

RISK ASSESSMENT AT AN INFORMAL E-WASTE RECYCLING SITE IN LAGOS STATE, NIGERIA

ISIMEKHAI K.A; WATT .J; GARELICK .H; PURCHASE .D
DEPARTMENT OF NATURAL SCIENCES, MIDDLESEX UNIVERSITY, LONDON



INTRODUCTION

E-waste is referred to obsolete, broken electronic devices such as mobile phones, televisions, computer monitors, laptops, printers, scanners, and associated wiring (Luther, 2010). E-waste is generated in large quantities (Tang et al., 2010); the composition of the waste creates a major problem. E-waste contains more than 1000 different substances, many of which are toxic metals and organic pollutants (Robinson, 2009). These include lead and cadmium in circuit boards; lead oxide and cadmium in monitor cathode ray tubes (CRTs); mercury in switches and flat screen monitors; cadmium in computer batteries; polychlorinated biphenyls (PCBs) in older capacitors and transformers; and brominated flame retardants on printed circuit boards, plastic casings, cables and polyvinyl chloride (PVC) cable insulation that release highly toxic dioxins and furans when burned to retrieve copper from the wires (BAN, 2002). Also, polybrominated diphenyl ethers (PBDEs) are used as brominated flame retardants in electronic circuit boards (Wang et al., 2005). Activities carried out in the site of interest include dismantling of the different electronic waste, sorting out of various parts and burning of wires and other parts to get valuable metals. The complex composition of e-waste may pose a threat to the environment and human health if they are not disposed correctly.

AIM

Assess the implication of the activities on the soil as well as human exposure at the site.

STUDY AREA

The study site was Alaba rago, Alaba international market which lies between latitude 06°27.731'N and longitude 03°11.492'E. Alaba International Market was founded in 1978. Located in Ojo Local Government Area of Lagos State, it is the largest market for used and new electronics and electrical equipments in West Africa.

