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Analysis of Trace Metals in Hand Dug Wells around Dumpsites in Okene Metropolis, Nigeria

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Abstract: This study examined the levels of trace metals in leachates from dumpsites and hand dug wells used as sources of drinking water by the inhabitants of Okene Metropolis, Kogi State Nigeria. This is important because the presence of toxic heavy metals in the environment continues to generate a lot of concern to environmental scientists, government agencies and public health practitioners leading to adverse health implications. The leachates and hand dug well water samples were collected during the wet season of 2019-2021 and analyzed for some selected trace metals (Cd, Cu, Ni, Pb, Zn, Cr, and Mn) using AA320N atomic absorption spectrophotometer. The result showed that there was high concentration of most of the trace metals in the leachate samples compared to the groundwater samples with some of the trace metals above the maximum limit set by W.H.O. It is recommended that a systematic treatment of heavy metals concentration in hand dug well in the study area should be carried out regularly either through chemical precipitation, ion exchange or reverse osmosis.

Keywords: *Hand dug wells, Leachate, Okene, Pollution, Trace metals*

Conflicts of interest: None
Supporting agencies: None

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1. Introduction

In developing countries and many of their growing cities, poor waste management poses several challenges for the well-being of dwellers, particularly those living adjacent to the dumpsites due to the potential of the waste to pollute the water, food sources, land, air and vegetation causing severe health implications (Hughes et al., 2005). Dumping of solid wastes without proper separation increases the concentration of heavy metals such as arsenic (As), iron (Fe), selenium (Se), molybdenum (Mo) cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg) and zinc (Zn). Nigeria as a country has generally considered economic growth, social and educational development and industrialization as key development priorities, while protection of the environment has not been given the same importance. The increasing growth of cities therefore has implications for municipal waste management among other social services required in the Nigeria communities. Data from many of the cities show inadequacy in the social services like shelter, provision of safe drinking water and efficient management of solid waste.

The presence of heavy metals at trace level and essential elements at elevated concentration do cause toxic effects if exposed to human population (Hughes et al., 2005). Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in biosystems through contaminated water, soil and air (Ikem et al., 2002). Heavy metals can accumulate in soils to toxic levels as a result of long term application of untreated wastewater and fertilizers. Soil being irrigated by wastewater does accumulate heavy metals in the surface, and when the capacity to retain heavy metals is reduced due to repeated application of wastewater, heavy metals will leach into ground water (Kruis, 2007). Research findings within some cities in Nigeria indicate that application of heavy doses of fertilizer; pollute ground water by nitrates and heavy metals through leaching (singh et al., 2008). In a study the concentration levels of selected heavy metals

(Cd, Cu, Mn, Ni, Pb and Zn) in soils around two major auto mechanic workshop clusters in Benue State, Central Nigeria, revealed that for the majority of heavy metals, the concentrations in the soils are above levels and permissible limits recommended for soils as indicated by the following ranges (mg/kg): Cu, 254-1,348; Pb, 283 - 665; Zn, 295-553; Mn, 58.8-272.; Ni, 18.0 - 41; and Cd, 10.50-12.7, with a variation pattern in the order: Cu>Pd>Zn>Mn>Ni>Cd. The order of accumulation of metals in the auto mechanic workshop locations is Gboko>Apir (Temilola et al., 2014).

Heavy metals for Gboko North and South dumpsites were investigated and the analysis of heavy metals indicated that samples from Gboko North show mean concentrations (mg/kg) of heavy metals as; Pb (0.966), Ni (0.514) Cd (0.298), Al (0.223),Cr (0.092), As (0.051). On the other hand, the levels of Pb, Cr, Al, and As were higher in Gboko South than Gboko North. All the heavy Metals were within the WHO acceptable limits except Cd and Cr which were slightly above these limits in some dumpsites (Anhwange et al., 2012).

Heavy metal levels of leachates at the Rumuodumaya dumpsites and the surface water of its adjacent river using AGILENT 55B spectrometer shows that as of the time of analysis, there is no serious threat to its immediate environment except the nickel concentrations in the dumpsites and surface water of the river whose values were beyond the recommended limit of WHO/USEPA (0.05 mg/L) for safe drinking water. The trend of the results also indicates that the dumpsites are sources of numerous soil and water pollutants capable of depleting oxygen levels in the river and this could pose several and serious health risk to humans and aquatic life (Faith et al., 2019).

