ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 5 No. 2a December 2019*

Physicochemical and Microbiological Qualities of Government Approved Solid Waste Dumpsites in Benin City

[1,3*]**Enerijiofi, K. E. and** [2,3]**Ekhaise, F. O.**
[1]Department of Biological Sciences, College of Basic and Applied Sciences, Samuel Adegboyega University,Ogwa, Edo State.
[2]Department of Microbiology, Faculty of Life Science, University of Benin, Benin City
[3]Applied Environmental Bioscience and Public Health Research Group, Department of Microbiology, University of Benin, Benin City.
Email: kingsmore1luv@gmail.com

Abstract
The dumping of solid waste has continued unabated affecting humans in the environment. Soil samples were collected from two Edo State Government approved dumpsites, Iguomo and Otofure in Benin City on a monthly basis for one year (January to December, 2014) to determine the physicochemical and microbiological properties of the soil samples using standard methods. The pH recorded range from 6.04±0.01 to 9.51±0.32 in March and August, 2014 respectively at Iguomo dumpsite while Otofure dumpsite ranged from 6.23±0.01 to 8.64±0.14 in March and July,2014 respectively. Electrical conductivity ranged from 142±0.12 in March to 2622±0.30 in August, 2014. In addition, cation exchange capacity, sulphate, nitrate and all cations had high significant difference at both sampled depths (p<0.001). Iron had the highest concentration of 122.50±0.21mg/Kg in May and 57.59±0.98mg/Kg in July among all metals analysed at Iguomo and Otofure dumpsites respectively. However, the mean concentrations of iron, zinc, copper and chromium recorded at the upper depths showed high significant difference across soil depths and time at both dumpsites (p < 0.001). Iguomo had the highest bacterial counts of 1.79±0.22 x 10^{12} *cfu/g in August while Otofure had the highest fungal counts of 1.45±2.10 x* 10^{12} *cfu/g in September. Iguomo dumpsite had high significant difference for both counts at both depths (p<0.001). Bacillis cereus and Aspergillus* sp. *had the highest frequency of occurrence, 43.14% in May and 54.55% in January at the lower depth at Iguomo dumpsite. Also, Alcaligens faecalis displayed a high significant difference at both depths in Otofure dumpsite (p<0.001). Rhizopus* sp., *Aspergillus* sp. *and Mucor* sp. *had high significant difference at the lower depth at Iguomo dumpsite (p<0.001). This study gave a leeway into the physicochemical and microbial diversity patterns from different depths in solid waste contaminated soil environment. However, due to the public health implications, indiscriminate disposal of solid wastes in open sites is out of date and cannot be a sustainable option in solid waste management.*

Keywords: Depths, Environmental sustainability, Microorganisms, Public health, Season, Solid waste dumpsite

INTRODUCTION
The management of solid waste remains a daunting task facing human existence till date. However, the use of Municipal solid waste landfill which is the oldest and predominant method of disposal is still prominently in use today (Osazee *et al*., 2013).The implication is made worse when the rate at which a country's population is growing faster than that at

**Author for Correspondence*

which the wastes are being efficiently and effectively managed as in the case of Nigeria (Oviasogie *et al*., 2010). This creates a call for great concern, locally and internationally (Babayemi and Dauda, 2009). Increasingly, the amount of municipal solid waste constitutes environmental and public health risks due to the unlimited landscape (Enerijiofi and Ekhaise, 2019a). At present there is a particular interest in the relationship between biodiversity and their function there off. The importance of biodiversity in the functioning of ecosystems was stressed by Agenda 21, a document from the United Nations Conference on Environment and Development, prepared in Rio de Janeiro in 1992 (Atalia *et al*., 2015).

The Management of solid waste reduces adverse impacts on the environment and human health and supports economic development and improved quality of life. A number of processes are involved in effectively managing solid waste which are monitoring, collection, transportation, processing, recycling, incineration, landfilling and composting (Enerijiofi and Ekhaise, 2019a). Also included is the remediation of the contaminated sites (Okechukwu *et al*., 2012). It is worthwhile to point out that microbial activities in disposed solid wastes play a crucial role in decomposing organic waste and greenhouse gas emissions (Slezak *et al*., 2015). These various microorganisms proliferate abundantly in landfills due to richness of the different organic matter and substrate complexity; making landfills to be considered as microbial pools (Song *et al*., 2015 a,b).

Studying microbial diversity in solid waste dumpsite using traditional and molecular methods are important so as to decipher the rich microbial content of the solid waste for remediation purposes. However, municipal solid wastes are known to contain large amount of persistent organic pollutants (Courtney and Mullen, 2008). The concentration and transformation of heavy metals in solid municipal wastes has led to accumulation in food web (Enerijiofi and Ajuzie, 2012). The municipal waste dumpsites in Benin City are of environmental interest because of the closeness of these dumpsites to residential houses as a consequence of urbanization and the lack of pre-classification and sorting-out of wastes prior to disposal. Although, many studies have been carried out on landfills, but vertical diversity studies are limited (Osazee *et al*., 2013; Oluseyi *et al*., 2014; Atalia *et al*., 2015). The vertical distance from the surface to the bottom of a landfill may present different levels of moisture content and other environmental factors, composition of stored waste as well as change in the abundance and distribution of the microbial communities (Gomez *et al*., 2011).Two Edo State Government approved dumpsites, Iguomo and Otofure were selected for this study to determine their physicochemicals and heavy metals concentration as well as the microbial diversity from different soil depths as it relates to season, depth and time.

