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# Effect of solid-wastes disposal on microbial population and heavy metals elevation in dumpsites

[1]Agbor R.B, [2]Antai S.P., [1]Anyaike F.I

*[1]Environmental Biotechnology unit, Department of Genetics and Biotechnology, Faculty of Biological Sciences, University of Calabar, Calabar, Cross River State, Nigeria*
*[2]Department of Microbiology, Faculty of Biological Sciences, University of Calabar, Calabar, Cross River State, Nigeria*

**Email. agborreagan@yahoo.com, reaganagbor@unical edu.ng**

## ABSTRACT

**Background**
Solid waste management is a challenge to sustainable development in Calabar metropolis and Nigeria at large. Wastes are discharged into the environment with little or no treatment. Due to activities of microbes, some of these waste undergo degradation releasing toxins into the environment.

**Objective**
The present study evaluated the solid wastes disposal as a major factor to heavy metals and microbial increase in dumpsites

**Methods**

Soil samples for heavy metals and microbial loads were collected from six different dumpsites, 2.5g of the soil was weighed, air-dried and sieved in a 2mm sieve. 5 ml of concentrated nitric acid, 2ml of hydrochloric acid and 1ml of hydrofluoric acid were added. The vessels were then capped and heated in microwave unit at 800W to a temperature of 210$^{o}$C for 20 minutes with pressure of 40 bars using atomic absorption spectrophotometer method for heavy. Data collected were subjected to a two-way analysis of variance (2-way ANOVA) in completely randomized design.

**Results**

The result showed that heavy metals, Cd, Cr, Cu, Pb, Zn, Fe and Ni ranged from 0.19-2.883mg/kg, 0.08-0.183mg/kg, 0.440-1.200mg/g, 0.57-1.07mg/kg and 0.011-0.014mg/kg respectively. The heavy metals are in order of Cd>Fe>Mn>Zn>Cu>Cr>Pb>Ni, while microbial load shows that the total heterotrophic bacteria and fungi ranged from 1.66-2.29CFU/g and 1.22-1.85CFU/g respectively. The following microbial species where identified; *Pseudomonas aeruginosa*, *Bacillus species*, *E.coli*, *P. vulgaris*, *Penicillium specie*, *Aspergillius sp*, *Mucor and Rhizopus sp.* Analysis of variance showed that there were significant differences ($P<0.05$) in microbial loads and heavy metals.

**Conclusions**

The level of contaminations in the dumpsite indicates that the continuous and precarious dumping of solid waste areas in Calabar metropolis should be discourage due to their associated negative health impacts.

**Key words: Waste, contamination, pollution, management, dumpsite, metals, disposal**

## INTRODUCTION

Solid wastes disposal in an unsanitary way as adversely affected human health and ecosystem, thus, culminated into global issues over the years. Solid wastes generates chemical and biological substances that interferes with normal functioning of the environment, due to their abundance that exceed the threshold limit. Research over the years have shown that availability of solid waste increases the abundance of heavy metals into the surrounding soil and ground water [1, 2]. Soil is a natural reservoir of metals whose concentrations are associated with several factors such as biological and biogeochemical cycling, parental among others. However, large amount of these heavy metals are released into the soil as a result of increased anthropogenic activities such as agricultural deposit, industrial activities and waste disposal methods thus leading to the pollution of the soil [3, 4].

Waste generation has drastically increased over the years due to expanded industrialization and overwhelming human population. Solid waste is ubiquitous, the disposal and management practice in developing countries appears to be a major problem unlike the advanced countries. Environmental sanitation is a huge problem in many areas in Nigeria due to ungoverned and failures to regulate the disposal of wastes. It is a common habit that huge refuge are dumped around residential areas, minor and major roads leading to decomposition and invariably pollution of suitable air, soil and water environment [5]. Inadequate waste management is a major threat to sustainable development in Nigeria. Waste are generated in nearly all sectors of the economy (hospitals, agriculture, market, workshops, food processing etc). Mismanagement of hospital waste which are termed hazardous are discharged into the environment without treatment. This waste include pathological, hazardous chemicals, radioactive, stock cultures, blood and blood products, animal carcass, pharmaceutical, pressurized containers, batteries, plastics, low level radioactive materials, disposable needles, syringe, scalpels, clinical bandages, gauze etc. Poor waste management poses a great challenge to the well-being of inhabitants of such areas, particularly those living adjacent to the dumpsites [1]. However, if regulatory bodies cannot constitute policies that will ensure effective disposal of wastes, the current Corona virus (COVID-19) ravaging the world would not be properly manage, because of our poor attitude in the management of wastes generated from isolation centers. It is my fear that burying of wastes generated from such centers without proper incineration could lead to another great pandemic which could evolved due to multiplication effects when the existing virus interact with other viruses in the soil.