Comparative assessment of the impact of a functional and an abandoned waste dump site on the quality of neighbouring groundwater in Lagos Nigeria was carried out and it was found that metals in the water samples were within WHO and NSDWQ permissible limit except for Lead in both dumpsites with mean concentration of 0.069 ± 0.075mg/l for wells near Oke-Afa dumpsite and 0.17 ± 0.086mg/l for wells near Olusosun dumpsite. The soil samples in both dumpsites show a considerable level of pollution as all the metal determined exceeded the specified WHO limit. The comparative analysis of the abandoned dumpsite with the active dumpsite reveals no significant difference in the concentration of soil and water parameters measured (Temilola et al., 2014).

In another study, heavy metals (chromium, nickel, zinc, lead and copper) in soil at four different directions (east, west, north and south) were determined by wet digestion spectrophotometrically and the results obtained were zinc (1133±897 mg/kg), nickel (26.3± 51.1 mg/kg), copper (110±90 mg/kg), lead (137± 64 mg/kg) and chromium (3.63±2.46 mg/kg) while the index of geo-accumulation revealed soil to be moderately to strongly polluted with zinc, copper and lead (Godwin et al., 2020).

The effects of leachate on heavy metals content of dumpsite soils using atomic absorption spectrophotometer (AAS) Gombe state Nigeria showed that Iron (Fe) was the most abundant metal, with the highest concentration observed at the Rumuigbo dumpsite. The least concentrated metal in the dumpsites was vanadium (V) with the lowest value observed at the Slaughter dumpsite. The order of the metal concentrations in the dumpsites were Fe>Cu>Zn>Mn>Ni>Pb>Cr>Cd>V. All the metals except cadmium (Cd) were below the required permissible limit in soils by DPR, China and the world average value in shale (Marcus et al., 2017)

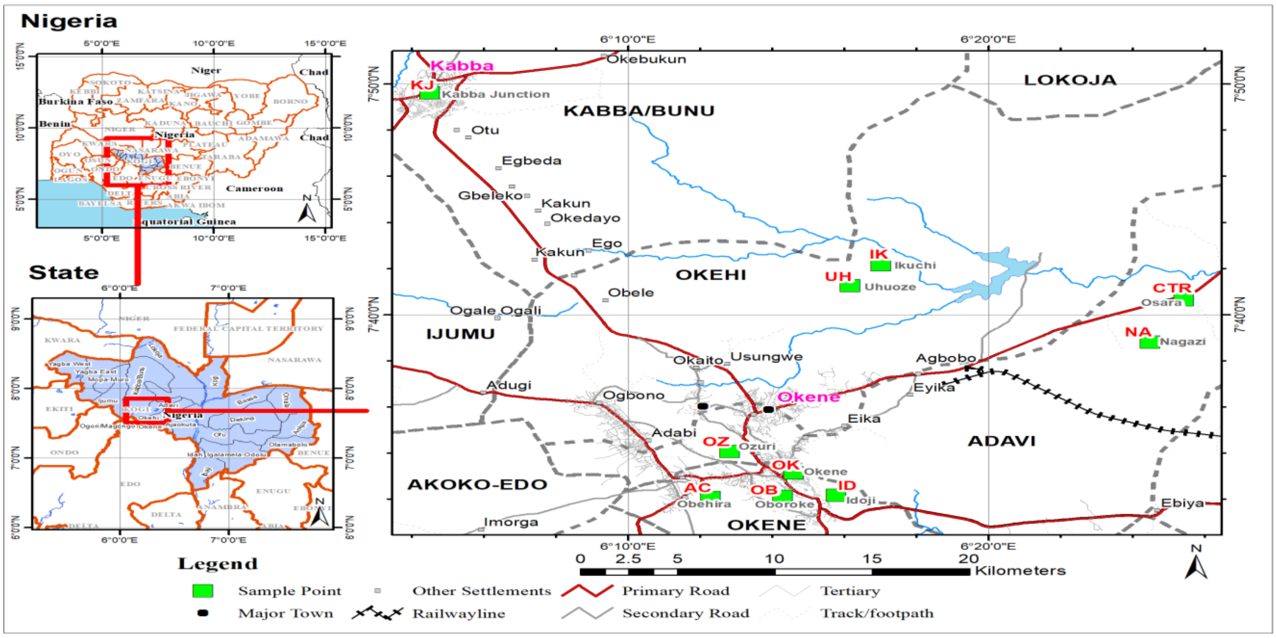
An evaluation (Michael, 2014) of the accumulation of heavy metals (Cd, Cu, Fe, Ni, Pb and Zn) in Talinum triangulare plant around two municipal solid waste dumpsites in Gombe, Nigeria was carried out using Atomic Absorption Spectrophotometer which revealed that the average soil concentrations of the metals in the two dumpsites were in the order Fe>Zn>Pb>Cu>Ni>Cd while the order in Talinum triangulare was Fe>Zn>Cu>Pb>Ni>Cd. The result of soil enrichment factor implicated anthropogenic activities rather than lithogenic inputs as the sources of these heavy metals.

