Environmental and health impacts of informal electronic waste recycling

Ohajinwa, C.M.

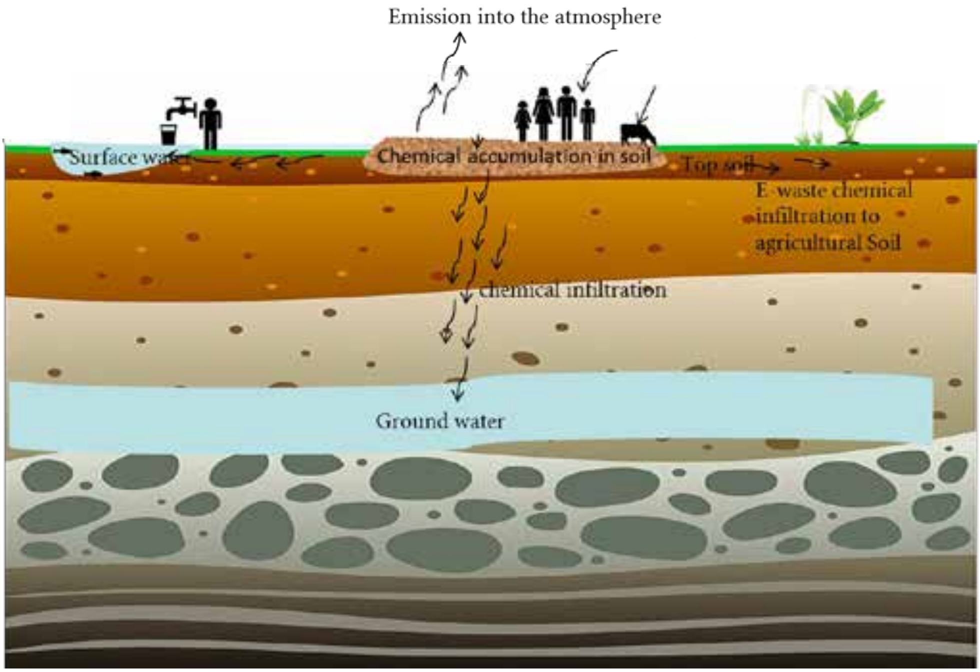
Author: Ohajinwa, C.M.
Title: Environmental and health impacts of informal electronic waste recycling
Issue Date: 2018-10-23

Chapter 6

Health Risk of Polybrominated Diphenyl Ethers and Metals at Informal Electronic Waste Recycling sites

Chimere May Ohajinwa*, Peter M. van Bodegom, Qing Xie, Jingwen Chen, Martina G. Vijver, Willie J.G.M. Peijnenburg

(Submitted)

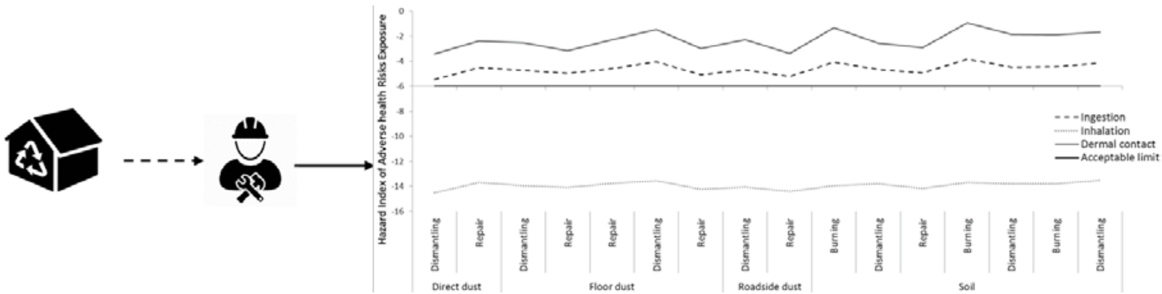


Contamination Routes due to Informal E-waste Recycling at one Site

Abstract

Concerns about the negative consequences of informal e-waste recycling in developing countries are increasing. Insight into the pollution level and its associated health risks to humans through scientific assessments, offers a crucial basis for devising appropriate e-waste recycling management strategies aimed at reducing adverse health effects of informal e-waste recycling. To understand the health impacts of various informal e-waste recycling activities in Nigeria, we calculated the average daily dose for 17 Polybrominated Diphenyl Ethers (PBDEs) congeners and 22 metals in top soils and dust samples, through 3 different exposure routes:- ingestion, inhalation, and dermal contact.

The estimates of non-carcinogenic and cancer risks of both PBDEs and metals exceeded the safe threshold limit by several folds. The major route of exposure was dermal contact followed by ingestion, while inhalation was found to be the least important exposure route. The high health risk revealed in this study should be considered as a wake-up call on the need for appropriate safety measures to be enforced in the e-waste recycling sector in Nigeria.



Graphical Abstract

6.1 Introduction

Information Communication Technology (ICT) has revolutionized our everyday life, consequently causing an increasing demand for ICT. This growing importance of ICT coupled with rising obsolescence due to rapid technological advancements and decreasing electrical electronic equipment (EEE) lifetime has led to a rapid increase in the volume of waste electrical electronic equipment (WEEE also known as *e*-waste) generated around the globe. E-waste consists of electrical and electronic devices including all separate components (such as wires, cables, batteries, circuit boards) which are at the end of their useful life (Baldé *et al*., 2015). The global estimate of e-waste generated in 2014 was 41.8 million metric tons, which increased to 44.7 million metric tons in 2016, and 52 million metric tons are expected to be generated by 2021 (Baldé *et al*., 2017). Of the quantity generated, only about 20% of e-waste generated is properly collected and recycled (Baldé *et al.,* 2017). About 80% of the e-waste generated globally is recycled in informal settings in developing countries such as Nigeria, Ghana, Brazil, Mexico, China, India, Vietnam, and the Philippines (Perkins *et al*., 2014, Awasthi *et al.,* 2016). E-waste is one of the most complex waste streams because of the wide variety of components, compositions, and rapidly changing product designs. It is also one of the fastest growing municipal waste streams in the world.

Electronic and electrical equipment contains over 1000 different substances, some of which are compounds of potential concern (COPC) which include metals, products of incomplete combustion (PICs), and/or reformation products. PICs include any organic compound emitted during incomplete combustion, whereas reformation products are organic compounds that are formed immediately after combustion, due to interaction of specific constituents in the combustion gasses during the combustion process. Some of the organic compounds are persistent organic pollutants (POPs) such as brominated flame retardants (BFRs) like Polybrominated Diphenyl Ethers (PBDEs), non-dioxin like Polychlorinated Biphenyls (PCB), Polycyclic Aromatic Hydrocarbons (PAHs), Polychlorinated Dibenzo-p-dioxins and Furans, or PCDD/Fs. These POPs along with other organic compounds may pose significant implications for human health and environmental safety (UNEP-DTIE, 2007, Brigden *et al*., 2008; Asante *et al.,* 2012).

In this study, we considered PBDEs as a proxy for the cocktail of POPs emitted at informal e-waste recycling sites. POPs like PBDEs are toxic, highly persistent in the environment, bioaccumulative in food chains, and they have a high potential for long-range environmental transport. In addition,

metals from e-waste are non-biodegradable, they persist in the environment and can disturb the ecological balance of the aquatic and the terrestrial environment, as well as affect human health.
These chemicals have been detected in humans and in increasing concentrations in various environmental matrixes, including air, water, soil, sediment, animals and foods in all regions of the world. Evidence of effects of exposure to informal e-waste recycling activities also includes injuries (Ohajinwa *et al*., 2017b), infection of wounds, skin and eye injuries and irritations, respiratory problems, and noise among others (Kristen, 2013; Chen *et al*., 2011). There is also evidence on harmful effects of long-term exposure of humans and wildlife, which include effects on fetal/child development, impacts on thyroid and neurologic functions, immunotoxicity, reproductive toxicity, and endocrine disruption with endpoints related to induction of cancer: See table 1 for more information on health effects due to exposure to organic and metal contaminants.

Table 6.1: Some evidences of Health Effects due to Long-term Exposure to Persistent Organic Contaminants.

Chemical	**Effects**	**Reference**
PCDD/Fs	Thyroid function	Zhang *et al*. 2010
PBDEs	Thyroid function, Reproductive health, endocrine disruption	Zhang *et al*. 2010, Yuan *et al*. 2008, Wu *et al*. 2010, Wang *et al*. 2010,
PCBs	Reproductive health, thyroid function	Zhang *et al*. 2010, Wu *et al.* 2010
PATHs, PFOA	Reproductive health	Wu *et al*. 2011,Wu *et al*. 2012
Cr, Mn, Ni	Lung function	Zheng *et al*. 2013
Pb, Cr, Cd, Ni	Reproductive health	Guo et al. 2010, Li *et al*. 2008a, Xu *et al*. 2012
Mn, Ni, Pb	growth	Huo *et al*. 2007, Zheng *et al*. 2013
Pb	Mental health outcomes	Liu *et al.* 2011, Li *et al*. 2008b
As, Cd, Ni, Cr, Hg, Cu	Cancer, oxidative stress, DNA damage	IARC, 2012, Järup 2003, European Commission 2003

Due to a lack of infrastructure for environmentally sound management of e-waste, lax environmental laws/regulations, and weak enforcement of existing laws/regulations (NESREA 2013, FRN 2011, SAICM 2009, UNEP 1991, WHO 1989), e-wastes are often informally recycled using crude methods such as manual dismantling, smelting, and open burning. Informal e-waste recycling is unsafe, unregulated, unorganised and often overlooked (Brigden *et al*., 2008, Asante *et al*., 2012, Ohajinwa *et al*., 2017a). This leads to incomplete combustion, consequently releasing a mixture of hazardous chemicals, including PBDEs and metals, which in turn cause environmental contamination and health problems.

Disturbingly high concentrations of metals and PBDEs have been found at and around informal e-waste recycling sites, of which Nigeria is inclusive (Ohajinwa *et al.,* 2018). Large quantities of e-waste are informally recycled in Nigeria using various recycling activities such as repair, dismantling, and burning. Each of these activities may pose a potential significant source of human exposure to pollutants (toxic metals and organic pollutants) e.g. through direct inhalation, ingestion, dermal contact or via consumption of food and water. So far, to our knowledge, no study has estimated the associated health risks. Therefore, there is a need to estimate the health risks associated with exposure to e-waste chemicals such as metals and PBDEs. The most evident health-related issues are associated with direct occupational exposure. In addition to these apparent health issues, which are sometimes short term, there might be some unforeseen threatening health issues in the long run or even after the person has stopped working at e-waste sites. To provide an understanding of the health risks to which e-waste workers at the informal e-waste recycling sites in Nigeria are exposed to, we estimated the health risks of exposure to metals and PBDEs pollution as present in top soils (0-10cm) and various dust samples (floor dust, floor dust, and direct dust from electronics). We did this by calculating average daily doses for workers exposed via inhalation, dermal contact and oral ingestion.

Specifically, we aimed to investigate the potential of e-waste workers for (1) non-cancer risks and (2) cancer risk as a result of exposure to metals and PBDEs. In this study, we consider exposure to PBDEs and metals as a proxy for organic and inorganic chemicals respectively. E-waste workers are inadvertently exposed to both classes of chemicals at various informal e-waste recycling sites. In this paper we evaluate 17 PBDE congeners BDE-17, BDE-28, BDE-71, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-138, BDE-183, BDE-190, BDE-208, BDE-206, BDE-209, as well as 22 metals Ag, As, Ba, Cd,Cr, Co, Cu, Fe, Ga, Ge, Hg, Mn,Ni, Pb, Se, Sn, Sb, Te, Ti, Ta, V, and Zn, at the various sites.

6.2 Methods

6.2.1 Study Locations and Designs

The methods employed in this study have been well detailed in our previous studies (Ohajinwa *et al*., 2017a, Ohajinwa *et al.,* 2017b, Ohajinwa *et al.,* 2018). In brief, this study was conducted in three study locations/cities are Ibadan, Lagos, and Aba. The three study locations are some of the large cities in Nigeria where e-waste is recycled (Ogungbuyi *et al*., 2012). In each study location, two e-waste recycling areas were selected. In Lagos, the selected sites were Computer village, Ikeja (6.593°N, 3.342°E) and Alaba international market Ojor (6.462°N, 3.191°E). In Ibadan, the selected sites were Ogunpa (7.383°N, 3.887°E) and Queens Cinema areas (7.392°N, 3.883°E). In Aba, the shopping centre (5.105°N, 7.369°E) and Port-Harcourt Road/Cementary (5.104°N, 7.362°E) and Jubilee road/St Michael's Road (5.122°N, 7.379°E) were selected (figure 6.1).

A comparative cross-sectional study design was adopted to gain an understanding on the pollution levels at the e-waste recycling sites in the three study locations in Nigeria. In each study location, a multi-stage random systematic sampling technique was used to ensure representative inclusion of various e-waste recycling activities (burning, dismantling, and repair) in the selected e-waste recycling areas. Soil and dust samples were collected from the selected sites depending on the feasibility of collecting such samples. For metal analysis, a total of 62 samples consisting of 23 top soil (0-10 cm depth), 31 floor dust, 3 roadside dust, and 5 direct dust samples collected from the inside and outside of electronic devices were analysed. For the PBDE analysis, a total of 56 samples consisting of 16 top soils (0-10cm), 29 floor dust, 5 roadside dust, and 6 direct dust samples collected from the inside and outside of electronic devices were analysed, see supplementary figure 6.1a and 6.1b.

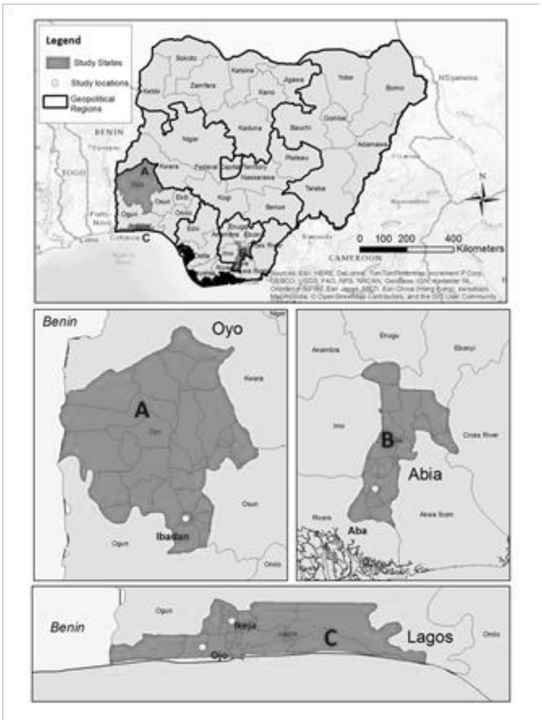


Figure 6.1. Map of Nigeria showing the Study Locations

6.2.2 Description of Recycling Activities and likely Exposure Pathways

The recycling activities include storage, washing, cleaning, dismantling, and metal recovery through stripping of wires or open burning. Most *e*-waste recycling activities (especially at dismantling and burning sites) are carried out outdoors, which involve manually dismantling (disassembling) using hammer, machetes or any tool that can help separate the parts. Open burning leads to incomplete combustion and processed materials from the various e-waste activities are dumped outside on bare ground (no vegetative cover on the ground). Most repair activities, which involve soldering of various parts, take place indoors but also sometimes outdoors, depending on the settings of the work environment and the weather condition. These activities release large quantities of hazardous substances without any emission control.

The workers work without caution to protect their health (no use of personal protective equipment (PPE)) or the environment. The majority (82%) of the workers work without use of any PPE such as gloves, nose mask, also most of them work in shorts, short-sleeved shirts, and slippers (Ohajinwa *et al.,* 2017a,b. This means that they have multiple routes of exposure (directly and indirectly) to the e-waste chemicals. The exposure routes are via ingestion, inhalation, or dermal contact. Informal e-waste recycling happens mostly in urban slums, usually with no official governance, regulations, and people work mainly for economic benefits. Within the e-waste recycling vicinities, there are other (non e-waste recycling) informal businesses. In some locations there are water bodies less than 2 km away from the burning sites. In addition, most residences use boreholes (ground water) and deep wells as a source of water as confirmed by Healya *et al*., 2017. Historically, it seems that e-waste recycling activities were the first activities that release hazardous substances at least at the levels observed. Due to stricter enforcement of the e-waste regulations by the National Environmental Standards and Regulations Enforcement Agency (NESREA), the e-waste dumpsites/burning sites have been moved more than once at Alaba, Lagos. After a while the new sites were crowded with both old and new in-coming workers (usually migrants in search of greener pasture in the cities). As the migrants settle around the dumpsites, the sites finally turn into a small temporary unplanned residential community. One major concern is that current e-waste sites could be used for other activities in the future, which means that the impact of the emissions from e-waste recycling could go beyond the e-waste workers. We recognize that children around the e-waste recycling sites may be exposed to e-waste mixture chemicals, but in this study we focus on e-waste workers' exposure to metals and PBDEs that are likely to be emitted during e-waste recycling.

6.2.3 Health Risk Assessment

Considering the high concentrations of metals and PBDEs at the e-waste sites and the poor work practices, we estimated the potential health risks exposure of e-waste workers via various routes at the various sites. Risk assessment is the process of quantitatively determining the likelihood of adverse health effects resulting from exposure to contaminants over a specified time period. The risk estimation as based on the magnitude, frequency, and duration of human exposure to chemicals

(PBDEs and metals in this study) in the environment is commonly expressed as the average daily dose (ADD). Information on the socio-demographic (age, weight, height) and occupational characteristics were obtained from the e-waste workers, which were used for the health risk estimates. The health risk or hazard of each of the metals, each of the PBDE congeners, and ∑PBDEs is expressed in terms of either a carcinogenic risks or a non-carcinogenic health hazards. Exposure to PBDEs and metals can occur via three main pathways: (a) direct inhalation of vapour or of atmospheric particulates through mouth and nose; (b) incidental ingestion of dust and top soils due to their deposition on food or drinks or via hand-to-mouth activity, and (c) dermal absorption of substances present in particles adhering to exposed skin (Ferreira-Baptista and Miguel, 2005). The models used in this study to calculate the exposure of humans to metals and PBDEs in dust and soil is based on the models developed by the Environmental Protection Agency of the United States (USEPA 2002, USEPA 2001) and the exposure Factors Handbook (USEPA, 1997).

The average daily dose (ADD) (mg/kg/day) of a pollutant in soil and dust taken up via ingestion, dermal contact, and inhalation as exposure pathways can be estimated using Equations (1-3), given below. $ADD_{ingestion}$, $ADD_{inhalation}$, and ADD_{dermal} are the daily amounts of PBDEs and metals taken up through ingestion, inhalation and dermal contact (mg/kg/day) respectively. Median concentrations of the pollutants were used in these calculations. The values and factors used for the estimations are from the standards set by USEPA and actual data, see table 6.2 also for meanings of the abbreviations.

$$ADD_{ingestion} = C \times \frac{R_{ing} \times EF \times ED}{BW \times AT} \times CF \qquad \text{Equation (1)}$$

$$ADD_{dermal} = C \times \frac{SA \times AF \times ABS \times EF \times ED}{BW \times AT} \times CF \qquad \text{Equation (2)}$$

$$ADD_{inhalation} = C_{dust} \times \frac{R_{inh} \times ET \times EF \times ED}{PEF \times BW \times AT} \times CF \qquad \text{Equation (3)}$$

Table 6.2: Exposure Parameters for Adults (E-waste workers) with Associated References.

