Scientia Africana, Vol. 18 (No. 1), June, 2019. Pp 25-27
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PCB LEVELS IN SOIL AT E-WASTE DUMPSITE, ALABA INTERNATIONAL MARKET, OJO, LAGOS.

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Received: 15-02-17
Accepted:30-03-17

ABSTRACT

The improper dumping of materials containing polychlorinated biphenyls known as PCBs has caused many dangerous environmental and health effects. This is due to the environmental persistence, bioaccumulation and biomagnification in the terrestrial and aquatic food chains, to humans and other living organisms. This study was undertaken to determine the level of PCBs in the soil environment of Alaba International Market, Ojo in Lagos State of Nigeria. Samples of varying distances were collected from five e-waste dumpsites in the market. Extract from the samples were analyzed using a GC coupled with ECD detector. The results of the study show that the total amount of PCB congeners in the different sites ranged from 0.058mg/kg to 1.352 mg/kg with a mean concentration of 0.386mg/kg. Statistical test showed that there was no significant difference ($P > 0.05$) in sites 1, 2, 4 and 5. The concentration values of total PCBs were higher than the allowable limit of 0.050mg/kg in soil by the WHO. The result from this study has given an oversight function by human in the indiscriminate dumping of electronic waste in soil environment.

Keywords: PCBs, E-waste, dumpsite, GC/ECD, Alaba International Market, Statistical test.

INTRODUCTION

The widespread use of electrical and electronic wastes (e-waste) coupled with improper disposal practices have led to significant environmental contaminations. E-wastes have been disposed indiscriminately over the years, without any precautions being taken. As a result, large volumes of hazardous substances contained in e-wastes have been introduced into the environment. These materials have caused several damages to human health and the environment. Polychlorinated biphenyls (PCBs) are one of the most hazardous substances found in e-waste. PCBs are found in many solid waste materials worldwide. They are a family of compounds consisting of a biphenyl nucleus carrying from 1 to 10 chlorine atoms (Bedard et al. 1987; Quensen et al. 1990; Mousa et al. 1996; ATSDR, 2001). PCBs are considered suitable for use in various commercial and industrial electrical and electronic applications such as capacitors and components in computers, phones, radios and transformers in fire sensitive areas; heat transfer and hydraulic equipment; coolants and lubricants. They serve as plasticizers which provided flexibility in paints, plastics, caulking and rubber products; in pigments,

Scientia Africana, Vol. 18 (No. 1), June, 2019. Pp 28-37
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dyes and carbonless copy paper and for many other applications. They are also used as flame retardants due to their chemical stability and high boiling point (Brievik et. al., 2002; Environmental Health Perspectives, 2013).

The environmental fate and transport pathways of these chemical pollutants are continually concerned because of their potential exposure to humans. The soil is a major pathway for these chemical pollutants to transport and redistribute in the environment. PCBs exist between the liquid phase and particle phase in the ambient air and soil. Soils may serve as a large reservoir of mobile PCBs due to its persistence (Harner et. al. 1995; Krauss, et. al. 2000; Ockenden et. al. 2003).

PCBs are very persistent in both the environment and in the human body. They also have adverse health effects on several different organ systems, including immune system function. They are known to suppress immune function in animals and humans. Human exposure to these PCBs commonly occurs via consumption of contaminated animal fats and fishes. Recent evidence has shown that inhalation of these semi-volatile compounds is also a significant route of exposure (Zhang et al. 2008). There are a number of reports of increased rates of infectious diseases in children exposed to PCBs. Some studies have also demonstrated elevations in respiratory tract infections in exposed children. The toxicological endpoints of concern for environmental levels of PCBs are likely to be thyroid hormone disruption, neuro-developmental deficits and cancer (Osibanjo, 2006; Gilbert and Osibanjo, 2009; Roland et al. 2011).

MATERIALS AND METHODS

Sampling sites

The study area was the Alaba International Markets Ojo located in Lagos State, Southwest, Nigeria. Alaba International was only residential neighborhood until late 1999 and early 2000. They contain hundreds of small scale businesses that sell, repair and service fairly used electronics, pirated software to brand new electronics (BAN SVTC, 2002). The market has informal dumpsites where irreparable and damaged electronics are discarded and later set ablaze to reduce the volume. The map showing the sampling sites at Alaba International are indicated inFigure 1.

Soil Sample Collection

A total of fifteen 50g each soil samples were collected from 0–15cm depth and 25 meters apart from site using a stainless steel shovel around the e-waste dumpsites. Samples were packed with aluminum foil into clean polyethylene bags and transported to the laboratory. Soils were air dried at ambient temperature for a month and subsequently reduced to powder form using a laboratory mortar and pestle and passed through a 2 mm sieve.

