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PHYSICOCHEMICAL AND MICROBIOLOGICAL CHARACTERISATION OF EDAIKEN AND SANTANA MARKETS OPEN SOLID WASTE DUMPSITES SOILS IN BENIN CITY, NIGERIA.

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ABSTRACT

The indiscriminate disposal of solid waste has been compromising soil quality worldwide including Benin City. This study assessed the physicochemical parameters and microbial diversity of Edaiken and Santana Markets open dumpsites soils in Benin City. Soil samples were aseptically collected using sterilised auger from depths 0-15cm and 15-30cm from January to December, 2014. The physicochemical and microbiological qualities were determined using standard methods. Santana market recorded the highest pH and electrical conductivity values of 8.78 ± 0.01 in July and 2064 ± 0.21 mg/kg in May respectively. There was a highly significant difference for electrical conductivity and cation exchange capacity at both markets (p<0.001). Edaiken market recorded the highest concentration of 31.55±0.11mg/kg for Iron in July of all heavy metals studied, however, the concentrations of heavy metals reported in this study were generally above the control. The bacterial counts ranged from 0.26±0.15 to 1.28 ±0.59 and fungal from 0.25±0.23 to 1.38±0.21cfu/g with Edaiken market recording the highest. Edaiken market dumpsite soils had a high significant difference in both bacterial and fungal counts (p<0.001). Santana market had the highest frequency of bacterial and fungal isolates; Alcaligens faecalis (45.65%) in January followed by Bacillus sp. (42.86%) in September and Aspergillus sp. (47.37%) among the fungal isolates followed by Mucor sp. with 44.83% in January at Edaiken market. Dumpsites and depths had high significant effects on the soil parameters studied (p<0.001) while time had no significant effect. The solid wastes negatively influenced the soil properties studied.

Key Words: Dumpsite Soils, Edaiken, Santana, Soil microorganisms, heavy metal.

INTRODUCTION

Solid wastes are described as unwanted or unusable materials which could also be known as trash, refuse, garbage or junk (Zaved et al., 2008; Osunwoke and Kuforiji, 2012). A lot of materials are discarded everyday ranging from animal carcasses, plastics, hazardous chemicals, batteries and many different kinds of junks (Oyeleke et al., 2008). The rapid rate of solid waste generation is fast becoming an excarlating and important global issue all over the last decade due to the rising growth in world population resulting in increased solid waste production. Okechukwu et al. (2012) reiterated that rapid, uncontrolled and unplanned rate of urbanisation in the developing nations of the world particularly Africa has brought untold environmental degradation. According to Lyse (2003), Nine (9) out of every 10 African city are encountering challenges with waste management. According to Odeyemi (2004) per capita generation of waste by urban dwellers in Nigeria may be as high as 2kg per day.

In most cases, collection, transportation and disposal are the only major systems involved in waste management, other methods such as sorting. processing, recycling and monitoring are most often ignored in the environment (Ogbonna and Igbenijie, 2006). This results in waste materials being deposited in certain open dumpsites and allowed to heap till they are transported or incinerated. Also, through indiscriminate solid waste disposal, pathogenic microorganisms and harmful chemicals are introduced into the environment especially when they are not managed properly (Oviasogie et al., 2010; Zhang et al., 2013). Wastes resulting from such indiscriminate disposal become contaminants to surface and ground water as well as soil and air which poses more problems for humans, other species and ecosystems than imagined (Momodu and Anyakora, 2010). According to Eia et al. (2010), only 10% of Solid Waste is being recycled, 80% goes into landfills and 10% is incinerated.

However, open dumpsites poses environmental and public health consequences such as soil, air, surface and groundwater contamination, aesthetic nuisance, breeding ground for pathogenic microorganisms, mosquitoes and rodents (Saha and Santra, 2014, Oviasogie *et al.*, 2010, Yahaya *et al.*, 2010; Osunwoke and Kuforiji, 2012).

Solid waste dumping in metropolitan states cut across approved and unapproved dumpsites and most cities in Nigeria like Uyo, Aba, Onitsha and Benin conveniently use erosion gullies, tipping sites, burrow pits as sites for open dumping solid waste (Eja *et al.*, 2010; Oviasogie *et al.*, 2010). Soil is an integral component of the environment which functions as a central organizer of the terrestrial ecosystem. Its quality is a fundamental foundation of environmental health. However, the preponderance of open solid waste dumpsites in Benin City markets has spurred the need to examine Edaiken and Santana Markets open solid dumpsites for their effects on the receiving Soil' physicochemical parameters and microbial diversity.

MATERIALS AND METHODS

Edaiken market dumpsite lies on lat 6° 24' 32.6''N, 5° 36' 51.32''E and it is situated in Edaiken market, along Ugbowo – Lagos road, Egor Local Government Area of Edo State. Santana market dumpsite lies on lat 6° 19' 28.56''N, 5° 37' 31.44''E and it's situated along Benin – Sapelle Road, Ikpoba - Okha Local Government Area of Edo State. They are dumpsites that are unauthorised by the Edo Government and play host to solid wastes of agricultural, domestic and commercial origin form traders and residents. Residential buildings are erected around the dumpsites with occupants in them for decades.

The soil samples selected for this study have been exposed to solid wastes dumping for over 7years. The surface debris were removed and fifty grams (50g) of contaminated composite soil samples were aseptically collected from Edaiken and Santana Markets dumpsites in Benin City manually with the aid of a sterilised auger at depths of 0-15cm for top - soil and 16-30cm for sub - soil. Soil samples were also collected from virgin land which served as control. One set for microbiological analyses was collected in a labelled sterile screw-capped bottle while the second set for physiochemical was collected in labelled sterile polyethylene bags (Osakwe, 2012).

The determination of the physicochemical parameters were carried out carried out using the methods of Association of Official and Analytical Chemist AOAC (2005) and Ujowundu *et al.*, (2011). The pH was determined with a glass electrode pH metre Jenway, model 3510 in a 1:2 of soil to water while the electrical conductivity was estimated with electrical conductivity metre, Cation exchange capacity (CEC) by NH₄ saturation, total organic Carbon (Org. C), nitrogen (N), sulphate (SO₄), phosphate (PO₄), nitrate (NO₃) were also determined.

