Levels of Heavy Metals, Phthalates and Polyaromatic Hydrocarbons in Soil and Groundwater within Vicinity of E-waste Recycling/Dumpsites in Ibadan City

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Abstract

Migration of leachates from e-waste dumpsites could lead to contamination of soil and groundwater in the vicinity surrounding the dumpsites. This article discusses the level of e-waste contaminants (heavy metals, phthalates and Polyaromatic Hydrocarbons) in soil and groundwater within the vicinity of two major e-waste dumpsites in Ibadan, Nigeria. Dumpsites (Oke – Padre and Iwo road) were purposely selected. Heavy metals, Polyaromatic Hydrocarbons and Phthalates were analysed in soils collected at depth 0-15cm and groundwater collected 50m away from e-waste dumpsites. Control samples were obtained where e-waste is not being dumped. Analyses were conducted using Atomic absorption Spectrophotometer, Gas chromatograph Flame Ionization Detector, and High Performance Liquid Chromatograph. Recovery studies were carried out on selected samples. Data were analyzed by descriptive statistics. Concentration of heavy metals (Lead, Cadmium, Nickel, Copper, Chromium, and Zinc) in soil were 2286.83mg/Kg, 6.18mg/Kg, 208.93mg/kg, 4870mg/Kg, 3.07mg/Kg, 139.43mg/Kg (Oke-Padre) and 2607.75mg/Kg, 5.17mg/Kg, 33.24mg/Kg, 3243.81mg/Kg, 21.78mg/Kg, 162.51mg/Kg (Iwo road) respectively were above USEPA and WHO limits. Other metals except Lead (5.28mg/L for Oke-Padre and 1.12mg/L for Iwo-Road) were below detection limits in water samples. Lead concentration exceeded USEPA permissible limits (0.003mg/L). All soil samples in both locations were contaminated with Polyaromatic Hydrocarbons with concentration ranging from 0.097mg/Kg-2.420mg/Kg. Only Oke-Padre water sample had fluorene concentration of 0.004mg/L, while none was present in Iwo-road water sample. Concentration of phthalates in soil ranged from 96.36μg/g-660.99μg/g and in water 3.87μg/ml-61.36μg/ml. Samples from both locations revealed phthalates contamination. These experimental results suggested that soil and water in both locations were heavily polluted with these contaminants.

Introduction

Electronic waste is a term used to refer to used, obsolete, broken or irreparable devices, some of which are destined for reuse, recycling, resale, salvage or disposal (Balakrishnan et al., 2007, Yuan et al., 2007). Due to the ever increasing growth

of the electrical and electronics industry fueled by the rise in demand for new and up to date electronic/electrical equipments (mobile phones, personal computers, television sets, I pads etc) and ICT equipment, e-waste has become a global challenge (Aborele, 2013). This is because many of these used electrical gadgets are discarded indiscriminately. E-waste contains hazardous components that can harm the environment if not managed properly. Many of these are constituents of the internal components, casings and electrical wiring (Wang et al.2005, Yadong et al. 2006). It also contains some brominated flame retardants and some organochlorine pesticides such as polychlorinated biphenyls (PCBs) and Polybrominated Diphenyl Ethers (Freeman and Catteil, 1990, Wang et al., 2005).

E-waste is generated through recycling and dumping from other countries (Nnorom and Osibanjo, 2008). In the absence of adequate infrastructure to manage e-waste safely especially in developing countries like Nigeria, old mobile phones, computers and televisions are broken to extract valuable metals for recycling, burnt in the open, incinerated, buried or disposed into surface water bodies. As these electronics break down especially during incineration or burning, they release heavy metals (e.g. Cadmium, Mercury and Lead from television and computer monitors, Zinc, beryllium and nickel from circuit boards), flame retardants and other hazardous chemicals like dioxins, furans, Polyaromatic hydrocarbons, hydrogen chloride and phthalates which are used as PVC plasticizers used in the casings of most computers and television sets (USEPA, 1996, Colon et al., 2000, Deng et al., 2006,Deng et al., 2007, Wang et al., 2005, Wong et al., 2006). All these consequently lead to toxic pollution of soil and water. The disadvantage of this method is that toxins released from these processes tend to leach into surrounding soil and groundwater thereby polluting it and rendering it useless for drinking and other domestic use (Sepulvida et al., 2010, Wong et al., 2006). Toxic emissions released from burning and recycling e-wastes to water and soil pose serious health and environmental hazards such as brain damage, respiratory disease, muscle weakness and even death (Deng et al., 2006, Ogundiran and Osibanjo, 2008).

