

ASSESSMENT AND ENVIRONMENTAL IMPACT OF SELECTED METALS IN SURFACE WATER OF OGBUNABALI CREEK, NEAR E-WASTE DUMPSITE, PORT HARCOURT, RIVERS STATE, NIGERIA



Gbarakoro, S. L.,³ Hamilton-Amachree, A.² and Adooh, L. S. K.³

*Department of Science Laboratory Technology, School of Applied Sciences, Kenule
Beeson Saro-Wiwa Polytechnic, Bori, Rivers State, Nigeria.*

Department of Chemistry, Federal University Otueke, Bayelsa State, Nigeria.

*Department of Statistics, School of Applied Sciences, Kenule Beeson Saro-Wiwa
Polytechnic, Bori, Rivers State, Nigeria.*

Abstract:

The concentration of selected metals including Li, Co, Ni, Ag and Au were determined in surface water of Ogbunabali creek, Port Harcourt, Rivers State, Nigeria, impacted by disposal of electronic wastes. Three (3) water samples (A, B and C) were collected into plastic sampling bottles along the Ogbunabali creek and transported to the laboratory for analysis. The water samples were digested using HNO₃ and HCl and quantified using flame atomic absorption spectrophotometry. The concentration (in mgL⁻¹) of metals obtained from the analysis were Li: 0.007, 0.0015 and 0.0009; Co: 1.6750, 1.8130 and 1.6620; Ni: 0.7564, 0.2480 and 0.8706; Ag: 0.0417, 0.0325 and 0.0398; and Au: 0.0510, 0.0381 and 0.0399 for samples A, B and C respectively. Some of the heavy metals (Li, Co, Ni, Ag and Au) analyzed were relatively high and above the WHO set limit. The analyzed metals could exert negative effects on human health and the environment. It is therefore concluded that deposition of e-wastes on landfill close to the creek leach the heavy metals used in producing them into the environment.

Keywords: *Metals, Electronic waste, Surface water, Environmental Impact, Atomic absorption spectrophotometry.*

Introduction

One of the major problems of pollution globally is the deposition of unrecyclable wastes in our environment. Availability of proper waste management system is

seriously lacking in the world with developing countries like Nigeria having little or no waste management system to recycle its waste (Isildar *et al.*, 2019; Abalansa *et al.*, 2021). This has led to uncontrolled disposal of wastes from different industrial processes and used devices like discarded cell phones, computers, television sets, printers, refrigerators, radios, copiers, fax machines, uninterruptible power supply or source (U. P. S.), fans, torch, bulbs, sockets, air conditioners, electric cookers, chargers, and batteries, etc. popularly called "Electronic Wastes (e-waste)" (Otache *et al.*, 2014; Dave *et al.*, 2016).

E-Wastes refer to used or discarded electrical and electronic products approaching the end of their "useful life" and are not economically useful to consumers anymore (Admed *et al.*, 2019). These unwanted electronic products comprise of precious metals: gold (Au), silver (Ag), copper (Cu), cobalt (Co), nickel (Ni), lithium (Li), etc, toxic metals such as lead (Pb) mercury (Hg), etc. (Admed *et al.*, 2019; Isildar *et al.*, 2019), wood, plastic and glass (Khaliq *et al.*, 2014; Yunus and Sengupta, 2016), which differ in products across different categories of items (Kavitha, 2014). Precious metals have wide applications in the electronic industries because they are highly chemically stable and have good conducting properties (Cui and Zhang, 2008).

Both precious and toxic metals in e-waste can be hazardous to the environment and ecosystem, which can lead to deterioration of human health. The content of heavy metals in the environment is at an increasing rate due to the improvement of global economy and the advancement of technology in recent years (Singh *et al.*, 2018). This has been triggered by the activities of man, which has hitherto contaminated the environment (Raju *et al.*, 2013).

