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Target Quotient Index of Heavy Metals in Soil Samples from Spatial Refuse Dump Sites within Enugu Metropolis

Nwanjoku Chioma Helen[1, 2], Ebede Samuel O[2], Nwanjoku Kingsley O[3], Nwokoye Kingsley U[3] and Oparaji Emeka Henry[4, *]

[1]*Department of Applied Biology, Enugu State University of Science and Technology, Enugu, Enugu State, Nigeria*

[2]*Department of Medical Microbiology, Faculty of Basic Clinical Science, University of Nigeria Teaching Hospital, Enugu State, Nigeria*

[3]*Procurer In-Chief, Aninri L.G.A., Enugu State, Nigeria*

[4]*Department of Biochemistry, University of Nigeria, Nsukka, Enugu State, Nigeria*

[*]**Corresponding Author:** Oparaji Emeka Henry, Department of Biochemistry, University of Nigeria, Nsukka, Enugu State, Nigeria, Tel.: +234-070357549133, E-mail: emeka.oparaji65@yahoo.com

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Abstract

Trace metals due to their relativity in abundance and bioavaiability are metals with relatively high atomic mass and thus which reflect in their atomic weights. In the present study, soil samples from refuse dump sites within Enugu metropolis were sampled, digested and analysed for heavy metal deposits. In-silico tools were utilized to determine the targeted hazard quotients of the respective identified heavy metals. Hg, As and Cd were found at below detectable limit in all the sampled soils except for cadmium which were found in solid waste from dump site III (0.12± 0.2 mg/g). Heavy metals like Fe (4.11± 0.02; 28.76± 0.14; 24.52± 0.12; 35.62± 0.2; 28.43± 0.04 mg/g), Cu (21.21 ± 0.1; 44.3± 0.2; 32.33± 0.3; 40.20± 0.5; 43.4± 0.5mg/g) were relatively in abundance in the respective soil sample I,II,III and IV compared to the control experiment however, Pb was not recorded in the control experiment. Fe and Pb was significantly (P<0.05) high in the experimented soil when compared with the control experiment but considered insignificant (P>0.05) among the test experimental soil heavy metals. Target quotient index of the respective heavy metals showed Pb: 3.4 x 10-31.011.12 x 10-22.8 x 10-2 0.8 x 10-2 mg/g for samples I,II,III and IV respectively; Fe: 5.3 x 10-34.03 x 10-23.0 x 10-28.0 x 10-23.0 x 10-2 mg/g while Cu showed 2.3 x 10-43.9 x 10-33.6 x 10-28.6 x 10-24.2 x 10-2 mg/g however, As, Cd and Hg were below detectable limits for all the analysed soil samples from refuse dump sites I,II,II and IV. The present studyhave shown with empirical the health index of toxicants accruing from unguided refuse dumping.

Keywords: heavy metals; target quotient; refuse dumps

Background of the Study

Solid wastes persistent in their ecological niche significantly have varying degree of impact within the ecological cosm. Functional dynamics of ecosystem reveals the significance of these wastes upon their bioavailability in the environment. Impact assessment study shows the effect of these wastes through biochemodynamics upon interaction with the environment [1]. Upon many significant properties of the ecosystem affected by solid waste; trace metals stand to the test of significant clinical and health implicated elements of these waste [2]. As reported by Oparaji [3], they stated that resultant effect of these waste largely depends on characteristic nature of these solids waste, their timing biochemical transformation within their accumulated niches and original nature of accumulator composites.

Trace metals due to their relativity in abundance and bioavaiability are metals with relatively high atomic mass and thus which reflect in their atomic weights examples includes Arsenic, beryllium, cadmium, chromium, lead, manganese, mercury, nickel, and selenium. They take part in bio-geochemical reactions and are transported between compartments by natural processes, the rate of which are at times greatly altered by human activities [4].

Heavy metals are connected with severe health abnormalities such as nephrotoxicity, neurotoxicity and malignancies of various types Goyer. Lead (Pb) interferes with haem biosynthesis [5]. It inhibits the activity of 2-amino laevulinic acid dehydratase which leads to accumulation of protoporphyrin in the red blood cell [6]. Toxicological studies on clinical significance of trace metal deposits in the ecosystem have suggested the variant potentialities of these trace metals modeled through mathematical factorials (Valero).

An investigation on trace metal concentrations in some non coastal sediment carried out by Ezemoye and Ezemoye [7] revealed an elevated level of these pollutants in the sediments studied. EPA [8] suggested a significant increase in trace metal concentrations in most dumping sites especially when impacted during much moist condition. In thereof, successive impact of these wastes especially the majorly solid waste due their persistence in the surrounding is of oblivion to eco-toxicology records. Enugu east L.G.A of Enugu state is a pendulated town with four major municipal towns of Abakpa, out conurbated community of Emene, inward satellite of trans-Ekulu and discrete of ogui-Nike patch settlement. Within the enlisted niches are much arousing human populations with increasing tones of productivities from human, industries and naturals processes.

