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Evaluating Potential Human Health Impacts at an E-Waste Dumping Site in Uyo, Akwa Ibom State, Nigeria

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Abstract: Heavy metals in the soil have continued to pose a serious threat to the environment and its users, especially human beings. In this research, Assessing the Human Health Implications of an Electronic Wastes Dumpsite in Uyo, Akwa Ibom State, Nigeria was carried out. Twelve soil samples were taken at the dumpsite for investigation at the laboratory. This was done to assess the level of concentration of some heavy metals within the dumpsite which could be used to find out the health risk associated with the concentration levels. After the analysis, the mean values for the soil (in mg/kg) both at the dumpsite and the control, twenty metres away from the source were; Cadmium (Cd): 2.782 and 1.008, Chromium (Cr): 17.293 and 4.401, Lead (Pb) : 10.332 and 5.586, Arsenic (As) : 0.226 and 0.131, Mercury (Hg):0.012 and <0.001, Iron (Fe) : 31.089 and 14.091, Manganese (Mn) : 5.062 and 1.409, Nickel (Ni): 17.29 and 5.326. From the analyzed result, Cd, Pb and As at both the source and the control exceeded the soil limit values of 0.8, 8.5 and <0.001 mg/kg from both the World Health Organization (WHO, 2020) and Federal Ministry of Environment (FMENv) standards. Cr, Hg and Ni did not exceed the standard limit of 100, 1.9 and 35 mg/kg. It was based on these findings that health risk assessment was modelled for both the soil and the groundwater. The results showed all health indices exceeding one for adults, children and infants indicating a high risk of adverse health effects.

Keywords: *E-Waste – Electronic Wastes, WEEE - Waste Electronic and Electrical Equipment, SS- Soil Sample, SSC- Soil Sample Control, GW - Groundwater, GWC - Groundwater Control*

I. INTRODUCTION

An electronic waste (or e-waste) is one of the most rapidly growing pollution problems worldwide. New technologies are rapidly superseding millions of analogue appliances leading to their disposal in prescribed landfills despite potentially their adverse impacts on the environment(Jahan and Begum, 2013). The consistent advent of new designs, ‘‘smart’’ functions and technology during the last 20 years is causing the rapid obsolescence of many electronic items. For example, the average lifespan of a new computer has decreased from 4.5 years in 1992 to an estimated 2 years in 2005 and is further decreasing (Widmer *et al*., 2005) resulting in much greater volumes of computers for either disposal or export to developing countries. While difficult to quantify the volume of e-waste generated globally, Bushehri (2010) presented an overview of the volume of e-waste generated in a range of categories in China, Japan and US based on available information for the period 1997–2010 . The estimate showed that over 130 million computers, monitors and televisions become obsolete annually and that the annual number is growing. Electronic waste is any broken or unwanted electrical or electronic appliance(Enegide and Chukwuma, 2018). Electronic products or appliances are substances that use electrical cables or batteries for providing its power. Electronic waste (E-waste) typically consists of a broad range of electrical and electronic products including computers, mobile phones, televisions, and their components such as printed circuit boards, etc. It also encompasses a broad and growing range of electronic devices from household appliances like refrigerators, air conditioners, etc. Otache, *et al* (2014), verified that electronic devices contain small amounts of toxic chemicals that when improperly disposed of, infiltrate into the soil, thereby contaminating the groundwater and this can exert negative effects on human health and the environment(Tchounwou *et al*, 2014).The management of these discarded electronic devices has been an issue of concern for the solid waste community. These devices are known to contain small amounts of toxic chemicals that can exert, upon exposure, negative impacts on human health and the environment. These toxic substances include Brominated Flame Retardants (BFRs), Polychlorinated Biphenyls (PCBs,) Lead, Cadmium, mercury, plastics, etc. Even in the developed countries where Municipal Solid Waste (MSW) is properly land filled, some level of concern is still shown because some MSW landfills have been found to contain sufficient heavy metals to pollute groundwater, and can be expected to cause such pollution as the landfill liner systems deteriorate and fail to completely or reliably collect and remove the leachate. At this time, it is unclear whether or not the disposal of electronic wastes in MSW landfills will significantly increase the heavy metal-pollution of groundwater once the liners systems fail to collect and remove all leachate generated in the landfill (Briffa *et al*,2020). On the other hand, In developing countries including Nigeria, waste from electronic components are managed through various inappropriate routes including disposal at open dumps, unsanitary , landfills and material recovery through back yard recycling (informal recycling) . In comparison, the extent of groundwater pollution in open dump system is worse as the leachate is directly absorbed into surface and groundwater. In the society generally, electronic waste is treated the same way as household waste as people are unaware of its relative toxicity. It is most often disposed of at open dumps, or primitively recycled which lack adequate pollution control measures (Ali, 2019). The hazards associated with improper management of electronic waste includes contamination of topsoil which is used for agricultural production, contamination of surface and groundwater which have attendant health implications. Disposal of electronic waste is an emerging global environmental issue, as these wastes have become one of the fastest growing waste types in the world. The e-wastes, if not disposed of appropriately can become a source of trace metal contaminants in the

