
The threatening effects of open dumping on soil at waste disposal sites of Akure City, Nigeria

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Abstract: This study examines the influence of uncontrolled deposition of MSW disposal on soil in four selected dumpsites across Akure city, Nigeria. Physicochemical and microbial tests were carried out using standard procedure. Soil samples were randomly collected using soil auger from the major (Igbatoro and Iju-Itaogbolu), and the minor (Ijare and FUTA) dumpsites, at depths (0–10, 10–20, 20–30 cm), with control samples taken at a distance 20 m away from each dumpsite. The physicochemical parameters measured include pH, total organic matter, total organic carbon and particle size distribution. The results showed that samples were predominantly acidic (4.12 to 6.73), sandy (32.69 to 65.40) with values ranging from 0.17 to 4.14 and 0.02 to 3.15 for organic matter and organic carbon respectively. The mean values for both aerobic bacterial counts and heterotrophic fungal counts from control to the dumpsites ranged from 188×10^6 to 258×10^6 cfu/mL, and 128×10^6 to 193×10^6 cfu/mL, respectively. Although there exists some positive impacts of dumpings on soil, their adverse effects are life threatening.

Keywords: soil pollution; solid wastes; dumpsites; indiscriminate disposal; Nigeria.

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1 Introduction

The emerging danger of environmental deterioration due to uncontrolled generation and regulation of municipal solid waste (MSW) peculiar to developing countries is of severe concern and has ceaselessly gained public attention. The unmanaged disposal of MSW is ever-increasing, one so attributed to dearth of resources and unwitty governing administration, rapid development, increasing population, inferior living condition, environmental insensitivity, socio-economic development and inadequate management of environmental knowledge (Ogu, 2000; Krishnamurti and Naidu, 2003; Karak et al., 2013). Several studies on improper solid waste management in different cities of different countries have been documented (Chatterjee, 2010; Akinbile and Ajayi, 2011; Apale et al., 2011; Vásquez and Alfaro, 2011; Amadi et al., 2012; Das and Bhattacharya, 2013; Mohanty et al., 2014). Owing to the poor management of solid waste, it has become a pollution source that has caused multifarious environmental effects that are injurious to human health and safety (Shazwin and Nakagoshi, 2010; Akinbile et al., 2016a; Marfe and Stefano, 2016; Adewumi et al., 2017). Majority of these wastes come in different forms such as household, industry, biomedical and commercial activities (Singh et al., 2011), which requires specific technique for their management, otherwise could pose long term degrading effects on environment (Pattnaik and Reddy, 2010).

In Nigeria, unlike in the developed countries where there is appropriate and efficient system driven by high level of technology to arrest the issue of waste management (Wilson, 2007), waste management is characterised by inefficient collection methods, inadequate coverage of collection system and inappropriate disposal of MSW. Open dumping system of waste disposal is a common phenomenon in Nigeria, especially in the cities where the population continue to grow unabated due to urbanisation. Ogwueleka (2009) reported that Nigeria generated solid waste of 250 to 370 kg/m³ which is higher than generated densities of solid waste found in developed countries, with major cities like Lagos, Kano and Port Harcourt generating an average of 255,556, 156,676 and 117,825 tonnage per month respectively and the waste generation rates ranged from 0.44 to 0.66 kg/capita/day. Adeniran et al. (2017) documented that Nigeria generates more than 32 million tons of solid waste annually, out of which only 20–30% is collected. The enormous wastes produced without proper management methods have continued to have deleterious effects on the environment, ecosystem and public health (Abdus-Salam, 2009).

Soil is a composite of materials originating from living organisms and materials of inorganic substances. It represents a pool having a marked absorption capacity for pollutants, examples of which are metals and minerals and chiefly influencing the

distribution of the pollutants (Wang et al., 2011; Cetin, 2014). Previous land usage, and present soil employment, and proximity to pollution sources affect soil properties. Human activities such as urban-industrial expansions, mining operations and most recently, uncontrolled electronic waste recycling have led to serious environmental challenges that produce from release of hazardous substances (Brigden et al., 2008; Wu et al., 2008; Luo et al., 2011).

Open dumping has been reported to have serious long-term damaging effect on environmental factors (Phil-Eze, 2010; Yasin and Usman, 2017), especially in the soil environment (Adewumi and Ajibade, 2015; Breza-Boruta et al., 2016; Akortia, et al., 2017; Kodirov et al., 2018) which is as a result of inappropriate landfill sites and poor management techniques (Adewumi et al., 2019; Ajibade et al., 2019). Ali et al. (2014) observed significant modifications in soil properties of some dumpsites with high values of pH, total dissolved solids and electrical conductivity as compared to the control sites. Also, Breza-Boruta et al. (2016) found that accumulated waste in the dumpsite causes depletion in soil organic matter which inhibits microorganism growth. Alteration in physical and biochemical properties of soil can lead to soil degradation (Civeira and Lavado, 2008). Groundwater and surface water could also be affected through rainwater infiltration of toxic materials (Ilori et al., 2019) and soil erosion of contaminants from the dumpsites and mining activities to the nearby stream (Ugya et al., 2018). Efforts by government to improve on the system of waste collection and disposal has yielded little or no result as open dumpsites can still be found at strategic places in most cities across Nigeria. The consequence of this is damaging to the ecosystem and soil around the dumpsites because we are experiencing more bacteria that are multi-resistant which can pose a severe public health issue (Elbendary et al., 2018). Thus, this study investigates the prevailing condition of physicochemical and bacteriological properties of soil at selected dumpsites across Akure City, Nigeria.