Abbreviations	Exposure factors	Exposure values	References
C (mg/g)	Median Concentration of the PBDE or metals	Shown in supplementary tables 6.1-6.6	This study
R_{ing} (mg/day)	Ingestion rate	30 mg/day	USEPA 2011
R_{inh} (m^3/day)	inhalation rate	20 m^3/day	USEPA, 2001
EF (days/year)	Exposure frequency	313 days/year	This study
Work days	Average work days	6 days/week	This study
ED (years)	Exposure duration	24 years	USEPA, 2001
ET (hours/day)	Exposure time in hours/day at work	9 hours/day	This study
BW (kg)	Average body weight	67 kg	This study
AT (days)	Average time (ED X 365 days) for non-carcinogens)	24 X 365 days	USEPA, 2001
	Average time (70 X 365 days) for carcinogens	70 X 365 days	USEPA, 2001
Age	Median age of the workers	29 years	This study
SA (cm^2)	Skin surface area	5700 cm^2 (most of them do not use any PPE)	USEPA, 2004
AF (unitless)	Skin adherence factor	0.2 mg/cm^2.day	USEPA, 2001
ABS (unitless)	Dermal absorption factor	0.1 (for semi-volatile compounds)	USEPA, 2001
PEF (m^3/kg)	Particle emission factor	1.36 X 10^9 m^3/kg	USEPA, 2001
CF	Conversion factor	10^{-6}	USEPA, 2001
RfD_i (mg/kg/day)	reference dose via ingestion, inhalation, and dermal contact	available for four PBDE congeners and 19 metals	USEPA 2017
RfC (mg/m^3)	Reference concentration	--	USEPA 2017
IUR	Inhalation Unit Risk	--	USEPA 2017
ADD (mg/kg/day)	average daily dose	Calculated and shown in supplementary tables 6.7-6.12	This study
HQ (unitless)	Hazard quotient	--	
HI	Hazard index	--	
SF	Slope factor	--	USEPA 2017

Based on the ADDs, and the toxicity risk indices, the health risks for no-cancer hazards and cancer risks) of the PBDEs and metals were estimated using equation 4-5. The Hazard Quotient (HQ) is used to calculate the non-carcinogenic risks based on reference daily dose (RfD) (USEPA, 2005), (Lim, Lee, Chon, & Sager, 2008). The RfD is an estimate of the allowable daily exposure to the human population (Leung *et al*., 2008). Values for RfD were available only for four PBDEs congeners (BDE-47, BDE-99, BDE-153, and BDE-209), and for 19 metals: Ag, As, Ba, Cd, Cr, Co, Cu, Fe, Hg, Mn, Ni, Pb, Se, Sn, Sb, Ti, Ta, V, and Zn from USEPA 2011 and USEPA 2017. A HQ value below one indicates that there is an acceptable level of risk (indicating no probability of any adverse effect), while HQ values exceeding one are indicative of unacceptable risks (indicating probability of an adverse health effect) and HQ values exceeding one are assumed to be of concern (USEPA, 2011). The HQ for each of the pollutants (PBDEs and metals) was calculated for ingestion, dermal contact, and inhalation pathways. The health risk for carcinogen risk characterization is based on the slope factor (SF) and the Inhalation Unit Risk (IUR). The slope factor (mg kg-1 day-1) is used in risk assessment to estimate the lifetime probability of an individual developing cancer as a result of exposure to a particular carcinogen. The carcinogenic risk is the probability of an individual developing any type of cancer from lifetime exposure to carcinogenic chemicals. A risk above 1×10^{-4} is generally considered to be unacceptable, a risk below 1×10^{-6} is considered not to trigger any health effect, while risks calculated to be in between 1×10^{-4} and 1×10^{-6} are within the acceptable limits. This means that a risk at 1×10^{-6} is interpreted as indicating that an individual has a one in 1,000,000 chance of developing cancer from the exposure evaluated (Adamu *et al*., 2015; Du *et al*., 2013; Olujimi *et al*., 2015).

Oral Hazard Quotient (HQ_{ing}) = ADD/RfD Equation (4a)

Inhalation Hazard Quotient (HQ_{inh}) = ADD/RfC Equation (4b)

Dermal Hazard Quotient (HQ_{der}) = ADD/(RfD X GIABS) Equation (4c)

Carcinogenic $risk_{ing}$ = ADD_{ing} X SF Equation (5a)

Carcinogenic $risk_{inh}$ = ADD_{inh} X IUR Equation (5b)

Carcinogenic $risk_{der}$ = ADD_{der} X (SF X GIABS) Equation (5c)

GIABS is the gastrointestinal absorption factor was assumed to be equal to one (assuming the total absorption of contaminants for all congeners) (USEPA 2017).

In addition, the Hazard Index (HI) is used to assess the potential of exposure to multiple chemicals or multiple exposure routes at the sites to cause non-carcinogenic effects through different pathways. The hazard index is equal to the sum of the HQ values for the individual chemicals. Since the workers are exposed to multiple substances (both metals and PBDEs) within individual exposure pathways, we estimated the total non-cancer hazard by summing up the HIs of metals and PBDEs for each of the exposure routes. We assume there are no interactions between PBDEs and metals.

6.3 Results

6.3.1 Descriptive Statistics of the PBDE and Metals

In the Supplementary tables S6.1 – S6.6, a summary of the medians of the various PBDE and metal concentrations in soil and in dust samples at the various e-waste recycling sites is shown for each of the three study locations. The general pattern of the PBDEs and metal distribution in top soil and dust samples from the sites showed concentrations in this increasing order: control sites < repair sites < dismantling sites < burning sites. The concentrations of most of the PBDE and metals congeners at the e-waste sites in the three locations exceeded the concentrations at the corresponding control sites.

6.3.2 Human Health Risk Assessment

6.3.2.1 Quantitative Estimation of Non-Carcinogenic Effects

The HI values for dermal exposure to soil and dust were greater than one at all e-waste recycling sites (burning, dismantling, and repair sites), particularly for metals. This indicates that the concentrations at those sites exceeded the threshold (safe) limit and the workers are at risk of contracting non-cancer health effects via dermal exposure, followed by ingestion of soil and dusts at the sites. In contrast, the non-carcinogenic risks via inhalation were negligible. Dermal contact was shown to be the main route of exposure to both metals and PBDEs and consequently poses a higher risk. Generally for the PBDEs, BDE-209 contributed most to the health risk, followed by BDE-99 in Lagos and Ibadan, while in Aba BDE-99 contributed most followed by BDE-153. Figures 6.2 and 6.3 present the hazard index (HI) of top soils and dust for non-cancer risks via all exposure pathways at the e-waste sites for the three locations for PBDEs and metals, respectively. See supplementary tables 6.13-6.15 and 6.17-6.19 for more details.

Combining the HIs for non-cancer risks of metals and PBDEs also revealed that the total HI exceeded the acceptable (safe) limit for non-cancer hazards via dermal exposure at all sites in all locations, and also via ingestion of direct dust at repair sites and ingestion of top soils at burning sits in Lagos (figure 6.4, and supplementary table 6.17). We also considered the cumulative non-cancer effects by summing the risks from all exposure routes. The cumulative non-cancer effects exceeded the accepatable limit at all sites in all locations, see figure 6.5.

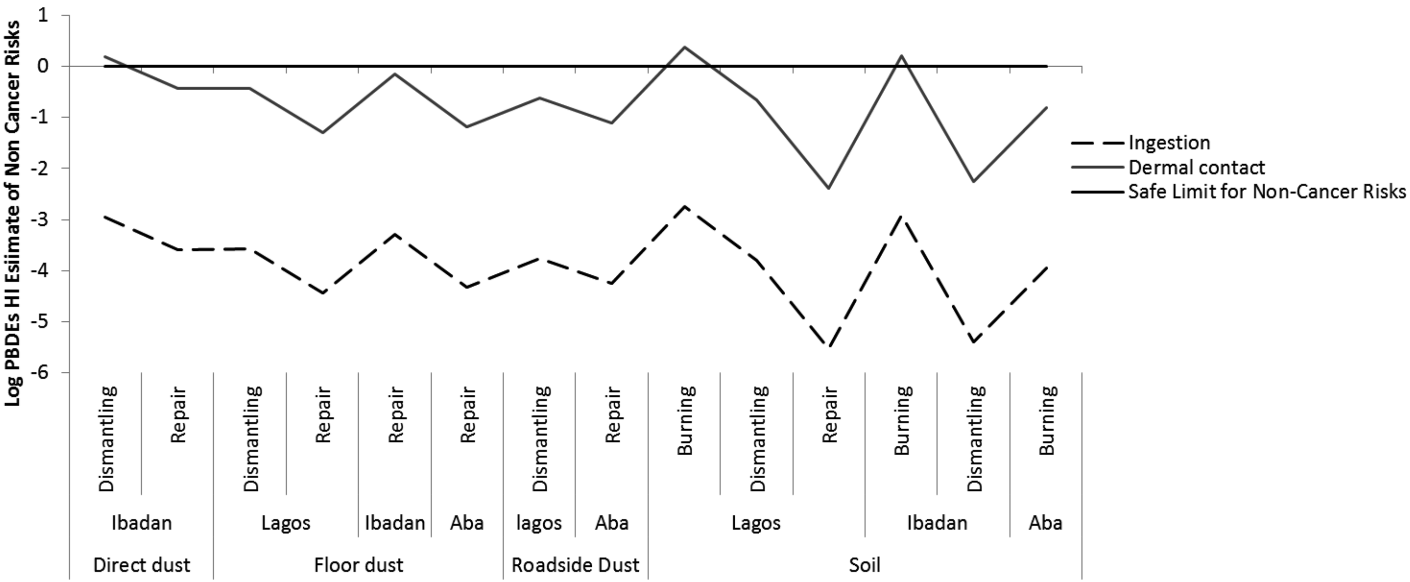


Figure 6.2. Hazard index (HI) for Non-Cancer Risk via Ingestion and Dermal Contact of PBDEs in Soil and Dust at various E-waste sites in Three locations.

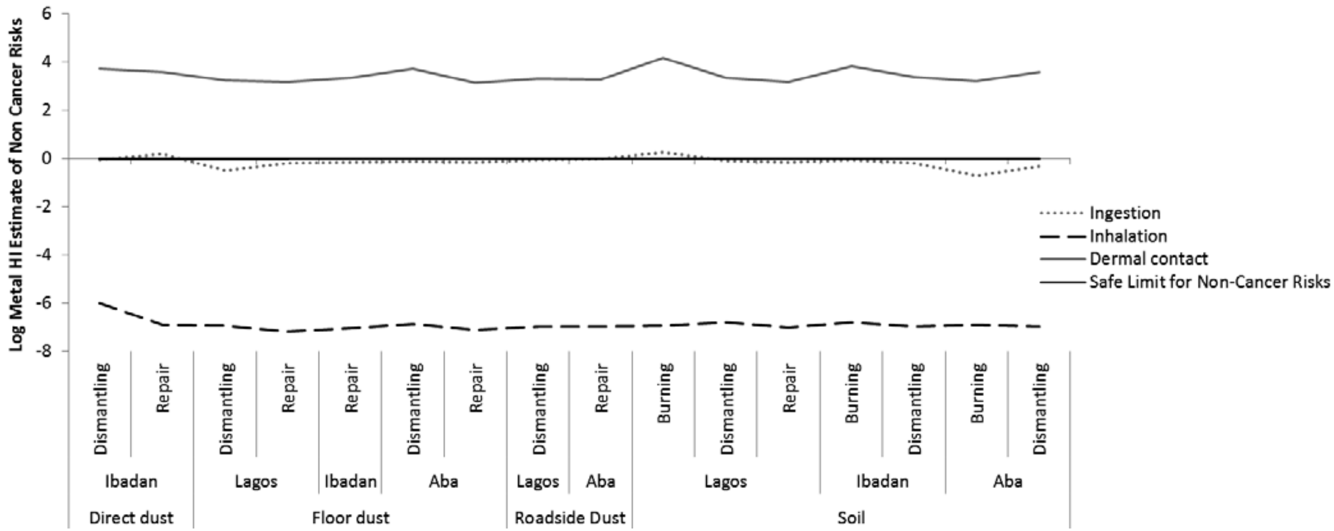


Figure 6.3. Hazard index (HI) for Non-Cancer Risk of Metal Exposure via Ingestion, Inhalation, and Dermal Contact of Soil and Dust at various E-waste sites in the three locations. It shows that e-waste workers are prone to non-cancer risks via dermal contact with metals in soils and dust, also via ngestion of top soils at burning sites in Lagos.

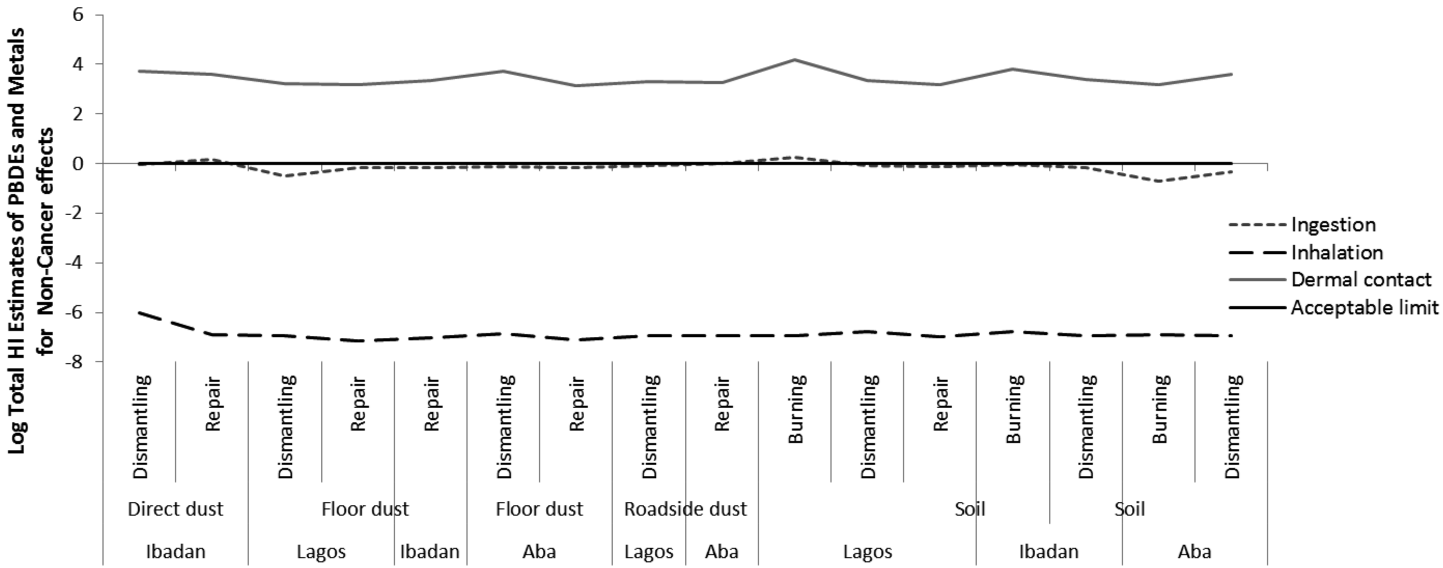


Figure 6.4. Total Hazard index (HI) for Non-Cancer Risk via each Exposure Route of Metal and PBDEs in Soil and Dust at various E-waste sites in the three Locations.

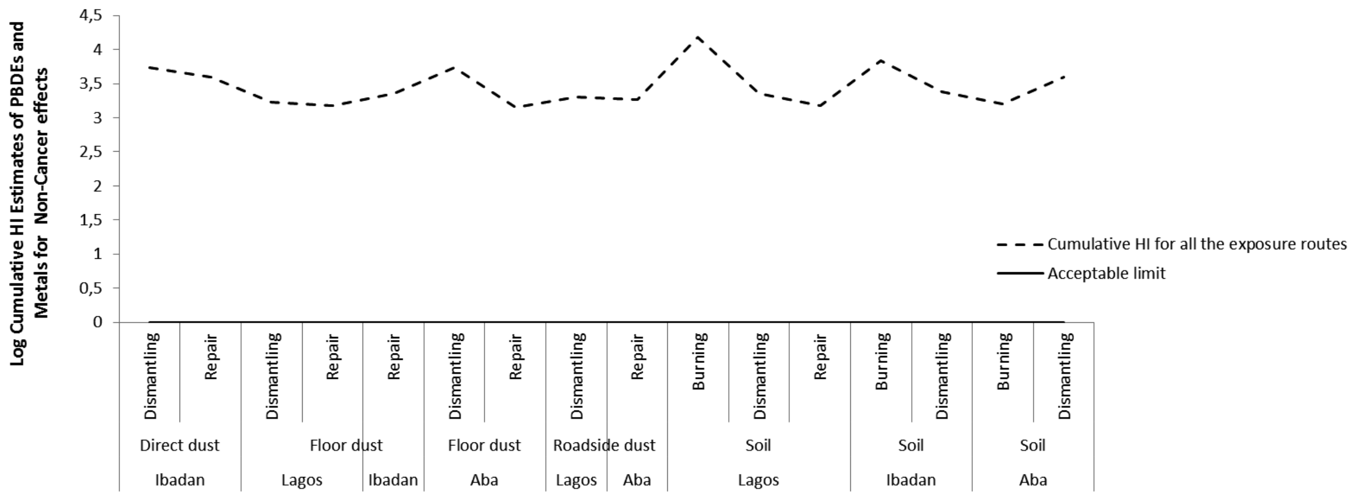


Figure 6.5. Cumulative Hazard index (HI) of all Exposure Routes for Non-Cancer Risk of Metal and PBDEs in Soil and Dust at various E-waste Sites in the Three Locations

6.3.2.2 Quantitative Estimation of Risk of Contracting Cancers

The cancer risk for BDE-209 via ingestion is within the range of 2.3 X 10^{-10} to 8.5 X 10^{-06}, and for dermal uptake is between 3.2 X 10^{-07} to 1.2 X 10^{-2}. This indicates that the risks of contracting cancer via ingestion and dermal contact are above the safe limit of 1 X 10^{-6}, showing that workers at the burning sites are prone to cancer risks via dermal contact of PBDEs; see Figure 6.6 and supplementary tables 6.21-6.23 for more details. These findings indicate that exposure of e-waste workers to PBDEs is potentially harmful to their health.

Only six metals with toxicity values (Cr, Co, Ni, As, Cd, Pb) were used to estimate the potential cancer risks via ingestion, inhalation, and dermal contact. The HI for cancer risk through metals via ingestion ranged from 3.4 X 10^{-06}, to 1.5 X 10^{-04}, via inhalation it ranged from 3.3 X 10^{-15} to 2.90 X 10^{-14}, and via dermal contact it ranged from 3.9 X 10^{-04} to 1.2 X 10^{-01}, see figure 6.7 the results for each of the locations, and the supplementary tables 6.24-6.26 for more details. These results show that exposure via inhalation induces risks that are below the safe limit, while exposure via ingestion and dermal contact induces risks that exceeded the safe limits at all sites in all locations. These findings indicate that the workers are at most risk of adverse non-cancer health effects via dermal contact, followed by ingestion, while exposure via inhalation induces negligible risks. The burning sites seem to be the most unsafe sites followed by the dismantling and repair sites. These findings indicate that exposure of e-waste workers to metals is harmful to their health.

Since the workers are exposed to multiple substances (both metals and PBDEs) within individual exposure pathway, we estimated the total cancer risk by summing up the HIs of metals and PBDEs for each of the exposure routes. The total HI shows that the exposure via ingestion and dermal contact of metals and PBDEs exceeded the acceptable (safe) limit for cancer risks at all sites in all locations (figure 6.8, and supplementary table 6.27). We also considered it appropriate to sum risks from multiple exposure routes (i.e the cumulative risk of exposure). Obviously, the cumulative cancer risk also exceeded the acceptable (safe) limit at all sites in all locations, see figure 6.9.

