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Seasonal Evaluation of Groundwater Quality and Radiometric Parameters Around the Igbenre-Ekotedo Dumpsite in Ota, South-West, Nigeria

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Abstract
This study was carried out in response to public concerns on the status of groundwater tapped from boreholes by some residents around the study area. The area was also assessed for its radiometric status. Water samples were obtained from nine (9) sampling points around the dumpsite to determine their physicochemical parameters. Analysis of the water samples carried out in May 2018, and March 2019 indicated that TDS, EC, hardness, Ca^{2+}, Mg^{2+}, pH, Fe, Mn, Cl^-, NO_3^- around the western part of the dumpsite were higher when compared with WHO, 2007 benchmark. Leachates from the dumpsite could have been responsible for these high values. In terms of seasonal variation of the measured parameters, the values obtained for the dry season were relatively higher than those obtained during the rainy season. The depths of boreholes around the western part where contamination was inferred are within 30 m to 40 m. Therefore, borehole location for water in the future should target deeper aquifers to avoid being contaminated, and attention must be given to water treatment during the dry season. The mean annual radiation level for all the profiles were41.11 $\mu Svyr^{-1}$, 44.73 $\mu Svyr^{-1}$, 36.81 μSvy^{-1}, 45.00 $\mu Svyr^{-1}$, 16.16 $\mu Svyr^{-1}$ and 19.69 $\mu Svyr^{-1}$ respectively. The results of the radiation emission study showed that the general average absorbed dose rate measured on the dumpsite did not surpass the minimum radiation level of 70 $\mu Svyr^{-1}$ as prescribed by UNESCO on the effect of Atomic Radiation. Therefore, the dumpsite does not pose any radiometric threat to the inhabitants of the community.

Keywords: *Contamination, Dumpsite, Physicochemical, Groundwater, Radiation.*

Introduction

The Igbenre Ekotedo dumpsite is the main dumpsite in Ota Ogun State, where waste materials generated from the entire Ota city are deposited. The Local Authority did not design the dumpsite for this purpose, but rather indiscriminate dumping started in this area, which was initially a jungle. With expansion resulting from the influx of people from the already congested Lagos State, development in terms of building led to communities currently surrounding the dumpsite. The adverse effect and the impact on the community cannot be overemphasized. The amount of atmospheric pollution emanating from the constant burning of waste by scavengers is enormous, while recent concerns arising from contamination of water from borehole around some part of the community has also increased. Contaminants associated with groundwater around such an area are products of leachates resulting from the decomposition of the biodegradable components of waste materials on the dumpsite. To appreciate the gravity of the challenge associated with the community, this study was designed to investigate the extent of the impact of the contaminants on the subsurface environment.

In dumpsites that are not constructed according to international standard (without liners), leachates that are formed within the waste materials eventually find their way into the subsurface environment, where they contaminate groundwater bodies (Ameloko *et al.,* 2018a). Typical dumpsite leachates are characterized by highly concentrated complex effluents and composed of dissolved organic matters; inorganic compounds, such as ammonium, Ca^{2+}, Mg^{2+}, Na^+, K^+, Fe, SO_4^{2-}, Cl^- and heavy metals such as Cd, Cr, Cu, Pb, Ni, Zn among others (Nakhaei *et al.,* 2015). Excess concentration of these elements may be found in groundwater below the Igbenre Ekotedo dumpsite. As a result of lateral migration, the groundwater may have them moved away from the source, and they spread to contaminate groundwater aquifers. The primary source of water for the entire city is borehole, and many residents in the study area have recently raised the alarm on the contamination of water produced from their borehole.

Hazards associated with dumpsites are not only in terms of the presence of disease-causing micro-organism and odour, but also danger can occur from the radioactive emission from such dumpsite (Ojoawo *et al.,* 2011). Outcomes from previous research work revealed that radioactivity measurement around waste sites had shown the existence of traces of radionuclide in books (Imtiaz *et al.,* 2005) and in food materials consumed in Nigeria (Eyebiokin *et al.,* 2005, Jibiri *et al.,* 2010). It has also been revealed from previous research that vegetation (in the forests and around the environment) in Nigeria shows traces of radionuclides (Akinloye and Olomo, 2005). All these are found in the household waste materials which are indiscriminately dumped on waste sites (Ojoawo *et al.,* 2011). Other radiometric studies carried out around landfills in Nigeria include the works of Obed *et al.,* (2005), Ademola, (2008), Ademola *et al.,* (2014), Avwiri and Olatubosun, (2014).

The aim of the research, therefore, is to carry out physio-chemical analysis on water samples from selected boreholes around the area to ascertain the quality of water being consumed by residents of the community and to evaluate the seasonal variation of the quality of groundwater. In addition to this, the current status of the site's radiometric parameters was investigated to ascertain its potential health implication.

The study Area

The Igbenre Ekotedo dumpsite is located in Ota, along the Sango-Idiroko road (Figs. 1 and 2). It is about 800 m away from the High Court's major express road, opposite Nestle Company. The dumpsite is bounded by residential buildings and a very deep gulley. Currently, waste is indiscriminately being dumped on the ground surface, without any compaction effort in the site, and all the waste piles usually undergo some degree of massive burning.

