IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 11, November 2016
ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
www.ijiset.com

Microbiological Analysis and Solid Waste Biodegradation Potential among Some Selected Isolates from Municipal Dumpsite in Calabar Municipality, Cross River State

S. P. Antai , A.D. Asitok, D.R. Tiku, and O.I. Louis
Department of microbiology, University of Calabar, Calabar-Nigeria

Abstract: The study was aimed at investigating the microbiological analysis and solid waste biodegradation potential among some selected isolates from municipal dumpsite. Municipal wastes, its leachate, soil and air samples within the dumpsites were randomly sampled (during wet and dry seasons) within Calabar metropolis. The research was undertaken within a period of six months. Standard microbiological methods were used to isolate, characterized and identify both bacteria and fungi isolates from the collected samples. A leachate collection system constructed using four-sided polyethylene water container attached to bottle with perforated holes on one side, and pushed under (perforated sides up) the waste hip at various locations was used for leachate collection. The result of the dump site samples collected showed that the total bacterial count of the dump site sample was generally higher in the wet season than dry season. In the dry season, there were no significant differences ($p<0.05$) between the waste soil bacterial count, waste soil fungal count, waste fungal count and dump site air fungal count. For the wet season, there was no significant differences in the waste-soil bacterial count and waste bacteria count but a significant difference in the waste fungal count and waste soil fungal count was observed. Bacteria isolates from the waste samples were identified as *Bacillus spp,* and *Klebsiella sp, Escherichia coli, Enterobacter sp, Salmonella sp, Staphylococcus sp, Shihella sp* and *Pseudomonas sp,* while the fungi isolates were identified as *Aspergillus sp, Mucor sp, Nocardia sp,* and also the filamentous bacteria-*Actinomyces sp* was identified. The result of the screen test for the biodegradation of plant and paper wastes by the fungal and bacterial isolates from the collected samples revealed that amongst the isolates identified, *Bacillus spp, Nocardia spp, Aspergillus spp and Mucor spp* showed potentials of paper and plant biodegradability compared to other isolates from the collected samples. However, from this research study, the garden street dump site has been proven to be a considerable source of microbiological contamination and infection in Calabar municipality, as the examined waste samples from the aforementioned site contained considerable quantities of potentially pathogenic microorganisms. Therefore, its extended influences on the air, as well as the soil, plant and surrounding ground water should be given due considerations by government and other environmental agencies in the state, by providing a well constructed and operated land fill sites for municipal waste disposal, so as to safe guard both the public and environmental health from future potential hazards. However the ability of some of the screened isolates (*Nocardia spp, Bacillus spp, Aspergillus spp, and Mucor spp*) to bio-utilize plant

and paper wastes was an added advantage, as they could be developed for potential, sustainable, and eco-friendly composting process.

INTRODUCTION

Solid waste management has remained an undisputable environmental problem in the developing countries of the world and it stands out amongst the arrays of global environmental hazards besieging metropolitan cities (UNEP, 2007). This problem has become increasingly complex due to the increase in human population, industrial and technological revolutions, in addition to the fact that the processes that control the fate of wastes in the receiving media are complex (Eni *et al*, 2014). Sold waste are any non-fluidic/non-flowing substance which has been identified to be of no use or has no immediate economic demand at a particular point or source either as a raw material, end product, expired products, containers or after use reminants and which must be disposed of (Longe *et al*, 2010 ; Eni *et al*, 2011). They are generated from various human activities such as domestic, hospital, industrial and agricultural activities. According to Udiba *et al*, 2015 and Patil *et al*, 2013 , it may be categorized according to its origin (domestic, industrial, commercial, construction or institutional), according to its contents (organic material, glass, metal, plastic paper etc) or according to hazard potential (toxic, non-toxin, flammable, radioactive, infectious etc). landfills and open dumping remains the major method of disposing solid waste in Nigerian cities, and solid waste disposed in landfills is usually subjected to series of complex biochemical and physical processes, which leads to the production of both leachate and gaseous emissions (Ezenwa, 2014) while municipal waste dumping sites as an alternnative, are designate places where waste from various sources are deposited (Ekpo *et al*, 2013). These sites are not properly constructed nor designed, and consequently wastes dumped there over the years biodegrade and generate leachates that ultimately become point source of pollution into soil and ground water (Agbor *et al*, 2013) when precipitation occurs, percolating water (leachates) dissolves many organic and inorganic salts with may be transported to nearby aquifers resulting in the alternation of the water quality (Ezike *et al*, 2012). The rate of production and characteristics of leachate produced depends on a number of factors which include but not limited to solid waste composition, particle size, degree of compaction, hydrology of site, age of land fill, moisture, temperature conditions and availability of oxygen (Adakole *et al*, 2010). The implication of the dumpsite on groundwater hydrology is that leachates from the dumpsite infiltrates into the ground and also move in the direction of groundwater flow thereby contaminating the groundwater along its path (Aydin, 2007), consumption leads to several health challenging and it has been observed that bad quality water issue such as typhoid, kidney disease, liver and environmental health related problems. However, various searches have shown that the indiscriminate handling and disposal of wastes, leads to environmental degradation, destruction of ecosystem and noses great risks to public health (Fakayode, 2005). It is on this basis that this research study is focused on microbiological analysis and solid waste

biodegradation potentials of some selected isolates from municipal dumpsites in Calabar Municipality, Cross River State.

MATERIALS AND METHODS

The study area,

The study area was Calabar Municipality (fig. 1), which is located between latitude $4^0$13' and $5^0$15' and longitudes $8^0$15' and $8^0$25' in Nigeria. The area is characterized by the wet and dry seasons with high annual rainfall in the range of 350-400mm and run-off estimated to reach 90% (CRBDA, 1982).

Materials used

The materials used for this work includes; petri-dishes, test tubes, conical flasks, pipettes, slides, cover slips, filter paper, masking tape, aluminum foil, polyethylene bottles, and McCartney bottles.

Culture media

The following culture media were used for the isolation, identification and characterization of microorganisms from the samples, nutrient agar (NA), MacConkey ager (MCA), Sabouraud pledextrose agar (SAD), Triple Sugar Iron (TSI) agar and Citrate agar. All the media were products of Diagnostics laboratory, USA, and they were all prepared in accordance to the manufacture's instruction.

Chemicals and reagents

For the identification and characterization of the isolates, chemicals used include; crystal violet, 95% ethanol, Lugol's iodine, Safranin, Lactophenol in cotton blue, Kovac's reagent, hydrogen peroxide (H_2O_2), Methyl red (MR) vogues proskauer reagents, d-Napthnol solution, potassium hydroxide (KOH) and methylated spirit.

Sample Collection

Leachate collection system was constructed using four- sided polyethylene water containers. Holes were perforated on one side of the bottle. These bottles were pushed (perforated sides up) under the waste heap at various locations with the stopper cover sticking out for easy identification. Each bottle was taken as leachate collection chamber. Sterile conical flasks well stoppered with cotton wool and aluminum foil were used for collection of leachate and borehole water samples. the samples were labeled and stored under refrigeration temperature until use.

