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Assessment of Quality Status of Soils Around Dumpsites in Ilorin Metropolis, Nigeria

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ABSTRACT

Pathogenic microorganisms in solid waste can be introduced into the environment when improperly managed. This study evaluates the microbiological and physicochemical properties of topsoil samples obtained from three municipal waste dumpsites and a dumpsite free area (control sample) all located in Ilorin, Kwara State, Nigeria. Soil samples were collected on a spot at depth range of 15-30 cm for laboratory analyses which included measurements of temperature, pH, moisture content and microbiological population. The pH values of the samples ranged from 6.7 to 7.9. The temperature ranged from 26 ^oC to 28 ^oC which falls within the mesophilic range. The total aerobic heterotrophic bacteria population ranged from 1.8×10^5 cfu/ml to 5.8×10^5 cfu/ml for all the three dumpsites and 1.0×10^5 cfu/ml for the control. The specie of bacteria isolated from the soil samples from the dumpsites included Staphylococcus auerus, Streptococcus faecalis, Klebsiella aerogenes, Bacillus subtilis, Proteus vulgars and Micrococcus cuteus. Only Bacillus subtilis and Micrococcus cuteus were dominant in the control. The total viable fungal population ranged from 1.0×10^4 cfu/ml to 2.6×10^4 cfu/ml for all the soil samples from the dumpsites and 1.1×10^4 cfu/ml from the control. The fungi isolated from the soil samples included Aspergillus flavus, Rhizopus stolarifer, Aspergillus niger, Penicillium chrysogenium and Alteruaria tenuis. Only chrypsogspuss and Alteruaria tenuis were identified in the control. Presence of microorganisms in dumpsites around Ilorin metropolis suggests that environmental quality has been significantly affected as the soil sample showed high population of pathogenic microorganisms. Hence, remediation is suggested.

1. INTRODUCTION

Globally, waste generation has been an issue for communities since the beginning of civilization (Sawyerr *et al.,* 2017). Waste (also referred to as rubbish, trash, refuse, garbage, or junk) can be described as unwanted or unusable materials. Population growth and economic development lead to enormous amount of solid

waste generation by the dwellers of the urban areas and they are also sources of chemical substances going above their threshold limit into the environment (Obasi *et al.,* 2012; Verge and Rowe, 2013). Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities (Williams and Hakam, 2016). Solid waste pollutants serve as an external force affecting the physicochemical characteristics of soil that ultimately contribute to poor production of vegetation and other crops (Christensen *et al*., 2014). In Nigeria, collected wastes are usually burnt outdoors and ashes are poorly disposed of on-site. This act destroys the organic components of the soil and causes the oxidation of metals. The ashes left behind are enriched with metal, which results in pollution of the surrounding environment (Adeyi and Majolagbe, 2014). According to Mpofu *et al.* (2013), the movement of contaminants from sites where wastes are disposed of to the adjoining ecosystems is complex and involves biological and physiochemical processes. Pathogenic microorganisms and harmful chemicals in solid waste can be introduced into the environment when the waste is not properly managed (Ogbonna and Igbenijie, 2006). Waste can contaminate surface water, ground water, soil and air which poses more problems for humans, other species, and ecosystems (Obire et al., 2002). Soil contamination through waste discharges, particularly hazardous waste, is a global phenomenon and carries different metals which are then transferred to plants in different ways (Akinbile and Yusoff, 2012).