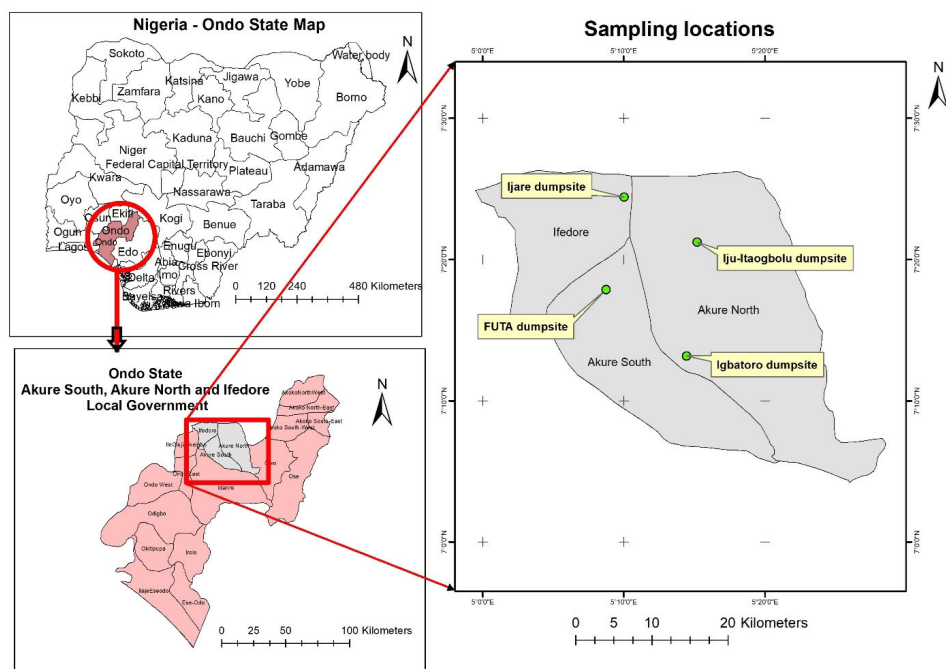
2 Materials and methods

2.1 Description of the study area

Akure city, the capital of Ondo State is located in the southwestern part of Nigeria (Figure 1). It lies between latitudes 7° 15' and 7° 17' north of the Equator and between longitudes 5° 14' and 5° 15' east of the Greenwich Meridian. It is bounded in the North-West by Ekiti State, West-Central by Osun State, South-West by Ogun State, South-East by Delta State and in the South by Atlantic Ocean (Ajibade, 2013). The city covers a total land area of 15,500 km² with about 370 m above the sea level (Ajibade et al., 2014a, 2014b). Its climate is tropical humid with two clearly different seasons, a somewhat dry season from November to March and a wet or rainy season from April to October with mean annual temperature of 24°C–27°C (Ajibade and Adewumi, 2017). There has been tremendous growth in its population from 17,106 of the 1963 National census to 239,124 and 360,268 in 1991 and 2006 respectively, with a projection of 476,159 in the year 2014 (NPC, 2006). The city has a sandy soil at the surface with underlying clay texture in the subsoil (Akinbile et al., 2016a, 2016b) and as a result, the soil is sensitive to erosion and water logging. The soil parent materials are majorly of crystalline acid rocks which is made up of ferruginous tropical soils supporting the

cultivation of agricultural produce such as maize, cassava and yams (Adewumi and Ajibade, 2019).

Figure 1 Map of study area showing sampling locations (see online version for colours)



2.2 Soils sampling

For this study, four dumpsites were selected which cover three local government areas of the city and have been in existence for more than two years. Among them are two major dumpsites located along Igbatoro road, and Ijare area in Akure North and Ifedore local government areas respectively, and the minor dumpsites at Iju-Itaogbolu and the Federal University of Technology Akure (FUTA) in Akure North and Akure South local government areas respectively. The two major dumpsites were selected based on the high daily influx of refuse and their strategic locations around the coverage city while the two minor dumpsites were chosen as a result of the propinquity and peculiarity of their locations (FUTA is the main University in the city and Iju-Itaogbolu dumpsite is close to the neighbouring towns in the city).

