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Impact of Refuse Dumps on Heavy Metal Concentration of Soils

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Abstract: *The non-availability of landfills in urban and sub-urban centres has resulted in many dumpsites in farmlands. Cultivation of crops in and around such refuse dumpsites is a common practice in Nigeria despite the attended health hazards and environmental pollution. In response to this unhealthy practice, comparative analysis of heavy metals such as Cd, Co, Cu, Ni and Pb was undertaken at some selected dumpsites in Nsukka, Nigeria, to determine the level of contamination. Analysis of the results showed that the various metals have their concentrations increased above the control by 0.5 to 5.5 mg/kg for Cd, 8.0 to 74.2 mg/kg for Pb, 5.5 to 15.6 mg/kg for Co, 1.9 to 23.5 mg/kg for Ni and 3.9 to 32.5 mg/kg for Cu. The results also showed that Odenigbo dumpsite has Pb and Cd above WHO maximum allowable. In addition, pH level varied from 4.68 to 4.82 with the control value of 4.48. Crops cultivated in such contaminated soils pose health problems to their consumers. The panacea to this problem amongst other things is provision of landfills, which will encourage proper refuse disposal and treatment.*

Keywords: *Dumpsites, Heavy metals, Pollution, Soil, Crops,*

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I. Introduction

Pollution is the contamination of earth's environment with materials that interfere with human health, quality of life, or the natural functioning of ecosystems. Environmental pollutions are categorized into biodegradable and non-biodegradable pollutants. Solid wastes such as metals, plastics and other synthetic materials are regarded as non-biodegradable pollutants, which are materials that either do not decompose or decompose slowly in the natural environment, thereby contaminating the environment. Studies have shown that unlike organic pollutants which may degrade to less harmful fragments as a result of biological or chemical processes, metals are not degradable by natural processes due to their intrinsic nature [1]. The effects of metal pollution on the environments (air, soil and water), and organisms may therefore be far-reaching and long lasting in spite of different efforts towards remediation. Heavy metals with the attended undesirable health effects in human metabolism, raises serious concerns in many parts of the World due to their persistence in the environment as well as their known potential for serious health consequences [2],[3]. The toxic metals could reach human beings through various means including oral intake, consumption of food grown in heavy metal--contaminated soils, food chain, and inhalation [4],[5]. Soil is a vital source of heavy metals in crops and vegetables since their roots can absorb these pollutants from soil and transfer them to the seeds [6]. The penetration of heavy metals into the soil influences soil ecological conditions such as soil type, soil pH, concentration and bond of heavy metals, humus content in soil, microbial decomposition of inorganic and organic substances, soil moisture, temperature and utilized fertilizers [7]. Plants grown on a land polluted with municipal domestic or Industrial waste can absorb heavy metals in the form of mobile ions present in the soil solution through their roots or through foliar absorption. These absorbed metals get bioaccumulated in the roots, stems, fruits, grain and leaves of plants [8-9] . The crops/vegetables grown on such contaminated soil potentially impose high risks to human health [10-13]. Like pesticides, heavy metals become more concentrated as animals that fed on plants are consumed in turn by other animals. At certain level of concentration, they become poisonous and can lead to health problems similar to those caused by pesticides and herbicides. The harmful effect of soil pollution ranges from toxicity to the ecosystems to diseases such as cancer and gene mutation [2,12]. Vegetable fields have a high risk of heavy metal contamination from pollution sources in suburban and industrial areas of cities [14]. Metal contamination of urban soils and home-grown products has actually generated a lot of concern in recent time [15] and these concerns can constitute a barrier to urban agriculture [4]. There are extensive literatures on deposition of heavy metals on the environment, their toxicity, bioaccumulation tendency and threat to human life [16-21] Although, living organisms require some of these metals, any excess amount of them can be detrimental to the organisms [22].

Sewell [23] and Omishakin [24] observed that dumpsites that contain biodegradable pollutants harbour disease causing microbes, bacteria and offer attractive food source to insects and rodents. Encarta [25] illustrated the vulnerable effects of non-biodegradable pollutant on the food chain, where mercury released into the Minamata Bay accumulated in the bodies of the residents who consumed the fish from the contaminated Bay developed nervous disorders, tumours and paralysis in a mysterious epidemic in 1950s and 1960s. Trace heavy metals, such as arsenic, cadmium, lead, chromium, nickel, and mercury, constitute vital environmental pollutants, especially in areas with high level of anthropogenic activity [26]. Report has shown that lead and cadmium released from various anthropogenic sources have the ability to accumulate in tissues of living organisms [27]. Exposure to heavy metals such as arsenic (As), lead (Pb), and cadmium (Cd) in either the short or the long term can cause cancers in humans [28]. Lead is a contaminant of toxicological concern to humans, and many urban agricultural sites contain high level of it. [29] Lead has been implicated as the most common contaminant in urban areas [4]. Lead derived from lead pipes and solder materials deposit at dumpsites when leached to ground water causes mental retardation in children exposed to such lead contaminated water. The bioaccumulation of lead in human body interferes with the functioning of mitochondria, thereby impairing respirations and causes constipations, swelling of brain, paralysis and eventual death [30]. Cadmium in fertilizer derived from sewage sludge can be absorbed by crops when consumed by human leading to increase concentration of cadmium, which causes diarrhoea and overtime, liver and kidney damage.