Landfilling of municipal solid waste is a common waste management practice and one of the cheapest methods for organized waste management in many parts of the world while dumpsite is an old traditional method of disposal similar to landfill method of waste management (Jhamnani and Singh 2009; Osazee *et al.,* 2013). Nigeria is faced with rapid deterioration of environmental conditions due to the conventional system of collection and dumping of solid wastes (Akinbile *et al.,* 2016). Sawyerr *et al.* (2017) and Ogunmodede *et al.* (2014) reported that open dumpsites could be a source of microbial and toxic chemical pollution of the soils of the dumpsites which can also pollute hand dug wells, posing serious health risks and leading to the destruction of biodiversity in the environment. Water can percolate through the refuse pile in the dumpsites and this leads to the formation of leachates (Sawyerr *et al.,* 2017). Leachate from dumpsites is of particular interest when it contains potentially toxic heavy metals which are known to bio-accumulate in soil and have long persistence time through interaction with soil component and consequently enter food chain through plants or animals (Dosumu, 2003). Wastes composition influence the concentration of the leachates' constituents which may be adsorbed on to the soil during diffusion (Shaikh *et al.,* 2012). This process creates health hazards, soil and water pollution, and offensive odors, which increase with an increase in ambient temperature levels (Abdus-Salam *et al*., 2011). Therefore, this study was designed to assess the significant impact of dumpsites in the three Local Government Areas (LGA) of Ilorin Metropolis, Kwara State, Nigeria in order to determine the levels of microbial and physicochemical parameters on the quality of soil.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The City of Ilorin, the capital of Kwara State in North Central Nigeria is located on latitude 8^0 30'N and longitude 4^0 35'E. It is about 500 kilometers from Abuja, the Federal Capital of Nigeria and strategically located at the geographical and cultural confluence of the Northern and Southern part of Nigeria. Ilorin metropolis is made up of three local government areas namely Ilorin West, Ilorin East and Ilorin South. The City can be classified into three sub areas; old residential area, new residential area and Government reservation area. The old residential area is the indigenous part of town which is located in the central core area. The new residential area is the post-colonial area located around the core area of the city, while the Government reservation area is the high status neighbourhood area (Ayanshola *et al*., 2015). As of 2006 census, it had a population of 777, 667, making it the 6^{th} largest city by population in Nigeria according to

Federal Republic of Nigeria 2006 population census. The study areas considered in this research as shown in Figure 1 are located at different areas within Ilorin metropolis which are Tanke dumpsite (Ilorin South Local Government Area); Offa Garage Dumpsite (Ilorin West LGA); Kankatu Dumpsite (Ilorin East LGA) and a control site (Ilorin South LGA). These dumpsites are witnessing daily influx of refuse from around the town.

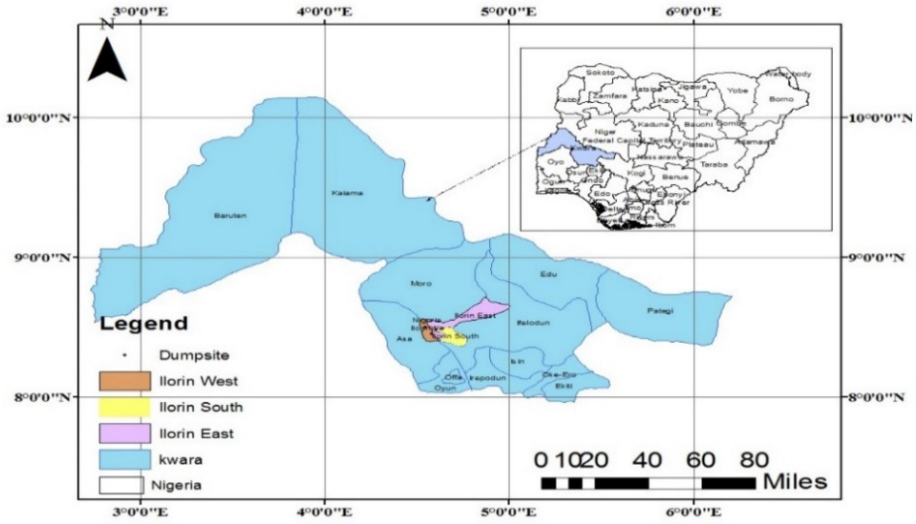

Figure 1: Map of Kwara State showing the various dumpsite and their LGAs

2.2. Material Collection and Preparation

The soil samples were collected from three different dumpsites located in the three LGAs of Ilorin, Kwara State, Nigeria. Prior to sampling, the surface debris of the soils were removed. The samples were collected within 15-30 cm depth at the dumpsites and reference site and placed in appropriately labelled sterile black polythene bags and taken immediately to the laboratory for analyses. Table 1 shows the locations of each of the dumpsites using global positioning system.