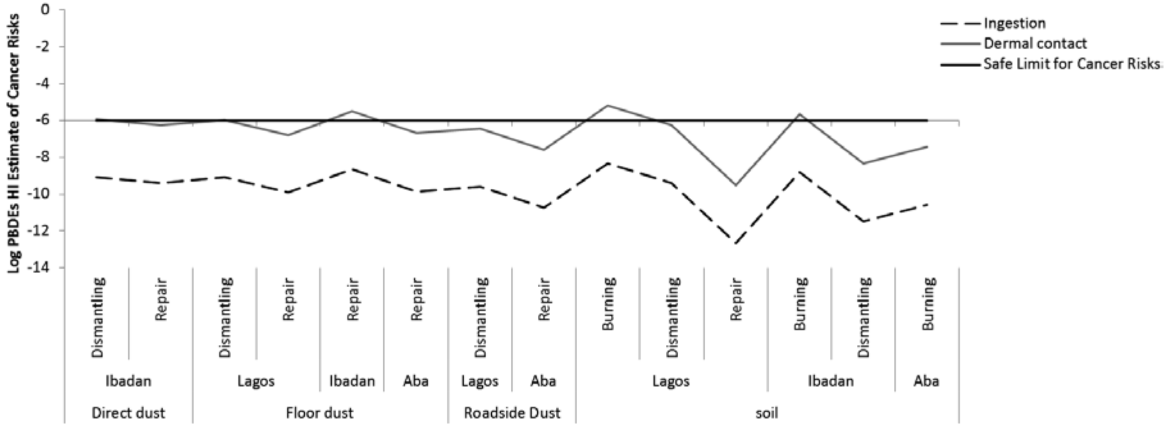


Figure 6.6. Hazard index (HI) for Cancer Risk via Ingestion and Dermal Contact of PBDEs in Soil and in Dust at various E-waste Sites in the Three Locations.

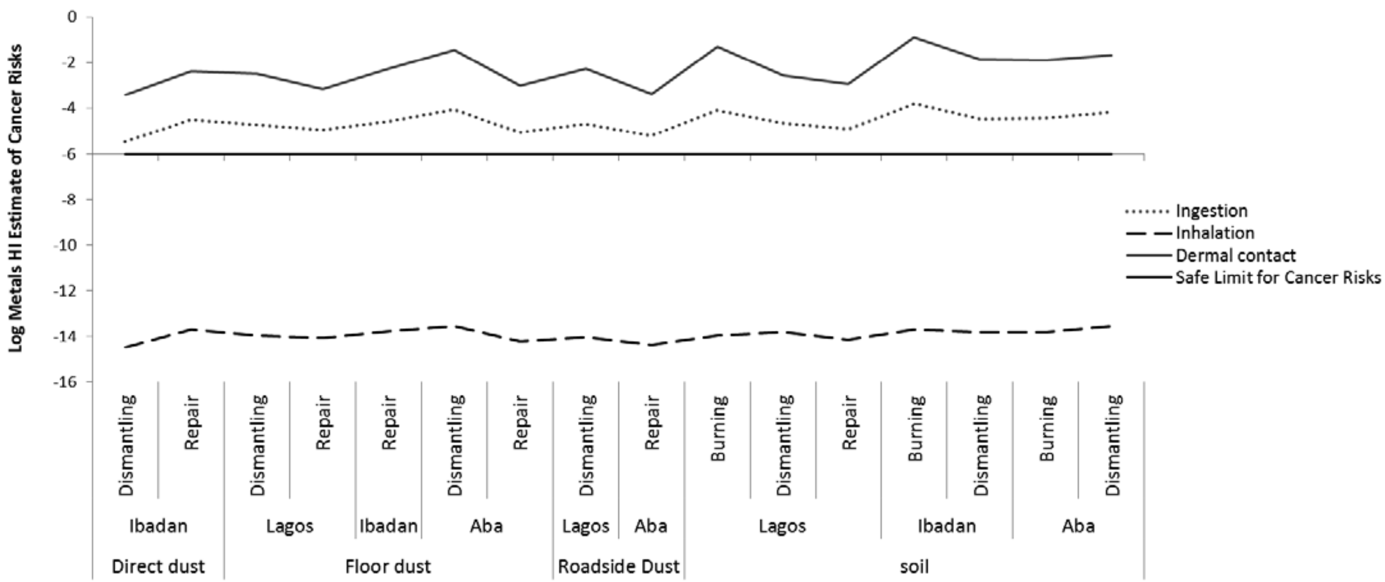


Figure 6.7. Hazard index (HI) for Cancer Risk via Ingestion and Dermal Contact of Metals in Soil and Dust at various E-waste Sites in the Three Locations.

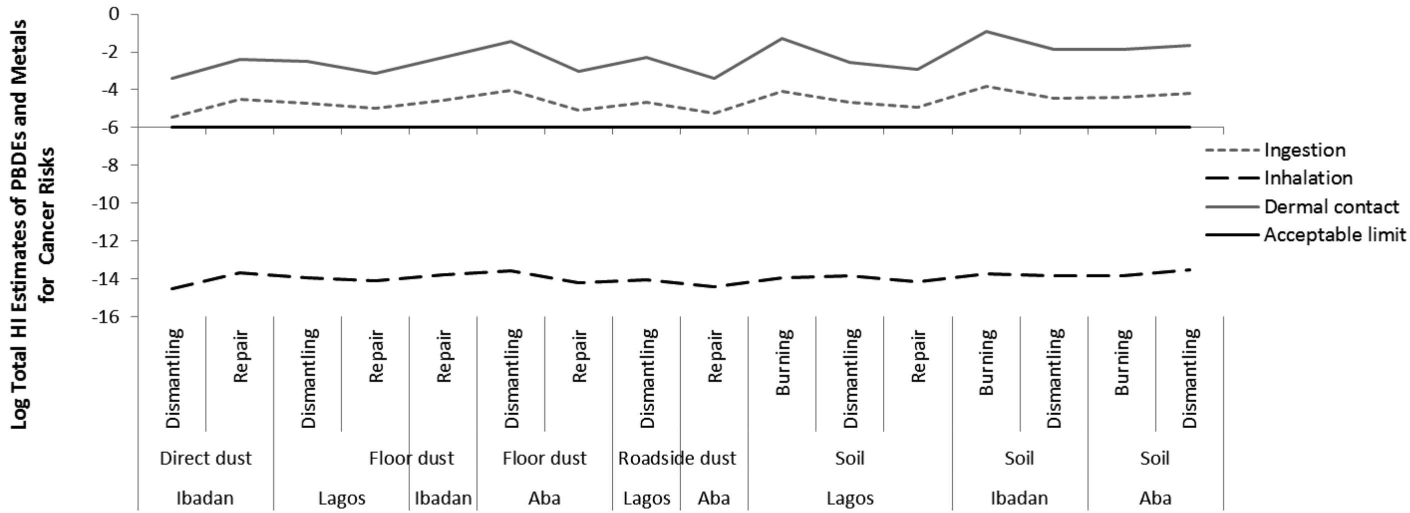


Figure 6.8. Total Hazard index (HI) for Cancer Risk via each Exposure Route of Metal and PBDEs in Soil and Dust at various E-waste sites in the three locations.

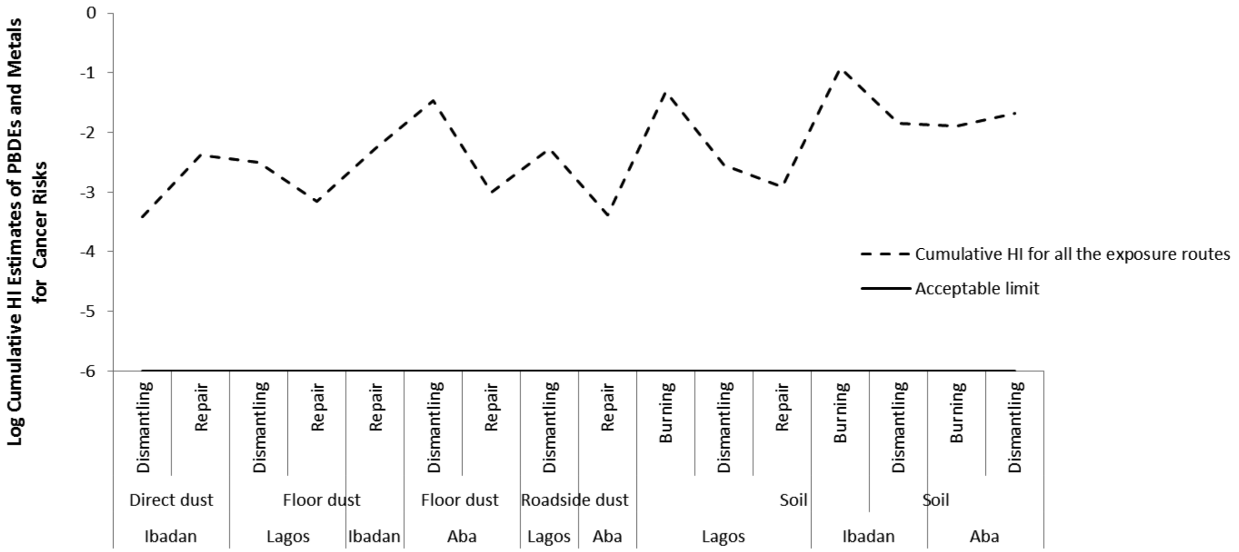


Figure 6.9. Cumulative Hazard index (HI) of all Exposure Routes for Non-Cancer Risk of Metal and PBDEs in Soil and Dust at various E-waste Sites in the Three Locations.

6.4. Discussion

As far as we are aware, this is one of the few studies that estimated the cancer risks and non-cancer hazards of exposure to PBDEs and metals in soil and dust samples from different informal e-waste activity sites (burning, dismantling, and repair sites). The strenghth of this study is that, we considered three exposure pathways, different e-waste recycling activities, various environmental samples (top soils and dusts) from different types of e-waste recycling, and compared exposure in three different cities in two different geopolitical zones in Nigeria. We estimated non-cancer effects, cancer risks, and the assessed the cumulative effect of exposure to both PBDEs and metals via all exposure routes. We also used some primary data on exposure parameters obtained from the respondents for the risk estimation, instead of using US EPA exposure parameters which are commonly used in other studies. In addition, we used epidemiological methods to select the right target groups and sites to ensure that the results obatained are a representative of the target groups and sites, and that the findings are applicable to similar situations anywhere in the world. Focusing on the three types of informal e-waste recycling provided a comprehensive insight on the health risks for different groups of e-waste workers. Workers are exposed to far more chemicals, therefore this study can be considered as being indicative of the risks due to both organic and inorganic chemicals.

The findings of this study as performed in Nigeria are likely to be representative for informal e-waste recycling in developing countries that lack the resources for safe e-waste recycling. Increasing amounts of electronic waste, unsafe recycling methods and disposal pose significant risks to the environment and human health, therefore hindering sustained health. Understanding the implications of scientific data related to informal e-waste recycling contributes towards the achievement of Sustainable Development Goals (SDGs) related to environmental protection (Goals 6, 11, 12, and 14), health (Goal 3), and Goal 8 that focuses on employment and economic growth (United Nations, 2015).

6.4.1 Health Risk Assessments

The median concentrations of the PBDEs and metals considered in this study showed overall an increasing trend of health risks at the sites as the intensity of the e-waste activities increased in this order: control sites < repair sites < dimantling sites < burning sites. This finding reveals that open burning of e-waste is the most risky e-waste processing/recycling activity. The risks associated with the high levels of e-waste chemicals and poor work practices call for concern.

The health risk assessment shows the impact of the different metals and PBDE congeners via viarious routes (ingestion, inhalation, and dermal contact). Overall, the non-cancer effects and cancer risks of exposure to PBDEs is in this order: dermal contact, followed by ingestion of soil and dust at all the sites (burning, dismantling and repair sites). The same pattern of exposure risks are revealed for metal exposure: dermal contact, followed by ingestion, while exposure via inhalation is negligble. This finding is consistent with a similar study on e-waste sites reported by Civan and Kara (2016).

6.4.1.1 Implications for Health Risks

The cumulative hazard index of PBDEs and metals via all exposure routes at all the e-waste sites exceeded the acceptable (safe) limits by several orders of magnitude. Considering the exposure via the different routes to both PBDEs and metals, the total risks calculated shows that exposure via dermal contact exceeds the acceptable limit for non-cancer effects in all locations at all sites with the burning sites having the highest risks. Similarly, total risks for ingestion and dermal contact exceeded the acceptable limits for cancer risks in all locations at all sites with the burning sites having the highest risks. For both non-cancer effects and cancer risks, dermal exposure is the main route of exposure. This stresses the need for use of personal protective equipment (PPE) especially, appropriate work cloths. In addition, the cumulative health risks via all routes of exposure (inhalation, ingestion, and dermal contact) exceeded the acceptable limits of both non-cancer effects and cancer risk at all e-waste sites and in all locations. This indicates that overall the e-waste workers are at the risk of adverse health effects. This further emphasises the need for use of PPE. Exposure of e-waste workers to PBDEs, metals and other hazardous substances is even worsened, because the majority (82%) of the e-waste workers do not use any PPE (Ohajinwa *et al*., 2017b), 88% unaware that e-waste contains hazardous chemicals, and 70% do not think that the chemicals in e-waste can pose any health risk (Ohajinwa *et al*., 2017a). Ohajinwa *et al*., (2017a) also reported a positive correlation between workers' knowledge and work practice. Therefore improving e-waste workers' knowledge on the health risks associated with their daily jobs may decrease risky practices.

It is also important to note that other non-e-waste workers, residents, and children around the e-waste sites are equally at risk of adverse health effects from informal e-waste recycling. The high metal and PBDE concentrations at the e-waste sites may also be an indirect source of pollution of surface and ground water, and air; and could consequently affect people farther away from the e-waste sites. It should therefore be explicitly noted that the actual health risks will be higher than the risks calculated in this study. This indicates an urgent need for more appropriate and effective policies, regulations and strategies for enforcement actions suitable for the informal sector.

It is crucial that e-waste workers are educated of the potential health risks peculiar to their jobs and the safety measures to be undertaken. We recommend that government and other formal institutions design effective occupational health and safety programmes for the informal e-waste workers. There is also need to enforce the policies and regulations. One effective way of enforcement, is for formal institutions to work with the informal e-waste associations to communicate the health risks peculiar to informal e-waste recycling and the safety measures to be undertaken. Enforcement agencies must not be seen to be at cross-purposes with the informal e-waste sector, as it frequently appears. We also recommend the ban of open burning of e-waste and other risky practices which will consequently affect those living far away from the recycling sites and might even effect the unborn generation. One way to ensure such a ban is to device appropriate alternative ways of e-waste recycling with caution to protect health and enviroenment, bridge the commucation gap between enforcement agencies and informal e-waste workers, and also for the informal e-waste recycling associations to be made accountable for safer practices.

We also recommend the use of hierarchical control method in the informal e-waste recycling sector. Such controls are simple steps that will help to minimise exposure and health risks associated with informal e-waste recycling, without impeding the workers' source of livelihood (Figure 6.10). This will not only protect the e-waste workers but also protect people around the e-waste recycing sites.

In our assessment, we assumed that there is no interactions of chemicals that increase toxic effects to humans. Moreover, it is known that the toxicity of the chemicals also depends on other parameters such as exposure time, dose, age, oxidation state, solubility, and properties of the environment among others (Egorova & Ananikov, 2017). To address these uncertainties, we recommend further studies on biomonitoring of the e-waste workers in the informal e-waste recycling. We recommend further toxicological studies to determine the cumulative toxicological effect associated with exposure to multiple chemicals through different exposure pathways, because the additive response method applied in this study might underestimate the potential for health effects. We also recognize that we did not identify all compounds present in the emissions at the e-waste recycling sites.

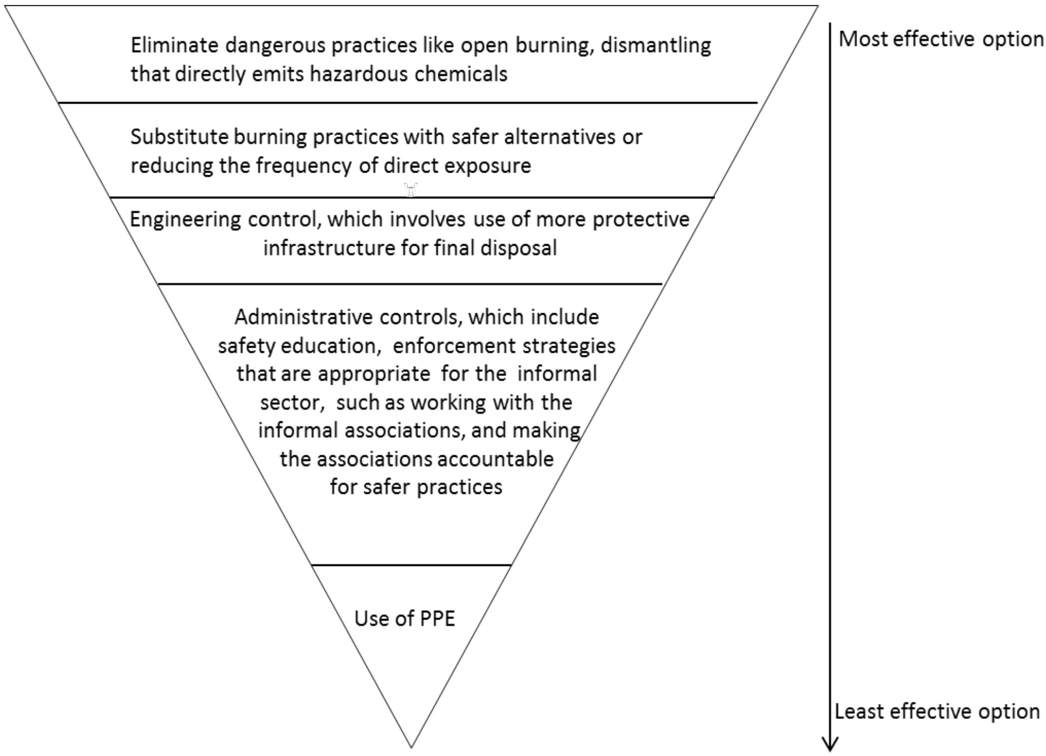


Figure 6.10. Hierachical Control at the Informal E-waste Recycling Sites (modified from OSHA 2016).

6.4.3 Conclusions

Our study is one of the few studies to estimate the total non-cancer effects and cancer risks of e-waste chemical (organic and inorganic) that e-waste workers and people around the e-waste recycling vicinity may be exposed to. The e-waste workers are prone to both adverse non-carcinogenic and carcinogenic health risks with dermal contact being the most important exposure route, followed by ingestion, while exposure via inhalation is the least important exposure route. This is even more worrisome as previous studies revealed that e-waste workers have poor work practices and low awareness of the health risks associated with informal e-waste recycling. These sobering findings call for the need for urgent action by both national and international govenments. There is a need for more appropriate e-waste management regulations that consider maximum participation of the informal e-waste workers to ensure a more sustainable improvement and development in this sector.

References

Adamu CI, Nganje TN, Edet A. 2015. Heavy Metal Contamination and Health Risk Assessment Associated with Abandoned Barite Mines in Cross River State, Southeastern Nigeria. *Environmental Nanotechnology, Monitoring & Management* 3:10–21; doi:10.1016/j.enmm.2014.11.001.

Awasthi AK, Zeng X, Li J. 2016. Environmental Pollution of Electronic Waste Recycling in India : A Critical Review. *Environmental Pollution*. 211:259–270; doi:10.1016/j.envpol.2015.11.027.

Baldé, C.P., Wang, F., Kuehr, R., Huisman J. 2015. The Global E-Waste Monitor 2014: Quantities, Flows and Resources. *A report of United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS).*

Baldé, C.P; Forti, V; Gray V ;Kuehr, R; Stegmann P. 2017. The Global E-waste Monitor 2017. *United Nations University(UNU), International Telecommunication Union (ITU) & International Solid Waste Association(ISWA), Bonn/Geneva/Vienna.*

Basel Convention and United Nations Environmental Programme (UNEP). 1989. Basel Convention On The Control of Transboundary Movements Of Hazardous Wastes and Their Disposal. Protocol on Liability and Compensation for Damage Resulting from Transboundary Movements of Hazardous Wastes and their Disposal 1–116; doi:10.15779/Z38D84V.

Chen A, Dietrich KN, Huo X, Ho S. 2011. Developmental Neurotoxicants in E-waste: An Emerging Health Concern. *Environmental Health Perspectives*. 119:431–438; doi:10.1289/ehp.1002452.

Civan MY, Kara UM. 2016. Risk assessment of PBDEs and PAHs in House Dust in Kocaeli, Turkey: Levels and sources. *Environmental Science Pollution Research* 23:23369–23384; doi:10.1007/s11356-016-7512-5.