Geologically, the study location falls within the Nigerian (Southwestern) section of the Eastern Dahomey Basin (Fig. 3). Through the availability of boreholes and recent road cuts a lot of information about the basin came to the fore after detailed borehole study was carried out by previous workers. The main lithostratigraphic units associated with the Basin are Abeokuta Formations (Ise, Afowo and Araromi Formations), and Ewekoro, Akinbo, Oshoshun, Ilaro and Benin Formations (Ehinola *et al.,* 2016).

Fig. 1: Water sample data acquisition map of the Igbenre Ekotedo dumpsite

Materials and methods

To ascertain the level of influence of the contaminants emanating from the waste site on the water-bearing aquifer units around the study area, nine (9) borehole water samples obtained around the community were analyzed to determine their hydrophysical content (TDS, pH values, hardness, and electrical conductivity). The water samples were obtained in a plastic bowl, and their characteristics were measured in place, with the

Fig. 2: Pictorial view of Igbere Eko-tedo dumpsite, Ota.

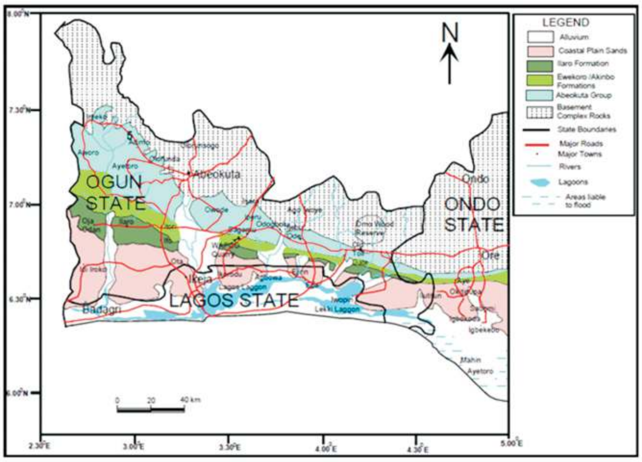

Fig. 3: Map of eastern Dahomey Basin showing the Geological setting (modified after Jones and Hockey, 1964)

help of a portable TDS/EC measuring instrument. The trace elements and the heavy metal composition of the water samples were analyzed in the Chemistry Department of the University of Lagos, deploying standard methods for the examination of water and wastewater quality (APHA, 1998). The water samples were analyzed in May 2018 (rainy season) and March 2019 (dry season).

The radiation data acquisition map of the dumpsite investigated is shown in Fig. 1. Six profiles were occupied on and around the waste site, at various intervals to a maximum of 260 meters. Two radiometric survey traverses were recorded at about 15 m intervals on the waste site, while four other profiles measured at varying distances from the waste site served as the reference profiles (Fig. 1). The measuring instrument used for the study was a simple hand-held, well-calibrated Radiometric Spectrometer (Model BG0-Super-SPEC RS 230). To enable measurements to reflect their original environmental characteristics, an in-place data collection approach of background radiation measurement was adopted in this survey.

GPS Channel 76 model Global Positioning System instrument was used to measure coordinates of the sampling points (Ameloko and Ayolabi, 2018b). The values of the observed TDS and EC were interpolated using the ArcGIS software to produce the subsurface spatial distribution maps of the area

Results and discussion

Physical parameters of groundwater

The results of the physicochemical parameters of groundwater obtained from the study are presented in Tables 1, 2, and 3. From Table 1, TDS concentration in water samples collected around the site ranged from 8 mg/L to 692 mg/L in the wet season and 15 mg/L to 731 mg/L in the dry season. The mean concentration of TDS at the site in 2018 increased from 125.89 mg/L to 195.33 mg/L in 2019, with a difference of 69.44 (55.16 %). When the WHO, (2007) prescribed limit of 500 mg/L for drinking water was compared with measured TDS values obtained from the wet and dry seasons from all sampled points, the results indicate that only well location BH 43 exceeded the minimum standard for the wet season (11.11 % of the sampled points) in 2018 and elevated values at BH 44 and BH 45. On the other hand, locations BH 43 and BH 45 (i.e., 22.22 % of sampled locations) showed higher values from the dry season results (Fig. 4).

The values of EC around the site ranged from 15 µS/cm –1,385 µS/cm during the rainy season and 30 µS/cm - 1458 µS/cm in the dry season with mean concentration increasing from 252.33 µS/cm in 2018 to 388.11 µS/cm in 2019. The WHO (2007) prescribed limit of EC for drinking water is 1000 µS/cm. When compared with measured EC from all sampled locations around the study area, the results from both wet and dry seasons indicated EC also exceeded the standard limit in 11.11 % of the sampled points from the wet season study (BH 43), and at locations BH 43 and BH 45 (about 22.22 % of sampled locations) from the dry season investigation (Fig. 5). A strong correlation exists between the concentration of EC and the TDS.