Soil Samples

A garden rake was used to remove the waste so as to expose the soil under it. Soil samples were then collected with hand trowel into aluminum foil and labeled.

Other samples

The decomposing waste, and plant leaves were each aseptically collected into sterile disposable petri-dishes sealed with masking tape and properly labeled. All samples were stored in the refrigerator before use.

Isolation of bacteria and fungi isolates

Soil at dumpsite (sd)

Serial dilutions 1.0g of soil samples was aseptically carried out in sterile distilled water. Using a 10-fold serial dilutions 0.1ml of dilutions, 10^{-3}, 10^{-6} and 10^{-9} were plated in triplicates on nutrient agar, MacConkey agar and Sabouraud dextrose agar by spread plate techniques. The Nutrient agar and MacConkey agar plates were then incubated at 37^0C for 18-24hours, while the Sabouraud dextrose agar plate was incubated at 35^0C for 48hours.

Waste at dumpsite (Wd)

Mixed decomposing wastes were aseptically collected and 10g of the waste was soaked in 100ml sterile distilled water in a conical flask and well shaken to dislodge the organisms using a 10^- fold serial dilution, 0.1ml of dilutions of 10^{-3}, 10^{-6} and 10^{-9} were each plated on nutrient agar, MacConkey agar and Sabouraud dextrose agar by spread plate technique. The Nutrient agar and MacConkey agar plates were then incubated at 37^0C for 18-24hours, while the Sabouraud dextrose agar plate was incubated at 35^0C for 48 hours.

Plant growing at dumpsite (Pd)

10g of plant leaves covered with dust and dirt at the dumpsite were introduced into 90mls of nutrient broth, to concentrate the organisms and was then incubated at 37^0C for 18-24 hours. The broth cultures were then plated by streaking on Nutrient agar, MacConkey agar and Sabouraud dextrose agar and incubated at 37^0C for 24 hours (Nutrient and MacConkey agar plates) and at 48-72hrs (Sabouraud dextrose agar plates).

Air at dumpsite/100 meters distance from dumpsite (Ad and A100).

Plates of Nutrient agar, MacConkey agar and Sabouraud dextrose agar were exposed in triplicates at the dumpsites and at 100m away from dumpsite for 60 minutes during the busy hours of the day. The plates were then covered and incubated at 37^0C for 24hours (Nutrient and MacConkey agar plates) and 35^0C for 48-72 hours (Sabouraud dextrose agar plates)

Total bacterial and fungal counts

For each sample, the Nutrient agar and Sabouraud dextrose agar plates were used to calculate the total number of bacteria and fungi in the sample. The average colony counts were multiplied by their dilution factor to obtain the total bacterial and fungal count while for the air sampling, the average

number of colonies per location was recorded as the total bacterial and fungal count of the air in that environment.

Purification and maintenance of culture

Purification of culture was by streak plate technique, pure cultures of isolates were maintained on Nutrient agar slants (for bacteria) and Sabouraud dextrose agar slants (for fungi) and stored in the refrigerator.

Identification of isolates

Bergey's manual of determinative bacteriology (Holt *et al.*, 1994; Cheesbrough,2000) was used in the characterization and identification of the isolates

Screening test for the biodegradation of plant and paper wastes by bacteria and fungal isolates from the collected samples.

The bacterial and fungal isolates were screened on mineral salt medium for their ability to degrade plant and paper waste as a source of carbon and energy. The bio-utilization medium was prepared as described by antai *et al* (1985). Paper waste was processed by shredding and grinding, while the plant waste was processed by drying, grinding and sieving. After which they were introduced into the medium as source of energy and carbon. Bacterial and fungal isolates were then inoculated into the medium and incubated at 37^0C for 24h (for bacteria) and 35^0C for 48h (for fungi). The isolates were then adjudged based on their growth pattern observed.

Statistical analysis

Data of bacterial and fungal count of the waste samples were subjected to analysis and significant means and were subjected to chi square

RESULTS

Average total bacterial and fungal counts of the two dumpsites.

Table 1 present the average total bacterial counts of the two dumpsites during the month of December, 2015. It showed that the garden street dumpsite had higher counts of 25.2±0.17 x10^7CFU/g from the waste sample against 15.2±0.11x10^7Cfu/g and 14.4±0.23x10^7Cfu/g from the Eastern, highway waste soil and waste samples respectively. The Eastern highway air sample had higher count of 2.7±0.18x10^7Cfu/g against 2.4±0.15x10^7Cfu/g from garden street. The average total fungal count of the two dumpsites during the month of December, 2015 is as presented in table 2. It showed that the fungal count for waste soil, waste and air samples were 1.2±0.11x10^7Cfu/g, 18±0.38x10^2Cfu/g, 0.7±0.01x10^1Cfu/g were recorded for the Eastern highway dumpsite samples respectively.

The average total bacterial counts of the two dumpsites during the month of January 2016 are recorded in Table 3. The Garden street dumpsites had higher counts of 21.2±2.33x10^7Cfu/g,

23.2±1.44x10^{7}Cfu/g and 3.6±0.88x10^{2}Cfu/g, as against 14.8±2.43x10^{7}Cfu/g, 14.8±1.88x10^{7}Cfu/g and 2.2±0.03x10^{2}Cfu/g for the eastern highway dumpsites from the soil, waste and air samples respectively.

Table 4 presents the average total fungal count for the month of January 2016, it showed that the count 15.0±1.83x10^{2}Cfu/g, 14±2.33x10^{2}Cfu/g and 0.80±0.10x10^{1}Cfu/g were obtain from the soil, waste and air samples from Garden street dumpsites while Eastern highway dumpsites samples had 10±1.33x10^{2}Cfu/g, 11.8±0.87x10^{2}Cfu/g and 0.50±0.01x10^{1}Cfu/g respectively from soil, waste and air samples.

Table 5 shows the total average bacterial counts for the two dumpsites in the month of February 2016. Garden street dumpsites had 18±1.38x10^{7}Cfu/g, 16.4±1.45x10^{7}Cfu/g and 2.5±0.44x10^{2}Cfu/g from soil, waste and air samples respectively, while he Eastern highway dumpsite samples had 14±1.58x10^{7}Cfu/g, 14.8±1.35x10^{7}Cfu/g and 2.0±0.33x10^{2}Cfu/g from soil, waste and air respectively. The average total fungal counts for the month of February 2016 from both dumpsites are presented in Table 6. The eastern highway dumpsite recorded higher fungal counts of 17±1.65x10^{2}Cfu/g and 17±0.85x10^{2}Cfu/g for the soil and waste samples respectively as against 14±0.85x10^{2}Cfu/g and 11±0.55x10^{2}Cfu/g obtained for the garden street samples respectively. The fungal counts in air was 0.7±0.10x10^{1}Cfu/g for Garden street and 0.3±0.01x10^{1}Cfu/g for Eastern highway dumpsite.

