Vol. 32 · July 2020
Print ISSN 2244-1573 · Online ISSN 2244-1581
International Peer Reviewed Journal
Journal Metrics: H Index = 2 from Publish or Perish
This journal is included in Thomson Reuters Journal Masterlist
Published by IAMURE Multidisciplinary Research,
an ISO 9001:2008 certified by the AJA Registrars Inc.

Assessment of Heavy Metal Concentration in the Soil of Ugwuaji Solid Waste Dump Environs, Enugu Nigeria

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Gunning Fog Index: 11.96 Originality: 99% Grammar Check: 99%
Flesch Reading Ease: 47.19 Plagiarism: 1%

ABSTRACT

Solid waste is a major environmental threat globally, and Nigeria is not an exception. The problem of improper disposal of solid waste is further compounded by population growth and economic development, which leads to the generation of an enormous amount of solid waste. The resultant effects are environmental pollution with various pollutants such as toxic heavy metals. This research determined the heavy metal concentration in the soil of Ugwuaji solid waste dump environs in Enugu, Nigeria. The oil samples were collected and transported to the laboratory for analysis. The soil samples were analyzed for heavy metal using Atomic absorption spectrophotometer (AAS). The study concludes that poor waste management and accumulation of tons of solid waste in the dumpsite negatively affects the soil quality in the area. Further, the open solid waste dumping exposed the soil to serious contamination with heavy metals (Cd, Pb, Cu, Zn, and Fe). This implies to serious human and animal health due to possible bioaccumulation and bio magnifications through plant uptake from the soil. It was recommended that proper waste management involving the use of 3R (reduce, reuse and recycle) and sanitary landfills and environmental principles and laws should be implemented to ensure the sustainability of the environment in the area.

KEYWORDS

Heavy metals, soil, solid waste, open dumping, pollution, environment, Nigeria

INTRODUCTION

The improper disposal of solid waste has continued to pose a serious challenge to environmental sustainability and public health, especially in developing countries. This is as a result of anthropogenic inputs and various development projects often seen in some developing countries. An increase in population and growth in economic activities always leads to the generation of tones of solid waste (Karishnamurti & Naidu, 2003). Most municipal solid waste seen in urban areas comes from the inhabitant in that area, small and medium scale businesses, and other economic activities (Singh et al., 2011). Municipal solid waste (MSW) is regarded as "garbage," "trash," or unwanted materials discarded away. Generally, Solid waste is a term used to describe waste whose liquid content is low or waste that is not biodegradable. They often come from sources like; household materials, economic activities, heavy industrial sites, hospitals, and clinical waste, etc. (Sarinas et al., 2014). They are waste gathered by the municipal waste management authority for sorting according to the waste management hierarchy (Tanee & Eshalomi-mario, 2015; Ezeoha, 2013; Anikwe & Nwobodo, 2002).

Open dumping of solid waste is common in developing countries, possibly because of poor budgetary allocations for waste disposal, poor attitude of people to proper refuse disposal, and no skilled manpower. For decades now, heavy metals have considerably damaged the soil quality and fertility due to increased environmental pollution from industrial, agricultural, and municipal sources. The solid wastes are also capable of leaching organic or chemical substances or compounds to contaminate the soil where such wastes lay in accumulation. Depending on the tendency of the contaminants, they end up either in water held in the soil or leached to the underground water. Contaminants like heavy metals such as Cd, Cu, Ni, Pb, and Zn can alter the soil chemistry and have an impact on the organisms and plants depending on the soil for nutrition (Shaylor et al., 2009). These heavy metals also cause physiological disorders in soils. Absorption of these metals through the root system retards plant growth and deprives it of vigor (Moustakas et al., 1994).

The indiscriminate disposal of solid waste is reported to cause harmful effects on human health and the environment (Sarinas et al., 2013). It contaminates drinking water, soil, air, and results in offensive odor and spread of disease like malaria, diarrhea, typhoid fever, etc. Furthermore, solid wastes indiscriminately and openly disposed of can cause pollution when carried by rainwater run-offs

or by the flood to the streams. These contaminating residues will find their ways into layer water bodies. Hence, there is a need for proper solid waste disposal practices to prevent or reduce the chances of any of these environmental problems resulting from poor waste disposal practice

The effect of heavy metals on soil biological properties needs to be studied in detail to fully understand the effect of these metals on the soil ecosystem (Sarinas et al., 2014). Much literature has been written on dumping waste openly and its negative effect on soil quality, aesthetic value, health implications, and biodiversity loss. Tanee & Albert (2013) reported that the plant and soil have a high concentration of heavy metal on heavy metal contamination of roadside soil and plants along three major roads. The established that the plant in the study area has higher heavy metal concentration than the soil. Also, the concentration of heavy metals decreases with increasing distance from the road. Ezeoha & Ezenwanne (2013); Nda-Umar et al. (2012) revealed that the sampled soil is heavily contaminated with lead, Cadmium, Copper, Iron, Nickel, and Manganese.