In each dumpsite, soil samples were randomly sampled from four different spots from each dumpsite using hand auger (2.5 cm diameter) in a systematic pattern (100 × 100 m grid) in a vertical profile of 0.4 m deep (Kodirov et al., 2018). Three soil samples were collected from each dumpsite and one soil sample as control (Figure 2). Moreover, to achieve a representative sample, the soil samples were collected at different points from the upper soil layer (0–10 cm), 10–20 cm depth and 20–30 cm depth and the control sample recovered at distance 20 m away from each dumpsite. Thereafter, collected samples were moved to the laboratory for analysis in labelled non-reacting polyethylene bags.

Figure 2 Soils sampling, (a) Igbaturo dumpsite (b) depth measurement to obtain samples (c) use of soil auger to obtain samples at different depths on a spot (d) use of shovel to remove grasses to obtain control samples (20 m away from dumpsite) (see online version for colours)



2.3 Sample preparation and analysis

Collected soil samples were air-dried at room temperature, sieved through 2 mm mesh, ground, and homogenised in an agate mortar (Kodirov et al., 2018). After which the samples were divided into two sets. One set was used for physicochemical analysis and the other set was used for microbial analysis. Several analyses were conducted to evaluate the soil quality under various parameters.

2.4 Physicochemical parameters of the soil

The physicochemical and particle size distribution analyses of the soil samples collected involved determining the soil pH, soil organic matter, soil organic carbon, and particle size distribution analysis. Each soil sample was analysed for pH in soil to water ratio of 1:5 using 2 digital portable combination meter (Milwaukee MW802). Organic matter (OM) was determined by Walkley-Black wet oxidation method (Ibitoye, 2006). The analysis of particle size distribution was carried out in accordance to ASTM D6913 (2017) and ASTM D7928 (2017).

2.5 *Microbial analyses*

For microbial analyses, pure cultures of bacteria were obtained by aseptically colonies representation of different morphological features which include colour, types and shapes of spores, conidia and hyphae, which appeared on the cultured plates. This was put into the freshly prepared nutrient agar plates which were incubated at 25°C for five days. Potato dextrose agar to which 1% (w/v) chloramphenicol has been added (to inhibit fungi growth) was used for fungi isolates. The developed discrete bacterial colonies were sub-cultured on freshly prepared potato dextrose agar and incubated at 25°C for five days. These served as pure stock cultures for subsequent characterisation tests. The following standard characterisation were performed in triplicate; gram staining, catalase test, oxidase test, indole test, motility and oxygen relation test, spores staining, carbohydrate utilisation, sugar fermentation test, and oxidation fermentation test. Identification of pure isolates were based on cultural, morphological, and biochemical characteristics as described in Obire et al. (2002).

2.6 *Statistical analysis*

Basic descriptive statistics was done using Origin 9.0 as a plotting tool. The results obtained were statistically analysed in SPSS software (Version 20.0). Correlation between independent variable and dependent variables was performed using Duncan Multiple Range test, F-test and Pearson correlation at $p < 0.05$ level of significance.

3 **Results and discussion**

Statistical analysis showing the average values of physicochemical and bacteriological parameters of soils, at both the studied dumpsites and their respective controls, are shown in Tables 1 and 6 respectively.

3.1 *Comparative analysis of physicochemical properties at control and dumpsites*

The selected physicochemical properties of the soil samples are presented in Table 1. The pH value at the control sites ranges from 5.04 to 6.55, and from 4.12 to 6.73, at different depths, for the studied dumpsites (Table 1), which indicates acidic nature of the soils. Igbatoro has the highest pH value of 6.73 at 20–30 cm depth and FUTA has the lowest value of 4.12 at 10–20 cm depth which is consistent with similar study by Ogunmodede et al. (2013). The higher acidity level of the Igbatoro dumpsite at 20–30 cm soil depth could be attributed to the various anthropogenic activities around the site. Increased pH for soils at 0–10 cm depth is highly likely to reports by Abdus-Salam (2009) who gave an account of the acid nature of surface soil from numerous waste dumpsites in Ilorin, Central Nigeria and Port Harcourt, Southern Nigeria. Breza-Boruta et al. (2016) stated that increased pH value affects the availability, retention and mobility of metals. For the measured pH values of all the dumpsites and their respective controls, only the Igbatoro at 0–10 cm and 10–20 cm depths, and control sample of Igbatoro dumpsite are within the Nigerian Federal Environmental Protection Agency (FEPA) and World Health Organization (WHO) (6.5–8.5). At a depth of 10–20 cm, the pH of the soils for all the

dumpsites increases except that of FUTA which slightly decreases due to decrease in volume of waste in recent year. Fig. 3 shows the variation of pH with depth of soil. A cut in nutrient supply, greater metal ion content in solution particularly manganese, copper and Aluminium and impediment of leguminous processes to fix nitrogen are a primary effect of soil acidification (Dorraj et al., 2010). Statistical analysis shows that at depths 20–30 cm, Ijare and Iju-Itaogbolu dumpsites are not significantly different in the level of occurrence. The degree of occurrence from soil samples obtained at the surface (topsoil) and 20–30 cm depth of FUTA dumpsites do not show significant difference ($P < 0.05$). However, the Pearson correlation analysis in Table 2 reveals that only Iju-Itaogbolu dumpsite had negative significant relationship of pH with FEPA/WHO standard. The pH of Igbatoro, Ijare and FUTA were all found to be significant at $0.48 < r < 0.78$ with significant level of 0.05.