Du Y, Gao B, Zhou H, Ju X, Hao H, Yin S. 2013. Health Risk Assessment of Heavy Metals in Road Dusts in Urban Parks of Beijing, China. *Procedia Environmental Sciences* 18:299–309; doi:10.1016/j.proenv.2013.04.039.

Egorova KS, Ananikov VP. 2017. Toxicity of Metal Compounds: Knowledge and Myths. *Organometallics* 36:4071–4090; doi:10.1021/acs.organomet.7b00605.

EPA. 2017. Regional Screening Level (RSL) Summary Table. www.epa.gov/risk/regional- screening-levels-rsls-generic-tables-may-2016 ?

European Commission, Health & Consumer Protection Directorate General. 2003. SCF (2003) Opinion of the Scientific Committee on Food on the Tolerable Upper Intake Level of Copper. *Healthe & Consumer. Protection Directorate* .SCF/CS/NUT/UPPLEV/57 Final

Federal Republic of Nigeria Official Gazette. 2011. The National Environmental (Electrical Electronic Sector) Regulations SI No 23 of 211. B729-797.

Guo Y, Huo X, Li Y, Wu K, Liu J, Huang J, et al. 2010. Monitoring of Lead, Cadmium, Chromium and Nickel in Placenta from an E-waste Recycling Town in China. *Science of the Total Environment*. 408:3113–

3117; doi:10.1016/j.scitotenv.2010.04.018.

Healya Adrian,. 2017. Resilience in Goundwater Supply Systems (RIGSS): Findings from a Survey of Private Households in Lagos, RIGSS Working Paper.

Huo X, Peng L, Xu X, Zheng L, Qiu B, Qi Z, et al. 2007. Elevated Blood Lead levels of Children in Guiyu, an Electronic Waste Recycling Town in China. *Environental Health Perspective*. 115:1113–7; doi:10.1289/ehp.9697.

International Agency for Research on Cancer. 2012. *IARC Monographs*: Arsenic, Metals, Fibres, and Dusts. 100C.

Järup L. 2003. Hazards of heavy metal contamination. *British Medical Bulletin.* 68:167–182; doi:10.1093/bmb/ldg032.

Kristen Grant, Fiona C Goldizen, Peter D Sly, Marie-Noel Brune, Maria Neira, Martin van den Berg REN. 2013. Health consequences of exposure to e-waste : A Systematic Review. *Lancet Global Health*e 1:e350–e361; doi:10.1016/S2214-109X(13)70101-3.

Li Y, Xu X, Liu J, Wu K, Gu C, Shao G, et al. 2008a. The Hazard of Chromium Exposure to Neonates in Guiyu of China. *Science of the Total Environment*. 403:99–104; doi:10.1016/j.scitotenv.2008.05.033.

Li Y, Xu X, Wu K, Chen G, Liu J, Chen S, et al. 2008b. Monitoring of Lead load and its effect on Neonatal Behavioral Neurological Assessment Scores in Guiyu, an Electronic Waste Recycling Town in China. Journal of Environmental Monitoring 10:1233; doi:10.1039/b804959a.

Lim HS, Lee JS, Chon HT, Sager M. 2008. Heavy Metal Contamination and Health Risk Assessment in the Vicinity of the Abandoned Songcheon Au-Ag mine in Korea. *Journal of Geochemical Exploration*. 96:223–230; doi:10.1016/j.gexplo.2007.04.008.

Liu J, Xu X, Wu K, Piao Z, Huang J, Guo Y, et al. 2011. Association between Lead exposure from Electronic Waste Recycling and Child Temperament Alterations. *Neurotoxicology* 32:458–464; doi:10.1016/j.neuro.2011.03.012.

National Environmetal Standards and Regulations (NESREA). 2013. Guide for Importers of Used Elecetrical and Electronic Equipment into Nigeria.

Occupational Safety and Health Administration (OSHA). 2016. Recommended Practices for Safety and Health Programs.

Ogungbuyi O, Nnorom IC, Osibanjo O, Schluep M. 2012. e-Waste Country Assessment Nigeria. *A Report of e-Waste Africa Project of the Secretariat of the Basel Convention.*

Ohajinwa C, Van Bodegom P, Vijver M, Peijnenburg W. 2017a. Health Risks Awareness of Electronic Waste Workers in the Informal Sector in Nigeria. *International Journal of Environmental Research* Public Health 14:911; doi:10.3390/ijerph14080911.

Ohajinwa CM, van Bodegom PM, Vijver MG, Olumide AO, Osibanjo O, Peijnenburg WJGM. 2017b. Prevalence and injury patterns among electronic waste workers in the informal sector in Nigeria.

Injury Prevention injuryprev-2016-042265; doi:10.1136/injuryprev-2016-042265.

Olujimi O, Steiner O, Goessler W. 2015. Journal of African Earth Sciences Pollution indexing and health risk assessments of trace elements in indoor dusts from classrooms , living rooms and offices in Ogun State , Nigeria. *Journal of African Earth Sciences* 101:396–404; doi:10.1016/j.jafrearsci.2014.10.007.

Osibanjo O, Nnorom IC. 2007. The Challenge of Electronic Waste (e-waste) Management in Meveloping Countries. *Waste Managment & Research.* 25:489–501; doi:10.1177/0734242X07082028.

Perkins DN, Brune Drisse M-N, Nxele T, Sly PD. 2014. E-Waste: A Global Hazard. *Annals of Global Health*. 80:286–295; doi:10.1016/j.aogh.2014.10.001.

Strategic Approach to international Chemicals Management (SAICM). 2009. Background Information in Relation to the Emerging Policy Issue of Electronic Waste. *International Conference Chemical Management Second Session* 1–13.

United Nations Environmental Programme (UNEP). 1991. Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes Within Africa. *www.lexmercatoria.org*1–31.

United States Environmental Protection Agency (USEPA). 2011. Exposure Factors Handbook: 2011 Edition. *United States Environmental. Protection. Agency* EPA/600/R-:1–1466; doi:EPA/600/R-090/052F.

USEPA. 1997. Exposure Factors Handbook. *United States Environmental Protection Agency (USEPA)* I:1193; doi:EPA/600/P-95/002Fa-c,.

United States Environmental Protection Agency (USEPA). 2001. Risk Assessment Guidance for Superfund (RAGS) Volume III - Part A: Process for Conducting Probabilistic Risk Assessment, Appendix B. *Office of Emergency and Remedial Response U.S. Environmental Protection Agency* Washington, DC 20460.

United States Environmental Protection Agency (USEPA). 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. *United States Environmental Protection Agency, Solid Waste Emergency Response (OSWER 9355)*.

Wang Hongmei H, Zhang Y, Liu Q, Wang F, Nie J, Qian Y. 2010. Examining the Relationship Between Brominated Flame Retardants (BFR) Exposure and changes of Thyroid Hormone Levels around E-waste Dismantling Sites. *International Journal Hygiene and Environmental Health* 213:369–380; doi:10.1016/j.ijheh.2010.06.004.

Wu K, Xu X, Liu J, Guo Y, Huo X. 2011. In Utero Exposure to Polychlorinated Biphenyls and Reduced Neonatal Physiological Development from Guiyu, China. *Ecotoxicology and Environmental Safety*. 74:2141–2147; doi:10.1016/j.ecoenv.2011.07.038.

Wu K, Xu X, Liu J, Guo Y, Li Y, Huo X. 2010. Polybrominated Diphenyl Ethers in Umbilical Cord Blood and

Relevant Factors in Neonates from Guiyu, China. *Environmental Science & Technology* 44:813–819; doi:10.1021/es9024518.

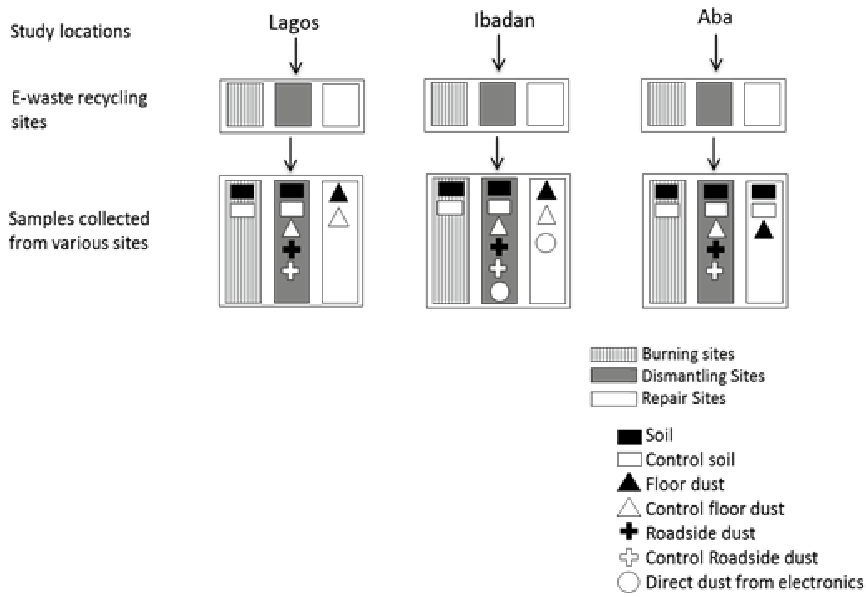
Wu K, Xu X, Peng L, Liu J, Guo Y, Huo X. 2012. Association Between Maternal Exposure to Perfluorooctanoic Acid (PFOA) from Electronic Waste Recycling and Neonatal Health Outcomes. *Environmental International* 48:1–8; doi:10.1016/j.envint.2012.06.018.

Xu X, Yang H, Chen A, Zhou Y, Wu K, Liu J, et al. 2012. Birth outcomes related to informal e-waste recycling in Guiyu, China. *Reproductive. Toxicology.* 33:94–8; doi:10.1016/j.reprotox.2011.12.006.

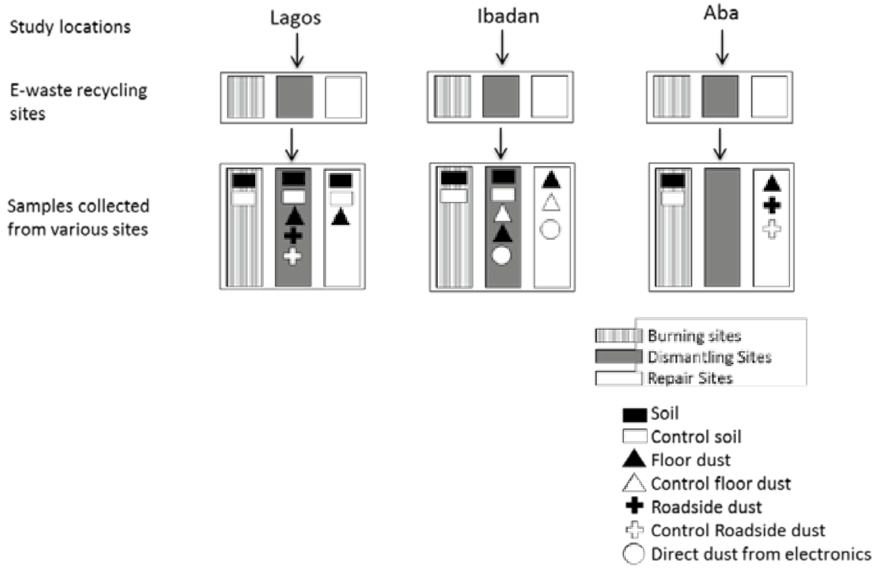
Yuan J, Chen L, Chen D, Guo H, Bi X, Ju Y, et al. 2008. Elevated Serum Polybrominated Diphenyl Ethers and Thyroid-Etimulating Hormone Associated with Lymphocytic Micronuclei in Chinese Workers from an E-waste Dismantling Site. *Environmental Science &f Technology*. 42: 2195–200.

Zhang J, Jiang Y, Zhou J, Wu B, Liang Y, Peng Z, et al. 2010. Elevated Body Burdens of PBDEs, Dioxins, and PCBs on Thyroid Hormone Homeostasis at an Electronic Waste Recycling Site in China. *Environmental Science &f Technology.* 44:3956–3962; doi:10.1021/es902883a.

Zheng G, Xu X, Li B, Wu K, Yekeen TA, Huo X. 2013. Association between Lung Function in school Children and Exposure to three Transition Metals from an E-waste Recycling Area. *Journal of Exposure Science and Environmental Epidemiology.* 23:67–72; doi:10.1038/jes.2012.84.



Supplementary Figure 6.1a. Flow Diagram of Sample Collection for Metal Analysis in the Study Locations



Supplementary Figure 6.1b. Flow Diagram of Sample Collection for PBDEs Analysis in the Study Locations

Supplementary Table 6.1: Median PBDE Concentrations (mg/kg) and Exeedance of Concentrations in Soil and Dusts across various E-waste Sites in Lagos

	Top Soil 0-10cm							Floor dust (control soil)				Roadside dust	
PBDE	Control	Burning sites		Dismantling sites		Repair sites		Dismantling sites		Repair sites		Dismantling sites	
	Median	Median	Exceed	Median	Exceed	Median	Ex	Median	Exceed	Median	Exceed	Median	Exceed
BDE-17	0	3.71		0.08		0.03		0.13		0.02		0.12	
BDE-28	0.005	40.54	8108	0.96	192	0.02	4	0.9	176	0.5	100	0.18	36.00
BDE-71	0.12	433..16	3610	9.4	78	0.13	1.08	23.3	194	1.6	13	8.1	67.50
BDE-47	0.04	17.05	426	3.67	92	0.1	2.50	6.3	158	0.54	14	8.02	200.50
BDE-66	0.02	8.42	421	1.49	75	0.04	2.00	1.4	70	0.14	7	0.61	30.50
BDE-100	0.06	86.02	1434	1.4	23	0.31	5.17	4.1	68	0.4	6.7	4.44	74.00
BDE-99	0.155	158.11	1020	10.83	70	0.53	3.42	15	97	1.8	12	19	122.58
BDE-85	0	22.22		0.04		0		0.21		0.01		0.47	
BDE-154	0.055	80.25	1460	2.68	49	0.21	3.82	5.4	98	0.41	7.45	2.5	45.45
BDE-153	0.085	64.19	755	9.93	117	0.24	2.82	8.9	105	1.9	22.35	8.2	96.47
BDE-138	0	3.24		0.14		0		0.82		0.12		0.29	
BDE-183	0.065	153.73	2365	11.41	176	0.2	3.08	17.6	270	5	77	10.76	165.54
BDE-190	0.06	164.12	2735	4.31	72	0.19	3.17	3.3	55	0.44	7.33	1.19	19.83
BDE-208	0.12	497.38	4145	8.66	72	0.1	0.83	6.33	53	3	25	3.28	27.33
BDE-207	0.25	952.29	3809	21.03	84	0.17	0.68	18.8	75	5.7	23	9.37	37.48
BDE-206	0.145	626.79	4323	8.72	60	0.07	0.48	15	104	2.8	19	9.49	65.45
BDE-209	3.42	17587	5143	1491	436	0.85	0.25	3009	880	432.74	127	961	280.99
$\sum_{16}$PBDE	1.2	3311	2759.35	88	73.33	2.34	1.95	125	104.17	25	20.83	99	82.50
$\sum_{17}$PBDE	4.67	20899	4475.07	1579	338.12	3.19	0.68	3134	671.092	452	96.79	1060	226.98
pH	8.04	7.7		7.89		7.87		8.4		8.31		8.29	
TOC	3.13	36.3		7.83		1.51		4.9		3.35		4.43	

Supplementary Table 6.2: Median Metals Concentrations (ng/kg) and Exeedances of the Concentraions in Soil and Dusts across various E-waste Sites in Lagos

	Top Soil 0-10cm							Floor dust (control soil)				Roadside dust	
Metals	Control	Burning sites		Dismantling sites		Repair sites		Dismantling sites		Repair sites		Dismantling sites	
	Median	Median	Exceed	Median	Exceed	Median	Exceed	Median	Exceed	Median	Exceed	Median	Exceed
V	43..8	24..2	0.6	50.85	1.16	10.2	0.23	38	0.87	26	0.59	35	0.8
Cr	70	68.7	1.0	103.2	1.47	49.3	0.70	78	1.11	57	0.81	62.5	0.9
Mn	116.5	160.1	1.4	694.9	5.96	81.4	0.70	680	5.84	301	2.58	426	3.7
Co	1.5	1.5	1.0	2.53	1.69	1.5	1.00	1.5	1.00	1.5	1.00	2.8	1.9
Ni	18	194.5	10.8	49.4	2.74	100	5.56	99.4	5.52	28	1.56	83	4.6
Cu	15	12590	839.3	759	50.60	27.6	1.84	766	51.07	82	5.47	236	15.7
Zn	44	3152	71.6	810.7	18.43	24.5	0.56	1342	30.50	312	7.09	924	21.0
Ga	9	1.45	0.2	15.4	1.71	4	0.44	7.8	0.87	4	0.44	5.8	0.6
Ge	0.25	0.25	1.0	0.43	1.72	0.8	3.20	0.6	2.40	0.25	1.00	2.1	8.4
As	0.8	83.2	104.0	4.93	6.16	3.6	4.50	5.7	7.13	0.25	0.31	13	16.3
Se	0.25	6	24.0	0.2	0.80	0.25	1.00	0.65	2.60	0.25	1.00	0.6	2.4
Mo	0.5	8.5	17.0	0.5	1.00	1.5	3.00	0.5	1.00	0.5	1.00	0.5	1.0
Ag	1	41.1	41.1	5.5	5.50	1	1.00	34.5	34.50	1.3	1.30	7.7	7.7
Cd	2.55	10.4	4.1	2.55	1.00	2.55	1.00	2.55	1.00	2.55	1.00	2.55	1.0
Sn	1.5	2722	1814.7	53.35	35.57	2.8	1.87	349	232.67	106	70.67	63	42.0
Sb	1.5	1544	1029.3	22.5	15.00	1.5	1.00	43	28.67	4	2.67	14	9.3
Te	0.5	1.5	3.0	1.5	3.00	1.5	3.00	1.5	3.00	1.5	3.00	1.5	3.0
Ba	78.4	1378	17.6	256.35	3.27	106.8	1.36	716	9.13	227	2.90	498	6.4
Hg	0.5	0.5	1.0	2.45	4.90	0.5	1.00	2.3	4.60	0.5	1.00	0.18	0.4
Tl	0.50	0.5	1.0	0.6	1.20	0.5	1.00	0.5	1.00	0.5	1.00	0.75	1.5
Pb	15.7	6358	405.0	199	12.68	12.2	0.78	277	17.64	57	3.63	374	23.8
Ta	17.8	0.5	0.0	19.9	1.12	18	1.01	6	0.34	16.4	0.92	21	1.2
Fe	11860	7373	0.6	31240	2.63	11000	0.93	32960	2.78	16610	1.40	24720	2.1
Ti	7696	4546	0.6	7804	1.01	5108	0.66		0.61	3059	0.40	4538	0.6

Supplementary Table 6.3: Median PBDE Concentrations (mg/kg) and Exeedances of the Concentrations in Soil and Dusts across various E-waste Sites in Ibadan

