AJEHS
African Journal of Environmental Health Sciences
Volume 7, November, 2020
http://www.ehsanonline.org
ISSN: 2476-8030 (Prints)
ISSN: 2714-2930 (Online)
pp 57-66

Assessment of Selected Heavy Metal Concentrations in Water and Sediment around Ikirun Iron-Smelting Industry, Ikirun, Osun State, Nigeria

*Okoya, A. A., Awofisayo, O. F., Oginni, O. A. and Akinyele, A. B.

Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Nigeria.

E-mail: ronkeokoya@yahoo.com

Corresponding Author:
Aderonke Okoya, as above

Keywords:
Heavy metals, Permissible limits, Surface water, Underground water, Iron-smelting emission

Mots clés:
Métaux lourds, limites admissibles, eaux de surface, eaux souterraines, émissions de fonte de fer

Abstract

This study was carried out on a stream, three ponds, and two wells located within the vicinity of the Iron-smelting industry in Ikirun, Ifelodun Local Government Area of Osun State. Water samples were collected from seven sampling points along the stream, two hand-dug wells, and three ponds. A total of 72 water samples were taken at two-month interval between January and November. Sediments' samples (60) were also collected from the same locations where water was sampled, except for the hand dug wells. Heavy metals (Fe, Zn, As, Pb, and Cd) were analysed using Atomic Absorption Spectrophotometry. Cadmium (0.01 ± 0.00 mg/l), Pb (0.01 ± 0.00 mg/l), and As (0.01 ± 0.00 mg/l) had concentrations above both World Health Organization (WHO) and Nigerian Industrial Standards (NIS) limits in both the surface and underground waters while Zn (0.13 ± 0.03) and Fe (0.18 ± 0.00 mg/l) had concentrations below the maximum permissible limits of WHO and NIS in both surface and underground water samples. Pb (0.01 ± 0.00), Zn (0.12 ± 0.00), and As (0.01 ± 0.00 mg/l) were observed to be lower in water than their corresponding values in sediment (0.05 ± 0.00, 0.23 ± 0.00, and 0.04 ± 0.00 mg/kg) respectively. The study concluded that the water bodies around the iron-smelting industry have high heavy metal contents above the regulatory standards and the water could not be recommended for drinking purpose.

Une Évaluation de certaines concentrations de métaux lourds dans l'eau et les sédiments autour de l'industrie de la fonte d'Ikirun, Ikirun, État d'Osun, Nigéria

Abstrait

Cette étude a été réalisée sur un ruisseau, trois étangs et deux puits situés à proximité de l'industrie de la fonte du fer à Ikirun, dans la région du gouvernement local d'Ifelodun de l'État d'Osun. Des échantillons d'eau ont été prélevés à sept points d'échantillonnage le long du cours d'eau, à deux puits creusés à la main et à trois étangs. Au total, 72 échantillons d'eau ont été prélevés tous les deux mois entre janvier et novembre. Des échantillons de sédiments (60) ont également été prélevés aux mêmes endroits où l'eau a été prélevée, à l'exception des puits creusés à la main. Les métaux lourds (Fe, Zn, As, Pb et Cd) ont été analysés par spectrophotométrie d'absorption atomique. Le cadmium (0,01 ± 0,00 mg / l), le Pb (0,01 ± 0,00 mg / l) et l'As (0,01 ±

0,00 mg / l) avaient des concentrations supérieures aux limites de l'Organisation mondiale de la santé (OMS) et des normes industrielles nigérianes (NIS) dans les deux cas. les eaux de surface et souterraines, tandis que le Zn (0,13 ± 0,03) et le Fe (0,18 ± 0,00 mg / l) présentaient des concentrations inférieures aux limites maximales admissibles de l'OMS et du NIS dans les échantillons d'eau de surface et souterrains. On a observé que Pb (0,01 ± 0,00), Zn (0,12 ± 0,00) et As (0,01 ± 0,00 mg / l) étaient inférieurs dans l'eau à leurs valeurs correspondantes dans les sédiments (0,05 ± 0,00, 0,23 ± 0,00 et 0,04 ± 0,00 mg / kg) respectivement. L'étude a conclu que les plans d'eau autour de l'industrie de la fonte du fer ont des teneurs élevées en métaux lourds au-dessus des normes réglementaires et que l'eau ne peut être recommandée à des fins de consommation.

Introduction

Environmental pollution is a challenge in most developed societies of the world and in recent times it is increasingly becoming a major problem in African societies including Nigeria.

Environmental issues such as global warming, depletion of the ozone layer, population growth, destruction of rain forests, air pollution, water pollution, groundwater depletion and contamination are of great concern to environmentalists (Evelyn and Tyav, 2013).