Waste sorting is a practice Nigerian government have never thought of; industrial, municipal, domestic and medical wastes are deposited in open unsecured dumpsites and non-sanitary landfills [6].Waste are haphazardly deposited as a result of which adjoining lands get enriched in salts and trace metal thereby posing threat to the environment thus, there is an increasing awareness to minimize the levels of the wastes discharged into the environment. The UNEP is drawing the attention of Nations towards the consequences of waste management [7].

Landfill is the most common form of disposal of Municipal solid waste (MSW) world wide. Municipal dumpsite represent a large part of the waste disposal system in developing countries. Infact, a considerable portion of the municipal solid waste is disposed in open dumps or poorly managed landfills even in industrialised countries [8]. The root cause of environmental pollution has been man’s tendency to dilute and disperse waste rather than remove them at the source. With the ever increasing population, Urbanization and industrialization, the environment is considerably polluted even in the developed countries.

Heavy metals are known as harmful pollutants in soil having a negative effect on soil biota including microorganisms. Some heavy metals such as lead even at low levels are toxic while others such as zinc and copper at low concentrations are essential for microorganisms [9]. Toxicity may also be exerted by many inorganic and organic metal complexes. Heavy metals affect microorganisms in soil in various ways. They shift the structure of microbial populations, impoverish their diversity, and affect species compositions, reproduction and activity of indigenous microorganism [10].

The composition of municipal solid waste is quite heterogeneous. This mixed composition results in the presence of a variety of microorganisms that reach densities which are relatively high, and which remain high even after many years in a landfill. Microorganism densities in the air at municipal solid waste processing plants tend to be higher than levels near wastewater treatment facilities. This may be due to indoor operations. Composting can inactive essentially all of the microorganisms associated with fecal matter, but thermophile fungi may cause adverse health problems. The presence of microorganisms in municipal solid waste does not mean that there is a high risk of infection or disease if a person is occupationally exposed to the waste. Dose-response relationships with various microorganisms have shown that a relatively large number of microbes are necessary to initiate an infection or cause disease. The solid waste dumpsites are dominated by bacteria and fungi of different groups, shapes and sizes.

Waste disposal poses threat to both man, animals and the soil. Like chemical hazard, etiologic agents might be disposed in the environment through water and wind. Poisonous plants, insects, animals and indigenous pathogens are biologic hazards that might be encountered at the waste site [11]. When waste is dumped on land, soil microorganism including fungi and bacteria, readily colonize the waste carrying out the degradation and transformation of degradable (Organic) materials in the waste [12]. Microorganism in waste dump use the waste constituents as nutrient. Thus detoxifying the materials as their digestive processes breakdown complex organic molecules into simpler less toxic molecules [13]. This metabolic activity can be attributed to their high growth rate, metabolism and their digestive processes breakdown complex organic molecules into simpler less toxic molecule.

## RESULTS AND DISCUSSION

## RESULTS

### Heavy metals contents from dumpsites

The cadmium in the lemna new dumpsite soil sample was significantly higher ($p<0.05$) than other samples. This was followed by the cadmium content in soil from OLD (1.997), Marian

(0.247) and Watt market (0.225) with no significant difference (p>0.05) in mean values obtained. UCTH and General hospital soil had the lowest cadmium level (Table 1). This result imply that the lemna dumpsite soil had the highest cadmium level while hospital and market soil dumpsite had significantly reduce cadmium level. The soil from NLD had the highest level of chromium, copper, manganese, nickel, lead and zinc than other samples. The chromium level obtained from UCTH and OLD, copper, manganese from OLD, lead and zinc from General Hospital with no significance difference (P>0.05) in mean values obtained (Table l). The chromium content in soil samples from Marian (0.170), Watt market (0.190) dumpsite, copper and manganese (1.190) from UCTH (0.290), lead Marian soil (0.08), Watt market (0.100), UCTH (0.12) and zinc from Marian market (0.853) and Watt market dumpsite (0.890) with no significant difference (p>0.05) in the mean values obtained. The chromium content from G. Hospital (0.140), copper from Marian market dumpsite (0.11), manganese from Watt market (0.57) and zinc from UCTH dumpsite (0.440) had the lowest mean values with no significant difference (p>0.05). This result thus imply that chromium, cadmium, copper, iron, manganese, nickel, lead and zinc from the lemna dumpsites was significantly higher (p<0.05) than other soil samples obtained from hospital and market dumpsite. However, the market dumpsite (Marian & Watt market) tend to have the lowest copper, iron, manganese and lead level in the soil. The implication of this could be attributed to the composition of the wastes that is mostly vegetable without any metals associate properties (Table 2).

