Faculty of Natural and Applied Sciences Journal of Scientific Innovations
Print ISSN: 2814-0877 e-ISSN: 2814-0923
www.fnasjournals.com
Volume 3; Issue 2; March 2022; Page No. 71-76.

EVALUATION OF HEAVY METALS' CONTAMINATION OF GROUND WATER AND SOIL AROUND MBODO-ALUU DUMPSITES FOR SUSTAINABLE AGRICULTURE

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Abstract
Evaluation of heavy metals contamination in soil and groundwater around Mbodo-Aluu dumpsites was carried out at three foremost sites; farmlands around the dumpsite, Egbelu River, and some Boreholes in Ogbogoro town. The water sample was obtained in triplicates at a hand-dug pit at 10m depth; borehole water was used as control while soil samples were taken randomly at 0-15cm and 15-30cm depth. Standard procedure was adopted in determining the physicochemical properties of groundwater and soil samples; heavy metal concentration was determined by Atomic Absorption Spectrophotometer**.** Results of the analysis showed pH of 4.2 around the dumpsite and 6.2 in the control sample. The conductivity of 11 and 40 uS/cm deviated from NIS/WHO set the standard; Chloride and Nitrate content around the dumpsite were 63.81mg/Land 56mg/L, while the control sample was 23mg/L and 0.22mg/L, respectively. Heavy metal analysis showed high concentrations of Cadmium (0.86mg/L), Nickel (0.42mg/L), and lead (0.017mg/L) around the dumpsite. In the control sample, lead and arsenic were absent. Meanwhile Chromium concentration was 0.219mg/L and 0.102mg/L for both samples. The result of soil analysis in this study showed pH of 3.41 and 5.89 as Pb concentration varied between 0.08 and 11.98 mg/L, and Cadmium ranged from 2.3-3.71mg/L, result also revealed that Nickel and chromium concentrations ranged from 0.05 - 0.38 mg/L and 0.07- 0.56 mg/L. An increase in heavy metals contamination in groundwater and soil can be linked to human activities rather than normal. It is therefore recommended that dumpsites be properly managed, and hazardous wastes separated before disposal.

Keywords: MbodoAluu, Dumpsite, Groundwater, Soil, Heavy Metal, Contamination

Introduction
Cadmium, Chromium, Lead, Mercury, Arsenic, Iron, Copper, Nickel, and Zinc are included among the *heavy metals* that exist naturally on earth (Olayiwola, et al., 2017). However, the increase in human activities has increased their generation and concentration in an ecosystem (Lagerkvist, 2019). Heavy metals are toxic even at low concentrations, making them a threat to both plants and animal survival. Cobalt, Copper, iron, Mn, Mo, Ni, and Zn are beneficial but are needed in small quantities (Sabejeje, et al., 2014). In recent times, Rivers State has witnessed an increase in human population resulting in the generation of a large volume of domestic waste more than the number coming from industries. There were indiscriminate dumping of refuse and a lack of waste management, which informed the establishment of Rivers State Waste Management Authority (RIWAMA) which in turn has sited dumpsites in different parts of the state to ensure a clean environment.

However, increases in a waste generation are not commensurate with the capacity in which they are disposed of. There were a lot of unplanned public waste disposal systems, thus, the waste management authority (RIWAMA) is faced with challenges of insufficient waste recycling system, hazardous wastes not separated for safe disposal, and dumpsites not properly set to prevent contamination. This has resulted in serious threats from heavy metals to the ecosystem and healthy agricultural development (Duggal et al., 2017). Leachates coming from dumpsites is an intricate mixture of contaminants with heavy metals (Nartey et al., 2012). These materials can spread by dissolving and discharging into groundwater, soil, and plant nutrient and is capable of distorting the food system leading to food insecurity (Sanjeevi, et al., 2018).