This study is important because hand dug wells are the major sources of fresh water to inhabitants of Okene metropolis since it is readily available source of water for domestic, agricultural and industrial use. Therefore the quality of hand dug water in Okene metropolis is a major concern to environmental health policy makers in Kogi state. However, very little attention has been paid to its impact on the availability of drinking water in Okene. Thus, this research took into account the hand dug wells that are located in the vicinity of the Idoji (ID), Okene (OK), Ikuehi (IK), Oboroke (OB), Uhuoze (UH), Nagazi(NA), Ozuri (OZ), Kabba Junction (KJ), Obehira (AC) dumpsites. This research provides information on the distribution of heavy metals of leachates and water from hand dug wells from the vicinity of the selected dumpsites in Okene Metropolis.

2. Materials and methods

Okene Metropolis is located at latitude 07o 33' N and longitude 06o 14’ E and is presently one of the most important cities in Kogi State North Central Nigeria comprising of three local government areas namely Okene, Adavi and Okehi. It has a population of 722, 453 people (population census, 2006). It has total area of 339 Km2. It has a tropical continental climate with dry season, lasting up to six months (October - March). The residence around the dumpsites has access to water from the hand dug wells located in the vicinity of the dumping sites.

The samples includes leachates being collected from the dumpsites and water from hand dug wells used by dwellers in the vicinity of Okene metropolis. Samples were collected during the wet season of 2019-2021 using plastic containers cleaned using nitric acid and rinsed twice with water/leachates sample before collections. Samples for heavy metal analysis were acidified with nitric acid and preserved in refrigerator. Leachate samples were collected at two edges of each of the dumpsites: first leachate sample site was located upstream at the edge of the dumpsite at a distance of 4-5m and at about 50 cm of depth; the second leachate sample site was located downstream the first site at a distance of 7-8 m from the dumping at about 70 cm in depth. The samples from upstream and downstream were then used to form a composite (Chopra et al., 2009, Amadi et al., 2010, Yakubu and Baba, 2010). Hand dug well water samples were taken at three wells located in the vicinity of selected dumpsites. The collected leachates and water samples were digested in aqua-regia and filtered prior to analysis using AA320N atomic absorption spectrophotometer. Results were statistically analysed using SPSS 26.0.



Map of Okene Metropolis showing sampling points

3. Results and discussion

3.1. Cadmium (Cd) concentrations in leachates and hand dug wells

The concentration range of Cd in dumpsite leachates ranged from 0.056 (CTR) to 1.261 mg/L (AC) as shown in Figure 1. Leachate concentration of Cd exceeds the European standard for industrial waste waters that are allowed to be discharged only into specific water bodies permitted by authority agencies (0.02 mg/L). The presence of Cd could be due to the discharge of municipal solid waste at the dumpsites which contain nickel-cadmium batteries, discarded consumer electronic products such as televisions, calculators, stereos and plastics. The results obtained in this studies is comparable to the mean concentration of 0.072- 1.204mg/l for Cd in leachates in a similar studies (Amadi et al., 2010 and Michael, 2014). Cadmium concentrations in hand dug wells varies from 0.003 (CTR) to 0.054 mg/L (NA). Some of the hand dug wells showed Cd concentration above the WHO permissible value of 0.003 mg/L (Figure 1). Although, Cd was not detected in wells at the vicinity of OK, CTR, OB, UH, OZ, KJ and AC dumpsites. Cadmium in some hand dug wells is an indicator of anthropogenic pollution around the dumpsites where they are located.

