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# PHYSICOCHEMICAL AND BACTERIOLOGICAL QUALITIES OF SELECTED SOLID WASTE DUMPSITES WITHIN ABUJA, NIGERIA

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***ABSTRACT***

*Solid waste dumpsites have been found to have impacts on the quality of the receiving environments and thus, needs constant monitoring for appropriate regulatory/mitigation strategies. This study characterized some physicochemical (temperature, pH, electrical conductivity-EC) and resident bacteria in selected waste dumpsites (Abaji, Bwari, Gosa, Gwagwalada, Kuje and Kwali) and control soil (2 km away from dumpsites) samples (0 – 45 cm depth) within Abuja, Nigeria, using standard techniques. Data were analyzed statistically and compared ($p<0.05$) with the controls. Temperature (27.0 ± 1.35 - 28.9 ± 1.25 °C), pH (8.0 ± 0.45 - 8.4 ± 0.40) and EC (329 ± 135- 474 ± 200 µS/cm) were significantly ($p<0.05$) elevated when compared with the control, but were all within the EEPA and WHO standard limits. Gwagwalada dumpsite recorded the highest temperature and pH variations, while Bwari dumpsite had the highest EC values. Total aerobic bacterial populations of dumpsites ranged from $5.42 \times 10^6$ CFU/g (Bwari dumpsite) to $6.89 \times 10^9$ CFU/g (Gosa dumpsite) and were significantly ($p<0.05$) greater than the control soil ($4.22 \times 10^4$- $3.42 \times 10^6$CFU/g). A total of 54 bacterial isolates distributed among the 6 genera; Proteus (33.3 %), Providencia (29.6 %), Pseudomonas (16.6 %), Bacillus (9.3 %), Micrococcus (5.5 %), Escherichia coli (2.1 %), Enterobacter (2.1 %) and Serratia* spp. *(2.1 %), were recovered. This study suggest the waste dumpsites significantly recorded elevated temperature, pH, electrical conductivity (EC) and resident bacteria and, thus constant public education on proper waste management coupled with application of appropriate remediation strategies are recommended.*

**Keywords**: Bacterial community, dumpsites, environmental pollutants, physicochemical parameters

## INTRODUCTION

Waste includes all materials that are no longer useful to man and his services. They are usually discarded at a designated location or converted to other uses. Waste generation has been an age long practice, with little or no noticeable environmental impacts as a results of normal natural recycling processes. However, with the increase in human populations, urbanization, industrial and technological breakthroughs, the rate of waste generation has skyrocketed with unprecedented environmental impacts. Due to poor waste management technologies in many developing countries (Al-Khatib *et al*, 2010), there has been increase in environmental pollutions, disease causing agents, toxins, heavy metal leachates, greenhouse gases and other hazardous pollutants. The major sources of these wastes include agriculture, industries (textile, food, pharmaceutical, mining, plastic, petrochemical, paper industries) and other anthropogenic activities (Ibikunle *et al*., 2020). The rate at which solid waste is generated in Nigeria is greater than quarter a million tonnes annually with a ratio of 1: 1.5 in rural and urban area (Okoronkwo and Okpokwasili, 2018). In the recent times, the quantity of wastes and dumpsites from Abuja and environ has increased as a result of rise in human populations, constructions, businesses and production/manufacturing companies (Ojiego *et al.*, 2019; Saidu *et al.,* 2021). These wastes continue to impact on the quality of the receiving soil environments. When the soil capacity to naturally handle waste is breached, pollution ensues with its attendant effects on the chemical and microbial contents as well as the soil's ability to support plants and animals. Previous studies have shown that leachates from dumpsites in several towns within Nigeria remarkably impacted on the physical, chemical and biological/microbiological properties of the receiving soil, water (surface and underground), air and agricultural crops within and around the locations (Oviasogie *et al*., 2010; Ndimele *et al.,* 2014; Bassey *et al.,* 2015; Igborgbor and Ogu. 2015; Williams and Hakam, 2016; Dashu, 2017; Oshoma *et al*., 2017; Sawyerr *et al*., 2017; Nireti *et al.*, 2018; Okoronkwo and Okpokwasili, 2018; Auta and Paul, 2020; Odum *et al.,* 2020; Okafor-Elenwo *et al*., 2022). Changes in the levels of some properties, such as temperature, pH, electrical conductivity and microbial populations, are mostly the indicating factors of the impact of wastes/pollutants in soil/water environments (Edward, 1990; Onwuka and Mang, 2018).