environment and this is very worrying especially in Nigeria as it has been reported that it receives large volumes of e-waste from developed countries for reuse but most of these second - hand electronics end up in the landfills after useful parts have been removed (Ibrahim *et al*,2013).

E-waste or electronic waste is created when an electronic product is discarded after the end of its useful life(Qia *et al* 2020). The rapid advancement of technology, combined with a consumer-driven culture, has resulted in a massive amount of e-waste. The electronic waste can also be seen as the waste generated from electrical devices and household appliances like refrigerators, televisions, and mobile phones and they contain hazardous materials which if not managed properly, may end up badly affecting our environment and causing fatal health issues(Aniefiok *et* al, 2013). Disposal of these materials require a lot of manpower and properly managed facilities. Not only for disposal, but also for processing, these products necessitate large facilities and natural resources (aluminum, gold, copper, silicon, and so on), all of which end up harming our environment and causing pollution. Electronic waste has been around for a very long time; however, the need for the proper disposal of that electronic waste began in the mid-70s. Soon thereafter the United States passed the Resource Conservation and Recovery Act (RCRA). This law made it illegal to dump electronic waste in the United States. This is when the recycling industry was formed and the proper disposing of and recycling electronic waste and old worn out electronic equipment of all kinds (Ojo, 2018). E-waste is a popular, informal name for electronic products nearing the end of their useful life. Electronic industry is the world's largest, innovative and fastest growing industry during the last century which radically changed the people's lifestyle. Although this development has helped the human race, mismanagement has led to new problems of contamination and pollution. Almost every used electronic items are considered as e-waste such as discarded cell phones, cameras, Compact Disc (CD) players, televisions, radios, drillers, fax machines, photocopiers, printers, toners, ink cartridges, batteries, re-chargeable batteries, digital calculators and clocks, Cathode Ray Tubes (CRT) monitors, electric solders, computer mother boards, key board, industrial and house hold electronic machinery such as oven, fridge, sewing and washing machines, fan, air-conditioner, grinder, iron, heater, military and laboratory electronic equipment, etc. ElectronicElectronic equipment contains many hazardous metals such as lead, cadmium, and beryllium and brominated flame-retardants like tetrabromobisphenol-A (TBBA), polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE). Every year tons of electronic items are shipped over oceans, however, after their usage they become a complex waste matter which consists of iron, copper, aluminium, gold and other heavy metals in e-waste is over 60%, while non degradable plastics accounts for about 30% and the hazardous pollutants comprise only about 2.70% (Widmer *et al*., 2005) . An estimated 50 million tons of e-waste is produced each year in the world. Mostly e-wastes are dumped, burnt or exported to recyclers. During dismantling process like shredding, tearing and burning, the smoke and dust particles are eliminated. These smoke and dust particle consists of carcinogens and other hazardous chemicals which causes severe inflammations and lesions including many respiratory and skin diseases (Sivakumaran and Sivaramanan, 2013) . Circuits are burnt to hunt the valuable metals such as gold, platinum, cadmium but the wire coat of these consists of Pressure Control Valve (PCV) and Printed Circuit Boards (PCB) which may produce erotic smoke and carbon particles from the toners are carcinogens, they may lead to lung and skin cancer (Kevin *et al*., 2008).