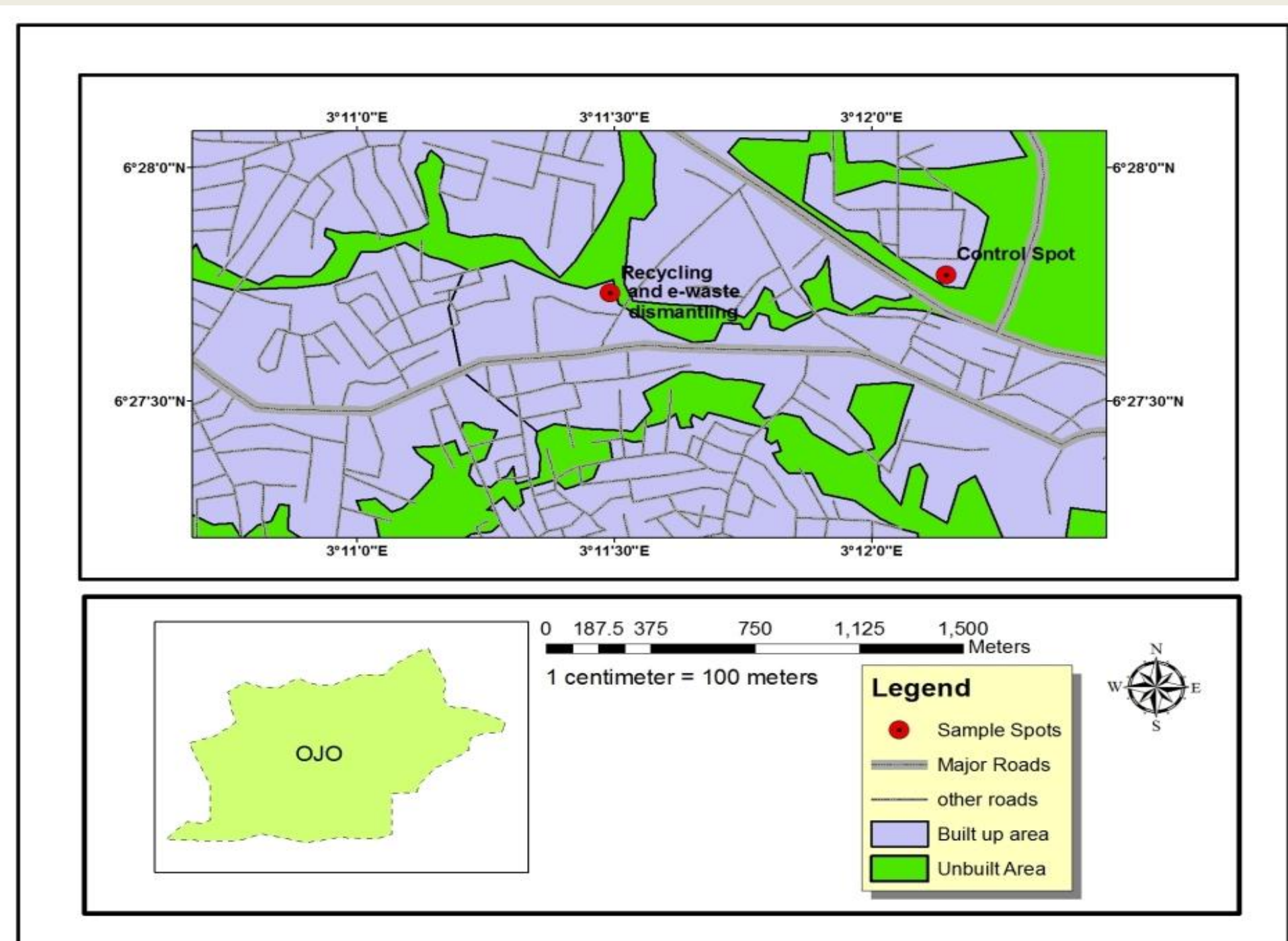


Fig 1: Land use within the sample area and clear identification of sample spots

SAMPLING STRATEGY

Soil samples were collected from the topsoil to the depth of 20cm with the aid of a soil auger and a stainless steel trowel to scoop the samples into the sampling/storage bags and labelled. The labelling was done according to sampling points and depth from which the soil was collected. A distance of 10 metres was measured at intervals in directions of the cardinal points. Also, surface soil samples only were collected randomly at the dismantling section of the site.



Fig 2: indicating the sampling points.