Table 7 presents the results of the average total bacterial count of samples from the two dumpsites during the month of April 2016 for the soil samples from Garden street site, a bacterial count 25.8±1.37x10^{7}Cfu/g was obtained while 15.6±1.26x10^{7}Cfu/g was obtained for samples from the Eastern highway site soil, for the waste samples, an average of 29.4±1.33x10^{7}Cfu/g was obtained for Garden street dumpsite while for the Eastern highway dumpsite the count of 15.4±1.28x10^{7}Cfu/g was recorded. For the air samples, 3.1±0.87x10^{1}Cfu/g and 2.80±0.55x10^{1}Cfu/g were obtained for air at dumpsite (Ad) and air at a 100m distance (Ad100) away from the dumpsite respectively for the Garden street dumpsite, while 1.90±0.06x10^{1}Cfu/g and 2.0±0.03x10^{1}Cfu/g were obtained for the two samples (Ad and Ad100) respectively from the Eastern highway dumpsite. Bacterial counts for the plant samples (Pd) had an average of 11.0±1.48x10^{4}Cfu/g and 7.3±1.33x10^{4}Cfu/g For the Garden street and Eastern highway dumpsites respectively. The leachate analysis revealed an average total bacterial count of 19.6±1.88x10^{7}Cfu/g for the Garden street dumpsite.

Table 8 shows the average total fungal count of samples, from the two dumpsites during the month of April, 2016. The soil samples (Sd) gave 1.8±0.06x10^{3}Cfu/g for the garden street dumpsite and 0.7±0.01x10^{3}Cfu/g for the Eastern highway dumpsite. The waste samples (Wd) gave 1.7±0.03x10^{3}Cfu/g and 0.9±0.01x10^{3}Cfu/g for the Garden street and eastern highway dumpsites respectively. From the two air samples, air at dumpsite (Ad) and air 100m away from the dumpsite (Ad_{100}) gave 0.5±0.1x10^{3}Cfu/g and 0.5±0.01x10^{3}Cfu/g were recorded respectively for both dumpsites. The plant at dumpsite sample gave

$0.4\pm0.10x10^{3}$Cfu/g and $0.5\pm0.11x10^{3}$Cfu/g. Total fungal count in the Garden street leachate was $1.4\pm0.11x10^{3}$Cfu/g. the average total bacterial countries of the two dumpsites obtained for the month of May, 2016 are recorded in Table 9. For the soil samples (Sd), counts of $26.4\pm1.88x10^{7}$Cfu/g and $16.1\pm0.87x10^{7}$Cfu/g were obtained from garden street and pastern highway dumpsites respectively. The waste samples (Wd) from Garden street and Eastern highway dumpsite had a total bacterial count of 26 $\pm2.87x10^{7}$Cfu/g and $18.8\pm1.97x10^{7}$Cfu/g respectively. A total of $2.6\pm0.86x10^{1}$Cfu/g and $2.5\pm0.79x10^{7}$Cfu/g was recorded for the two air samples (Air at dumpsite(Ad) and Air 100m from dumpsite (Ad_{100}) respectively for the garden street dumpsite while $2.1\pm0.18x10^{1}$cfu/g and $2.1\pm0.16x10^{1}$cfu/g were recorded from the two air sample (Ad and Ad_{100}) respectively for the Eastern highway dumpsite. The plant samples gave $9.0\pm1.84x10^{4}$cfu/g and $5.2\pm0.98x10^{4}$cfu/g for the garden street and eastern highway samples respectively while the leachate from Garden street gave $2.4\pm0.88x10^{7}$cfu/g.

Table 10 presents the average total fungal counts of samples from the two dumpsites during the month of May, 2016. The soil samples (Sd) had an average count of $1.4\pm0.03x10^{3}$cfu/g and $0.9\pm0.01x10^{3}$cfu/g. For the Garden street dumpsite and Eastern highway dumpsite. Air from dumpsite (Ad) and air 100m away from the dumpsite (Ad_{100}) recorded $0.4\pm0.01x10^{1}$cfu/g and $0.5\pm0.4x10^{10}$cfu/g and $0.5\pm0.02x10^{1}$cf/g respectively for the eastern highway dumpsite. The plant sample (Pd) and the laachate showed a count of $0.4\pm0.02x10^{3}$cfu/g and $1.2\pm0.0x10^{1}$cfu/ml respectively for the garden street dumpsite while the eastern highway plant sample had $0.5\pm0.01x10^{3}$cf/g.

Table 11 presents the result of the average total bacterial count of the two dumpsites for the month of June, 2016. For the Garden street dumpsites, soil sample (Sd) and waste samples (Wd) recorded a count of $25.6\pm2.86x10^{2}$cfu/g and $26.\pm2.33\ x10^{7}$cfu/g respectively, whereas Eastern highway dumpsite recorded $17.6\pm1.77\ x10^{7}$cfu/g and $14.4\ \pm1.87\ x10^{7}$cfu/g for the same samples respectively. For the air samples at dumpsite (Ad) and 100 meters way from dumpsite (Ad_{100}), Garden street recorded $2.4\pm0.85\ x10^{1}$cfu/g and $2.4\pm0.57\ x10^{1}$cfu/g respectively while Eastern highway recorded $19.0\ \pm0.86x10^{1}$cfu/g and $2.3\pm0.88x10^{1}$cfu/g respectively. Plant leaf surfaces from the Garden street dumpsite had $9.5\pm1.33\ x10^{4}$cfu/g while plant from the Eastern highway dumpsite and $5.0\pm1.26\ x10^{4}$cfu/g. for the leachate sample (L), the garden street dumpsite had $23.6\pm2.89\ x10^{7}$cfu/ml.

Table 12 presents the average total fungal count for the month $1.83\pm0.31\ x10^{3}$cfu/g was obtained in soil samples (Sd) from Garden street and Eastern highway dumpsites respectively. The waste samples from the Garden street dumpsite had an average of $0.7\ \pm0.11\ x10^{3}$cfu/g while that of the Eastern highway dumpsite had $1.7\ \pm0.23\ x10^{2}$cfu/g. the two air samples, Ad and Ad_{100}, both had $0.5\pm0.01x10^{1}$cfu/g for the

Garden street dumpsite and 0.4±0.11 x10^1cfu/g for the eastern highway dumpsite. The garden street leachate showed a count of 1.2 ±0.18 x10^3cfu/ml.

Fig. 2 to 6 shows a comparative analysis of the two dumpsite based on the monthly counts of the microbial load of the samples. Fig. 2 and 3 showed that the air counts were higher in the dry season of the year, that is from December to February, than the wet season. In fig. 4, it was observed that the Garden street plant leaves sample had more hacteral counts than that of Eastern highway. Fig. 5 shows an increase in the waste soil bacteria count in the wet season of the year and a decrease in the dry season from the two dumpsite samples. In fig. 6, it was observed that apart from the high counts observed in February and June, the soil fungal counts from the eastern highway samples were lower than that of garden street.

Characterization and identification of isolates from the waste samples.