Table 1 Selected physicochemical properties of soils at different depths of the dumpsites

<i>Sampling location</i>	<i>Soil depth (cm)</i>	<i>pH</i>	<i>Organic matter</i>	<i>Organic carbon</i>
Igbatoro	0–10	6.55±0.25 ^b	1.12±0.01 ^h	0.64±0.01 ^h
	10–20	6.73 ±0.01 ^a	0.55 ±0.02 ⁱ	0.29 ±0.01 ^h
	20–30	5.57 ±0.08 ^d	0.28 ±0.02 ^k	0.16 ±0.05 ^h
	Control	5.04±0.50 ^f	0.25 ±0.00 ^k	0.13±0.01 ^h
Iju-Itaogbolu	0–10	5.23±0.18 ^e	2.19±0.00 ^d	1.27±0.00 ^e
	10–20	6.35 ±0.03 ^c	0.40 ±0.01 ^j	0.23 ±0.05 ^h
	20–30	6.03 ±0.02 ^c	0.17 ±0.02 ^k	0.02 ±0.10 ^h
	Control	6.52±0.11 ^b	3.26±0.01 ^b	2.00±0.01 ^c
Ijare	0–10	5.48±0.10 ^d	4.14±0.02 ^a	2.40±0.02 ^b
	10–20	5.48 ±0.05 ^d	1.31 ±0.14 ^g	0.79 ±0.83 ^h
	20–30	5.86 ±0.07 ^d	3.28 ±0.01 ^b	1.00 ±0.02 ^f
	Control	5.45±0.01 ^d	2.81±0.01 ^c	1.62±0.01 ^d
FUTA	0–10	4.41±0.10 ^g	2.19±0.02 ^d	3.15±0.06 ^a
	10–20	4.12 ±0.09 ^h	1.54 ±0.00 ^f	0.96 ±0.49 ^g
	20–30	4.52 ±0.08 ^g	2.01 ±0.01 ^e	0.68 ±0.15 ^h
	Control	5.05±0.10 ^f	2.12±0.02 ^d	1.24±0.03 ^e

Each data is presented as mean ± standard deviation ($n = 3$). Values with the same superscript letter(s) within a column are not significantly different ($P < 0.05$) according to Duncan multiple range test.

The organic matter content for all the sampled dumpsites, except Ijare (top soil and at depth of 20–30 cm), are in accordance with the FAO criterion less 3% (Bot and Benites, 2005). It was found that organic matter decreases for all dumpsites (except for Iju-Itaogbolu) with increasing distance towards the control as shown in Figure 4. An elevated composition of organic materials observed in the neighbourhood of the dumpsite in Ijare encourages a rising moisture quantity, water retention ability, and permeability (Akinbile et al., 2016c). The continuous occurrence of depositing of freely disintegrating organic remains effected the production of complex composite organic matter that unite soil particles into structural assemblages. The assemblages facilitate loose, open and

granular condition. This situation permits the downward percolation of water transporting pollutants through the soil (Shepherd et al., 2002). The percentage organic matter at the top soil (0–10 cm) of all the dumpsites from 1.12 to 4.14%, with a mean value of 2.40% (Table 1). This is higher than the control samples with highest value 3.26%. The disparity probably stemmed from increasing disintegration and composting processes of municipal refuse dumps including nylons, paper, food wastes, and ash. Statistically, the soil samples, 20–30 cm depth, at Igbatoro and Iju-Itaogbolu dumpsites and the control at Igbatoro dumpsite do not differ significantly in occurrence. The level of occurrence of organic matter in soil samples obtained at the topsoil (0–10 cm) of Iju-Itaogbolu and FUTA dumpsites are not significantly different ($P < 0.05$). However, the Pearson correlation analysis in Table 2 shows that only Iju-Itaogbolu dumpsite had negative significant relationship of pH with FEPA/WHO standard. The organic matter content of Igbatoro, Ijare and FUTA were all found to be significant at $0.48 < r < 0.78$ with significant level of 0.05.