METHODS

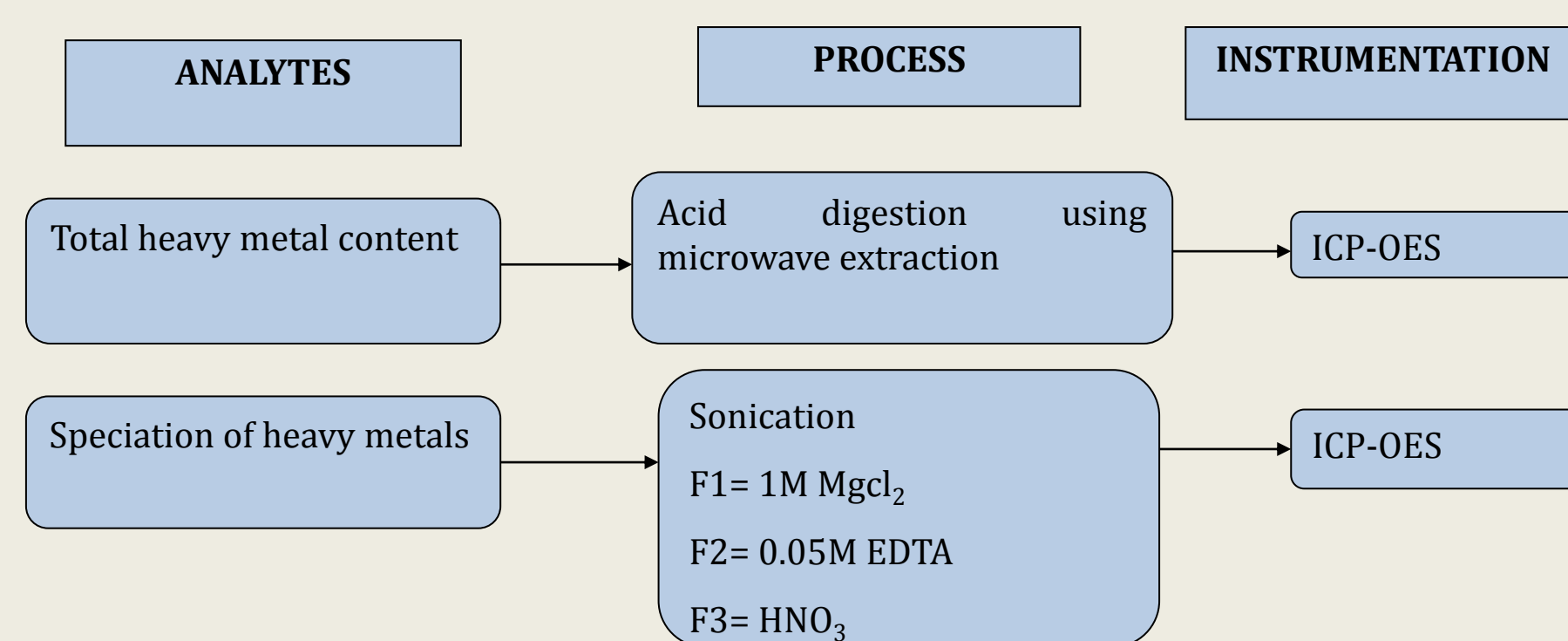


Fig 3: Flow diagram showing the analytical process

RESULTS

Elevated levels of various heavy metals were observed.

Parameters (mg/kg)	DUTCH		DEFRA SGV		RECYCLING SITE VALUES	MEAN VALUES AT RECYCLING SITE	VALUES AT CONTROL SITE
	Target value	Intervention value	Residential	Industrial			
Cadmium (Cd)	0.8	12	1-8	140	5-70	22.05± 1.67	8.37
Chromium (Cr)	100	380			8-103	35.56±2.75	3.53
Copper (Cu)	36	190			2217-8000	4982±122	66.88
Nickel (Ni)	35	210	50	5000	4-160	44.57±4.12	8.7
Lead (Pb)	85	530	450	750	637-9623	2349±166	20.22
Antimony (Sb)	3	15			5-141	45.03±2.79	2.12
Zinc (Zn)	140	720		826	5510	2188±90.9	24.53

Table 1: indicating soil guideline values alongside values derived at the informal recycling site.