The characterization of cellular morphology and biochemical characterization and identification of bacterial isolates in the wet season are presented in table 13 and 14, while table 15 presents the biochemical characterization and identification of bacterial isolates obtained in the dry season. From these results, 17 bacterial isolates were obtained in the wet season while 8 isolates were obtained in the dry season. The bacterial isolates identified from the waste samples during the wet season were *Staphylococcus spp, Enterococcus spp, Proteus spp, E. Coli, Klebsiella spp, Shigella spp, Salmonella spp, Bacillus spp, Micrococcus spp* and *Pseudomonas spp*, while those identified during the dry season were; *E.coli, Kebsiella spp, Shigella spp, Salmonella spp, Bacillus spp, Micrococcus spp* and *Pseudomonas spp.*

From the Sabouraud dextrose agar plates, nine isolates were obtained from the various samples as summarized in table 16. They were identified based on their colony appearance on the agar medium and the morphological characteristics as *Aspergillus spp, Mucor spp, Nocardia spp* and *Actinomyces spp*

Screen test for plant and paper waste utilization by bacterial and fungal isolates from dump waste

Table 17 and 18 pre**se**nt the results of utilization of plant and paper wastes by bacterial and fungal isolates from dump site respectively.it showed that *Bacillus spp* and *Nocardia spp* were able to utilize the plant and paper waste compared to other bacterial isolates (Table 17), while *Aspergillus spp* and *Mucor spp* were also able to utilize the plant and paper waste

ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
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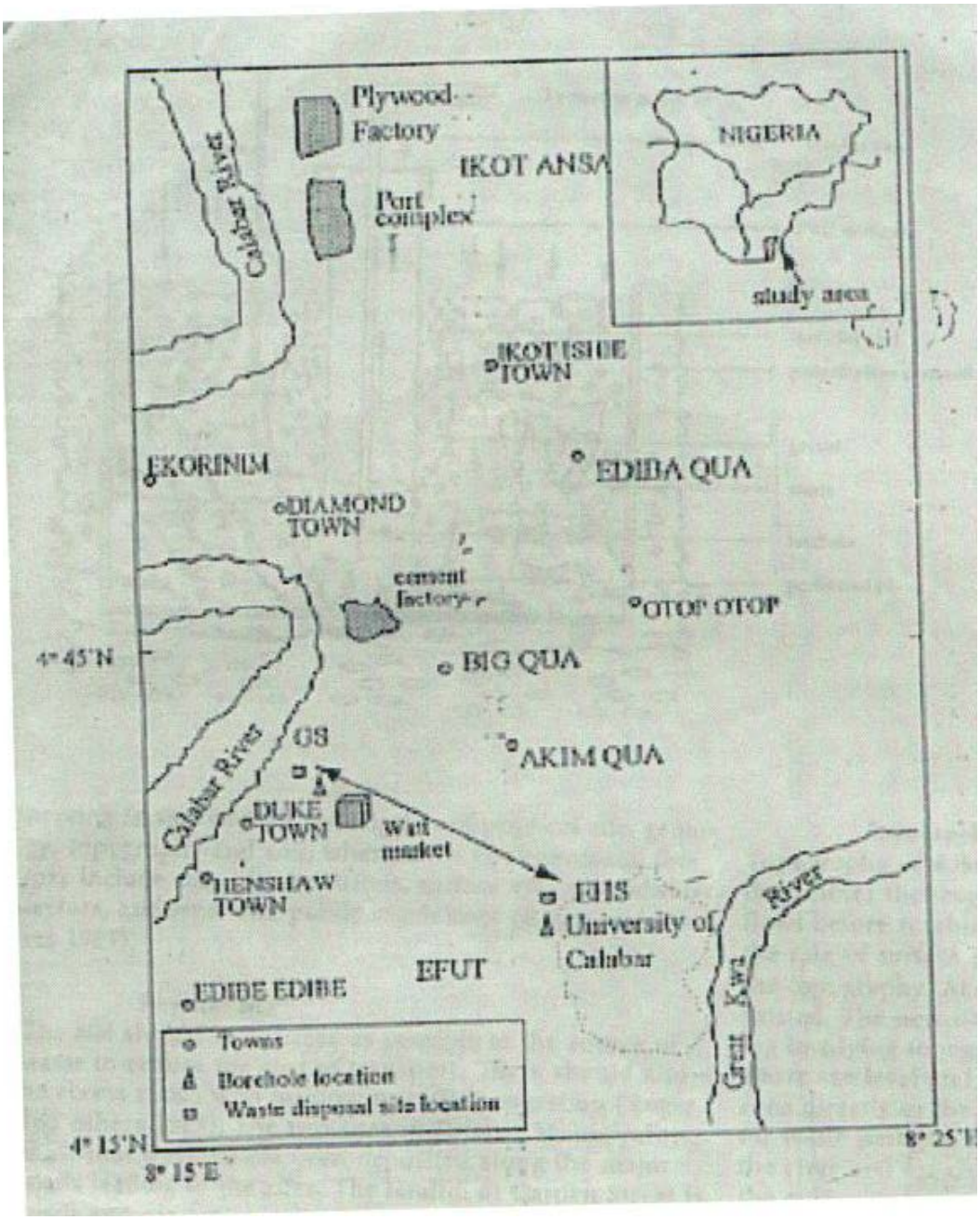

Fig 1: Map of Calabar Municipality showing sample location

Table 1: Total heterotrophic bacterial counts of the Eastern highway and Garden street dumpsites during the month of December 2015

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	$25.2\pm0.22x10^7$ cfu/g	$15.2\pm0.11x10^7$cfu/g
W_d	$22.4\pm22.4x10^7$cfu/g	$14.4\pm0.23x10^7$ cfu/g
A_d	$2.4\pm0.15x10^2$ cfu/g	$2.7\pm0.17x10^2$ cfu/g

Key: S_d - Soil dumpsite
W_d – Waste at dumpsite
A_I - Air at dumpsite

Table 2: Total fungal count of the Garden street and Eastern highway dumpsites during the month of December 2015

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	$14\pm0.33x10^2$cfu/g	$11\pm1.22\ x10^2$cfu/g
W_d	$12\pm1.32x10^2$cfu/g	$18\pm0.38x10^2$cfu/g
A_d	$1.1\pm0.11x10^1$ cfu/g	$0.7\pm0.01x10^1$cfu/g

Key: S_d - Soil dumpsite
W_d - Waste at dumpsite
A_I - Air at dumpsite

Table 3: Total bacterial counts of the Garden street and Eastern highway dumpsites during the month of January 2016

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	21.2 ±2.33x10^7cfu/g	14.8±2.4 x10^7cfu/g
W_d	23.3±1.44x10^7cfu/g	14.8±1.88 x10^7cfu/g
A_d	3.6 ±0.88 x10^2 cfu/g	2.2±0.03x10^2cfu/g

Key: S_d - Soil dumpsite
W_d - Waste at dumpsite
A_I - Air at dumpsite

Table 4: Total fungal count of the Garden street and Eastern highway dumpsites during the month of January 2016

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	15.0 ±1.83x10^2cfu/g	10±1.33 x10^2cfu/g
W_d	14±2.33x10^2cfu/g	11±0.87 x10^2cfu/g
A_d	0.80±0.01x10^1cfu/g	0.50±0.01x10^1cfu/g