E-waste from developed countries find an easy way into developing countries in the name of free trade is further complicating the problems associated with waste management (Joseph, 2007). In the case of Nigeria, it was reported by United Nations Industrial Development Organization (UNIDO 2014) that every year, the amount of e-wastes that enter the country unlawfully through Apapa and Tincan seaports, Lagos airport; and other ports in the country is about 100,000 tonnes of e-wastes enter the country unlawfully. The said report stated further that Nigeria generates (1.1 million tonnes of e-waste) annually and invariably, more than the total volume of e-wastes being generated by all other countries in the ECOWAS region combine together (The Guardian, 2018). But, like many of the developing countries; Nigeria is bereaved of a functional structure that can enable a cross cutting edge in e-waste management. The general population is invariably exposed to e-waste scenarios leading to all kinds both environmental and health risks.

It is a well- known fact that the society makes use of electronic gadgets in the day to day life. Most of these used electronics, overtime are either landfilled/burnt leaving high toxics to the soil which may be detrimental to the soil, water and the environment. It is against this background that there is dire need to determine the level of toxicity of the heavy metals components of e-waste in the soil of the study location. The knowledge from this research will proffer better results on the proper ways to dispose, recycle and manage our e-waste.

The objectives of this paper included analysing selected heavy metals within the study location and using the analysed metals to find out the human risk implications of people living within the dumpsite.

Composition of e-waste

E-waste normally contains valuable, as well as potentially toxic materials. The composition of e-waste depends strongly on factors such as the type of electronic device, the model, manufacturer, date of manufacture, and the age of the scrap. Scrap from IT and telecommunication systems contain a higher amount of precious metals than scrap from household appliances (Chancerel, 2009). For instance, a mobile phone contains more than 40 elements, base metals such as copper (Cu) and tin (Sn); special metals such as lithium (Li) cobalt (Co), indium (In), and antimony (Sb); and precious metals such as silver (Ag), gold (Au), and palladium (Pd) (Liu *et al*, 2009). Special treatment of e-waste should be considered to prevent wasting valuable materials and rare elements. Materials such as gold and palladium can be mined more effectively from e-waste compared to mining from ore. By contrast, e-waste contains PBDEs, which are flame retardants that are mixed into plastics and other components. Circuit boards found in most of the electronic devices may contain arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), and other toxic chemicals. Typical printed circuit boards treated with lead solder in electronic devices contain approximately 50 g of tin-lead solder per square meter of circuit board. Obsolete refrigerators, freezers, and air conditioning units contain ozone depleting Chlorofluorocarbons (CFCs). The prominent materials such as barium, cadmium, copper, lead, zinc, and other rare earth metals are contained in end-of-life (EOL) cathode ray tubes (CRTs) in computer monitors, and televisions. For example, items such as leaded glass provide protection against X-rays produced in the picture projection process in CRTs . The average lead in CTR monitors is 1.6-3.2

kg. Thus, the US and other developed countries in the EU and Japan have banned the disposal of cathode ray tubes in landfills because of their toxic characteristics. A critical challenge in designing and developing strategies to manage e-waste is the changing composition of the many constituents due the advancement of technology, particularly in the electronic components (Robinson, 2009) . It is against this background that e-waste recycling and disposal methods ought to keep pace with the changing composition of e-waste. Several factors influence the composition of e-waste, including economic conditions, availability of a reuse market, and infrastructure of the recycling industry, waste segregation programs, and regulation enforcement.

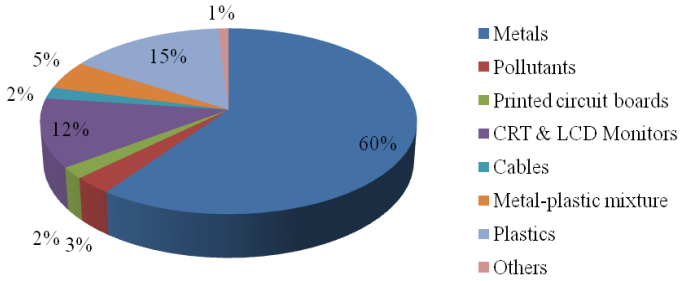

Figure 1: Distinctive contents of Waste Electrical and Electronic Equipment

Source: (Ongondo *et al*, 2011)

Due to the rapid production and use of the electronic wastes, the discarded or unused ones are normally disposed. Several methods are basically used to discard these electronic wastes. Some of these ways are incineration, landfilling, acid bath and removal of heavy metals.