3.2. Copper (Cu) concentrations in leachates and hand dug wells

The concentration of Cu in the leachate samples across dumpsites ranges from BDL (CTR) to 0.996 mg/L (AC) is shown in Figure 2. These relatively high values may be due to complexation of copper ions as metal ions, dumping of wastes such electrical materials, utensils and house hold items made of copper (Namen et al., 2014). This result was lower than that of Mor et al., (2006) and higher than 0.207 – 2.312 mg/l reported by Rizwan et al., (2011). The concentration of Cu in the hand dug wells was BDL (ID, OK, CTR, OZ, AC) to 0.009 mg/L (NA) respectively. Thus, copper might have been removed by precipitation and complexation process before getting to the wells (Namen et al., 2014). The other reason for low copper concentration in well water could be that few discharged solid waste at Okene metropolis do not contain bioavailable copper forms (Ferrara et al., 2013) to be released into the hand dug wells. The concentrations of Cu in the selected hand dug wells are below the WHO permissible value of 2 mg/L for Cu (Figure 2). This study revealed that even though hand dug wells located in the vicinity of the dumpsites are not yet polluted by Cu, it requires further analysis to ensure their suitability for human consumption because trace metals may get into it sooner than later.

3.3. Nickel (Ni) concentration in hand dug wells and leachates

The concentration range of 0.014 (CTR) to 0.206 mg/L (UH) was recorded for Ni in the leachate samples across the dumpsites while the concentration range of Ni in the hand dug wells was BDL (CTR, OZ) to 0.016 mg/L (ID) respectively as shown in Figure 3. This is attributed the dumping of batteries containing nickel and electronic wastes as evident at many of the dumpsites (Ameh, 2013). The values obtained for the leachates were above the WHO recommended limit of 0.1mg/l for nickel in drinking water while all the values obtained for hand dug well at the vicinity of the dumpsites were below WHO limit (Figure 3).

3.4. Lead (Pb) concentrations in leachates and hand dug wells

The concentrations range of Pb in the leachate samples was BDL (CTR) to 1.563 mg/L (KJ) across the dumpsites as shown in Figure 4. The presence of Pb in the leachate samples indicates the plausible disposal of Pb batteries, chemicals for photograph processing, Pb-based paints and pipes at the landfill site (Tiwari et al., 2015). At Okene dumpsite, the discharged Pb batteries were observed. Other possible sources would be Pb-based paints and pipes may be the source of lead in the leachate samples. Lead concentration in leachate samples were above the European standard for industrial waste water which shall not be discharged into surroundings (1 mg/L). Lead concentrations in hand dug wells ranges in the hang dug wells across the dumpsites during were BDL (ID, CTR) to 1.563 mg/L (KJ) and were above the WHO permissible value of 0.01 mg/L (Figure 4). The high concentration of Pb at some of the hand dug wells comes from the dumping site because leachates flows through the ground into the nearby hand dug wells. Other possible source of Pb in the hand dug wells is the fertilizer applied to crops in the nearby gardens around the vicinity of the dumpsites. This should be further explored as Pb contamination sources and other heavy metals in general in the Okene hand dug well system might be complex. At most dumpsites, the level of Pb was higher for leachates than hand dug well except for KJ dumpsites as shown in Figure 4.

3.5. Zinc (Zn) concentrations in leachates and hand dug wells

The range of Zn recorded in the leachate samples across the dumpsites was 0.056 (IK) to 1.261 mg/L (KJ) while the concentration ranges of Zn in the hand dug well water across the dumpsites during wet seasons were 0.003 (CTR) to 0.054 mg/L (NA) respectively as shown in Figure 5. The mean level of zinc in the selected dumpsites could be attributed to continuous dumping of copper-containing electrical gadgets, recyclable non-ferrous metals, steel materials, zinc containing batteries, nuts and bolts containing zinc plate, organ pipes, toys, automobile waste materials, paints and rubbers made of zinc, dye containing zinc materials and unused calamine lotions (Sobhanardakani, 2016). The results obtained for zinc concentration in both leachates and hand dug wells were below the WHO recommended value of 5.0 mg/l.

3.6. Chromium (Cr) concentrations in leachates and hand dug wells

The concentrations range of Cr for leachates samples was BDL (CTR) to 0.019mg/L (NA) across the dumpsites as shown in Figure 6. All the average concentration obtained for Cr was below the European standard for industrial waste water which shall not be discharged into surroundings (0.5-2 mg/L). The low Cr concentration in leachates at selected dumpsites might be due to the use of paints containing chromium or more likely the medical wastes that may have been discharged at the dumpsites (Ebong et al., 2007; Ameh and Akpan, 2011; Ikem et al., 2002). The concentration ranges of Cr in the hand dug well water across the dumpsites during wet seasons were BDL (ID, CTR UH, AC) to 0.006 mg/L (OB, KJ) as shown in Figure 6 respectively. All the average concentration obtained for Cr was below the European standard (0.5-2 mg/L) for water for consumption.