Tanee & Eshalomi-mario (2015) reported on heavy metal content in plants and soil in the abandoned solid waste dumpsite. The result showed that there was an increase in the concentration of heavy metals in the two dumpsite soils than that in the soil at the control sites.

Syeda & Hawkins (2014) on open dumping of municipal solid waste and its hazardous impacts on soil and vegetation diversity at waste dumping site in Islamabad city reported high pH, total dissolved solids and electric conductivity in comparison with the control site, also there was high presence of heavy metals at disposal site

Anikwe & Nwobodo (2002) opined that that heavy metal (Pb, Cu, Fe, and Zn) increased by 214% and 2040% in dumpsite soil relative to the non-dump site. Karim (2015) also noted that the total heavy metal content in MSW is higher in one location than the other location, and the metals are predominantly associated with fine soil fraction. The total heavy metals in the MSW in the study area are less than the total metal content in MSW at the dumping sites reported from Japan, India, and Thailand.

Kanmani (2013) maintained that the presences of heavy metals in the soil samples are an indication that the soil in this study area was contaminated as a result of leachate movement in the soil of the study area. He opined that the concentration of heavy metals in the soil samples ranged in the order Mn >Pb>Cu>Cd.

Several studies have shown that soil and plant sampled in their study areas have a high concentration of heavy metals (Fosu-Mensah et al., 2017; Ogundele et al., 2015; Oladunni et al., 2013; Ekwue et al., 2012). The results further showed that the total mean concentration of heavy metals decreased with depth in soil samples and distance from the dumpsite. Also, it was observed that the concentration of most of the heavy metals under investigation exceeded maximum permissible limits.

The sustainable management of Solid waste is a universal problem in Enugu metropolitan areas. The area's population is projected to be between 1,000,000 to 3,267,837, generating waste of more than 25,000 tonnes of refuse daily, 75,000 tonnes weekly, and 900,000 tonnes yearly (Okafor, 2008). According to studies, it has been noted that the major problems in Enugu were the accumulation of tons of solid waste (Madu, 2004). The solid waste generated in Enugu urban is regularly throw off in dumpsite, gutters, and behind houses by residents that generate them. Enugu State government, through her agency Enugu state waste management authority (ESWAMA), has employed several methods to manage their waste. Still, all to no avail as waste is seen littered along streets and gutters of Enugu town.

It is a common practice by residents all over Enugu city to indiscriminate. It improperly disposes of domestic waste in the streets, markets, gutters, streams, and any available plot of land, leading to poor soil quality. Delay in the evacuation of waste contributes to its accumulation and decay in any dumpsite. Improper waste management is harmful to the environment and health. It contaminates underground and surfaces water, polluting the air and land by producing offensive odors and smells as well as poisonous chemicals (leachate).

OBJECTIVES OF THE STUDY

This research examines the effects of the accumulation of solid waste on the soil in Ugwuaji dumpsite environs in Enugu State, Nigeria. The study further checked whether the soil in Ugwuaji dumpsite is heavily contaminated with metals with respect to distance, i.e., one moves away from the dumpsite.

METHODOLOGY

Ugwuaji is located in Enugu South local government area of Enugu State, Nigeria. It lies between Latitude 6°26′ and 6°27′N and Longitude 7°32′ and7°33′E

with an area extent of about 10sqkm. The area is accessible by roads, railway, footpaths, and a major route (Enugu-Port Harcourt express way). Ugwuaji is a central dumpsite where all kinds of wastes (domestic, construction/demolition, industrial, and agricultural) generated in Enugu metropolis are openly dumped.

A study was carried out on the soil on which the waste accumulate and also on a free soil with no solid waste accumulation. The solid waste that accumulates on a particular spot might likely pollute the soil. The collection of soil samples was taken at the end of the week when the waste is heavily accumulated on that specific spot. Soil samples were collected with hand auger at different distances, such as 5m away from each other to compare the level of heavy metals concentration as one move away from the disposal site. The distance includes 5m before, 5m away, 10m away, and 15m away from the dumpsite.

