Journal of Applied Sciences, Information, and Computing
Vol. 1, No. 2 (December, 2020)

ISSN: 1813-3509 https://jasic.kiu.ac.ug

EVALUATION OF HEAVY METALS CONCENTRATIONS IN SOIL AND WATER SAMPLES AROUND E-WASTE DUMPSITES IN OLABISI ONABANJO UNIVERSITY, AGO-IWOYE, SOUTH-WESTERN NIGERIA

Odunaike, K.[1], Adeniji, Q. A. [1 & 2]*, Talabi, A. T. [1], Olabamiji, O. A. [1] & Oluwasola F. R. [1]

[1]Department of Physics, Olabisi Onabanjo University, Ago-Iwoye, Nigeria.
[2] Department of Physics, Federal University Kashere, Gombe State. Nigeria.
*Corresponding Author: qadeniji@yahoo.com
Orcid No: 0000-0002-1970-3836)

Abstract

In this paper, the health implications of electronic wastes (E-Wastes) on the inhabitants of the University site at Ago-Iwoye, Ogun State South Western Nigeria were reported. The main goal of this study was to evaluate heavy metals concentrations in the soil around e-wastes dumpsite in soil and water samples at Olabisi Onabanjo University, Ago-Iwoye Ogun State. The heavy metal concentrations in soil and water around the e-waste dumpsites were measured and compared with international standard limits. The values recorded for soil and water were below the recommended safety limit. This is an indication that the soil and water of Olabisi Onabanjo University can be used for drinking, agricultural purposes, and construction of buildings without causing any health hazard. The results of this study revealed that the presence of heavy metals in water was not significant and in the order of increased magnitude Cd < As < Ni < Co < Zn < Pb < Cr < Cu. However, care must be taken to face the challenges in the future for health safety.

Keywords: Heavy metals, Soil and water samples, E-wastes, OOU, Environmental challenges, and toxic.

1. Introduction

Electronic wastes (e-wastes) can be defined as electronic products and/or their components that have been used up and deserted. They contain electronic devices ranging from refrigerators, air conditioners, cell phones, personal stereos, to consumer electronics and computers which have been discarded by the users. Also, these wastes involve both hazardous and non-hazardous forms which consist of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards (PCB), concrete and ceramics, rubber, and other items. Electronic waste can be further explained as unwanted electronic or electrical appliances such as old and outdated computers, laptops, televisions, cellular phones, MP3 players, telecommunication equipment, keyboards, mice, photocopiers, typewriters, etc. (PPCC, 2006; Ogbomo *et al*., 201; Obaje, 2013).

Electronic waste has many toxic and hazardous elements/materials that are sources of environmental pollution and contamination of groundwater, surface water, air, and soil (Tereda, 2012). The hazard from e-waste cannot be overemphasized as it endangers the whole ecosystems and poses environmental health challenges to both human beings and other animals (aquaculture and fisheries, wildlife, etc.) (Puckett *et al*., 2002). Indiscriminate dumping and disposal of E-wastes on our lands prevented the lands from being used for Agricultural purposes and these have possessed a serious threat to the inhabitants (Ogungbuyi *et al*., 2002; Opara, 2013). The water contents found in the area that harbored the E-wastes are not exempted from being contaminated by this indiscriminate dumping thereby endanger humanity by making the water unfit for domestic and agricultural purposes and these among other reasons that motivated this study. This study measures the heavy metals concentration in soil and water samples around e-waste dumpsites at Olabisi Onabanjo University campuses, Ago-Iwoye to evaluate the level of contamination in the water and soil within the study areas.

1.1 The study area

Ago-Iwoye lies on longitude 3º55 East of Greenwich meridian and latitude 6º56' North of the equator. It covers a mass area of 460 square km and sited on the basement complex. Ago-Iwoye has an estimated population of about 40,000 as of the year 2006 and it is the second-largest populated town in Ijebu North Local Government (Alausa and Odusote, 2013) (as shown in Figure 1). Olabisi Onabanjo University main campus, Ago-Iwoye habituating over 15,000 students, over 2500 staff, and frequent visitors including small scale businessmen and women in the school perimeter. It also has the Mini campus where the University took off in 1983. The Mini campus currently harbors the Centre for Continuing Education (CCED) which comprises Pre-degree and the JUPEB programs with an estimated population of about 10,000 students which include both male and female students living in the hostel within the Mini campus.