The indigenous people of MbodoAluu in Ikwerre local government area of Rivers State, who are predominant crop farmers have been noticing a decline in crop yield and water quality since a dumpsite was located in some part of the community. Although, people are unaware of the risk imposed by heavy metals contamination of groundwater and soil traceable to dumpsites, hence, this paper is aimed at evaluating the effect of heavy metals contamination of groundwater and soil around Mbodo-Aluu dumpsite and their effects on sustainable agriculture.

Materials and Methods

Study Area: This study was carried out at a dumpsite located around Mbodo-Aluu in Ikwerre Local Government Area of Rivers State, Nigeria. The sampling locations covered the dumpsite area, upstream and downstream of Egbelu River, some boreholes located in Ogbogoro town were used as the control sample. Mbodo-Aluu with geographic coordinates within latitude 4°46'N to 5°00'N and longitudes 6°55'E to 7°03'E has a tropical wet climate with an average temperature of 31.2°C. Mbodo-Aluu is in the rain forest, and the indigenous people are predominant crop farmers, soils are mainly sandy, loamy, clay, and mud. Some major areas around the dumpsite are the Egbelu River, OPM church, and the forest around Sarrs Road Port Harcourt.

Sample Collection*:* Samples of water were randomly collected in a sterilized plastic bottle from three locations; hand-dug pit 10m depth around farmlands at Mbodu Aluu dumpsite site, Egbelu River (upstream and downstream) and Boreholes (control) collected from Ogbogoro town.

Soil samples were collected at 0 – 15 cm and 30cm depth with a sterilised auger mixed to form a composite sample and packed in a high-density polythene bag (HDPE).

Methods of Analysis: The methods described by the Association of Official Agricultural Chemists, [AOAC] and Food Safety and Standards Authority of India [FSSAI] (2016) were followed in determining the physicochemical properties of the water sample including, pH, conductivity, chloride, Nitrate, Phosphate, and total dissolved solids while heavy metals analysis were carried out to determine the amount of Cadmium, Chromium, Arsenic, Nickel and Lead in the water.

Sample Preparation and Analysis

Water Analysis*:* Triplicate groundwater samples were collected at random with sterilized plastic bottles. At each sampling point, the water to be collected was used to rinse the sterilized sampling bottle before collection. The water samples were filtered through a cellulose acetate filter into another sterilized plastic bottle before analysis which was carried out within 48 h of sampling. Borehole water was collected and used as the control sample.

pH

The pH values of the water samples were determined on the field using a pH meter after calibrating against buffer pH 4.7 and 9.2solution.

Determination of Conductivity

The Specific conductance of the water sample was determined by using a bridge where a variable resistance was adjusted equal to the resistance of the unknown solution between platinised electrodes of a standard conductivity cell. The cell constant was determined using the correlation below:

Specific conductance = Conductance × Cell constant, or

Specific conductance $=\frac{\text{Cell constant}}{Resistance}$

Chloride content

Into a 250 mL conical flask, 100 mL water sample was added and 1.0 mL of potassium chromate indicator solution was added. This was titrated with standard silver nitrate solution until a pinkish-yellow colour appears. A blank titration was also conducted simultaneously.

Calculation:

Chloride, mg/L $=\frac{(v1-v\ 2)\times N\times 35450}{v3}$

Where

V1 = mL of silver nitrate used

V2 = mL of silver nitrate used in Blank titration

V3= volume in mL of sample taken for titration

N= Normality (N) of silver nitrate solution

Nitrate Determination

Nitrate was reduced to nitrite in presence of cadmium. The nitrite produced was measured using a colorimeter after a highly colour azo dye developed.