Plastic containers for the soil collection was properly washed with water to avoid contamination of the soil samples with foreign or unfamiliar objects. In every spot, three samples were collected on different days to check the differences in each collection day. Immediately after collection, the soil sample was taken to the laboratory for digestion. Digestion was done using aqua regia digestion method to digest the soil. The heavy metal analysis was conducted using Varian AA240 Atomic Absorption Spectrophotometer according to the method of American Public Health Association APHA, 1995.

RESULTS AND DISCUSSION

Table 1: Percentage concentration of oxides of elements detected in soil from various study locations (mg/kg).

Study location	Cd	Pb	Cu	Zn	Fe
5m (BDS)	1.59	45.78	71.87	247.55	794.62
5m (ADS)	1.93	46.86	176.9	253.39	812.12
10m (ADS)	1.56	49.34	31.07	251.27	810.33
5m (BDS)	0.12	21.79	16.82	199.2	808.19
5m (ADS)	0.00	0.00	2.63	72.08	756.83
10m (ADS)	0.00	0.99	20.43	163.6	811.01
15m (ADS)	0.18	0.00	12.69	90.07	781.72
5m (BDS)	2.54	733.1	369.69	251.52	820.82
5m (ADS)	1.65	346.04	386.32	252.55	790.58

Control	0.00	0.00	7.54	161.92	812.58
Control	0.00	22.47	65.65	253.35	820.03
5m (BDS)	0.33	14.49	16.36	199.36	818.45
5m (ADS)	0.00	6.24	3.97	165.02	818.83
10m (ADS)	0.13	7.99	12.87	44.23	821.99
15m (ADS)	0.05	2.49	5.36	36.54	815.57

Note: (BDS) = Before the dumpsite
(ADS) = Away the dumpsite

Table 1 shows that the concentration of heavy metal occurs in the order Fe>Zn>Cu>Pb>Cd. Compared with the control downstream, the result showed a high concentration of heavy metals in the soil of Ugwuaji dumpsite environs. Enugu Nigeria. The result further revealed that the soil is heavily polluted with these heavy metals. This calls for urgent action to ensure proper solid waste disposal for environmental sustainability in the area.

The concentration of Zinc (Zn) recorded from different distances ranged from 36.54mg/kg in 5m away from the dumpsite on the third day of the experiment to 247.55mg/kg in 5m before the dumpsite on the first day of soil sample collection. The presence of Zn in the soil samples at various distances could be attributed to the occurrence of dry cells in the dumpsite, as reported by Thorpe & Harrison (2008) and the burning of e-waste materials. Zinc is an essential microelement that plays an essential catalytic role in enzyme reaction, but its content varies with the type of soil. However, Zinc›s high concentration can pose a health threat to humans (Saha, 2017).

The concentration of Copper ranges from 2.63mg/kg to 386. 32mg/kg at 5m away from the dumpsite on the second day of sampling. Copper was also detected at the control samples with 7.54mg/kg and 65.65mg/kg; these high concentrations of Copper could be attributed to the burning of electronic gadgets. The result is similar to the findings of Zhang, Wu, & Simonnot (2012), which recorded an extremely high concentration of Copper in the e-waste site, which was beyond the acceptable agricultural soil limits of 50mg/kg in China.

The lead (Pb) level in the soil samples analyzed ranged from 0.99mg/kg to 346.04mg/kg. Lead is known to exert its most significant effect on the nervous system, including motor disturbances, sensory disturbances, the hematotiopic system, and the kidney and, ultimately, major brain damage (Verstraeten, Aimo, & Oteiza, 2008)). Pb's presence was relatively low and is not in alignment or

agreement with (Aliyu & Bello, 2004), who recorded a high concentration of lead due to high traffic volume and automobile mechanic workshops in the area. However, lead is widely known to be toxic even at low concentrations, especially in young children (Ara & Usmani, 2015).

The cadmium concentration revealed that either it was absent or very low in some distance away from the dumpsite. Cadmium (Cd) was the least abundant heavy metal recorded in the study area, whereas Iron was the highest among the heavy metals with 821.99mg/kg. Cadmium presence ranged from 0.049mg/kg to 2.54mg/kg. Though little, Cadmium presence may be attributed to non-residual fractions, of heavy metals and thus makes them mobile and potentially bio-available for uptake by the plant (Zhang *et al.,* 2009). The values obtained for Cadmium were far below the values obtained by Aliyu & Bello (2004) of 4.8mg/kg and 3.46mg/kg in soils of battery chargers workshop and mechanical workshops, respectively Sokoto.