Key: S_d - Soil dumpsite
W_d - Waste at dumpsite
A_I - Air at dumpsite

Table .5: Total heterotrophic bacteria counts of the Garden street and Eastern highway dumpsites during the month of February 2016

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	18±1.38x10^7cfu/g	14±1.58 x10^7cfu/g
W_d	16.4±1.45x10^7cfu/g	14.8±0.1.35 x10^7cfu/g
A_d	2.5±0.48 x10^2 cfu/g	2.0± 0.033 x10^2cfu/g

Key: S_d - Soil dumpsite
W_d - Waste at dumpsite
A_I - Air at dumpsite

Table 6: Total fungal count of the Garden street and Eastern highway dumpsites during the month of February 2016

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	14 ±0.8x10^2cfu/g	17±1.65 x10^2cfu/g
W_d	11±0.55 x10^2cfu/g	17±0.0.85 x10^2cfu/g
A_d	0.7±0.11x10^1 cfu/g	0.3±0.01x10^1cfu/g

Key: S_d - Soil dumpsite
W_d - Waste at dumpsite
A_I - Air at dumpsite

Table 7: Total heterotrophic bacterial count of the Garden street and Eastern highway dumpsites during the month of April 2016

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	25.8 ±1.37 x10^7cfu/g	15.6±1.26 x10^7cfu/g
W_d	29.4±1.33x10^7cfu/g	15.4±1.28x10^7cfu/g
A_d	3.1±0.87x10^1 cfu/g	1.90±0.06 x10^7cfu/g
Ad_{100}	2.80±0.55x10^1 cfu/g	2.0±0.03x10^1 cfu/g
Pd	11±1.48 x10^1 cfu/g	7.3 ±1.33x10^4 cfu/g
L	19.6±1.87x10^7 cfu/g	

Key: S_d - Soil dumpsite
W_d - Waste at dumpsite
A_d - Air at dumpsite
A_{d100} - Air at a distance of 100meters from the dumpsite
P_d - Plant at dumpsite
L - Leachate

Table 8: Total fungal counts of the Garden street and Eastern highway dumpsite during the month of April, 2016

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	$1.8 \pm 0.06 \times 10^3$ cfu/g	$0.7 \pm 0.01 \times 10^3$ cfu/g
W_d	$1.7 \pm 0.03 \times 10^3$ cfu/g	$0.9 \pm 0.01 \times 10^3$ cfu/g
A_d	$0.5 \pm 0.01 \times 10^1$ cfu/g	$0.5 \pm 0.01 \times 10^1$ cfu/g
Ad_{100}	$0.5 \pm 0.01 \times 10^1$ cfu/g	$0.5 \pm 0.01 \times 10^1$ cfu/g
Pd	$0.4 \pm 0.01 \times 10^3$ cfu/g	$0.5 \pm 0.11 \times 10^3$ cfu/g
L	$1.4 \pm 011 \times 10^3$ cfu/g	-

Key: S_d - Soil dumpsite
W_d - Waste at dumpsite
A_d - Air at dumpsite
A_{d100} - Air at a distance of 100meters from the dumpsite
P_d - Plant at dumpsite
L - Leachate

Table 9: Total heterotrophic bacterial count of the Garden street and Eastern highway dumpsites during the month of April 2016

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	$26.4 \pm 1.88 \times 10^7$ cfu/g	$16.1 \pm 0.87 \times 10^7$ cfu/g
W_d	$26 \pm 2.87 \times 10^7$ cfu/g	$18.8 \pm 1.1.97 \times 10^7$ cfu/g
A_d	$2.6 \pm 0.86 \times 10^1$ cfu/g	$2.1 \pm 0.18 \times 10^1$ cfu/g
Ad_{100}	$2.5 \pm 0.70 \times 10^1$ cfu/g	$2.1 \pm 0.16 \times 10^1$ cfu/g
Pd	$9.0 \pm 1.1.84 \times 10^4$ cfu/g	$5.2 \pm 0.98 \times 10^4$ cfu/g
L	$2.4 \pm 0.88 \times 10^7$ cfu/g	-

Key: S_d - Soil dumpsite
W_d - Waste at dumpsite
A_d - Air at dumpsite
A_{d100} - Air at a distance of 100meters from the dumpsite
P_d - Plant at dumpsite
L - Leachate

Table 10: Total fungal count of the Garden street and Eastern highway dumpsites during the month of May 2016

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	$1.4\pm0.03 \times 10^3$cfu/g	$0.9\pm0.01 \times 10^3$cfu/g
W_d	$1.2\pm0.05 \times 10^3$cfu/g	$0.7\pm0.01 \times 10^3$cfu/g
A_d	$0.4\pm0.0.01 \times 10^1$ cfu/g	$0.5 \pm0.01 \times 10^1$cfu/g
Ad_{100}	$0.5\pm0.01 \times 10^1$ cfu/g	$0.5\pm0.04 \times 10^1$ cfu/g
Pd	$0.4\pm0.02 \times 10^3$ cfu/g	$0.5\pm0.01 \times 10^3$ cfu/g
L	$1.2\pm0.01 \times 10^3$ cfu/g	

Key:
- S_d - Soil dumpsite
- W_d - Waste at dumpsite
- A_d - Air at dumpsite
- A_{d100} - Air at a distance of 100meters from the dumpsite
- P_d - Plant at dumpsite
- L - Leachate

Table 11: Total heterotrophic bacterial count of the Garden street and Eastern highway dumpsites during the month of June 2016

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	25.6 ±2.86 x10^7cfu/g	7.6±1.77 x10^7cfu/g
W_d	26±2.33x10^7cfu/g	16.4±1. 87x10^7cfu/g
A_d	2.4±0.85x10^1 cfu/g	1.9±0.086 x10^1cfu/g
Ad_{100}	2.4±0.57x10^1 cfu/g	2.3±0.088x10^1 cfu/g
Pd	9.5±1.33 x10^4 cfu/g	5.0±1.26x10^4 cfu/g
L	23.6±2.89x10^7 cfu/g	

Key: S_d - Soil dumpsite
W_d - Waste at dumpsite
A_d - Air at dumpsite
A_{d100} - Air at a distance of 100meters from the dumpsite
P_d - Plant at dumpsite
L - Leachate

Table 12: Total fungal counts of the Garden street and Eastern highway dumpsites during the month of June 2016

Sample	Garden street (cfu/g)	Eastern highway (cfu/g)
S_d	1.1±0.13x10^3cfu/g	1.83±0.31x10^3cfu/g
W_d	0.7±0.11x10^3cfu/g	1.7±0.23x10^3cfu/g
A_d	0.5±0.01x10^1 cfu/g	0.4±0.011 x10^1cfu/g
Ad_{100}	0.5±0.01x10^1 cfu/g	0.5±0.01x10^1 cfu/g
Pd	0.4±0.11 x10^4 cfu/g	0.5±0.12x10^1 cfu/g
L	1.2±0.18x10^3 cfu/g	