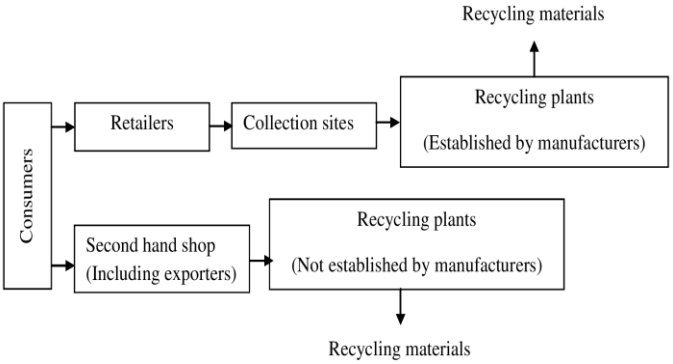

Figure 2: Flow of the Electronic Wastes system. Source: (Chung *et al, 2008)*

II. MATERIALS AND METHODS

Study Area

The E-wastes dumpsite which is about 25 square metres in size is located at Ediene Ikot Obio Imo in Uyo Local Government Area, Akwa Ibom State, Nigeria. The area which is of latitude 40"N and longitude 38"E bounded by Ikono, Abak, Ibiono and Nsit Ibom Local Government Areas. From findings, it has been in existence for more than 5 years. This is the dumpsite where e-waste collectors and recyclers work, live in sheds and indulge in burning and other crude methods of recycling in an attempt to extract valuable components of e-waste without care for their health or environment. The devices generating the e-wastes are mostly imported second-hand electrical-electronics products.

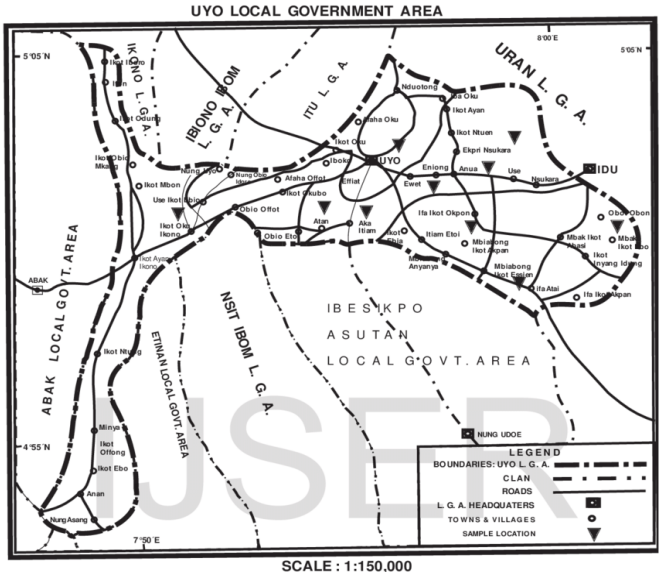

Figure 3: Map of Uyo Local Government Areashowing the study location

Collection and Study Design

Twelve sampling points were taken within the e-waste dumpsite. At each of the sampling points, the top and the bottom soils samples were taken at the depth of 0-15cm and 15- 30cm respectively using soil auger. Each of the twelve samples of the topsoils (0-15cm) were mixed to form a composite sample. Similar procedure was carried out for the bottom soil (15-30cm). This was for homogeneity and reliable results. The same process was carried out for the control sample which was located 20 metres away from the dumpsite. Each composite sample was put into a clean container, labelled and immediately taken to the laboratory for analysis.The study design used for this research was the analytical study design. In this case, the samples were collected and taken to the laboratory for the analysis of the experiment.

Figure 4: Soil and water samples taken at the e-waste dumpsite

Similarly, water sample from the groundwater located at the dumpsite was collected. The control sample located 15metres away from the dumpsite was also collected. This was to determine the toxic effects of the e-waste on the water source around the location.

Data Collection Methods

The data collection method used in the research was the quantitative method in which sample were obtained from the site using some tools and thereafter taken to the laboratory for subsequent analysis.