Recently, it is observed that industrial growth and urbanization are the major cause of these environmental problems especially pollution. Water is said to be the most vulnerable aspect of the environment because it accumulates all pollutants in the environment (Momodu and Anyakora, 2010). Water pollution is a serious global problem because of the direct link between the availability of adequate quantity of good quality water and the well-being of the people or public health. Therefore, there is a need for monitoring and control of surface and ground water pollutions (Alao *et al.,* 2010).

Iron smelting activities are one of the industrial activities that introduces great amount of pollutants especially metals into the environment. Metals may be released as fine particles or volatile compounds as emissions from iron smelting operations while organic vapours and sulphur oxides can also be released from secondary smelting roasting operations and fuel combustion. This can cause smog, containing ozone, fine airborne particles, nitrogen oxides, sulphur dioxide and carbon monoxide. However, metal-bearing dust particles can travel far distances to pollute the soil, vegetation and surface waterways. Ground water is also polluted with this smelting process since pollutants in soil and vegetation also find their way into both the ground and surface water environment (Al-Khashman, 2004; Ipeaiyeda *et al.,* 2012; Manoj *et al.,* 2016).

Among the pollutants associated with iron-smelting activities are heavy metals. Heavy metals are often known to exhibit extreme toxicity or chronic poisoning at some specific amount in aquatic animals, some at trace levels and some at excessive amounts (Jaishankar *et al*., 2014). In view of this, heavy metals are significant pollutants of the aquatic system which are sensitive indicators for monitoring changes in the water environment (Omale *et al.,* 2014; Manoj *et al.,* 2016; Ali *et al.,* 2019).

According to Patil *et al.,* (2012) human beings have a great use of water which includes domestic purposes as well as industrial and agricultural purposes. Highly impure water has various negative impacts on human beings. Human beings can be affected by heavy metals (Ali *et al.,* 2019; Amir and Mohammad, 2019) or they may be infected by different bacteria present in water resulting in different body organs and physiological disorders. Hard water is unsuitable for domestic use such as washing, bathing, cooking as well as other purposes. Hard water is also not suitable for industrial and agricultural use as it causes damage to the delicate machineries and affects the quality and stability of production. Thus, the main reason for the

assessment of the water bodies in the environment has been, traditionally, the need to verify whether the observed water quality is suitable for intended use (Ali *et al.,* 2019).

Therefore, it is most essential and important to establish levels of heavy metals in the different water bodies being used for domestic purposes around the iron smelting industry.

Materials and Methods

Sampling

The study was carried out on a stream, three ponds, and two wells located within the vicinity of the Iron-smelting industry in Ikirun, Ifelodun Local Government Area of Osun State. A total of 72 water samples and 60 sediment samples were collected from seven sampling points along the stream, two sampling points from two hand-dug wells, and three sampling points from three ponds every two months for the period of one year. Sediment samples were collected from all water sampling points except the wells. The sampling points were randomly selected within a radius of 2.4km from the iron-smelting industry (Figure 1 and Table 1). Sampling was conducted bimonthly cutting through the wet and dry seasons of a whole year. Heavy metals analysis was carried out using atomic absorption spectrophotometer (APHA, 1995).

