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Research Article

Ecological Assessment of Soil Samples Around Refuse Dump Sites Within the Metropolis of Enugu State, Nigeria

Nwanjoku Chioma Helen[1, 2], Ameh Godwin Ikechukwu[1], Edeoga Cyril Onyeka[1], Emeka Henry Oparaji[3, *]

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

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

[3]Department of Biochemistry, University of Nigeria, Nsukka, Nigeria

Abstract

This study looked at assessing the impact of solid wastes within Enugu metropolis on heavy metal concentrations and otherphysicochemical properties of soil samples from the site locations. Physicochemical analysis of the soil from the respectiverefusedump sites showed pH of 4.24, 6.3 and 5.87 respectively in the presence of the control experiment which maintained atpH of 7.6 throughout the experiment. Soil conductivity of the respective refuses ites within Enugu municipal showed a progressive increase of soil conductivity. Mineral contents were found in the following order: Cl>Ca>Mg>K>PO_3. Heavy metals of Hg, As and Cd were found at below detectable limit range (BDL) in both the sampled soils from the respective refuse dumpsite andcontrol experiment. Cu, and Pb were significantly high in all the sampled soil from the dumpsites however, Cd was only detected in the soil sample from refuse dump III. Fe showed a progressive decrease across the dumpsites oil samples.

Keywords

Physicochemical, Heavy Metals, Dump Site, Minerals

1. Introduction

Solid wastes persistent in their ecological niche significantly have varying degree of impact within the ecological cosm [1]. 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 [50]. 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 [7].

As reported by Oparaji *et al*. [32], 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 bio-

*Corresponding author: emeka.oparaji65@yahoo.com (Emeka Henry Oparaji)

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avaiability 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 [33]. 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, 8, 41, 45].

Heavy metals are connected with severe health abnormalities such as nephrotoxicity, neurotoxicity and malignancies of various types [17, 19]. Lead (Pb) interferes with haem biosynthesis [49, 11, 14, 18]. It inhibits the activity of 2-amino laevulinic acid dehydratase which leads to accumulation of protoporphyrin in the red blood cell [52, 2].

The average volume of waste generated daily by human activities and in some serendipity state depends on the availability of the composite quantity, the cultural level and type, and the economic conditions. 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 [52, 34, 35]. The present study investigate the presence of heavy metals and variations in the properties of soil samples around certain selected refuse dump sites within Enugu metropolis of Enugu state.

2. Material and Methods

2.1. Materials

All the reagents, equipment used in the present study were of analytical grade and products of BDh, May and Baker, Sigma Alrich. The equipments are calibrated at each use.

2.2. Methods

2.2.1. Collection of the Experimental Samples

Arable soils were collected directly from three refuse dump sites within the metropolis of Enugu state (Long.14^0N, SE 4) Nigeria as described by Ezenwelu *et al*. [17]. These sites were popularly for heavy anthropogenic activities of refuse collections and disposals. The soil was collected in clean sterile sample containers and was taken to the lab for further experiments.

2.2.2. Determination of Physicochemical Properties of the Soil

Physicochemical properties of the respective soils were determined as described in the Journal of ATSDR, (2009). The following physicochemical properties were determined:

1) Soil pH profiling test
2) Soil conductivity test
3) Determination of macro and micro contents of the soil: Potassium ion (K), Chloride ion
4) Concentration of chloride ion in both mixtures were deduced from the formula:

$$\text{Chloride: } 100\ \text{mEq/L} = \frac{V_A - VB \text{ X } M \text{ X } 70{,}900}{\text{Vol.ml.}}$$

Where V_A= Volume of the standard solution; V_B= Volume of the blank solution, M= molarity of the standard solution.