Sample Treatment

Soil samples obtained was air dried and crushed to pass through 2mm sieve (Dikko and Ibrahim, 1999). This is to eliminate stones and other materials extraneous to the soil. Dried samples were refrigerated upon receipt and analyzed as soon as possible.Dried soil samples were accurately weighted into platinum crucible. Few drops of de-ionized water were added to dampen the samples. Six centimeters cube of concentrated HCl acid and 1 cm^3 of hydrofluoric acid were added. The mixture was heated on a hot plate. After cooling, 5cm^3 of hydrofluoric acid and 1cm^3 of concentrated HCl acid was heated on a sand – bath at a temperature of 200 – 230 degree Celsius until the acids to dryness. Six centimeter cube (6cm^3 hydrochloric acid (1moldm-3) was added after cooling and the result was boiled for 10 minutes. It was filtered, made up to mark with de-ionized water in a 25cm^3 volumetric flask. Also, 50ml of the water samples around the sample area was transferred. The digestive tube was filled with 5ml of HNO3 and gently swirled. The mixture was heated for 30 minutes in a digestive furnace. All digests were cooled and filtered through filter paper before being diluted with distilled water to make 50ml. Each digested sample was then transferred to sample bottles for heavy metal analysis.The sample solutions were analyzed using Atomic Absorption Spectrophotometer(AAS), Varian 1200 with air acetylene flame (Jimoh and Mohammed, 2001). Here the concentrations of the heavy metals were analyzed. StandardStandard solution was prepared firstly by serial dilution for each metal. Afterwards each standard was calibrated using the AAS machine and a calibration curve was generated. The importance of the calibration curve was to determine an unknown concentration. The AAS involves the measurement of the drop in light intensity of initial radiation to final radiation. After calibration, analysis of each metal was done.

Human Health Risk Estimates

Health risk estimation includes the identification of exposure pathways, which is the course a chemical takes from a source to an organism and an exposure route, the way a chemical comes in contact with a receptor (i.e., by ingestion, inhalation, dermal contact, etc.). In this study, ingestion of soils contaminated with metals was considered as the main pathways for risk assessment. The health hazard to human adults and children from metals was derived after hazard quotient (HQ) estimation. HQ is the measure of the magnitude of exposure potential or a quantifiable potential for developing health effects after an averaged exposure period.The potential for non-cancer effects was evaluated by comparing the estimated average daily dose (mg kg-1 d-1) of the metal with the reference dose (RfD) (mg kg-1 d-1). The total health hazard was derived simply by summing the HQ values of all the metals. This total HQ is referred to as the Hazard Index (HI). Recommended equations used for estimating ADD, HQ, and HI were from Environmental Protection Agency (2008)

$$ADD(mgkg-1day-1)=\frac{CsxIRxFxEFxED}{BWxAT} \quad (1)$$

$$HazardQuotient=\frac{LADD}{RfD} (2)$$

$$HazardIndex(HI)=HQcd+HQcr+HQpb+HQAs+HQHg+HQFe+HQMn+HQNi \quad \text{Equation (3)}$$

where Cs is the metal's concentration in soil (mg kg-1), IR is the soil ingestion rate (adult, 100 mg day-1; children, 200 mg day-1), F is the unit conversion factor, EF is exposure frequency (365 days/year), ED is the lifetime exposure duration (children, 12 years; adults, 70 years), BW is the bodyweight (children, 27 kg; adults,70 kg), and AT is the averaging time ($EF \times EDdays$).

$RfD$is the reference dose for individual metal (mg kg-1 day-1) for soil and (mg/l/day) for water. The RfD for the soil are (Cd =0.003, Cr = 1.5, Pb = 0.00014, As =0.0003, Hg = 0.00016, Fe = 1.6, Mn = 0.14, Ni = 0.02) while that of water is [Cd = As = Fe = Ni = NA (Not Available), Cr = 0.003, Pb = 0.0036, Mn = 0.14](Kumer B, et al, 2014). The metals such as As, Cd, Cr and Pb are classified into metals with carcinogenic risk, and Fe, Zn, Cu, Ni and Co are non-carcinogenic. If the HI is <1, no risks from non-carcinogenic effects probably occurred, and if the HI is >1, adverse health effects are possible, and the probability of health effects increases with the increase in the HI values.