Heavy metals when released may leach into surrounding water bodies and because they are soluble in water, non-biodegradable with long biological half lives, they tend to bio accumulate inside the body when animals are exposed to it and this may have damaging effects on man and animals (Ogundele et al., 2013). Phthalates also have been known to be endocrine disruptors while Polyaromatic hydrocarbons have genotoxic and carcinogenic potentials which can pose risks to the surrounding environment and human beings (Liao et al., 2006, Tang et al., 2005 and Yuan et al., 2012). Data abound for levels of heavy metals, phthalates and polyaromatic hydrocarbons within the vicinity of e-waste recycling/dumpsites in other areas but there is paucity of information concerning this in Ibadan city. Therefore this study was carried out to ascertain levels of contamination in soil and well water surrounding two selected e-waste dumpsites within Ibadan city and possible risk it may pose to inhabitants of the area.

Materials and Methods

Description of study area

Two major electronic waste dumpsites located at Ile –pupa, Iwo road axis and Oke-Padre in Ibadan metropolis were considered for investigation. Iwo road is one of the major places where used electronics which were imported into the country are sold, while electrical fittings and cables are sold at Oke –padre. The two dumpsites are situated close to two major markets which lie between Longitude $3^0 56^1 16$"E, Latitude $7^0 24^1 18$"N and Longitude $3^0 53^1 47$"E, Latitude $7^0 22^1 47$"N respectively as shown in Figure 1.
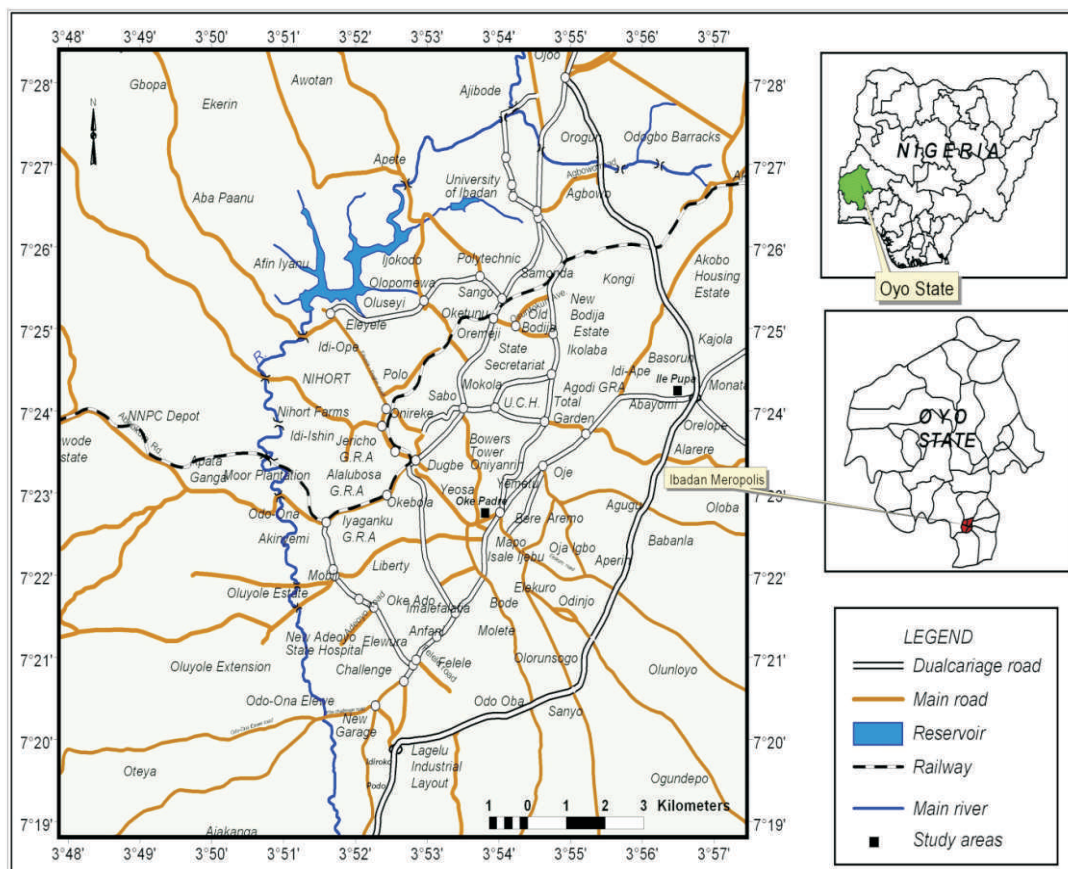
Figure 1: Map of Ibadan showing the two study sites