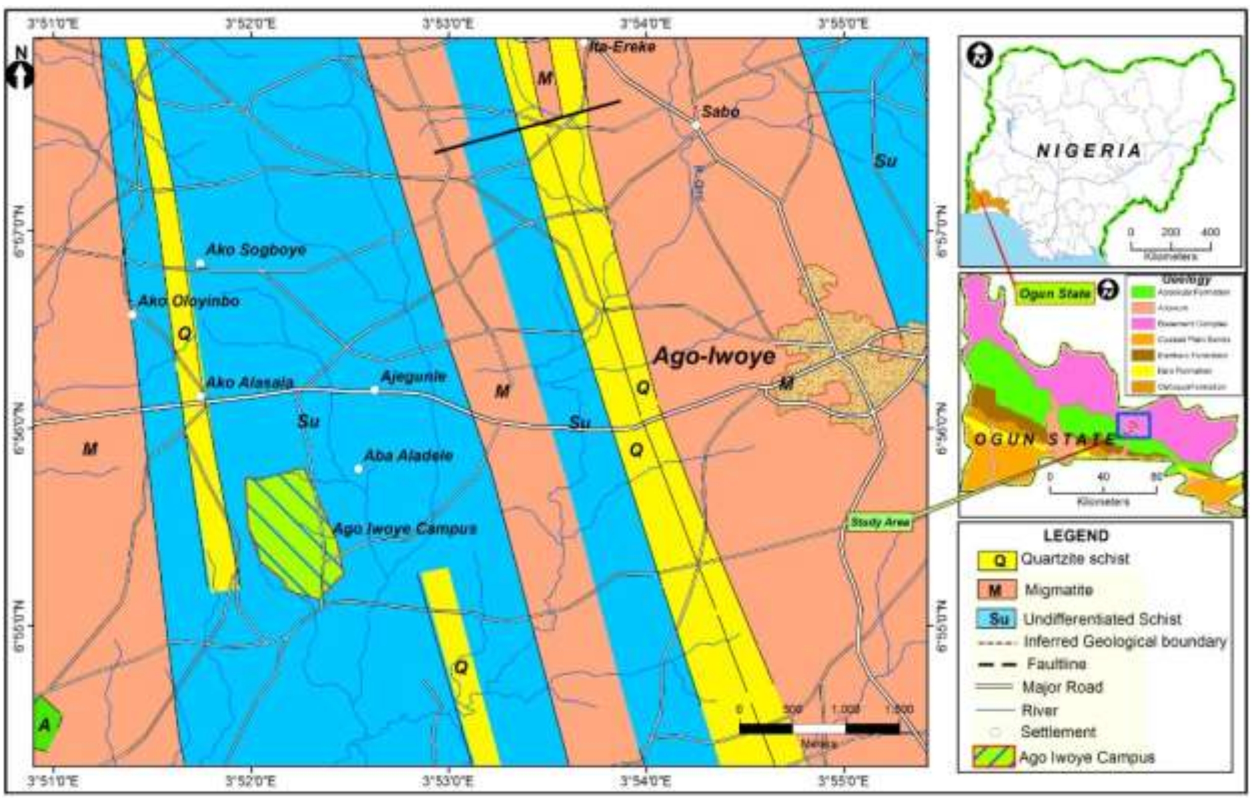

Figure 1: Geological map of Ogun State showing the study area (Alausa and Odusote, 2013)

2. Materials and Methodologies

Soil and water samples were collected in three (3) locations which were from the main campus market where most e-wastes were dumped and the mini campus e-waste dumpsite, school hostels (main campus and mini campus hostel) dumpsites. At each sampling point, soil samples were collected at a depth between 150 mm and 200 mm below the soil surface, and a total of ten soil samples were collected from five grid areas. The samples were thoroughly mixed to form a sample representation. Also, water samples from the well and boreholes nearest to the dumpsites were collected for heavy metal analysis.

The mixtures of soil samples which have been crushed to finesse and treated with concentrated HNO_3 were kept inside a switch-on fume cupboard and heated for 2 hours at about 104 °C in the following day. Deionized water was then added and filtered with the aid of filter paper and topped up to make up 100 ml in a volumetric flask. The solution was passed into sampling bottles and labeled for analysis in a Perkin-Elmer Analyst 400 AAS (Atomic Absorption Spectrophotometer). On the other hand, water samples were subjected to AAS analysis directly.