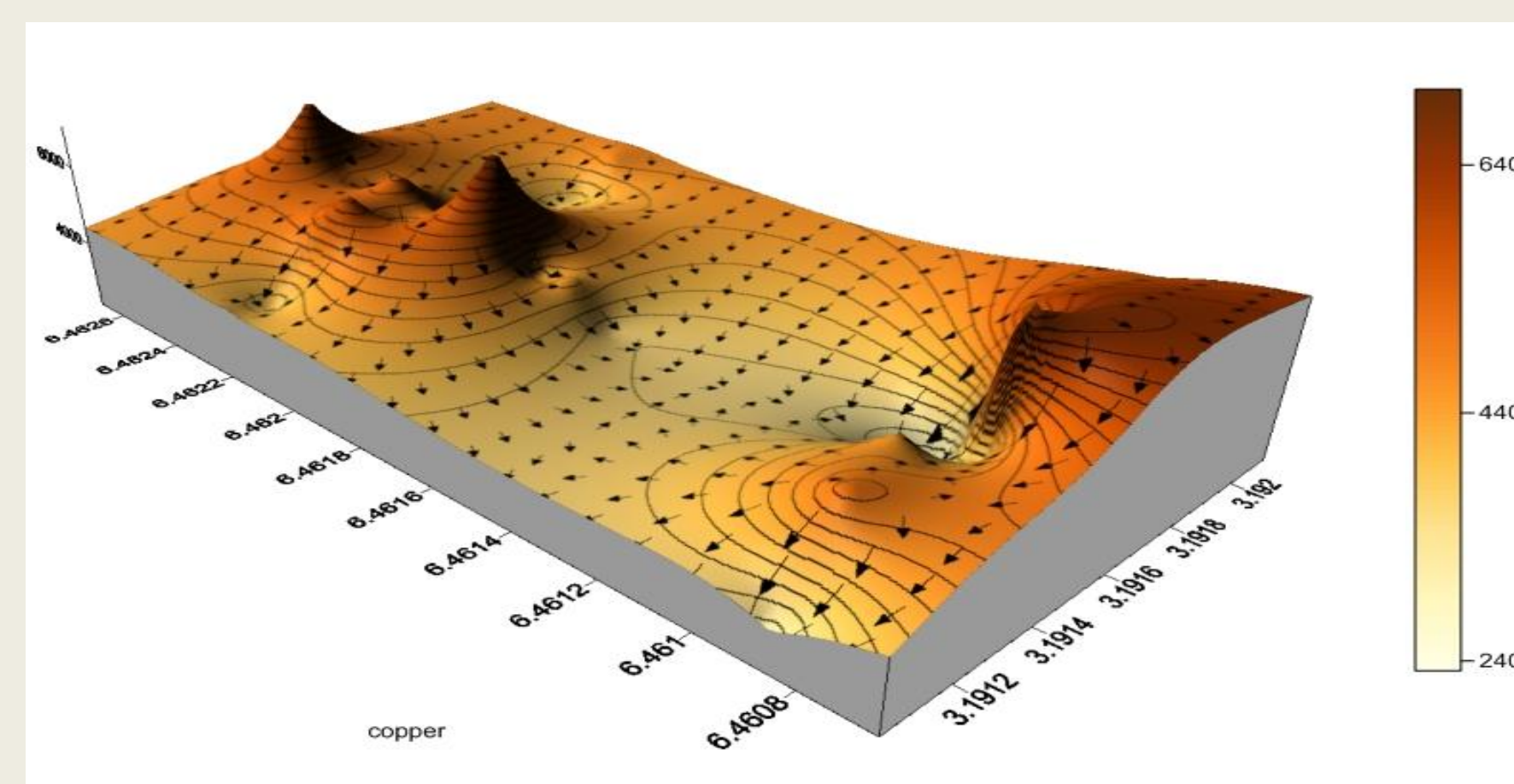


Fig 3: Copper distribution on topsoil within the recycling site.