Table 1: Geographical location of the dumpsites

Location	LGAs	Longitude (°)	Latitude (°)
Tanke	Ilorin East	8.48456	4.60211
Offa Garage	Ilorin South	8.45434	4.58291
Kankatu	Ilorin West	8.50264	4.54529

The soil samples were air dried, crushed, passed through a sieve (2 mm) and put in clean polythene bags and stored at room temperature for laboratory analysis. All glass wares used at any stage of the analysis were thoroughly washed with detergent solution. Clean water was then used to rinse them to remove foams, and then distilled water was used to rinse the glass ware and drained. They were then wrapped with aluminium foil and sterilized in the hot air oven at $160^{O}C$ for one hour. The work bench was swabbed with 70% ethanol before and after every practical work in order to provide an aseptic environment. Inoculating loop and inoculating needles were heated to redness using Bunsen flame while spatulas were dipped in 70% ethanol and flamed.

2.3. Analytical Methods

The analytical phase involved the analysis of physicochemical, heavy metal concentrations and microbial parameters in the soil samples collected from the three dumpsites and the control site, in order to measure the impact of the dumpsites on the soil quality. The physicochemical properties of the soil samples were determined according to the Association of Official Analytical Chemist's standard methods (AOAC, 2005). The parameters assessed were pH, temperature and organic carbon using glass electrode pH meter, thermometer and Walkley Black wet oxidation method respectively. The heavy metals analysis was carried out using hydrochloric acid digestion. An atomic absorption spectrophotometer (model BUCK ACCUSYS 211) equipped with hollow cathode lamp was used for the determination of metal ion concentrations. Each sample was aspirated and the mean signal response recorded at the metal ion's wavelength. These metals include Zinc (Zn), Iron (Fe) and Cadmium (Cd). Serial fold dilutions were then made up to 10^{-6} and aliquots of each dilution were cultured on plates of nutrient agar for mean heterotrophic bacterial count and potato dextrose agar (PDA) for mean heterotrophic fungal count respectively by pour plate method (Aneja, 2003). Also, MacConkey agar for enumeration of coliform, Eosin methylene blue agar for faecal coliform and yeast extract agar was used for enumeration of yeast. Prior to pouring, all the respective prepared culture media were autoclaved at 121 °C for 15 min. Inoculation pour plating and sub-culturing were all carried out near naked flame to achieved aseptic condition. Plating was done in duplicates and the culture plates were swirled, allowed to solidify and incubated at 35 ^{o}C for 48 hr and ambient room temperature (28±2 ^{o}C) for 5 days in respect of the mean aerobic bacterial and heterotrophic fungal counts respectively.

2.4. Characterization and Identification of Fungi Isolate

The fungi isolates were characterized and identified after obtaining pure culture of the isolates through repeated sub-culturing by using their surface texture, pigmentation and under surface texture. Microscopic examination of the fungi isolate was carried out using methyl blue indicator. A sterile needle was used to pick a little of each of the isolate and place on a grease from slide that contains the methylene blue indicator, then tease out the organism on the clean slide and cover slip then examined under lower magnification using microscope. The fungal isolates were characterized based on their cultural, biochemical, properties and microscopic appearances described by Cheesebrough (2005).