3. Results

Table 1: Elemental concentrations (mg/kg) of heavy metals in the E-wastes soil samples at the main campus

S/N	Sampling points	Pb	Zn	Cd	Cr	Cu	As	Ni	Co
1	Dumpsite	396.1±55	167.2	32.5	160.3	130.5	61.1	73.5	162.5
2	Dumpsite	400.6	166.5	35.2	167.6	131.4	61.3	74.5	167.9
3	100m away	358.1	164.1	32.5	164.4	140.2	60.1	70.6	160.4
4	100m away	389.6	166.1	28.6	160.3	137.4	61.5	69.9	151.9
5	200m away	312.4	166.5	27.9	158.3	120.6	57.9	64.7	158.6
6	200m away	325.7	163.3	27.3	160.1	115.9	55.7	60.4	150.9
7	300m away	318.1	160.7	26.9	149.3	105.3	45.7	56.8	147.5
8	300 away	319.7	158.4	25.5	124.6	109.5	40.9	59.9	148.6
9	400m away	311.4	156.2	24.3	116.3	89.6	38.6	50.6	135.6
10	400m away	314.3	150.3	22.8	120.1	87.4	33.7	53.5	139.6

Table 2: Elemental concentrations (mg/kg) of heavy metals in the E-wastes soil samples at the mini campus

S/N	Sampling points	Pb	Zn	Cd	Cr	Cu	As	Ni	Co
1	Dumpsite	342.1	161.7	31.5	170.1	125.8	57.5	76.2	181.2
2	Dumpsite	400.6	162.5	35.2	167.6	131.4	61.2	74.5	167.5
3	100m away	358.1	174.1	32.5	164.4	140.2	60.6	70.6	162.7
4	100m away	329.6	171.4	28.6	160.4	137.4	61.8	69.9	156.2
5	200m away	312.4	166.7	27.4	158.8	110.6	57.3	64.7	158.2
6	200m away	325.7	137.8	27.3	160.7	110.5	55.6	60.4	155.1
7	300m away	318.1	147.1	26.2	149.8	105.3	45.3	56.8	147.8
8	300 away	319.7	158.4	25.1	124.2	89.5	40.5	59.9	148.4
9	400m away	311.4	156.2	24.8	116.3	85.7	38.3	50.6	150.3
10	400m away	314.3	140.9	22.4	120.1	77.4	33.2	53.5	140.9

Table 3: Elemental concentrations (mg/kg) of heavy metals in the E-wastes soil samples at the hostel

S/N	Sampling points	Pb	Zn	Cd	Cr	Cu	As	Ni	Co
1	Dumpsite	344.3	161.6	38.5	162.5	125.4	57.5	70.9	172.8
2	Dumpsite	347.6	161.5	35.2	167.1	128.4	51.9	74.2	177.5
3	100m away	338.1	164.1	32.2	162.5	110.2	58.6	72.5	170.1
4	100m away	339.6	161.4	28.3	150.4	117.4	60.8	72.2	161.6
5	200m away	312.0	162.7	27.7	138.8	110.6	57.3	64.1	157.2
6	200m away	320.4	157.8	27.5	120.7	110.5	56.3	63.0	149.1
7	300m away	318.1	157.1	28.1	119.8	108.3	50.3	66.9	143.4
8	300 away	319.7	152.4	29.4	114.7	88.8	49.5	69.3	153.4
9	400m away	315.4	153.2	26.6	110.3	85.5	48.3	61.2	150.3
10	400m away	310.3	150.9	24.9	100.7	78.6	43.6	63.4	150.2

Table 4: Elemental concentrations (mg/L) of heavy metals in the E-wastes in water samples around the campuses

S/N	Sampling points	Pb	Zn	Cd	Cr	Cu	As	Ni	Co
1	Tap	0.045	0.037	0.004	0.200	0.410	0.008	0.070	0.050
2	Tap	0.045	0.040	0.004	0.200	0.406	0.008	0.070	0.050
3	Tap	0.045	0.030	0.004	0.200	0.410	0.008	0.070	0.042
4	Tap	0.037	0.030	0.004	0.200	0.400	0.008	0.070	0.042
5	Tap	0.029	0.030	0.004	0.200	0.400	0.008	0.070	0.040
6	Well	0.029	0.031	0.004	0.200	0.400	0.008	0.070	0.040
7	Well	0.029	0.030	0.004	0.160	0.400	0.008	0.070	0.043
8	Well	0.029	0.030	0.004	0.200	0.390	0.008	0.070	0.042
9	Well	0.029	0.030	0.004	0.120	0.400	0.008	0.070	0.041
10	Well	0.029	0.030	0.004	0.180	0.401	0.008	0.070	0.040