There is a tremendous increase in the generation of e-waste each year (Debnath *et al.*, 2018). This is due to rapid technological advancements in the electronic sector (Wang *et al.*, 2020), coupled with decreasing economic lifespan and easy affordability (Isildar *et al.*, 2019). Electronic-waste is fast becoming a global environmental issue as its abundance in the society is within a short time (Elaigwu, 2007). It is estimated that 50 million tons of e-waste are manufactured on a yearly basis (Sthiannopkao, 2012), out of which 75-80 % is shipped to Asian and African countries for recycling and dumping. Guiyu in Hong Kong, China is the biggest e-waste collector worldwide while Accra in Ghana and Lagos in Nigeria are next to Guiyu in the importation of e-wastes (Dave *et al.*, 2016). According to the Basel Action Network (BAN, 2002), an estimated 500 shipping containers with a load equal in volume to 400,00 computer monitors or 175,000 large TV sets enter Lagos, Nigeria each month.



Figure 1: E-wastes deposited near Ogbunabali creek, Port Harcourt

In developing countries like Nigeria, electronic waste is regarded and treated as household waste due to the fact that people are unaware and are not educated about its potential hazard and toxicity to the environment. Therefore, people tend to dispose it at open dumps, unsanitary landfills or recycle it primitively which lack adequate pollution control measures (Brigden *et al.*, 2005; Keith *et al.*, 2008; Osibanjo and Nnorom, 2008). The wrong disposal and mismanagement of the faulty electronic or electrical components are hazardous due to the chemicals in them that are released with time into the environment causing an environmental and health threat (Jain, 2009). In Nigeria, e-wastes are deposited in landfill site with subsequent incineration due to lack of proper management and recycling (Oboro, 2011). A greater component of surface water in Nigeria is polluted and unsafe for human consumption as a result of indiscriminate dumping of e-waste in or near water bodies. Even the habitation of aquatic organisms (plants and animals) within Nigeria is hampered, as Nigeria is seriously lacking behind in the regulations of e-waste and the implementation of international environmental treaties because there is virtually no national framework policy to implement them (Joshi, 2007).

There are several studies on the impact of e-waste on the environment. Otache *et al.*, (2014) studied the level of heavy metals in e-wastes on both topsoil and groundwater from and around a dumpsite in Alaba electronics market, Lagos, Nigeria, The authors concluded that heavy metals from e-wastes are been leached into the soil within and around the dumpsite, which resulted in exceeding the set limits for lead, cadmium and zinc. It has been documented that the dissolution of lead ion in lead containing glass mixed with acid waters and these occur frequently

in landfills (Ramachandra and Saira, 2004; Sivakumar, 2011). In another study, Iniaghe and Adie (2018) showed that toxic metals in discarded cathode ray tube glass possessed very high potentials to leach Pb and Cd, which contaminated surrounding soils to levels greater than recommended limits. The efficient management of the ever-increasing volume of e-waste generated is therefore imperative in order to minimize its inherent harm to the environment (Sinha-Khetriwal *et al.*, 2005).

In Nigeria, e-wastes are commonly discarded together with municipal wastes in landfill sites.

Hence, if such landfill sites are not properly structured environmental hazard becomes inevitable. The heavy metals content in incinerated or leached e-waste have the tendency to undergo bioaccumulation in aquatic organisms such as fish and crab, thereby contaminating the food chain, which can cause health problems to humans.

This study is aimed at determining the concentration and possible impact of selected metals in electronic wastes in Ogbunabali creek, Port Harcourt, Rivers State, Nigeria.

