its historical use. From this research, it was deduced that all the metals considered were beyond the standard, which makes the soil around the company unsuitable for agricultural purposes

CONCLUSION

The study's findings indicate that the well nearer to the factory should not be used for residential use and also the soil around the factory was unsuitable for farming. As well as this particular type of industry needs to be located far from residential areas. Additionally, the local population needs to be educated about the potential risks the company poses to their health and the environment.

REFERENCES

[1] Ademoroti, C.M.A. (2001). ”Studies on physicochemical methods of wastewater treatment” Ph.D.Thesis,University of London. pp 59 -84.

[2] Alkorta, I.J., Hernandez-Allica, M., Becerril, I., Amezaga, I., Albizu, B., and Garbisu, C. (2004). Recent findings on the phytoremediation of soils contaminated with environmentally toxic heavy metals and metalloids such as zinc, cadmium, lead, and arsenic. Reviews in Environmental Science and Biotechnology , 3, 71–90.

[3] Angima, S (2010) . Toxic heavy metals in farm soil. Oregon State University Small Farm News. http://smallfarms.oregonstate.edu/sfn/su10 toxic metals.

[4] APHA. (1998). Standard method for Examination of water and waste water, 20th edition. American Public Health Association,Washington D.C.

[5] *Barakat, M.A. (2011). New Trends in Removing Heavy Metals from Industrial Waste water. Arabian Journal of Chemistry,77: 361-377.*

[6] *Berrow, M.L and Mitchell, R.L. (1993). Location of trace elements in soil profiles: total and extraceable content of individual horizons. International Journal of Canadian society of soil science.23 :52 -78.*

[7] *Caneghem, J.V., Block, C., Cramm, P., Mortier, R and Vandecasteele, C. (2010). Improving coefficiecy in the steel industry. Journal of Cleaner Production, 18: 807-814.*

[8] *Chatterjee, A. (1995). "Recent Developments in Iron making and Steel making". Iron and Steel making 22:2, 100-104.*

[9] Dalal, L.P., Kalbende, S.P., and Nisal, R.S. (2013). Physico-chemical Assessment of Water Quality of River and the Hydro-biological Study of Algae. *International Journal of Scientific & Engineering Research.* 4 (3) 2229-5518.

[10] Hamel, S., Heckman, J and Murphy, S. (2010). Lead contaminated soil: minimizing health risks. Fact sheet FS336. Rutgers, the State University of New Jersey, New Jersey Agricultural Experiment Station. http://njaes.rutgers.edu/pubs/publication.

[11] *Hari, O, Nepal, S, Aryo, M and Singh, N (1994). "Combined effect of waste of distillery and sugar mill on seed germination and seeding growth and biomass of okra (Abelmoschus esculentus 10 Moench) ". Journal of Environment Biology 3: 171- 175.*

[12] Hernandez – Allica, J., Garbisu, C., Barrutta, O and Becerril, J.M . (2007). EDTA induced heavy metal accumulation and phytotoxicity in carbon plants, Environmental experiment on botany. 60(1):26-32.

[13] Hindwood, A.L., Sim, M.R., Jolley, D., Bastone, E.B., Gerostamoulos, J and Drummen, D.H. (2004). Exposure to inorganic arsenic concentration of residents living in old mining areas. *Environmental Journal on geochemistry and health* 26:27-36.

[14] Jain, C.K and Bhatia, K.K.S. (1987). Physicochemical Analysis of water and wastewater. National Institute of Hydrology, Roonkee.

[15] *Jonathan, R., and Chinhanga, M. (2010). Impact of industrial effluent from an iron and steel company on the physicochemical quality of Kwekwe River water in Zimbabwe. International Journal of Engineering, Science and Technology. 2(7) 129-140.*

[16] Karczewska, A., Bogda, A., and Kurnikowska, B. (2001). Nickel, chromium, lead and cadmium in soils and common plant species in the area of nickel mining and smelting (SW Poland). Proceedings of the 6th ICOBT.

[17] Khan, N., Basheer, F., Singh, D and Farooqi, I. (2011). Treatment of paper and pulp mill wastewater by column type sequencing batch reactor. *Journal of Industrial Research Technology*,1(1):12-16

[18] *Liu, H., Probit, A and Liao, B. (2004). Metal Contamination in soils and crops affected by the cherizhou lead / Zinc mine spill (Hunan, China).*

[19] *Morris, R.L. (2005)."Determination of iron in water in the presence of heavy metals";Journal of Analytical chemistry. 25:1376- 1382.*

[20] Navneet, K., Kumar, D and Sinha, K. (2010). Drinking water quality management through correlation studies among various physicochemical parameters: A case study, *International Journal of Environmental Sciences*, 16(2):253-259.

[21] Nwankwoala, H.O, Youdeowei, P.O and Daka, E.R (2018). Physicochemical, Heavy Metals and Microbiological concentrations in soil and water samples around Veritas University campus,

Obehie, Southeastern Nigeria. British Journal of Environmental Sciences, 6(1):12-18.

[22] Ogundele, O and Olarinde, G. M (2018) : Physico chemical properties and heavy metals concentration in waste water discharged from two industries in Agbara, Lagos State, Nigeria. *International Research Journal of Public and Environmental Health*, 5 (3): 32-37.

[23] *Ohimain, E.I. (2013). Scrap Iron and Steel Recycling in Nigeria. Greener Journal of Environmental Management and Public Safety. 2 (1): 1 -9.*

[24] *Ohimain, E.I and Jenakumo, C.B. (2013). Scrap metal recycling and valorization in Bayelsa State, Nigeria. The Journal of Materials Science. 119: 137 – 147.*

[25] *Sanjeev, K.S., Vikas, K.S., Samir, K and Anup, T. (2014) . A study on the wastewater Treatment Technology for steel industry: Recycle and Reuse. American Journal of Engineering Research, 3(4), 309 – 315.*

[26] Stehouwer, A and Macneal, D. (1999). Lead in residential soils: sources, testing, and reducing exposure. Pennsylvania State University, College of Agricultural Sciences, Cooperative Extension. http://cropsoil.psu.edu/extension/esi/lead-in-soil.

[27] *USEPA, (2010). Municipal solid waste generations, recycling and disposal in USA. USEPA.*

[28] *WHO (2007). Combating Waterborne Diseases at the Household Level. Part1.ISBN9789241595223.http://www.who.int/water_sanitation_health/publications/cobating disease part1lowres.pdf.*

[29] *Yoon, Y., Cao, X., Zhou, Q and Mal, Q. (2006) . Accumulation of Pb, Cu and Zn in active plants growing on a contaminated Florida site. Journal of Science of Total Environment. 36(8):456 – 464.*