4. Discussion

Heavy metals which include lead (Pb), zinc (Zn), cadmium (Cd), chromium (Cr), copper (Cu), arsenic (As), nickel (Ni), and cobalt (Co) concentrations in soil and water samples collected from three e-waste dumpsites within the campus of Olabisi Onabanjo University have been measured and the results are discussed concerning the World Health Organization (WHO) recommended values (WHO, 2008). The element concentration range (mg/kg) regulatory limit (mg/kg) lead 600, cadmium 100, Arsenic 20, chromium 100, mercury 270, copper 600, zinc 1500 (Salt *et al*., 1995). Besides, it was observed from the results that the concentrations of heavy metals also decreased as the soil sampling distance from the dumpsite increased.

4.1 Heavy Metals concentration of E-wastes in Soil

Concentrations of heavy metals lead (Pb), zinc (Zn), cadmium (Cd), chromium (Cr), copper (Cu), arsenic (As), nickel (Ni), and cobalt (Co) in soils at various distances, depths from the dumpsite are presented in Tables 1-3. The concentrations of the heavy metals were found to range from 22.8 to 400.6 mg/kg, the least was found in cadmium (Cd) while the highest was measured in lead (Pb). The soil samples exhibited the highest concentration of lead (Pb) which was far above the permissible limit of 200 mg/kg set by the World Health Organization (WHO). High concentrations of lead (Pb) in the e-waste dump may be due to the disposals of cathode ray tubes, computer monitor glass, printed wiring boards, and lead-acid batteries, lead-based paint. Lead as a soil contaminant is a widespread issue. Besides, Lead is the most common contaminant of soils (permanent resident). Organic matter binds and holds itself in other metals very effectively. Lead can enter the human body through the uptake of food (65%), water (20%), and air (15%). Since the concentration of lead in all the soil samples was recorded above the permissible limit the soil strongly inhibits seed germination, root and plant growth, and seedling development, and cannot be fertile for agricultural use. However, the concentration of cadmium in all the collected soil samples ranged from 22.4 to 38.5 mg/kg. Cadmium average concentration was recorded below the maximum permissible limit set by the international standard value of 100 mg/kg. The average concentration of cadmium may not affect root and plant growth within the vicinity of the dumpsite, hence, soil in the surrounding could be used for agricultural practice. Chromium is toxic in high amounts to both plants and humans. The concentration of Chromium in e-waste samples in the present study ranged from 77.4 to 170.1 mg/kg. The concentration levels were above the critical value for most countries such as Australia with a limit of 50 mg/kg, Tanzania with a limit value of 100 mg/kg. Also, the value of chromium in this study was found to be within the range of values reported by Tariq *et al*., 2014. The average concentration value of chromium recorded in the present study suggests that the parent rock could be mafic (Tariq *et al*., 2014). Copper and zinc are micronutrients that play important role in soil by facilitating the respiration, photosynthesis, and metabolic process in plants. Copper and Zinc concentrations in the present study are 77.4-131.4 mg/kg and 138.4-167.2 mg/kg respectively. The bioavailability of copper and zinc in soil depends on many factors such as pH and organic matter content of the soil. Tariq *et al*., 2014 reported that clayey sediments contain about 80–120 mg/kg concentration of Zinc and this is in agreement with the result of this present study. Nickel is another heavy metal that is twice as abundant as Cu in the earth's crust, with an average concentration of 75 mg/kg. The concentration of Nickel in the present study ranged from 50.6 mg/kg to 76.2 mg/kg which is permissible and no hazard attached. In US, for example, the regulatory limit for nickel is 72 mg/kg while Canada has the highest Ni concentrations of 100 mg/kg (Santanu and Chumki, 2018).