Key: S_d - Soil dumpsite
W_d - Waste at dumpsite
A_d - Air at dumpsite
A_{d100} - Air at a distance of 100meters from the dumpsite
P_d - Plant at dumpsite
L - Leachate

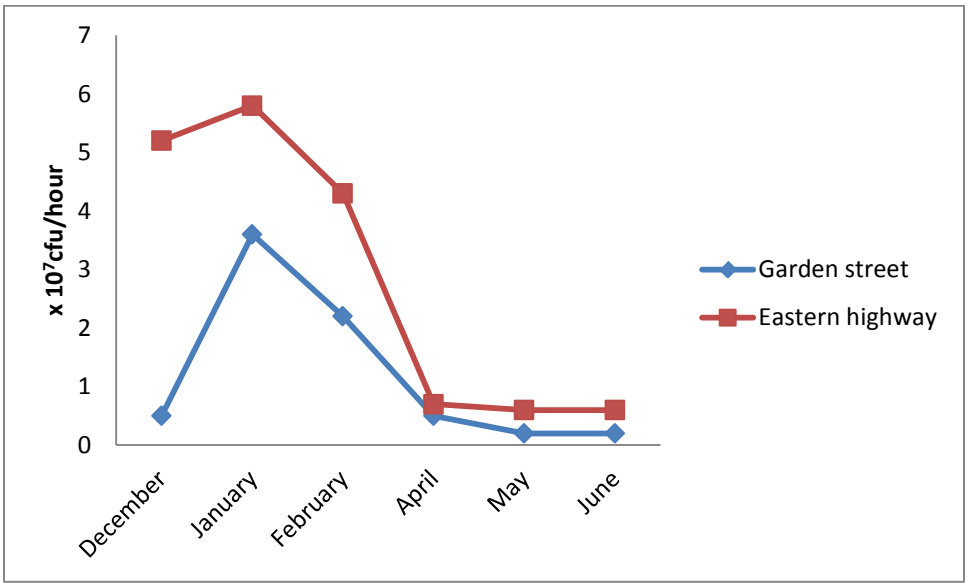

Fig. 2: Bacterial counts of the air samples for the two seasons of the year

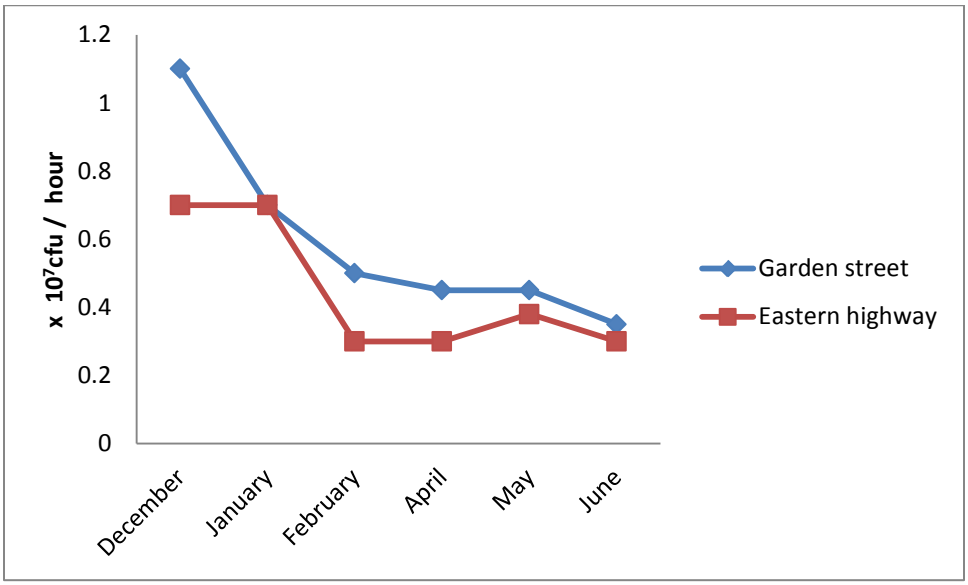

Fig. 3: The fungal counts of the air samples for the two seasons of the year

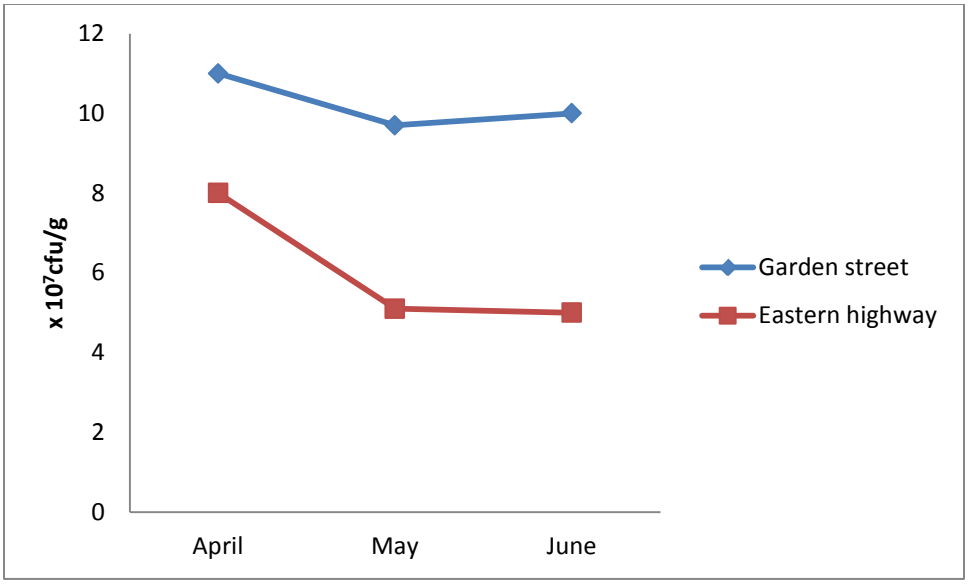

Fig .4: The bacterial counts of the plant samples for the wet season of the year

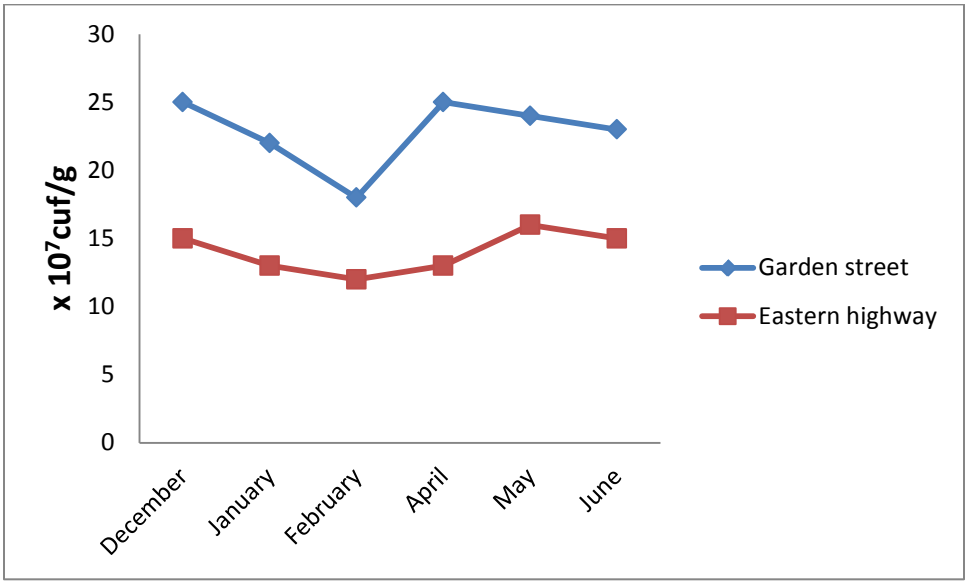

Fig. 5: The bacterial counts of the soil samples of the two season of the year

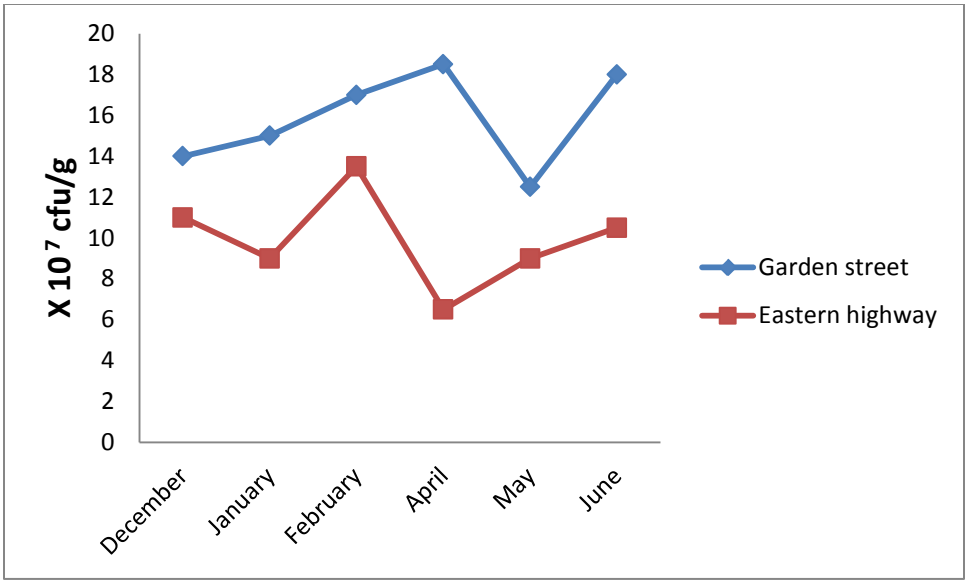

Fig. 6: The fungal counts of the soil samples for the two seasons of the year

Table 13: Characterization of cellular morphology of bacterial isolate (April to June 2016)

Colony	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Pigmentation	Cream	Straw yellow	Off white	Off white	Cream	Pin	Cream	Cream	Cream	Yellow	Cream	Cream	Pink
Elevation	Flat entire	Raised entire	Flat lobate	Flat lobate	Raised entire	Flat entire	Convex entire	Flat entire	Raised entire	Raised entire	Flat rhizoid	Raised entire	Nat undulate
Optical characteristics	Transluce nt	Transluce nt	Transluce nt	Opaque viscid	Transluce nt	Transluce nt	Transpare nt	Transluce nt	Opaque	Opaque	Opaque	Opaque	Translucent
Consistency colony	-	butyrous	Butyrous	Membrano us	Butyrous	Viscid	Viscid	Viscid	Viscid	Butyrous	Dry	Butyrous	
Surface colony shape	Glossy circular	Glossy circular	Dull/dry circular	Dull/dry circular	Glossy circular	Glossy circular	Glossy circular	Glossy circular	Glossy circular	Glossy circular	Dry	Glossy	Dull
Gram’s reaction	+ve	+ve	+ve	+ve	+ve	+ve	-ve	-ve	+ve	+ve	-ve	+ve	+ve
Cell shape	Rods	Cocci	Rods	Rods	Rods	Cocci	Rods	Rods	Cocci	Cocci	Rods	Cocci	Rods