Total Hardness

An aliquot of 50 mL water sample was pipette into a 250 mL beaker and 1 mL hydroxylamine hydrochloride solution added, followed by the addition of 1mL buffer solution to achieve pH of 10.0, 2 mL Eriochrome black T indicator solution was added to the water sample before titrating with standard 0.1N EDTA solution stirring quickly at the start and little by little towards the end until endpoint is reached when all the traces of red and

purple colour disappeared and solution became clear sky blue. Blank titration was also carried out in the same approach for comparison.
Calculation
Calculate the hardness as follows

Total hardness as ($CaCO_3$), mg/L = $\frac{[1000(V1 - V2)}{V3}$ x CF

Where
V1 = volume in mL of the EDTA standard solution used
V2 = volume in mL of the EDTA solution used in blank titration
V3 = volume in mL of the sample taken for analysis

Heavy metals concentration
Cadmium, Chromium, Arsenic, Nickel and Lead concentration in the water around the dumpsite and water sample drawn from borehole used as control were analysed using a specific hollow cathode lamp at a specific wavelength, and then aspirated into the flame of atomic absorption spectrophotometer (AAS) (PerkinElmer Analyst 200). All the analytical procedures described in this study followed the recommendations of the American Public Health Association (APHA 2019).

Soil Analysis

Digestion of Soil samples
Samples were air-dried and sieved through a 2 mm sieve to remove coarse particles before chemical analysis. 0.5 g of air-dried soil was measured and transferred into 250 mL conical flask; 5 mL of concentrated H_2SO_4 was added and 25 mL of concentrated HNO_3 acid and 5 mL of concentrated HCl were also added. The flask was heated at 200°C for 1h in a fuming hood and then cooled to room temperature. After cooling, 20 mL of distilled water was added and the mixture was transferred to a 50 mL volumetric flask and filled up to the mark with distilled water. It was left to settle for 15 hours after which it was filtered and filtrate analysed for total Cd, Cr, AS, Ni and Pb using Atomic Absorption Spectrometer (AA500F).

Results
The physiochemical and heavy metal concentrations in groundwater around Mbodo Aluu dumpsite are presented in Table 1. pH of the contaminated underground water was 4.2 while that of the control was 6.0. Results obtained for conductivity were 11 and 40uS/cm, respectively for both water samples. Chloride content was 63.81mg/L in the groundwater whereas the control sample was 56mg/L. Nitrate, phosphates and total hardness showed values of 23mg/L, 0.22 mg/L, 1.66 mg/L, 0.72mg/L, 15.84mg/L and 12.45 mg/L in that order for groundwater and control samples.

The result presented also revealed a high concentration of heavy metals in the groundwater and control samples; Cadmium and Chromium were 0.119mg/L and 0.102 mg/L, Arsenic gave a value of 0.04mg/L in groundwater around the dumpsite but was not detected in the control sample, Nickel and lead concentrations were 1.425 and 0.067mg/L, 0.017 and 0.00 mg/L in the groundwater and control sample. Heavy metals' contaminations of soil around the dumpsite are summarized in Table 2. Lead (Pb) ranged from 0.08 -11.98 mg/L, while Cadmium (Cd) varied between 2.33and 3.71mg/L at dumpsite sub-surface 15-30cm depth and 15-30 cm depth. Nickel and chromium concentration varied between 0.01 and 0.38 mg/L, 0.07 and 0.56 mg/L respectively.

Table 1: Physiochemical and Heavy Metals Concentration in Groundwater around Aluu Dumpsite

Parameters	Dumpsite	Borehole	NIS (2007)	WHO (2017)
pH	4.2	6.0	6.5–8.5	6.5–8.5
Conductivity(uS/cm)	11	40	1000	1000
Chloride(mg/L)	63.81	56	250	200–300
Nitrate(mg/L)	23	0.22	50	50
Phosphates (mg/L $PO_4^{3-)}$	1.66	0.72	0.024	0.024
Total Hardness(mg/L)	15.84	12.45	60–120	60–120
Cadmium(mg/L)	1.86	0.119	0.003	0.003
Chromium(mg/L)	0.219	0.102	0.05	0.05
Arsenic(mg/L)	0.14	ND	0.02	0.02
Nickel(mg/L)	1.425	0.067	0.02	0.07
Lead(mg/L)	0.017	0.00	0.01	0.01