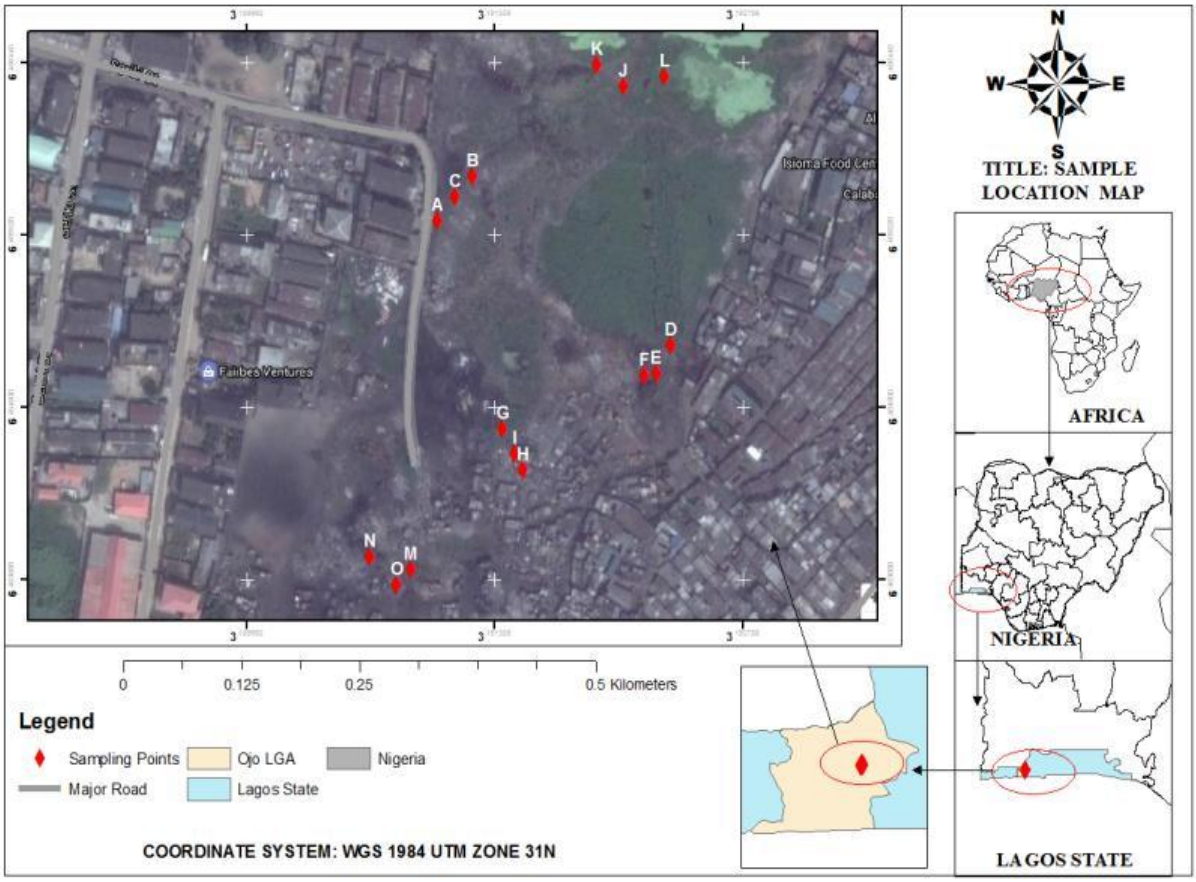

Figure 1: Map showing sampling site

Extraction and clean up

The soil samples were homogenized and 10g was weighed into a 500 ml Duran glass container with a seal. Two surrogates PCB Nr. 209 and tetrachloronaphthalene (TCN) were then added as required. 10g of sodium sulphate (drying agent) was added to the sample to remove the water content in the sample. 50 ml of the solvent mixture of N-hexane and acetone (1:1 mix) used for extraction was added to the solution. It was then allowed to sonicate in an ultrasonic bath for 20 minutes, transferred to a shaking machine where extraction lasted for two hours. The extract was allowed to settle for one hour and an aliquot of the extract was taken and added to 1ml ISTD-Solution (2.5µl 1, 11-dibromundecane in 250ml hexane) before being concentrated to 1ml (Osibanjo and Adeyeye, 1995). Clean up was carried out on the soil sample extracts using silica based SPE cartridges. A combined double effect isolute 1g SAX/SCX (Biotage, Sweden) was used as follows: Pre-conditioning of the cartridges was performed using approximately 4ml of the eluting solvent (hexane) under very low vacuum condition (35 millibar or 0.51 psi). The complete extract was concentrated to 1ml and then introduced directly into the isolute cartridge. The extract was allowed to stand for 5 minutes before eluting with approximately 5ml of hexane. The collected elute was then concentrated with nitrogen or compressed air to 1ml ready for GC injection.