MATERIALS AND METHOD

Area of study

Iguomo and Otofure dumpsites are Government-approved. They are located in Uhumwonde and Ovia North East Local Government areas of Edo state respectively. Iguomo dumpsite lies on lat 6^0 20′ 0″N, 5^0 44′ 0″E and cited in a burrow pit by the Bypass linking Benin – Agbor road to Benin - Ekpoma Road in Benin City. Otofure dumpsite lies on lat 6^0 26′ 58.92″N, 5^0 35′ 49.45″E and situated in a pit by the bypass linking Benin - Lagos road to Benin – Ekpoma road in Benin City. They play host to solid wastes of agricultural, domestic, manufacturing, industrial and construction origins on a daily basis being emptied in them by accredited and unaccredited waste managers of the State waste management board. Residential and commercial buildings were erected and some still being erected at a distance of less than 1km to the dumpsites.

Collection of Samples

The surface debris were removed and fifty grams (50g) of contaminated composite soil samples were aseptically collected from the two dumpsites manually with the aid of a sterilised auger at depths of 0 - 15cm for top soil and 16- 30cm for sub soil. Soil samples were also collected from virgin land which served as control. One set for physiochemical and heavy metal analyses was collected in labelled sterile polyethylene bag while the second for microbiological analysis was collected in a labelled sterile screw-capped bottle.

Physiochemical and Heavy metal Analyses of Soil Samples

The determination of physicochemical parameters were carried out using the methods of Association of Official and Analytical Chemist AOAC (2005). The pH was determined with a glass electrode pH metre Jenway, model 3510 in a 1:2 of soil to water while the electrical conductivity was estimated with electrical conductivity metre, Cation exchange capacity (CEC) by NH_4 saturation, total organic Carbon (Org. C), nitrogen (N), sulphate (SO_4), phosphate (PO_4), nitrate (NO_3) were also determined. The heavy metals were analysed according to the method of Enerijiofi and Ekhaise, (2019a). The soil samples were dried in the laboratory to constant weight through exposure to air and then grounded with a ceramic mortar and pestle. The samples were sieved with 2mm mesh to exclude debris. Two grammes (2g) of the sample was digested with HNO_3: HCl in 1:10. Twenty five millilitres (25mls) of distilled water was added to the mixture and placed in a water - bath followed by heating for 20min to obtain a milky colour. Thereafter, they were removed from heat, allowed to cool and transferred into 50ml sample bottles and made up to the 25ml mark with distilled water. The concentration of metals; sodium, potassium, calcium and magnesium were determined using flame photometer, Jenway, model PFP7 while the concentrations of the heavy metals were determined using Atomic Absorption Spectrophotometer (AAS), model PG 550.

Microbiological Analyses of Soil Samples

Enumeration and Isolation of heterotrophic Bacterial and Fungal Counts

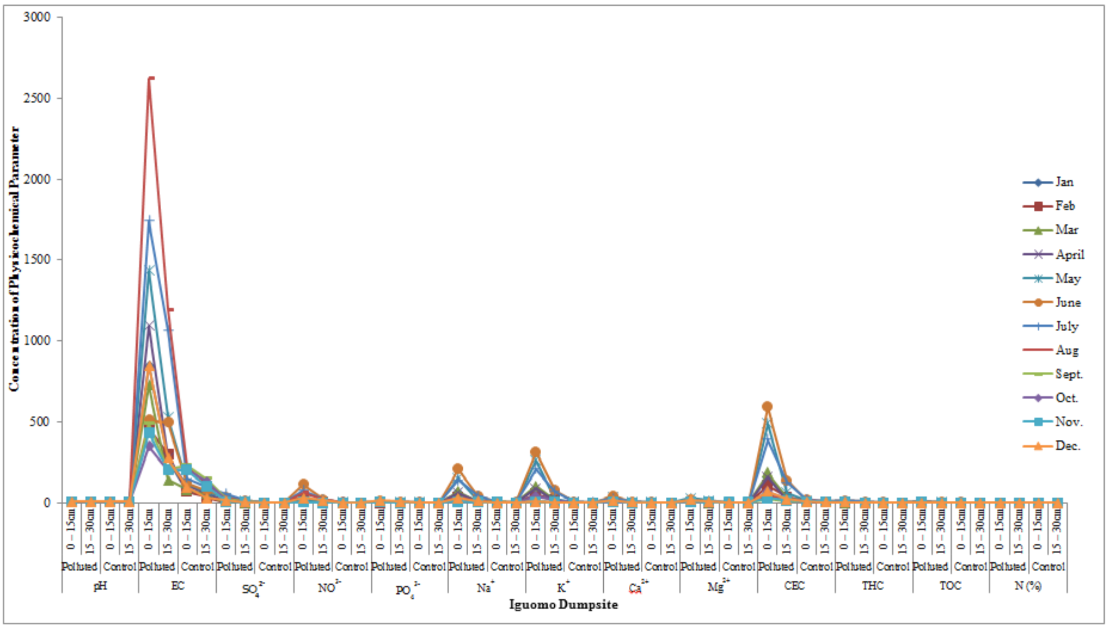
One gram (1g) of soil sample was homogenized in 9mls sterile distilled water to obtain the stock. The stock was thoroughly mixed and serially diluted up to twenty folds. Appropriate 0.1ml aliquots of soil sample dilution from 10^{-6}, 10^{-12} and 10^{-18} were plated on nutrient agar plates in triplicates containing fushin and potato dextrose agar plates containing two drops of streptomycin. The nutrient agar plates were inoculated at $37^{o}C$ for 48h for the determination of total bacterial counts while the potato dextrose agar plates were incubated at room temperature for 72h. The counts were recorded in colony forming units per gram (cfu/g). The various isolates were further identified and characterized (Fawole and Oso, 2001; Cheesbrough, 2006; Eja *et al*., 2010).