2.5. Characterization and Identification of Bacterial Isolates

The isolates were characterized and identified after obtaining pure culture of isolates through repeated sub culturing by using their colonial morphology cellular, cellular morphology and biochemical reaction. Gram staining, motility test, biochemical test, catalase test, coagulase test, oxidase test, indole test, urease test, Voges Proskauer test, methyl red test, starch hydrolysis and sugar Fermentation were all carried out using Bergey's manual of classification (Cheesebrough, 2006).

3. RESULTS AND DISCUSSION

3.1. Physical Parameters

The temperature values of soil samples from the dumpsites with the reference (control site) are shown in Table 2. The temperatures of the soil samples were determined and the values ranged from 26.5 ^{o}C to 28 ^{o}C

for all the dumpsites. The mean temperature values for dumpsites located in the South, West, East, and control site were 26.5 ºC, 28 ºC, 27 ºC and 24 ºC respectively. The temperature at the dumpsites in Ilorin metropolis were found to be higher compared to that at the control site. The soil temperature values of the dumpsites fell within the mesophilic range of temperatures for most pathogenic bacteria whose optimum temperature for growth is 37 ºC with upper and lower temperature limits of 40-50 and 15-20 °C, respectively (Arora, 2004). Obire *et al.* (2002) reported that during initial compositing development in dumpsites, the mesophilic flora predominates and are responsible for most of the metabolic activities that occur. Increased microbial activities elevate the temperature of compost, with the subsequent replacement of mesophilic population by thermophilic flora such as *bacillus* and *Aspergillus* reported in this study.

Table 2: Mean temperature (ºC) values of dumpsites soil and control site

Soil samples	Depth (cm)	Temp. (ºC) (Dumpsite in South)	Temp. (ºC) (Dumpsite in West)	Temp. (ºC) (Dumpsite in East)
Dumpsites	15-30	26.5	28	27
Control	15-30		24	

The pH reported in this study for all the waste dump sites ranged from pH 6.7 and 7.1. Soil pH influences a number of factors affecting microbial activity, like solubility and ionization of inorganic and organic soil solution constituents, and these will in turn affect soil enzyme activity (Voroney, 2007). The soil sample for the waste dumpsite at the south, west and east ranged from slightly acidic to basic while the control site was found to be slightly basic. This observation is similar to report of Abdus-Salam (2009) which reported the acidic characteristics of topsoil sourced from several municipal waste dumpsites in Ilorin, Central Nigeria. The pH values of the soil samples of the three dumpsites and the control site are presented in Table 3.

Table 3: pH values of soils samples of the dumpsites and control

Soil samples	Depth (cm)	pH (Dumpsite in South)	pH (Dumpsite in West)	pH (Dumpsite in East)
Dumpsite	15-30	6.7	6.9	7.1
Control	15-30		7.4	

The organic carbon was likely due to decomposition of plants, animals and anthropogenic sources such as chemical contaminants, fertilizers or organic rich waste on the dumpsites. The values of organic carbon ranged from 1.86% to 2.26% for all the three dumpsites and 1.68% for the control site. This implies that there is less effect of the decomposed wastes on the control site compared to the respective dumpsites.

Table 4: Organic carbon (%) content of soils samples of the dumpsites and control

Soil samples	Depth (cm)	Organic carbon % (Dumpsite in South)	Organic carbon % (Dumpsite in West)	Organic carbon % (Dumpsite in East)
Dumpsite	15-30	1.86	1.96	2.26
Control	15-30		1.68	

The results show that Zn and Cd concentrations were practically low. High concentration of Fe could be partly due to the Fe content of Ilorin soil and partly due to high content of Fe-based waste materials been generated through domestic and industrial wastes. Most of the Fe is bound to organic matter and residual

(Abdus-Salam, 2009). Excess of some heavy metals in the environment can cause serious environmental health consequences because of their biomagnification and bioaccumulation (Ogunmodede et al., 2014)