In Abuja and environs, some of the aborigines use dumpsites areas as farm lands for cultivating some annual crops without recourse to their impacts on these edible crops, vis-à-vis animals and humans. When these solid wastes are generated, they are indiscriminately dumped in open spaces, particular barren lands, burrow pits, along major roads and water bodies without any treatments (Afon and Okewole, 2007; Dladla *et al.,* 2016). The public health implications of improperly managed waste are unprecedented. Thus, a proper environmental waste management cannot been over-emphasized especially in developing countries such as Nigeria, where indiscriminate dumping of waste is a common place (Adekola *et al.,* 2021). Considering the increasing rate of anthropogenic activities and persistent generation of indiscriminate dumpsites in major cities, with little or no special treatments/sorting/remediation mechanisms, it pertinent to constantly monitor the soil properties within and around the dumpsites for proper enlightenment and regulatory measures. The study was therefore undertaken to characterize some physicochemical and bacteriological properties of soil samples from selected dumpsites within Abuja, the Federal Capital Territory (FCT) of Nigeria, which harbours diverse solid wastes from constructions, institutions and other industries.

## MATERIALS AND METHODS

### Study area

The study was carried out within the FCT Abuja, Nigeria (Figure 1). Abuja is geographically situated at coordinates of latitude $8^o22'$ and $9^o20'$ N and longitude $6^o45'$ $7^o39'$ E, with a vast land mass of about 7,315 $km^2$ and an estimated human population of 2,238,800 (Sawyerr *et al.,* 2017). The six employed as sampling sites included Abuja municipal (Gosa), Abaji, Bwari, Gwagwalada, Kuje and Kwali local government areas. These areas harbour huge amount of diverse solid waste from constructions, institution, agricultures, industries and other anthropogenic activities.

### Sample collection

A quadrant ($2m^2$) thrown randomly at the different dumpsites, before using AMS soil augers to collect soil samples from dumpsites and control sites (2 km away) at about 12 different points (between 0-45 cm depth), maintaining aseptic conditions during the process.

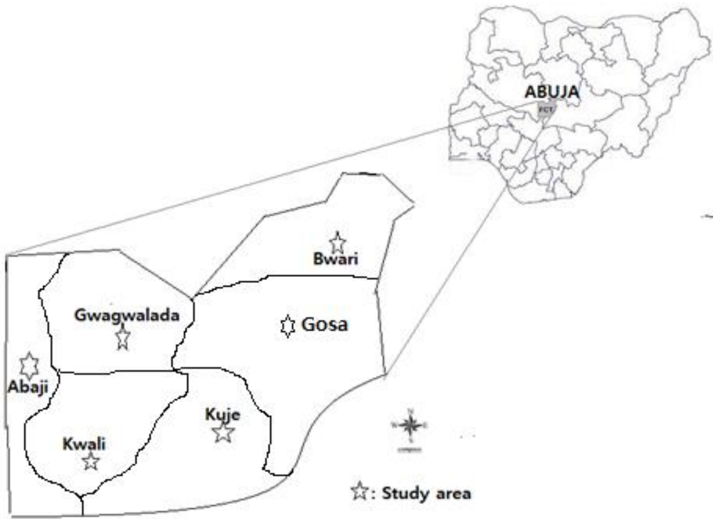


**Figure 1:** Map of Nigeria and Abuja and the six sampling locations

### Media preparation and sterilization

Nutrient broth/agar (Oxoid UK) was prepared according to the manufacturer's specification, sterilized using the autoclave at 121 $^oC$ for 15 min

### Enumeration of total bacterial population

A gram (1 g) of each soil samples was weighed out, and homogenized into 9 mL of sterile distilled deionized water and gently shaken to dislodge adhered bacteria. Thereafter, 10-fold serial dilution of the homogenates was made using sterile pipettes and 1 mL aliquot was serially diluted to obtain dilutions $10^1$to $10^{10}$. These dilution were then cultured in triplicates using spread plate techniques on sterile separate nutrient agar plates. The plates were incubated at 25 – 37 $^oC$ for 24 to 48 h. All the plates were examined for growth and enumerated using colony counting machine. Results were expressed as colony-forming-units per gram of soils ample (CFU/g) (Cowan and Steele, 1974; Cheesebrough, 2001).