	Top Soil 0-10cm					Floor dust (control soil)		Direct dust			
PBDE	Control	Burning sites		Dismantling sites		Repair sites		Dismantling sites		Repair sites	
	Median	Median	Exceed	Median	Exceed	Median	Exceed	Median	Exceed	Median	Exceed
BDE-17	0	5.7		0		0.095		0.24		0.37	
BDE-28	0.03	18.5	616.7	0.04	1.33	1.03	34.33	1.24	41.33	3.8	127
BDE-71	0.05	40.14	802.8	0.4	8	8.78	176	18.21	364,2	23.2	464
BDE-47	0.12	83	692.5	0.2	1,7	4.12	34,33	64.6	538,33	14.62	121.83
BDE-66	0.04	25	625	0.04	1	1.1	27.5	5.4	135	2.53	63.25
BDE-100	0.1	20	200	0.17	1.7	1.51	15.1	24.2	242	4.8	48
BDE-99	0.27	107	396.3	0.42	1.6	10.64	39.41	151.2	560	26	95.2
BDE-85	0.005	8	1600	0	0	0.31	62	4.14	828	1.04	208
BDE-154	0.09	22.5	250	0.1	1.1	1.61	18	12.4	138	4.3	47.8
BDE-153	0.17	60	363.6	0.5	3.03	7.5	45.5	33.1	201	12.4	75.15
BDE-138	0	3.5		0		0,43		1.73		1.05	
BDE-183	0.07	38.7	553	1.2	17.14	14.5	206.57	16.7	238.6	15.5	221.42
BDE-190	0.03	32.4	1080	0.1	3.33	1.5	50	2.6	87	4.9	163.33
BDE-208	0.15	173.5	1157	1.2	8	25	164.7	14.2	94.5	25.3	168,33
BDE-207	0.27	367.3	1360	1.9	7.04	78.4	290.37	31.7	117.41	42	155.6
BDE-206	0.19	120	632	0.4	2.11	65	342.105	31.7	166.8	33.44	176
BDE-209	9	5850	650	13	1.44	8043	893.7	3181	353.4	1464	162.7
$\sum_{16}$PBDE	1,56	1124	720,51	5,1	3,269	237	151,92	413	264,74	221	142
$\sum_{17}$PBDE	10,54	6974	661,67	18,00	1,708	8280	785,58	3594	340,99	1685	160
pH	8.2	8.19		5		8.8		-		9	
TOC	3.6	16.78		5.8		5.29		-		18.56	

Supplementary Table 6.4: Median Metal Concentrations (mg/kg) and Exeedances of the Concentrations in Soil and Dusts across various E-waste Sites in Ibadan

	Top Soil 0-10cm					Floor dust (control soil)		Direct dust			
Metals	Control	Burning sites		Dismantling sites		Repair sites		Dismantling sites		Repair sites	
	Median	Median	Exceed	Median	Exceed	Median	Exceed	Median	Exceed	Median	Exceed
V	80	54	0.68	55.2	0.69	65	0.81	922	11.53	111	1.39
Cr	141	123	0.87	105	0.74	121	0.86	14.3	0.10	141	1.00
Mn	597	740	1.24	562	0.94	758	1.27	1607	2.69	797	1.34
Co	8.3	1.5	0.18	1.5	0.18	1.5	0.18	72.3	8.71	1.5	0.18
Ni	51.3	93	1.81	65	1.27	43	0.84	320	6.24	78	1.52
Cu	70	12749	182.13	1344	19.20	323	4.61	42	0.60	321	4.59
Zn	300	3327	11.09	1829	6.10	1152	3.84	122	0.41	2464	8.21
Ga	8.6	5.2	0.60	10	1.16	3	0.35	21	2.44	7.6	0.88
Ge	1.1	0.25	0.23	0.25	0.23	0.6	0.55	1	0.91	0.73	0.66
As	4	103	25.75	10.3	2.58	0.25	0.06	1.2	0.30	5	1.25
Se	0.5	26	52.00	4.4	8.80	1	2.00	0.25	0.50	0.9	1.80
Mo	4.2	8	1.90	7.2	1.71	0.6	0.14	1.3	0.31	2.7	0.64
Ag	14.2	16	1.13	8.5	0.60	5.5	0.39	1.35	0.10	15	1.06
Cd	2.55	7	2.75	2.55	1.00	2.55	1.00	2.55	1.00	2.7	1.06
Sn	44.4	1214	27.34	118	2.66	970	21.85	1.5	0.03	53	1.19
Sb	2	592	296.00	52	26.00	20	10.00	1.5	0.75	48	24.00
Te	1.5	1.5	1.00	1.5	1.00	1.5	1.00	1.5	1.00	1.5	1.00
Ba	638	930	1.46	589	0.92	469	0.74	90	0.14	1049	1.64
Hg	1.1	4.6	4.18	1.3	1.18	0.7	0.64	0.5	0.45	2.7	2.45
Tl	0.9	10	11.11	0.8	0.89	0.7	0.78	0.5	0.56	2.25	2.50
Pb	305	21423	70.24	2455	8.05	950	3.11	0.5	0.00	451	1.48
Ta	21	0.5	0.02	14	0.67	16	0.76	18	0.86	36	1.71
Fe	35835	31435	0.88	50110	1.40	42540	1.19	175000	4.88	57365	1.60
Ti	5265	6595	1.25	4691	0.89	3478	0.66	53190	10.10	4958	0.94

Supplementary Table 6.5: Median PBDE Concentrations (mg/kg) and Exceedances of the Concentrations in Soil and Dusts across various E-waste Sites in Aba

Top Soil 0-10cm (control Roadside dust)				Floor dust (control roadside dust)		Roadside dust (control roadside dust)		
PBDE	**Control**	**Burning sites**		**Repair sites**		**Repair sites**		**Control**
	Median	**Median**	**Exceed**	**Median**	**Exceed**	**Median**	**Exceed**	
BDE-17	0	0.65	0	0.03	0	0.31	0	0.000
BDE-28	0.02	2.3	115	0.16	8	1.44	72.00	0.02
BDE-71	0.06	5.6	93.33	0.73	12.17	3.35	55.83	0.06
BDE-47	0.47	5.6	11.91	1.42	3.02	3.9	8.30	0.47
BDE-66	0.4	2.3	5.75	0.2	0.50	1.6	4.00	0.04
BDE-100	0.18	1.64	9.11	0.38	2.11	0.6	3.33	0.18
BDE-99	1.08	11.7	10.83	2.55	2.36	5.84	5.41	1.08
BDE-85	0.04	4.85	121.25	0.13	3.25	0	0.00	0.04
BDE-154	0.13	7.74	59.54	0.43	3.31	2.46	18.92	0.13
BDE-153	0.23	20.7	90.00	1.6	6.96	7.9	34.35	0.32
BDE-138	0.02	1.6	80.00	0.1	5.00	0.54	27.00	0.02
BDE-183	0.33	13.4	40.61	8.72	26.42	4.56	13.82	0.33
BDE-190	0.07	7.5	107.14	0.37	5.29	2.82	40.29	0.07
BDE-208	0.57	4.4	7.72	3.4	5.96	2.57	4.51	0.57
BDE-207	1.13	8.74	7.73	10	8.85	3.46	3.06	1.13
BDE-206	1.2	3.63	3.03	6	5.00	2.15	1.79	1.1
BDE-209	71.5	103.3	1.44	534	7.47	69	0.97	71.5
$\sum_{16}$PBDE	5.68	102.25	18.00	41.56	7.32	42	7.39	5.7
$\sum_{17}$PBDE	77.7	205.55	2.65	553.15	7.12	111.4	1.43	77.7
pH		7.52		8.11		8.1		8.17
TOC		16.11		2.46		1.5		1.44

Supplementary Table 6.6: Median Metal Concentrations (ng/kg) and Exceedances of the Concentrations in Soil and Dusts across various E-waste Sites in Aba

	Top Soil 0-10cm (control soil)					Floor dust (control soil)				Roadside dust (Roadside dust soil)	
PBDE	**Control**	**Burning sites**		**Dismantling sites**		**Dismantling sites**		**Repair sites**		**Dismantling sites**	
	Median	**Median**	**Exceed**	**Median**	**Exceed**	**Median**	**Exceed**	**Median**	**Exceed**	**Median**	**Exceed**
V	39	28	0.72	46	1.18	26	0.67	17	0.44	42	1.08
Cr	63	102	1.62	197	3.13	188	2.98	42	0.67	30	0.48
Mn	257	419	1.63	540	2.10	654	2.54	307	1.19	274	1.07
Co	1.5	1.5	1.00	1.5	1.00	1.5	1.00	1.5	1.00	1.5	1.00
Ni	20	86	4.30	153	7.65	149	7.45	23	1.15	16	0.80
Cu	21	4435	211.19	7880	375.24	13580	646.67	191	9.10	23	1.10
Zn	85	3553	41.80	5650	66.47	5401	63.54	474	5.58	119	1.40
Ga	10	10	1.00	14.5	1.45	15	1.50	1.8	0.18	4.7	0.47
Ge	0.5	0.7	1.40	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50
As	2	24	12.00	40	20.00	71	35.50	0.25	0.13	0.25	0.13
Se	0.25	2.5	10.00	11.5	46.00	4	16.00	0.25	1.00	0.25	1.00
Mo	0.5	14	28.00	17	34.00	17.5	35.00	0.5	1.00	0.5	1.00
Ag	1	8	8.00	14.5	14.50	40	40.00	1	1.00	1	1.00
Cd	2.55	0.5	0.20	24	9.41	30	11.76	2.55	1.00	2.55	1.00
Sn	1.5	81	54.00	238	158.67	740	493.33	338	225.33	5.5	3.67
Sb	1.4	49	35.00	203	145.00	382	272.86	10	7.14	1.1	0.79
Te	1.5	1.5	1.00	1.5	1.00	1.5	1.00	1.5	1.00	1.5	1.00
Ba	60	973	16.22	3906	65.10	992	16.53	215	3.58	170	2.83
Hg	18.5	0.5	0.03	0.5	0.03	0.5	0.03	0.5	0.03	1	0.05
Tl	**0.9**	0.5	0.56	0.5	0.56	0.5	0.56	0.5	0.56	0.5	0.56
Pb	**0.5**	1505	3010.00	2271	4542.00	3770	7540.00	150	300.00	34	68.00
Ta	29	0.5	0.02	1	0.03	1	0.03	17	0.59	26	0.90
Fe	21710	51330	2.36	70090	3.23	97260	4.48	18860	0.87	17780	0.82
Ti	8314	5748	0.69	2608	0.31	4969	0.60	3850	0.46	5488	0.66

Supplementary Table 6.7: PBDEs Estimation of Average Daily Dose (ADD) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Lagos

	Top Soil 0-10cm									Floor dust (control soil)						Roadside dust		
PBDE	**Burning sites**			**Dismantling sites**			**Repair sites**			**Dismantling sites**			**Repair sites**			**Repair sites**		
	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}
BDE-17	1.4E-06	6.3E-15	2.0E-03	3.1E-08	1.4E-16	4.3E-05	1.2E-08	5.1E-17	1.6E-05	5.0E-08	2.2E-16	6.9E-05	7.7E-09	3.4E-17	1.1E-05	4.6E-08	2.0E-16	6.4E-05
BDE-28	1.6E-05	6.9E-14	2.2E-02	3.7E-07	1.6E-15	5.1E-04	7.7E-09	3.4E-17	1.1E-05	3.4E-07	1.5E-15	4.7E-04	1.9E-07	8.5E-16	2.7E-04	6.9E-08	3.0E-16	9.6E-05
BDE-71	1.7E-04	7.3E-13	2.3E-01	3.6E-06	1.6E-14	5.0E-03	5.0E-08	2.2E-16	6.9E-05	8.9E-06	3.9E-14	1.2E-02	6.1E-07	2.7E-15	8.5E-04	3.1E-06	1.4E-14	4.3E-03
BDE-47	6.5E-06	2.9E-14	9.1E-03	1.4E-06	6.2E-15	2.0E-03	3.8E-08	1.7E-16	5.3E-05	2.4E-06	1.1E-14	3.4E-03	2.1E-07	9.1E-16	2.9E-04	3.1E-06	1.4E-14	4.3E-03
BDE-66	3.2E-06	1.4E-14	4.5E-03	5.7E-07	2.5E-15	7.9E-04	1.5E-08	6.8E-17	2.1E-05	5.4E-07	2.4E-15	7.5E-04	5.4E-08	2.4E-16	7.5E-05	2.3E-07	1.0E-15	3.2E-04
BDE-100	3.3E-05	1.5E-13	4.6E-02	5.4E-07	2.4E-15	7.5E-04	1.2E-07	5.3E-16	1.7E-04	1.6E-06	6.9E-15	2.2E-03	1.5E-07	6.8E-16	2.1E-04	1.7E-06	7.5E-15	2.4E-03
BDE-99	6.1E-05	2.7E-13	8.4E-02	4.2E-06	1.8E-14	5.8E-03	2.0E-07	9.0E-16	2.8E-04	5.8E-06	2.6E-14	8.0E-03	6.9E-07	3.0E-15	9.6E-04	7.3E-06	3.2E-14	1.0E-02
BDE-85	8.5E-06	3.8E-14	1.2E-02	1.5E-08	6.8E-17	2.1E-05	0.0E+00	0.0E+00	0.0E+00	8.1E-08	3.6E-16	1.1E-04	3.8E-09	1.7E-17	5.3E-06	1.8E-07	8.0E-16	2.5E-04
BDE-154	3.1E-05	1.4E-13	4.3E-02	1.0E-06	4.5E-15	1.4E-03	8.1E-08	3.6E-16	1.1E-04	2.1E-06	9.2E-15	2.9E-03	1.6E-07	6.9E-16	2.2E-04	9.6E-07	4.2E-15	1.3E-03
BDE-153	2.5E-05	1.1E-13	3.4E-02	3.8E-06	1.7E-14	5.3E-03	9.2E-08	4.1E-16	1.3E-04	3.4E-06	1.5E-14	4.7E-03	7.3E-07	3.2E-15	1.0E-03	3.1E-06	1.4E-14	4.4E-03
BDE-138	1.2E-06	5.5E-15	1.7E-03	5.4E-08	2.4E-16	7.5E-05	0.0E+00	0.0E+00	0.0E+00	3.1E-07	1.4E-15	4.4E-04	4.6E-08	2.0E-16	6.4E-05	1.1E-07	4.9E-16	1.5E-04
BDE-183	5.9E-05	2.6E-13	8.2E-02	4.4E-06	1.9E-14	6.1E-03	7.7E-08	3.4E-16	1.1E-04	6.7E-06	3.0E-14	9.4E-03	1.9E-06	8.5E-15	2.7E-03	4.1E-06	1.8E-14	5.7E-03
BDE-190	6.3E-05	2.8E-13	8.7E-02	1.7E-06	7.3E-15	2.3E-03	7.3E-08	3.2E-16	1.0E-04	1.3E-06	5.6E-15	1.8E-03	1.7E-07	7.5E-16	2.3E-04	4.6E-07	2.0E-15	6.3E-04
BDE-208	1.9E-04	8.4E-13	2.6E-01	3.3E-06	1.5E-14	4.6E-03	3.8E-08	1.7E-16	5.3E-05	2.4E-06	1.1E-14	3.4E-03	1.2E-06	5.1E-15	1.6E-03	1.3E-06	5.6E-15	1.7E-03
BDE-207	3.7E-04	1.6E-12	5.1E-01	8.1E-06	3.6E-14	1.1E-02	6.5E-08	2.9E-16	9.1E-05	7.2E-06	3.2E-14	1.0E-02	2.2E-06	9.7E-15	3.0E-03	3.6E-06	1.6E-14	5.0E-03
BDE-206	2.4E-04	1.1E-12	3.3E-01	3.3E-06	1.5E-14	4.6E-03	2.7E-08	1.2E-16	3.7E-05	5.8E-06	2.6E-14	8.0E-03	1.1E-06	4.7E-15	1.5E-03	3.6E-06	1.6E-14	5.1E-03
BDE-209	6.8E-03	3.0E-11	9.4E+00	5.7E-04	2.5E-12	7.9E-01	3.3E-07	1.4E-15	4.5E-04	1.2E-03	5.1E-12	1.6E+00	1.7E-04	7.3E-13	2.3E-01	3.7E-04	1.6E-12	5.1E-01
∑PBDE	**8.0E-03**	**3.5E-11**	**1.1E+01**	**6.1E-04**	**2.7E-12**	**8.4E-01**	**1.2E-06**	**5.4E-15**	**1.7E-03**	**1.2E-03**	**5.3E-12**	**1.7E+00**	**1.8E-04**	**7.7E-13**	**2.4E-01**	**4.0E-04**	**1.8E-12**	**5.6E-01**

Supplementary Table 6.8:PBDEs Estimation of Average Daily Dose (ADD) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Ibadan

	Top Soil 0-10cm						Floor dust (control soil)			Direct dust					
PBDE	Burning sites			Dismantling sites			Repair sites			Dismantling sites			Repair sites		
	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}
BDE-17	2.2E-06	9.7E-15	3.0E-03	0.0E+00	0.0E+00	0.0E+00	3.6E-08	1.6E-16	5.1E-05	9.2E-08	4.1E-16	1.3E-04	1.4E-07	6.3E-16	2.0E-04
BDE-28	7.1E-06	3.1E-14	9.9E-03	1.5E-08	6.8E-17	2.1E-05	4.0E-07	1.7E-15	5.5E-04	4.8E-07	2.1E-15	6.6E-04	1.5E-06	6.4E-15	2.0E-03
BDE-71	1.5E-05	6.8E-14	2.1E-02	1.5E-07	6.8E-16	2.1E-04	3.4E-06	1.5E-14	4.7E-03	7.0E-06	3.1E-14	9.7E-03	8.9E-06	3.9E-14	1.2E-02
BDE-47	3.2E-05	1.4E-13	4.4E-02	7.7E-08	3.4E-16	1.1E-04	1.6E-06	7.0E-15	2.2E-03	2.5E-05	1.1E-13	3.4E-02	5.6E-06	2.5E-14	7.8E-03
BDE-66	9.6E-06	4.2E-14	1.3E-02	1.5E-08	6.8E-17	2.1E-05	4.2E-07	1.9E-15	5.9E-04	2.1E-06	9.1E-15	2.9E-03	9.7E-07	4.3E-15	1.3E-03
BDE-100	7.7E-06	3.4E-14	1.1E-02	6.5E-08	2.9E-16	9.1E-05	5.8E-07	2.6E-15	8.0E-04	9.3E-06	4.1E-14	1.3E-02	1.8E-06	8.1E-15	2.6E-03
BDE-99	4.1E-05	1.8E-13	5.7E-02	1.6E-07	7.1E-16	2.2E-04	4.1E-06	1.8E-14	5.7E-03	5.8E-05	2.6E-13	8.1E-02	9.9E-06	4.4E-14	1.4E-02
BDE-85	3.1E-06	1.4E-14	4.3E-03	0.0E+00	0.0E+00	0.0E+00	1.2E-07	5.3E-16	1.7E-04	1.6E-06	7.0E-15	2.2E-03	4.0E-07	1.8E-15	5.5E-04
BDE-154	8.6E-06	3.8E-14	1.2E-02	3.8E-08	1.7E-16	5.3E-05	6.2E-07	2.7E-15	8.6E-04	4.8E-06	2.1E-14	6.6E-03	1.7E-06	7.3E-15	2.3E-03
BDE-153	2.3E-05	1.0E-13	3.2E-02	1.9E-07	8.5E-16	2.7E-04	2.9E-06	1.3E-14	4.0E-03	1.3E-05	5.6E-14	1.8E-02	4.8E-06	2.1E-14	6.6E-03
BDE-138	1.3E-06	5.9E-15	1.9E-03	0.0E+00	0.0E+00	0.0E+00	1.7E-07	7.3E-16	2.3E-04	6.6E-07	2.9E-15	9.2E-04	4.0E-07	1.8E-15	5.6E-04
BDE-183	1.5E-05	6.6E-14	2.1E-02	4.6E-07	2.0E-15	6.4E-04	5.6E-06	2.4E-14	7.7E-03	6.4E-06	2.8E-14	8.9E-03	6.0E-06	2.6E-14	8.3E-03
BDE-190	1.2E-05	5.5E-14	1.7E-02	3.8E-08	1.7E-16	5.3E-05	5.8E-07	2.5E-15	8.0E-04	1.0E-06	4.4E-15	1.4E-03	1.9E-06	8.3E-15	2.6E-03
BDE-208	6.7E-05	2.9E-13	9.2E-02	4.6E-07	2.0E-15	6.4E-04	9.5E-06	4.2E-14	1.3E-02	5.4E-06	2.4E-14	7.5E-03	9.7E-06	4.3E-14	1.3E-02
BDE-207	1.4E-04	6.2E-13	2.0E-01	7.3E-07	3.2E-15	1.0E-03	3.0E-05	1.3E-13	4.2E-02	1.2E-05	5.4E-14	1.7E-02	1.6E-05	7.1E-14	2.2E-02
BDE-206	4.6E-05	2.0E-13	6.4E-02	1.5E-07	6.8E-16	2.1E-04	2.5E-05	1.1E-13	3.5E-02	1.2E-05	5.4E-14	1.7E-02	1.3E-05	5.7E-14	1.8E-02
BDE-209	2.2E-03	9.9E-12	3.1E+00	5.0E-06	2.2E-14	6.9E-03	3.1E-03	1.4E-11	4.3E+00	1.2E-02	5.4E-11	1.7E+01	5.6E-04	2.5E-12	7.8E-01
∑PBDE	**2.7E-03**	**1.2E-11**	**3.7E+00**	**7.6E-06**	**3.3E-14**	**1.0E-02**	**3.2E-03**	**1.4E-11**	**4.4E+00**	**1.2E-02**	**5.5E-11**	**1.7E+01**	**6.4E-04**	**2.8E-12**	**8.9E-01**