Key: WHO- World health Organization, NIS -Nigeria industrial Standard

Table 2: Mean Concentrations of Heavy Metals in Soil around Aluu Dumpsite

Source	pH	Pb mg/kg	Cd mg/kg	Nickel mg/kg	Chromium mg/kg
Upstream surface soil (0-15 cm)	4.86	3.28	2.50	0.11	0.08
Upstream sub-surface soil (15-30 cm)	5.01	4.8	3.71	0.24	0.11
Downstream surface soil (0-15 cm)	4.59	6.79	1.05	0.32	0.24
Downstream sub-surface soil (15-30 cm)	4.79	9.42	0.04	0.38	0.30
Control surface (0-15 cm)	5.50	0.08	0.04	0.02	0.07
Control sub-surface soil (15-30cm)	5.89	0.09	0.07	0.01	0.09
Main dumpsite surface (0-15cm)	3.41	4.55	2.33	0.05	0.12
Main dumpsite sub-surface (15- 30cm)	3.84	5.19	3.08	0.07	0.14
Aluu dumpsite surface 0-15cm)	4.02	9.37	2.55	0.09	0.38
Aluu dumpsite sub-surface (15-30cm)	4.00	11.98	3.54	0.1	0.56
WHO / NIS standards	6.5-8.5	0.01	0.003	0.02	0.05

Key:*WHO- World health Organization, NIS-Nigeria industrial Standard*

Discussion

Results of the physiochemical and heavy metal concentration in groundwater around Mbodo Aluu dumpsite showed that the pH is slightly acidic, these values are however, lower than acceptable limits of pH 6.5–8.5 set standards for potable water by WHO, (2017) and NIS, (2007). Values obtained for conductivity ranged between 11 and 40µs/cm for both samples were below the (WHO, 2011) and (SON, 2015) permissible limit, values are significantly ($p<0.05$) different from set standard of 1000 uS/cm. The conductivity of precipitation samples depends on the concentrations of the various ion species and their different ability to transport electric charges in a solution. The presence of heavy metals' ions in water affects the electrical conductivities (Ukah, et al., 2019).

Chloride concentrations in the water samples were below the maximum allowable limits of 250 mg/L. However, based on the low chloride contents, the groundwater samples if properly managed and treated will make for portable water (Egbueri, et al., 2019). The result of the analysis in this study showed that the groundwater samples are contaminated with heavy metals which have become a threat to man and plants' survival. Lead (Pb), chromium (Cr), and cadmium (Cd) are the major contaminants with their values higher than the tolerable limit set by WHO, (2017) and NIS, (2007). Nickel and Arsenic concentrations in the groundwater were higher than the WHO/NIS limits; meanwhile, Arsenic was not detected in the control water samples. The presence of heavy metal in groundwater have been traced to different activities including improper refuse disposal, as well as dumpsite leachates (Garba & Abubakar, 2018). Water contaminated with excess Pb, Ni, Cr, and Cd can lead to several health risks (Adamu et al, 2014; Barzegar et al., 2018, 2019; Duggal et al., 2017). A contaminated borehole sample signifies untreated water or water from shallow aquifers (Egbueri, 2018).

Soil pH range of 3.41-5.89 measured at two different depths 0-15 cm and 15-30 cm is lower than WHO tolerable limits. pH of the soil samples was acidic; this is unfavourable as low pH aids the mobility of heavy metal ions (Barzegar et al., 2018). Data presented in Table 2 shows how much contamination of heavy metal is in the soil samples around the dumpsite; Lead (Pb) concentrations at various depths exceeded the (WHO, 2011) and (SON, 2015) limit of 0.01mg/L. The result obtained for Pb is similar to the results reported by Adelekan and Abegunde, (2011). Though, high Pb concentrations may be linked to waste battery materials, metal products, and Pb-based pipes at the dumpsite which may have leached into the soil (Garba & Abubakar, 2018).