The analyses of cations and heavy metals were carried out according to the method of Edori and Edori (2012). The soil samples were dried in the laboratory to constant weight through exposure to air and then grounded with a ceramic mortar and pistle. The samples were sieved with 2mm mesh to exclude debris. Two grammes (2g) of the samples were digested with HNO₃: HCl in 1: 10. Twenty five milliliters (25mls) of distilled water was added to the mixture and placed

in a water – bath followed by heating for 20min to obtain a milky colour. Thereafter, they were removed from the heat, allowed to cool and transferred into 50ml sample bottles and made up to the 25ml mark with distilled water. The concentrations of the metals, Sodium, Potassium, Calcium and Magnesium were determined directly using flame photometer, Jenway, model PFP7 while the concentrations of the heavy metals were also determined directly using Atomic Absorption Spectrophotometer (AAS), model PG 550. The carrier gas used was air acetylene flame.

Bacteriological and Fungal Analyses of Soil Samples

One gram of soil sample was homogenized in 9mls sterile distilled water to obtain the stock. The stock was thoroughly mixed and serially diluted up to twentyfold. Appropriate 0.1ml aliquots of soil sample dilution from 10⁻⁶, 10⁻¹² and 10⁻¹⁸ was plated on Nutrient agar plates in triplicates containing fucshin and Potato Dextrose agar plates containing two drops of streptomycin for the determination of total heterotrophic bacterial and fungal counts respectively. The culture plates were incubated at 37°C for 48h and at room temperature of 28°C for 72h for bacterial and fungal enumeration respectively. After incubation, counts obtained from culture plates were recorded and expressed in the colony forming unit per gram (cfu/g) of the original sample. The various isolates were further identified and characterized (Barnett and Hunter, 1975; Cheesbrough, 2006; Eja et al., 2010; Fawole and Oso, 2001).

Statistical Analysis of Data

Data obtained were recorded in mean and standard deviation. They were statistically analysed by chi square contingency test. The data were compared to determine significant difference based on depths, dumpsites and time at 95% and 99% probability level (Ogbeibu, 2005).

RESULTS AND DISCUSSION

Table 1a shows the physicochemical parameters of Edaiken market dumpsite soils. The pH ranged from 6.17 at a depth of 0 - 15cm in August to 8.75 at a depth of 15 - 30cm in June which were almost the same range as the control values recorded. However Electrical conductivity ranged from 111 ± 0.11 mg/kg to 956 ± 0.11 mg/kg in the top soils and 109 ± 0.11 mg/kg to 729 ± 0.31 mg/kg in sub soils. There was high significant difference for electrical conductivity at both sampled depths (p < 0.001). Also, the cation exchange capacity with values ranging from 12.92 ± 0.23 mg/kg to 75.56 ± 0.20 mg/kg for top soils and 4.91 ± 0.67 mg/kg to 31.94 ± 0.03 mg/kg for the sub

soils. There was high significant difference (p < 0.001) at both sampled depths. Potassium at the top soil also displayed high significant difference (p < 0.001).

In Table 1b, electrical conductivity values ranged from 111 ± 0.13 to 2064+0.21mg/kg and 59 ± 0.12 to 1543 ± 0.02 mg/kg in December and May respectively with high significant difference p< 0.001) across the sampled months.

Sulphate, Nitrate, Sodium, Potassium and Cation exchange capacity had high significant difference at both depths (p<0.001) while total hydrocarbon content had high significant difference p< 0.001) at the upper depths.

Table 2a revealed the heavy metals concentration in Edaiken market dumpsite soils. Iron values recorded ranged from 2.14 ± 0.59 in March to $31.55\pm$ in July at upper depths and 0.15 ± 0.11 to 10.10 ± 0.51 mg/kg at the lower depths. There was high significant difference at both sampled depths (p<0.001). Also, table 2b recorded a high significant difference at the upper depths for iron with values ranging from 0.58±0.01 in January to $26.83\pm1,51$ mg/kg in May.

The heterotrophic bacterial and fungal counts are recorded in Table 3. Edaiken market had the high significance at both sampled depths for bacterial and fungal counts. Edaiken market values ranged from 0.81 ± 0.24 in May to 1.28 ± 0.59 mg/kg in September at the upper depths and 0.26 ± 0.15 to 0.67 ± 0.11 mg/kg in October at the lower depths for bacterial counts. Also, the same market had fungal counts which ranged from 0.63 ± 1.18 mg/kg in December to 1.38 ± 0.21 mg/kg at the upper depths and 0.25 ± 0.23 mg/kg in November to 0.66 ± 0.52 mg/kg in September. Santana market dumpsite soils had a high significant difference in the fungal counts with values ranging from 0.25 ± 0.23 in December to 0.70 v0.57 mg/kg in September.

Table 4 shows the frequency of occurrence of bacterial isolates from both markets dumpsites soils. Alcaligens faecalis had the highest frequency of occurrence (45.65%) at the upper depth, followed by Bacillus sp. (42.86%). Also, Providencia rettegeri had no count in both contaminated and control soil samples in the month of January. There was high significant difference in the frequency of occurrence of Alcaligens faecalis at both sampled depths (p < 0.001). Alcaligens faecalis had high significant difference at both sampled depths in Santana market. Bacillus sp. had high significant difference at the top soils and sub soils at Edaiken and Santana markets respectively. Also, Pseudomonas aeruginosa displayed high significant difference at the lower depths in Edaiken market.

In Table 5, *Aspergillus* sp. had the highest frequency of occurrence among all fungal isolates *FULafia Journal of Science & Technology Vol. 5 No.2 June 2019* with 47.37% in January at Santana market top soils. This is followed by *Mucor* sp. with 44.83% at Edaiken market sub soils and least in same market with 3.03% by *Candida albicans*. However, there was high significant difference in the frequency of occurrence in *Aspergillus* sp. at the lower depth in Edaiken market and upper depths at Santana market. Also, *Mucor* sp. had high significant difference at the lower depth in Edaiken and Santana markets.