Supplementary Table 6.9: PBDEs Estimation of Average Daily Dose (ADD) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Aba

	Top Soil 0-10cm			Floor dust (control soil)			Roadside dust		
PBDE	**Burning sites**			**Repair sites**			**Repair sites**		
	ADD_{ing}	**ADD_{inh}**	**ADD_{der}**	**ADD_{ing}**	**ADD_{inh}**	**ADD_{der}**	**ADD_{ing}**	**ADD_{inh}**	**ADD_{der}**
BDE-17	2.5E-07	1.1E-15	3.5E-04	1.2E-08	5.1E-17	1.6E-05	1.2E-07	5.3E-16	1.7E-04
BDE-28	8.8E-07	3.9E-15	1.2E-03	6.1E-08	2.7E-16	8.5E-05	5.5E-07	2.4E-15	7.7E-04
BDE-71	2.2E-06	9.5E-15	3.0E-03	2.8E-07	1.2E-15	3.9E-04	1.3E-06	5.7E-15	1.8E-03
BDE-47	2.2E-06	9.5E-15	3.0E-03	5.5E-07	2.4E-15	7.6E-04	1.5E-06	6.6E-15	2.1E-03
BDE-66	8.8E-07	3.9E-15	1.2E-03	7.7E-08	3.4E-16	1.1E-04	6.1E-07	2.7E-15	8.5E-04
BDE-100	6.3E-07	2.8E-15	8.7E-04	1.5E-07	6.4E-16	2.0E-04	2.3E-07	1.0E-15	3.2E-04
BDE-99	4.5E-06	2.0E-14	6.2E-03	9.8E-07	4.3E-15	1.4E-03	2.2E-06	9.9E-15	3.1E-03
BDE-85	1.9E-06	8.2E-15	2.6E-03	5.0E-08	2.2E-16	6.9E-05	0.0E+00	0.0E+00	0.0E+00
BDE-154	3.0E-06	1.3E-14	4.1E-03	1.7E-07	7.3E-16	2.3E-04	9.4E-07	4.2E-15	1.3E-03
BDE-153	7.9E-06	3.5E-14	1.1E-02	6.1E-07	2.7E-15	8.5E-04	3.0E-06	1.3E-14	4.2E-03
BDE-138	6.1E-07	2.7E-15	8.5E-04	3.8E-08	1.7E-16	5.3E-05	2.1E-07	9.1E-16	2.9E-04
BDE-183	5.1E-06	2.3E-14	7.1E-03	3.3E-06	1.5E-14	4.6E-03	1.8E-06	7.7E-15	2.4E-03
BDE-190	2.9E-06	1.3E-14	4.0E-03	1.4E-07	6.3E-16	2.0E-04	1.1E-06	4.8E-15	1.5E-03
BDE-208	1.7E-06	7.5E-15	2.3E-03	1.3E-06	5.8E-15	1.8E-03	9.9E-07	4.4E-15	1.4E-03
BDE-207	3.4E-06	1.5E-14	4.7E-03	3.8E-06	1.7E-14	5.3E-03	1.3E-06	5.9E-15	1.8E-03
BDE-206	1.4E-06	6.1E-15	1.9E-03	2.3E-06	1.0E-14	3.2E-03	8.3E-07	3.6E-15	1.1E-03
BDE-209	4.0E-05	1.7E-13	5.5E-02	2.1E-04	9.0E-13	2.8E-01	2.6E-05	1.2E-13	3.7E-02
∑PBDE	**7.9E-05**	**3.5E-13**	**1.1E-01**	**2.2E-04**	**9.7E-13**	**3.0E-01**	**4.3E-05**	**1.9E-13**	**6.0E-02**

Supplementary Table 6.10: Metal Estimation of Average Daily Dose (ADD) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Lagos

	Top Soil 0-10cm									Floor dust (control soil)						Roadside dust		
Metals	Burning sites			Dismantling sites			Repair sites			Dismantling sites			Repair sites			Dismantling sites		
	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}
V	9.3E-06	4.1E-14	1.3E-02	2.0E-05	8.6E-14	2.7E-02	3.9E-06	1.7E-14	5.4E-03	1.5E-05	6.4E-14	2.0E-02	1.0E-05	4.4E-14	1.4E-02	1.3E-05	5.9E-14	1.9E-02
Cr	2.6E-05	1.2E-13	3.7E-02	4.0E-05	1.7E-13	5.5E-02	1.9E-05	8.4E-14	2.6E-02	3.0E-05	1.3E-13	4.2E-02	2.2E-05	9.7E-14	3.0E-02	2.4E-05	1.1E-13	3.3E-02
Mn	6.1E-05	2.7E-13	8.5E-02	2.7E-04	1.2E-12	3.7E-01	3.1E-05	1.4E-13	4.3E-02	2.6E-04	1.2E-12	3.6E-01	1.2E-04	5.1E-13	1.6E-01	1.6E-04	7.2E-13	2.3E-01
Co	5.8E-07	2.5E-15	8.0E-04	9.7E-07	4.3E-15	1.3E-03	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	1.1E-06	4.7E-15	1.5E-03
Ni	7.5E-05	3.3E-13	1.0E-01	1.9E-05	8.4E-14	2.6E-02	3.8E-05	1.7E-13	5.3E-02	3.8E-05	1.7E-13	5.3E-02	1.1E-05	4.7E-14	1.5E-02	3.2E-05	1.4E-13	4.4E-02
Cu	4.8E-03	2.1E-11	6.7E+00	2.9E-04	1.3E-12	4.0E-01	1.1E-05	4.7E-14	1.5E-02	2.9E-04	1.3E-12	4.1E-01	3.1E-05	1.4E-13	4.4E-02	9.1E-05	4.0E-13	1.3E-01
Zn	1.2E-03	5.3E-12	1.7E+00	3.1E-04	1.4E-12	4.3E-01	9.4E-06	4.2E-14	1.3E-02	5.2E-04	2.3E-12	7.1E-01	1.2E-04	5.3E-13	1.7E-01	3.5E-04	1.6E-12	4.9E-01
Ga	5.6E-07	2.5E-15	7.7E-04	5.9E-06	2.6E-14	8.2E-03	1.5E-06	6.8E-15	2.1E-03	3.0E-06	1.3E-14	4.2E-03	1.5E-06	6.8E-15	2.1E-03	2.2E-06	9.8E-15	3.1E-03
Ge	9.6E-08	4.2E-16	1.3E-04	1.7E-07	7.3E-16	2.3E-04	3.1E-07	1.4E-15	4.3E-04	2.3E-07	1.0E-15	3.2E-04	9.6E-08	4.2E-16	1.3E-04	8.1E-07	3.6E-15	1.1E-03
As	3.2E-05	1.4E-13	1.3E-02	1.9E-06	8.4E-15	7.9-04	1.4E-06	6.1E-15	5.8E-04	2.2E-06	9.7E-15	9.1E-04	9.6E-08	4.2E-16	4.0E-05	5.0E-06	2.2E-14	2.1E-03
Se	2.3E-06	1.0E-14	3.2E-03	7.7E-08	3.4E-16	1.1E-04	9.6E-08	4.2E-16	1.3E-04	2.5E-07	1.1E-15	3.5E-04	9.6E-08	4.2E-16	1.3E-04	2.3E-07	1.0E-15	3.2E-04
Mo	3.3E-06	1.4E-14	4.5E-03	1.9E-07	8.5E-16	2.7E-04	5.8E-07	2.5E-15	8.0E-04	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04
Ag	1.6E-05	7.0E-14	2.2E-02	2.1E-06	9.3E-15	2.9E-03	3.8E-07	1.7E-15	5.3E-04	1.3E-05	5.8E-14	1.8E-02	5.0E-07	2.2E-15	6.9E-04	3.0E-06	1.3E-14	4.1E-03
Cd	4.0E-06	1.8E-14	5.5E-05	9.8E-07	4.3E-15	1.4E-05	9.8E-07	4.3E-15	1.4E-05	9.8E-07	4.3E-15	1.4E-05	9.8E-07	4.3E-15	1.4E-05	9.8E-07	4.3E-15	1.4E-05
Sn	1.0E-03	4.6E-12	1.4E+00	2.0E-05	9.0E-14	2.8E-02	1.1E-06	4.7E-15	1.5E-03	1.3E-04	5.9E-13	1.9E-01	4.1E-05	1.8E-13	5.6E-02	2.4E-05	1.1E-13	3.4E-02
Sb	5.9E-04	2.6E-12	8.2E-01	8.6E-06	3.8E-14	1.2E-02	5.8E-07	2.5E-15	8.0E-04	1.7E-05	7.3E-14	2.3E-02	1.5E-06	6.8E-15	2.1E-03	5.4E-06	2.4E-14	7.5E-03
Te	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04
Ba	5.3E-04	2.3E-12	7.3E-01	9.8E-05	4.3E-13	1.4E-01	4.1E-05	1.8E-13	5.7E-02	2.7E-04	1.2E-12	3.8E-01	8.7E-05	3.8E-13	1.2E-01	1.9E-04	8.4E-13	2.7E-01
Hg	1.9E-07	8.5E-16	2.7E-04	9.4E-07	4.2E-15	1.3E-03	1.9E-07	8.5E-16	2.7E-04	8.8E-07	3.9E-15	1.2E-03	1.9E-07	8.5E-16	2.7E-04	6.9E-08	3.0E-16	9.6E-05
Tl	1.9E-07	8.5E-16	2.7E-04	2.3E-07	1.0E-15	3.2E-04	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04	2.9E-07	1.3E-15	4.0E-04
Pb	2.4E-03	1.1E-11	3.4E+00	7.6E-05	3.4E-13	1.1E-01	4.7E-06	2.1E-14	6.5E-03	1.1E-04	4.7E-13	1.5E-01	2.2E-05	9.7E-14	3.0E-02	1.4E-04	6.3E-13	2.0E-01
Ta	1.9E-07	8.5E-16	2.7E-04	7.6E-06	3.4E-14	1.1E-02	6.9E-06	3.0E-14	9.6E-03	2.3E-06	1.0E-14	3.2E-03	6.3E-06	2.8E-14	8.7E-03	8.1E-06	3.6E-14	1.1E-02
Fe	2.8E-03	1.2E-11	3.9E+00	1.2E-02	5.3E-11	1.7E+01	4.2E-03	1.9E-11	5.9E+00	1.3E-02	5.6E-11	1.8E+01	6.4E-03	2.8E-11	8.8E+00	9.5E-03	4.2E-11	1.3E+01
Ti	1.7E-03	7.7E-12	2.4E+00	3.0E-03	1.3E-11	4.2E+00	2.0E-03	8.7E-12	2.7E+00	1.8E-03	8.0E-12	2.5E+00	1.2E-03	5.2E-12	1.6E+00	1.7E-03	7.7E-12	2.4E+00

Supplementary Table 6.11: Metal Average Daily Dose (ADD) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Ibadan

	Top Soil 0-10cm						Floor dust (control soil)			Direct dust					
Metals	Burning sites			Dismantling sites			Repair sites			Dismantling sites			Repair sites		
	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}
V	2.1E-05	9.1E-14	2.9E-02	2.1E-05	9.4E-14	2.9E-02	2.5E-05	1.1E-13	3.5E-02	3.5E-04	1.6E-12	4.9E-01	4.3E-05	1.9E-13	5.9E-02
Cr	4.7E-05	2.1E-13	6.6E-02	4.0E-05	1.8E-13	5.6E-02	4.6E-05	2.0E-13	6.4E-02	5.5E-06	2.4E-14	7.6E-03	5.4E-05	2.4E-13	7.5E-02
Mn	2.8E-04	1.3E-12	3.9E-01	2.2E-04	9.5E-13	3.0E-01	2.9E-04	1.3E-12	4.0E-01	6.2E-04	2.7E-12	8.6E-01	3.1E-04	1.4E-12	4.2E-01
Co	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	2.8E-05	1.2E-13	3.9E-02	5.8E-07	2.5E-15	8.0E-04
Ni	3.6E-05	1.6E-13	5.0E-02	2.5E-05	1.1E-13	3.5E-02	1.7E-05	7.3E-14	2.3E-02	1.2E-04	5.4E-13	1.7E-01	3.0E-05	1.3E-13	4.2E-02
Cu	4.9E-03	2.2E-11	6.8E+00	5.2E-04	2.3E-12	7.2E-01	1.2E-04	5.5E-13	1.7E-01	1.6E-05	7.1E-14	2.2E-02	1.2E-04	5.4E-13	1.7E-01
Zn	1.3E-03	5.6E-12	1.8E+00	7.0E-04	3.1E-12	9.7E-01	4.4E-04	2.0E-12	6.1E-01	4.7E-05	2.1E-13	6.5E-02	9.5E-04	4.2E-12	1.3E+00
Ga	2.0E-06	8.8E-15	2.8E-03	3.8E-06	1.7E-14	5.3E-03	1.2E-06	5.1E-15	1.6E-03	8.1E-06	3.6E-14	1.1E-02	2.9E-06	1.3E-14	4.0E-03
Ge	9.6E-08	4.2E-16	1.3E-04	9.6E-08	4.2E-16	1.3E-04	2.3E-07	1.0E-15	3.2E-04	3.8E-07	1.7E-15	5.3E-04	2.8E-07	1.2E-15	3.9E-04
As	4.0E-05	1.7E-13	1.6E-02	4.0E-06	1.7E-14	1.6E-03	9.6E-08	4.2E-16	4.0E-05	4.6E-07	2.0E-15	1.9E-04	1.9E-06	8.5E-15	8.0E-04
Se	1.0E-05	4.4E-14	1.4E-02	1.7E-06	7.5E-15	2.3E-03	3.8E-07	1.7E-15	5.3E-04	9.6E-08	4.2E-16	1.3E-04	3.5E-07	1.5E-15	4.8E-04
Mo	3.1E-06	1.4E-14	4.3E-03	2.8E-06	1.2E-14	3.8E-03	2.3E-07	1.0E-15	3.2E-04	5.0E-07	2.2E-15	6.9E-04	1.0E-06	4.6E-15	1.4E-03
Ag	6.1E-06	2.7E-14	8.5E-03	3.3E-06	1.4E-14	4.5E-03	2.1E-06	9.3E-15	2.9E-03	5.2E-07	2.3E-15	7.2E-04	5.8E-06	2.5E-14	8.0E-03
Cd	2.7E-06	1.2E-14	3.7E-05	9.8E-07	4.3E-15	1.4E-05	9.8E-07	4.3E-15	1.4E-05	9.8E-07	4.3E-15	1.4E-05	1.0E-06	4.6E-15	1.4E-05
Sn	4.7E-04	2.1E-12	6.5E-01	4.5E-05	2.0E-13	6.3E-02	3.7E-04	1.6E-12	5.2E-01	5.8E-07	2.5E-15	8.0E-04	2.0E-05	9.0E-14	2.8E-02
Sb	2.3E-04	1.0E-12	3.2E-01	2.0E-05	8.8E-14	2.8E-02	7.7E-06	3.4E-14	1.1E-02	5.8E-07	2.5E-15	8.0E-04	1.8E-05	8.1E-14	2.6E-02
Te	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04
Ba	3.6E-04	1.6E-12	5.0E-01	2.3E-04	1.0E-12	3.1E-01	1.8E-04	7.9E-13	2.5E-01	3.5E-05	1.5E-13	4.8E-02	4.0E-04	1.8E-12	5.6E-01
Hg	1.8E-06	7.8E-15	2.4E-03	5.0E-07	2.2E-15	6.9E-04	2.7E-07	1.2E-15	3.7E-04	1.9E-07	8.5E-16	2.7E-04	1.0E-06	4.6E-15	1.4E-03
Tl	3.8E-06	1.7E-14	5.3E-03	3.1E-07	1.4E-15	4.3E-04	2.7E-07	1.2E-15	3.7E-04	1.9E-07	8.5E-16	2.7E-04	8.6E-07	3.8E-15	1.2E-03
Pb	8.2E-03	3.6E-11	1.1E+01	9.4E-04	4.2E-12	1.3E+00	3.6E-04	1.6E-12	5.1E-01	1.9E-07	8.5E-16	2.7E-04	1.7E-04	7.6E-13	2.4E-01
Ta	1.9E-07	8.5E-16	2.7E-04	5.4E-06	2.4E-14	7.5E-03	6.1E-06	2.7E-14	8.5E-03	6.9E-06	3.0E-14	9.6E-03	1.4E-05	6.1E-14	1.9E-02
Fe	1.2E-02	5.3E-11	1.7E+01	1.9E-02	8.5E-11	2.7E+01	1.6E-02	7.2E-11	2.3E+01	6.7E-02	3.0E-10	9.3E+01	2.2E-02	9.7E-11	3.1E+01
Ti	2.5E-03	1.1E-11	3.5E+00	1.8E-03	7.9E-12	2.5E+00	1.3E-03	5.9E-12	1.9E+00	2.0E-02	9.0E-11	2.8E+01	1.9E-03	8.4E-12	2.6E+00

Supplementary Table 6.12: Metal Average Daily Dose (ADD) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Aba