The hardness of water samples around this site ranged from 10 mg/L to 212 mg/L in the wet season and 15 mg/L to 365 mg/L in the dry season. All the measured hardness values during the wet season were below the standard limit of 150 mg/L except at location BH 43 (about 11.11 %), while about 33.33 % of sampled location (BH 43, BH 45 and BH 47) exceeded the minimum standard during the dry condition. The mean concentration value of hardness increased from 77.44 mg/L in 2018 to 147.78 mg/L in 2019 (90.83 % change).

The more acidic groundwater is, the more its capacity to leach or dissolves solid materials. The WHO (2007) minimum standard of pH (6.5-8.5) for drinking water when compared with values obtained from all sampled positions during the wet and dry season surveys are presented in Table 1. All the pH values obtained were below the prescribed limit in both seasons. The mean concentration increased from 5.48 to 5.75 (4.93 % change), with values ranging from 4.52-6.01 in May 2018 and 5.2-6.25 in March 2019.

Trace elements and heavy metals Concentration in Groundwater Samples

Tables 2 and 3 provide both wet and dry season results of the elemental composition of groundwater samples analyzed around the study area. Ca^{2+} and Mg^{2+} concentrations in water samples obtained from all the selected locations have a mean concentration of 31.67 mg/L and 9.22 mg/L in 2018 and 59.23 mg/L and 21.63 mg/L in 2019, respectively. Comparing the WHO, (2007) standard of 50 mg/L for Ca^{2+} and 2.0 mg/L for Mg^{2+} for drinking water quality with the measured values from all locations, the results indicated that Ca^{2+} did not exceed the standard limit from the dry season investigation except at locations BH 43, BH 44, BH 45 and BH 47, while the rainy season investigation shows that Ca^{2+} concentration exceeded the standard limit at only location BH 43 (Fig. 6). Mg^{2+} concentration surpassed the permissible limit of 2.0 mg/L from the wet season survey at the sampled locations except at BH 47, while the dry season study showed that all investigated samples exceeded the standard limit. The measured K^+ values when compared with the WHO (2007) minimum standard of 1.0 mg/L -2.0 mg/L surpassed it at about 22.22 % of the sampled locations (BH 43 and BH 44) from the dry season investigation, while all values obtained during the rainy condition exceeded the permissible limit (Fig. 7). The measured values of Na^+ content in all sampled points during both rainy and dry season conditions decreased below the minimum WHO standard of 200 mg/L. The Cl^- concentration in all water samples were below the prescribed limit of 250 mg/L from both the dry and rainy season surveys (Fig. 8). The mean value of Cl^- concentration reduced in 2018 from 125.11 mg/L to 80.76 mg/L in 2019 (54.9 % change). The concentration of SO_4^{2-} ion in water samples exceeded the minimum standard (100-200 mg/L) set by WHO (2007) in about 11.11 % during the wet season investigation (at BH 46), but all sampled locations in the dry season were within the standard limit. The concentration of NO_3^- ions in water obtained during the rainy season were all below the standard set by WHO (10 mg/L). 66.7 % of NO_3^- ion concentration in water (at BH 42, BH 43, BH 44, BH 45, BH 46, and BH 49) in the dry condition however surpassed the WHO prescribed limit.

Table 3 provides both wet and dry season results of the heavy metal composition of groundwater samples analyzed around the study area. The concentration of Cr in water samples at the site did not exceed the WHO standard of 0.05 mg/L from both rainy and dry season investigations except at BH 43 (11.11 % of sampled locations). The concentration of Pb exceeded the WHO prescribed level of 0.01 mg/L at locations BH 46, BH 48 and BH 49, but within the limit at about 33.33 % of the locations (at BH 41, BH 45, and BH 47), and not detectable in the remaining locations from the wet season result. The dry season results however, indicated that Pb was not detectable from all the sampled locations. The mean concentration value of Cu reduced from 0.48 mg/L in the rainy season to 0.24 mg/L in the dry season while the WHO permissible level of 0.5 mg/L was surpassed in all measurement around the dumpsite except at BH 43, BH 44, BH 45 and BH 47 from the rainy season investigation while the prescribed level was not surpassed in all sampled points from the dry season measurements (Fig. 9). The concentration of Fe in all water samples investigated at the site surpassed the WHO minimum standard of 0.3 mg/L in the rainy season, while the dry season measurement showed that Fe did not exceed the standard at all sampled points. The mean concentration value of Fe reduced from 3.25 to 0.11 mg/L with an interval difference of 3.14 (2855 %), with values ranging from 2.39-4.5 in 2018 and 0.04-0.18 in 2019. The concentration of Zn in the investigated water samples around the site compared with the WHO standard limit of 5.0 mg/L was not surpassed in both rainy and dry seasons (Fig. 10). The measured Mn level in the water samples investigated during the rainy season was above the WHO prescribed limit of 0.5 mg/L. On the other hand, the standard limit was not surpassed in all the dry season samples (Fig. 11).

Spatial distribution maps of EC and TDS show that the South-western zone of the studied site is most likely more impacted by the leachate plume formed in the dumpsite and migrating with groundwater towards the south-western direction (Figs. 12 and 13).