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0.41±0. 0.11±1.12 2.08±1.11 0.14±0.16 32+0.2 23±0.56 83±1.12 99±0.47 14±0.18 7.0+00 28+0.0 4±0. Ľ, 0.15±0.71 5610.43 31±0.04 79±0.12 98±0.11 86±0.01 2.92±0.2 510.2 har. 35±0.10 58±0.21 14±0.23 04±0.16 64+0.0 11±0.19 0.04±0.00 32±1.08 3±0.15 30±0.12 11±1.11 6910.2 CN 1+C 1±1.31 22±0.18 HC (mg/kg) OC (mg/kg) 01² (mg/kg) EC (mg/kg Va" (mg/kg) 12,"(mg/kg) dg²mg/kg) 01² (mg/k) (mp/kg) C (mg/kg 0); (mg) ontrol ontrol ontrol atrol 8 Control 퓟 0-15cm 15-30cm 0-15cm 15-30cm 0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm 0-15cm 15-30cm 0-15cm 15-30cm 0-15cm 15-30cm 0-15cm 15-20cm 15 - 30cm 0 - 15cm 15 - 30cm 0-15cm 15-30cm 0-15cm 15-30cm Science 96 2 5 15<u>cm</u> 15cm 븘 2 S 0-15cm 5 0-15cm 15cm 1 - 5 1 5 5 ź 1 1 22 1 ź ź