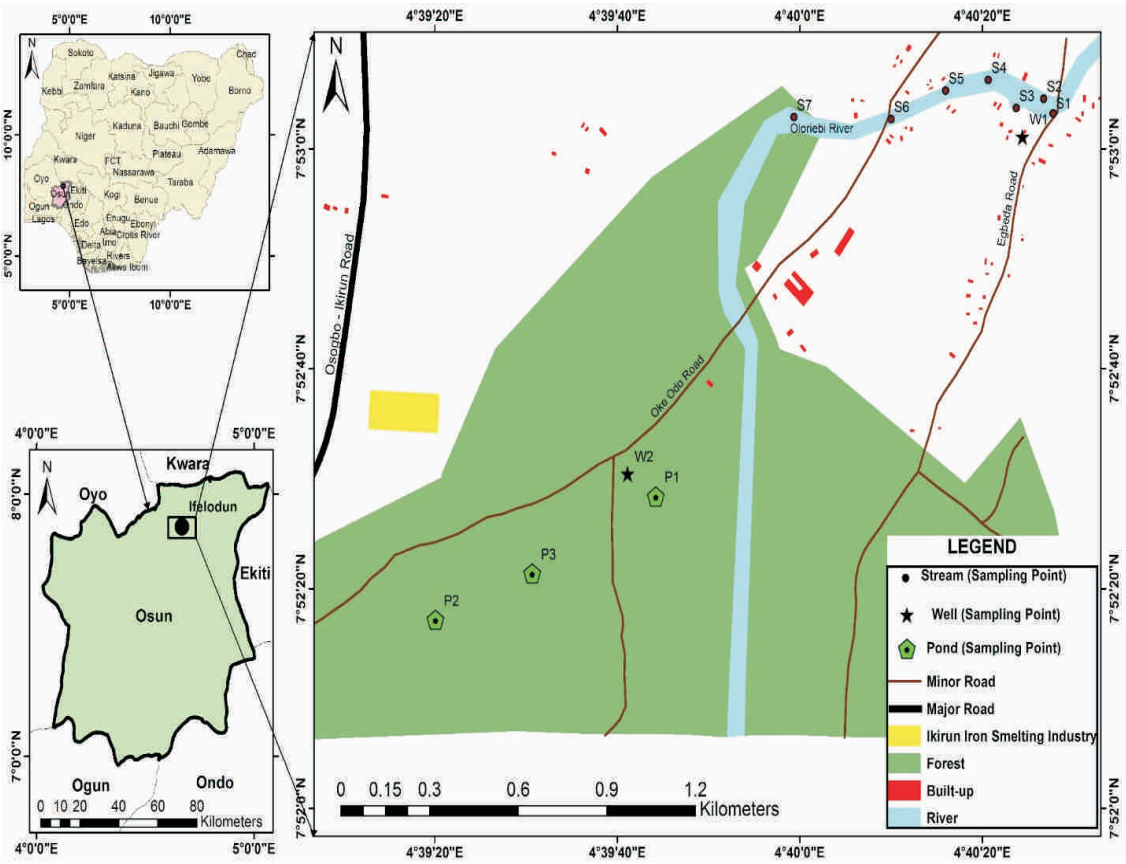

Figure 1: Location of Sampling Points in Ifelodun Local Government Area of Osun State

Table 1: The Geographical Locations of the Sampling Stations

S/N	Sampling points	Grid Co-ordinates		Elevation (m)	Distance from Ikirun Iron smelting industry (km)
		Northing	Easting		
1	Olori-ebi stream 1	7.884220°	4.674370°	395	2.37
2	Olori-ebi stream 2	7.884596°	4.674087°	388	2.33
3	Olori-ebi stream 3	7.884360°	4.673250°	383	2.25
4	Olori-ebi stream 4	7.885070°	4.672400°	385	2.18
5	Olori-ebi stream 5	7.884800°	4.671100°	386	2.05
6	Olori-ebi stream 6	7.884080°	4.669440°	380	1.83
7	Olori-ebi stream 7	7.884130°	4.666480°	377	1.57
8	Well 1	7.883633°	4.673438°	392	2.23
9	Well 2	7.875120°	4.661418°	380	0.78
10	Pond 1	7.874550°	4.662280°	378	0.88
11	Pond 2	7.871430°	4.655570°	388	0.58
12	Pond 3	7.872604°	4.658519°	392	0.63

Digestion of Sediments Samples

The samples collected were air dried and later grounded with mortar and pestle. Then the samples were sieved using a sieve (aperture 63 μm). One gram (1g) of the dried, ground lower particle size fraction of the sediment sample was weighed accurately into a clean beaker; 20ml HF was added and heated to near dryness, 15 ml of HNO_3 was then added and heated again to mop up the residue. On near dryness, it was allowed to cool, 20ml distilled water was added to boil off the acid. After boiling to one-third its volume, the sample was allowed to cool and filtered. The filtrate was made up to 50ml mark in a volumetric flask with distilled water. Determination of metals was then carried out on the digested solution.

Analysis of Water and Sediment Samples

For complete digestion, 2.5ml of Nitric acid (HNO_3) and 2.5ml of perchloric acid ($HClO_4$) solution were added to 100ml of sample and heated in a water bath at 100°C for 30 minutes. The sample was then allowed to cool and filtered to remove residue and the filtrate was made up to 100ml using double distilled water. Afterwards, the sample was analysed for each heavy metal (Pb, Cd, Fe, As, and Zn) using the Atomic Absorption Spectrophotometer (AAS) (200A Model) at Centre for Energy Research and Development, Obafemi Awolowo University, Ile-Ife. Blank (distilled water) was also analysed using the same procedure (APHA, 1995).

Statistical Analysis of Data

All the data obtained were subjected to statistical methods using SPSS (Statistical Package for Social Scientists). The statistical methods include descriptive statistics, one-Way Analysis of Variance (ANOVA), paired T-Test, and regression analysis. All statistical analysis were conducted at $P < 0.05$.