## Table 1

### Heavy metal accumulation in soil samples from different dumpsites

| Parameter mg/kg | MM | WM | UCTH | GH | OLD | NLD | LSD | WHO [16] | FEPA |
|---|---|---|---|---|---|---|---|---|---|
| Cadmium | **0.24$^{b}$±0.01** | **0.225$^{b}$±0.01** | **0.166$^{c}$±0.001** | **0.19$^{c}$+0.001** | **1.997$^{b}$+0..03** | **2.883$^{a}$±0.06** | **0.03** | 0.03 | 0.03 |
| **Chromium** | **0.170$^{c}$±0.01** | **0.190$^{c}$±0.006** | **0.227$^{b}$±0.09** | **0.140$^{a}$±0.006** | **0.280$^{b}$±0.006** | **0.310$^{a}$±0.006** | **0.02** | 0.02 | 0.03 |
| **Copper** | **0.11$^{f}$±0.01** | **0.170$^{e}$+0.01** | **0.290$^{c}$±0.01** | **0.233$^{d}$±0.01** | **0.380$^{b}$±0.01** | **0.473$^{a}$±0.01** | **0.03** | 0.2 | 0.2 |
| **Iron** | **0.57$^{b}$±0.01** | **0.65$^{c}$±0.01** | **1.07±0.01** | **1.10±0.01** | **1.770±0.01** | **1.640±0.011** | 0.02 | 0.3 | 0.3 |
| **Manganese** | **0.750$^{e}$+0.01** | **0.57$^{I}$±0.01** | **1.090$^{c}$±0.01** | **0.953$^{a}$x0.01** | **1.27$^{b}$±0.01** | **1.390$^{a}$±0.01** | **0.11** | 0.05 | 0.05 |
| **Nickel** | **0.013$^{a}$±0.001** | **0.014$^{a}$±0.00** | **0.01 l$^{a}$±0.001** | **0.013$^{a}$±0.00** | **0.014±0.00** | **0.13±0.0** | **NS** | 0.07 | 0.07 |
| **Lead** | **0.08$^{c}$±0.01** | **0.100$^{c}$+0.01** | **0.12$^{c}$±0.01** | **0.150$^{b}$±0.01** | **0.183$^{a}$±0.01** | **0.19$^{a}$±0.01** | **0.02** | 0.05 | 0.05 |
| **Zinc** | **0.853$^{c}$±0.01** | **0.890$^{c}$+0.01** | **0.440$^{a}$±0.01** | **0.970$^{b}$±0.01** | **1.177$^{a}$±0.01** | **1.200$^{a}$±0.01** | **0.04** | 0.01 | 0.01 |

Mean with the same superscript along the horizontal arrays indicates to significant difference (P>0.05)

**Abbreviations: MM, Marian Market; WM, Watt Market; UCTH, University of Calabar Teaching Hospital; GH, General hospital; OLD, Old lemna dumpsite; NLD, New Lemna dumpsite; LSD, Least significant difference.**