3.7. Manganese (Mn) concentrations in leachates and hand dug wells

The range of Mn recorded for leachates samples across dumpsites was BDL (ID, OK, CTR, IK, OB, UH, NA, OZ,) to 0.001 mg/L (KJ and AC) while the concentration ranges of Mn in the well water across the dumpsites during the wet seasons were BDL (CTR, IK, UH, NA, OZ, KJ) to 0.002 mg/L (OB, AC) as show in Figure 7 respectively. The mean concentration of most of the dumpsites was Below Detection Limit (BDL) with few exceptions as shown in Figure 7. This is attributed to non-biodegradable wastes which might have inhibited the biodegradation of solid waste (Awode et al., 2008; Anake et al., 2009; Praveena, 2019).

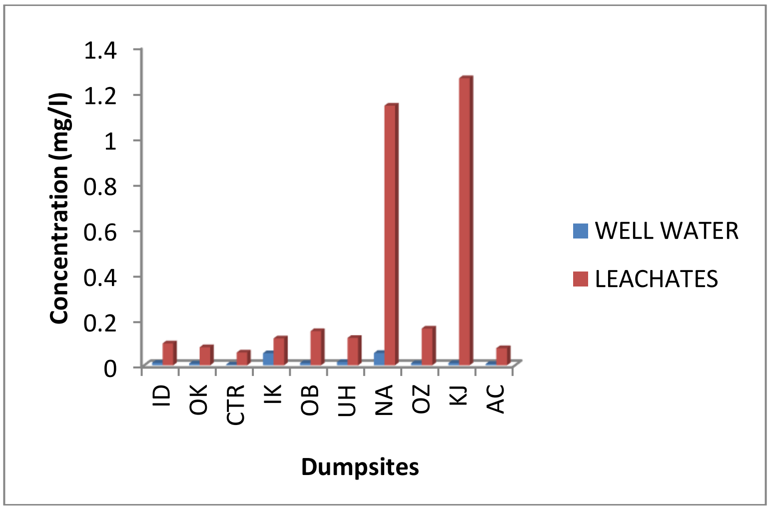


Figure 1: Concentration of cadmium in well waters and dumpsite-leachates copper concentration in hand dug wells and leachates