2.2.3. Calcium Hardness

$$CaCO_3 \text{ content (mg/Kg)} = \frac{\text{VxE } (CaCO_3) \text{ x } 100}{50}$$

$$\text{Calcium metal (mg/kg)} = \frac{\text{Tx } 400.5 \text{ x } 1.05}{50}$$

T= titre value.
V= titre volume
E= equimolar concentration

2.2.4. Magnesium Hardness

$$\text{Magnesium (as mg/l)} = (T–C) \text{ x } 0.243$$

Where; T= total hardness mg/l (as $CaCO_3$)
C= Calcium hardness mg/l (as $CaCO_3$)

2.2.5. Total Organic Carbon Contents

$$\text{TOC (mg)} = V_b - V_s \text{ X } 16{,}000/ \text{ vol. of sample used}$$

Total organic matter content (TOM) = 1.23 X TOC
V_s= total volume of standard
V_b= total volume of blank

2.2.6. Determination of Heavy Metal Concentrations in the Soil Samples

Heavy metals in the soil samples were determined as described by Oparaji *et al*. [32]; Rantama [39] (2018). Prior to the analysis, the respective soil were digested in an acid treatment of aqua regia, aqua fortis and hydrofluoric acid partitioned concentrations (HNO_3, HCl and HF in the ratio 3:2:1) and heated on a hot plate. The digested sample were dissolved and filtered. The filtrates were subjected to heavy metal determinations using the atomic absorption spectrophotometer machine. Equivalent values of the determined metal were read off from the standard curve.

3. Results and Discussion

Tables 1, 2, 3 below respectively show the physicochemical properties of soil sample from the respective dump sites within Enugu metropolis. From the table the samples, there are significant variations in the physicochemical features of the soil samples within the grouped dump sites and the control experiment. Soil phosphorus was considered insignificant in

refuse dump site I at P.> 0.05. Dissolved mineral contents of Ca, K, Mg, P and Cl were considered insignificant (P>0.05) in the experimented soil samples from refuse dump site I, II and III. Physical parameters were considered significant in the experimented soil samples.

Table 1. *Physicochemical properties of soil samples from refuse dump site I.*

Physiochemical parameters	Control experiment	Soil sample
pH	7.6 ±0.01	6.62 ±0.03
Soil Conductance	610 ±0.04	1134 ±0.12
Chloride ion (Mg/g)	433 ±0.03	1143.18 ±0.21
Phosphorus (Mg/g)	1.78 ±0.05	1.43 ±0.3
Magnesium (Mg/g)	6.27 ±0.011	16.04 ±0.05
Potassium (Mg/g)	7.22 ±0.021	16.28 ±0.03
Total hydrocarbon (THC) (Mg/g)	672.34 ±0.04	1309.06 ±0.4
Total Organic Carbon (TOC) (Mg/g)	78.45 ±0.06	127.12 ±0.22
Total Organic Matter (TOM) (mg/g)	96.45 ±0.06	156.36 ±0.01

N=2mean ±SD

Table 2. *Physicochemical properties of soil samples from refuse dump site II.*

Physiochemical parameters	Control experiment	Soil sample
pH	7.6 ±0.01	6.16 ±0.22
Soil Conductance	610 ±0.04	1219 ±0.32
Chloride ion (Mg/g)	433 ±0.03	1265.09 ±0.42
Phosphorus (Mg/g)	1.78 ±0.05	0.94 ±0.4
Magnesium (Mg/g)	6.27 ±0.011	13.28 ±0.01
Potassium (Mg/g)	7.22 ±0.021	18.63 ±0.14
Calcium (Mg/g)	16.34 ±0.04	41.06 ±0.04
Total hydrocarbon (THC) (Mg/g)	672.34 ±0.04	1342.21 ±0.3
Total Organic Carbon (TOC) (Mg/g)	78.45 ±0.06	131.43 ±0.45
Total Organic Matter (TOM) (mg/g)	96.45 ±0.06	161.65 ±0.11

N=2mean ±SD

Table 3. *Physicochemical properties of soil samples from refuse dumpsite III.*

Physiochemical parameters	Control experiment	Soil sample
pH	7.6 ±0.01	5.87 ±0.34
Soil Conductance	610 ±0.04	965 ±0.02
Chloride ion (Mg/g)	433 ±0.03	1056.45 ±0.25
Phosphorus (Mg/g)	1.78 ±0.05	4.04 ±0.04