Results and Discussion

Heavy metals content in water samples

The mean concentration of heavy metals in the water samples collected from the sampling points

and the seasonal variations in the mean concentrations of selected metal ions of surface and ground water collected are shown in Tables 2 and 3 respectively, while the comparison of heavy metals values with Nigeria and International standards for water quality is presented in Table 4. The results of the selected heavy metals show no significant difference among the sampling locations as presented in Table 2. This could imply that the water bodies are exposed to the same environment loading of metals. The concentration range of arsenic obtained during the sampling period was 0.003 – 0.018mg/L and the mean concentration of arsenic (As) throughout the sampling locations was (0.01±0.00) mg/L. The concentration range of lead obtained during the sampling period was 0.003 – 0.023mg/L and the mean concentration of lead (Pb) throughout the sampling locations was 0.01±0.00 mg/L (Table 2). The mean concentrations of both Pb and As are slightly above the NIS and WHO standards of 0.01mg/L (Table 4) (Saiful *et al*., 2015). Also, the concentration range of cadmium (Cd) obtained during the sampling period was 0.004 – 0.027mg/L and the mean concentration of cadmium throughout the sampling locations was 0.02±0.00 mg/L which is above both WHO and NIS limits of 0.003 mg/L (Table 4). The concentration range of Zinc (Zn) obtained during the sampling period was 0.033 – 0.219mg/L and the mean concentration is high (0.13±0.04 mg/L) in Well 1 and lowest (0.08±0.01) mg/Lin in Pond 1 within the sampling locations (Table 2). The concentration range of Iron (Fe) obtained during the sampling period was 0.088 – 0.209mg/L and the mean concentration was high (0.18±0.005 mg/L) in Well 2 and lowest in Pond 1 (0.15±0.02 mg/L) (Table 2). The mean values of Iron (Fe) were significantly different ($P<0.05$) between the seasons in surface water but not significantly different in ground water. The mean concentration of Fe was highest in dry season (0.19±0.02) and lowest in wet season (0.12±0.00) in surface water (Table 3). The high range values of Zn and Fe compared with other heavy metals observed could be as a result of the emission from the nearby Iron Smelting Plant in the study area which is precipitated by rainfall (Owoade *et al*., 2015; Ogundele *et al*., 2017) among other factors that could be associated to soil formation from weathering of different parent rocks (Owoade *et al*., 2014; Nwineewii and Edem, 2014; Okoya *et al*., 2010).

Table 2: The Mean (± SE) Concentration of Heavy Metals in the Water Samples Collected from the Sampling Points

Heavy Metals	F value	P value	STREAM			POND 1			POND 2			POND 3			WELL 1			WELL 2		
			mean±SE	min	max	mean±SE	min	max	mean±SE	min	max	mean±SE	min	Max	mean±SE	min	max	mean±SE	min
Pb (mg/L)	0.58	0.71	0.01±0.00	0.010	0.013	0.02±0.00	0.006	0.023	0.01±0.00	0.003	0.021	0.01±0.00	0.006	0.016	0.01±0.00	0.008	0.017	0.01±0.00	0.003
Cd (mg/L)	0.21	0.96	0.02±0.002	0.008	0.025	0.02±0.00	0.006	0.021	0.02±0.00	0.004	0.023	0.01 ±0.00	0.007	0.02	0.02±0.00	0.009	0.026	0.02±0.00	0.007
Fe (mg/L)	0.54	0.75	0.17±0.01	0.106	0.205	0.15±0.02	0.097	0.209	0.16±0.02	0.088	0.216	0.17±0.01	0.145	0.206	0.18±0.00	0.164	0.192	0.15±0.01	0.12
Zn (mg/L)	0.39	0.85	0.09±0.02	0.175	0.420	0.08±0.01	0.037	0.121	0.10±0.03	0.036	0.204	0.10±0.03	0.04	0.192	0.13±0.03	0.036	0.219	0.09±0.02	0.033
As (mg/L)	0.16	0.98	0.01±0.00	0.008	0.014	0.01±0.00	0.006	0.018	0.01±0.00	0.003	0.027	0.01±0.00	0.005	0.018	0.01±0.00	0.008	0.015	0.01±0.00	0.005

NB: Using sig 0.01 and 0.05 (99% and 95% confidence), values below 0.01 are very significant, values below 0.05 are significant, values above 0.05 are not significant. Max=maximum value of concentration; Min=minimum value of concentration; SE=standard error

Table 3: Seasonal Variations in the Mean (± SE) Concentrations of Selected Metals in the Surface Water and Groundwater