### Isolation and phenotypic characterization of bacterial isolates

Representatives of each colony were purified by repeated sub-culturing onto fresh nutrient agar plates. The pure cultures obtained were then stored in agar slants for characterization. The pure cultures were characterized using their colonial morphologies, microscopic appearances (Grams staining reactions, shapes and arrangements) and biochemical test, such as catalase test, oxidase test, motility test, spore test, indole test, methyl red test, vogesproskauer test, urease test, citrate test, nitrate reduction test, glucose fermentation test, fructose fermentation test, lactose fermentation test, sucrose fermentation and mannitol fermentation test as described previously (Cheesebrough, 2001; Ogbulie *et al*., 2001). The test results were compared with standard references of Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons, 1974; Holt *et al.,* 2002) for identification of the isolates.

**Determination of some physicochemical properties of soil samples**

The three physicochemical parameters analyzed were pH, temperature and electrical conductivity (EC). Temperature was measure using an environmental thermometer. To determine the pH and EC, 5 g lump soil samples were gently homogenized in 50 mL distilled water before immersing the probes of pH meter (Jenway 3015 model) and EC meter (Jenway 4010 model) into the solution and left to stabilize at room temperature (Osuji and Nwoye, 2007). The process was done in triplicate and the readings were recorded accordingly.

**Data analysis**

Data were analyzed descriptively in triplicates and values were expressed as mean ± standard deviation and presented in tabular and graphical formats. Where necessary, data obtained were statistically analyzed using Analysis of variance (ANOVA) adopting probability levels below 5%. Differences in means were analyzed using the Duncan's Multiple Range Test.

## RESULTS AND DISCUSSION

Open solid waste dumpsites are common practices in Nigeria and other African countries. Due to the lack of proper waste management systems in the countries, the soil environment is exposed to risks of pollution. A healthy soil supports the existence of plants, animals and human beings. Hence, consistent monitoring of waste dumpsites cannot be overemphasized in major cities where the generation rate is almost double that of rural communities. This study investigated some physicochemical and bacteriological properties of soil samples from selected dumpsites within Federal Capital City, Abuja, which harbours diverse quantities of municipal, agricultural and industrial solid wastes (Ojiego *et al.*, 2019; Saidu *et al.*, 2021).

The data obtained from physicochemical analyses of the soil samples (Table 1) revealed temperature (27.2 ± 1.05 - 28.9 ± 1.25 °C), pH (8.0 ± 0.45 - 8.4 ± 0.40) and EC (329 ± 135 - 474 ± 200 $\mu$S/cm) varied significantly ($p<0.05$) higher when compared with the control. Gwagwalada dumpsite recorded highest temperature and pH variations, while Bwari dumpsite had the highest EC values suggesting greater impacts of leachates in soil. The lowest temperature (27.2 ± 1.05 °C), pH (8.0 ± 0.45) and EC (329 ± 135 $\mu$S/cm**)** values were recorded from Kuje, Gosa and Kwari dumpsites, respectively. Although, the three (3) physicochemical parameters studied were below the EEPA and WHO limits, it is pertinent to underscore the implications of their variations in soil environments. The temperature of soil environments fluctuates constantly due to the changes in the intensity of sun light energy. It is an important index which controls the physical and biochemical processes within the soil as well as determines the rate of enzymatic degradations of organic compounds within the soil (Onwuka and Mang, 2018). The increasing order of variations in temperature was Kuje<Gosa<Bwari<Kwari<Abaji<Gwagwalada, indicating that Kuje and Gwagwalada dumpsites had the least and most changes. The variations obtained might be attributed to the differences in the season changes, topography, altitude and vegetation covers within the dumpsites. This finding is in concordance with the report of Mekonnen *et al.* (2020), who made similar observation in their studies on the effect of solid waste dumpsite on surrounding soil within Ethiopia. The pH range (8.0 ± 0.45 - 8.4 ± 0.40) obtained in suggest that the

dumpsites slightly alkaline. This could be attributed to the increased temperature which might have enhanced organic acid denaturation and increase the soil pH as reported earlier (Mensies and Gillman. 2003).