Nickel and Cadmium concentrations were above the WHO/SON allowable limits in all the locations and depth analyzed. A high level of Cadmium could be natural or leachate from used phosphate fertilizer (Ukah, et al., 2018); on the other hand, Ni contamination could come from effluent discharge from industries. Nickel is toxic and can enter the food system through plants growing in contaminated soil (Adelasoye & Ojo, 2014). Chromium concentrations in the soil samples (0.08-0.56 mg/L) are above the acceptable limits, high chromium contamination of soil can be traced to dumpsites or industrial waste. (Adamu et al., 2014).

Conclusion

Normally, heavy metals are found on the earth's surface; however, human activities owing to the increase in population have increased waste generation and accumulation. Attempts to solve this problem have necessitated different ways of waste disposal including burning burying and waste dumpsites. (Barzegar et al. 2018; Mgbenu et al., 2019). Contamination of water and soil for agriculture depends on the amount of heavy metal (above permissible limits) leached from uncontrolled dumpsites. Heavy metals in the waste materials can change soil chemical properties by altering the nutrient equilibrium and upset crop yield, food system, and food security (Soltani, et al., 2017). Contamination of heavy metals in soil and groundwater and subsequently in food and water may result in the undesirable taste of foods, and gastrointestinal pain, some are carcinogenic; while some can cause lung injuries, dermatitis, and psychological impediment (Sabejeje et al., 2014). Barzegar et al (2019) reported heavy metals' toxicity to nervous systems and inhibition of vitamin D metabolism; restlessness in children; acute mental illness; anaemia; harm to hearing and blood cell's structure and so on.

Recommendations

The dumpsite at MbodoAluu is impacting the United Nations' Sustainable Development Goals which include Zero Hunger and Good Health. It is, therefore, recommended that:

1. Waste recycling be introduced
2. Before waste disposal, hazardous wastes should be separated for safety
3. dumpsites should be properly designed to prevent soil and groundwater contamination
4. Remediation of dumpsite with heavy metals above standard guidelines is recommended

References

Adelasoye, KA., & Ojo., OA, (2014). Accumulation of heavy metal pollutants in soil and cassava leaf and their effects on soil microbial population on roadsides in Ogbomoso, Nigeria. *International Journal of Applied Agriculture and Apiculture Research* 10**:**1-2.

Adamu, C. I., Nganje, T. N., & Edet, A. (2014). Heavy metal contamination and health risk assessment associated with abandoned barite mines in Cross River State, southeastern Nigeria.,*EnvironmentNanotechnology Monitoring and Management*. https//org/10.1016/j.enmm.2014.11.001.

Adelekan, B.A., & Abegunde, K.D. (2011). "Heavy metals contamination of soil and groundwater at automobile mechanic villages in Ibadan, Nigeria". *International Journal of the Physical Sciences,* volume 6, number 5, 1045-1058

Association of Official Agricultural Chemists, AOAC, (2019). International, Official Method 922.06. Fat in Grain and Flour, 21sted., Gaithersburg, MD.

American Public Health Association, APHA. (2019). *Standard methods for the examination of water and wastewater* (22nd ed.). American Public Health Association.

Barzegar, R., Moghaddam, A. A., Adamowski, J., (2018). Assessing the potential origins and human health risks of trace elements in groundwater: A case study in the Khoy plain, Iran. *Environmental Geochemistry and Health*. https //org/10.1007/s10653-018-0194-9.

Barzegar, R., Moghaddam, A. A., Soltani, S., (2019). Natural and anthropogenic origins of selected trace elements in the surface waters of Tabriz area, Iran. *Environmental Earth Science, 78,* 254. https :// org/10.1007/s1266 5-019-8250-z

Duggal, V., Rani, A., Mehra, R.(2017). Risk assessment of metals from groundwater in northeast Rajasthan. *Journal of the Geological Society of India, 90*(1), 77–84

Egbueri, J. C., Mgbenu, C. N., & Chukwu, C. N. (2019). Investigating the hydrogeo-chemical processes and quality of water resources in Ojoto and environs using integrated classical methods. *Modeling Earth Systems and Environment*. http:///10.1007/ss 40808-019-00613 -y.