Table 1b: Mean Physico- chemical Parameters in Santana Market Dumpsite Soils

Sampling Depth 0 = 15cm	Parameter	Jan 7.41+0.02	Peb 7 14:012	Mar 7 36:0 21	April 7 94:0 11	May 7.41+0.13	June 8 49±0.24	July 7 00:0 21	Aug 8.12:011	Sept. 8.42.40.00	Oct. 8.21:40.31	Nov. 7 28±0.12	Dec. 6.96±0.13	X ² 0.600	
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	И	7.41±0.02 6.64±0.11 7.96±0.12 6.61±0.11	7.1410.12 6.9640.02 6.05±0.01 6.01±0.01	7.3640.21 6.2140.11 6.98±0.11 7.86±0.01	7.94±0.11 7.56±0.02 7.14±0.01	7.9940.015 7.9940.01 8.14±0.01 7.98±0.01	8.1940.00 8.6840.00 8.1940.00 8.1940.00	7.98±0.00 8.87±0.02 8.82±0.00 7.98±0.00	8.3240.11 7.0740.31 8.12±0.30 7.6740.34	5.4240.00 7.1240.02 7.6240.34 6.0340.34	8.2160.31 8.1040.14 7.7640.02 7.1640.02	7.2860.12 6.42a0.10 6.51±0.00 6.72a0.00	6.98±0.01 6.48±0.01 6.08±0.00 6.08±0.00	0.000 1.345 1.170 1.0.18	2 2
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	EC (mg/kg)	121=0.21 89±0.00 67±0.00 42±0.01	137±0.31 88±0.01 71±0.01 41±0.10	222±0.01 98±0.11 79±0.00 51±0.01	714±0.02 193±0.01 101±0.03 62±0.30	2064±0.21 1543±0.02 122±0.17 65±0.11	701±0.32 546±0.23 121±0.11 73±0.11	731±0.06 472±0.02 147±0.12 96±0.00	1237±0.02 923±0.31 221±0.20 123±0.01	540±0.01 2666±0.02 231±0.01 151±0.01	511±0.10 326±0.16 211±0.04 131±0.12	449±0,11 230±0,01 198±0,21 101±0,01	111±0.13 59±0.12 95±0.11 31±0.12	5.476.0 5221.8 297.95 210.82	8 6 1 7 8
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	SO, ² (mg/kg)	4,44±0.26 0.98±0.00 1.00±0.01 0.11±0.00	2.74±0.35 0.88±0.12 1.11±0.11 016±0.11	2.22±0.12 0.54±0.01 1.23±0.13 0.18±0.00	41.28±0.32 15.43±0.12 7.56±0.02 7.14±0.01	3.24±0.01 2.46±0.08 1.98±0.11 0.96±0.11	4.21:0.14 3.15:0.13 2.72±0.21 1.05±0.21	4,14±0,12 3,42±0,14 2,01±0,01 1,06±0,01	3.54±0.01 2.18±0.02 4.13±0.02 1.41±0.03	2.74±0.05 0.88±0.12 0.64±0.01 0.12±0.00	2.2040.27 0.5940.21 0.6140.11 0.1140.11	3.54±0.06 2.18±0.01 0.61±0.01 0.11±0.11	22.95±0.18 10.36±0.11 1.00±0.21 1.12±0.11	147.845 46.095 5.222 0.000	
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	NO ₇ (mg/kg)	8.88+0.11 1.27±0.17 2.11±0.13 0.51±001	5.48±0.16 1.44±0.13 2.16±0.05 1.23±0.23	4,4440.18 0.77±0.26 2.14±0.13 0.31±0.10	8.88±0.08 1.27±0.04 2.19±0.21 0.44±0.35	5.24+0.21 1.29±0.11 2.47±0.05 0.47±0.02	49-48-0.14 12.00-0.12 2.72+0.21 1.05±0.21	29.2440.13 6.1440.11 3.1340.11 1.29n0.10	82.56±0.48 20.06±0.51 3.22±0.13 1.31±0.21	4.3440.05 1.1940.11 23140.01 15140.01	4.4440.00 2.0840.13 2.2440.11 1.4340.11	3.17±0.32 1.48±0.18 1.56±0.27 1.00=0.41	2.58±0.29 1.27±0.41 1.96±0.26 1.12±0.10	305.222 76.583 1.143 0.000	
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	$PO_{\kappa}^{\lambda}(mg/kg)$	0.96±0.21 0.318±0.10 1.118±0.11 0.17±0.01	0.59±0.32 0.28±0.01 0.23±0.11 0.14±0.11	0.48±0.43 0.18±0.25 0.61±0.62 0.11±0.01	0.95±0.14 0.31±0.11 0.068±0.01 0.26±0.01	8.88±0.01 4.83±0.32 2.88±0.31 0.98±0.23	5.32±0.00 2.89±0.20 3.24±0.17 1.06±0.24	3.14±0.10 1.48±0.13 2.98±0.12 1.12±0.21	0.56±0.21 0.31±0.35 1.15±0.48 0.36±0.56	4.92±0.15 2.16±0.01 1.21±0.54 0.82±0.55	5.01±0.14 3.56±0.20 1.86±0.30 1.04±0.41	3.97±0.19 2.31±0.12 1.64±0.21 1.08±0.18	1.01±0.25 0.08±0.14 1.43±0.21 0.12±0.10	16.222 3.824 4.737 0.000	
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	Na [*] (mg/kg)	7.55±0.58 1.08±0.91 2.17±0.16 1.01±0.24	4.66±0.39 0.97±0.38 2.24±0.24 1.03±0.22	3.77±0.22 0.65±0.15 2.41±0.36 0.78±0.47	7.55a0.42 1.08a0.22 2.76±0.10 1.07±0.17	70.18±0.22 16.97±0.01 4.26±0.08 2.21±0.90	42,0640,15 10,1540,09 6,76±0,11 3,19±0,25	24.85±0.06 5.19±0.22 8.15±0.21 3.56±0.45	4,45:0.51 1.09:0.46 7.32±0.19 2.12±0.74	13.96i0.22 8.14i0.21 5.1240.90 1.6340.58	10.36±0.32 5.26±0.07 4.51±0.85 2.01±0.64	9.66=0.29 3.27=0.52 2.46=0.29 1.48=0.41	4,45±0.38 1.09±0.21 2.01±0.67 0.73±0.49	190.400 42.667 13.939 5.857	