motility	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	-ve	+ve	+ve	+ve	-ve

Table 14: Biochemical characterization/identification of bacterial isolates (April-June 2016)

Isolate	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Catalase	+	+	+	+	+	+	+	+	-	+	+	+	+
citrate	-	-	-	+	-	-	-	-	-	-	_	-	+
Hs													
Production	-	-	-	-	-	-	-	+	-	-	+	-	-
Coagulase	-	-	-	-	-	-	-	-	-	-	-	-	-
Indole	-	-	-	-	-	-	-	-	-	-	-	-	-
MR-VP	- +	+ -	- +	- -	+ +	- -	+ +	- +	+ +	+	+ +	+	+ +
Oxidase	+	+	+	+	-	+	-	+	+	-	-	-	-
Glucose	A	-	A	A	A	-	A	A	-	-	AG	A	A
Lactose	-	-	+	-	-	+	+	A	A	A	AG	-	A
Manitol	-	-	-	-	-	-	-	-	-	-		-	A
Sucrose	-	-	-	-	-	-	-	-	-	-	AG	-	A
Probable organism	***Bacillus spp***	**Micrococ ciluteus**	**Bacillus spp**	**Bacillus spp**	**Bacillus sp**	**Micrococ ci roseus**	**Bacillus spp**	**Bacillus spp**	**Enteroc occus faecalis**	**Staphylo coccus spp**	**Proteus spp**	**Staphylo coccus spp**	**Klebsiella spp**

Key: + Positive

\- Negative

A Acid

AG Acid and gas

MR Methyl red

VP Vogues proskaeur

Table 15: Biochemical characterization/identification of bacterial isolates (April-June 2016)

Isolate	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Grams reaction	-	-	-	-	-	+	+	-
Cell shape	Rod	Rod	Rod	Rod	Rod	Rod	Cocci	Rod
Motility	+	-	+	-	+	+	-	+
Indole	+	-	-	-	-	-	-	-
Catatlase	+	+	+	+	+	+	+	+
Citrate	-	+	+	-	+	+	-	-
MR	+	-	-	+	-	+	-	-
VP	-	+	+	-	+	+	-	-
Glucose	AG	AG	AG	-	AG	A	A	A
Lactose	A	A	A	-	-	A	A	-
Mannitol	A	A	A	-	A	A	-	-
Sucrose	A	A	A	-	A	A	A	A
Probable organism	*E.coli*	*Klebsiella spp*	*Enterobacter spp*	*Shigella spp*	*Salmonella spp*	*Bacillus spp*	*Micrococcus spp*	*Pseudomonas*

Key: + Positive

\- Negative

A Acid

AG Acid and gas

MR Methyl red

VP Vogues proskaeur

Table 16:Morphological characterization of isolates from the garden street dumpsite samples grown on sabauroud dextrose agar