Egbueri, J. C. (2018). Assessment of the quality of groundwater proximal to dumpsites in Awka and Nnewi metropolises: a comparative approach. *International Journal of Energy and Water Resources,* https: //10.1007/s4210 8-018-0004-1.

Food Safety and Standards Authority of India, FSSAI, (2016). Manual of Methods of Analysis of Foods Water, www.fssai.gov.in

Garba, S. T., & Abubakar, M. A. (2018). Source and Distribution of the Heavy Metals: Pb, Cd, Cu, Zn, Fe, Cr, and Mn in Soils of Bauchi Metropolis, Nigeria. *American Journal of Engineering Research, 7*(2), 13–23

Lagerkvist, L Dahlén, (2019,) Solid Waste Generation and Characterization, in: Recovery of Materials and Energy from Urban Wastes:

Nigerian Industrial Standard, NIS. (2007). Nigerian standard for drinking water quality *Nigerian Industrial Standard, 554,* 13–14.

Nartey VK, Hayford EK., & Ametsi SK (2012) Assessment of the impact of solid waste dumpsites on some surface water systems in the Accra Metropolitan area, Ghana. *Journal of Water Resources Protection* 4:605–615

Cite this article as:
Otomewo, J. N..(2022). Evaluation of heavy metals' contamination of ground water and soil around Mbodo-Aluu dumpsites for sustainable agriculture. *FNAS Journal of Scientific Innovations, 3*(2), 71-76.

Olayiwola, L., Abudulawal, G.K., Adewuyi, M.O., & Azeez, (2017) Heavy metal contents in soil and plants at dumpsites: A case study of Awotan and Ajakanga dumpsite Ibadan, Oyo State, Nigeria, *journal Environmental Earth Science*. 7 11–24.

Sabejeje, A. J., Oketayo, O.O., Bello, I.J., & Sabejeje T. A (2014). Elemental Analysis of Leachates from Open-Dump-Solid Wastes in Ondo State, Nigeria: Implication on Underground Water and Surface Water Safety". *American Journal of Research Communication, 2(10)*, 287-296.

Sanjeevi, N., Freeland-Graves, J., & Hersh, M. (2018). Food Insecurity, Diet Quality and Body Mass Index of Women Participating in the Supplemental Nutrition Assistance Program: The Role of Intrapersonal, Home Environment, Community and Social Factors. *Appetite* 125:109–17.

Soltani, S., Asghari Moghaddam, A., Barzegar, R., Kazemian, N., & Tziritis, E. (2017). Hydrogeochemistry and water quality of the Kordkandi-Duzduzan plain, NW Iran: application of multivariate statistical analysis and PoS index. *Environmental Monitoring and Assessment, 189,* 455.

Standard Organsation of Nigeria, SON (2015). Nigeria standard for drinking water quality. Nigeria industrial standard NIS 554

Ukah B. U., Egbueril, J. C., Unigwe, C. O. & Ubido, O. E. (2019). Extent of heavy metals pollution and health risk assessment of groundwater in a densely populated industrial area, Lagos, Nigeria

Ukah, B. U., Igwe, O., & Ameh, P. (2018). The impact of industrial wastewater on the physicochemical and microbiological characteristics of groundwater in Ajao-Estate Lagos, Nigeria. *Environmental Monitoring and Assessment, 190,* 235

World Health Organisation, WHO, (2017). *Guidelines for drinking water quality* (3rd ed). World Health Organization

World Health Organisation, WHO (2011). *Guidelines for drinking water quality* (4th ed), volume 1, p. 472

Cite this article as:
Otomewo, J. N..(2022). Evaluation of heavy metals' contamination of ground water and soil around Mbodo-Aluu dumpsites for sustainable agriculture. *FNAS Journal of Scientific Innovations, 3*(2), 71-76.