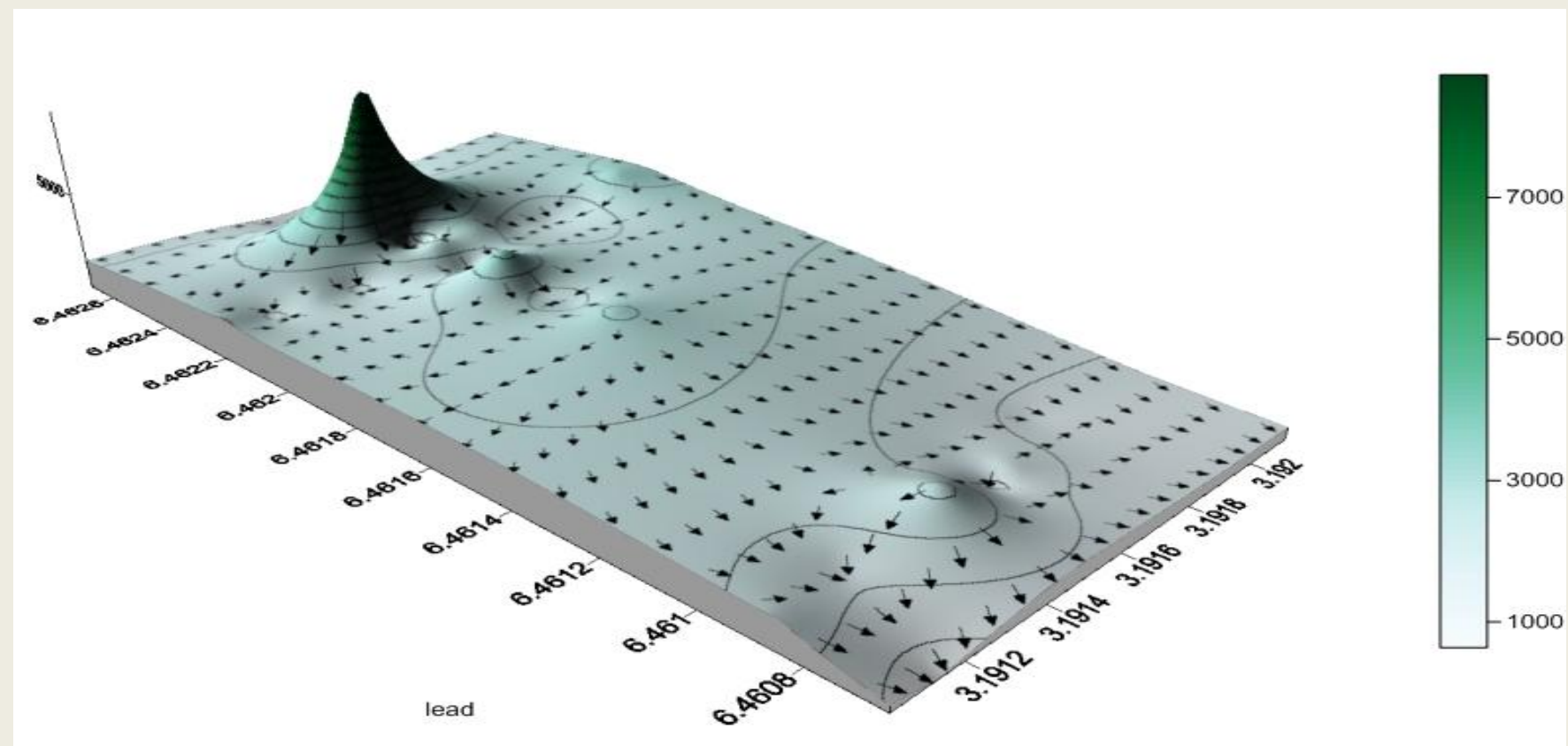


Fig 4: Distribution of lead on topsoil within the recycling site.