Materials and Methods

Materials

All the equipments, reagents used in the present study are of analytical grade and optimally calibrated at each use. The materials sources was majorly sourced from: Sigma-Aldrich, May and Baker, British drug house chemicals, Vickers ltd, BDh, Merck, Pyrex, Uday Burdon, American scientific products, WESP, American scientific products etc.

Study Area

Enugu East L.G.A is within the Enugu east senatorial zone of Enugu state, Nigeria. It has an area of 383 km2 and a population of 279,089 at the 2006 census. Its Coordinates: 6°32′N 7°32′E. Figure two below shows the study map area of the zone.

Methods

Sampling of Compost Soil samples

Compost soil was collected around dump sites within Enugu East L.G.A as described by Ezenwelu [9]. The compost soil was collected in clean sterile sample market and was taken to the lab for acclimatization and analysis.

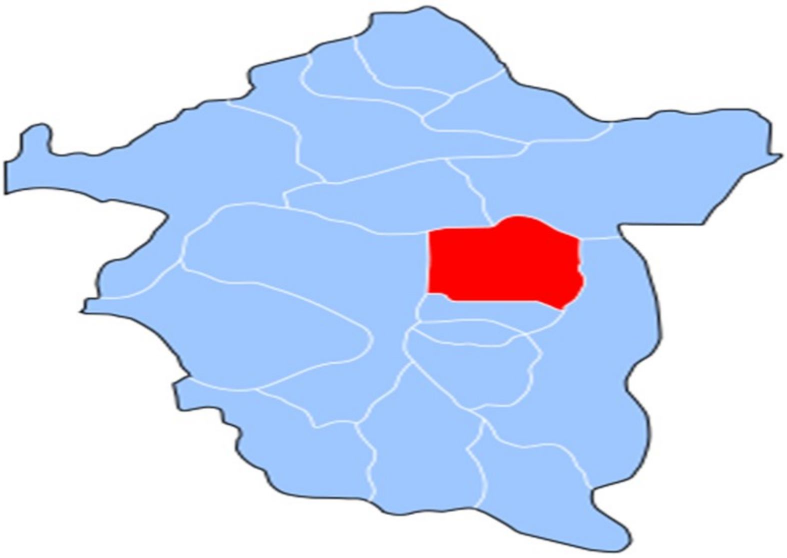

Figure 1: Map coordinate of Enugu East L.G.A.

Source: Vanguard News (2022).

Heavy metals Analysis

Soil Digestion for Heavy Metal Analysis

Briefly, 10 ml of soil sample solution was digested in 250 ml conical flask by adding 30 ml of aqua regia (HNO_3, HCl and HF in the ratio 3:2:1) and heated on a hot plate until volume remains about 7-12 ml. The digest will be filtered using what-man filter paper and the volume will be made up to the mark in a 50ml volumetric flask, and will be then stored in a plastic container.

Atomic absorption spectrophotometer was used in the analysis of the digested soil for heavy metals determination.

Health Risk Assessment of Heavy Metals

The health risks connected with the eating of the samples analyzed in this study were assessed based on the Target hazard quotient (THQ),

Target Hazard Quotient

Target Hazard Quotient (THQ) is the ratio between exposure and reference oral dose (RfDing) and it is normally used to express the risk of non-carcinogenic effects. According to this ratio, exposed populations are prone to experience health risks if the value is equal to or greater than 1. Values less than 1 consequently indicate no health risk for those metals for the exposed population.

THQ was calculated based on the equation below:

$$THQ = \frac{Concentration of metals \times Daily exposure}{RfD \times Average Bodyweight} \quad (1)$$

Where: THQ is target hazard quotient

RfD is reference oral dose Di Leo et al. (2010); Nkpaa *et al.* (2016).

Results and Discussion

Heavy Metal Concentrations in the Sampled Solid Wastes

The table below shows the heavy metals concentrations from the respective solid wastes sample from dump sites within Enugu east L.G.A Enugu state. From the table toxicant implicated heavy metals were found at below detectable limit in all the sampled soils except for cadmium which were found in solid waste from dump site III. Heavy metals like Fe, Cu were relatively in abundance compared to the control experiment. Heavy metals such as Cd, Hg, and As were below detectable limit in the both the control and experimented solid waste samples from dump sites I,II and IV respectively; however, Pb was not recorded in the control experiment. Fe and Pb was significantly (P<0.05) high in the experimented soil refuse dump site samples when compared with the control experiment but considered insignificant (P>0.05) among the test experiment.