Materials and Methods

Description of Study Area

Ogbunabali town is situated in Port Harcourt city local government area of Rivers State, Nigeria. Port Harcourt city is the capital of Rivers State and is located in the south-south geopolitical zone of Nigeria, also referred to as the Niger Delta region. The latitude of Ogbunabali is $4^{\circ}48'19''\text{N}$ and the longitude is $7^{\circ}0'1.35''\text{E}$, having wet season period from April to October. However, occasional precipitation occurs in the dry season periods ranging from November to March (NMA, 2008). The total annual rainfall is between 160 mm and 298 mm; humidity is over 90% and average temperature is 27°C (Gobo, 1988; Udom *et al.*, 2002). The Ogbunabali creek extends from Okrika and meanders through Marine base to Ogbunabali and Fruit Garden creek. The creek water flows from Okrika and back to Okrika. Ogbunabali creek has mangrove vegetation made up of shrubs like *Rhizophora racemosa* and aquatic macrophytes like *Raffia* (Figure 2). The e-wastes at Ogbunabali are waste generated from the computer village (a place where electrical and electronic devices are sold and repaired). A landfill is located near the creek. A map of the study area is shown in Figure 3.



Figure 2: Picture of Ogbunabali Creek

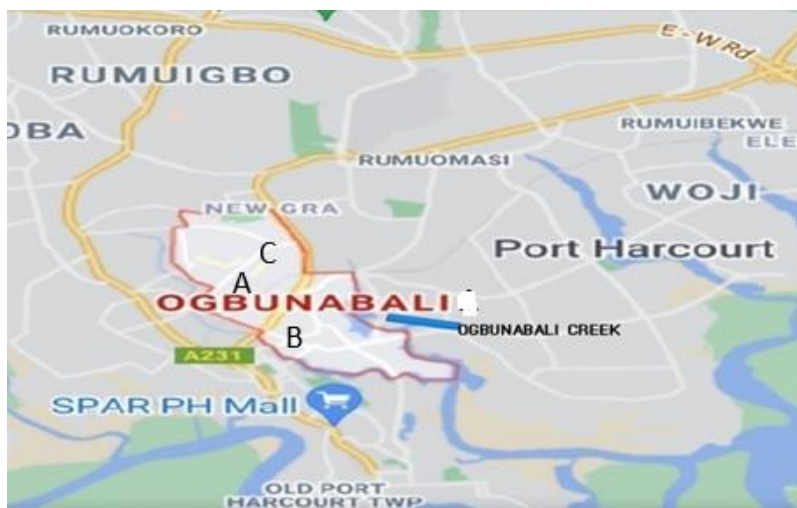


Figure 3: Map of Port Harcourt showing Ogbunabali Creek

Study Design

The study was carried out at three different sites, namely, A, B and C while site C served as the control experiment. Water samples for heavy metals analysis were collected from the three study sites in a Completely Randomized Design.

Sample Collection and Preparation

The water samples from Ogbunabali creek in Port Harcourt were collected and put into sterilized one (1) litre plastic sampling bottles. All collected samples were

labeled as A, B and C, respectively. The samples were then transferred to JACH Petro-analytical Laboratories Limited, Port Harcourt for Atomic Absorption Spectrophotometry (AAS) analysis.

One hundred (100) mL of water samples were measured into Pyrex beakers containing 10 mL of concentrated HNO₃. Heat was slowly applied to the samples which were then allowed to evaporate to a lesser volume of about 20 mL. The beakers were allowed to cool before the addition of 5 mL of concentrated HNO₃ to complete the digestion process. The samples were evaporated to dryness while the beakers were cooled. Thereafter, 5 mL of 5 M HCl was added and then separated by filtration. The filtrates were transferred to 100 mL volumetric flasks and diluted to the mark with distilled water. These solutions were analysed using Flame atomic absorption spectrometry (FAAS) for the determination of selected heavy metals (Li, Co, Ni, Ag and Au) (Standard methods for Examination of Water and Wastewater, APHA 24th edition).

Quantification of metals

The FAAS was standardized by aspirating a blank solution into the air-acetylene flame and the graph was adjusted to zero, which was done for each of the selected heavy metals (Li, Co, Au and Ag). Calibration was carried out using standard solutions of the heavy metals to be analyzed for calibration curve. This was prepared from solution of known concentration of sample element to be analyzed (Li, Co, Ni, Au and Ag) by aspirating a standard solution into the air-acetylene flame to check the absorbance point of the calibration curve graph.