Statistical Analysis of Data

The data obtained were recorded in mean and standard deviation. They were statistically analysed by chi square contingency test using Statistical package for social sciences, version 20. The data were compared to determine significant difference based on depths, dumpsites and time (Ogbeibu, 2005).

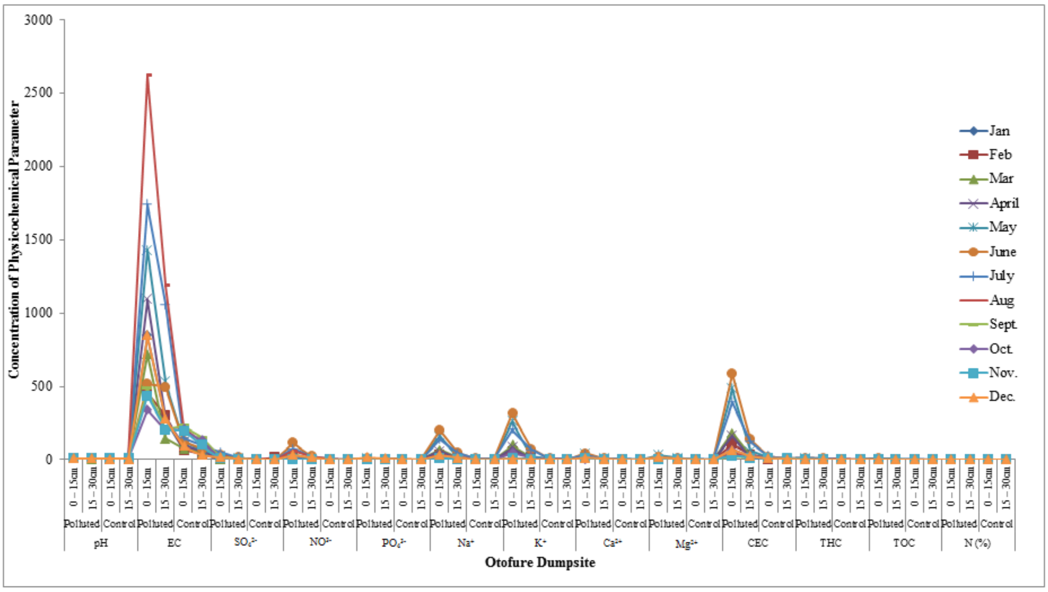
RESULTS

The mean physicochemical parameters of Iguomo dumpsite is recorded in Figure 1 while Otofure dumpsites is recorded in Figure 2. The least pH at Iguomo dumpsite of 6.04±0.01 was recorded in March while the highest of 9.51±0.32 was in August (Figure 1). The least pH of 6.23±0.01 at Otofure dumpsite was recorded in March while the highest of 8.64±0.14 was in July. Electrical conductivity ranged from 142±0.12 in March to 2622±0.30 in August, cation exchange capacity, 12.28±0.17 in September to 592.58±0.23 in June. (Figure 2). The mean heavy metal concentrations of Iguomo and Otofure dumpsites are recorded in Figures 3 and 4 respectively. Iron had the highest concentration of 122.50±0.21mg/Kg in May and 57.59±0.98mg/Kg in July among all metals analysed at Iguomo and Otofure dumpsites respectively. However, mercury had < 0.001mg/Kg across the sampled period in both dumpsites and across season and depth. Figure 5 recorded the mean heterotrophic bacterial and fungal counts. Iguomo dumpsite had the highest bacterial counts of 1.79±0.22 x 10^{12} cfu/g in August while Otofure dumpsite had the highest fungal counts of 1.45±2.10 x 10^{12} cfu/g in September. Also, the least bacterial and fungal counts of 0.30±0.13 x 10^{12} cfu/g in December and 0.22±0.12 x 10^{12} cfu/g in January were recorded at Iguomo and Otofure dumpsites respectively. Iguomo dumpsite had a high significant difference ($p< 0.001$) for bacterial and fungal counts at both depths respectively. Figures 6 and 7 records the frequency of occurrence of bacterial and fungal isolates respectively. *Bacillis cereus* and *Aspergillus* sp. had the highest frequency of occurrence, 43.14% in May and 54.55% in January respectively at the lower depth in Iguomo dumpsite. Also, *Alcaligens faecalis* displayed a high significant difference at both depths in Otofure dumpsite ($p<0.001$). *Rhizopus* sp., *Aspergillus* sp. and *Mucor* sp. had high significant difference at the lower depth at Iguomo dumpsite ($p<0.001$).