Physiochemical parameters	Control experiment	Soil sample
Magnesium (Mg/g)	6.27±0.011	10.13±0.44
Potassium (Mg/g)	7.22±0.021	08.21±0.11
Calcium (Mg/g)	16.34±0.04	42.11±0.52
Total hydrocarbon (THC) (Mg/g)	672.34±0.04	1102.34±0.33
Total Organic Carbon (TOC) (Mg/g)	78.45±0.06	112.41±0.35
Total Organic Matter (TOM) (mg/g)	96.45±0.06	138.26±0.42

N=2mean±SD

Physicochemical analysis of the soil from the respective refuse dumpsites showed pH of 4.24, 6.3 and 5.87 respectively in the presence of the control experiment which maintained a pH of 7.6 throughout the experiment. This can be attributed to the nature of the contaminant in the soil such as oil and other acidic compounds (oleic, benzoic acids) as stated in the proceedings of the ASTDR [3]. Soil conductivity of the respective refuse sites within Enugu municipal showed a progressive increase of soil conductivity.

Dissolved mineral contents were found in the following order: Cl>Ca>Mg>K>PO_3. Solid wastes as stated by Vallero [50] contain numerous minerals which impound in any receiving body and increase the physicochemical properties of the body. However, Oparaji *et al*. [32] reported as a significant concentration of Ca and Mg in their analysis on inorganic ions dynamisms in soil samples from Fordoes terminal, Portharcourt, Rivers state. In their suggestions they went further to state that this significant increase can be attributed to the quarry and other anthropogenic activities going on the given location.

Table 4. *Heavy Metals Concentrations Solid Wastes from the Respective Dump Sites.*

Heavymetals	Control	Dumpsite I	Dumpsite II	Dumpsite III
Iron (Mg/g)	4.11±0.02	28.76±0.14	24.52±0.12	35.62±0.2
Cadmium (Mg/g)	BDL	BDL	BDL	0.12±0.2
Mercury (Mg/g)	BDL	BDL	BDL	BDL
Arsenic (Mg/g)	BDL	BDL	BDL	BDL
Lead (Mg/g)	1.09±0.4	4.17±0.17	12.24±0.1	14.35±0.25
Copper (Mg/g)	21.21±0.1	44.3±0.2	32.33±0.3	40.20±0.5

N=2

Analysis of Heavy Metal Concentrations

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.

Heavy metals of Hg, As and Cd were found at below detectable limit range (BDL) in both the sampled soils from the respective refuse dumpsite and control experiment. Concentration of Cu and Pb increases across the refuse dumpsite except for Fe which showed an upward decrease. Cd among the relative toxic trace metals was seen only in dump site III but was below detectable limit in dump site I and II, respectively. Valero [50] in the biosystem approach of heavy metal pollutions and toxicities stated that presence of these transition metals within any biological niches can be resultant

manifestation of biochemodynamism of jetty activity, beneath soil pollutions from volcanisation effects and other physical interactions of the soils and other ecosystems.

The progressive decrease in the concentration of Fe can be attributed by the availability of masking elements such as oxygen, sulphur and other ligands which competitively bind to iron and diminishes their bioavailability. The result was in correlation with findings of Khalid *et al.* [20] in their study on soil pollution and lead bioaccumulations revealed higher quotients of heavy metals like Fe, Pb and Cu in the soil while heavy metals of Hg, As, Cd were found below detectable limits in the soil.

4. Conclusion

The present research through experimental approach(es) has shown with empirical the presence of certain recalcitrants in soil samples around three refuse dumpsites within Enugu municipal, Enugu state, Nigeria. Solid wastes from the respective waste sites showed impact on the surrounding soil as were estimated compared to the control experiment. The afore with data will provide the health and risk assessment 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.

Abbreviations

Pb	Lead
Zn	Zinc
Cu	Copper
BDL	Below Detectable Limit
mg/g	Milligram Per Gram

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Ethics

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

Author's Contributions

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

Edeoga Cyril Onyeka: Co-supervised the research and revised the manuscript.

Emeka Henry Oparaji: processed the data and revised the manuscript.

Ameh Godwin Ikechukwu: Designed the experiment, read the manuscript and processed the data.

Conflicts of Interest

The authors declare no conflicts of interest.

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