Table 1: Wet and dry season results of hydrophysical content of groundwater around Igbenre Ekotedo dumpsite

	May 2018 results (Wet Season)				March 2019 results (Dry Season)		
Sample	Location	Coordinate	pH	Temp (°C)	EC (μS/cm)	TDS (ppm/mg/L)	Hardness (mg/L)
BH 41	Progress Lane	06°41′ 17.14″N 003° 12′ 01.15″E	5.47 5.94	25.2 31.4	60 101	29 50	85.0 15.0
BH 42	Samsom Abayomi Close	06°41′ 20.91″N 003° 12′ 04.56″E	5.18 5.52	25.2 31.5	23 72	11 36	75.0 45.0
BH 43	Adeyemo Street	06°41′ 26.48″N 003° 11′ 56.22″E	4.52 6.25	26.1 31.3	1385 1203	692 601	212.0 365.0
BH 44	Adeyemo Street (by sch.)	06°41′ 28.96″N 003° 11′ 55.25″E	6.01 6.24	25.6 31.3	353 418	175 211	75.0 130.0
BH 45	Quarter Street	06°41′ 31.48″N 003° 11′ 58.90″E	5.79 5.92	25.0 31.4	1272 1458	136 731	170.0 365.0
BH 46	Owolabi Street (Hill top)	06°41′ 34.31″N 003° 12′ 04.36″E	5.53 5.55	26.1 30.7	30 30	15 15	90.0 95.0
BH 47	Anuoluwapo Street	06°41′ 32.24″N 003° 12′ 07.58″E	5.27 5.52	24.4 30.8	15 74	8 47	10.0 165.0
BH 48	Igbenre Rd Onipan	06°41′ 23.38″N 003° 11′ 55.87″E	5.65 5.64	24.8 31.4	50 96	25 47	40.0 75.0
BH 49	Igbenre Rd Onipan	06°41′ 24.00″N 003° 11′ 54.60″E	5.95 5.20	24.0 31.4	83 41	42 20	40.0 75.0
Mean			5.48 5.75		252.33 388.11	125.89 195.33	77.44 147.78
Range			4.52-6.01 5.2-6.25		15-1385 30-1458	8-692 15-731	10-212 15-365
St. Dev.			0.46 0.36		441.36 550.53	220.51 275.12	56.72 130.65
Coef. Of Variation (%)			8.39 6.26		174.91 141.84	175.16 140.85	73.24 88.41
	WHO/SON Standard		6.5-8.5	-	1000	500	150

Table 2: Wet and dry season results of elemental content of groundwater around the Igbenre Ekotedo dumpsite

	May 2018 results (Wet Season)				March 2019 results (Dry Season)			
Samples	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	Cl^- (mg/L)	SO_4 (mg/L)	PO_4 (mg/L)	NO_3 (mg/L)
BH 41	34.72 6.01	12.38 2.19	2.67 1.88	7.04 12.67	159.53 35.45	38.0 62.0	40.6 1.43	2.2 8.3
BH 42	30.06 18.04	10.19 6.55	2.81 1.23	5.91 11.89	106.35 35.45	26.0 152.0	39.2 0.16	7.9 46.0
BH 43	89.97 146.29	13.11 54.12	2.57 2.91	7.02 14.08	159.53 248.2	45.0 160.0	10.8 0.75	1.9 11.50
BH 44	30.06 52.10	10.92 18.93	2.71 2.88	7.08 13.52	186.58 124.1	27.0 64.0	11.10 0.58	4.8 147.0
BH 45	28.07 146.29	10.19 53.15	2.31 1.90	6.04 10.69	106.35 53.18	11.0 88.0	32.40 0.21	6.7 66.0
BH 46	36.07 38.08	13.11 13.83	2.07 1.79	7.11 12.78	70.90 53.18	278.0 44.0	10.3 0.36	3.4 48.0
BH 47	4.01 66.13	1.46 24.03	2.94 1.44	5.82 10.96	88.63 53.18	125.0 70.0	22.4 0.24	6.2 7.0
BH 48	16.03 30.06	5.83 10.92	2.82 1.87	5.89 13.77	88.63 88.63	33.0 60.0	42.3 1.08	1.3 4.6
BH 49	16.03 30.06	5.83 10.92	2.56 1.89	6.71 12.90	159.53 35.45	22.0 70.0	38.5 1.18	2.8 19.5
Mean	31.67 59.23	9.22 21.63	2.61 1.98	6.51 12.58	125.11 80.76	67.22 85.55	27.51 0.67	4.13 39.77
Range	4.01-89.97 6.01-146.3	1.46-13.11 2.19-54.12	2.1-2.94 1.23-2.9	5.82-7.1 10.6-14	70.9-186.58 35.45-248.2	11-278 44-160	10.3-42 .16-1.43	1.3-7.9 4.6-147
St. Dev.	24.23 52.36	4.00 19.23	0.27 0.57	0.58 1.19	41.28 69.30	85.74 41.60	13.88 0.47	2.36 45.83
Coef. Of Variation	77 88.40	43 88.9	10 28.78	9 9.45	33 85.80	128 48.62	21 70.14	57 115.24
WHO/SON Standard	50	2.0	1.0-2.0	200	250	200/100	5.0	10