* EC (µS/cm), other physicochemical parameters (mg/kg) except pH

Figure 1: Mean Physicochemical Parameters in Iguomo Dumpsite



* EC (µS/cm), other physicochemical parameters (mg/kg) except pH

Figure 2: Mean Physicochemical Parameters in Otofure Dumpsite

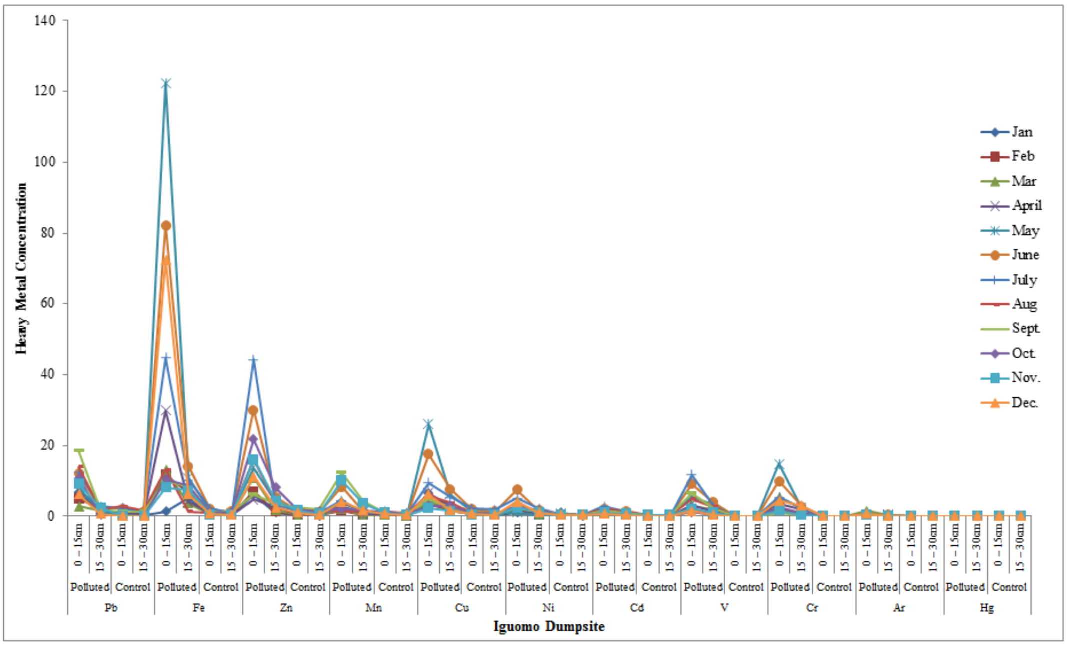