The observed higher EC values EC (329 ± 135 - 474 ± 200 $\mu$S/cm) over the control soil suggest that the dumpsites has higher quantities of dissolved ions/mineral salts such as chloride, potassium among others are present in Bwari dumpsites. It also measures the salty nature, nutrient levels, and water holding capacity of the soil and thus variations in the EC values determine the levels of mineral nutrients availability within the environment. However, shown that very high EC above the standard permissible limits might be harmful to soil health. Findings from our study suggest that the range of temperature, pH and EC were within the EEPA and WHO standard limit for soil leachates. Obianefo *et al*. (2017) reported acidic pH range (4.86±0.18 – 7.66±0.44) and lower EC values (32.06 ± 2.5 – 299.5 ± 1.5$\mu$S/cm) sol samples from selected solid waste dump sites in Port Harcourt, Rivers State, Nigeria. Similarly, Sam-Uroupa and Ogbeibu (2020) reported acidic pH range (5.23 and 5.83), but higher EC variations (562.00 - 982.33µS/cm) from solid waste disposal soil samples in Benin Metropolis, Nigeria. A study from solid waste dumpsite in Ethiopia reported higher temperature (32.9 ± 0.29 $^{o}$C), higher alkaline pH (8.5 ± 0.12) and comparable EC (391.3 ± 0.01) values. Our findings are relatively higher that those reported by Sawyerr (2017) for temperature (7.1 ± 0.1 – 7.8 ± 0.1 $^{o}$C), pH (6.0 ± 1.4 - 0.8 ± 0.3) and EC (81.8 ± 1.0 – 137.3 ± 2.4 in some satellite towns within Abuja, Nigeria. The slight various could be linked the differences in the period of study, depth of soil and sampling techniques used.

**Table 1**: Some physicochemical properties of soil samples from dumpsites within Abuja

| **Sampling Location** | **Soil sample** | **Temperature ($^{o}$C)** | **pH** | **Electrical conductivity ($\mu$S/cm)** |
|---|---|---|---|---|
| Abaji | Dumpsite | 28.8 ± 1.60* | 8.3 ± 0.11* | 465 ± 136* |
| | Control | 26.7 ± 0.06 | 7.8 ± 0.04 | 102± 26 |
| Bwari | Dumpsite | 27.3 ± 1.12* | 8.1 ± 0.26* | 474 ± 200* |
| | Control | 26.1 ± 0.11 | 7.9 ± 0.00* | 201 ± 21 |
| Gosa | Dumpsite | 27.2 ± 1.05* | 8.0 ± 0.45* | 362 ± 674* |
| | Control | 25.9 ± 0.00 | 6.8 ± 0.40 | 198 ± 46 |
| Gwagwalada | Dumpsite | 28.9 ± 1.25* | 8.4 ± 0.40* | 438 ± 170* |
| | Control | 26.5 ± 0.05 | 6.9 ± 1.10 | 127 ± 76 |
| Kuje | Dumpsite | 27.0 ± 1.35 | 7.9 ± 0.35 | 389 ± 183* |
| | Control | 26.9± 0.63 | 7.5± 1.00 | 110± 101 |
| Kwari | Dumpsite | 28.3 ± 1.39* | 8.1 ± 0.30* | 329 ± 135* |
| | Control | 25.9 ± 0.20 | 6.9 ± 0.02 | 109 ± 32 |
| EEPA (2003) standard limits | | 5 - 30 | 6 – 9 | 1000 |
| WHO (2004) standard limits | | NA | 6.5 – 8.5 | 1400 |

***Key****: Values are mean ± standard deviation of triplicate determinations. *Means are significantly different from control at p<0.05*