Table 3: Wet and dry season results of heavy metal content of groundwater around Igbenre Ekotedo dumpsite

May 2018 results (Wet Season) — March 2019 results (Dry Season)

Samples	Fe (mg/L)	Zn (mg/L)	Mn (mg/L)	Cu (mg/L)	Pb (mg/L)	Ni (mg/L)	Cr (mg/L)
BH 41	3.91	2.30	0.71	0.52	0.01	0.02	0.02
	0.18	1.62	0.02	0.19	ND	ND	0.05
BH 42	3.34	2.02	0.92	0.67	ND	0.02	0.01
	0.04	1.77	0.02	0.23	ND	0.002	0.05
BH 43	4.50	2.07	0.84	0.44	ND	0.02	0.02
	0.12	1.09	0.02	0.24	ND	0.006	0.09
BH 44	3.02	2.11	0.68	0.36	ND	0.02	0.01
	0.10	2.06	0.09	0.23	ND	0.005	0.03
BH 45	2.91	2.01	0.72	0.29	0.01	0.01	0.01
	0.10	2.31	0.03	0.22	ND	ND	0.04
BH 46	2.39	3.11	0.91	0.57	0.02	0.01	0.01
	0.06	2.70	0.03	0.31	ND	ND	0.03
BH 47	2.56	2.91	0.77	0.32	0.01	0.02	0.01
	0.16	2.14	0.03	0.41	ND	ND	0.02
BH 48	3.11	3.08	0.78	0.58	0.02	0.03	0.01
	0.06	2.67	0.02	0.28	ND	ND	0.02
BH 49	3.49	2.07	0.87	0.53	0.03	0.03	0.02
	0.18	2.11	0.04	0.09	ND	0.04	0.03
Mean	3.25	2.41	0.8	0.48	0.01	0.02	0.01
	0.11	2.05	0.03	0.24	-	0.013	0.04
Range	2.39-4.5	2.01-3.11	0.68-0.92	0.29-0.67	0-0.03	0.01-0.03	0.01-0.02
	0.04-0.18	1.09-2.7	0.02-0.09	0.09-0.41	-	.002-0.04	0.02-0.09
St. Dev.	0.66	0.48	0.09	0.13	0.01	0.007	0.005
	0.053	0.51	0.022	0.09	-	0.02	0.022
Coef. Of	20	20	11	27	1.0	35	5
Variation	48.18	24.9	73.3	37.5	-	153.8	55
WHO/SON Standard	0.3	5.0	0.5	0.5	0.01	0.02	0.05

Note: ND = Not Detected

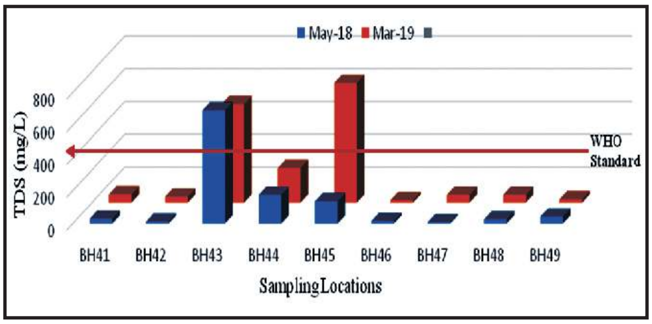

Fig. 4: Wet and dry season plot of TDS content of groundwater against WHO permissible limit around the dumpsite

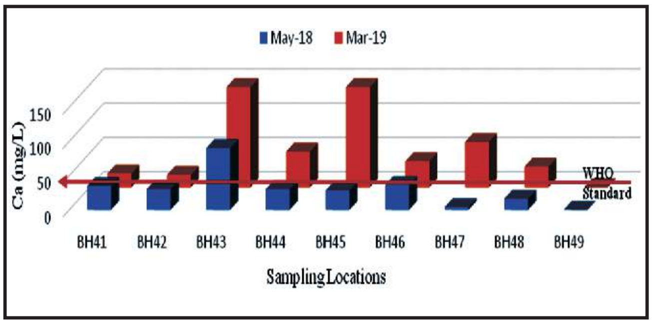

Fig. 6: Wet and dry season plot of Ca content of groundwater against WHO permissible limit around the dumpsite

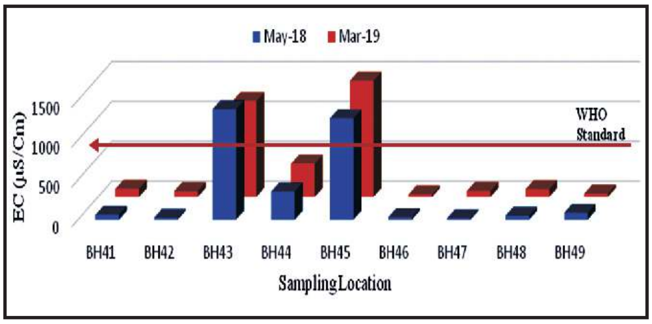

Fig. 5: Wet and dry season plot of EC content of groundwater against WHO permissible limit around the dumpsite