Figure 3 Comparison of soil pH value of dumpsites with control at different depths (see online version for colours)

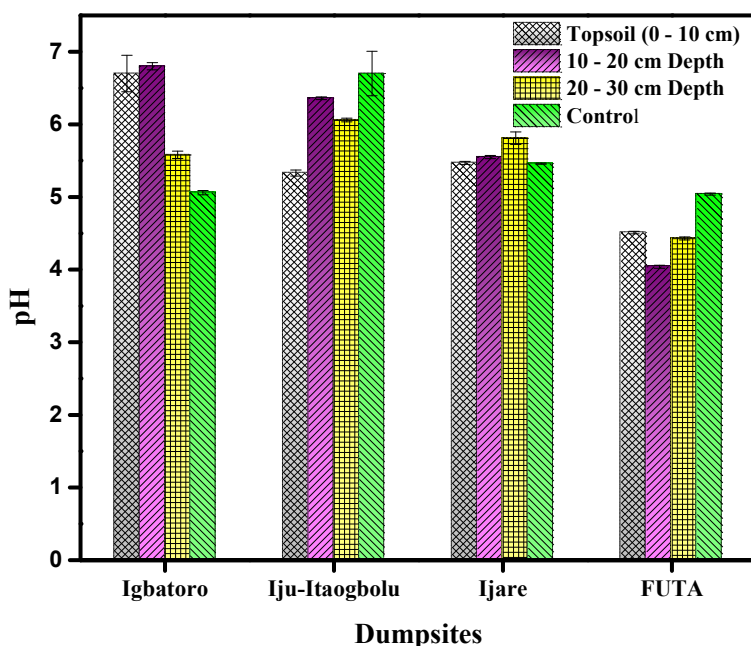


Table 2 Correlation of pH between WHO/FEPA standard and selected dumpsites

	<i>FEPA/WHO</i>	<i>Igbatoro</i>	<i>Iju-Itaogbolu</i>	<i>Ijare</i>	<i>FUTA</i>
FEPA/WHO	1				
Igbatoro	0.483	1			
Iju-Itaogbolu	−0.257	0.123	1		
Ijare	0.781	0.525	0.402	1	
FUTA	0.534	0.231	0.635	0.920	1

The percentage organic carbon varies between 0.02% for Iju-Itaogbolu at 20 - 30 cm depth and 3.15% for FUTA at 0–10 cm depth as shown in Figure 5. This is attributed to the fact that the top soil usually contains more plant residue and vegetation leading to greater plant productivity than lower layers of the soil. The values of percentage organic matter within the dumping sites resulted from burning of solid wastes around the dumpsites. Burning have many undesirable environmental effects such as global warming and emissions of other greenhouse gases. Burning of wastes could translate into acid rain which results from the release of Sulphur (IV) oxide and oxides of nitrogen into the atmosphere (Al Sabahi et al., 2009). Statistically, only soil samples from the Igbatoro control site and Iju-Itaogbolu dumpsite (20–30 cm) do not differ greatly.

Figure 4 Comparison of soil organic matter of dumpsites with control at different depths (see online version for colours)