Figure 3: Heavy metal concentrations (mg/kg)in Iguomo Dumpsite

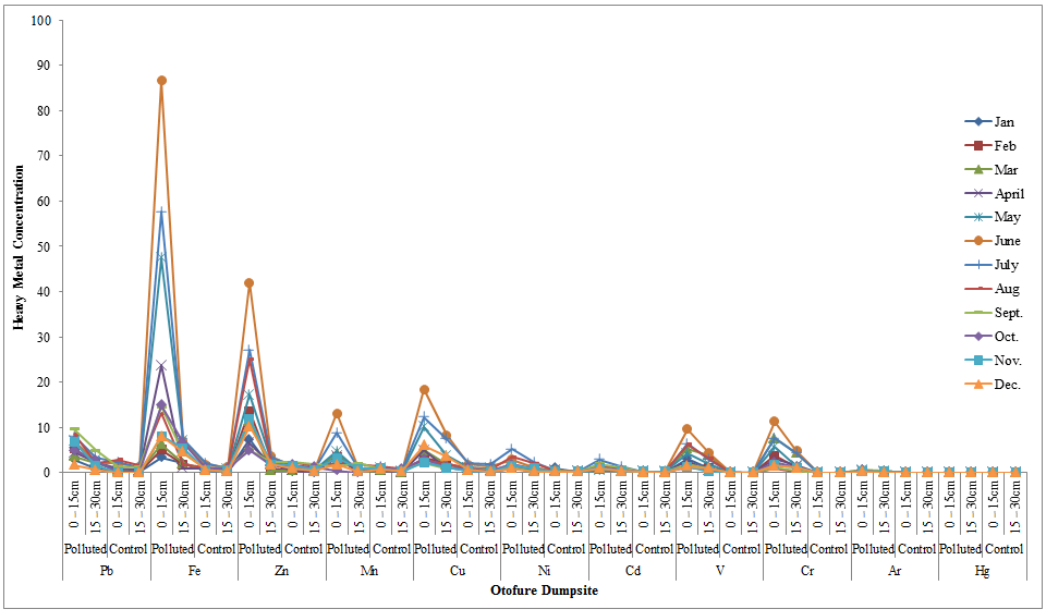


Figure 4: Heavy metal concentrations (mg/kg) in Otofure Dumpsite

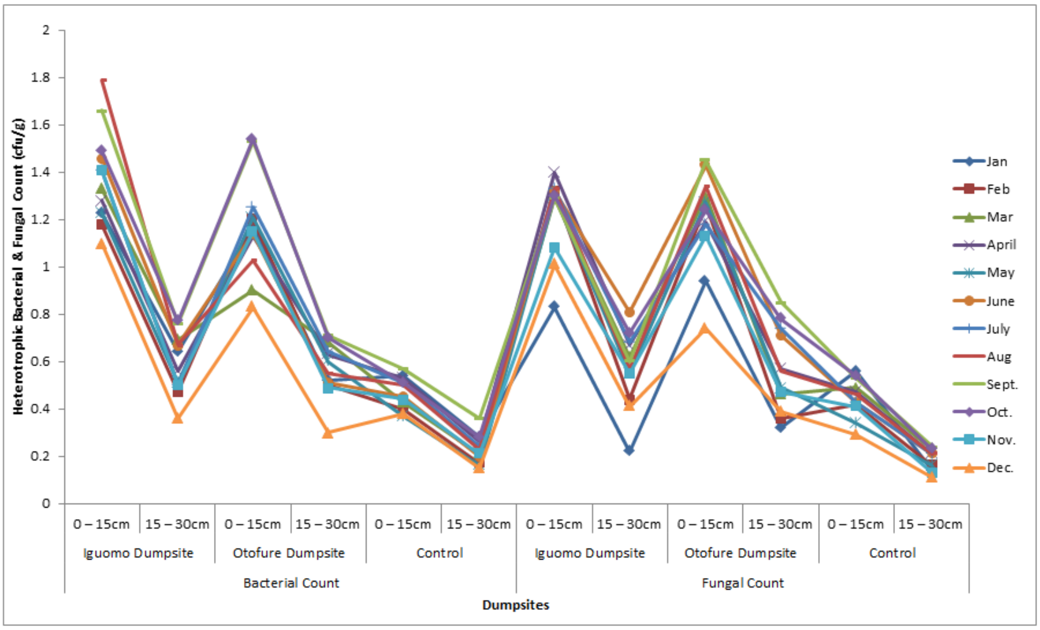
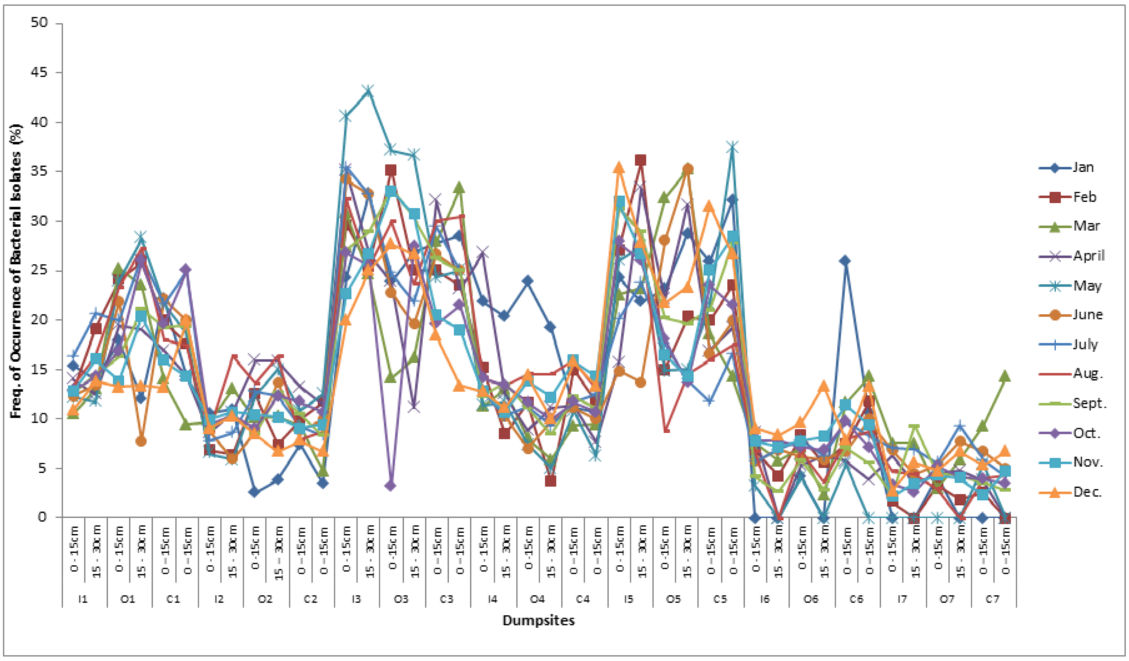
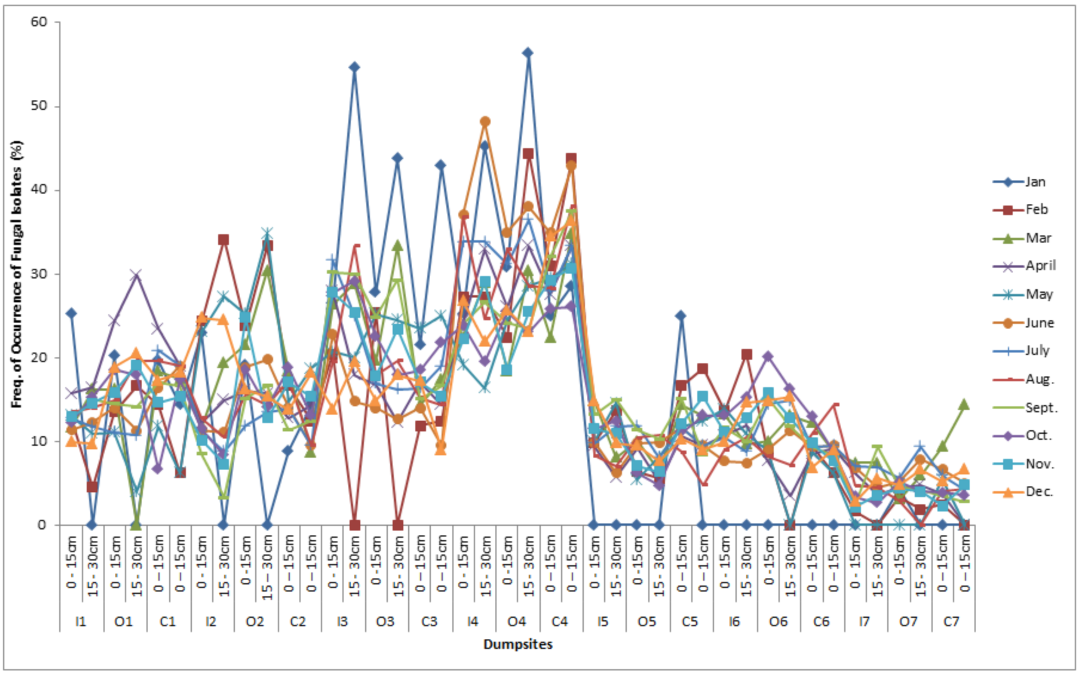