Isolates	Colony appearance	Nature of hyphae	Arrangement of spores	Columella	Probable organism
1.	Black	Aseptate	Spores not embedded	Absent	*Aspergillus sp*
2.	Grey	Aseptate	Spores in sporangia	Present	*Mucoer sp.*
3.	Greenish yellow	Aseptate	Spores not enclosed in sporangia	Absent	*Aspergillus sp*
4.	Cottony white	Aseptate	Spores in sporangia	Present	*Mucor sp.*
5.	Velvet green	Mass of tiny filaments	Not observed	Absent	*Nocardia.sp*
6.	Yellow	Aseptate	Spores not enclose	Absent	*Aspergillus sp*
7.	Dark green	Mass of tiny filaments	Not observed	Absent	*Nocardia sp*
8.	Black	Aseptate	Spores not enclose	Absent	*Aspergillus sp*
9.	White drops	Not observed	Granular spores	Absent	*Actinomyces sp*

Table 17; Utilization of plant and paper waste bacterial isolates Obtained from the waste dump

	Growth Pattern	
Bacteria Isolate	**Plant waste**	**Paper waste**
Bacillus sp	++	+++
Micrococcus sp	-	+
Enterococcus sp	+	+
Staphylococcus spp	+	+
Proteus sp	+	+
Nocardia spp	++	++
Actinomyces sp	+	+

Key: **-= No growth**

+= poor growth

++ = Moderate growth

+++ = Profuse growth

Table 18; Utilization of plant and paper wastes by fungal Isolates Obtained from the waste dump

	Growth Pattern	
fungal Isolates	**Plant waste**	**Paper waste**
Aspergillus spp	++	+++
Mucor spp	+++	++

Key:

++ = **Moderate growth**

+++ = **Profuse growth**

DISCUSSION

From this study, a higher total bacterial count was observed in the garden street dumpsite compared to its eastern highway dumpsite counterpart. This could be due to the fact that the garden street dumpsite is an unplanned, uncontrolled and open dumpsite compared to the eastern, highway dumpsite which was a bit closed. Also the higher bacteria count observed in the garden street dumpsite could have also been due to its close proximity to the market, as it receives fresh waste daily and in large quantities. A comparative analysis of the two dumpsite showed that there was no significant difference ($P.\geq 0.05$) in the bacterial and fungal counts of the two dumpsite during dry season (December to February) as in calculated x^2 (2.818) was less than the tabulated bacterial count (5.991) was also lesser than the tabulated (5.991) while for the fungal count, the calculated x^2 (0.8303) was also lesser than the tabulated (5.991). during the rainy season (April to June), there was no significant difference in the soil bacteria count between the two dumpsites as the calculated x^2 (0.806) was less than the tabulated x^2 (5.991), as the reverse was the case in the soil fungal count, as the calculated x^2 (6.698) was greater than the tabulated x^2(5.991). Also during the dry season. For the dumpsite air samples during the dry season showed significant difference (Calculated x^2, $23.174 > x^2$ tabulated 5.991), while there was no significant difference in the fungal counts between the dumpsite (calculated x^2,$0.416 < x^2$ tabulated, 5.991). a comparative analysis of the dumpsite samples showed that there was a higher bacterial and fungal counts during the wet seasons (April to June) compared to the dry seasons (December to February). The rationale behind this observation could probably have been due to the increased moisture content in the waste dumpsite during the wet season, as research has shown that water is required for both metabolic activities and proliferation of microbial cells (Eni *et al*, 2011). The presence of pathogenic bacteria such Bacillus *spp, Proteus sp, Enterococcus sp,*

Micrococcous Pseudomonas sp, Staphylococcus sp and *Coliforms* such as *Klebsiella sp, E.coli, Shigella sp*, and *Salmonella sp* in the *waste* dumpsite as observed in the study was not surprising, at it corroborates with that of (Diyce-udden *et al*, 2014), who reported to have identified the presence of *Coliforms, Faccal Coliforms* and pathogens such as *Escherichia Coli, Streptococcus, Pseudomonas and Salmonella* from samples collected close to sewage sites. Also the observation was in line with that of who identified the presence of *Bacillus, Staphylococcus, Klebsiell*a from a waste dumpsite located at eagle island, River State (Igbinosa and Okoh, 2009). The presence of these identified organisms in the study site is a thing of great concern as these bacteria have been associated with a number of public health problems *Proteus* are human pathogens and has been shown to occur in manure, soil and polluted wasters (Ogbonna *et al*, 2006) they are human pathogens and are capable of causing urinary tract infections and also they serve as secondary inhalers that may cause septic lesions In burn patents. *Klebsiella* and other species are opportunistic pathogens that has been reported to occur in soil, water, vegetables and waste sites, they can cause bactericemia, Pneumonia, urinary tract and other human infections (Obire *et al*, 2002), they frequently cause infections in neonatal, intensive care and immune suppressed patients (Obire et al, 2002). *Enterobacter* has been reported to occur in soil, fresh water, sewage, plants, vegetables and are associated with urinary tract infections *E. coli* are capable of producing enterotoxins and other virulence factors including invasive and colonization factors, they can cause diarrheal disease, urinary tract infections and nosocomial infections including septicemia and meningitides (Podschun and Ullman, 1998). *Salmonella* and *Shigella* are human pathogens and are the causative agents of typhoid fever, enteric fevers, gastroenteritis, septicemia and dysentery respectively (Ishii and Sadowskey, 2008).

The presence of fungi such as *Aspergillus sp* and *Actinomycetes sp*, is of public health importance, as actinomycetes are known to actinomycosis and nocardiosis in cattle, dogs and humans (Bennett, 2010), while *Aspergillus spp* are important producers of mycotoxins (e.g alfatoxins of *A. Flavus*). In human, they cause Aspergillosis and they have been reported to colonize the mucosal surface and then lungs thereby causing immune-suppression (Bennett, 2010). The spores of *Aspergillus* in the environment also causes allergic response, and they may also cause opportunistic infections in immuno- compromised persons. The ability of some of the isolates; *Bacillus spp, Nocardia spp, Aspergillus spp, Mucor spp* to bio-utilize plant and paper wastes and use them as carbon and energy source was not surprising as similar study by Atalia et al.,(2015), who reported Actinomycetes, Nocardia, Fusarium, Neurospora, Rhizopus, Mucor, among others , to have shown positive catabolic reactions with selective organic substrates.

CONCLUSION

Solid waste disposed in open dumpsite is usually subjected to series of complex biochemical and physical processes, which lead to the production of both leachate and gaseous emissions, and

when this leachate leaves the dumpsite and reaches the water tables, it results in borehole contamination. Besides, the aforementioned consequence, open dumpsite also serve as breeding sites for pathogenic organisms which are capable of causing both public health as well as environmental hazard. Although some organisms (*Bacillus spp, Nocardia spp, Mucor spp and Aspergillus spp*) from dump site as observe in this study have shown solid waste (paper and plant) biodegradability potentials, but nevertheless with all other negative approaches accrued to open dumpsite, we therefore call on government and environmental agencies to help provide well planned and closed dumpsite, as well as good waste management systems, and to also develop the aforementioned strains as they could have applicability in potential sustainable and eco-friendly composting processes.

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