	Top Soil 0-10cm						Floor dust						Roadside dust		
Metals	**Burning sites**			**Dismantling sites**			**Dismantling sites**			**Repair sites**					
	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}	ADD_{ing}	ADD_{inh}	ADD_{der}
V	1.1E-05	4.7E-14	1.5E-02	1.8E-05	7.8E-14	2.4E-02	1.0E-05	4.4E-14	1.4E-02	6.5E-06	2.9E-14	9.1E-03	1.6E-05	7.1E-14	2.2E-02
Cr	3.9E-05	1.7E-13	5.4E-02	7.6E-05	3.3E-13	1.0E-01	7.2E-05	3.2E-13	1.0E-01	1.6E-05	7.1E-14	2.2E-02	1.2E-05	5.1E-14	1.6E-02
Mn	1.6E-04	7.1E-13	2.2E-01	2.1E-04	9.1E-13	2.9E-01	2.5E-04	1.1E-12	3.5E-01	1.2E-04	5.2E-13	1.6E-01	1.1E-04	4.6E-13	1.5E-01
Co	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04
Ni	3.3E-05	1.5E-13	4.6E-02	5.9E-05	2.6E-13	8.1E-02	5.7E-05	2.5E-13	7.9E-02	8.8E-06	3.9E-14	1.2E-02	6.1E-06	2.7E-14	8.5E-03
Cu	1.7E-03	7.5E-12	2.4E+00	3.0E-03	1.3E-11	4.2E+00	5.2E-03	2.3E-11	7.2E+00	7.3E-05	3.2E-13	1.0E-01	8.8E-06	3.9E-14	1.2E-02
Zn	1.4E-03	6.0E-12	1.9E+00	2.2E-03	9.6E-12	3.0E+00	2.1E-03	9.1E-12	2.9E+00	1.8E-04	8.0E-13	2.5E-01	4.6E-05	2.0E-13	6.3E-02
Ga	3.8E-06	1.7E-14	5.3E-03	5.6E-06	2.5E-14	7.7E-03	5.8E-06	2.5E-14	8.0E-03	6.9E-07	3.0E-15	9.6E-04	1.8E-06	8.0E-15	2.5E-03
Ge	2.7E-07	1.2E-15	3.7E-04	9.6E-08	4.2E-16	1.3E-04	9.6E-08	4.2E-16	1.3E-04	9.6E-08	4.2E-16	1.3E-04	9.6E-08	4.2E-16	1.3E-04
As	9.2E-06	4.1E-14	3.8E-03	1.5E-05	6.8E-14	6.4E-03	2.7E-05	1.2E-13	1.1E-02	9.6E-08	4.2E-16	4.0E-05	9.6E-08	4.2E-16	4.0E-05
Se	9.6E-07	4.2E-15	1.3E-03	4.4E-06	1.9E-14	6.1E-03	1.5E-06	6.8E-15	2.1E-03	9.6E-08	4.2E-16	1.3E-04	9.6E-08	4.2E-16	1.3E-04
Mo	5.4E-06	2.4E-14	7.5E-03	6.5E-06	2.9E-14	9.1E-03	6.7E-06	3.0E-14	9.3E-03	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04
Ag	3.1E-06	1.4E-14	4.3E-03	5.6E-06	2.5E-14	7.7E-03	1.5E-05	6.8E-14	2.1E-02	3.8E-07	1.7E-15	5.3E-04	3.8E-07	1.7E-15	5.3E-04
Cd	1.9E-07	8.5E-16	2.7E-04	9.2E-06	4.1E-14	1.3E-02	1.2E-05	5.1E-14	1.6E-02	9.8E-07	4.3E-15	1.4E-03	9.8E-07	4.3E-15	1.4E-03
Sn	3.1E-05	1.4E-13	4.3E-02	9.1E-05	4.0E-13	1.3E-01	2.8E-04	1.3E-12	3.9E-01	1.3E-04	5.7E-13	1.8E-01	2.1E-06	9.3E-15	2.9E-03
Sb	1.9E-05	8.3E-14	2.6E-02	7.8E-05	3.4E-13	1.1E-01	1.5E-04	6.5E-13	2.0E-01	3.8E-06	1.7E-14	5.3E-03	4.2E-07	1.9E-15	5.9E-04
Te	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04	5.8E-07	2.5E-15	8.0E-04
Ba	3.7E-04	1.6E-12	5.2E-01	1.5E-03	6.6E-12	2.1E+00	3.8E-04	1.7E-12	5.3E-01	8.3E-05	3.6E-13	1.1E-01	6.5E-05	2.9E-13	9.1E-02
Hg	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04	3.8E-07	1.7E-15	5.3E-04
Tl	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04	1.9E-07	8.5E-16	2.7E-04
Pb	5.8E-04	2.5E-12	8.0E-01	8.7E-04	3.8E-12	1.2E+00	1.4E-03	6.4E-12	2.0E+00	5.8E-05	2.5E-13	8.0E-02	1.3E-05	5.8E-14	1.8E-02
Ta	1.9E-07	8.5E-16	2.7E-04	3.8E-07	1.7E-15	5.3E-04	3.8E-07	1.7E-15	5.3E-04	6.5E-06	2.9E-14	9.1E-03	1.0E-05	4.4E-14	1.4E-02
Fe	2.0E-02	8.7E-11	2.7E+01	2.7E-02	1.2E-10	3.7E+01	3.7E-02	1.6E-10	5.2E+01	7.2E-03	3.2E-11	1.0E+01	6.8E-03	3.0E-11	9.5E+00
Ti	2.2E-03	9.7E-12	3.1E+00	1.0E-03	4.4E-12	1.4E+00	1.9E-03	8.4E-12	2.6E+00	1.5E-03	6.5E-12	2.1E+00	2.1E-03	9.3E-12	2.9E+00

Supplementary Table 6.13: Hazard Quotient (HQ) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Lagos

PBDE	RfD	Top Soil 0-10cm									Floor dust (control soil)						Roadside dust		
		Burning sites			Dismantling sites			Repair sites			Dismantling sites			Repair sites			Dismantling sites		
		HQing	HQinh	HQder	HQing	HQinh	HQder	HQing	HQinh	HQder	HQing	HQinh	HQder	HQing	HQinh	HQder	HQing	HQinh	HQder
BDE-47	1.00E-04	6.5E-05		9.1E-02	1.41E-05		2.0E-02	3.8E-07		5.3E-04	2.42E-05		3.36E-02	2.07E-06		2.88^{E}-03	3.08^{E}-05		4.27^{E}-02
BDE-99	1.00E-04	6.1E-04		8.4E-01	4.16E-05		5.8E-02	2.0E-06		2.8E-03	5.80E-05		8.04E-02	6.91E-06		9.59^{E}-03	7.30^{E}-05		1.01E-01
BDE-153	2.00E-04	1.2E-04		1.7E-01	1.91E-05		2.6E-02	4.6E-01		6.4E-04	1.71E-05		2.37E-02	3.65E-06		5.06^{E}-03	1.57^{E}-05		2.18E-02
BDE-209	7.00E-03	9.6E-04		1.3E+00	8.18E-05		1.1E-01	4.7E-07		6.5E-05	1.65E-04		2.29E-01	2.37E-05		3.29^{E}-02	5.27^{E}-05		7.31E-02
∑HQ=HI		**1.76E-03**		**2.4E+00**	**1.57E-04**		**2.2E-01**	**2.93E-06**		**4.06E-03**	**2.64E-04**		**3.67E-01**	**3.64E-05**		**5.04^{E}-02**	**1.72^{E}-04**		**2.39E-01**

Supplementary Table 6.14: Hazard Quotient (HQ) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Ibadan

PBDE	RfD	Top Soil 0-10cm						Floor dust (control soil)			Direct dust					
		Burning sites			Dismantling sites			Repair sites			Dismantling sites			Repair sites		
		HQ_{ing}	HQ_{inh}	HQ_{der}	HQ_{ing}	HQ_{inh}	HQ_{der}	HQ_{ing}	HQ_{inh}	HQ_{der}	HQ_{ing}	HQ_{inh}	HQ_{der}	HQ_{ing}	HQ_{inh}	HQ_{der}
BDE-47	1.00E-04	3.2E-01		4.4+02	7.7E-04		1.1E+00	1.6E-02		2.2E+01	2.48E-01		3.4E+02	5.61E-02		7.8E+01
BDE-99	1.00E-04	4.1E-01		5.7E+02	1.6E-03		2.2E+00	4.1E-02		5.7E+01	5.81E-01		8.1E+02	9.87E-02		1.4E+02
BDE-153	2.00E-04	1.2E-01		1.6E+02	9.6E-04		1.3E+00	1.4E-02		2.0E+01	6.35E-02		8.8E+01	2.38E-02		3.3E+01
BDE-209	7.00E-03	3.2E-01		4.5E-02	7.1E-04		9.9E-01	4.4E-01		6.1E+02	1.74E+00		2.4E+03	8.03E-02		1.1E+02
∑HQ=HI		**1.2E+00**		**1.6E+03**	**4.1E-03**		**5.6E+00**	**5.1E-01**		**7.1E+02**	**2.64E+00**		**3.7E+03**	**2.59E-01**		**3.6E+02**

Supplementary Table 6.15: Hazard Quotient (HQ) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Aba

		Top Soil 0-10cm			Floor dust (control soil)			Roadside dust		
PBDE	**RfD**	**Burning sites**			**Repair sites**			**Repair sites**		
		HQ_{ing}	**R_{ing}**	**R_{der}**	**HQ_{ing}**	**R_{ing}**	**R_{der}**	**HQ_{ing}**	**R_{ing}**	**R_{der}**
BDE-47	1.00E-04	2.2E-02		3.0E+01	5.45E-03		7.6E+00	1.50E-02		2.1E+01
BDE-99	1.00E-04	4.5E-02		6.2E+01	9.79E-03		1.4E+01	2.24E-02		3.1E+01
BDE-153	2.00E-04	4.0E-02		5.5E+01	3.07E-03		4.3E+00	1.52E-02		2.1E+01
BDE-209	7.00E-03	5.7E-03		7.9E+00	2.93E-02		4.1E+01	3.78E-03		5.2E+00
∑HQ=HI		**1.1E-01**		**1.6E+02**	**4.76E-02**		**6.6E+01**	**5.64E-02**		7.8E+01

Table 6.16: Oral Reference Dose (RfD), Inhalation Reference Dose (RfC), Gastrointestinal Absorption Factor (GIABS) for metals

Metals	**RfD**	**RfC**	**GIABS**
V	5.00E-03	1.00E-04	2.60E-02
Cr	3.00E-03	1.00E-04	2.50E-02
Mn	1.40E-01	5.00E-05	1.00E+00
Co	3.00E-03	6.00E-06	1.00E+00
Ni	1.10E-02	1.40E-05	4.00E-02
Cu	4.00E-02	1.40E+09	1.00E+00
Zn	3.00E-01		1.00E+00
As	3.00E-04	1.50E-05	1.00E+00
Se	5.00E-03	2.00E-02	1.00E+00
Mo	5.00E-03		1.00E+00
Ag	5.00E-03		4.00E-02
Cd	1.00E-03	1.00E-05	2.50E-02
Sn	6.00E-01		1
Sb	4.00E-04	0.00E+00	1.50E-01
Ba	2.00E-01	5.00E-04	7.00E-02
Hg	3.00E-04	3.00E-04	0.07
Pb	8.50E-03	1.20E-05	
Ta	1.00E-05		1.00E+00
Fe	7.00E-01		1.00E+00
Ti		1.00E-04	1

Supplementary Table 6.17: Total HI Estimate for PBDEs and Metals for Non-Cancer Effects (Log Transformed Data)

Samples	Location	Activity	Ingestion	Inhalation	Dermal contact
Direct dust	Ibadan	Dismantling	-0.05	-6	3.73
		Repair	0.18	-6.89	3.6
Floor dust	Lagos	Dismantling	-0.48	-6.92	3.23
		Repair	-0.18	-7.17	3.18
	Ibadan	Repair	-0.16	-7.02	3.36
	Aba	Repair	-0.13	-6.85	3.74
		Dismantling	-0.16	-7.09	3.15
Roadside Dust	Lagos	Dismantling	-0.06	-6.96	3.3
	Aba	Repair	0	-6.96	3.26
Soil	Lagos	Burning	0.26	-6.92	4.18
		Dismantling	-0.08	-6.77	3.36
		Repair	-0.14	-7	3.18
	Ibadan	Burning	-0.05	-6.77	3.83
		Dismantling	-0.17	-6.96	3.38
	Aba	Burning	-0.7	-6.89	3.2
		Dismantling	-0.34	-6.96	3.6
Safe Limit			0	0	0

Supplementary Table 6.18: Hazard Quotient (HQ) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Lagos

Metals	Top Soil 0-10cm									Floor dust (control soil)						Roadside dust		
	Burning sites			Dismantling sites			Repair sites			Dismantling sites			Repair sites			Dismantling sites		
	HQ_{ing}	HQ_{inh}	HQ_{der}	HQ_{ing}	HQ_{inh}	HQ_{der}	HQ_{ing}	HQ_{inh}	HQ_{der}	HQ_{ing}	HQ_{inh}	HQ_{der}	HQ_{ing}	HQ_{inh}	HQ_{der}	HQ_{ing}	HQ_{inh}	HQ_{der}
V	1.9E-03	4.1E-10	9.91E+01	3.9E-03	8.6E-10	2.08E+02	7.8E-04	1.7E-10	4.18E+01	2.9E-03	6.4E-10	1.56E+02	2.0E-03	4.4E-10	1.07E+02	2.7E-03	5.9E-10	1.4E+02
Cr	8.8E-03	1.2E-09	4.88E+02	1.3E-02	1.7E-09	7.33E+02	6.3E-03	8.4E-10	3.50E+02	1.0E-02	1.3E-09	5.54E+02	7.3E-03	9.7E-10	4.05E+02	8.0E-03	1.1E-09	4.4E+02
Mn	4.4E-04	5.4E-09	6.09E-01	1.9E-03	2.4E-08	2.64E+00	2.2E-04	2.8E-09	3.10E-01	1.9E-03	2.3E-08	2.59E+00	8.3E-04	1.0E-08	1.15E+00	1.2E-03	1.4E-08	1.6E+00
Co	1.9E-04	4.2E-10	2.66E-01	3.2E-04	7.1E-10	4.49E-01	1.9E-04	4.2E-10	2.66E-01	1.9E-04	4.2E-10	2.66E-01	1.9E-04	4.2E-10	2.66E-01	3.6E-04	7.9E-10	5.0E-01
Ni	6.8E-03	2.4E-08	2.35E+02	1.7E-03	6.0E-09	5.98E+01	3.5E-03	1.2E-08	1.21E+02	3.5E-03	1.2E-08	1.20E+02	9.8E-04	3.4E-09	3.39E+01	2.9E-03	1.0E-08	1.0E+02
Cu	1.2E-01	1.5E-20	1.68E+02	7.3E-03	9.2E-22	1.01E+01	2.6E-04	3.3E-23	3.67E-01	7.4E-03	9.3E-22	1.02E+01	7.9E-04	9.9E-23	1.09E+00	2.3E-03	2.9E-22	3.1E+00
Zn	4.0E-03		5.60E+00	1.0E-03		1.44E+00	3.1E-05		4.35E-02	1.7E-03		2.38E+00	4.0E-04		5.54E-01	1.2E-03		1.6E+00
As	1.1E-01	9.4E-09	1.43E+01	6.3E-03	5.6E-10	2.63E+00	4.6E-03	4.1E-10	1.92E+00	7.3E-03	6.4E-10	3.0E+00	3.2E-04	2.8E-11	1.33E-01	1.7E-02	1.5E-09	6.9E+00
Se	4.6E-04	5.1E-13	6.39E-01	1.5E-05	1.7E-14	2.13E-02	1.9E-05	2.1E-14	2.66E-02	5.0E-05	5.5E-14	6.92E-02	1.9E-05	2.1E-14	2.66E-02	4.6E-05	5.1E-14	6.4E-02
Mo	6.5E-04		9.05E-01	3.8E-05		5.33E-02	1.2E-04		1.60E-01	3.8E-05		5.33E-02	3.8E-05		5.33E-02	3.8E-05		5.3E-02
Ag	3.2E-03		1.09E+02	4.2E-04		1.46E+01	7.7E-05		2.66E+00	2.6E-03		9.19E+01	1.0E-04		3.46E+00	5.9E-04		2.1E+01
Cd	4.0E-03	1.8E-09	2.22E+00	9.8E-04	4.3E-10	5.43E-01	9.8E-04	4.3E-10	5.43E-01	9.8E-04	4.3E-10	5.43E-01	9.8E-04	4.3E-10	5.43E-01	9.8E-04	4.3E-10	5.4E-01
Sn	1.7E-03		2.42E+00	3.4E-05		4.74E-02	1.8E-06		2.49E-03	2.2E-04		3.10E-01	6.8E-05		9.41E-02	4.0E-05		5.6E-02
Sb	1.5E+00		1.37E+04	2.2E-02		2.00E+02	1.4E-03		1.33E+01	4.1E-02		3.82E+02	3.8E-03		3.55E+01	1.3E-02		1.2E+02
Ba	2.6E-03	4.7E-09	5.24E+01	4.9E-04	8.7E-10	9.75E+00	2.1E-04	3.6E-10	4.06E+00	1.4E-03	2.4E-09	2.72E+01	4.4E-04	7.7E-10	8.64E+00	9.6E-04	1.7E-09	1.9E+01
Hg	6.4E-04	2.8E-12	1.27E+01	3.1E-03	1.4E-11	6.2E+01	6.4E-04	2.8E-12	1.3E+01	2.9E-03	1.3E-11	5.8E+1	6.4E-04	2.8E-12	1.3E+01	2.3E-04	1.0E-12	4.6E+00
Pb																		
Ta	1.9E-02		2.66E+01	7.6E-01		1.06E+03	6.9E-01		9.59E+02	2.3E-01		3.20E+02	6.3E-01		8.73E+02	8.1E-01		1.1E+03
Fe	4.0E-03		5.61E+00	1.7E-02		2.38E+01	6.0E-03		8.37E+00	1.8E-02		2.51E+01	9.1E-03		1.26E+01	1.4E-02		1.9E+01
Tl		7.7E-08			1.3E-07			8.7E-08			8.0E-08			5.2E-08			7.7E-08	
∑HQ	**1.8E+00**	**1.2E-07**	**1.5E+04**	**8.4E-01**	**1.7E-07**	**2.3E+03**	**7.2E-01**	**1.0E-07**	**1.5E+03**	**3.3E-01**	**1.2E-07**	**1.7E+03**	**6.6E-01**	**6.8E-08**	**1.5E+03**	**8.7E-01**	**1.1E-07**	**2.0E+03**

Supplementary Table 6.19: Hazard Quotient (HQ) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Ibadan

	Top Soil 0-10cm						Floor dust (control soil)			Direct dust					
Metals	**Burning sites**			**Dismantling sites**			**Repair sites**			**Dismantling sites**			**Repair sites**		
	HQ_{ing}	**HQ_{inh}**	**HQ_{der}**	**HQ_{ing}**	**HQ_{inh}**	**HQ_{der}**	**HQ_{ing}**	**HQ_{inh}**	**HQ_{der}**	**HQ_{ing}**	**HQ_{inh}**	**HQ_{der}**	**HQ_{ing}**	**HQ_{inh}**	**HQ_{der}**
V	4.1E-03	9.1E-10	2.21E+02	4.2E-03	9.4E-10	2.26E+02	5.0E-03	1.1E-09	2.66E+02	7.1E-02	1.6E-08	3.78E+03	8.5E-03	1.9E-09	4.55E+02
Cr	1.6E-02	2.1E-09	8.73E+02	1.3E-02	1.8E-09	7.46E+02	1.5E-02	2.0E-09	8.59E+02	1.8E-03	2.4E-10	1.02E+02	1.8E-02	2.4E-09	1.00E+03
Mn	2.0E-03	2.5E-08	2.81E+00	1.5E-03	1.9E-08	2.14E+00	2.1E-03	2.6E-08	2.88E+00	4.4E-03	5.4E-08	6.11E+00	2.2E-03	2.7E-08	3.03E+00
Co	1.9E-04	4.2E-10	2.66E-01	1.9E-04	4.2E-10	2.66E-01	1.9E-04	4.2E-10	2.66E-01	9.3E-03	2.0E-08	1.28E+01	1.9E-04	4.2E-10	2.66E-01
Ni	3.2E-03	1.1E-08	1.13E+02	2.3E-03	7.9E-09	7.87E+01	1.5E-03	5.2E-09	5.20E+01	1.1E-02	3.9E-08	3.87E+02	2.7E-03	9.4E-09	9.44E+01
Cu	1.2E-01	1.5E-20	1.70E+02	1.3E-02	1.6E-21	1.79E+01	3.1E-03	3.9E-22	4.30E+00	4.0E-04	5.1E-23	5.59E-01	3.1E-03	3.9E-22	4.27E+00
Zn	4.3E-03		5.91E+00	2.3E-03		3.25E+00	1.5E-03		2.05E+00	1.6E-04		2.17E-01	3.2E-03		4.37E+00
As	1.3E-01	1.2E-08	5.5E+01	1.3E-02	1.2E-09	5.5+00	3.2E-04	2.8E-11	1.33E-01	1.5E-03	1.4E-10	6.4E-01	6.4E-03	5.6E-10	2.66E+00
Se	2.0E-03	2.2E-12	2.77E+00	3.4E-04	3.7E-13	4.69E-01	7.7E-05	8.5E-14	1.07E-01	1.9E-05	2.1E-14	2.66E-02	6.9E-05	7.6E-14	9.59E-02
Mo	6.1E-04		8.52E-01	5.5E-04		7.67E-01	4.6E-05		6.39E-02	1.0E-04		1.38E-01	2.1E-04		2.88E-01
Ag	1.2E-03		4.26E+01	6.5E-04		2.26E+01	4.2E-04		1.46E+01	1.0E-04		3.59E+00	1.2E-03		3.99E+01
Cd	2.7E-03	1.2E-09	1.49E+00	9.8E-04	4.3E-10	5.43E-01	9.8E-04	4.3E-10	5.43E-01	9.8E-04	4.3E-10	5.43E-01	1.0E-03	4.6E-10	5.75E-01
Sn	7.8E-04		1.08E+00	7.6E-05		1.05E-01	6.2E-04		8.61E-01	9.6E-07		1.33E-03	3.4E-05		4.70E-02
Sb	5.7E-01		5.25E+03	5.0E-02		4.62E+02	1.9E-02		1.78E+02	1.4E-03		1.33E+01	4.6E-02		4.26E+02
Ba	1.8E-03	3.2E-09	3.54E+01	1.1E-03	2.0E-09	2.24E+01	9.0E-04	1.6E-09	1.78E+01	1.7E-04	3.0E-10	3.42E+00	2.0E-03	3.6E-09	3.99E+01
Hg	5.9E-03	2.6E-11	1.2E+02	1.7E-03	7.3E-12	3.3E+01	9.0E-04	4.0E-12	1.8E+01	6.4E-04	2.8E-12	1.3E+01	3.5E-03	1.5E-11	6.9E+01
Pb															
Ta	1.9E-02		2.66E+01	5.4E-01		7.46E+02	6.1E-01		8.52E+02	6.9E-01		9.59E+02	1.4E+00		1.92E+03
Fe	1.7E-02		2.39E+01	2.7E-02		3.81E+01	2.3E-02		3.24E+01	9.6E-02		1.33E+02	3.1E-02		4.36E+01
Tl		1.1E-07			7.9E-08			5.9E-08			9.0E-07			8.4E-08	
ΣHQ	**9.0E-01**	**1.7E-07**	**6.8E+03**	**6.7E-01**	**1.1E-07**	**2.4E+03**	**6.9E-01**	**9.5E-08**	**2.3E+03**	**8.9E-01**	**1.0E-06**	**5.4E+03**	**1.5E+00**	**1.3E-07**	**4.0E+03**