Figure 5: Mean Heterotrophic Bacterial and Fungal counts in Soil samples from Iguomo and Otofure Dumpsites (× 10^{12}cfu/g)



Legend:
I= Iguomo Dumpsite, O= Otofure Dumpsite, I1 and O1 = *Alcaligens faecalis*, I2 and O2 = *Raoutella* sp.,
I3 and O3 = *Bacillus cereus*, I4 and O4= *Pseudomonas aeruginosa*, I5 and O5 =*Myroides odoratimimus*,
I6 and O6= *Providencia vermicola*, I7 and O7= *Providencia rettegeri*, C1 – C7 = control.

Figure 6: Frequency of occurrence of Bacterial isolates from Iguomo and Otofure Dumpsites (%).



Legend:
E= Edaiken market, S= Santana market, I1 and O1 = *Penicillium* sp., I2 and O2 = *Rhizopus* sp., I3 and O3 = *Aspergillus* sp.,
I4 and O4 = *Mucor* sp., I5 and O5 = *Candida albicans,* I6 and O6 = *Saccharomyces cerevisiae*, C1 – C6 = control.

Figure 7: Frequency of occurrence of fungal isolates from Iguomo and Otofure Dumpsites (%)

DISCUSSION

The mean physicochemical parameters of Iguomo and Otofure dumpsites are recorded in Figures 1 and 2. The least pH at Iguomo dumpsite of 6.04±0.01 was recorded in March while the highest of 9.51±0.32 was in August. The least pH of 6.23±0.01 at Otofure dumpsite was recorded in March while the highest of 8.64±0.14 was in July. The range reported in this study agreed with the 6 - 9 and 6.61 - 8.08 reported by FEPA (1991) as well as Osunwoke and Kuforiji (2012) respectively. Electrical conductivity ranged from 142±0.12 in March to 2622±0.30 in August, cation exchange capacity, 12.28±0.17 in September to 592.58±0.23 in June. (Figure 2). In addition to earlier parameters, sulphate, nitrate, sodium, potassium, calcium, magnesium had high significant difference at both sampled depths ($p<0.001$). The mean pH range of values in the soil samples collected from both solid waste dumpsites was between slightly acidic to neutral. The reported range is known to positively influence microbial activity, solubility and ionization of inorganic and organic soil solution constituents which in turn affect soil enzymatic activities (Voroney, 2007). In this study, most physicochemical parameters decreased with increasing soil depth but with increasing rainfall, their concentration increased compared to the months of no rain as documented earlier by Enerijiofi and Ekhaise (2019a). The total organic carbon were of high concentration implying that the dumpsites were rich in organic matter (Alasohty *et al.,* 2011, Ogunmodede *et al*., 2014).The rainfall could have had profound influence on increased rate of decomposition of organic materials as well as leaching and percolation which may have led to increased cations and anions availability especially sulphate, nitrate, sodium, potassium, calcium, magnesium which were higher during the rainy season. These high values obtained could be due to the continuous deposition of municipal solid wastes into these dumpsites on a daily basis which corroborated with the earlier report by (Courtney and Mullen, 2008; Enerijiofi and Ekhaise, 2019a).