Our findings on bacterial populations of the dumpsite and control soil samples using standard bacteriological techniques, are presented in Table 2. The mean total aerobic bacterial count was significantly (p<0.05) highest in Gosa dumpsite (6.89 × $10^{9}$ CFU/g), followed by Gwagwalada dumpsite (4.67 × $10^{8}$ CFU/g), Kwali dumpsite (7.84 × $10^{7}$ CFU/g), Kuje dumpsite (2.31 × $10^{7}$ CFU/g), Abaji dumpsite (9.98 × $10^{6}$ CFU/g) and Bwari dumpsite (5.42 × $10^{6}$ CFU/g) being the least (Table 1). The variations might be as a result of differences in the levels of biodegradable organic waste, moisture, pH and temperature. The pH and temperature of the dumpsites studied were within the optimal range for bacterial growth and biodegradation activities (Onwuka and Mang, 2018). Soil samples from all the dumpsites had higher populations of bacteria than the control soil samples which ranged from $4.22 \times 10^4$ - $3.42 \times 10^6$ CFU/g. Bacteria are the most ubiquitous and abundant microorganisms that can utilize both organic and inorganic materials as sources of nutrients and energy (Atashgahi *et al.,* 2018). Thus, the higher population of bacteria in the dumpsites indicates the organisms are well exposed and adapted biotic and abiotic conditions prevailing thereby. The population of bacteria in this study were comparable to other studies reported in Nigeria, such as $2.4 \times 10^7 – 1.2 \times 10^8$ CFU/g from Port Harcourt dumpsites (Williams and Hakam, 2016), $4.3 \times 10^5 – 4.78 \times 10^6$CFU/mL from Yola dumpsites (Dashu, 2017), $5.0 \pm 0.\ 4 \times 10^4– 1.0 \pm 0.\ 4 \times 10^7$ from Benin City dumpsites (Oshoma *et al.,* 2017), $2.228 \times 10^{10} – 2.659 \times 10^{10}$ CFU/mL from Jere Local Government Area dumpsites, Bornu State (Auta and Paul, 2020), $4.7\pm1.25 \times 10^6– 1.66\pm2.62\times 10^7$ CFU/g from Lemna dumpsite in Calabar, Cross River State (Baasey *et al.,* 2015) and 1.23 x $10^6$– 9.70 x $10^9$ CFU/g Oduduwa University Campus dumpsites. Differences the depth of soil sampling, age of the dumpsites, compositions of the waste could have accounted for the observed variations in the populations of bacteria.

**Table 2.** Total aerobic bacterial population of soil samples from selected dumpsites in Abuja

| Sampling location | Total bacterial count (CFU/g) | | P – value |
|---|---|---|---|
| | **Dumpsite soil** | **Control soil** | |
| Abaji dumpsite | $9.98 \times 10^{6e}$ | $2.21 \times 10^6$ | 0.012 |
| Bwari dumpsite | $5.42 \times 10^{6f}$ | $2.02 \times 10^5$ | 0.000 |
| Gosa dumpsite | $6.89 \times 10^{9a}$ | $3.42 \times 10^6$ | 0.000 |
| Gwagwalada dumpsite | $4.67 \times 10^{8b}$ | $5.35 \times 10^5$ | 0.000 |
| Kuje dumpsite | $2.31 \times 10^{7d}$ | $4.22 \times 10^4$ | 0.000 |
| Kwali dumpsite | $7.84 \times 10^{7c}$ | $1.02 \times 10^6$ | 0.001 |

*****Data presented as Mean ± Standard deviation of triplicate values; values with different superscript alphabets are significantly different ($p<0.05$)*