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	K' (mghg)	11.70±0.21 2.05±0.11 2.25±0.11 1.16±0.40	7.2240.26 1.8340.71 2.1440.23 1.4140.18	5.86i0.41 1.91±0.11 2.12±0.11 1.17±0.20	11.70±0.21 2.04±0.17 3.56±0.21 1.11±0.11	108.77±0.19 32.08±0.90 4.35±0.14 1.67±0.52	65.1940.14 19.19±0.21 7.23±0.28 1.81±0.45	38.52a0.26 9.81±1.00 9.18±1.18 3.26a2.11	14.41a1.11 6.63±0.27 4.06±1.13 1.24a1.11	14.59±0.67 5.02±0.35 2.18±0.11 0.72±0.01	6.90±0.48 2.06±0.34 1.39±1.23 1.18±0.25	10.51±0.47 4.43±0.19 1.21±0.94 1.31±0.42	8.54±0.20 2.850.10 1.48±1.12 1.27±1.20	3.75.600 107.022 21.615 3.500	
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	$Ca^{2*}(mg/kg)$	2.66±0.18 0.29±0.27 1.19±0.17 0.97±0.98	1.64±0.27 0.26±0.26 1.24±0.16 1.01±1.12	1.33±0.17 0.18±0.55 1.24±0.27 1.01±1.11	2.66±0.25 0.29±0.11 1.83±1.12 1.04±1.24	24,77±0.34 4,63±0.26 3,13±0.89 1.31±0.22	14.84±0.35 2.77±0.11 2.80±0.44 1.72±0.21	8.77±0.26 1,42=0.89 3.75=0.37 1,36±0.78	8.42±0.27 4.98±0.24 2.38±0.38 1.12±0.02	7.14±0.60 4.14±0.72 2.17±0.89 1.02±1.24	8.12±1.12 5.19±0.28 2.01±0.36 1.00±0.14	L57±L18 0.03a,14 L42a1.26 0.19±L13	6.52±1.02 4.95±0.18 1.12±0.93 0.49±1.12	56.911 3.500 4.261 0.818	
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	Mg^{2} (mg/kg)	0.81±0.04 0.35±0.09 0.11±1.10 0.11±1.11	1,69±0,20 0,23±0,23 0,36±0,67 0,18±0,91	1.16±0.21 0.21±047 1.12±0.12 0.24±1.15	1.39±0.11 0.39±0.27 1.14±0.18 0.31±0.89	12.88±0.41 6.11±0.03 2.21±0.01 0.86±0.01	7.72±0.01 3.66±0.02 2.47±0.21 1.06±0.43	4.56±0.35 1.87±1.10 2.63±0.20 1.01±0.44	0.82±0.12 0.39±0.01 1.12±1.12 0.73±1.27	9.78±0.29 4.42±0.61 2.72±0.23 1.35±0.17	9.9640.12 5.1440.36 3.1640.11 2.51±0.23	7.26±1.15 4.49±0.63 3.39±0.27 2.84±0.11	8,440.11 5,840.29 1,9640.45 1,0240.45	36.701 2.645 1.714 4.000	
0 – 15cm 15 – 30cm 0-15cm 15 – 30cm	CEC (mg/kg)	22.72a0.26 3.76±0.25 5.74±0.55 3.24±0.85	15.21±0.26 3.29±0.47 5.98±1.29 2.78±0.08	12.11±0.25 3.02±0.03 6.88±0.11 3.19±1.14	23.30±0. 3.80±0.1.12 9.29±0.68 3.53±0.20	216.60±0.62 59.79±0.21 13.95±0.02 6.05±0.00	129.81±0.10 35.77±0.53 19.26±0.31 7.78±0.31	76.7040.76 18.29±1.12 23.71±0.31 9.19±0.20	28.10±0.13 13.09±0.11 14.88±1.02 5.21±0.98	45.47a0.01 21.72a0.04 12.19a0.93 5.21a0.11	35.3440.11 17.7640.26 11.07±0.22 6.70±0.58	29.0041.11 12.2240.1.24 8.48±0.43 6.54±0.28	25.07±0.47 14.73±0.01 6.57±0.21 3.51±0.11	740.302 173.692 30.522 11.281	
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	THC (mg/kg)	0.85±0.31 0.48±0.34 0.001±0.01 0.001±0.01	0.001±0.01 0.001±0.10 0.001±0.52 0.001±0.02	0.43±0.02 0.001±1.01 0.01±0.02 0.01±0.05	0.21±0.11 0.001±0.75 0.01±0.27 0.01±2.01	0.89±0.11 0.65±0.29 1.01±0.56 0.07±0.65	12.45±0.24 8.73±0.05 2.89±0.20 1.73±0.36	12.11±0.21 7.41=0.12 2.89=0.20 1.73=0.36	7.03±0.00 2.14±0.19 4.54±0.32 2.22±0.09	0.31±0.11 0.11±0.001 2.73±0.22 1.56±0.41	0.31±0.16 0.11±0.12 1.43±0.00 0.97±0.19	7.03±0.22 2.14±0.11 0.09±0.26 0.02±0.15	1.18±0.10 0.56±0.02 0.09±0.26 0.02±0.15	30.268 11.636 4.556 0.800	
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	TOC (mg/kg)	4,11±0.29 0.96±1.11 1.21±1.31 1.01±0.12	2.5440.23 0.7141.03 2.0140.37 1.4240.20	2.98±0.11 0.92±0.23 2.06±0.21 1.76±0.14	2.23±1.08 0.41±0.10 2.08±1.11 0.14±0.16	6.18±0.09 4.51±0.87 2.17±0.24 1.34±0.31	7,14±0,11 3,15±0,21 3,04±0,12 1,46±0,12	6.01±0.93 2.98±0.88 3.17±0.62 2.00±0.17	4,1640.20 1.21a1.11 2.0140.18 1.68±1.11	2.87±1.23 0.78±0.03 1.97±0.01 1.32±0.14	1.23±0.27 0.58±0.30 1.11±1.11 0.61±0.10	1.23±0.06 0.58±1.61 1.01±1.36 0.42±1.29	4,16±0.22 1.21±1.21 0.96±0.15 0.11±0.11	9,636 7,053 5,000 1,500	
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	N (mg/kg)	0.41±0.01 0.10±0.12 0.11±0.11 0.01±0.14	0.2540.11 0.0720.34 0.0940.11 0.0340.00	0.3040.13 0.09±0.25 0.15±0.14 0.04±0.12	0.22±0.20 0.04±0.11 0.41±0.10 0.09±0.11	1.0540.11 0.92±0.12 1.39±0.87 0.21±0.11	1.25±0.16 1.11±0.01 1.01±0.00 0.25±0.00	1_20±0.10 0.44±0.14 1.00±0.14 0.45±0.21	0.42±0.23 0.28±0.24 0.98±0.10 0.51±0.21	0.1240.11 0.0640.11 1.1640.10 0.3840.05	0.4340.12 0.0640.01 0.9140.19 0.1740.11	0.19±0.04 0.08±0.01 0.92±0.11 0.41±0.22	0.2240.23 0.0640.41 0.6140.11 0.1240.17	0.000 0.000 0.180	
NOTE: I	p >0.05 = n	to significal	nt difference	e, p<0.001**	*= high sig	inficant diffe	srence	X2 = Chi	i square Valı	ue Values ai	te in Mean±	: standard de	eviation		