4.2 Heavy Metals concentration in water

The concentrations of the heavy metals in the water samples from the sampling points around the e-waste dumpsites in Olabisi Onabanjo University are presented in Table 4. The highest concentration of the heavy metals was Cu while the lowest value was Cd. The order of increased magnitude was Cd < As < Ni < Co < Zn < Pb < Cr < Cu. From Table 4, it can be observed that the concentration of Cu was between 0.401 and 0.410 mg/L while that of Pb and Cr ranged from 0.029 to 0.045 mg/L and 0.120 to 0.200 mg/L respectively. Cadmium has no benefit to the ecosystem, non-essential to a biological system. Though it is the most toxic heavy metal but could enter the environment through the application of phosphate fertilizers and e-waste dumping. Cadmium toxicity causes renal dysfunction, lung cancer, increasing blood pressure. The highest concentration of cadmium 0.004 mg/L recorded in this study was below the WHO recommended value of 00.5 mg/L and this reveals that the water in both the well and borehole of the study area is safe for consumption. Also, the report in the present study showed that consuming the water close to the e-waste dumpsite is safe from heavy metal contamination because the values were less than the world permissible level.

5. Conclusion

The heavy metal concentrations in soil and water around e-waste dumpsites at Olabisi Onabanjo University have been measured and compared with international standard limits. The values recorded for soil and water were below the recommended safety limit. This is an indication that the soil and water of Olabisi Onabanjo University can be used for drinking, agricultural purposes, and construction of buildings without causing any health hazard. The results from this study revealed the presence of heavy metals in water was not significant and in the order of increased magnitude Cd < As < Ni < Co < Zn < Pb < Cr < Cu. From the results of the study, it could be recommended to the Authority of Olabisi Onabanjo University need to legislate on the management of e-waste on the campus

to forestall the effects of waste-related problems in the future. Also, modern waste disposal facilities should be adopted by management, and appropriate waste disposal sites are chosen to avoid the injurious effects of indiscriminate disposal of e-waste, and the dumpsite should be sited farther away from markets to avoid environmental pollution health hazard.

Conflicts of Interest: No conflicts of interest among the authors.

Acknowledgments

The authors are grateful to the staffer of the Centre for Radiation and Health, University of Ibadan, Nigeria for their supports during the laboratory analysis of this work.

References

Alausa, S. K., and Odusote, O. O. (2013). Radiological health impact due to activity concentrations of natural radionuclides in the soils from two major areas in Ijebu-North Local Government, Ogun State, Nigeria. *The Nucleus*, 50(4): 293-299.

Obaje, S. O. (2013). Electronic Waste Scenario in Nigeria: Issues, Problems, and Solutions. *International Journal of Engineering Science Invention*, 2(11): Pp.31-36. ISSN (Online): 2319-6734, ISSN (Print): 2319-6726.

Ogbomo, M. O., Obuh, A. O., and Ibolo, E. (2012). Managing ICT waste: A case study of Delta State University, Abraka, Nigeria. Library Philosophy and Practice.

Ogungbuyi, O., Nnorom, I.C., Osibanjo, O., and Schluep, M. (2012). E-waste Africa Project of the Secretariat of the Basel Convention, Pp. 94.

Opara, S. Experts. The Punch 9 April 2013 edition. (2013).www.punchnh.com/business/technology /experts-move-to-tackle-ewaste-problem.

PPCC, (2006). Global trends in electronic waste. Available in http://dstepudcherry.gov.in/third news.pdf.

Puckett, J. Byster, L., and Westervelt, S. (2002). Exporting Harm: The High-Tech trashing of Asia. The Base Action Network (BAN) and Silicon Valley Toxics Coalition (SVTC).

Salt, D.E., Blaylock, M., Kumar, P., Dushenkov, V., Ensley, B.D., Chet, I. and Raskin, A. (1995). Biotechnology. Pp 198-206.

Santanu, B., and Chumki, B. (2018). Monitoring and Management Burdeigh Dodds Science Publishing, Cambridge, UK. ISBN: 978178676192.

Tariq, K., Muhsin, J., Naseer, A., and Huma, A. (2014). Demystifying E-Waste. *Journal of soils and sediment*. 14(11). Pp. 67.

Tereda, C. (2012). Recycling Electronic Wastes in Nigeria: Putting Environmental and Human Rights at Risk. *Northwestern Journal of International Human Rights*. 10(3): Pp. 154-172.

World Health Organization (WHO) (2008). WHO Library Catalogue-in-Publication Data.