The predominant bacteria encountered in each of the dumpsite (Tables 3a and 3b) revealed a total of 54 isolates distributed among the genera of *Proteus*, *Providencia*, *Pseudomonas, Escherichia coli, Bacillus, Micrococcus*, *Enterobacter* and *Serratia.* The percentage occurrence of the bacteria were found to be *Proteus* spp. (33.3 %), *Providencia* spp. (29.6 %), *Pseudomonas* spp. (16.6 %), *Bacillus* spp. (9.3 %), *Micrococcus* spp. (5.5 %), *Escherichia coli* (2.1 %), *Enterobacter* spp.(2.1 %) and *Serratia* spp. (2.1 %) as shown in Figure 2. The three major genera, namely; *Proteus, Providencia,* and *Pseudomonas*spp. were isolated in all the six (6) dumpsites, while *Bacillus* and *Micrococcus* spp. were detected in both Gosa and Gwagwalada dumpsites. *Escherichia coli, Enterobacter* and *Serratia* spp. were respectively recovered from Bwari, Abaji and Gwagwalada dumpsites. Control soil samples generally had *Pseudomonas, Bacillus, Micrococcus* and *Serratia* spp. (Table 3). To survive in polluted environments, some native bacteria develop requisite enzymatic machineries to utilize pollutants. The high populations of *Proteus, Providencia,* and *Pseudomonas* spp. suggest they possess the requisite enzymatic capacity to utilize the biodegradable wastes. According to Atashgahi *et al.* (2018), the versatility and dominance of any bacteria is a function of the quality of enzymes it possesses to breakdown and utilize the biodegradable organic compounds in their ecosystem. Some of the bacterial isolates, such as *Providencia, Pseudomonas, Proteus, Bacillus, Micrococcus,* and *Serratia* spp. have been recently reported as potential degraders of hydrocarbon contaminated systems (Borah *et al*., 2019; Ba and Mosimileol, 2020; Okoye *et al.*, 2020; Gebrie *et al*., 2022). The significantly high prevalence of *Proteus* spp. agrees with previous report that they possess various metabolic capacities to adapt favourable to different concentrations of environmental pollutants (Drzewiecka, 2016). Hence, *Proteus*, *Providencia*, and *Pseudomonas* species, which were the most predominant isolates in all the dumpsites could be considered as bioremediation tools for waste pollutants in the study locations.Though significantly low populations of *Escherichia coli* and *Enterobacter* spp. were encountered, they are of public health importance in those locations due to their pathogenic natures. The bacterial isolates from this study have been reported previously (Oviasogie *et al*., 2010; Ndimele *et al*, 2014; Williams and Hakam, 2016; Oshoma *et al.*, 2017, Sawyerr *et al*, 2017; Nireti *et al.*, 2018; Odum *et al.*, 2020; Okafor-Elenwo *et al.*, 2022).

**Table 3a:** Phenotypic characterization of bacterial isolates from selected FCT dumpsites, Abuja

| Sampling site | Isolate Code | Colonial morphology | Microscopic characteristics | | |
|---|---|---|---|---|---|
| | | | Gram reaction | Shape | Arrangement |
| Abaji (ABDi) | *2ABDi1* | Large/small smooth, mucoid, blue/green colonies | (-) | Rods | Singly, pairs |
| | *2ABDi2* | Large, dull grey, non-swarming colonies | (-) | Rods | Singly, pairs |
| | *1ABDi3* | Large/medium, cream coloured, shiny, round mucoid, swarming, colonies | (-) | Rods | Short chains, pairs singly |
| | *1ABDi4* | Colourless to yellowish circular, smooth colonies | (-) | Short Rods | Singly pairs |
| | *1ABDi5* | Medium, pale brown, smooth, round, undulated, raised colonies | (+) | Rods | Singly pairs |
| Bwari (BWDi) | *2BWDi1* | Large/medium, cream coloured, shiny, round mucoid, swarming, colonies | (-) | Rods | Short chains, pairs singly |
| | *1BWDi2* | Large, dull grey, non-swarming colonies | (-) | Rods | Singly, pairs |
| | *1BWDi3* | Large, smooth, white, flat, serrated colonies | (-) | Rods | Singly, pairs |
| | *1BWDi4* | Large/small smooth, mucoid, blue/green colonies | (-) | Rods | Singly, pairs |
| Gosa (GODi) | *2GODi1* | Large/small smooth, mucoid, blue/green colonies | (-) | Rods | Singly, pairs |
| | *5GODi2* | Large/medium, cream coloured, shiny, round mucoid, swarming, colonies | (-) | Rods | Short chains, pairs singly |
| | *4GODi3* | Large, dull grey, non-swarming colonies | (-) | Rods | Singly, pairs |
| | *1GODi4* | Medium, pale brown, smooth, round, undulated, raised colonies | (+) | Rods | Singly pairs |
| | *1GODi5* | Large yellow coloured, non-diffusible pigment, round, convex, opaque, smooth colonies | (+) | Cooci | Singly pairs |
| Gwagwalada (GWDi) | *2GWDi1* | Large/small smooth, mucoid, blue/green colonies | (-) | Rods | Singly, pairs |
| | *1GWDi2* | Small, pink, smooth, convex, entire round colonies | (-) | Short rods | Singly, pairs |
| | *2GWDi3* | Large/medium, cream coloured, shiny, round mucoid, swarming, colonies | (-) | Rods | Short chains, pairs singly |
| | *2GWDi4* | Large, dull grey, non-swarming colonies | (-) | Rods | Singly, pairs |
| | *2GWDi5* | Medium, pale brown, smooth, round, undulated, raised colonies | (+) | Rods | Singly pairs |
| | *1GWDi6* | Large yellow coloured, non-diffusible pigment, round, convex, opaque, smooth colonies | (+) | Cooci | Singly pairs |
| Kuje (KUDi) | *4KUDi1* | Large/medium, cream coloured, shiny, round mucoid, swarming, colonies | (-) | Rods | Short chains, pairs singly |
| | *3KUDi2* | Large, dull grey, non-swarming colonies | (-) | Rods | Singly, pairs |
| | *2KUDi3* | Large/small smooth, mucoid, blue/green colonies | (-) | Rods | Singly, pairs |
| | *1KUDi4* | Medium, pale brown, smooth, round, undulated, raised colonies | (+) | Rods | Singly pairs |
| Kwali (KWDi) | *4KWDi1* | Large, dull grey, non-swarming colonies | (-) | Rods | Singly, pairs |
| | *4KWDi2* | Large/medium, cream coloured, shiny, round mucoid, swarming, colonies | (-) | Rods | Short chains, pairs singly |
| | *1KWDi3* | Large/small smooth, mucoid, blue/green colonies | (-) | Rods | Singly, pairs |