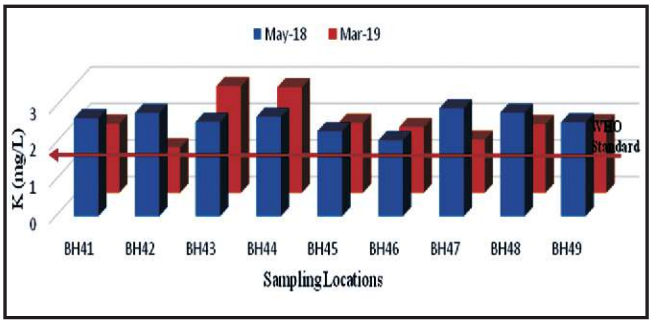

Fig. 7: Wet and dry season plot of K content of groundwater against WHO permissible limit around the dumpsite

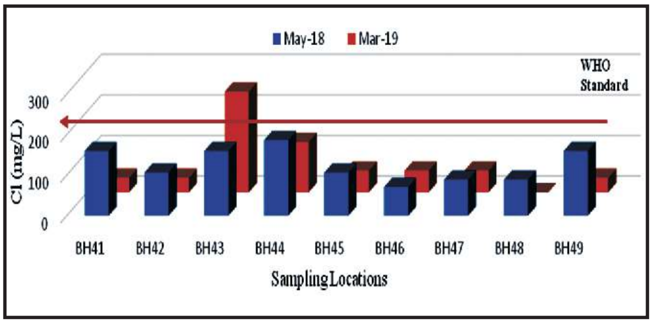

Fig. 8: Wet and dry season plot of Cl content of groundwater against WHO permissible limit around the dumpsite

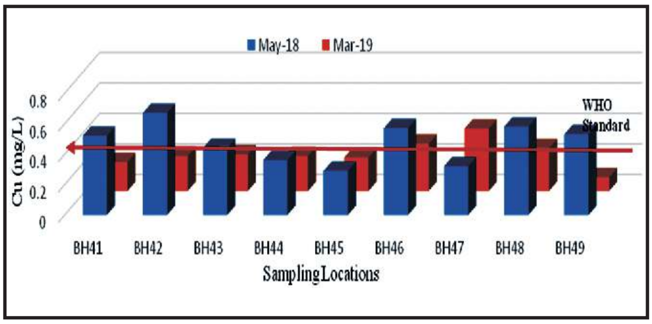

Fig. 9: Wet and dry season plot of Cu content of groundwater against WHO permissible limit around the dumpsite

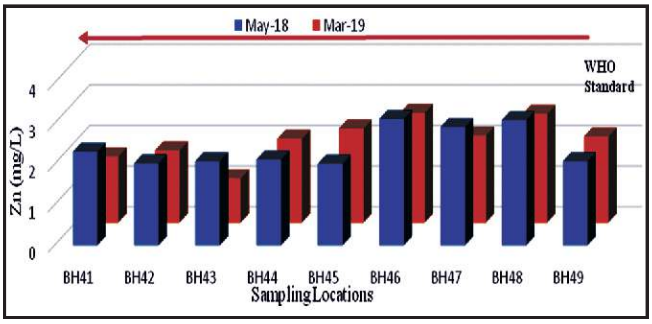

Fig. 10: Wet and dry season plot of Zn content of groundwater against WHO permissible limit around the dumpsite

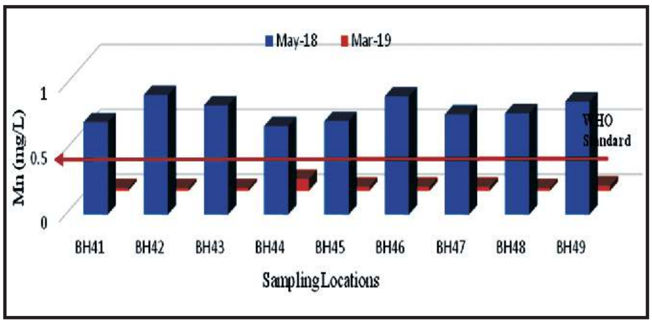

Fig. 11: Wet and dry season plot of Mn content of groundwater against WHO permissible limit around the dumpsite