Table 2a: Heavy metal concentrations in Edaiken Market Dumpsite Soils

Sampling	Heavy	Jan	Feb	Mar	April	May	June	July	duA	Sept.	Oct.	Nov.	Dec.	X ²	p- value
	Pb Control		0.94±0.31 0.82±0.21 0.41±0.21 0.20±0.11	1.20±0.12 0.16±0.02 0.56±0.32 0.32±0.12	2.36±1.01 1.03±0.20 0.82±0.11 0.57±0.10	3.28±0.76 1.22±0.59 0.21±0.41 0.09±0.21	5.01±0.08 3.51±0.02 2.18±0.01 1.24±0.01	5.42±0.30 2.98±0.18 2.32±0.05 1.18±0.02	5.14±2.21 2.29±1.24 2.75±0.85 1.56±0.21	4.85±0.04 1.28±0.26 1.28±0.22 1.18±0.05	0.45±0.06 0.32±0.20 0.11±0.04 0.09±0.01	0.28±1.52 0.12±0.06 0.02±0.07 0.01±0.03	0.19±1.03 0.12±0.21 0.02±0.10 0.01±0.03	9.286 4.769 2.000 0.667	0.319 0.574 0.849 0.881
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	Fe Control	3.94±0.01 1.10±0.65 0.41±0.38 0.29±0.02	2.63±0.69 0.61±0.21 0.59±0.51 0.37±0.24	2.14±0.59 0.15±0.11 0.67±1.03 0.21±0.19	9.47±1.21 1.58±0.11 0.91±0.42 0.13±0.21	18.61±0.45 3.54±1.08 1.14±1.11 0.76±0.23	24.62±0.11 6.56±0.16 1.91±1.36 1.18±0.27	31.55±1.11 4.89±2.01 2.10±0.98 1.01±0.11	15.91±1.05 10.10±0.51 1.04±0.31 1.01±0.10	8.99±0.97 6.44±0.34 1.00±0.11 1.21±0.11	9.24±0.82 6.56±0.44 0.96±1.28 0.87±0.93	9.21±0.61 8.28±2.11 0.46±0.99 0.41±0.89	6.86±0.98 2.17±0.21 0.61±0.22 0.20±0.10	78.333 31.340 1.333 0.667	:: 1111
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	Zn Control	2.95±0.12 0.59±0.56 0.31±0.13 0.11±0.10	1.99±0.98 0.33±0.11 0.39±0.42 0.14±0.13	3.73±0.19 0.13±2.01 0.45±0.98 0.41±0.14	6.27±0.63 0.50±0.61 0.47±0.17 0.14±0.08	7.33±0.67 1.18±0.14 1.18±1.17 0.63±1.21	9.70±0.95 2.19±0.31 1.49±0.37 0.91±0.01	$\begin{array}{c} 10.13 \pm 0.9 \\ 2.63 \pm 0.21 \\ 1.64 \pm 0.10 \\ 1.01 \pm 0.21 \end{array}$	12.43±1.1 4.13±1.03 2.33±0.62 1.46±0.10	9.14±0.12 5.42±0.01 2.42±0.14 1.93±0.18	8.46±1.05 4.19±0.56 1.74±1.01 1.16±0.42	7.95±2.13 1.14±1.11 1.63±0.26 0.62±0.12	6.15±0.96 1.74±0.11 0.97±0.32 0.37±0.19	14.247 9.760 1.154 0.750	0.220 0.462 0.992 0.993
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	Mn Control	1.95±1.06 0.21±0.32 0.42±0.35 0.08±0.11	0.75±0.44 0.05±0.36 0.46±0.26 0.04±0.18	0.50±0.12 0.13±0.27 0.46±0.23 0.10±0.01	1.15±0.56 0.50±0.35 0.51±0.34 0.11±0.32	1,86±1,23 0,47±0.91 0,96±1,28 0.26±0.94	2.46±0.75 0.87±0.21 1.11±0.20 0.39±0.01	3.15±0.97 0.65±1.05 1.26±0.50 0.61±0.01	2.21±0.75 1.63±0.05 1.31±0.49 0.98±0.01	$\begin{array}{c} 1.41\pm0.03\\ 1.12\pm0.10\\ 0.91\pm0.32\\ 0.76\pm0.21 \end{array}$	1.39 ± 0.01 1.13 ± 0.32 1.14 ± 0.19 0.64 ± 0.28	1.43±0.15 0.95±0.23 1.01±0.36 0.21±0.04	1.17±0.21 0.63±0.01 0.74±0.11 0.32±0.01	0.778 7.878 0.000 0.000	0.998 0.724 1.000 1.000
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	Cu Control	2.01±1.03 0.88±0.86 0.41±0.10 0.21±0.10	1.59±0.31 0.99±0.21 0.62±0.21 0.47±0.11	1.07±0.21 0.65±0.02 0.61±0.32 0.38±0.12	2.89±1.03 1.86±0.20 0.91±0.11 0.53±0.10	3.95±0.86 1.97±0.19 1.14±0.46 0.96±0.21	5.22±0.08 3.65±0.02 1.91±0.01 1.28±0.01	6,69±0.34 2.72±0.18 2.10±0.05 1.81±0.02	3.37±2.02 1.84±1.42 1.04±0.58 0.71±0.21	3.53±1.04 1.14±0.26 1.00±0.21 0.61±0.05	3.89±0.06 1.21±0.02 0.96±0.04 0.47±0.01	3.46±1.12 1.11±0.06 0.46±0.07 0.21±0.03	2.76±1.03 1.14±0.34 0.61±0.10 0.30±0.06	6.400 5.300 0.000 1.500	0.845 0.870 1.000 0.993
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	Ni Control	0.45±0.07 0.39±0.21 0.91±0.02 0.12±0.01	0,46±0.08 0.22±0.02 0.31±0.79 0.19±0.21	0.96±0.86 0.34±0.05 0.60±0.06 0.26±0.13	0.57±0.31 0.35±0.20 0.63±0.11 0.16±0.05	0.45±0.09 0.39±0.01 0.31±0.10 0.21±0.01	1.13±0 09 0.79±0.01 0.41±1.02 0.21±0.03	1.49±0.05 1.46±0.01 0.46±0.02 0.12±0.01	1.91±1.10 1.09±0.31 0.51±0.36 0.18±0.01	2.92 ± 0.19 1.18 ±0.27 0.48 ±0.01 0.21 ±0.02	2.01±0.86 0.24±0.01 0.18±0.01 0.18±0.01	1.98±0.01 1.34±0.12 0.17±0.35 0.14±0.21	$\begin{array}{c} 1.82 \pm 0.90 \\ 1.02 \pm 0.86 \\ 0.21 \pm 0.01 \\ 0.14 \pm 0.01 \end{array}$	2.400 0.000 0.000 13.333	0.966 1.000 1.000 0.064
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	Cd Control	0.17±0.56 0.01±0.00 0.06±0.35 0.02±0.12	0.25±0.06 0.05±0.10 0.09±0.01 0.02±0.01	0.32±0.10 0.11±0.01 0.12±0.13 0.08±0.02	1.41±0.21 0.62±0.11 0.21±0.70 0.11±0.12	1.25+0.06 0.12+0.01 0.18±0.10 0.14±0.01	1.66±0.54 0.08±0.21 0.19±0.01 0.12±0.01	1.84±0.32 0.45±0.02 0.21±0.02 0.06±0.01	1.96±0.07 0.98±0.01 0.21±0.21 0.16±0.05	2.07±0.01 0.34±0.05 0.19±0.05 0.14±0.01	1.64±0.05 0.97±0.14 0.11±0.35 0.09±0.37	1.01±0.18 0.87±0.15 0.26±0.12 0.14±0.02	0.17±0.01 0.07±0.01 0.09±0.01 0.04±0.01	1.154 0.000 13.333 15.000	0.992 1.000 0.063 0.059
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	V Control	0.56±1.12 0.20±0.10 0.07±0.01 0.01±0.10	0.83±0.16 0.72±0.02 0.01±0.10 0.01±0.01	0.89±0.26 1.98±0.02 0.04±0.02 0.02±0.02	1.48±1.02 0.64±0.12 0.06±0.01 0.01±0.01	2.05±1.04 1.43±1.01 0.05±0.01 0.02±0.01	2.72±0.85 2.65±1.01 0.01±0.34 0.01±0.21	3.18±0.11 1.90±0.10 0.05±1.02 0.04±0.02	3.48±1.10 1.92±1.26 0.04±1.36 0.02±0.01	2.08±2.06 1.54±2.11 0.04±0.05 0.01±0.01	1.14±0.18 0.63±0.05 0.02±1.23 0.02±0.01	1.12±0.48 0.56±0.21 0.01±0.01 0.01±0.01	1.75±0.83 0.61±0.65 0.01±0.01 0.01±0.01	4.714 3.059 20.00 22.50	0.944 0.980 0.000
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	Cr Control	0.95±0.97 0.51±0.62 0.00±0.00 0.00±0.00	0.64±0.99 0.28±0.06 0.00±0.00 0.00±0.00	1.00±0.17 0.49±0.29 0.00±0.00 0.00±0.00	1.20±2.12 0.45±0.98 0.00±0.00 0.00±0.00	2.36±0.12 1.02±0.27 0.00±0.00 0.00±0.00	3.12±0.15 1.88±0.02 0.00±0.00 0.00±0.00	4.00±0.38 1.40±0.46 0.00±0.00 0.00±0.00	2.67±0.84 1.17±0.16 0.00±0.00 0.00±0.00	2.21±0.13 1.15±0.09 0.00±0.00 0.00±0.00	2.01±0.11 0.98±0.79 0.00±0.00 0.00±0.00	2.02±0.17 0.43±0.02 0.00±0.00 0.00±0.00	1.36±0.21 0.02±0.05 0.00±0.00 0.00±0.00	5.696 0.750 -	0.893 0.993 -
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	Ar Control	0.11±0.05 0.46±0.12 0.01±0.01 0.01±0.00	0.18±2.39 0.04±2.01 0.01±0.01 0.01±0.01	0.21±0.36 0.08±0.11 0.01±0.01 0.01±0.01	0.44±0.57 0.12±0.32 0.01±0.01 0.01±0.01	0.38±0.97 0.22±0.35 0.01±0.01 0.01±0.01	0.44±0.10 0.22±0.01 0.01±0.01 0.01±0.01	0.54±1.11 0.32±0.08 0.01±0.01 0.01±0.01	0.38±0.21 0.22±0.05 0.01±0.01 0.01±0.01	$\begin{array}{c} 0.46\pm0.12\\ 0.11\pm0.01\\ 0.01\pm0.01\\ 0.01\pm0.01 \end{array}$	0.18±0.32 0.04±0.01 0.01±0.01 0.01±0.01	0.33±0.43 0.15±0.24 0.01±0.01 0.01±0.01	0.31±0.35 0.12±0.12 0.01±0.01 0.01±0.01	7.016 13.333	0.534 0.064 -
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	Hg Control	< 0.001< 0.001< 0.001< 0.001	100.0 > 100.0 > 100.0 >	<pre>< 0.001</pre> <pre>< 0.001</pre> <pre>< 0.001</pre> <pre></pre> <pre><</pre>	<pre>< 0.001 < 0.001 < 0.001 < 0.001 < 0.001 </pre>	100.0 > 100.0 > 100.0 >	<pre>< 0.001 < 0.001 < 0.001 < 0.001 </pre>	100.0 > 100.0 > 100.0 >	<pre>< 0.001 < 0.001 < 0.001 < 0.001 < 0.001</pre>	< 0.001< 0.001< 0.001< 0.001< 0.001	< 0.001 < 0.001 < 0.001 < 0.001	< 0.001 < 0.001 < 0.001 < 0.001	<pre>< 0.001 </pre>	<pre>< 0.001 < 0.001 < 0.001 < 0.001 < 0.001 </pre>	