| | | | | |
|---|---|---|---|---|
| *1KWDi4* | Large yellow coloured, non-diffusible pigment, round, convex, opaque, smooth colonies | (+) | Cooci | Singly pairs |

***Key:*** *ABDi =Abaji dumpsite isolates, BWDi = Bwari dumpsite isolates, GODi = Gosa dumpsite isolates, GWDi = Gwagwalada dumpsite isolates, KUDi = Kuje dumpsite isolates, KWDi = Kwalidumpiste isolates*

**Table 3b***:* Phenotypic characterization of bacterial isolates of from selected dumpsites in Abuja

| | Isolates codes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Biochemical test** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** |
| Catalase | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) |
| Oxidase | (-) | (+) | (-) | (-) | (-) | (-) | (+) | (+) |
| Motility | (+) | (+) | (+) | (+) | (+) | (+) | (-) | (-) |
| Spore | (-) | (-) | (-) | (-) | (-) | (-) | (-) | (-) |
| Indole | (-) | (+) | (-) | (-) | (+) | (-) | (-) | (-) |
| Methyl red | (-) | (+) | (+) | (-) | (+) | (-) | (-) | (-) |
| Vogesproskauer | (-) | (-) | (-) | (+) | (-) | (+) | (+) | (+) |
| Urease | (-) | (-) | (+) | (-) | (-) | (+) | (-) | (-) |
| Citrate test | (+) | (+) | (+) | (+) | (-) | (+) | (+) | (-) |
| Nitrate reduction | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) |
| Glucose | (+) Ac | (+) Ac | (+) Ga | (+) Ac/Ga | (+) Ac/Ga | (+)Ac | (+)Ac | (+)Ac |
| Fructose | (-) | (-) | (-) | (+) | (+) | (+) | (+) | (-) |
| Lactose | (-) | (-) | (-) | (+) | (+) | (-) | (+) | (-) |
| Sucrose | (+) | (-) | (-) | (+) | (+) | (+) | (+) | (-) |
| Mannitol | (+) | (-) | (-) | (+) | (+) | (+) | (+) | (-) |
| Probable identity | *Pseudomonas* spp. | *Providencia* spp. | *Proteus* spp. | *Enterobacter spp.* | *E. coli* | *Serratia* spp. | *Bacillus* spp. | Micrococcus spp. |