Collection of Soil sample and treatment

The sampling was conducted during rainy season as this will enhance the dissolution of components from the waste under investigation as they leach into the surrounding soils and groundwater supply. Each study site was divided into five (5) sections and five samples were randomly collected from each of the sections at a depth of 15cm using a handmade soil auger. A total of 25 samples were collected at random from the two sites. The soil samples were collected as grabs and later composited. The soil samples were placed in an aluminum foil, stored in an ice-bag and transported immediately to the laboratory. The soil was air-dried for 3days and later ground using a mortar and a pestle and then sieved through a 2mm sieve.

Collection of water samples and treatment

A total number of six grab samples were collected at random from three different wells surrounding the dumpsites by the use of a scoop and composited into one representative sample. This was done for heavy metals, Polyaromatic hydrocarbons (PAHs) and phthalates esters determination. For heavy metal determination: samples were collected in plastic bottles and 2-3 drops of concentrated HNO_3 was added to prevent adsorption of metal ions to the sides of the container. For Polyaromatic hydrocarbons (PAHs): amber bottles were used in order to minimize photolytic decomposition. This was transported to the laboratory in an ice bag at 4^0C. For Phthalate esters: glass bottles which have been soaked in 5% chromic acid solutions overnight, rinsed with distilled water, ketone and petroleum ether successively were used.

This was then transported immediately to the laboratory in an ice-bag at 4^0C.

Collection of control Samples

Soil samples were collected at Botanical garden, University of Ibadan and water samples were collected at Ajibode area, Ibadan where electronic waste is not been dumped. Control samples were wrapped in aluminum foil and placed in ice-bag at 4^0C and was immediately transported to the laboratory for pre-treatment and analysis.

Laboratory Analysis
Reagents and Chemicals

All reagents and chemicals used in this study were of analytical grade. All glass wares used were thoroughly washed and copiously rinsed with distilled water.

Determination of Polyaromatic Hydrocarbons in soil:

5g of the pre-treated soil samples were extracted using the soxhlet with 90ml acetone: hexane (1:1) for 16hours. The extracts were then concentrated to 2ml using rotary evaporator. Clean up was carried out with glass chromatographic column packed with 2.5g of silica gel and about 2cm high of anhydrous Sodium sulphate added to the top of the column. The column was wet with 25g of n-hexane which was collected and discarded. Extract solution was eluted through the column with 15ml (3:7) dichloromethane: hexane. The eluates were concentrated and made up to 2ml with hexane prior to Gas chromatography with flame ionization detector (GC-FID) analysis.

Determination of Phthalates in soil:

5g of soil sample was taken and extracted with 20% acetone in petroleum ether for 16hours with a soxhlet extractor. The extract was filtered using a glass fibre and concentrated to 2ml using water bath set at 50^0C. Clean up was done with glass column packed with 2.5g of silica gel and 2cm high of anhydrous Sodium sulphate added to the top of the column. The sample extract was adsorbed unto the top of the chromatographic column and then eluted with 6ml petroleum ether: diethyl ether (10:0.5ml) and then with 10ml petroleum: diethyl ether (10:3ml). The flow rate was set at 0.3-0.4ml/min. The phthalate fraction was concentrated nearly to dryness with nitrogen gas stream and then redissolved in 1.0ml methanol for High Performance Liquid Chromatographic analysis.