The reduction in the concentration of detected heavy metal over distance is as a result of leachate processes and rainfall factor. The heavy metal penetrates the soil through the leaching process, and rainfall acts as a catalyst that speeds up this action. This constitutes a serious problem for the underground aquifer and soil micro-organism. The study emphasized that the water sample collected from a hand-dug shallow well located 10km away from the waste dump is also seriously contaminated. This is in alignment with the findings of Ogbuene et al. (2012). The heavy metals that reduce as distance increase from waste dumpsite find its way into the soil and groundwater aquifer.

The rate of reduction in the level of concentration as a distance increase shows that the soil is highly polluted with the metal detected. The waste dump comprised industrial waste, chemical waste, clinical waste, commercial waste, household waste, etc. These various chemical wastes react with each other, thus deteriorating the environment so much. There is a need for urgent management strategies. The waste dump is currently seen as a slow-onset environmental hazard.

Sun et al. (2014) also found that metal species were comparatively higher in industrial effluent accumulations site and regarded as unsafe as these heavy metals were eventually picked up by growing plants and thereby entering the food chain. Sun et al. findings are along with what the researcher observed and investigated at the Ugwuaji dumpsite. At Ugwuaji, the case is not different as plants in the process of taking up nutrients pick up those detected heavy metals and store it in the food chain.

CONCLUSION

The presence of heavy metal in the soil of Ugwuaji dumpsite environs is attributed to indiscriminate open waste dumping in the area. The study concludes that poor waste management and accumulation of tones of solid waste in the dumpsite negatively affects the soil quality in the area. Further, the open solid waste dumping exposed the soil to serious contamination with heavy metals (Cd, Pb, Cu, Zn, and Fe). The implication is serious human and animal health due to possible bioaccumulation and biomagnifications through plant uptake from the soil. Although some of these heavy metals such as Copper and Fe at a moderate level are biologically essential and play an important role in the growth of the plant, animal and man but becomes can also become toxic even at low concentrations.

RECOMMENDATIONS

There is a need for periodic monitoring of heavy metal accumulation in the area. The waste management authority should ensure proper waste management is put in practice to reduce or possibly prevent the introduction of contaminants in the environment. This would involve resource use or reuse of materials, treatment of waste that requires treatment, recycling of waste, and safe disposal in a sanitary landfill. Future studies should concentrate on the health impact of these heavy metals on the human population in the area.

LITERATURE CITED

Aliyu, M., & Bello, M. (2004). Trace metals Contamination of selected workshops in Sokoto Municipality. Nigerian Journal of Basic and Applied Sicence, 13, 29-34. Retrieved on April 10, 2020 from https://bit.ly/2VrUSs4

Anikwe, M. A. N., & Nwobodo, K. C. A. (2002). Long term effect of municipal waste disposal on soil properties and productivity of sites used for urban agriculture in Abakaliki, Nigeria. *Bioresource technology*, *83*(3), 241-250. Retrieved on April 10, 2020 from https://bit.ly/38h71W4

Ara, A., & Usmani, J. A. (2015). Lead toxicity: a review. Interdisciplinary toxicology, 8(2), 55-64. Retrieved on April 10, 2020 from https://bit.ly/3ianZKb

Fosu-Mensah, B. Y., Addae, E., Yirenya-Tawiah, D., & Nyame, F. (2017). Heavy metals concentration and distribution in soils and vegetation at Korle Lagoon area in Accra, Ghana. *Cogent Environmental Science*, *3*(1), 1405887. Retrieved on April 10, 2020 from https://bit.ly/2YGvMHW

Ezeoha, S. L., & Ezenwanne, J. N. (2013). Production of biodegradable plastic packaging film from cassava starch. *IOSR Journal of Engineering*, *3*(10), 14-20. Retrieved on April 10, 2020 from https://bit.ly/2ZdLiKq

Fosu-Mensah, B. Y., Addae, E., Yirenya-Tawiah, D., & Nyame, F. (2017). Heavy metals concentration and distribution in soils and vegetation at Korle Lagoon area in Accra, Ghana. *Cogent Environmental Science*, *3*(1), 1405887. Retrieved on April 10, 2020 from https://bit.ly/2YGvMHW

Kanmani, S., & Gandhimathi, R. (2013). Investigation of physicochemical characteristics and heavy metal distribution profile in groundwater system around the open dump site. *Applied Water Science*, *3*(2), 387-399. Retrieved on April 10, 2020 from https://bit.ly/3eG2jU0

Krishnamurti, G. S., & Naidu, R. (2003). Solid–solution equilibria of cadmium in soils. *Geoderma*, *113*(1-2), 17-30. Retrieved on April 10, 2020 from https://bit.ly/3iaAtBo

Moustakas, M., Lanaras, T., Symeonidis, L., & Karataglis, S. (1994). Growth and some photosynthetic characteristics of field grown Avena sativa under copper and lead stress. *Photosynthetica (Czech Republic)*. Retrieved on April 10, 2020 from https://bit.ly/2ND7IPU