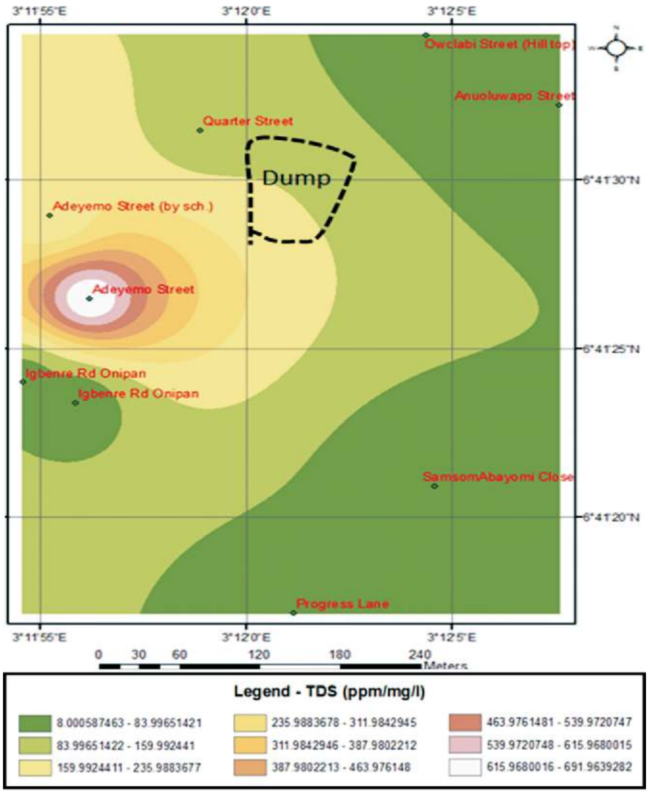

Fig. 12: TDS concentration distribution map around the Igbenre Ekotedo dumpsite in 2018

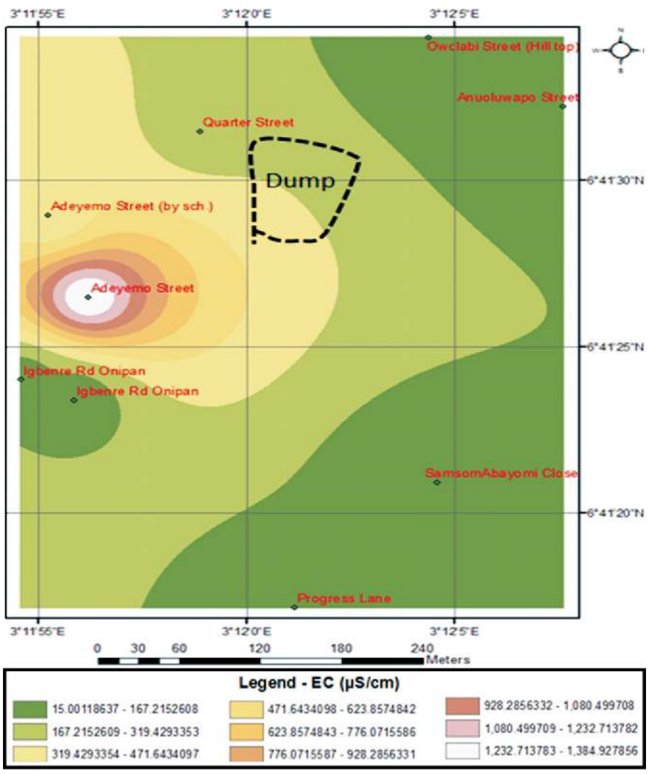

Fig. 13: EC concentration distribution map around the Igbenre Ekotedo dumpsite in 2018

Radiometric Survey on the Igbenre Ekotedo Dumpsite Ota

Fig. 14 presents the histograms showing the acquired radiation parameters associated with the site and surrounding, versus the standard radiation of 70 $\mu Svyr^{-1}$. The mean annual absorbed dose rate for all the traverses along the lines are 41.11 $\mu Svyr^{-1}$, 44.73 $\mu Svyr^{-1}$, 36.81 $\mu Svyr^{-1}$, 45.00 $\mu Svyr^{-1}$ 16.16 $\mu Svyr^{-1}$ and 19.69 $\mu Svyr^{-1}$ respectively. A maximum radiation value of 66.39 $\mu Svyr^{-1}$ was obtained on traverse 1 (Fig. 14a), while a minimum radiation value of 10.19 $\mu Svyr^{-1}$ was recorded on the dumpsite along traverse 5 (Fig. 14e).

The results obtained on the dumpsite are comparably lower than the results obtained by Odunaike *et al.,* 2008. The control traverses showed a relatively lower level of radiation compared to the measurements obtained on the dumpsite. The maximum value of 66.39 $\mu Svyr^{-1}$ annual absorbed dose rate recorded on the dumpsite suggests that the high radiation level though not exceeding the World's average of 70 $\mu Svyr^{-1}$, maybe the resultant effect of increased waste deposition on the dumpsite. Generally, the radiation level for all the traverses was below the normal standard level and, therefore, does not call for any alarm in terms of radiological risk to the community's inhabitants around the dumpsite.