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Instrumental analysis

The extracts were injected into a Hewlett Packard 6890 GC-ECD equipped with auto-injector. An HP-5 fused silica capillary column (30 m length, 0.32 mm i.d., 0.25m film thickness) coated with 5% phenyl 95% methylpolysiloxane was used for the analysis. The oven temperature started at 90°C (holding time 1 min), increased to 140°C at 20°C/min, to 240°C at 3°C/min (holding time 5 min) and finally to 300°C at 10°C/min (holding time 10 min). Injector and detector temperatures were 280°C and 310°C respectively. Nitrogen was used as the carrier and make-up-gas.

RESULTS AND DISCUSSION

The results from Table 1 showed the split of contamination with corresponding location at different points starting from 0, 10 and 20 meters in each dump site. The values measured in the soil samples have the lowest total PCBs concentration of 0.058 mg/kg in site 5 of sample point N, and the highest value of 1.352mg/kg in site 3 point I (Figure 2). Thus giving a mean concentration of 0.386mg/kg. The total PCB concentrations of the samples show that site 1 with points A,B, and C has values of (0.573, 0.276 and 0.498)mg/kg, site 2 with points D,E and F has values of (0.059, 0.346 and 0.399) mg/kg, the values of site 3 with points G,H and I are (0.404, 0.661 and 1.352) mg/kg, site 4 whose points are J,K and L has concentration values of (0.155, 0.157 and 0.472) mg/kg and points M,N and O of site 5 has total concentration values of (0.074, 0.058 and 0.300) mg/kg. In practice, PCBs are found in a variety of different mixtures which is based on the distribution of the individual PCB congeners.

Table 1: Concentration of PCB congeners in soil sample (mg/kg)

Site	Sample Point	Distance from dumpsite (m)	PCB 28	PCB 52	PCB 101	PCB 138	PCB 153	PCB 180	Σ PCB *4.3	Aroclor Found
1	A	0	0.052	0.026	0.024	0.008	0.006	0.016	0.573	1248
	B	10	0.011	0.005	0.009	0.002	0.003	0.035	0.276	1268
	C	20	0.049	0.016	0.017	<0.001	0.003	0.029	0.498	1242
2	D	0	0.004	0.003	0.004	0.001	0.001	0.002	0.059	1254
	E	10	0.005	0.040	0.024	0.002	0.004	0.006	0.346	1248
	F	20	0.006	0.006	0.013	0.003	0.053	0.012	0.399	1260
3	G	0	0.033	0.019	0.011	0.007	0.003	0.021	0.404	1242
	H	10	0.037	0.022	0.007	0.003	0.009	0.076	0.661	1262
	I	20	0.135	0.057	0.014	0.004	0.002	0.102	1.352	1221
4	J	0	0.001	0.007	0.002	0.001	0.014	0.012	0.155	1260
	K	10	0.015	0.007	0.001	0.004	0.002	0.008	0.157	1221
	L	20	0.029	0.013	0.015	0.008	0.014	0.032	0.472	1254
5	M	0	0.002	0.002	0.003	0.003	0.002	0.004	0.074	1262
	N	10	0.001	0.003	0.004	0.003	0.002	0.001	0.058	1254
	O	20	0.005	0.017	0.029	0.014	0.001	0.005	0.300	1254