Metals	Surface water										Groundwater					
	P value	T value	Stream		Pond 1		Pond 2		Pond 3		Well 1		Well 2		T value	P value
			Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet		
Pb	0.43	0.91	0.01 ±0.00	0.01 ±0.00	0.02 ±0.00	0.01 ±0.00	0.01 ±0.01	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	0.01 ±0.01	0.01 ±0.00	0.099	0.93
Cd	0.681	0.454	0.02 ±0.00	0.02 ±0.00	0.02 ±0.00	0.02 ±0.00	0.02 ±0.01	0.02 ±0.00	0.01 ±0.00	0.02 ±0.00	0.01 ±0.01	0.02 ±0.00	0.01 ±0.01	0.02 ±0.00	3.638	0.068
Fe	0.011	5.653	0.19 ±0.00	0.15 ±0.00	0.17 ±0.03	0.12 ±0.00	0.18 ±0.02	0.14 ±0.00	0.18 ±0.02	0.16 ±0.00	0.18 ±0.00	0.18 ±0.00	0.15 ±0.03	0.16 ±0.00	0.159	0.888
Zn	0.204	1.617	0.07 ±0.00	0.12 ±0.00	0.08 ±0.02	0.08 ±0.00	0.10 ±0.05	0.10 ±0.00	0.06 ±0.01	0.14 ±0.00	0.11 ±0.06	0.14 ±0.00	0.07 ±0.03	0.10 ±0.00	0.872	0.475
As	0.903	0.133	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	0.01 ±0.01	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	0.00 ±0.00	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	1.054	0.402

NB: Using sig 0.01 and 0.05 (99% and 95% confidence), values below 0.01 are very significant, values below 0.05 are significant, Values above 0.05 are not significant

Table 4: Comparison of Heavy Metals Concentrations in Water Samples within Nigeria and International Standards

Parameters	Stream	Pond 1	Pond 2	Pond 3	Well 1	Well 2	W.H.O. Standard	NIS Standard
Pb (mg/L)	0.01 ± 0.00	0.016 ± 0.00	0.011 ± 0.00	0.011 ± 0.00	0.013 ± 0.00	0.012 ± 0.00	0.01	0.01
Cd (mg/L)	0.016 ± 0.0026	0.017 ± 0.00	0.015 ± 0.00	0.014 ± 0.00	0.017 ± 0.00	0.016 ± 0.00	0.003	0.003
As (mg/L)	0.012 ± 0.00	0.012 ± 0.00	0.012 ± 0.00	0.011 ± 0.00	0.011 ± 0.00	0.011 ± 0.00	0.01	0.01
Zn (mg/L)	0.097 ± 0.01	0.082 ± 0.01	0.099 ± 0.03	0.102 ± 0.03	0.125 ± 0.03	0.085 ± 0.02	3	3
Fe (mg/L)	0.169 ± 0.02	0.147 ± 0.02	0.160 ± 0.02	0.168 ± 0.01	0.177 ± 0.00	0.152 ± 0.01	0.3	0.3

Heavy Metals Content in Sediment Samples

Table 5 shows the mean concentration of physico-chemical parameters of sediment samples in the study area while Table 6 shows the seasonal variation in the mean concentration of physico-chemical parameters of sediment samples in the study area. Cadmium, Lead, and Arsenic values in this study ranged from 0.011 – 0.109 mg/kg, 0.012 – 0.101 mg/kg and 0.008 – 0.12 mg/kg respectively. The mean concentration value of Cd is highest in the stream (0.056±0.011) mg/kg and lowest in Pond 1 (0.027±0.007) mg/kg while the mean concentration value of Pb is highest in Pond 2 (0.031±0.014) mg/kg and lowest in Pond 3 (0.020±0.003) mg/kg and the mean concentration value of As is highest in Pond 1 (0.058±0.028) mg/kg and lowest in the stream (0.054±0.019) mg/kg within the sampling location (Table 5). The values of Zinc and Iron obtained from this study are a bit higher than other heavy metals analysed and ranged from 0.067 – 0.521 mg/kg and 0.017 – 0.21 mg/kg respectively. The mean concentration value of Zn was the highest in Pond 2 (0.255±0.064 mg/kg) and lowest in Pond 1 (0.217±0.072mg/kg). The mean concentration of Fe is highest in Pond 1 (0.120±0.032 mg/kg) and lowest in Pond 3 (0.106±0.037 mg/kg) (Table 5). The high concentration for Fe in the sediment observed in this study is in accordance with the high concentration of Fe in soil observed by Olayiwola (2013). The similarities in the trend suggest some level of relationship in the run-off of soil to the water bodies. The heavy metals elemental concentration in sediments are in the decreasing order of Zn > Fe > As > Pb > Cd in dry season and Zn > Fe > Pb > As > Cd in wet season. This is in agreement with the result of Olayiwola (2013) in the study of accumulation of heavy metals in soil and vegetation around the same study area. The observed concentration of heavy metals in sediments is higher in the dry season than in the wet season in all sampling locations in this study. This could be because of low volume of water available to react with deposited metals in sediment during dry season.