Different cathode lamps composed of the selected heavy metals (Li, Co, Ni, Au and Ag) to be determined in the water samples were used for each of the respective metal analysis, in order to make the process relatively free from spectral or radiation interferences. The different wavelengths (in meters) for Li, Co, Ni, Au and Ag were set to 670.8, 341.5, 345.4, 328.1, and 267.6 respectively. A direct aspiration into an Air-Acetylene flame (Nitrous Oxide-Acetylene) was used to analyse the water samples by aspirating it into the flame for it to be atomize. The amount of light absorbed by the atomized elements in the flame was measured after passing the light beam into the flame and then to the monochromator, before it was passed to the detector. The amount of energy absorbed at the characteristic wavelength was proportional to the concentration of elements in the sample.

Results

The results of the concentration of selected heavy metals (Li, Co, Ni, Au and Ag) present in Ogbunabali creek are presented in Table 1 and Figure 4.

Table 1: Metal Concentrations in Water Samples

Metals	Concentration (mg L ⁻¹)			WHO Limit
	A	B	C	
Lithium (Li)	0.0007	0.0015	0.0009	-
Cobalt (Co)	1.6750	1.8130	1.6620	0.005
Nickel (Ni)	0.7564	0.2480	0.8706	0.02
Silver (Ag)	0.0417	0.0325	0.0398	0.10
Gold (Au)	0.0510	0.0381	0.0399	-

Figure 4: Selected metals concentrations in Ogbunabali creek

The results from this research work on Ogbunabali creek are; Li: 0.007, 0.0015 and 0.0009 mg/L, Co: 1.6750, 1.8130 and 1.6620 mg/L, Ni: 0.7564, 0.2480 and 0.8706 mg/L, Ag: 0.0417, 0.0325 and 0.0398 mg/L, Au: 0.0510, 0.0381 and 0.0399 mg/L for samples A, B and C respectively.

Discussion

The results show that Co is the most abundant metal in the water samples, followed by Ni and others in the order: Co>Ni>Au>Ag>Li. Lithium has the lowest concentration in the water samples because its concentrations in all the samples were <0.0015 mg/L, while the concentrations of other heavy metals were >0.0015 mg/L as seen in Figure 4. The high amount of Co recorded could be attributable to the high presence of laptop batteries deposited at the site. The main source of metals in surface water is by run-off from highly urbanized and industrialized areas (Rout *et al.*, 2003). Hence, Ogbunabali creek receives e-wastes as well as industrial and domestic run-offs from the surroundings,

The level of Co and Ni in all the samples were higher than the set limit for WHO water quality standard, while Silver (Ag) concentration was within the limit of the WHO. These values obtained at Ogbunabali creek were higher than the concentration values obtained by Otache *et al.*, (2014): (Cd: 0.002, 0.005, 0.004, 0.003 and 0.005, Cr: 0.003, 0.002, 0.001, 0.008 and 0.001, Ni: 0.011, 0.001, 0.011, 0.010 and 0.008, Pb: 0.008, 0.010, 0.020, 0.015 and 0.007, Zn: 0.003, 0.004, 0.004, 0.007 and 0.003 mg/L) on the effects of electronic wastes on soil and water. The results obtained from Ogbunabali creek are higher than the ones obtained by Rout *et al.*, (2003) who assessed the surroundings on water quality of Kulia Beel. The metals in e-waste analyzed showed higher values than most of the heavy metals found in Luubara creek, Rivers State (Gbarakoro *et al.*, 2014).

Conclusion

The presence of heavy metals in Ogbunabali creek indicate that the e-wastes deposited on landfills leached the heavy metals used in producing them into the aquatic environment. The concentrations of some of the metals exceeded the set

limits by WHO which indicate that the toxic substances found in electronic wastes have the potential of contaminating surface water. Therefore, the government and other relevant agencies should set up good and efficient e- waste recycling system to recycle the wastes.

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