X2 = Chi square Value Values are in Mean± standard deviation

NOTE: p > 0.05 = no significant difference, p < 0.001^{***} = high significant difference

Table 2b: Mean Heavy metal concentrations in Santana Market Dumpsite Soils

Sampling Depth	Heavy metal	Jan	Feb	Mar	April	May	June	July	ZnV	Sept.	Oct.	Nov.	Dec.	X3	p- value
0-15cm 15-30cm 0-15cm 15-30cm	e A	2.10±0.34 0.52±0.13 0.21±0.10 0.17±0.10	1.26±0.05 0.31±0.05 0.41±0.21 0.20±0.11	1.75±0.34 0.61±0.11 0.56±0.32 0.32±0.12	2.23±04.2 0.13±0.34 0.82±0.11 0.57±0.10	2.14±0.30 0.04±0.07 0.21±0.41 0.09±0.21	3.56±1.34 1.97±0.85 2.18±0.01 1.24±0.01	6.01±0.23 3.82±0.07 2.32±0.05 1.18±0.02	6.05±0.96 3.81±0.51 2.75±0.85 1.56±0.21	2.82±1.21 0.11±1.01 1.28±0.22 1.18±0.05	0.24±0.81 0.08±0.12 0.11±0.04 0.09±0.01	0.11±0.68 0.02±0.24 0.02±0.07 0.01±0.03	0.11±0.14 0.02±0.10 0.02±0.10 0.01±0.03	8.643 3.833 2.000 0.667	0.373 0.429 0.849 0.881
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	Fe	0.58±0.01 0.45±0.15 0.41±0.38 0.29±0.02	1.68±0.10 0.44±0.18 0.59±0.51 0.37±0.24	1.69±0.01 0.21±0.17 0.67±1.03 0.21±0.19	4.89±0.58 0.49±1.21 0.91±0.42 0.13±0.21	26.83±1.51 7.72±0.28 1.14±1.11 0.76±0.23	16.08±0.05 4.62±1.30 1.91±1.36 1.18±0.27	9.50±1.61 2.36±2.92 2.10±0.98 1.01±0.11	12.70±0.67 0.50±0.11 1.04±0.31 1.01±0.10	14.86±0.86 8.82±0.27 1.00±0.11 1.21±0.11	14.96±0.32 9.12±1.37 0.96±1.28 0.87±0.93	10.19±1.07 8.79±0.56 0.46±0.99 0.41±0.89	10.35±0.6 7.52±0.21 0.61±0.22 0.20±0.10	58.571 11.902 1.333 0.667	0.000 0.104 0.998 0.955
0 – 15cm 15 – 30cm 0 – 15cm 15 – 30cm	Zn	0.55±0.01 0.17±0.36 0.31±0.13 0.11±0.10	0.44±0.56 0.16±0.31 0.39±0.42 0.14±0.13	0.89±2.95 0.19±0.98 0.56±0.32 0.32±0.12	1.52±0.72 0.59±0.28 0.82±0.11 0.57±0.10	2.26±0.03 2.93±1.16 1.18±1.17 0.63±1.21	4.95±0.58 1.75±0.34 1.49±0.37 0.91±0.01	2.92±0.20 1.81±0.00 1.64±0.10 1.01±0.21	8.92±1.10 0.90±0.95 2.33±0.62 1.46±0.10	7.29±2.14 4.01±0.11 2.42±0.14 1.93±0.18	7.14±1.07 4.00±1.01 1.74±1.01 1.16±0.42	9,86±1.21 2,23±0.23 1,63±0.26 0,62±0.12	5.46±0.57 0.11±0.21 0.97±0.32 0.37±0.19	21.615 4.158 1.154 0.750	0.017 0.761 0.992 0.993
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	Mn	1.91±0.42 0.10±0.01 0.42±0.35 0.08±0.11	0.56±0.01 0.07±0.01 0.46±0.26 0.04±0.18	0.66±0.05 0.13±0.32 0.46±0.23 0.10±0.01	2.93±0.21 0.25±0.52 0.51±0.34 0.11±0.32	8.46±3.12 1.23±1.21 0.96±1.28 0.26±0.94	5.07±0.37 0.74±0.01 1.11±0.20 0.39±0.01	3.00±1.08 0.38±0.95 1.26±0.50 0.61±0.01	1.49±0.45 1.01±0.22 1.31±0.49 0.98±0.01	096±0.29 0.41±0.23 0.91±0.32 0.76±0.21	$\begin{array}{c} 1.11\pm 0.32\\ 0.96\pm 0.01\\ 1.1\pm 0.19\\ 0.64\pm 0.28\end{array}$	6.18±1.26 0.27±0.21 1.01±0.36 0.21±0.04	0.76±0.35 1.11±0.11 0.74±0.11 0.32±0.01	22.636 0.000 0.000 0.000	0.020 1.000 1.000
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	ō	1.11±0.34 0.21±0.13 0.41±0.10 0.21±0.10	0.89±0.05 0.56±0.05 0.62±0.21 0.47±0.11	$\begin{array}{c} 1.56\pm0.43\\ 0.78\pm0.13\\ 0.61\pm0.32\\ 0.38\pm0.12 \end{array}$	2.21±04.2 1.29±0.34 0.91±0.11 0.53±0.10	10.32±1.0 4.63±0.27 1.14±0.46 0.96±0.21	6.19±1.34 2.77±0.85 1.91±0.01 1.28±0.01	3.66±0.21 1.42±0.07 2.10±0.05 1.81±0.02	2.66±0.69 1.30±0.57 1.04±0.58 0.71±0.21	2.78±4.21 1.14±1.01 1.00±0.21 0.61±0.05	3.01±0.38 1.89±0.12 0.96±0.04 0.47±0.01	2.36±0.98 1.46±0.04 0.46±0.07 0.21±0.03	5.42±0.17 2.79±0.10 0.61±0.10 0.30±0.06	20.286 9.700 0.000 1.500	0.042 0.467 1.000 0.993