Table 5: Mean (± SE) concentration of physico-chemical parameters for sediment samples

Parameters	STREAM	POND 1	POND 2	POND 3
Cadmium (mg/kg)	0.056±0.011	0.027±0.007	0.040±0.008	0.043±0.015
Lead(Pb) (mg/kg)	0.023±0.006	0.028±0.016	0.031±0.014	0.020±0.003
Iron (Fe) (mg/kg)	0.116±0.033	0.120±0.032	0.112±0.021	0.106±0.037
Zinc (Zn) (mg/kg)	0.238±0.067	0.217±0.072	0.255±0.064	0.243±0.071
Arsenic(As) (mg/kg)	0.054±0.019	0.058±0.028	0.056±0.020	0.056±0.022
F- value	0.453	0.738	0.901	0.736
P- value	0.81	0.533	0.483	0.598

NB: Using sig 0.01 and 0.05 (99% and 95% confidence), values below 0.01 are very significant, values below 0.05 are significant, values above 0.05 are not significant.
Max = maximum value of concentration; Min = minimum value of concentration; SE = standard error.

Table 6: Seasonal Variations in the Mean (± SE) Concentrations of the physico-chemical parameters for sediment samples in Ikirun Environs

	Wet Season						Dry Season			
Metals	P value	T value	Stream	Pond 1	Pond 2	Pond 3	Stream	Pond 1	Pond 2	Pond 3
Pb	0.83	-0.228	0.05±0.00	0.01±0.00	0.05±0.00	0.05±0.00	0.05±0.00	0.03±0.00	0.03±0.00	0.035±0.00
Cd	0.03	4.012	0.02±0.00	0.01±0.00	0.02±0.00	0.02±0.00	0.04±0.06	0.03±0.00	0.05±0.00	0.023±0.00
Fe	0.01	6.32	0.09±0.00	0.07±0.00	0.10±0.00	0.08±0.00	0.14±0.05	0.14±0.00	0.13±0.00	0.129±0.00
Zn	0.05	3.178	0.23±0.00	0.08±0.00	0.17±0.00	0.17±0.00	0.24±0.06	0.26±0.00	0.34±0.00	0.314±0.00
As	0.01	6.265	0.04±0.00	0.01±0.00	0.03±0.00	0.04±0.00	0.07±0.03	0.07±0.00	0.08±0.00	0.77±0.00

NB: Using sig 0.01 and 0.05 (99% and 95% confidence), values below 0.01 are very significant, values below 0.05 are significant, values above 0.05 are not significant

The mean values obtained from Cd, As, and Fe in dry and wet seasons are significantly different ($P<0.05$). The mean concentration of Fe, Cd and As in sediment are also highest in the dry season (0.138±0.05, 0.046±0.00 and 0.078±0.00 mg/kg respectively) and lowest in the wet season (0.066±0.0019, 0.012±0.0013 and 0.009±0.00 mg/kg respectively) (Table 6).

The concentration of most heavy metals in this study is discovered to be significantly low in sediment during the wet season than in the dry season. This could be because of constant mixing of water by the rain during wet season which could hinder transport and re-suspension of these metals in the sediment thereby reducing their concentration during the wet season.

Comparison of the Physico-chemical Parameters in Water and Sediment Samples

Tables 7 and 8 revealed the correlation in the mean concentration values of the selected physico-chemical parameters values obtained from water and sediment samples in wet and dry season respectively. The mean values of Fe were higher in water than in sediment throughout the sampling period (Tables 7 and 8). Meanwhile, the mean values of Cd, Pb, Zn, and As were all higher in sediment throughout the sampling period (Tables 7 and 8). Odoemelam *et al.,* (2013) also recorded high load of metals in sediments than in water in a similar study outside smelting site and ascribed this to the fact that sediment acts as sink for metals and some other pollutants.

The higher concentration of heavy metals in sediments may be because of the occurrence of complex patterns of transport, deposition and re-suspension of sediments and the process of sorption and desorption. Therefore, settled sediments may frequently remove a considerable fraction of some heavy metals and cause reduction in concentration of these heavy metals in water (Omale *et al.,* 2014).

Table 7: Comparison of selected Metals Concentration of Water and Sediment Samples in Wet Season

Metals	P value	R value	Stream		Pond 1		Pond 2		Pond 3	
			Sediment mg/Kg	Water mg/L	Sediment mg/Kg	Water mg/L	Sediment mg/Kg	Water mg/L	Sediment mg/Kg	Water mg/Kg
Pb	0.198	0.802	0.051 ±0.00	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	0.047 ±0.0004	0.01 ±0.00	0.05 ±0.00	0.01 ±0.00
Cd	0.508	0.492	0.02 ±0.00	0.02 ±0.00	0.01 ±0.00	0.02 ±0.00	0.015 ±0.0010	0.02 ±0.00	0.02 ±0.00	0.02 ±0.00
Fe	0.479	0.521	0.09 ±0.00	0.19 ±0.02	0.07 ±0.00	0.12 ±0.00	0.095 ±0.0008	0.14 ±0.00	0.08 ±0.00	0.16 ±0.00
Zn	0.61	0.39	0.23 ±0.00	0.07 ±0.02	0.08 ±0.00	0.08 ±0.00	0.172 ±0.0009	0.10 ±0.00	0.17 ±0.00	0.14 ±0.00
As	0.375	0.625	0.04 ±0.00	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	0.033 ±0.0007	0.01 ±0.00	0.04 ±0.00	0.01 ±0.00