Determination of heavy metals in soil:

2g of pre-treated soil samples was digested with aqua regia on a hot plate at 95^0C for one hour and allowed to cool to room temperature. The resultant solution was diluted to 10ml and left to settle overnight. The supernatant was filtered prior to analysis using atomic absorption spectrophotometer (AAS). The samples were analyzed in duplicates.

Extraction and Concentration of water samples
Determination of Polyaromatic hydrocarbon in water:

100ml of sample was poured into a separatory funnel and 60ml of dichloromethane was added, the sample was extracted by shaking the funnel for 2 minutes with periodic venting to release excess pressure. The organic layer was allowed to separate from the water phase for a minimum of 10mins and then filtered through a glass wool. The dichloromethane extract was collected in a 250ml Erlenmeyer flask. The extraction procedure was repeated second and third time and the extracts combined in the flask. The extract was dried over a gentle stream of Nitrogen and concentrated to a volume of 2ml. This was then taken for instrumental analysis using Gas Chromatography with flame Ionization detector (GC-FID)

Determination of Phthalates in water:

Amber coloured bottles used in this study were previously washed, soaked in chromic acid and rinsed copiously with distilled water. The

bottles were dried at 105^0C and finally rinsed with dichloromethane prior to sampling. 100ml of water sample was saturated with 10g of NaCl to prevent the formation of persistent emulsions from the solvent and then extracted with 3 portions of 25ml dichloromethane. The three extracts were pooled together and dried over sodium sulphate in a glass fibre and the solvent was then evaporated using rotary evaporator. The residue obtained was re-dissolved in 2ml of dichloromethane for the clean up process. The extract was made to pass through a packed chromatographic column containing 2.5g of silica gel and then eluted with 20ml of n-hexane and 30ml ethyl acetate. The eluate was concentrated to 1ml by purging with Nitrogen gas. The residue was reconstituted with 1ml of acetonitrile and kept in the refrigerator below 4^0C until instrumental analysis was carried out.

Determination of Heavy metals in water:

10ml of concentrated HNO_3 was added to 10ml of water sample and the mixture digested on a hot plate. Another 5ml of concentrated HNO_3 was added to the mixture and refluxed for 30minutes after which the mixture was evaporated on a hot plate. Further HNO_3 was added and digestion continued until the mixture was light coloured. The resulting sample was filtered and the filtrate made up to 25ml with deionised water prior to analysis.

Sample Analysis using Atomic Absorption Spectrophotometer (AAS)

This analysis was carried out at multidisciplinary central Research Laboratory (MCRL), University of Ibadan. The absorbance of blank and working standard was measured. The heavy metals in the digest and blank were determined using a bulk scientific model 200a flame atomic adsorption spectrophotometer.

Instrumentation
Sample Analysis Using Gas Chromatography-Flame Ionization Detector (GC-FID)

This analysis was carried out at oceanography, Victoria Island, Lagos, Nigeria. The cleaned soil and water extracts for poly aromatic hydrocarbons were analyzed using GC-FID (Agilent HP GC 7890). Chromatographic separation was carried out using HP-5MS:30m×320µm×0.25µm column, 2.150 psi pulse pressure, FID Detector, 100^0C/min initial oven temperature, 20^0 C/min, 300^0C, 12min final oven temperature, 40.853ml/min average velocity, 1µL injection volume with Pulsed split less and Injection mode.

Sample analysis using High Performance Liquid Chromatography (HPLC)

The cleaned soil and water extracts for phthalate esters were analyzed using High performance Liquid Chromatography. The HPLC Model used is Agilent Technologies 1200 series. The instrument was equipped with a degasser, a quaternary pump, an auto sampler, ultra violet and fluorescence detector, a thermo stated column compartment, variable wavelength detector and a computer system. Chromatographic separation was carried out using a 150mm×4.6mm internal diameter. C_{18} analytical column with particle size of 5 µm. Detection of phthalate ester was done at 254nm wavelength. Chromatographic separation was performed under isocratic elution condition using acetonitrile : water (90:10). A flow rate of 0.3ml/min was used with an injection volume of 20µl and the temperature was set at 40^0C. Individual phthalate esters in the sample were identified according to their retention times.