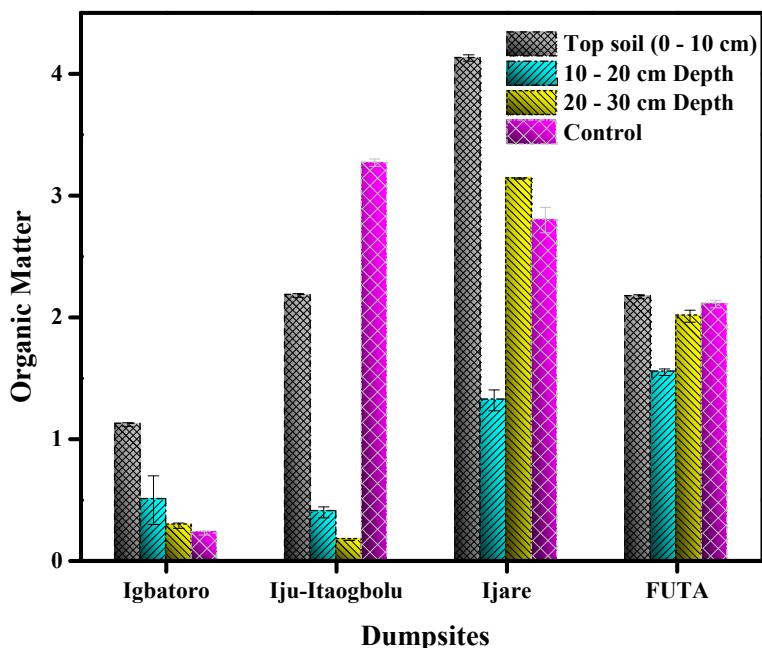


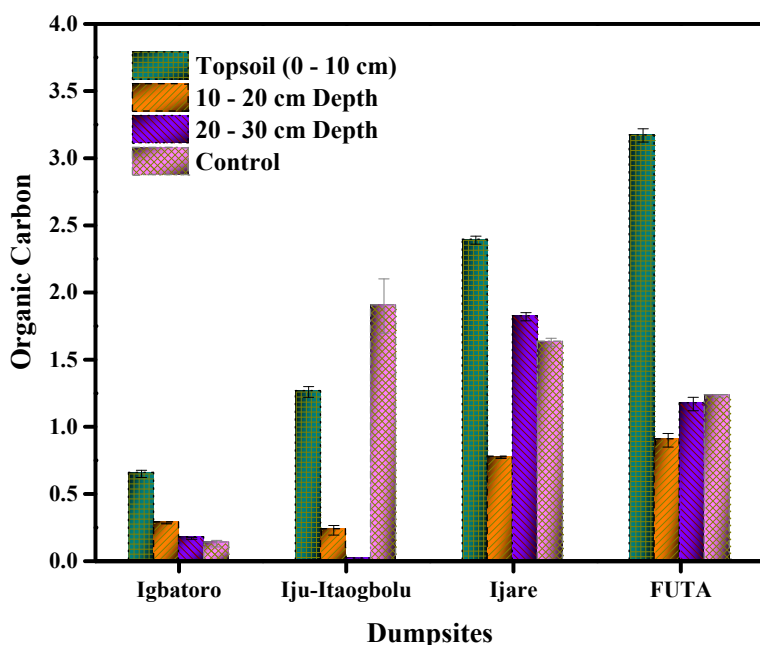
Table 3 Correlation of organic matter between WHO/FEPA standard and selected dumpsites

	<i>FEPA/WHO</i>	<i>Igbatoro</i>	<i>Iju-Itaogbolu</i>	<i>Ijare</i>	<i>FUTA</i>
FEPA/WHO	1				
Igbatoro	0.483	1			
Iju-Itaogbolu	-0.257	0.123	1		
Ijare	0.781	0.525	0.402	1	
FUTA	0.534	0.231	0.635	0.920	1

The range of soil particle size distribution was between 33.25 to 65.40% sand, 23.50 to 65.40% clay, and 0.40 to 31.40% silt for the studied dumpsites and 36.65 to 62.70% sand, 27.55 to 47.25% clay, and 7.50 to 15.95% silt for the controls (Table 4). The high level of clay content at Iju-Itaogbolu dumpsite occurred due to wearing away of the loose top soil

by erosion. Bacterial dissimilitude in soils is partly controlled by the distribution of soil particle sizes (Faoro et al., 2010). Sandy soils obtained from the localities of the dumpsites at Igbatoro, Ijare and FUTA could warrant employing these exposed garbage sites for land fill. Iju-Itaogbolu dumpsite has a low sand fraction 32.80% and 36.80% which is unsuitable for landfill. This correlates with Ogbonna et al. (2007) which related dumpsites with less than 40 percent composition of sand as unfit for waste land filling owing to their rapid permeability and giving way to great volume of leachate from the deposited refuse into the soil and inevitably to the groundwater resource. However, sand content decreases farther away (except for Iju-Itaogbolu) from the dumpsite showing a step down in organic matter as proximity to dumpsites decreases. Oshoma et al. (2017) made similar observations in his study where the sand content within the dumpsite decreases compared to the control. All the soil samples were mainly sandy except for Iju-Itaogbolu. This phenomenon agrees with studies by Ideriah et al. (2010) and Eneje and Lemoha (2012) where they noticed that the sandy nature that characterise surface soil from severe waste disposal sites in Owerri, Eastern Nigeria, Ile-Ife, Western Nigeria and Port Harcourt, Southern Nigeria respectively. Classification by texture of soil as Oyedele et al. (2008) stated, is defined by the materials that compose the soil.

Figure 5 Comparison of soil organic carbon of dumpsites with control at different depths (see online version for colours)



Each data is presented as mean $\pm$ standard deviation ($n = 3$). Values with the same superscript letter(s) within a column are not significantly different ($P < 0.05$) according to Duncan multiple range test.

A statistical analysis comparing the percentage of sand, clay and silt of soil samples taken from all the dumpsites shows that sand, clay and silt contents are significantly different (Table 5). From the analysis, Ijare dumpsite (10–20 cm) has similar sand

content with Iju-Itaogbolu control. Igbatoro dumpsite (0–10 cm) and Iju-Itaogbolu dumpsite (10–20 cm) have higher sand content than their respective control samples but lower in sand content than Igbatoro dumpsite (0–10 cm). The result also depicts that Igbatoro dumpsite has the highest sand content at depth (20–30 cm) followed by the top soil sample in FUTA. Igbatoro dumpsite at depth (20–30 cm) has the lowest clay content which makes the dumpsite most suitable for landfilling. The overall results indicate that the total sand contents for all the sampling locations are higher compared to the amount of clay and silt contents.