Key:***Ac****: Acid production,* ***Ac/Ga****: Acid and gas production; (+): Positive; (-): Negative*

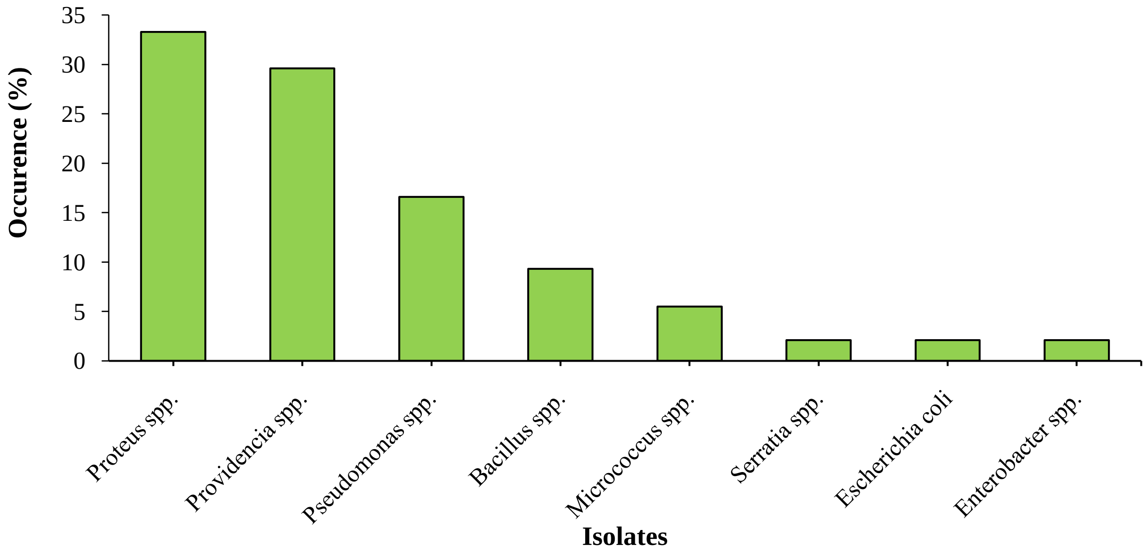


**Figure 2:** Percentage occurrence of bacterial isolates fromdumpsites in Abuja

**Table 3**: Distribution of isolates from selected dumpsites in Abuja

| **Dumpsites** | ***Pseudomonas* spp.** | ***Providencia* spp.** | ***Proteus* spp.** | ***Enterobacter spp.*** | ***Micrococcus* spp.** | ***Bacillus* Spp.** | ***Escherichia coli*** | ***Serratia* spp.** |
|---|---|---|---|---|---|---|---|---|
| Abaji | + | + | + | - | - | + | + | - |
| Bwari | + | + | + | + | - | - | - | - |
| Gosa | + | + | + | - | + | + | - | - |
| Gwagwalada | + | + | + | - | + | + | - | + |
| Kuje | + | + | + | - | - | + | - | - |
| Kwali | + | + | + | - | + | - | - | - |
| Control | + | - | + | - | - | + | - | + |

Key: +: detected; - : Not detected

## CONCLUSION

This study has shown that the six major open solid waste dumpsites situated at different locations within the FCT, Abuja significantly elevated the levels of temperature, pH, electrical conductivities and bacterial populations in the receiving soil environment when compared with control soil samples (2 km away) from the dumpsites. Gwagwalada dumpsite recorded the highest temperature and pH variations; Bwari dumpsite had the highest EC values, while Gosa dumpsite harboured the highest population of bacteria. Although, most of the bacterial isolates are normal environmental isolates, the high level of especially *Proteus* spp., and low levels of *E. coli* and *Enterobacter*, which are indicative of fecal pollution, suggest that precautionary measures should be taken when using water (surface and underground) around the dumpsites. Though, the physicochemical variations were within the EEPA and WHO standard limits, constant public education on proper waste management coupled with application of appropriate bioremediation strategies using the predominant native waste dumpsite bacterial (*Proteus, Providencia, Pseudomonas* and *Bacillus*) isolates will go a long way in making the dumpsites safer for plants, animals and humans.

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