Table 1: Heavy Metals Concentrations Solid Wastes from the Respective Dump Sites

Heavy metalsIron(Mg/g)	Control4.11± 0.02	Dumpsite I28.76± 0.14	Dump site II24.52± 0.12	Dumpsite III35.62± 0.2	Dumpsite IV28.43± 0.04
Cadmium(Mg/g)	BDL	BDL	BDL	0.12± 0.2	BDL
Mercury(Mg/g)	BDL	BDL	BDL	BDL	BDL
Arsenic(Mg/g)	BDL	BDL	BDL	BDL	BDL
Lead(Mg/g)	1.09± 0.4	4.17± 0.17	12.24± 0.1	14.35± 0.25	13.09± 0.4
Copper(Mg/g)	21.21 ± 0.1	44.3± 0.2	32.33± 0.3	40.20± 0.5	43.4± 0.5

N=2

Target Quotient of Trace Metals from the Respective Dumpsites

Table 2 below shows the target hazard quotient of the respective heavy metals from the dump sites respectively. From the afore stated, the concentration of metals of Pb, Fe and Cu in almost all the dump sites were not high (Table 6) enough to portent danger and are within the permissible limit (FAO/ WHO)

Table 2: Target Hazard Quotient of Heavy Metals

Heavy metals (mg/g)	Control experiment	Dumpsite I	Dump site II	Dump site III	Dumpsite IV
Lead	3.4×10^{-3}	1.01	1.12×10^{-2}	2.8×10^{-2}	0.8×10^{-2}
Iron	5.3×10^{-3}	4.03×10^{-2}	3.0×10^{-2}	8.0×10^{-2}	3.0×10^{-2}
Arsenic	BDL	BDL	BDL	BDL	BDL
Copper	2.3×10^{-4}	3.9×10^{-3}	3.6×10^{-2}	8.6×10^{-2}	4.2×10^{-2}
Cadmium	BDL	BDL	BDL	BDL	BDL

Mercury	BDL	BDL	BDL	BDL	BDL

THQ= target hazard quotient.

Nigeria as a sovereign nation with vast human population accruing to their heightened anthropogenic activities lined within their endowed biosphere [10]; The United Nation Statistics Division (UNSD) (2013 excerpt) describes waste as materials that are not prime products (that is, products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose.

Health risk assessment of heavy metals from the respective dump sites were evaluated using the Total hazard quotient (THQ) of the heavy metals as demonstrated in (Tables 4). This parameter as described by Valero reveals the potential of a particular recalcitrant towards eliciting toxicological responses in an ecological niche. Clinically, the hazard quotient is estimated within range(s); across the bench of a quotient are high potential toxicological compounds. The high concentration of Pb uncovered in the target hazard quotient is alarming because Pb obstructs the activities of essential minerals like copper, iron, zinc and calcium (Haas) and some enzymes in the erythrocytes. Pb is very toxic to the human body and dietary levels of 6 ppm are connected with severe health implications and Pb concentrations as low as 1 ppm possesses detrimental effects (Nwaichi). The elevated concentration of lead may be ascribed to a higher state of pollution from the use of leaded gasoline within the water (GESAMP). According to UNEP, Pb has the capability of displacing calcium from animal, fish and bone and it perpetuates free heavy metal, chemical and radical toxicity by covalently binding to sulfhydry bonds thus deactivating cysteine bound enzymes (Nwaichi). Furthermore numerous clinical experiments revealed that cadmium high levels of cadmium in the body can damage the kidney, testes and liver etc.

Lately numerous investigations (Shen and Chapman, Dhananjayan and Muralidharan) has demonstrated that nearly all human cancers like lung and prostate cancer can be ascribed to dietary sources. According to FAO/WHO (1999), the recommended daily intake for an adult is 48.0, 60.0, 3.0, 2.0–9.0, and 0.214 mg/day wet weight for Fe, Zn, Cu, Mn and Pb respectively While, the permissible daily intake of Cd is 0.1 μg/g wet weights. From the afore stated, the concentration of metals of Pb, Fe and Cu in almost all the dump sites were not high (Table 4) enough to portent danger and are within the permissible limit (FAO/WHO, 1999) indicating that some of the analyzed plantain samples are safe for human consumption.

Conclusion

Solid wastes from the respective waste sites showed its impact on the surrounding soil as were estimated compared to the control experiment. Heavy metals "can bind to vital cellular components, such as structural proteins, enzymes, and nucleic acids, and interfere with their functioning. The assessment have proven the toxicological evidence of unguided waste deposits within the environment in regards to health and risk plausible of inhabitants of concerned localities; moreso the present study has shown the level of pollution of the community agricultural soil and a guide to environmentalist in curbing indiscriminate refuse dumping around dense metropolis. This eco-toxicological result can serve as a clinical evidence to regulatory agencies within a country for proper guide and maintaining stringent policies towards waste generations, disposal and further treatments.

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Ethical Approval

Authors declared no ethical issues that may arise after the publication of this manuscript.

Author's Contributions

Nwanjoku HC: Conceived and designed the experiments, performed the experiment and processed the data, analyzed the data and wrote the manuscript.

Ebede SO: Co-supervised the research and revised the manuscript.

Nwanjoku KO: Carried out the experiment and provided the logistics

Nwokoye KU: Provided the experimental logistics and revised the manuscript

Oparaji EH: Designed the experiment, read the manuscript and processed the data.

Conflict of Interest

The authors and the correspondence declare no conflict of interest as regards to the manuscript

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