Many agricultural lands in Nigeria as well as in some other African countries have been polluted by the indiscriminate dumping of refuse, thereby leading to the release of heavy metals that end up in the soil as they sink when they are leached out from the dumpsites. The impact of heavy metals on the environment and the contamination of soil resources by the potentially toxic metals from the dumpsites is a major challenge to the international community, international agencies, national governments, national agencies and the public. The environmental assessment and identification of sources of heavy metals in the environment are important steps for the effective prevention of subsequent contamination and for the development of corrective measures [31]. In order to highlight the implications of the use of dumpsites as vegetable and other annuals farming areas, this work investigates the presence of heavy metals in three dumpsites in Nsukka town.

II. Materials and Methods

1. Study Area

Three sample collection locations were studied. These were dumpsites at Onuiyi, Odenigbo and junior staff quarters in the University of Nigeria, all in Nsukka. Nsukka is a semi-urban town in Nsukka Local Government Area of Enugu State, South Eastern Nigeria where the University of Nigeria is located. The Semi-urban status makes the town a busy place with waste dumpsites at different locations. The main occupation of the indigenes/rural dwellers is farming and dumpsites are attractive centres especially for vegetables and other annuals due to the high soil fertility of such sites, despite being contaminated by heavy metals.

2. Samples Collection

Samples were collected during the wet season. Each sampling was done at every 0 – 15cm interval with a minimum of 5 cores collected at a spot, and five spots per dumpsite. The core samples were bulked and the composites transferred into treated polyethylene bags. The soil depth was 0 – 15cm.

3. Sample Preparation

Large particles were removed and the soil was spread under sunlight to dry. It was then crushed in a mortar and passed through a 2 mm stainless sieve (No 10 sieve).

4. Digestion for Determination of Heavy Metals in the Soil Samples:

1 g of sieved air-dried soil sample was weighed in a 125 cm^3 hard-glass digestion tube. A few drops of pure HNO_3 were added slowly. After effervescence, 5 cm^3 of HNO_3 and 15 cm^3 of $HClO_4$ were carefully added and the mixture kept overnight. The samples were then heated until they became white, cooled for 15 minutes, filtered into a 100 cm^3 volumetric flasks and diluted to volume with de-ionized water.

5. Analysis of Samples

The concentrations of heavy metals were determined using Atomic Absorption Spectrophotometer (AAS), Pelkin Elmer Model 403 with deuterium background correction. To ensure quality assurance, blank and replicate analyses were done.

Note: For the determination of low concentrations of easily volatile elements, a micro-sampling cup was used to improve their detection limit.

6. Soil pH Determination

The soil pH was determined by pH meter. 10 g of sieved air-dried samples was weighed into a beaker. 25 ml of de-ionized water was poured into the beaker, the mixture was stirred intermittently for 30 minutes with a glass rod, and the pH determined after calibration of the meter with a buffer of pH 7.0.

III. Results and Discussion

The results of the analysis of total heavy metals concentrations in the three refuse dumpsites in Nsukka and undisturbed sites including the pH values are presented in Table 1.

Table 1: Heavy metal concentrations (mg/kg) and pH values from three dumpsites

Dumpsites	Cadmium (mg/kg)	Lead (mg/kg)	Cobalt (mg/kg)	Nickel (mg/kg)	Copper (mg/kg)	pH
Onuiyi	6.6	15.2	15.9	5.0	4.2	4.68
Odenigbo	5.2	75.3	24.6	24.8	32.8	5.46
Junior Staff Quarters	1.8	9.1	14.5	3.2	4.8	4.82
Control	1.3	1.1	9.0	1.3	0.3	4.48
Normal Cont. Interval	0.1 – 1.0	0.1 – 20	1 - 10	2 – 5	-	-
WHO Max. allowable	3.0	100	50	50	-	-

Cadmium (Cd)

The concentration of cadmium was the least in all the soil samples. However, the concentrations of the cadmium detected in the dumpsites sample were quite higher than the control, above the normal range and higher than the WHO specified maximum, in Onuiyi and Odenigbo dumpsites. The high amounts of cadmium might be as a result of cadmium in manure, pesticides, artificial phosphate fertilizers and dusts, which have been released in the dumpsites through human activities. The concentrations of cadmium detected in Onuiyi and Odenigbo dumpsites were higher than the recommended maximum limit for soils (3 mg/kg) [32]. The implication of this is that there is a high probability that any crop or vegetable grown in such environment will be highly contaminated with cadmium. Consumption of such crops or vegetables and annuals with high content of cadmium will increase the concentration of cadmium in the human body resulting in such individuals suffering cadmium related diseases and sicknesses such as diarrhoea, kidney failure and liver diseases. The pH value showed that the soil is highly acidic, and thus will enhance the cadmium uptake by plants. When cadmium concentrations in soils are high they can influence soil processes of microorganisms and poses treat to the whole ecosystem.