Nda-Umar, U. I., Nathaniel, G. S., Mann, A., & Yisa, J. (2012). Assessment of heavy metal species in some decomposed municipal solid wastes in Bida, Niger State, Nigeria. *Adv Anal Chem*, *2*, 6-9. Retrieved on April 10, 2020 from https://bit.ly/2VtJDPN

Ogbuene, E. B., Igwebuike, E. H., & Agusiegbe, U. M. (2013). The Impact of Open So A Case Study. Journal of Advance Academic Research, (1), 43-53. Retrieved on April 10, 2020 from https://bit.ly/3g8r8sg

Ogundele, D. T., Adio, A. A., & Oludele, O. E. (2015). Heavy metal concentrations in plants and soil along heavy traffic roads in North Central Nigeria. *Journal of Environmental & Analytical Toxicology*, *5*(6), 1. Retrieved on April 10, 2020 from https://bit.ly/3eO1mJC

Saha, N., Rahman, M. S., Ahmed, M. B., Zhou, J. L., Ngo, H. H., & Guo, W. (2017). Industrial metal pollution in water and probabilistic assessment of human health risk. *Journal of environmental management*, *185*, 70-78. Retrieved on April 10, 2020 from https://bit.ly/2BaYmbH

Sarinas, B. G. S., Gellada, L. D., Alfonsa, J. K. M., Domiquel, K., Gumawa, L. R. J., Malan, J. A., & Umali, J. V. G. (2014). Heavy Metal Concentration in Seawater at Villa Beach, Iloilo City, Philippines. IAMURE International Journal of Ecology and Conservation, 11, 41. Retrieved on April 10, 2020 from https://bit.ly/2ZdrPe5

Sarinas, B. G. S., Gellada, L. D., Magramo, M. M., Teruñez, M. R., Inocencio, G. M., Duero, C. E. S., ... & Cleofas, F. K. J. (2013). Heavy Metals in the Water Column of Iloilo-Guimaras Jetty Port (Parola Wharf). IAMURE International Journal of Ecology and Conservation, 6, 54. Retrieved on April 10, 2020 from https://bit.ly/2BVoGXk

Shayler, H., McBride, M., & Harrison, E. (2009). Sources and impacts of contaminants in soils. Retrieved on April 10, 2020 from https://bit.ly/2Bm9YbN

Singh, R. P., Singh, P., Araujo, A. S., Ibrahim, M. H., & Sulaiman, O. (2011). Management of urban solid waste: Vermicomposting a sustainable option. *Resources, conservation and recycling*, *55*(7), 719-729. Retrieved on April 10, 2020 from https://bit.ly/2YHXVOR

Smith, C. J., Hopmans, P., & Cook, F. J. (1996). Accumulation of Cr, Pb, Cu, Ni, Zn and Cd in soil following irrigation with treated urban effluent in Australia. Environmental Pollution, 94(3), 317-323. Retrieved on April 10, 2020 https://bit.ly/2YHCuNZ

Sun, L., Liao, X., Yan, X., Zhu, G., & Ma, D. (2014). Evaluation of heavy metal and polycyclic aromatic hydrocarbons accumulation in plants from typical industrial sites: potential candidate in phytoremediation for co-contamination. Environmental Science and Pollution Research, 21(21), 12494-12504. Retrieved on April 10, 2020 from https://bit.ly/2VsFOu7

Syeda, A. H., Hawkins, M., & McGlynn, P. (2014). Recombination and replication. *Cold Spring Harbor perspectives in biology*, *6*(11), a016550. Retrieved on April 10, 2020 from https://bit.ly/31mzQPn

Tanee, F. B. G., & Eshalomi-Mario, T. N. (2015). Heavy metal contents in plants and soils in abandoned solid waste dumpsites in Port Harcourt, Nigeria. *Research Journal of Environmental Toxicology*, *9*(6), 342. Retrieved on April 10, 2020 from https://bit.ly/38ak3V7

Tanee, F. B. G., & Albert, E. (2013). Heavy metals contamination of roadside soils and plants along three major roads in Eleme, Rivers State of Nigeria. *Journal of Biological Sciences*, *13*(4), 264-270. Retrieved on https://bit.ly/38a8woM

Verstraeten, S. V., Aimo, L., & Oteiza, P. I. (2008). Aluminium and lead: molecular mechanisms of brain toxicity. Archives of toxicology, 82(11), 789-802. Retrieved on April 10, 2020 from https://bit.ly/31sZqSK