III. RESULTS AND DISCUSSION

A.Amount of heavy metals in the soil

The distribution of heavy metals studied in the soils of all the sampling points is depicted in Table 1. The average concentrations of the heavy metals varied significantly and decreased in the following order Fe > Cr > Ni > Pb > Mn > Cd >As > Hg. Iron (Fe) has the highest average concentration compared with other metals studied. These agree with many reports indicating natural soils containing a significant amount of Fe. Cd, Hg, and Cr were below the standard limits for the soil. But Cd, Pb and As for the topsoil was above the standard indicating the soil being contaminated with Pb and As. Similarly, for the groundwater, Cr and Pb as stated in Table 2 exceeded the limit indicating that the water is unsafe.

Table 1: Analysis of heavy metals of the soil (mg/kg) and water(mg/l)

Para meters	SS1	SS2	SSC1	SSC2	GW	GWC
Cd	3.102	2.462	1.201	0.814	0.892	0.347
Cr	20.472	14.113	5.687	3.115	0.478	0.008
Pb	12.516	8.147	6.104	5.068	1.023	0.065
As	0.423	0.028	0.215	0.047	0.006	<0.001
Hg	0.021	0.002	<0.001	<0.001	<0.001	<0.001
Fe	34.284	27.893	15.067	13.114	3.102	1.523
Mn	6.432	3.692	1.872	0.946	1.024	0.367
Ni	16.156	12.134.	6.486	4.165	0.065	0.013

SS1- Soil Sample 1, SS2- Soil Sample 2, SSC1- Soil Sample Control 1, SSC2- Soil Sample Control 2, GW- Groundwater, GWC- Groundwater Control

Table 2 : Standard limits of some heavy metals

Parameters	Soil		Water	
	WHO (2020)	FMENv	WHO (2020)	FMENv
Cd	0.8	0.8	0.003	0.5-1-5
Cr	100	100	0.05	0.003
Pb	8.5	8.5	0.01	0.05
As	4.5	<0.001	0.01	<0.001
Hg	1.9	0.3	0.001	<0.001
Fe	NA	NA	NA	10-30
Mn	NA	NA	NA	NA
Ni	35	35	0.02	0.1

NA – Not available, FMENv –Federal Ministry of Environment, WHO – World Health Organization.

Human health risk assessment

Health risk assessment was based on the assumption that humans exposed to metals through soils may suffer harmful effects. It was assumed that human adults and children, even infants were exposed to metals through ingested soils all the days in a year during the life span. Risk was assessed by estimating the incremental lifetime average daily dose (LADD), hazard quotient (HQ), and hazard index (HI) for the selected metals. LADD is the amount of pollutant intake per kg of bodyweight per day that is sufficient to cause adverse health effects when absorbed into the body over a long period of time. If the HQ for a heavy metal is equal to or less than 1, it is assumed that there is no appreciable risk that health effects will occur. A hazard index (HQs) <1 suggests that risks are not expected from any heavy metal, alone or in combination with others. The average daily dose (ADD) and hazard index (HI) for adults and children from selected exposure to metals through soil contact are presented in Tables 3, 4 and 5. The ADDs of the soil at 0-15cm deep ranged from 3.009E-5 to 1.79E-2 mg/kg/day. That of 15-30cm depth ranged between 2.858E-6 and 2.066E-1 mg/kg/day. ADDs for the groundwater ranged from 1.8E-4 mg/L/day to 2.069 mg/L/day. Mean HQ of heavy metals for the soil was in the descending order of Pb > Cd > As > Ni > Hg > Cr > Fe > Mn. These estimated higher values of HI were all above the acceptable safe risk level (HI≤ 1), indicating high risk to human adults, children and infants from the studied metals through soil ingestion (Tables 3, 4 and 5). Since the HIs were more than 1, adverse health effects are likely to occur. Comparing the modelled values with the standard classification of the health hazard, there is utmost risk of health hazard to the adults, children and infants as their health indices were more than 1. The people leaving around the vicinity are likely to be vulnerable to some ailments. Equally, considering the chart in figure 5 below, infants leaving around the dumpsite are mostly susceptible to diseases as their chances is about 50%.