Recovery study and Quality Control:

This is done to ascertain the accuracy and efficiency of the analytical method employed in the determination of Polyaromatic hydrocarbons, Phthalate esters, and heavy metals. Recovery studies ware carried by spiking the analyzed

samples with known concentration of the reference standards and then reanalyzed. Recovery for heavy metals in soil was carried out for Copper in the two locations and percentage recovery obtained was 95%. This indicates a high accuracy for the method. For Polyaromatic hydrocarbons in soil, the recovery was 85.5% and for Phthalates in soil and water, the recovery was 80.9% and 87.9% respectively. The range of the result is comparable to percentage recoveries obtained in some studies on Phthalates which were 23.78-85.5% and 50-105% (Fatoki and Ogunfowokan, 1993, Vitali et al., 1997)

Results and discussion

Heavy Metals in Soil

Heavy metal concentrations in soil samples are presented in Table 1 and this shows that concentration of heavy metals in all the soil samples were higher than that of the control

with Copper having the highest concentration for both soil samples thus showing that the soils were highly polluted. This may be due to the presence of printed circuit boards and loud speaker scrap which has probably broken down or has been burnt (Blondeel et al., 2014, Leung et al., 2006), Comparing the concentration of the metals with the European union limit, the concentration of all metals except that of Chromium and Zinc were higher than the permissible limit. The statistical analysis shown by table 8 indicates a significant difference between the concentration of heavy metals in the control site and that of the study sites for Lead contamination. For Cadmium and Nickel, there is a significant difference between the concentration obtained at the control site and that of Oke-Padre location but there is no significant difference between that of Iwo-road and the control site. For Copper, Chromium and Zinc, there is a significant difference between the concentration of heavy metals in the control site and that of the two study sites.

Table 1: Mean Concentration of Heavy Metals in Soil (mg/kg) in Both Locations. (Oke−Padre and Iwo Road)

Location	Pb	Cd	Ni	Cu	Cr	Zn
Oke- Padre	2286.83±182.12	6.18±7.56	208.93±13.88	4870±30.56	3.07±0.48	139.43±0.003
Iwo Road	2607.75±59.63	5.17±0.40	33.24±11.36	3243.81±39.08	21.78±0.29	162.51±0.003
Control	0.005±0.007	ND	1.19±0.04	ND	ND	116±0.02

ND: Not Detected
European Union Limit for heavy metals in soil (mg/kg): Cu-(50-140), Cr-(100), Ni-(30-75), Zn- (150-300),
Pb- (50-300), Cd-(1-3).
(Source: Nnorom, 2009; Awashti, 2000)

Table 2: Anova (One Way) for Test of Significant Difference of Heavy Metals in Soil Samples at 95% Confidence interval.

Parameters	Oke-Padre	Iwo -Road	Control
Pb	2286.8[a]	2607.8[a]	0.0[b]
Cd	62.178[a]	5.165[b]	-2.178[b]
Ni	208.93[a]	33.24[b]	1.19[b]
Cu	4870.90[a]	3243.81[b]	-2.54[c]
Cr	3.0725[b]	21.7750[a]	-1.9050[c]
Zn	139.42750[b]	162.50750[a]	116.940[c]

Note: Means with the same subscript are not significantly Different (P=0.05)

Table 3: Mean Concentration of Heavy Metals (mg/L) in Water Samples in Both Locations. (Oke-Padre and Iwo Road)

Location	Pb	Cd	Ni	Cu	Cr	Zn
Oke-Padre	5.28±0.77	ND	ND	ND	ND	ND
Iwo- Road	1.12±0.48	ND	ND	ND	ND	ND
Control	ND	ND	ND	ND	ND	ND

Table 4: Comparison of the Mean Concentration of Water Samples from the two Dumpsites with Some Water Quality Standards.