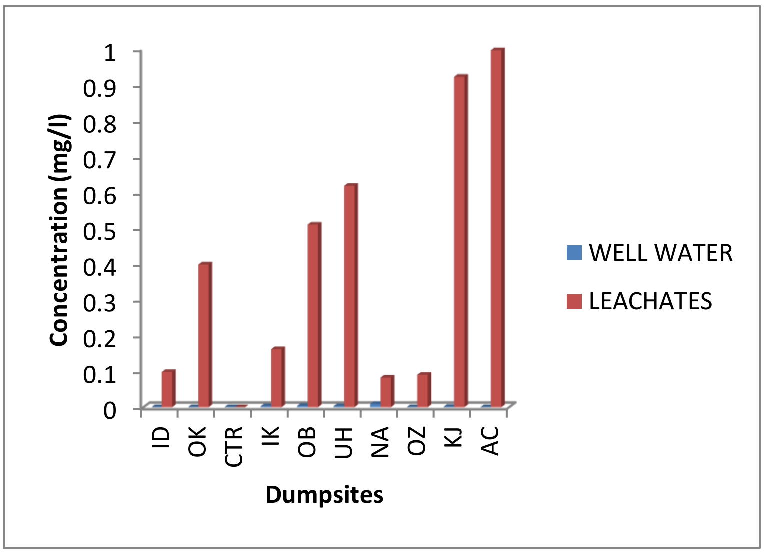


Figure 2: Concentration of copper in well waters and dumpsite-leachates

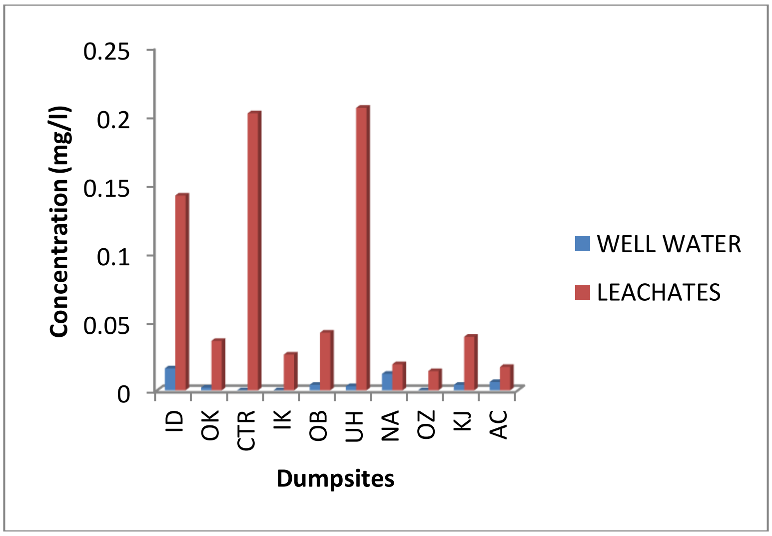


Figure 3: Concentration of nickel in well waters and dumpsite-leachates

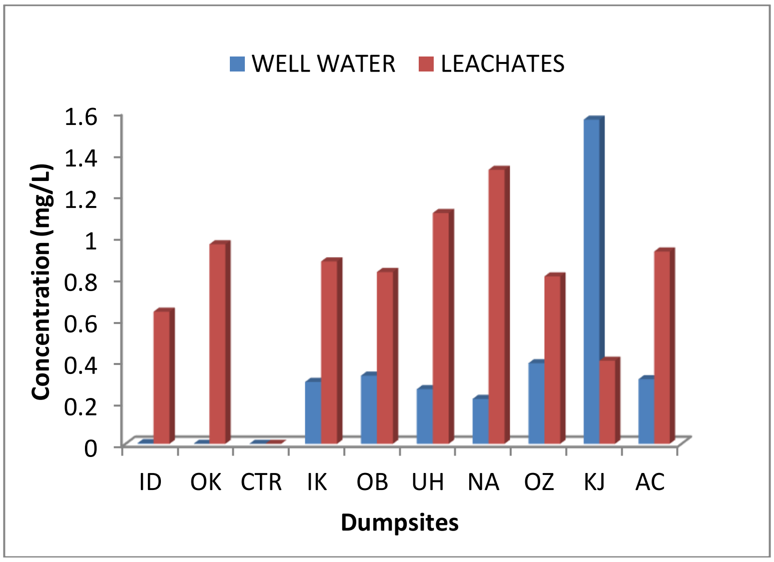


Figure 4: Concentration of lead in well waters and dumpsite-leachates

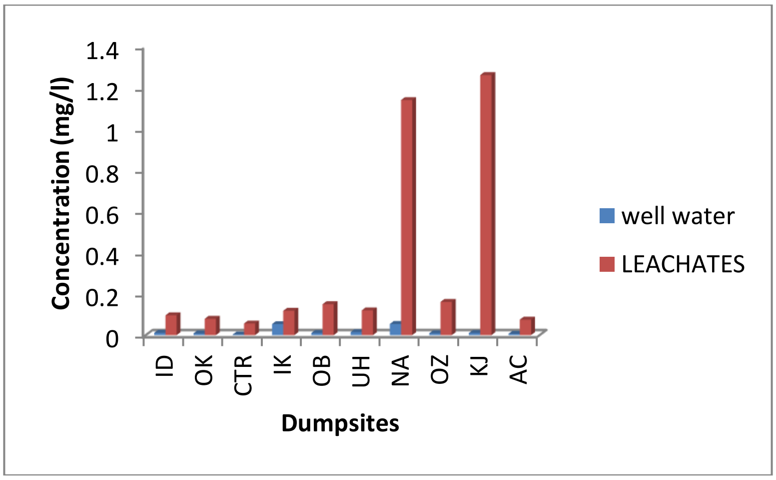


Figure 5: Concentration of zinc in well waters and dumpsite-leachates

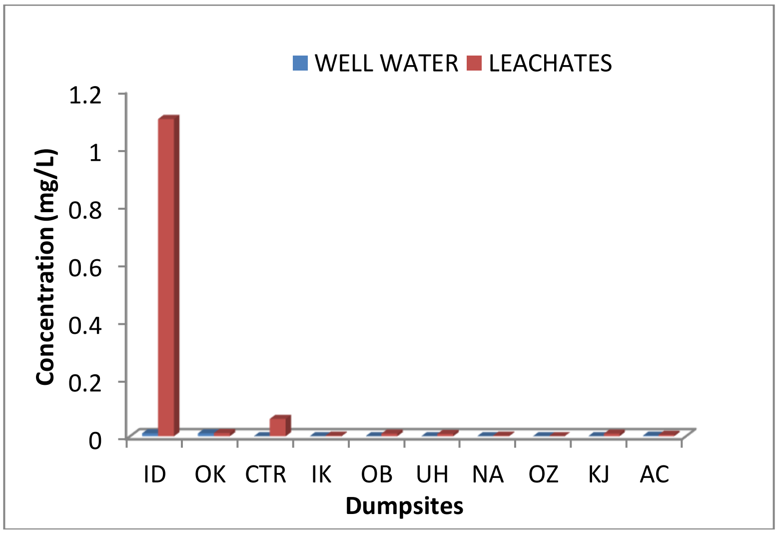


Figure 6: Concentration of chromium in well waters and dumpsite-leachates

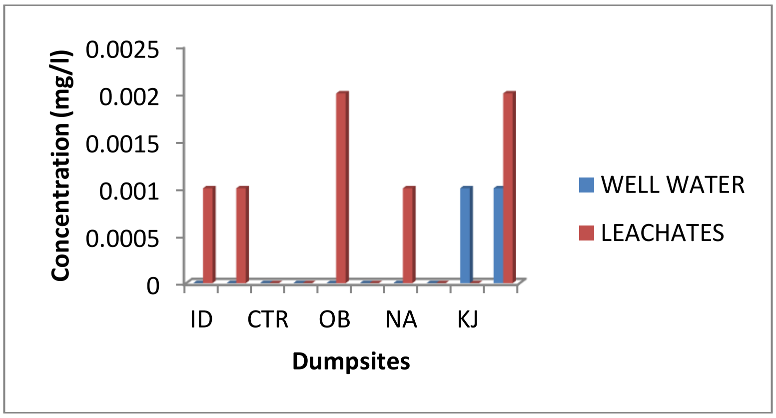


Figure 7: Concentration of manganese in well waters and dumpsite-leachates

4. Conclusion

The analysis of trace metals in the study area revealed that the Cd, Cu, Ni, Pb, Zn, Cr, and Mn were generally higher for the dumpsite leachates and above allowable limit. It was observed that some of the hand dug wells have higher values of Cu, Ni, Pb, Zn which may pose health risk to the dwellers of Okene metropolis. At many of the hand dug wells Cd, Cr, and Mn were Below Detection Limit (BDL). This study therefore recommend that proper leachates from dumpsites channeling and treatment should be carried out to avoid contamination of the hand dug wells by elevated amount of the selected metals, since the wells are the major sources of drinking water for human and animals in the metropolis.

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References

Amadi, A. N., Ameh M. I., & Jisa, J. (2010). The impact of dumpsites on groundwater quality in Markurdi Metropolis, Benue State. *Nature Applied Science Journal, 11*(1), 90–102.