**Table 2**

**Comparison of heavy metal and microbial load in soil**

| **Parameters (mg/kg)** | HD | MD | LD | **LSD** | **WHO [16]** | **FEPA** |
|---|---|---|---|---|---|---|
| Cadmium **(mg/kg)** | $0.18l^{b}\pm0.01$ | $0.236^{b}\pm0.01$ | $2.440^{a}\pm0.20$ | 0.52 | 0.03 | 0.03 |
| Chromium **(mg/kg)** | $0.183^{b}\pm0.02$ | $0.180^{b}\pm0.01$ | $0.295^{a}\pm0.01$ | 0.02 | ***0.02*** | ***0.03*** |
| Copper **(mg/kg)** | $0.262^{b}\pm0.01$ | $0.142^{c}\pm0.01$ | $0.427^{a}\pm0.02$ | 0.06 | 0.05 | 0.05 |
| Iron **(mg/kg)** | $1.087^{b}\pm0.01$ | $0.610^{c}\pm0.02$ | $1.705^{a}\pm0.03$ | 0.21 | 0.3 | 0.3 |
| Manganese **(mg/kg)** | $1.022^{b}\pm0.03$ | $0.66^{c}\pm0.04$ | $1.33^{a}\pm0.03$ | 0.16 | 0.50 | 0.50 |
| Nickel **(mg/kg)** | $0.012^{a}\pm0.001$ | $0.14^{a}\pm0.001$ | $0.020^{a}\pm0.001$ | NS | 0.07 | 0.07 |
| Lead **(mg/kg)** | $0.135^{b}\pm0.01$ | $0.09^{c}\pm0.01$ | $0.187^{a}\pm0.01$ | 0.03 | 0.05 | 0.05 |
| Zinc **(mg/kg)** | $0.705^{c}\pm0.12$ | $0.872^{b}\pm0.01$ | $1.188^{a}\pm0.01$ | 0.02 | 0.01 | 0.01 |
| Bacteria x $10^{7}$(CFU/g) | $1.92^{b}\pm0.32$ | $2.16^{a}\pm0.64$ | $1.88^{c}\pm0.98$ | 0.02 | | |
| Fungi x$10^{6}$(CFU/g) | $1.38^{b}\pm0.27$ | $1.74^{a}\pm0.52$ | $1.34^{b}\pm0.41$ | 0.12 | | |

Mean with the same superscript along the horizontal arrays indicates to significant difference (P>0.05)

**Abbreviations: HD, Hospital dumpsite; MD, Market dumpsite; LD, Lemna dumpsites; LSD, Least significant difference.**

### Microbial loads from different dumpsites

The microbial population as presented in Table 3 show that the bacteria counts from UCTH (1.97xl0$^7$CFU/g), Lemna dumpsite new and old (2.29x10$^7$CFU/g) and 2.03x10$^7$CFU/g) Marian market dumpsite (2.09 x 10$^7$CFU/g) was significantly higher (p>0.05) than other dumpsites, the counts obtained from General Hospital dumpsite (1.85 x 10 CFU/g) while Watt market (1.66 x 10$^7$CFU/g) had the lowest bacteria counts. This result imply that the bacteria counts from Lemna dumpsite was the highest, the hospital dumpsite while the market dumpsite had the lowest bacteria counts. The fungi counts from NLD was the highest (1.85 x 10$^6$CFU/g) followed by GHD (1.53 x 10$^6$CFU/g) while UCTH, Marian market and Watt market had the lowest fungi counts of 1.23 x 10$^6$CFU/g, 1.2 x 10$^6$ CFU/g and 1.42 x 10$^6$CFU/g and 1.42 x 10$^6$CFU/g respectively, with no significant difference (p>0.05). This result implies that Lemna dumpsite had the highest counts while Hospital and market dumpsite had the lowest fungi counts.

**Table 3**

**Microbial population of soil samples from different dumpsites**

| **Location** | **Source** | **Bacteria (x$10^7$ CFU/g)** | **Fungi (x$10^6$ CFU/g)** |
|---|---|---|---|
| Hospital dumpsite | GH | $1.85^b \pm 0.85$ | $1.53^b \pm 1.45$ |
| | UCTH | $1.97^a \pm 0.39$ | $1.22^c \pm 0.14$ |
| Lemna dumpsite | NLD | $2.29^a \pm 0.46$ | $1.85^a \pm 0.27$ |
| | OLD | $2.02^b \pm 0.45$ | $1.63^b \pm 0.21$ |
| Market dumpsite | MM | $2.09^a \pm 0.88$ | $1.25^c \pm 0.29$ |
| | WM | $1.66^c \pm 0.15$ | $1.42^c \pm 0.15$ |

Means with different superscript along the vertical arrays indicate significant difference at 5% probability level.

**Abbreviations: MM, Marian Market; WM, Watt Market; UCTH, University of Calabar Teaching Hospital; GH, General hospital; OLD, Old lemna dumpsite; NLD, New Lemna dumpsite.**