Table 4 Percentage of soil composition at the selected dumpsites

<i>Sampling location</i>	<i>Soil depth (cm)</i>	<i>Sand%</i>	<i>Clay%</i>	<i>Silt%</i>
Igbatoro	0–10	64.40 ±0.200 ^a	27.55 ±0.250 ^h	1.12 ±0.005 ^k
	10–20	61.50 ±0.550 ^c	25.25 ±0.500 ⁱ	12.53 ±0.015 ^g
	20–30	65.40 ±0.050 ^a	25.40 ±1.000 ⁱ	15.90 ±0.015 ^e
	Control	62.70 ±0.400 ^b	27.55 ±0.500 ^h	9.50 ±0.000 ⁱ
Iju-Itaogbolu	0–10	32.69 ±0.250 ⁱ	51.00 ±0.500 ^b	8.50 ±0.005 ⁱ
	10–20	33.25 ±0.500 ⁱ	54.50 ±0.500 ^a	0.40 ±0.005 ^k
	20–30	36.40 ±0.500 ^h	49.25 ±1.500 ^c	14.35 ±0.015 ^f
	Control	36.65 ±0.500 ^h	47.25 ±0.500 ^d	15.95 ±0.010 ^e
Ijare	0–10	37.20 ±0.500 ^g	31.40 ±1.000 ^f	31.40 ±0.500 ^a
	10–20	59.50 ±0.200 ^d	27.70 ±0.000 ^h	12.65 ±0.135 ^g
	20–30	52.30 ±1.000 ^e	31.35 ±1.000 ^f	16.25 ±0.550 ^d
	Control	48.50 ±1.000 ^f	43.09 ±1.000 ^e	7.50 ±0.015 ^j
FUTA	0–10	64.30 ±0.150 ^a	25.20 ±0.500 ⁱ	10.50 ±0.100 ^h
	10–20	59.50 ±0.300 ^d	23.50 ±0.500 ⁱ	16.50 ±0.000 ^d
	20–30	52.60 ±0.200 ^e	28.40 ±1.000 ^g	18.40 ±0.010 ^c
	Control	52.45 ±0.500 ^e	27.05 ±1.500 ^h	20.50 ±0.015 ^b

Table 5 Statistical analysis for soil samples at selected dumpsites

<i>Soil composition</i>		<i>Sum of squares</i>	<i>Mean square</i>	<i>F-calculated</i>	<i>Sig.</i>
Sand (%)	Between groups	4,122.567	274.838	793.040	0.000
	Within groups	5.545	0.347		
	Total	4,128.112			
Clay (%)	Between groups	3,856.373	257.092	2,116.796	0.000
	Within groups	1.943	0.121		
	Total	3,858.316			
Silt (%)	Between groups	397.936	26.529	127.017	0.000
	Within groups	3.342	0.209		
	Total	401.277			
F-tabulated			3.86		

3.2 Bacteriological analyses of the variables at control and dumpsites

All the soil samples' aerobic bacterial and heterotrophic fungal counts at all dumpsites ranged from 54×10^6 cfu/ml to 430×10^6 cfu/ml, and 87×10^6 cfu/ml to 420×10^6 cfu/ml respectively (Table 6). Soil sample from FUTA had the highest bacterial population followed by Igbatoro and Iju-Itaogbolu. Microorganisms find their way to the various dumpsites because of regular disposal of degradable waste. The result shows that microbial substance of the control soil was relatively lower than observed for samples of dumpsites. This is attributed to elevated amount of organic carbon and nitrogen in dumpsite soils. The frequent dumping of a variety of wastes at trash sites facilitating increasing presence of substrates that breakdown naturally through the action of biological agents might have prompted this occurrence. All the *Bacillus* isolates were all gram-positive, rod-shaped, spore formers. *Bacillus subtilis* which was isolated from all municipal waste dump soils was agreed with the findings of Oshoma et al. (2017).

Table 6 Bacteriological properties of soils at selected dumpsites

Dumpsites	Soil depth (cm)	Total bacteria count ($\times 10^6$)	Total fungal count ($\times 10^6$)
Igbatoro	0–10	296	198
	10–20	304	185
	20–30	260	284
	Control	121	170
Iju-Itaogbolu	0–10	312	189
	10–20	124	156
	20–30	293	115
	Control	147	102
Ijare	0–10	54	87
	10–20	135	148
	20–30	216	220
	Control	220	128
FUTA	0–10	430	420
	10–20	419	212
	20–30	248	96
	Control	264	112

The total number of fungi and bacteria found in the selected dumpsites and their respective control sites are presented in Tables 7 and 8. The results obtained from dumpsites were compared to those of the control. The isolation of *Aspergillus* sp., *Mucor* sp., and *Fusarium* sp. from the soil samples, shows similarity in the results presented by Obire et al. (2002) about the presence of microorganisms in soils collected from a waste dumpsite located at Eagle Island, Rivers State, Nigeria. Fungi such as *Aspergillus* sp., *Mucor* sp., *Fusarium* sp., found in all dumpsites are associated with waste biodegradation which is related to a study by Oshoma et al. (2017) where *Aspergillus*, *Fusarium*, *Mucor*, *Penicillium*, *Rhizopus* and a variety of yeasts were found to be associated with waste biodegradation. The abundance of fungi species at Igbatoro and FUTA can be attributed

to their wide distribution in soils and their association with buried and decaying plant materials.