Lead (Pb)

The concentrations of lead (Pb) were very high in Odenigbo and Onuiyi dumpsites compare to the control. The high concentrations of lead might have been due to accumulation of lead released through lead compounds in the refuse dumps and air pollution from automobile exhaust fumes. The amounts of lead detected in the dumpsites were lower than the recommended maximum limit by Ewers [32] and WHO, which is 100 mg/kg. Lead is particularly dangerous chemical, as it can accumulate in individual organisms, and also in entire food chains. When accumulated, lead can cause several unwanted effects, such as disruption of biosynthesis haemoglobin, and anaemia, a rise in blood pressure, kidney damage, miscarriages and subtle abortions, disruption of nervous systems, brain damage, declined tertiary mechanism through sperm damage, diminished learning abilities of children, such as aggression impulsive behaviour and hyperactivity.

Cobalt (Co)

The concentrations of Cobalt in the three dumpsites were lower than the recommended limit (50 mg/kg) [32]. The level of cobalt obtained could be due to pesticides, fertilizers and other lead-containing substances deposited at the dumpsites. Also, soils contaminated by ore smelting facilities and industrial pollution may contain high concentrations of Cobalt [33]. Cobalt has both beneficial and harmful effects on health. It is part of vitamin B12, which is essential for the maintenance of human health. Cobalt (0.16 – 1.0mg/kg of body weight) has also been used as a treatment for anaemia, including in pregnant women, because it causes red blood cells to be produced. Cobalt is also essential for the health of various animals, such as cattle and sheep. Exposure of humans and animals to levels cobalt normally found in the environment is not harmful. However, when too much is taken into the body, harmful health effect can occur.

Nickel (Ni)

The concentrations of nickel in the dumpsites were lower than the recommended limit for soil, that is, 50 mg/kg [32]. The presence of nickel-containing substances such as pesticides, fertilizers, stack of large furnaces used to make alloys, power plants or trash incinerator [34] in the dumpsites might be responsible for the level of nickel obtained in this study. A lot of Nickel released into the environment ends up in soil or sediments where it is strongly attached particles containing iron or manganese. Under acidic conditions, Nickel is more mobile in soil, than might seep into ground water. ATSDR, noted that some plants could take up and accumulate Nickel [33]. The most serious harmful effects from exposure to nickel, such as chronic bronchitis, reduced lung function, and cancer of the lung and nasal sinus have occurred in people who have breathed dust containing certain Nickel compounds while working in Nickel refineries or processing plants.

Copper (Cu)

The concentrations of copper obtained in the study were lower than the recommended limit [32]. The highest was obtained in the Odenigbois dumpsite while Juinor staff quarters had the least concentration. Some of human activities that could contribute to copper release in an environment and include wood production and phosphate fertilizer production. Copper does not break down in the environment, which makes it easy to accumulate in plants and animals when it is found in soils. Copper can interrupt the activities in soils as it negatively influences the activities of microorganisms and earthworm.

The results of the concentrations of the various metals at the three different dumpsites indicate that Odenigbo dumpsite has the highest concentrations, followed by Onuiyi dumpsite and then junior staff quarter dumpsites. This is because the Odenigbo dumpsite is situated by the roadside, and the area is highly populated and the waste has been long there and is frequently subjected to open incineration. The junior staff quarter dumpsite contains low concentrations of the heavy metals because the waste is mainly household waste.

pH

The pH is the measure of the degree of alkalinity and acidity of a substance. Soil acidity is the measure of the hydrogen ion concentration in the soil and influences all soil reactions and biological activity (e.g. oxidation, reduction, photodecomposition reaction, etc.)

The pH values of the dumpsites show that the sites are moderately acidic. Odenigbo dumpsite has the highest pH. At low pH most toxic metals become more soluble and available for plants [35]. Decaying organic matter produces H^+, and this may have contributed to the increase in acidity at the dumpsites. Soil pH affects the soil's physical, chemical, and biological properties and processes, as well as plant growth. The nutrition, growth, and yields of most crops decrease where pH is low and increase as pH rises to an optimum level. In general the best pH value range for soil is approximately 6 or 7 as this is the range in which most nutrients can be readily available.

IV. Conclusion

Dumpsites contain several heavy metals and the levels of Co, Cd, Ni, Pb, and Cu in Nsukka dumping site soil have been determined in this study by AAS. The analytical results show that there is increase in the concentrations of heavy metals in the soil where the dumpsites are located compared with the control. In addition, some of the concentrations of the heavy metals were higher than the W.H.O. normal content interval. The type of waste determines the level of concentration as the result of Odenigbo dumpsite indicated. Moreover, dumpsites with mainly household waste contaminate the soil less as seen in Junior staff quarters. It is noteworthy that although living organisms require some of the metals, any excess amount of these metals can be detrimental to the organisms. This work serves as a base-line study.

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