Supplementary Table 6.20: Hazard Quotient (HQ) Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Aba

	Top Soil 0-10cm						Floor dust						Roadside dust		
Metals	**Burning sites**			**Dismantling sites**			**Dismantling sites**			**Repair sites**					
	HQ_{ing}	**HQ_{inh}**	**HQ_{der}**	**HQ_{ing}**	**HQ_{inh}**	**HQ_{der}**	**HQ_{ing}**	**HQ_{inh}**	**HQ_{der}**	**HQ_{ing}**	**HQ_{inh}**	**HQ_{der}**	**HQ_{ing}**	**HQ_{inh}**	**HQ_{der}**
V	2.2E-03	4.7E-10	1.15E+02	3.5E-03	7.8E-10	1.88E+02	2.0E-03	4.4E-10	1.07E+02	1.3E-03	2.9E-10	6.96E+01	3.2E-03	7.1E-10	1.7E+02
Cr	1.3E-02	1.7E-09	7.24E+02	2.5E-02	3.3E-09	1.40E+03	2.4E-02	3.2E-09	1.33E+03	5.4E-03	7.1E-10	2.98E+02	3.8E-03	5.1E-10	2.1E+02
Mn	1.1E-03	1.4E-08	1.59E+00	1.5E-03	1.8E-08	2.05E+00	1.8E-03	2.2E-08	2.49E+00	8.4E-04	1.0E-08	1.17E+00	7.5E-04	9.3E-09	1.0E+00
Co	1.9E-04	4.2E-10	2.66E-01	1.9E-04	4.2E-10	2.66E-01	1.9E-04	4.2E-10	2.66E-01	1.9E-04	4.2E-10	2.66E-01	1.9E-04	4.2E-10	2.7E-01
Ni	3.0E-03	1.0E-08	1.04E+02	5.3E-03	1.9E-08	1.85E+02	5.2E-03	1.8E-08	1.80E+02	8.0E-04	2.8E-09	2.78E+01	5.6E-04	1.9E-09	1.9E+01
Cu	4.3E-02	5.4E-21	5.90E+01	7.6E-02	9.5E-21	1.05E+02	1.3E-01	1.6E-20	1.81E+02	1.8E-03	2.3E-22	2.54E+00	2.2E-04	2.8E-23	3.1E-01
Zn	4.5E-03		6.31E+00	7.2E-03		1.00E+01	6.9E-03		9.59E+00	6.1E-04		8.41E-01	1.5E-04		2.1E-01
As	3.1E-02	2.7E-09	1.28E+01	5.1E-02	4.5E-09	2.13E+01	9.1E-02	8.0E-09	3.78E+01	3.2E-04	2.8E-11	1.33E-01	3.2E-04	2.8E-11	1.3E-01
Se	1.9E-04	2.1E-13	2.66E-01	8.8E-04	9.7E-13	1.22E+00	3.1E-04	3.4E-13	4.26E-01	1.9E-05	2.1E-14	2.66E-02	1.9E-05	2.1E-14	2.7E-02
Mo	1.1E-03		1.49E+00	1.3E-03		1.81E+00	1.3E-03		1.86E+00	3.8E-05		5.33E-02	3.8E-05		5.3E-02
Ag	6.1E-04		2.13E+01	1.1E-03		3.86E+01	3.1E-03		1.07E+02	7.7E-05		2.66E+00	7.7E-05		2.7E+00
Cd	1.9E-04	8.5E-11	1.07E-01	9.2E-03	4.1E-09	5.11E+00	1.2E-02	5.1E-09	6.39E+00	9.8E-04	4.3E-10	5.43E-01	9.8E-04	4.3E-10	5.4E-01
Sn	5.2E-05		7.19E-02	1.5E-04		2.11E-01	4.7E-04		6.57E-01	2.2E-04		3.00E-01	3.5E-06		4.9E-03
Sb	4.7E-02		4.35E+02	1.9E-01		1.80E+03	3.7E-01		3.39E+03	9.6E-03		8.88E+01	1.1E-03		9.8E+00
Ba	1.9E-03	3.3E-09	3.70E+01	7.5E-03	1.3E-08	1.49E+02	1.9E-03	3.4E-09	3.77E+01	4.1E-04	7.3E-10	8.18E+00	3.3E-04	5.8E-10	6.5E+00
Hg	6.4E-04	2.8E-12	1.3E+01	6.4E-04	2.8E-12	1.3E+01	6.4E-04	2.8E-12	1.3E+01	6.4E-04	2.8E-12	1.3E+01	1.3E+01	5.6E-12	2.5E+01
Pb															
Ta	1.9E-02		2.66E+01	3.8E-02		5.33E+01	3.8E-02		5.33E+01	6.5E-01		9.05E+02	1.0E+00		1.4E+03
Fe	2.8E-02		3.91E+01	3.8E-02		5.33E+01	5.3E-02		7.40E+01	1.0E-02		1.43E+01	9.8E-03		1.4E+01
Tl		9.7E-08			4.4E-08			8.4E-08			6.5E-08			9.3E-08	
∑HQ	**2.0E-01**	**1.3E-07**	**1.6E+03**	**4.6E-01**	**1.1E-07**	**4.0E+03**	**7.4E-01**	**1.4E-07**	**5.5E+03**	**6.9E-01**	**8.1E-08**	**1.4E+03**	**1.0E+00**	**1.1E-07**	**1.8E+03**

Supplementary Table 6.21: Cancer Risk of BDE-209 through Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites in Lagos

PBDE	SF	Top soil									Floor dust (control soil)						Roadside dust		
		Burning sites			Dismantling sites			Repair sites			Dismantling sites			Repair sites			Dismantling sites		
		R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}
BDE-209	7.0E-04	4.73E-09		6.6E-06	4.0E-10		5.6E-07	2.3E-13		3.2E-10	8.1E-10		1.1E-06	1.2E-10		1.6E-07	2.6E-10		3.6E-07

Supplementary Table 6.22: Cancer Risk of BDE-209 through Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste In Ibadan

PBDE	SF	Top soil						Floor dust (control soil)			Direct dust					
		Burning sites			Dismantling sites			Repair sites			Dismantling sites			Repair sites		
		R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}
BDE-209	7.0E-04	1.6E-06		2.2E-03	3.5E-09	1.5E-17	4.8E-06	2.2E-06	9.5E-15	3.0E-03	8.5E-06	3.8E-14	1.2E-02	3.9E-07	1.7E-15	5.5E-04

Supplementary Table 6.23: Cancer Risk of BDE-209 through Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites and in Aba

PBDE	SF	Top soil			Floor dust (control soil)			Roadside dust		
		Burning sites			Repair sites			Repair sites		
		R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}
BDE-209	7.0E-04	2.8E-08		3.9E-05	1.4E-07	6.3E-16	2.05-04	1.9E-08	8.2E-17	2.6E-05

Supplementary Table 6.24: Cancer Risk of Metals through Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites and in Lagos

Metals				Top soil									Floor dust (control soil)						Roadside dust		
				Burning sites			Dismantling sites			Repair sites			Dismantling sites			Repair sites			Dismantling sites		
	Sf oral	IUR	GIABS	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der} =	R_{ing} =	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}
Cr	5.0E-01	8.4E-02	2.5E-02	1.3E-05	9.8E-15	4.6E-04	2.0E-05	1.5E-14	6.9E-04	9.5E-06	7.0E-15	3.3E-04	1.5E-05	1.1E-14	5.2E-04	1.1E-05	8.1E-15	3.8E-04	1.2E-05	8.9E-15	4.2E-04
Co		9.0E-03	1	0	2.3E-17			3.9E-17			2.3E-17			2.3E-17			2.3E-17			4.3E-17	
Ni		2.6E-04	4.0E-02	0	8.6E-17			2.2E-17			4.4E-17			4.4E-17			1.2E-17			3.7E-17	
As	1.5	4.3E-03	1	4.8E-05	6.1E-16	2.0E-02	2.8E-06	3.6E-17	1.2E-03	2.1E-06	2.6E-17	8.6E-04	3.3E-06	4.2E-17	1.4E-03	1.4E-07	1.8E-18	6.0E-05	7.5E-06	9.5E-17	3.1E-03
Cd		1.8E-03	2.5E-02	0	3.2E-17			7.8E-18			7.8E-18			7.8E-18			7.8E-18			7.8E-18	
Hg		3.00E-04	0.07	0	2.5E-19			1.2E-18			2.5E-19			1.2E-18			2.5E-19			9.1E-20	
Pb	8.50E-03	1.20E-05	1	2.1E-05	1.3E-16	2.9E-02	6.5E-07	4.0E-18	9.0E-04	4.0E-08	2.5E-19	5.5E-05	9.0E-07	5.6E-18	1.3E-03	1.9E-07	1.2E-18	2.6E-04	1.2E-06	7.6E-18	1.7E-03
HI				8.2E-05	1.1E-14	4.9E-02	2.3E-05	1.5E-14	2.8E-03	1.2E-05	7.1E-15	1.2E-03	1.9E-05	1.1E-14	3.1E-03	1.1E-05	8.2E-15	7.0E-04	2.1E-05	9.1E-15	5.2E-03

IUR = Inhalation Unit Risk. SF= Slope factor. GIABS = Gastrointestinal Absorption Factor

Supplementary Table 6.25: Cancer Risk of Metals through Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites and in Ibadan

Metals	**Sforal**	**IUR**	GIABS	**Top soil**						**Floor dust (control soil)**						**Direct dust**		
				Burning sites			**Dismantling sites**			**Dismantling sites**			**Dismantling sites**			**Repair sites**		
				R_{ing} =	R_{inh}	R_{derl}	R_{ing} =	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der} =	R_{ing}	R_{inh}	R_{der}
Cr	5.0E-01	8.4E-02	2.5E-02	2.4E-05	1.8E-14	8.2E-04	2.0E-05	1.5E-14	7.0E-04	2.3E-05	1.7E-14	8.1E-04	2.7E-06	2.0E-15	9.5E-05	2.7E-05	2.0E-14	9.4E-04
Co		9.0E-03	1		2.3E-17			2.3E-17			2.3E-17			1.1E-15			2.3E-17	
Ni		2.6E-04	4.0E-02		4.1E-17			2.9E-17			1.9E-17			1.4E-16			3.4E-17	
As	1.5	4.3E-03	1	5.9E-05	7.5E-16	2.5E-02	5.9E-06	7.5E-17	2.5E-03	1.4E-07	1.8E-18	6.0E-05	6.9E-07	8.7E-18	2.9E-04	2.9E-06	3.6E-17	1.2E-03
Cd		1.8E-03	2.5E-02		2.1E-17			7.8E-18			7.8E-18			7.8E-18			8.2E-18	
Hg		3.00E-04	0.07		2.3E-18			6.6E-19			3.6E-19			2.5E-19			1.4E-18	
Pb	8.50E-03	1.20E-05	1	7E-05	4.4E-16	9.7E-02	8.0E-06	5.0E-17	1.1E-02	3.1E-06	1.9E-17	4.3E-03	1.6E-09	1.0E-09	2.3E-06	1.5E-06	9.2E-18	2.0E-03
∑HQ=HI				**1.5E-04**	**1.9E-14**	**1.2E-01**	**3.4E-05**	**1.5E-14**	**1.4E-02**	**2.6E-05**	**1.7E-14**	**5.2E-03**	**3.4E-06**	**3.3E-15**	**3.9E-04**	**3.1E-05**	**2.0E-14**	**4.2E-03**

Supplementary Table 6.26: Cancer Risk of Metals through Ingestion, Inhalation, Dermal in Soil and Dust at various E-waste Sites and in Aba

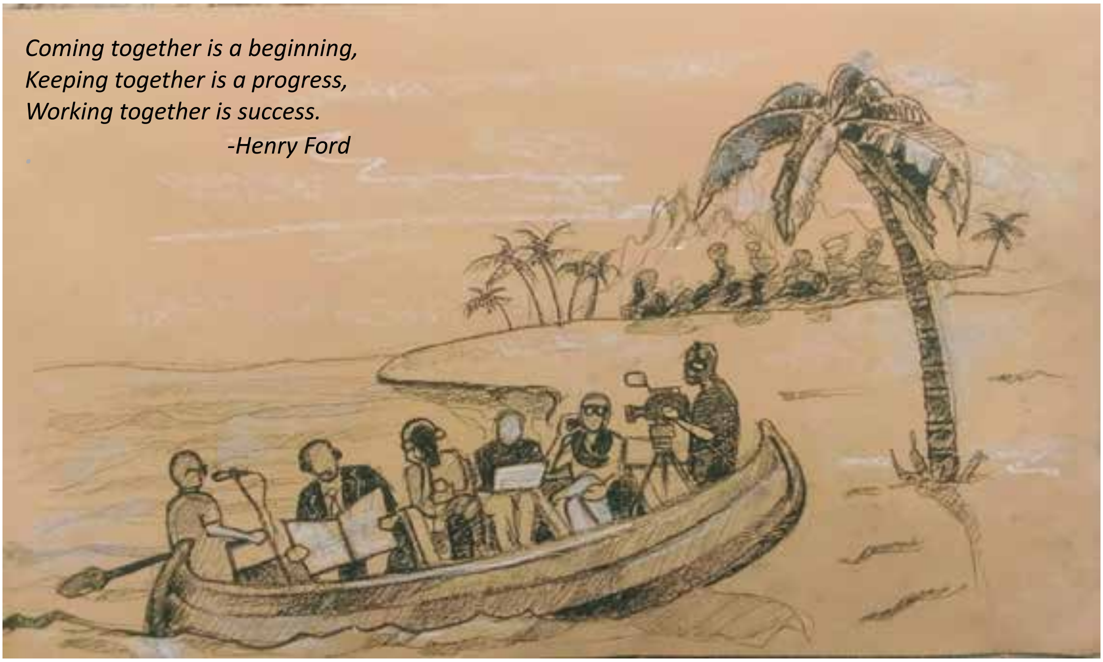
				Top soil						Floor dust (control soil)						Roadside dust		
				Burning sites			Dismantling sites			Dismantling sites			Repair sites			Repair sites		
Metals	Sforal	IUR	GIABS	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	R_{der}	R_{ing}	R_{inh}	$R_{der\ =}$	$R_{ing\ =}$	$R_{inh\ =}$	$R_{der\ =}$
Cr	5.0E-01	8.4E-02	2.5E-02	2.0E-05	1.5E-14	6.8E-04	3.8E-05	2.8E-14	1.3E-03	3.6E-05	2.7E-14	1.3E-03	8.1E-06	6.0E-15	2.8E-04	1.9E-03	4.3E-15	2.7E+00
Co		9.0E-03	1	0	2.3E-17			2.3E-17			2.3E-17			2.3E-17			2.3E-17	
Ni		2.6E-04	4.0E-02	0	3.8E-17			6.7E-17			6.6E-17			1.0E-17			7.0E-18	
As	1.5	4.3E-03	1	1.4E-05	1.7E-16	5.8E-03	2.3E-05	2.9E-16	9.6E-03	4.1E-05	5.2E-16	1.7E-02	1.4E-07	1.8E-18	6.0E-05	4.8E-04	1.8E-18	2.0E-01
Cd		1.8E-03	2.5E-02	0	1.5E-18			7.3E-17			9.1E-17			7.8E-18			7.8E-18	
Hg		3.00E-04	0.07	0	2.5E-19			2.5E-19			2.5E-19			2.5E-19			5.1E-19	
Pb	8.50E-03	1.20E-05	1	4.9E-06	3.1E-17	6.8E-03	7.4E-06	4.6E-06	1.0E-02	1.2E-05	7.7E-17	1.7E-02	4.9E-07	3.0E-18	6.8E-04	1.1E-07	6.9E-19	1.5E-04
∑HQ=HI				**3.8E-05**	**1.5E-14**	**1.3E-02**	**6.8E-05**	**2.9E-14**	**2.1E-02**	**8.9E-05**	**2.8E-14**	**3.5E-02**	**8.7E-06**	**6.0E-15**	**1.0E-03**	**6.0E-06**	**4.3E-15**	**4.1E-04**

Supplementary Table 6.27: Total HI Estimate for PBDEs and Metals for Cancer Risks (Log Transformed Data)

Samples	Location	Activity	Ingestion	Inhalation	Dermal contact
Direct dust	Ibadan	Dismantling	-5,47	-14,52	-3,41
		Repair	-4,51	-13,7	-2,38
Floor dust	Lagos	Dismantling	-4,72	-13,96	-2,51
		Repair	-4,96	-14,1	-3,15
	Ibadan	Repair	-4,58	-13,77	-2,28
	Aba	Dismantling	-4,05	-13,55	-1,46
		Repair	-5,06	-14,22	-3
Roadside Dust	Lagos	Dismantling	-4,68	-14,05	-2,28
	Aba	Repair	-5,22	-14,4	-3,39
Soil	Lagos	Burning	-4,09	-13,96	-1,31
		Dismantling	-4,64	-13,82	-2,55
		Repair	-4,92	-14,15	-2,92
	Ibadan	Burning	-3,82	-13,72	-0,92
		Dismantling	-4,47	-13,82	-1,85
	Aba	Burning	-4,42	-13,82	-1,89
		Dismantling	-4,17	-13,54	-1,68
Safe Limit			-6	-6	-6

Supplementary Table 6.28: Cumulative HI Estimate for PBDEs and Metals for Non-Cancer effects and Cancer Risks (Log Transformed Data)

Samples	Location	Activity	Non-cancer Effects	Cancer Risks
Direct dust	Ibadan	Dismantling	3.73	-3.41
		Repair	3.6	-2.38
Floor dust	Lagos	Dismantling	3.23	-2.51
		Repair	3.18	-3.15
	Ibadan	Repair	3.36	-2.28
	Aba	Dismantling	3.74	-1.46
		Repair	3.15	-3
Roadside Dust	Lagos	Dismantling	3.3	-2.28
	Aba	Repair	3.26	-3.39
Soil	Lagos	Burning	4.18	-1.31
		Dismantling	3.36	-2.55
		Repair	3.18	-2.92
	Ibadan	Burning	3.83	-0.92
		Dismantling	3.38	-1.85
	Aba	Burning	3.2	-1.89
		Dismantling	3.6	-1.68
Safe Limit			0	-6


Coming together is a beginning,
Keeping together is a progress,
Working together is success.
-Henry Ford