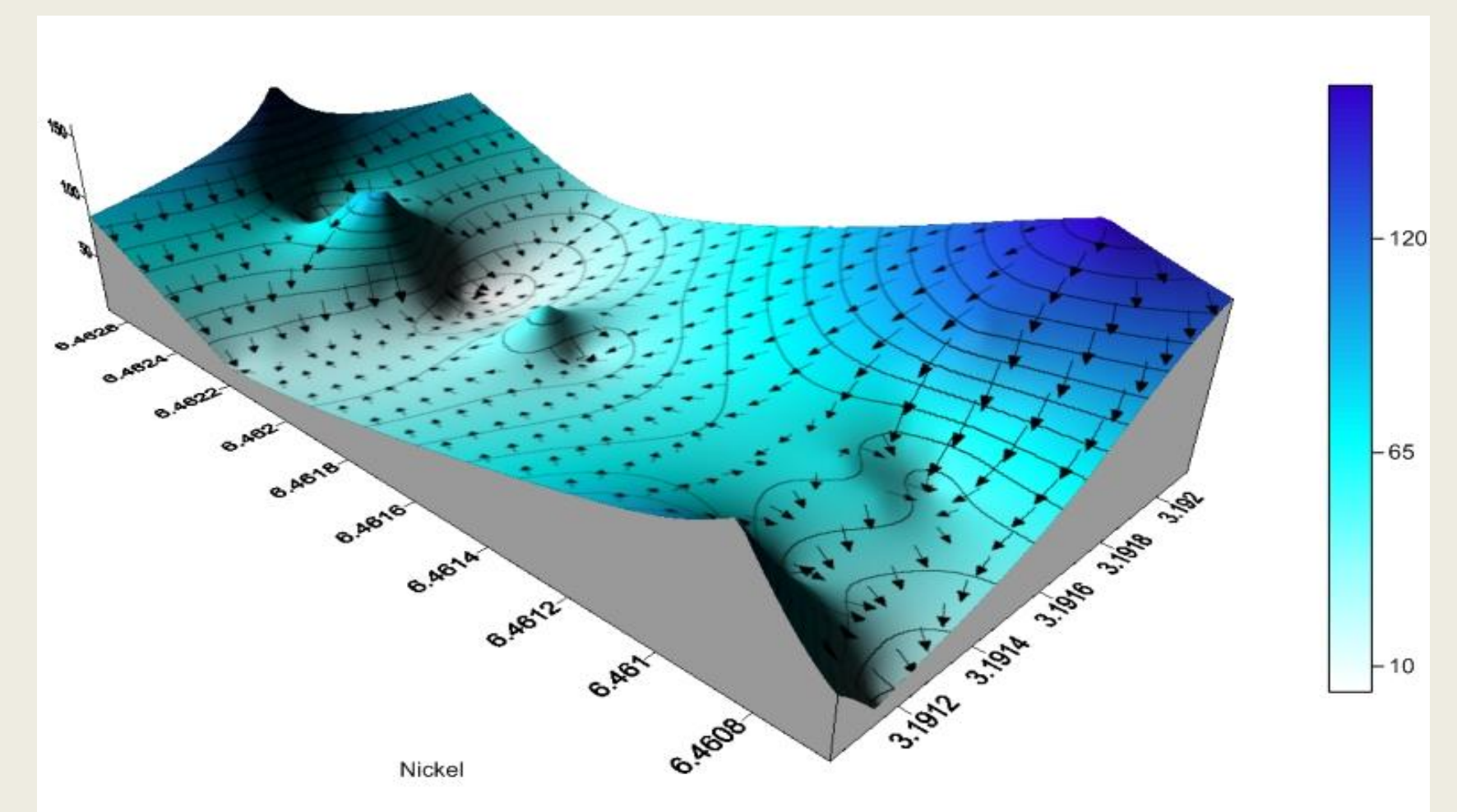


Fig 5: Distribution of Nickel on topsoil within the site

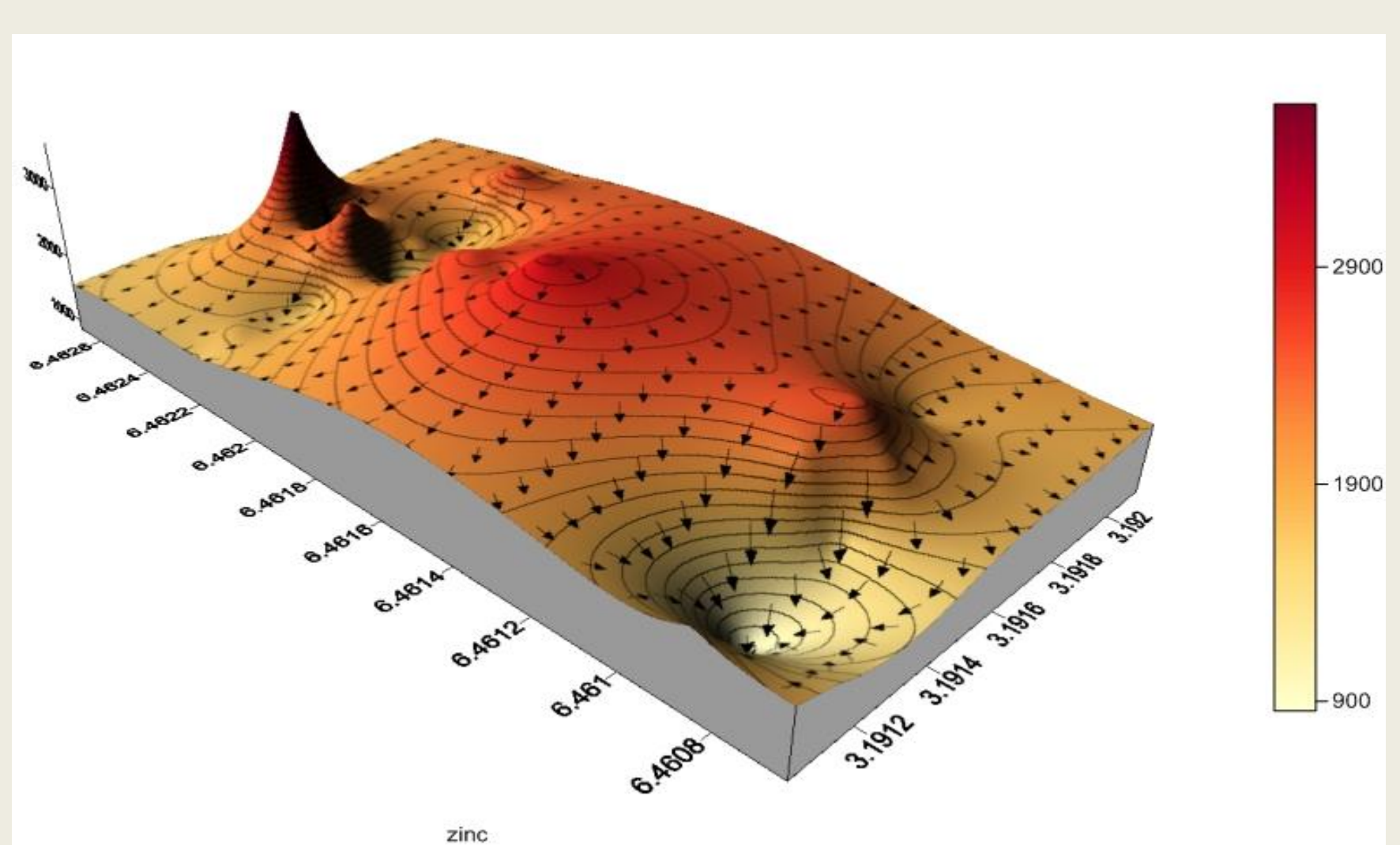


Fig 6: Distribution of zinc on topsoil within the recycling site.

SPECIATION OF METALS

Speciation fractionates heavy metals in the soil in order of decreasing solubility. F1, the exchangeable fraction is presumably the most mobile and bioavailable. F2, is bound to organic compounds, its