The mean heavy metal concentrations of Iguomo and Otofure dumpsites were recorded in Figures 3 and 4. Iron had the highest concentration during the raining season among all metals analysed at both dumpsites. This high value for iron may have arose from it being the most frequently disposed at the dumpsites. However, mercury had < 0.001mg/Kg across the sampled period in both dumpsites and across season and depth. Also, the mean concentrations of iron, zinc, copper and chromium recorded at the upper depths showed high significant difference across depths and time in both dumpsites compared to the control ($p<0.001$). This could be attributed to the high organic matter present at the dumpsites which is a store house for cations and due to biodegradation, increases their bioavailable fractions particularly during the months of rainfall. These heavy metals have been reported to accumulate in food chains which could cause series of environmental and public health challenges including substitution of calcium in bones causing skeletal abnormalities, kidney pains well as brain damage and among others (Enerijiofi and Ajuzie, 2012; Atalia *et al*., 2015).

Figure 5 recorded the mean heterotrophic bacterial and fungal counts. Iguomo had the highest bacterial counts while Otofure had the highest fungal counts in the raining season. Also, the least bacterial and fungal counts were recorded in the dry season. Iguomo dumpsite had a high significant difference ($p< 0.001$) for bacterial and fungal counts at both depths respectively. The implication of these high values means that the dumpsites are rich in biodegradable organic matter which is a source of nutrients. This high organic matter reported in this study could have been responsible for the high bacterial and fungal counts recorded.

In figures 6 and 7, *Bacillis cereus* and *Aspergillus* sp. had the highest frequency of occurrence, 43.14% in May and 54.55% in January respectively at the lower depth in Iguomo dumpsite. Also, *Alcaligens faecalis* displayed a high significant difference at both depths in Otofure dumpsite ($p<0.001$). *Rhizopus* sp., *Aspergillus* sp. and *Mucor* sp. had high significant difference at the lower depth at Iguomo dumpsite(p<0.001). However, Osazee *et al* (2003) reported *Bacillus* sp., *Pseudomonas* sp., *Aeromonas* sp., *Enterobacter* sp., *Klebsiella* sp. and *Staphylococcus* sp., *Aspergillus* sp., *Mucor* sp., *Saccharomyces* sp. and *Fusarium* sp. from solid waste dumpsite which agreed with the report of this study. Also, Achudume and Olawale, (2007) and Oviasogie *et al*. (2010) reported some of the organisms isolated in this study in addition to *Aeromonas*, *Neisseria, Klebsiella*, *Escherichia coli* and *Serratia* species. The biodegradable fraction of municipal solid waste dumpsites could have attracted lots of bacteria which were responsible for the huge microbial activities in soil (Ogwueleka, 2009). The abundance of *B. cereus* was possibly due to the spore structure of the *Bacilli* group. In corroboration, Odokuna and Abah, (2003), reported that the possession of this spore increases its power of uptake and aid in bioremoval which makes it being able to survive harsh environmental conditions. The high prevalence of *Alcaligens faecalis* and*Aspergillus* sp. could be traced to their constant presence in the soil environments as well as their biodegradable capabilities. However, the high presence of these identified microbial isolates are of public health risk since they are pathogens that could be responsible for a number of disease outbreaks. *Pseudomonas aeruginosa* is responsible for a number of infections which can proceed to septicemia if wounds are not sufficiently deep and mortalities can also occur in the form of secondary infections (Enerijiofi and Ekhaise, 2019a). Aflatoxin produced by *Aspergillus* sp. is known for the destruction of the liver by inducing fatty acid metamorphosis of its cells. This leads to decreased Ribosomal Nucleic acid polymerase activity with subsequent impairment in the synthesis of nucleic acid. It also weakens the body and is associated with inhibition of libido in males and ovulation in females (Enerijiofi and Ajuzie, 2012).

In conclusion, this research has offered new insights into microbial diversity patterns through different depths in solid dumpsites contaminated soil environment with unique physicochemical conditions, suggesting that bacterial diversity profiles may be highly influenced by the nature of pollutants present. Additionally, it implies that the culturable fraction at the site has a very important role in the community. Apart from the environmental and public health risks associated with solid waste dumpsites, open dumping is an ancient and unsustainable alternative in the management of soil wastes which should be abolished.

REFERENCES

Achudume, A. C. and Olawale, J. T. (2007). Microbial pathogens of public health significance in waste dumps and common sites. *Journal of Environmental Biology* **28** (1): 151 – 154.

Atalia, K. R., Buha, D. M., Joshi, J. J. and Shah, N. K. (2015). Microbial Biodiversity of Municipal Solid Waste of Ahmedabad. *J. Mater. Environ. Sci.* **6** (7): 1914-1923

Association of Official Analytical Chemists (2005). Method of Analysis, Washington D.C. 225pp.