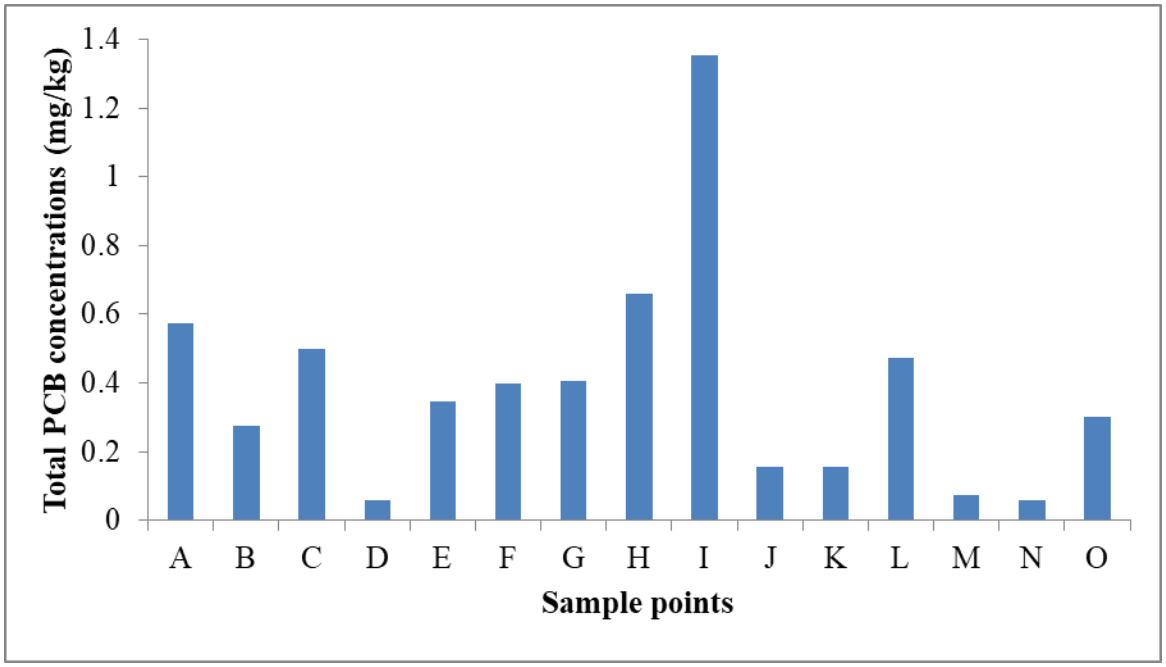

Figure 2: Total PCB concentrations in different sample points

The concentration of the different PCBs congeners in different sites were indicative of divers blends that gave Aroclors 1221 in site 3 and 4, Aroclors 1242 in site 1 and 3, Aroclors 1248 in 1 and 2, 1260 in 2 and 4, 1262 in 3 and 5., Aroclor1254 was identified in site 2,4 and 5 while Aroclor1268 was identified in site 1. These show that the dumpsites contain materials of similar composition. The total PCB concentrations in the sample sites were above the WHO standard (WHO, 1993).

These values show the kinds of activities in the sampling area of interest. From the following quantitative evaluation, all location of samplings are greatly contaminated with PCB mixtures which can pose hazardous effects on inhabitants and surrounding environments. The values in this report were higher than that given by Motelay-Massei et al. (2004), of which concentrations of seven congeners ranged from 0.09 to 150µgkg^{-1} with a mean value of 40µgkg^{-1} in soils of the Seine River basin, France. Also, the values here were higher compared to the work done on soil contamination by Danielovič et al. (2014) whose range of values were 4.7 ng.g^{-1} to 91 ng·g^{-1}. The ∑PCB in soil ranged between 1.32 and 12.94 µ g/kg in a work by Bentum et al. (2012) which were lower than the values reported in this study. Covaci et al. (2001) found average contents of 4, 57.3 and 722l gkg^{-1} (sum of 9 PCBs) for rural, urban and industrial sites respectively, while Notarianni et al. (1998) reported an average value of 0.8lgkg^{-1} for remote sites and more than 20lgkg^{-1} for urban sites. Results showed that PCB concentrations are still relatively high in soils because of their low degradation rate. Bioaccumulation is a critical aspect of environmental fate behavior of PCBs. They accumulate in almost all organisms as a result of their high lipid solubility and slow rate of metabolism and elimination (WHO, 1993).