## DISCUSSION

The bioaccumulation of heavy metal in an environment or soil ecosystem affects the population dynamics of microorganism due to its toxic effect above the normal threshold level. The amount or proportion of heavy metals found in the various dumpsites soils were alarming because of the injurious effects, they might cause to plant and microorganisms inhibiting the area. The uncivilized manner in which this refuse are dumped wound invariably cause an outbreak of a pandemic that will affect surrounding occupants of residential buildings. [15] observed a high level of heavy metals in their research on impact of dumpsites on groundwater quality. However, judging from the result, cadmium in NLD soil was far higher than what was obtained from other dumpsites (Table 1). The availability of cadmium was equally found in a lesser proportion in OLD (1.997mg/kg), Marian (0.247 mg/kg) and Watt market (0.225 mg/kg) with no significant variability in mean. While UCTH and General hospital dumpsite soil had the lowest cadmium level (Table 1). This result imply that the LD soil had the highest cadmium level while Hospital and market soil dumpsite had significantly reduce cadmium level, the Cadmium though high and low in most dumpsites exceed the WHO [16] and FEPA recommended standard. Cadmium and Lead are known to be toxic to microorganism even at a low concentration, and they might cause anomalies in metabolic functions of the organism especially in greater quantities. The soil from NLD had the highest level of chromium, copper, manganese, nickel, lead and zinc than other samples. The chromium, lead, zinc copper and manganese level from UCTH, OLD and general hospital were relatively reduce with no significant variation in mean values. The chromium content in soil samples from Marian (0.170 mg/kg), Watt market (0.190 mg/kg) dumpsite, copper and manganese (1.190 mg/kg) from UCTH (0.290 mg/kg), lead from Marian soil (0.08 mg/kg), Watt market (0.100 mg/kg), UCTH (0.12 mg/kg) and zinc from Marian market (0.853 mg/kg) and Watt market dumpsite (0.890 mg/kg) were also found in reduce proportion with no significant difference ($p>0.05$) mean. While the chromium content from G. Hospital (0.140 mg/kg), copper from Marian market dumpsite (0.11 mg/kg), manganese from Watt market (0.57 mg/kg) and zinc from UCTH dumpsite (0.440 mg/kg) had the lowest mean values with no significant difference ($p>0.05$). This result imply that chromium, cadmium, copper, iron, manganese, nickel, lead and zinc from the LD were significantly higher ($p<0.05$) than other soil samples obtained from hospital and market dumpsite. However, the market dumpsite (Marian & Watt market) tend to have the lowest copper, iron, manganese and lead level in the soil. The implication of this could be attributed to the composition of the wastes that is mostly vegetable without any metals associated properties (Table 2). Dumpsites spread pollutants across our aquatic and terrestrial environment, they damage the health and violate the human rights of hundreds of millions of people who are living on or around them. The disposition of wastes in landfills area increases the level of heavy metal content, which adversely leaked into the underground water table and thus contaminating the aquifer. The disposition of waste affects the aquifers but also alter the soil physiochemical properties. The accumulation of heavy metal in soil enters the food chain, which may cause food poisoning. Lead (Pb) is a particular dangerous metal that has two beneficial relevance in biology but known to affect children negatively at high level. The lead found in the various dumpsites was significantly high and above the threshold standard as recommended by WHO and FEPA. The high level of Pb in the samples could be attributed to the high metals deposits in the dumpsite areas. However, the level of Cd, Cr, Cu, Fe, Mn, Ni and Zn were observed to be higher than the WHO minimum acceptable standard for drinking water. The heavy metals such as Zn and Copper are essential during metabolism in organism. The toxicity and essentiality of this metals is a major concern. Chromium poses a threat to public health because of its carcinogenic properties. [15] in their report on microbial load and heavy metal analysis of leachate samples noticed a spike in the microbial and heavy metal (Cd, Cr, Fe, Pb, Mn, Cu, Hg) and attributed it to the continuous and precarious dumping of solid waste in the sampled area. Manganese may leach out of the soil under prolonged waterlogged environment. The microbial load in the soil samples especially in LD was alarming but expected because of the regularities in the dumping of all assorted types of wastes. The microbial load from the clinical waste site was far reduce. This could be attributed to the frequent evacuation of the waste from such environment. The microbial load from the market dumpsites was higher than that of clinical dumpsites. However, the market dumpsite generate mostly vegetable wastes which are liable to decomposition (decay), and degradation thus producing lots of soil microbes. [17, 18] observed an appreciation increase in the heavy metal and microbial load in ground water samples collected from landfill and non-landfill areas in Calabar. *P.vulgaris, E. Coli Bacillus derma sp, Mucor sp, Penicillium, Rhizopus sp and Asperepllus sp* were the most prevailing microorganism identified from the dumpsites. The abundance of this species of bacteria and fungi in the soil sample is an indication that the soil could be a real source of nutrient for plants growth and productivity.