Table 5: Heavy metal properties of soil samples from the dumpsites and control

Parameters	Control	Dumpsite in South	Dumpsite in West	Dumpsite in East
Zinc (mg/kg)	0.19 ± 0.00	0.82 ± 0.6	1.55 ± 0.66	1.24 ± 0.92
Iron (mg/kg)	0.15 ± 0.00	3.70 ± 4.10	5.15 ± 5.95	5.80 ± 4.45
Cadmium (mg/kg)	ND	ND	0.02 ± 0.01	ND

ND = Not Detected

3.2. Microbial Population

The value for the total aerobic heterotrophic bacteria count per gram of soil at the dumpsite are 3.4×10^5 *CFU* in south, 2.5×10^5 *CFU* in west, 2.4×10^5 *CFU* in east while 1.0×10^5 *CFU* at the control site. South recorded highest total number of 3.4×10^5 *CFU* while control site recorded the lowest total number of 1.0×10^5 *CFU*. The value of heterotrophic bacteria count was found to be high at the dumpsites compared to the control, this could be due to the fact that microorganisms find their way to the various dumpsites as a result of regular disposal of degradable waste.

The value of total viable fungi per gram soil at the dumpsite as presented in Table 4 ranged from 1.5×10^4 *CFU* in south, 1.6×10^4 *CFU* in west, 1.9×10^4 *CFU* in east while 1.1×10^4 *CFU* at the control. East recorded highest total number of 1.9×10^4 *CFU* while the control recorded the lowest total number of 1.1×10^4 *CFU*. The fungi counts were found to be higher at the dumpsite compared to control. All the microbial isolates identified from the soil samples is an indication that microbes are not only ubiquitous in nature but also populate the soil, thus increase the nutritional value of the soil (Williams and Hakam, 2016).

Table 6: Total aerobic heterotrophic bacterial and viable fungi counts

Sample site	Depth (cm)	Bacteria count (cfu/ml)	Fungi count (cfu/ml)
Dumpsite (South)	15-30	3.4×10^5	1.5×10^4
Dumpsite (West)	15-30	2.5×10^5	1.6×10^4
Dumpsite (East)	15-30	2.4×10^5	1.9×10^4
Control	15-30	1.0×10^5	1.1×10^4

3.3. Characterization of Bacterial Isolates

The results of characterization of bacteria isolates is presented in Table 7. The analysis revealed that six bacteria were identified from the various dumpsite samples while only two were identified in the control site. At the waste dumpsites, the bacteria identified were *Staphylococcus auerus, Streptococcus faecalis, Klebsiella aerogenes, Bacillus subtilis, Proteus vulgars* and *Micrococcus cuteus* as presented in Table 8. Only *Klebsiella aerogenes, Bacillus subtilis* and *Micrococcus cuteus* were characterized and identified at the control site as shown in Table 8. The isolation of *Staphylococcus auerus, Kleibsiella aerogene and Bacillus subtilis* was similar to a report by Obire *et al.* (2002) which stated the presence of these microorganisms in soils collected from a waste dumpsite located at Eagle island, Rivers State, Southern Nigeria. All the microbial isolates identified from the soil samples is an indication that microbes are not only ubiquitous in nature but also populate the soil, thus increase the nutritional value of the soil (Williams and Hakam, 2016).