Table 3 : Average daily dose intake, Health quotient and Health index for SS1 - soil sample (0-15cm)

Adult		Children		
ADD	HQ	ADD	HQ	
4.43E-03	4.43	2.33E-02	2.33E+01	Cd
2.93E-02	1.95E-02	1.52E-01	1.01E-01	Cr
1.79E-02	1.27E+02	9.27E-02	6.62E+02	Pb
6.00E-04	2	3.13E-03	10.4	As
3.00E-05	1.88E-01	1.56E-04	9.72E-01	Hg
4.90E-02	3.06E-02	2.54E-01	1.59E-01	Fe
9.19 E-3	6.56E-02	4.76E-02	3.40E-01	Mn
2.31E-02	1.16	1.20E-01	5.983	Ni
1.35E+02		7.03E+02		HI

Table 4: Average daily dose intake, Health quotient and Health index for SS2- soil sample (15-30cm)

Adult		Children		
ADD	HQ	ADD	HQ	
3.52E-03	3.52	1.82E-03	1.82	Cd
2.02E-02	1.35E-02	1.05E-02	1.01E-01	Cr
1.16E-02	1.27E+02	6.03E-02	6.62E+02	Pb
4.00E-05	2	2.10E-04	1.04E+01	As
2.86E-06	1.88E-01	1.48E-05	9.72E-01	Hg
3.99E-02	3.06E-02	2.07E-01	1.59E-01	Fe
5.30E-03	6.56E-02	2.69E-02	3.40E-01	Mn
1.73E-03	1.16	8.99E-02	5.98	Ni
1.31E+02		4.38E+02		HI

Table 5: Average daily dose, Health quotient and Health index of the groundwater (GW)

Adults		Children		Infants		
HQ	ADD	HQ	ADD	HQ		ADD
NA	5.90E-02	NA	3.23E-02	NA	Cd	2.70E-02
4.67	3.19E-02	10.63	1.73E-02	5.77	Cr	1.40E-02
8.61	6.80E-02	18.89	3.70E-02	10.28	Pb	3.10E-02
NA	4.00E-04	NA	2.20E-04	NA	As	1.80E-04
NA	NA	NA	NA	NA	Hg	NA
NA	2.07E-01	NA	1.12E-01	NA	Fe	9.31E-02
2.19E-01	6.83E-02	4.88E-01	3.71E-03	2.65E-01	Mn	3.07E-02
NA	4.34E-03	NA	2.40E-03	NA	Ni	1.95E-03
1.35E+01		3.00E+01		1.63E+01	HI	

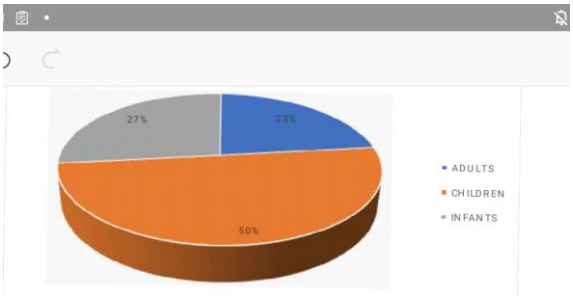

Figure 5: Charts showing the percentage distribution of the Health Indices of Adults, Children and Infants

CONCLUSION

The analysis carried on the heavy metal showed some exceeding the stipulated limits while others were within the limits. For the soil, cadmium, lead, chromium exceeded their approved limit while chromium and lead exceeded the limit for the groundwater. From the inferences, it was deduced that both the soil and groundwater of the study location were deeply contaminated by those trace elements. For the health risk assessment, it was noticed from the facts gotten from the model that the soil and the groundwater were unsafe as their health indices were greater than one.. This means, exposure to soil and groundwater of the study location could make the adults, children and infants prone to varying sicknesses ranging from liver, kidney to heart abnormalies. As the health indices were greater than one, it signaled a carcinogenic risks to humans mostly children.

Authors' Agreement

Authors approved the submission of this manuscript for review and publication in this reputable Journal.

Declaration of Competing Interest

The authors declare no competing interests or personal relationships that could have appeared to influence the work reported in this paper.

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