## MATERIALS AND METHODS

**Study area:** The study was carried out in Calabar metropolis located between latitude $5^{0}31$N, longitude $5^{0}45$E with average temperature ranging from 25-28$^{0}$C. It has an area of 406 square kilometers and a population of 529.363 according to 2015 population census. The city is one of the major hubs of tourism and business in Southern Nigeria. It is a commercial capital city of Cross River State and one of the cosmopolitan cities in Southern Nigeria, comprising originally of Efut, Quas and the Ijagam people. Six dumpsites (Watt and Marian market, General hospital and UCTH, Old Lemna dumpsites (OLD) (Fig. 2) and New Lemna dumpsites (NLD) (Fig. 1)) were identified for this study. These dumpsites served as the major means of waste disposal to the people of the community, patients and market vendors.

**Method of sample collection:** Samples were collected randomly at recognized and selected locations from the solid waste dumpsites into well labelled polythene bags. The twenty four (24) samples used for analysis were collected at 0-15cm depth using soil auger and transferred into polythene bags, tightly sealed with minimal air-space and stored in a cool place to prevent breaking of organic matter. Samples were air-dried for 48 hours and then sieve with 2mm mesh to remove debris, gravel and other materials prior to analysis.

**Materials/reagents:** Heavy metals analysis was carried out with atomic absorption spectrometer UNICAM 969 and operated as per the manufacturer's manual. The reagents employ for this study were all of analytical grade, and standard solutions were prepared from 1000µg /g stock solution of Cd, Cr, Pb, Cu, Fe, Ni, Zn and Mn. Additionally washed with 1.4 $HNO_3$ and then rinsed with distilled water.

**Sample treatment:** The sample containers (Conical flask) used to sample for heavy metal analysis were washed with metal free detergent and rinsed with tap water. They were soaked in

1M $HNO_3$ for 24 hours and later rinsed with de-mineralized water and kept in air-tight container till sampling period.

**Determination of heavy metal contents of the soil at the dumpsites:** The soil samples were air-dried and passed through a 2mm sieve. Soil portions (2.5g each), were acid digested in microwave assisted Kjeldahi digested by adding 5ml of concentrated nitric acid, 2ml hydrochloride acid and 1 ml of hydrofluoric acid. The vessels were capped and heated in a microwave unit as 800W to a temperature of $210^0$C for 20 minutes with pressure of 40 bar. The digested samples were analyzed for heavy metals (Pb, Ni, Cd, Cu, Zn, Fe and Cr) by atomic absorption spectrometer (AAS) of UNICAM 919 model at the Research and Development Laboratory, Ministry of Science and Technology, Obio Imo Street, Uyo, Akwa Ibom State. The instrument was calibrated with analytical grade standard metal solutions.

**Analytical method for bacteria and fungi counts:** The soil samples weighed at 1g each dissolved in 10ml of sterile distilled water. This formed the neat solution. This was further diluted by pipetting 1ml of the original solution adding 9ml of sterile water until the dilution of $10^{-5}$ was achieved for bacteria and 10-3 for fungi. 0.1ml of 10-5 was plated on nutrient and MacConkey agar and 0.1ml of 10-5 was plated out on Sabourand Dextrose Agar. Incubation was 18 – 24 hours for the bacteria culture and 3 -7 days for the fungi plate {14}. Pure culture of bacteria was taken aseptically streaking representative colonies of different morphological types. The cultural plate into fleshly prepared nutrient agar plates which was incubated at 370c for 24hours. Pure culture fungi were obtained by sub culture discrete colonies into freshly prepare sabourand's dextrose agar plates and incubate at $28^0$c for 5 to 7 days.

**Statistical analysis:** Data collection were subjected to a 3x2 factorial analysis in a Complete Randomized Design. While significant means were separated using least significant difference test (LSD) at 5% prohibited by level.



FIG. 1: NEW LEMNA DUMPSITE (NLD)

FIG. 2: OLD LEMNA DUMPSITE (OLD)


FIG. 3: SOLID WASTE MISMANAGEMENT

## Conclusion

Solid waste mismanagement (Fig. 3) has been a very serious problem in developing cities. Wastes taken to dumpsite for disposal yield toxins which cause serious environmental problems through the contamination of land and water resources. This finding revealed high levels of heavy metals in the soils from different dumpsites in Calabar metropolis. The microbial load, especially from Lemna dumpsites was higher than other sources. This result emphasizes on the necessity for better solid waste management in Calabar metropolis with source segregation of hazardous municipal and industrial waste before disposal as well as enforcing regulations.

## Ethical Statement

Not applicable.

## Conflict of interest

Agbor R.B, Antai S.P., Stanley, E.U declare that they have no conflict of interest.

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