Table 7: Characterization and isolation of bacteria

Isolate Form	1	2	3	4	5	6
Shape	Circular	Circular	Circular	Irregular	Irregular	Circular
Edge	Entire	Entire	Entire	Lobate	Lobate	Entire
Pigmentation	Yellow	Creamy	Creamy	Creamy	Creamy	Creamy
Colony Surface	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Consistency	Butyrous	Butyrous	Butyrous	Butyrous	Viscid	Butyrous
Elevation	Raised	Raised	Raised	Flat	Flat	Raised
Optics	Opaque	Opaque	Opaque	Opaque	Translucent	Opaque
Gram Stain	+	+	-	+	-	+
Motility Test	+	-	+	+	+	-
Oxygen R/ship	FA	FA	FA	FA	FA	FA
Methyl Red	-	-	+	+	+	-
Voges proskauer	-	-	+	+	+	-
Oxidase Test	-	+	+	-	-	+
Starch	+	+	-	+	-	-
Catalase	+	-	+	+	+	+
Indole	+	-	-	-	+	-
Coagulase	+	-	-	-	-	-
H_2S Sulphide	-	-	-	-	+	-
Urease	-	-	-	-	+	-
Citrate-utiliztn	-	-	-	+	-	-
Glucose	AG	AG	AG	A	AG	A
Lactose	A	A	AG	A	-	A
Sucrose	A	A	AG	A	AG	A
Maltose	A	A	AG	A	-	A
Fructose	A	A	AG	A	-	A
Maltose	A	A	AG	A	-	A

Key: (+) = Positive; (AE) = Aerobic; (-) = Negative; (FA) = Facultative Anaerobic; (A) = Acid production; (AG) = Acid and gas production

Table 8: Bacteria identified and isolated from the dumpsite and control site

Types of bacteria isolated	South	West	East	Control
Staphylococcus aureus	+	+	+	-
Streptococcus faecalis	+	+	+	-
Kleibsiella aerogene	+	+	+	+
Bacillus subtilis	+	+	+	+
Proteus vulgaris	+	+	+	-
Micrococcus cuteus	+	+	+	+

Key: (+) = Present; (-) = Absent

3.4. Characterization of Fungal Isolates

During the test, five different fungal were identified from the dumpsites as shown in Table 9 and they were *Aspergillus flavus, Rhizopus stolarifer, Aspergillus niger, Penicillium chrysogenium and Alteruaria tenuis*. Only three of this fungal were identified in the control site and these were *Aspergillus flavus, Rhizopus stolarifer, Aspergillus niger,* as shown in Table 10. The isolation of *Aspergillus sp., Mucor sp., Fusarium sp.* from the dumpsites, was similar to a report by Obire *et al.* (2002) which stated the presence of these

microorganisms in soils collected from a waste dumpsite located at Eagle Island, Rivers State, Southern Nigeria. Fungi such as those identified in this research work are associated with solid waste biodegradation.

The fungal species dwell in soil and aid in the decomposition of dead plants and animals. Through this, they are able to enrich the soil and contribute to the soil nutrient cycle. Their spores can survive in air, hence, their presence in the aerial samples (Evangeline et al., 2017).

Table 9: Characterization of fungi isolate

Surface texture	Powdery	Cotton strands	Powdery	Powdery	Powdery
Pigmentation	Green Yellow	White	Blackish	Bluish green with broad white margin	Dark greenish black with periphery black
Under surface texture	Creamy	Creamy	Creamy	Black	Creamy
Identification	*Aspergillus flavus*	*Rhizopus stolarifer*	*Aspergillus niger*	*Penicillium chrypsogspus*	*Alteruaria tenuis*

Table 10: Fungi identified from dumpsite and control

Types of Fungal Control	South	West	East	Control
Aspergillus flavus	+	+	+	+
Rhizopus stolarifer	+	+	+	+
Aspergillus niger	+	+	+	+
Penicillium Chrypsogspus	+	+	+	-
Alteruaria tenuis	+	+	+	-

+ = Present; - = Absent

4. CONCLUSION

This study revealed that the dumping of solid wastes has different effects on the physicochemical and biological properties of soil. It can be concluded that bacterial and fungal isolated from the soil at the study dumpsites are pathogenic. Therefore, the potential for disease epidemics from the open dumping of solid waste in Ilorin is high. In particular, the presence of *Staphylococcus* and *Streptococcus* in the solid waste soils, points to health risk associated with solid waste. From environmental point of view, the pollution from open dumping of waste could result in the production of not only unsightliness but also bad odour. Improper waste disposal technique could become a serious health hazard through unsuitable environment from which diseases can be transmitted.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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