Table 7 Isolated fungi in the selected dumpsites and control sites

Fungi	Dumpsites number %		Control number %	
<i>Aspergillus fumigatus</i>	5	7.81	-	-
<i>Mucor sp.</i>	5	7.81	-	-
<i>Aspergillus niger</i>	5	7.81	2	3.13
<i>Fusarium solani</i>	4	6.25	-	-
<i>Penicillium chrysogenum</i>	4	6.25	1	1.56
<i>Candida albican</i>	5	7.81	1	1.56
<i>Geotricum sp.</i>	3	4.69	2	3.13
<i>Verticillium alboatrium</i>	6	9.38	3	4.69
<i>Rhizopus stolonifera</i>	5	7.81	2	3.13
<i>Histoplasma capsulatum</i>	2	3.13	1	1.56
<i>Cocadioides immitis</i>	4	6.25	4	6.25

Table 8 Isolated bacteria in the selected dumpsites and control sites

Bacteria	Dumpsites number %		Control number %	
<i>Proteus sp.</i>	2	3.13	-	-
<i>Enterobacter sp.</i>	3	4.69	-	-
<i>Sterptococcus thermophilus</i>	2	3.13	1	1.56
<i>Clostridium sporogenes</i>	12	18.76	4	6.25
<i>Bacillus sp.</i>	12	18.76	8	12.5
<i>Staphylococcus sp.</i>	6	9.38	3	4.68
<i>Micrococcus sp.</i>	7	10.94	1	1.56
<i>Pseudomonas aeruginosa</i>	2	3.13	1	1.56

Bacillus sp., and *Clostridium sporogenes* had the highest frequency of presence while *Proteus sp.*, had the smallest appearing frequency of bacterial isolate. The isolation of *Bacillus sp.*, *Pseudomonas sp.*, *Staphylococcus sp.*, from the soil samples was in accordance with the work of Obire et al. (2002) which gave account of soils from a dumpsite at Eagle Island harboring these microorganisms and thus increase the soil's nutritional value (William and Hakam, 2016). Kosemani and Edward (2017) reported that the exotoxin produced by the microorganism like *Clostridium sporogenes* is deadly to aquatic organisms especially fish and has been the reason for high mortality rate in human. *Pseudomonas sp.*, found in all dumpsites especially in Ijare has major effect on nitrogen cycle. Kuan et al. (2016) observed the involvement of *Pseudomonas sp.* in nitrogen fixation in the soil. The high organic content of waste in Ijare serves as nutrients for pathogen like *Staphylococcus aureus*. Pathogenic *Staphylococcus aureus* can produce serious life-threatening diseases through its ability to multiply and spread widely in tissues (Fink and Campbell, 2018; Onuegbu, 2002). However, *Bacillus sp.* supports plant growth through replenishing soil nutrients (Kuan et al., 2016). High population of fungi and bacteria were observed in this study just as Bakare et al. (2003) documented

evaluated populations of total coliform, faecal coliform bacteria, faecal streptococci, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* in leachate from various landfills. Dobson et al. (1999) and Peng et al. (2008) also gave an account of the presence of *Staphylococcus* spp and *Streptococcus* spp in landfill leachate, ground water and surface water samples.

4 Conclusions

The open dumping of MSW alters to a great degree the underlying original characteristics of the soil. The dumpsites' soils have higher physicochemical characteristics compared to the control soil samples and most of the parameters were above the permissible limit stated by WHO/FEPA. The increased microbiological organisms across the dumpsites has somewhat beneficial effects though, the damaging impacts from increasing pollution levels are overwhelming. *Bacillus sp.* supports plant growth by replenishing soil nutrients through terrestrial carbon cycle and the nitrogen cycle, but *Staphylococcus aureus* causes serious diseases that pose great implication to human health in nearby settlements. The concentration of the physicochemical and bacteriological parameters in the MSW was found to cause biodegradation of soils, a phenomenon that decreases increasingly from the dumpsites to the control. The continuous open dumping of MSW will expedite the physicochemical and bacteriological properties of the soil at waste dumping sites. This, however, poses a long-term environmental danger not only to the soil, but also to the plants; and if not controlled, released harmful substances, such as concentrated leachate, become the entry point into the food chain. A proper measure to enable safe disposal of MSW such as waste management and treatment methods is therefore strongly recommended. Additionally, regular environmental impact study will undoubtedly curtail the entrance of harmful microbes into ground or surface water bodies that can become a possible peril to the environment and public health.

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