Conclusion

Water samples from boreholes located at various

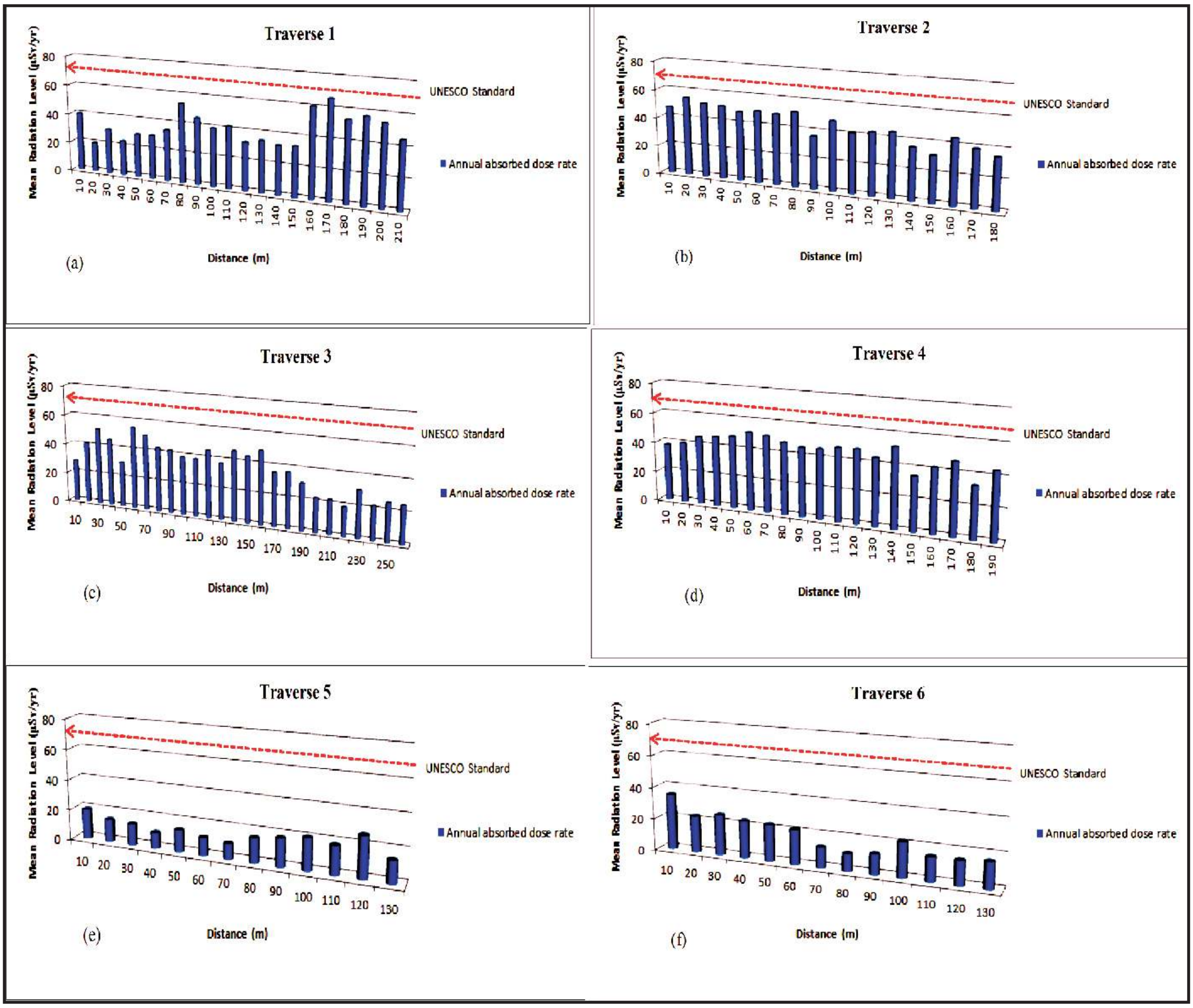

Fig. 14: Measured Radiation level versus Normal Background along Traverses 1-6.

distances from the dumpsite have been analyzed, and various physiochemical properties determined. The results showed that TDS, EC, NO_3^-, Ca^{2+} and their hardness concentrations exceeded the WHO 2007 standard limits for samples obtained around the southwestern part of the study area in both wet and dry seasons. These same locations also had elevated values of SO_4^{2-}, Cl^- and Mg^{2+} even though they were within the safe limit. The high values of these parameters may not be unconnected with the dumpsite leachate migration and mixing with groundwater around this area. Due to the elevated values of some of the physiochemical parameters of groundwater around the southwestern part of the area, shallow groundwater is at a risk of future contamination. Future exploration and exploitation of groundwater therefore should be done in other parts of the study area. Also, since boreholes around the study area are drilled to depths between 30 m- 40 m, deeper aquifers should be targeted around the south-western part for future groundwater exploitations so as to avoid producing contaminated water.

In terms of seasonal variation of the measured physicochemical parameters, the values obtained during dry season were relatively higher when benchmarked with those obtained during the rainy season. And so therefore, attention must be given to water treatment during the dry season.

The radiation parameters at some locations on the traverses, even though very high did not surpass the minimum standard of 70 μSvyr-1 as prescribed by UNESCO on effect of Atomic Radiation, while the absorbed radiation dose measured on the dumpsite and the control were minimal when compared with Nigeria's average and the world average. Therefore, this may not immediately portend any adverse health challenge to the people living around the dumpsite. However, with continuous exposure to the radiation, the level of risk to radiation related health conditions may increase. Therefore, constant study to monitor the radiation emission level at all times is encouraged.

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