Alashty, S. R., Bahmanyar, M. A. and Sepanlou, M. G. (2011).Change of pH, organic carbon (OC), electrical conductivity (EC), nickel (Ni) and chrome (Cr) in soil and concentration of Ni and Cr in radish and lettuce plants as influenced by three year application of municipal compost. *African Journal of Agricultural Research***6**(16): 3740-3746.

Babayemi, J. O. and Dauda, K. T. (2009). Evaluation of solid waste generation, categories and disposal options in developing countries: a case study of Nigeria. *Journal of Applied Science and Environmental Management* **13**(3): 83 – 88.

Cheesbrough M. 2006. District Laboratory Practices in Tropical Countries, Part 2, Second Edition. Cambridge Press, New York. p58 -100

Courtney, R. G. and Mullen, G. J. (2008). Soil quality and barely growth as influenced by the land application of two municipal solid waste types. *Technology* **99**:2913-2918.

Eja, M. E., Alobi, N. O., Ikpeme, E. M., Ogri, O. R. and Inyang, A. O. (2010). Environmental and public health - related assessment of solid waste management in Uyo, Akwa Ibom State, Nigeria. *World Journal of Applied Science and Technology* 2: 110 - 123.

Enerijiofi, K. E.andAjuzie, C. U. (2012).Health Impact of some heavy metals resistance in microbes isolated from Ikhueniro Refuse Dumpsite, Benin City.*Nigerian Journal of Microbiology*, **26**: 2592 – 2598.

Enerijiofi, K. E. and Ekhaise, F. O. (2019a). Physicochemical and microbiological characterisation of Edaiken and Santana markets open solid waste dumpsites soils in Benin City, Nigeria. *Fulafia Journal of Science and Technology* **5**(2): 136 -149

Fawole, M. O. and Oso, B. A. (2001). Laboratory manual of Microbiology: Revised edition Spectrum books Ltd Ibadan. 127pp.

Federal Environmental Protection Agency/Federal Ministry of Environment (FEPA/FMENV) (1991). National Guidelines and standards for industrial effluents, gaseous emissions and hazardous waste Management in Nigeria. Government Press, Lagos. 238pp.

Gomez, A. M., Yannarell, A. C., Sims, G. K., Cadavid-Restrepo, G. and Moreno – Herrera, C. X. (2011). Characterization of bacterial diversity at different depths in the Moravia Hill land fill site at Medellín, Colombia. *Soil Biology and Biochemistry* **43**: 1275 - 1284

Slezak, R., Krzystek, L., Ledakowicz, S. (2015). Degradation of municipal solid waste in simulated landfill bioreactors under aerobic conditions. *Waste Management*. **43**: 293–299.

Song, L.Y., Wang, Y.Q., Zhao, H.P., Long, D.T., (2015a). Composition of microbial and archaeal communities during landfill refuse decomposition processes. *Microbiol. Res.* **181**: 105–111.

Song, L.Y., Wang, Y.Q., Tang, W., Lei, Y., 2015b. Microbial community diversity in municipal waste landfill sites. *Appl. Microbiol. Biotechnol*. **99**: 7745–7756.

Odokuna, L. O. and Abah, A. F. (2003). Heavy metals bisorption by three bacteria isolated from a tropical industrial area. *Global Journal of Environmental Science* **2**(2): 98-101.

Ogbeibu, A. E. (2005). Biostatistics: A Practical Approach to Research and Data Handling. Mindex Publishing Company Limited. 264pp.

Ogunmodede, O.T., Adewole, E., Ajayi, O.O. and Onifade, A. K. (2014). Environmental assessment of solid waste management in Nigeria: a case study of IkereEkiti, Ekiti state. *Journal of Physical and Chemical Sciences* 1(1): 1-8.

Ogwueleka, T. C. (2009). Municipal solid waste characteristics and management in Nigeria, *Iran Journal of Environment and Health Science Engineering* 6(3): 173-180

Okechukwu, O. I., Okechukwu, A. A., Noye-Nortey, H. and Owusu-Agyei, L. (2012). Health perception of indiscriminate waste disposal – a Ghanaian case study. *Journal of Medicine and Medical Sciences* **3**(3): 146-154.

Osazee, O. J., Obayagbona, O. N. and Daniel, E. O. (2013). Microbiological and physicochemical analyses of top soils obtained from four municipal waste dumpsites in Benin City, Nigeria. *International Journal of Microbiology and Mycology* **1**(1): 23 30.

Osunwoke, J. I. and Kuforiji, O. O. (2012). Health impact of microorganisms associated with waste dump sites in a private university. *Journal of Sustainable Development and Environmental Protection*, **2**: 59 - 56.

Oluseyi, T., Adetunde, O. and Amadi, E. (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 and Technology* **3** (3**)**:1004 – 1015.

Oviasogie, F. E., Ajuzie, C. U. and Uyiosa, G. I. (2010). Bacterial analysis of soil from waste dumpsites. *Archives of Applied Science Research* **2** (5):161 - 167.

Voroney, R. P. **(**2007). The Soil Habitat. In: Eldor AP, (Ed.) Soil Microbiology, Ecology and Biochemistry. Third edition. New York: Elsevier, 25 – 49.