NB: Using sig 0.01 and 0.05 (99% and 95% confidence), values below 0.01 are very significant, values below 0.05 are significant, values above 0.05 are not significant.

Table 8: Comparison of selected Metals Concentration of Water and Sediment Samples in Dry Season

Metals	P value	R value	Stream		Pond 1		Pond 2		Pond 3	
			Sediment mg/Kg	Water mg/L	Sediment mg/Kg	Water mg/L	Sediment mg/Kg	Water mg/L	Sediment mg/Kg	Water mg/Kg
Pb	0.492	0.508	0.05±0.00	0.01±0.00	0.03±0.00	0.02±0.00	0.03±0.00	0.01±0.01	0.04±0.00	0.01±0.00
Cd	0.516	0.484	0.04±0.06	0.02±0.00	0.03±0.00	0.02±0.00	0.05±0.00	0.02±0.01	0.02±0.00	0.01±0.00
Fe	1	0	0.14±0.05	0.19±0.02	0.14±0.00	0.17±0.03	0.13±0.00	0.18±0.02	0.13±0.00	0.18±0.02
Zn	0.469	0.531	0.24±0.06	0.07±0.02	0.26±0.00	0.08±0.02	0.34±0.00	0.10±0.05	0.31±0.00	0.06±0.01
As	0.361	0.639	0.07±0.03	0.01±0.00	0.07±0.00	0.01±0.00	0.08±0.00	0.01±0.01	0.77±0.00	0.01±0.00

NB: Using sig 0.01 and 0.05 (99% and 95% confidence), values below 0.01 are very significant, values below 0.05 are significant, values above 0.05 are not significant

However, heavy metals such as Pb and As showed strong correlation between water and sediment samples in both dry and wet seasons. Fe showed strong correlation between water and sediment samples in the wet season while Zn showed strong correlation between water and sediment in the dry season (Tables 7 and 8).

Conclusion

This study has been able to document the quality of water in water bodies around Ikirun Iron-Smelting Plant. The detected levels of heavy metals like cadmium, lead and arsenic are above national and international guidelines. The concentrations of most heavy metals in this study were found to be significantly low in sediment during the wet season than in the dry season. However, heavy metals such as Pb and As showed strong correlation between water and sediment samples in both dry and wet seasons respectively. Whereas, Fe showed strong correlation between water and sediment samples in the wet season while Zn showed strong correlation between water and sediment in the dry season. High heavy metal loads were also recorded in sediments than in water. If this persists, it could lead to an overly polluted river which will be severe for aquatic life and extremely harmful for human use. The study concluded that the water bodies around the iron-smelting industry have high heavy metal contents above the regulatory standards and the water could not be recommended for drinking purpose.

References

Alao, O., Arojojoye, O., Ogunlaja, O., and A. Famuyiwa (2010). "Impact assessment of brewery effluent on water quality in Majawe, Ibadan, South-western Nigeria," *Researcher,* Vol. 2, No. 5, pp. 21-28.

Ali, H., Khan, E., and I. Ilahi (2019). "Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation," *Journal of Chemistry,* Vol. 2019, pp. 1 - 14.

Al-Khashman, O. A. (2004). "Heavy metal distribution in dust, street dust and soils from the work place in Karak Industrial Estate, Jordan," *Atmospheric Environment,* Vol. 38, pp. 6803–6812.

American Public Health Association, (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF) (1995). Standard methods for the examination of water and wastewater. 20 Edition, 1220pp.

Amir, H. B. and F. Mohammad (2019). "The potential risk of heavy metals on human health due to the daily consumption of vegetables," *Environmental Health Engineering and Management Journal,* Vol. 6, No. 1, pp. 11–16.

Evelyn, M. I. and T. T. Tyav (2013). "Environmental pollution in Nigeria: the need for awareness creation for sustainable development," *Journal of Research in Forestry, Wildlife and Environment*, Vol. 4, No. 2, pp. 98 – 106.

Ipeaiyeda, A. R., N., Umo, S., and G. E. Okojevoh (2012). "Environmental Pollution Induced by an Aluminium Smelting Plant in Nigeria," *Global Journal of Science Frontier Research,* Vol. 12, Issue 1, pp. 59 - 72.

Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B. B., and K. N. Beeregowda (2014). "Toxicity, mechanism and health effects of some heavy metals," *Interdisciplinary Toxicology,* Vol. 7, No. 2, pp. 60–72.

Manoj, K. T., Bajpai, S., and U. K. Dewangan (2016). "Air and Leaching Pollution Scenario by Iron and Steel Plants, in central India," *Elixir Pollution,* Vol. 101, pp. 44011 -44017.

Md Saiful, I., Md Kawser, A., Mohammad, R., Md Habibullah -Al- Mamun., and K. I. Muhammad (2015). "Heavy metal pollution in surface water and sediment: A preliminary assessment of an urban river in a developing country," *Ecological Indicators,* Vol. 48, pp. 282–291.

Momodu, M. A. and C. A. Anyakora (2010). "Heavy Metal Contamination of Ground Water: The Surulere Case Study," *Research Journal Environmental and Earth Sciences,* Vol. 2, No. 1, pp. 39-43.

Nigerian Industrial Standard (2007). "Nigerian Standard for Drinking Water Quality", Standards Organisation of Nigeria, NIS554:2007, ICS 13.060.20, 15-19.

Nwineewii, J. D. and Edem, C. A (2014). "Determination and Toxicological Effects of Some Heavy Metals in Surface Water from the Niger Delta, Nigeria." *IOSR Journal of Applied Chemistry* (IOSR-JAC), Vol 7, Issue 5 Ver. I., pp 32-36 DOI: 10.9790/5736-07513236.

Odoemelam, S. A., Okorie, D. O., and I. O. Oko (2013). "Physicochemical parameters and heavy metal content of water, fish and sediments from Cross River at Afikpo North Local Government Area of Ebonyi State, Nigeria," *Bioresearch Bulletin,* pp. 010-015.

Ogundele, L. T., Owoade, O. K., Hopke, P. K., and Olise, F. S (2017). "*Heavy metals in industrially emitted particulate matter in Ile-Ife, Nigeria." Environmental Research, Vol. 156, pp 320–325.* doi:10.1016/j.envres.2017.03.051.

Okoya, A. A., Elufowoju, M. A., Adepoju, K. A., and Akinyele, A. B. (2020). "Seasonal assessment of the physico-chemical properties of surface water and sediments in the vicinity of a scrap metal recycling industry in Southwestern Nigeria." *Journal of Environmental Chemistry and Ecotoxicology,* Vol. 12, No. 1, pp. 24–31. doi:10.5897/jece2019.0458

Olayiwola, O. A. (2013). "Accumulation and contamination of heavy metals in soil and vegetation from industrial area of Ikirun, Osun State, Nigeria," *Global Journal of Pure and Applied Chemistry Research,* Vol. 1, No. 1, pp. 25-34.

Omale, P. E., Okeniyi, S. O., Faruruwa, M. D., and A. B. Ngokat (2014). "Determination for levels of radionuclides of uranium, thorium and potassium in water, sediments and algae samples from selected coastal areas of Lagos, Nigeria; using energy dispersive x-ray fluorescence," *Global Journal of Pure and Applied Chemistry Research*, Vol. 2, No. 1, pp. 1-24.

Owoade, K. O., Hopke, P. K., Olise, F. S., Ogundele, L. T., Fawole, O. G., Olaniyi, H. B.,Jegede, O. O., Ayoola, M. A. and Bashiru, M. I (2015). "Chemical compositions and source identification of particulate matter (PM 2.5and PM 2.5-10) from a scrap iron and steel smelting industry along the Ife-Ibadan highway, Nigeria." Atmos. Pollut. Res. Vol. 6, pp. 107–119.

Owoade, O. K., Awotoye, O. O., and Salami, O. O. (2014). "Ecological vulnerability: seasonal and spatial

assessment of trace metals in soils and plants in the vicinity of a scrap metal recycling factory in Southwestern Nigeria." Environmental Monitoring and Assessment, Vol. 186, No.10, pp. 6879–6888. doi:10.1007/s10661-014-3896-1.

Patil, P. N., Sawant, D. V., and R. N. Deshmukh (2012). "Physico-chemical parameters for testing of water – A review," *International Journal of Environmental Sciences, Vol.* 3, No. 3, pp. 141-150.

World Health Organization (WHO), (2006). Guidelines for Drinking water. 1st Addendum to 3rd Edition. Recommendations, Geneva, pp. 254.

Okoya, A. A., Awofisayo, O. F., Oginni, O. A. and Akinyele, A. B.
© *African Journal of Environmental Health Sciences*
Volume 7, November, 2020
ISSN: 2476-8030 (Prints)
ISSN: 2714-2930 (Online)
pp 57-66