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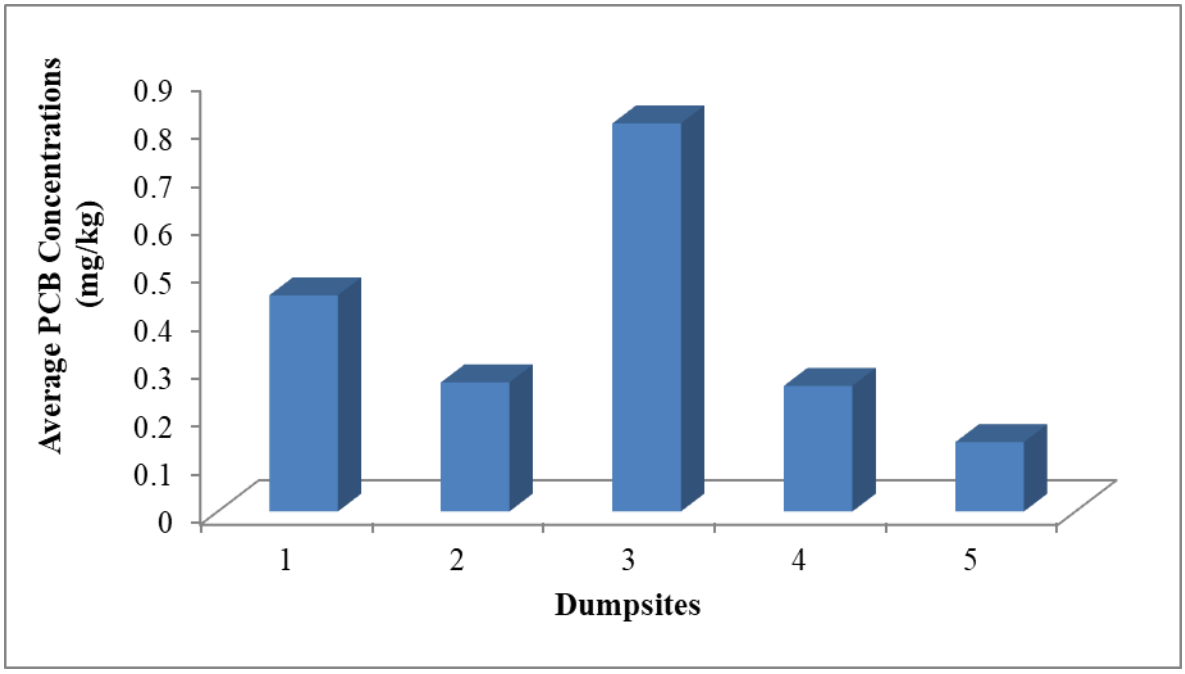

Figure 3: Average PCB concentrations in the dumpsites

Figure 3 gives the average level of PCB concentration in the studied five dumpsites. It showed that the level of contamination is highest in site 3 with an average value of 0.806mg/kg and site 5 gives the lowest average concentration with a value of 0.144mg/kg.

This study has given a clear picture of the rate of contamination in the various dumpsites in Alaba International Market. This can lead to toxic effect on humans having their domestic and commercial activities in the environment. Rain water can also wash down the PCBs and cause negative impact on other environments. PCBs exhibit a wide range of toxic effects in animals, including immunosuppression, liver damage, tumour promotion, neurotoxicity, reproductive toxicity, endocrine disruption and behavioural changes (Seegal and Shain, 1992; Safe, 1993; Brouwer et al., 1999; Rice, 1999). Some immunological and reproductive disorders in marine mammals have nevertheless been linked to elevated levels of persistent organochlorines, in particular the PCBs (Allsopp et al. 1999, 2001; Haave et al. 2003). Studies on the general populations of the Netherlands and the Arctic Swedish fishermen suggested that even relatively low levels of exposure to PCBs can result in impacts on the immune system, growth retardation and neurological effects (Allsoppet al. 1999, 2001; Weisglas-Kuperus et al. 2004). Liu et al. (2008) reported elevated concentrations of PBDEs and PCBs in soils, plants and snails from the town of Guiyu and the surrounding areas. They are translocated from soils to plants. There are elevated concentrations of PCBs, PAHs (Shen et al., 2009) and PBDEs (Cai and Jiang, 2006) in Chinese agricultural soils proximal to E-waste reprocessing sites.

The Duncan multiple range test was used to analyze the statistical data in the five sites. Table 2 shows a level of significance in two subset A and B. Sites 1, 2, 4 and 5 in subset A show no difference of significance

(p> 0.05) but is significantly different from those in subset B (p< 0.05). However site 1 has a level of analogy between the two subsets indicating similarity in the sites of contamination.

Table 2: Duncam Multiple Range Test

Sample locations	Replicates	Subset for alpha = 0.05	
		A	B
5	3	.1440	
4	3	.2613	
2	3	.2680	
1	3	.4490	.4490
3	3		.8057
Sig.		.217	.129

Means for groups in homogeneous subsets are displayed.

It was observed that a high relationship rate between the concentration in e-waste dumpsite and contaminated soil sample in variable distance. Hence, conclusion could be drawn that more percentage of PCBs in the environment of interest is caused by illicit dumping of electrical and electronic materials. The PCB distributions in soil samples provided information on sources and evidence for short range transport and should be regarded as a basis for further research aiming to quantify the global fate of toxic and persistent organic substances such as the PCBs. It is therefore pertinent to regulate and control the dumping of electronic waste in soil environments of human occupation in order to avert the health hazard effect. PCBs should be regulated and monitored at the state and federal levels. Responsible parties must determine the concentration and extent of contamination to make appropriate decisions regarding remediation of PCB contaminated soils.

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