mobility is dependent with time, decomposition or oxidation of organic matter. F3, is the residual fraction, the mobility is low and the residual fraction is only available after weathering or soil decomposition (Carapeto & Purchase, 2001)

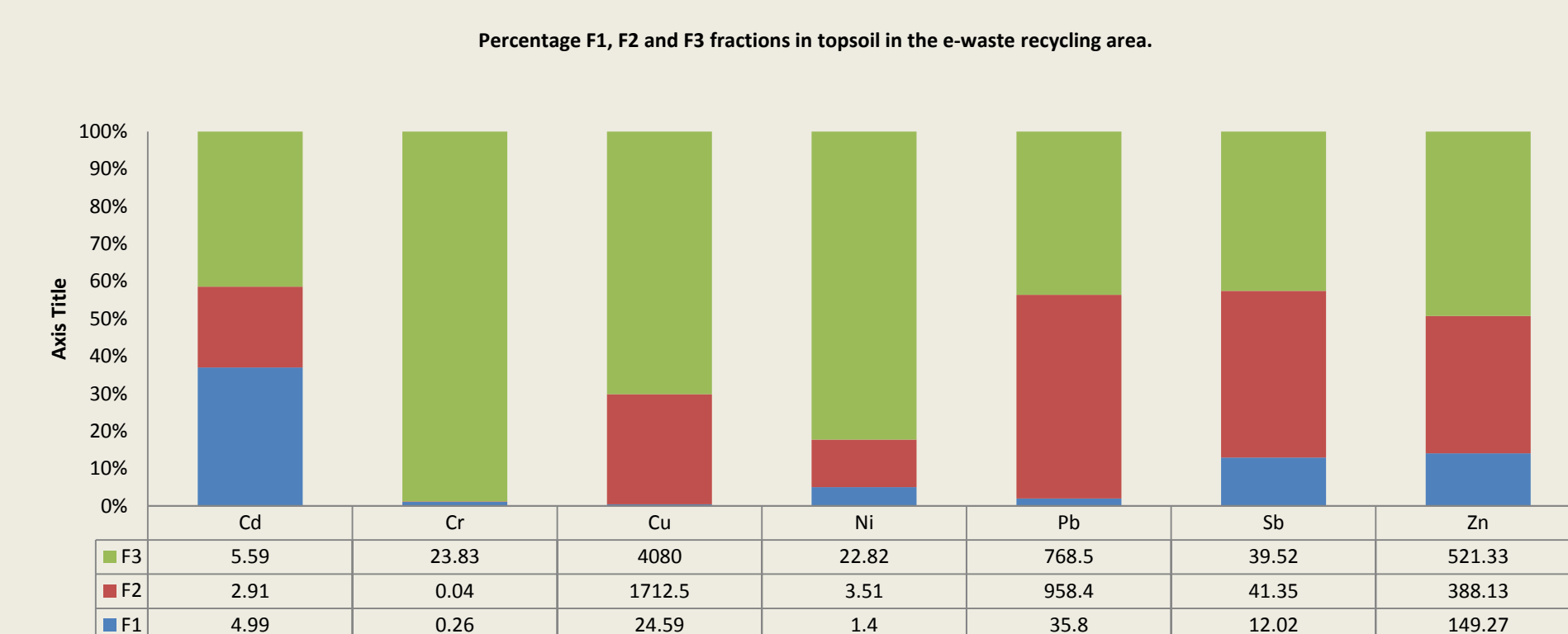


Table 2: A plot showing the different fractions (F1- bioavailable, F2- Organic bound and F3- Residual fraction) in the topsoil in the e-waste recycling area.