Parameters	WHO	USEPA	Oke -Padre	Iwo-Road
Ni(mg/L)	0.020	0.050	ND	ND
Zn(mg/L)	0.010	0.120	1.030	0.170
Cr(mg/L)	-	0.100	0.550	0.160
Cu (mg/L)	-	0.009	1.010	ND
Cd(mg/L)	0.003	0.002	0.095	0.180
Pb (mg/L)	0.010	0.003	5.280	1.140

Source: World Health Organisation drinking water guidelines (WHO, 1996),
        United State Environmental Protection Agency (USEPA, 1999).

Table 5: Concentration of Polyaromatic Hydrocarbons in Soil Samples (mg/Kg) in the Two Locations (Oke-Padre and Iwo-Road).

Analyte	Oke Padre	Iwo Road	Control
Anthracene	ND	ND	ND
Phenathrene	ND	2.420	ND
Pyrene	ND	ND	ND
Fluoranthrene	ND	0.236	ND
Naphthalene	0.862	ND	ND
Acenaphthylene	ND	ND	ND
Acenaphthene	0.288	ND	ND
Fluorene	0.307	1.901	ND
Chrysene*	0.572	ND	ND
Benzo (k)fluoran*	0.097	1.588	ND
Benzo (g,h,i) per	1.955	ND	ND
Indeno (1.2.3-cd)*	0.494	ND	ND
Benzo(a)anthracene*	ND	0.631	ND
Benzo (b) Fluoran	ND	ND	ND
Benzo(a)Pyrene*	ND	1.484	ND
Dibenzo (a, h) ant	ND	ND	ND

Note *= Carcinogenic PAHs

Heavy metals in Water

The concentration of heavy metals in the well water from the two locations is shown in Table 2.The concentration of Cadmium, Nickel, copper, Chromium and Zinc were below detection limits in both locations and also in the control sites, while the concentration of Lead in water samples from both locations (5.28mg/L for Oke-Padre and 1.12mg/l for Iwo-road) were

Table 6: Concentration of Polyaromatic Hydrocarbons in Water Samples (mg/Kg) in the Two Locations (Oke-Padre and Iwo- Road)

Analyte	Oke-Padre	Iwo-Road	Control
Anthracene	ND	ND	ND
Phenathrene	ND	ND	ND
Pyrene	ND	ND	ND
Fluoranthrene	ND	ND	ND
Naphthalene	ND	ND	ND
Acenaphthylene	ND	ND	ND
Acenaphthene	ND	ND	ND
Fluorene	0.004	ND	ND
Chrysene*	ND	ND	ND
Benzo (k)fluoran*	ND	ND	ND
Benzo (g,h,i) per	ND	ND	ND
Indeno (1.2.3-cd)*	ND	ND	ND
Benzo(a)anthracene*	ND	ND	ND
Benzo (b) Fluoran	ND	ND	ND
Benzo(a)Pyrene*	ND	ND	ND
Dibenzo (a, h) ant	ND	ND	ND

Note *= Carcinogenic PAHs, ND= Not detected

Table 7: Concentration of Phthalate Esters in Soil Samples (μg/g) in both locations.

Location	DEP	DPP	DBP	DEHP
Oke-Padre	305.78	177.16	96.36	186.18
Iwo-road	355.24	245.14	167.52	660.99
Control	ND	ND	ND	ND
USEPA	0.020	-	0.081	4.35

ND= Not detected

Table 8: Concentration of Phthalate Esters in Water Samples (μg/L) in Both Locations (Oke-Padre and Iwo-Road)

Location	DEP	DPP	DBP	DEHP
Oke-Padre	21.04	8.99	3.87	8.59
Iwo-road	61.36	16.79	6.35	8.87
Control	ND	ND	ND	ND
USEPA			0.02	0.006

ND= Not detected

higher than that of the control site and also exceeded the permissible limit set by USEPA which is 0.003mg/L. Contamination of water with heavy metals like Lead may cause hazards to the residents of the area and also affect the intelligent quotient of children exposed to this Lead laden water. The statistical analysis in Table 9 also shows that there is significant difference between the concentration of Lead in Oke-Padre and the control site but there is no significant difference between that of Iwo-road and the control site.