Amadi, A. N., Olasehinde, P. I, Okosun E. A, Okoye, N. O., Okunlola, I. A., Alkali, Y. B., & Dan-Hassan, M. A. (2012). A comparative study on the impact of Avu and Ihie Dumpsites on soil quality in Southeastern Nigeria. *American Journal of Chemistry, 2*(1), 17–23.

Ameh E. G. (2013). Geo-statistics and heavy metal indexing of surface water around Okaba coal mines, Kogi State, Nigeria. *Asian Journal Environmental Science, 8*(4), 1–8.

Ameh, E. G. & Akpah, F. A. (2011). Heavy metal pollution indexing and multivariate statistical evaluation of hydrogeochemistry of River PovPov in Itakpe iron-ore mining area, Kogi State, Nigeria. *Advance Applied Science Research, 2(*3), 33-46.

Anake, W. U., Adie, G. U. & Osibanjo, O. (2009). Heavy metal pollution at municipal solid waste dumpsites in Kano and Kaduna States, Nigeria. *Bulletin of Chemical Society, Ethiopia, 23(*1), 281–289.

Anhwange, B. Kaana, A., & Leke, L. (2012). Determination of heavy metals in some selected waste dumpsites in Gboko Metropolis, Benue State, Nigeria. *International Journal of Current Research*, 4, 278-280.

Awode, U. A., Uzairu, A., Balarabe, M. L., Harrison, G .F. S. & Okunola, O. J. (2008). Assessment of peppers and soils for some heavy metals from irrigated farmlands on the bank of river challawa, Northern Nigeria. *Pakistan Journal of Nutrition, 7(*7), 244–248.

Chopra, A. K., Pathak, C. & Prasad, G. (2009). Scenario of heavy metal contamination in agricultural soil and its management. *Journal of Applied Natural Science, 1(*1), 99–108.

Ebong, G. A., Etuk, H. S. & Johnson, A. S. (2007). Heavy metals accumulation by Talinum triangulare grown on waste dumpsites in Uyo Metropolis. *Journal of Applied Sciences, 7 (*10), 1404-1409.