The figure above indicates the different fractions of the various metals. It shows cadmium as the most bioavailable. Copper, nickel, chromium are more on the residual fraction.

RISK ASSESSMENT

The human risk associated with the heavy metals contaminants are assessed according to EPA (USEPA1989,1992,2011)

Medium	Exposure route	Calculation
Soil	Ingestion	$CDI = \frac{CS * IRS * EF * ED}{BW * AT}$
	Dermal	$CDI = \frac{CS * SA * AF * ABS * EF * ED}{BW * AT}$

Where CDI= chronic daily intake (mg/kg); CS= exposure concentration (mg/kg); IRS= ingestion rate (100mg/day); EF= exposure frequency (350 days/annum); exposure duration ; BW= body weight (70kg); AT= average time (365*exposure duration) or (365*70days for carcinogens); SA= exposed skin area= 5700cm²; AF= adherence absorption fraction (0.07mg/cm); ABS=dermal absorption fraction (0.001).

The non-carcinogenic risk from individual heavy metals can be expressed as the hazard quotient: $HQ = CDI/RFD$ where the non-cancer hazard quotient (HQ) is the ratio of exposure to hazardous substances, and RFD is the chronic reference dose of the toxicant (mg/kg/day)

	Cd	Cr	Cu	Pb	Zn	Sb	Ni	Sum
Ingestion	0.18	0.03	7.97	2.41	1.45	0.13	0.04	12.21
Dermal contact	0.07	0.13	31.79	9.63	5.79	0.51	0.15	48.07

Table 3: Chronic daily intake (CDI) mg/kg/day of heavy metals through ingestion and dermal contact within the e-waste recycling area

	Cd	Cr	Cu	Pb	Zn	Sb	Ni	Sum
Ingestion	180	10	199.25	602.5	4.83	13	2	1011.58

Table 4: Hazard quotients (HQs) for heavy metal exposure from ingestion within the e-waste recycling site

DISCUSSION

Both exposure routes explored above are of importance for workers at the site. The ingestion important due to hand to mouth activities either smoking a cigarette or eating while at work. The total chronic hazard index is a summation of all individual hazard quotients. HI values >1 indicates concern as acceptable standards is 1 at which there will be no significant health hazard. The individual metals above all have high hazard quotient, hence an elevated HI. The HI value above indicates high exposure to non-carcinogenic risk to the workers at the e-waste recycling site.

UNCERTAINTY

The model may provide over-estimations or underestimations of the risks involved. However, the results still provide some information to a certain extent which will help alleviate the environmental problem.

CONCLUSION

Informal and uncontrolled e-waste recycling has led to heavy metal contamination and this affects human health via different exposure routes. The activities carried out on the site as the results indicate has high health impacts on both the environment and human health.

RECOMMENDATION

Further studies will be carried out exploring the risk assessment on all other exposure routes as well as uptake with regards the bioavailable fraction.

REFERENCES

- Carapeto, C. & Purchase, D., 2000. Use of sequential extraction procedures for the analysis of cadmium and lead in sediments samples from a constructed wetland. *Bulletin for Environmental Contamination and Toxicology*, 64(1), pp. 51-58.
- Luther, L., 2010. Managing electronic waste: Issues with exporting E-waste. *Congressional Research Service*, pp. 1-16.
- Robinson, B. H., 2009. E-waste: An assessment of global production and environmental impacts. *Science of the Total Environment*, Issue 408, pp. 183-191.
- Tang, X. et al., 2010. Levels and distribution of polycyclic aromatic hydrocarbons in agricultural soils in an emerging e-waste recycling town in Taizhou area, China. *Journal of Environmental Science Health*, Volume 45, pp. 1075-1084.
- Wang, Y. et al., 2012. Polycyclic aromatic hydrocarbons (PAHs) in soil and vegetation near an e-waste recycling site in South China: Concentration, distribution, source and risk assessment. *Science of the Total Environment*, Volume 439, pp. 187-193.