Polyaromatic Hydrocarbons in Soil

Table 4 shows that soil samples from both sites were contaminated with Polyaromatic hydrocarbons. Acenaphene, Fluorene, Chrysene, Naphthalene,

Table 9: Anova for Test of Significant Difference of Heavy Metals in Water Samples at 95% Confidence Interval

Parameters	Oke-Padre	Iwo-Road	Control
Pb	2286.8[a]	2607.8[a]	0.0[b]
Cd	62.178[a]	5.165[b]	-2.178[b]
Ni	208.93[a]	33.24[b]	1.19[b]
Cu	4870.90[a]	3243.81[b]	-2.54[c]
Cr	3.0725[b]	21.7750[a]	-1.9050[c]
Zn	139.42750[b]	162.50750[a]	116.94000[c]

Note: Means with the same subscript are not significantly different (P=0.05)

Benzo (K) fluoran, Benzo (g,h,i) per, and Indeno (1,2,3-cd) with concentration 0.288mg/Kg, 0.307mg/Kg, 0.572mg/Kg,) 0.862mg/Kg, 0.097mg/Kg, 1.955mg/Kg, 0.494mg/kg respectively were observed in Oke-padre location, while Phenantrene, Fluoranthrene, Fluorene, Benzo K fluoran, Benzo anthracene and Benzopyrene with concentrations of 2.42mg/Kg, 0.236mg/Kg, 1.901mg/Kg, 1.588mg/kg, 0.631mg/Kg, 1.484mg/Kg were observed in Iwo road location. All these values were higher than that of control sites. The concentrations were above the standard Limits and guidelines set by WHO which is between 0 and 5ng while guideline values is between 0.5 and 1.0 ng/m^3 for PAHs in the environment If this crude method of burning e-waste continues in this area, it may bioaccumulate over time and therefore have carcinogenic, teratogenic and mutagenic effects to residents who are exposed to this water. The results obtained in this study were higher than those obtained in e-waste contaminated soils in china e.g. Wang et al., 2012 reported 1.3-1210ng/g while Leung et al., 2006 reported 0.7-131μg/Kg.

Polyaromatic Hydrocarbons in water samples

Contamination of water samples with polyaromatic hydrocarbons was observed only in water samples from Oke-padre and it was only fluorene that was observed there with concentration of 0.04mg/Kg. the control sites does not contain PAHs at all. This implies that

groundwater sampled around Iwo road dumpsite is not contaminated.

Phthalates in soil samples

Table 4 shows the concentration of Phthalates in soil samples from both locations. Soil samples from both locations are highly polluted with phthalate esters but Phthalate esters were below detection limits in control site. The content of phthalates in soils had been surveyed in some countries. Phthalates concentrations in uncultured soil, soils and sewage sludge-amended soil from Denmark**,** United Kingdom and Netherlands were lower than those measured in this study (VickelsØe et al., 2002, Gibson et al., 2005**,** Peijnenburg and Struijs, 2006). Cai's investigation on soil samples in china revealed six phthalate compounds with concentration ranging from 3.00- 45.67mg/Kg (Cai et al., 2006). This further confirms that these two locations are highly polluted.

Phthalates in water samples

The concentration of phthalate esters found in well water ranged from 3.87-21.04μg/ml for Oke-Padre and 6.35-61.36μg/ml for Iwo road. Comparing the results obtained from both sites with the control samples shows that the well water around those sites are polluted since phthalate esters are found to be below detection limits in all control samples.

Conclusion and Recommendation

The results obtained in this study revealed that soil in both locations are highly polluted with heavy metals, phthalate esters and poly aromatic hydrocarbons (including 4 out of the 7 carcinogenic polyaromatic hydrocarbons). Although water samples were not as polluted as the soil samples, the heavy metal concentration especially Lead, and Phthalate esters concentration have rendered it unfit for drinking and for various domestic purposes and this should be seriously looked into. Plants may grow on these contaminant laden soils and this goes into the food chain which eventually comes to man. Therefore, the dumping of e-waste on the soils has been found to increase the pollution of soils and consequently groundwater through leaching therefore creating a serious pollution problem. Given the present poor status of waste management in Ibadan metropolis, it is therefore recommended that government should prohibit the importation of E-waste scrap and non-repairable used electrical/electronic products into the country. End users should also stop and discourage indiscriminate dumping and burning of e-waste in their surroundings.

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