Faith, J. I., Ifeanyi, E. I. & Godson, N. I. (2019). Leachates and physicochemical characteristics of Rumuodumaya dumpsites, Niger-Delta, Nigeria. *Chemistry International*, 5, 126-131.

Ferrara, L., Iannace, M., Patelli, A. M. & Arienzo, M. (2013). Geochemical survey of an illegal waste disposal site under a waste emergency scenario (Northwest Naples, Italy). *Environment*, 185(3), 2671–82. doi: 10.1007/s10661-012-2738-2.

Godwin, A. E. Ekomobong, S. E. & Emmanuel, U. D. (2020). Impact of abattoir wastes on trace metal accumulation, speciation, and human health–related problems in soils within southern Nigeria. *Air, Soil and Water Research*, 13, 203-209.

Hughes, K. L., Christy A. D. & Heimlich J. E. (2005). *Abandoned dumps: Yesterday and tomorrow*. Extension fact sheet of the Ohio State University, CDFS-140-05.

Ikem A., Osibanjo, O., Sridhar M. K. C., & Sobande A. (2002), Evaluation of groundwater quality characteristics near two waste sites in ibadan and lagos, Nigeria. *Water, Air, and Soil Pollution*, 140(5), 314- 318.

Ikem, A., Osibanjo, O., Shridhar, M. K. & Sobande, A. (2002). Evaluation of groundwater characteristics near two waste sites in Ibadan and Lagos, Nigeria. *Water, Air and Soil Pollution*, 140 (1-4), 307-333

Kruis, F. (2007). *Environmental chemistry, selected methods for water quality analysis*. UNESCO-IHE, 9-20.

Michael, O. E. (2014). Evaluation of heavy metal accumulation in talinum triangulare grown around municipal solid waste dumpsites in Nigeria. *Bulletin of Environmental, Pharmacology and Life sciences*, 4, 92-100.

Mor, S., Ravindra, K., Dahiya, R.P. & Chandra, A. (2006). Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site. *Environmental Monitoring Assess*, 118(1–3), 435–56.

Namen, A. A., BrasilFda, C., Abrunhosa, J .J., Abrunhosa, G. G., Tarre, R. M. & Marques, F. J. (2014). RFID technology for hazardous waste management and tracking. *Waste Management Research*, 32(9), 59–66.

Onwugbuta, N., Anaero-Nweke G. N., & Ekweozor, I. K. E. (2018). Risk assessment of heavy metals in soil and vegetables of selected dumpsites in Port-Harcourt Metropolis. *International Journal of Science and Research*, 2, 10-17.

Praveena, S.M. (2019). Spatial eco-risk assessment and prediction of heavy metal pollution in surface soil: a preliminary assessment of an urban area from a developing country. *Toxin Reviews*, 38(2), 135-142.

Rizwan, R., Gurdeep S. & Manish K. J. (2011).Application of heavy metal pollution index for ground water quality assessment in Angul district of Orissa, India. International. *Journal of Research in Environmental Chemistry*, 11(5), 118–122.

Singh, K. U., Manish, K., Chauhan, R., Pawan, P. J., Ramanathan, A. L. & Subramanian V. (2008). Assessment of the impact of landfill on groundwater quality: A case study of the Pirana site in western India. *Environmental Monitoring Assess*, 141, 309-312.

Sobhanardakani, S. (2016). Evaluation of the water quality pollution indices for groundwater resources of Ghahavand Plain, Hamadan Province, Western Iran. *Iran Journal of. Toxicology, 10 (*2), 35-40

Temilola, O., Oluwatoyin, A. & Emmanuel A. (2014). Impact assessment of dumpsites on quality of near-by soil and underground water: a case study of an abandoned and a functional dumpsite in Lagos, Nigeria. International *Journal of Science, Environment Technology*, 3, 1004-1015.

Tiwari, A. K., Maio, M. D., Singh, P. K. & Mahato, M. (2015). Evaluation of surface water quality by using GIS and a heavy metal pollution index (HPI) model in a coal mining area, India. Bulletin of Environmental. *Contamination and Toxicology*, 95, 304-310.

WHO (1998). *Environmental health criteria*. International Program of Chemical Society.

Yusuf, K. A. (2006). Evaluation of the three stage BCR (European Community Bureau of Reference). Sequential extraction procedure to assess the potential mobility and toxicity of heavy metals in roadside soils. *Pakistan Journal of Science and Industrial Resource*, 49, 181-188.

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