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	Z	0.26±0.54 0.16±0.02 0.91±0.02 0.12±0.01	0.11±0.34 0.12±0.18 0.31±0.79 0.19±0.21	0.73±0.24 0.30±0.02 0.60±0.06 0.26±0.13	0.22±0.64 0.20±0.12 0.63±0.11 0.16±0.05	0.48±1.05 0.24±0.01 0.31±0.10 0.21±0.01	2.06±1.01 3.09±0.03 0.41±1.02 0.21±0.03	1.84±0.08 1.24±0.01 0.46±0.02 0.12±0.01	1.93±1.12 0.94±0.06 0.51±0.36 0.18±0.01	2.06±0.05 1.91±0.01 0.48±0.01 0.21±0.02	1.92±0.05 0.98±0.03 0.18±0.01 0.18±0.01	1.76±0.01 0.71±0.01 0.17±0.35 0.17±0.21	1.92±0.01 0.49±0.01 0.21±0.01 0.14±0.01	3.000 2.333 0.000 13.333	0.700 0.801 1.000 0.064
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	Cd	0.08±0.34 0.03±0.15 0.06±0.35 0.02±0.12	0.10±0.18 0.02±0.04 0.09±0.01 0.02±0.01	0.21±0.10 0.12±0.00 0.12±0.13 0.08±0.02	0.34±0.56 0.12±0.23 0.21±0.70 0.11±0.12	0.08±0.01 0.02±0.01 0.18±0.10 0.14±0.01	0.96±0.32 0.48±0.02 0.19±0.01 0.12±0.01	0.69±0.01 0.17±0.01 0.21±0.02 0.06±0.01	1.01±0.48 0.36±0.21 0.21±0.21 0.16±0.05	0.41±0.06 0.09±0.02 0.19±0.05 0.14±0.01	1.04±0.46 0.61±0.01 0.011±0.37 0.09±0.37	1.01±0.35 0.54±0.02 0.26±0.12 0.14±0.02	$\begin{array}{c} 0.06\pm0.02\\ 0.01\pm0.01\\ 0.09\pm0.01\\ 0.04\pm0.01 \end{array}$	0.600 0.000 13.333 15.000	0.896 0.063 0.063 0.059
0-15cm 15-30cm 0-15cm 15-30cm	^	0.20±1.01 0.21±0.46 0.07±0.01 0.01±0.10	0.25±0.03 0.32±0.02 0.01±0.10 0.01±0.01	1.72±0.27 1.33±0.01 0.04±0.02 0.02±0.02	1.40±0.12 0.36±0.100.06± 0.01±0.01	3.76±0.10 4.62±0.13 0.05±0.01 0.02±0.01	2.25±0.36 3.36±0.12 0.01±0.34 0.01±0.21	1.72±0.46 1.33±0.01 0.05±1.02 0.04±0.02	1.76±0.09 0.72±1.01 0.04±1.36 0.02±0.01	1.51±1.92 0.32±0.86 0.04±0.05 0.01±0.01	1.21±1.11 0.92±0.36 0.02±1.23 0.02±0.01	1.18±0.29 0.92±0.17 0.01±0.01 0.01±0.01	0.24±0.13 0.36±0.11 0.01±0.01 0.01±0.01	5.118 3.538 20.00 22.50	0.646 0.472 0.001 0.000
0-15cm 15-30cm 0-15cm 15-30cm	ò	0.29±0.01 0.14±0.98 0.00±0.00 0.00±0.00	0.23±0.32 0.10±0.02 0.00±0.00 0.00±0.00	1.53±0.18 0.77±0.25 0.00±0.00 0.00±0.00	2.46±0.95 1.16±0.35 0.00±0.00 0.00±0.00	4.32±2.01 2.53±0.14 0.00±0.00 0.00±0.00	2.59±0.06 1.51±0.42 0.00±0.00 0.00±0.00	2.53±0.01 0.77±0.21 0.00±0.00 0.00±0.00	2.19±0.17 0.61±.0.2 0.00±0.00 0.00±0.00	2.24±0.23 0.66±0.01 0.00±0.00 0.00±0.00	2.19±1.30 0.05±0.31 0.00±0.00 0.00±0.00	0.27±0.26 0.16±0.04 0.00±0.00 0.00±0.00	1.11±0.68 0.54±0.46 0.00±0.00 0.00±0.00	3.000 2.364 -	0.885 0.883 -
0 - 15cm 15 - 30cm 0 - 15cm 15 - 30cm	٨٢	0.04±0.37 0.02±0.21 0.01±0.01 0.01±0.00	0.02±0.56 0.32±0.23 0.01±0.01 0.01±0.01	0.39±1.16 0.10±0.07 0.01±0.01 0.01±0.01	$\begin{array}{c} 0.04{\pm}1.16\\ 0.01{\pm}0.05\\ 0.01{\pm}0.01\\ 0.01{\pm}0.01\end{array}$	0.51±1.13 0.24±0.3 0.01±0.01 0.01±0.01	0.51±0.54 0.22±0.11 0.01±0.01 0.01±0.01	0.55±1.23 0.21±1.10 0.01±0.01 0.01±0.01	0.51±0.68 0.24±0.65 0.01±0.01 0.01±0.01	0.14±0.11 0.03±0.14 0.01±0.01 0.01±0.01	0.02±0.03 0.01±0.02 0.01±0.01 0.01±0.01	0.42±0.35 0.22±0.21 0.01±0.01 0.01±0.01	0.54±0.31 0.23±0.14 0.01±0.01 0.01±0.01	1.600 7.5 -	0.449 0.484 -
0-15cm 15-30cm 0-15cm 15-30cm	Нg	100.0 > 100.0 >	<pre>< 0.001 < 0.001 < 0.001 < 0.001 </pre>	100.0 > 100.0 >	100.0 > 100.0 > 100.0 >	100.0 > 100.0 > 100.0 >	<pre>< 0.001 < 0.001 < 0.001 < 0.001 < 0.001 </pre>	100.0 > 100.0 >	100.0 > 100.0 >	100.0 > 100.0 >	<pre>0.001 </pre>	<pre>< 0.001 </pre>	<pre>0.001 0.002 0.001 0.002 0.001 0.002 0.001 0.002 0.001 0.002 0</pre>		

NOTE: p > 0.05 = no significant difference, $p < 0.001^{\text{***}} = high$ significant difference

Sampling	Sampling	Jan	Feb	Mar	April	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	X ²	p- value
locations	deptus						Ractorial	Counte							
Tabler	1	1	0.85 ± 0.11	0.86 ± 0.21	0.92 ± 0.11	$0.81 {\pm} 0.24$	0.91±0.17	1.08±0.01	0.98 ± 0.08	1.28 ± 0.59	1.13 ± 0.15	0.85 ± 0.18	0.60±0.21	1.333	0.000
market	4	;	0.43±0.12	0.54 ± 0.13	0.51±0.17	0.37±0.11	0.48 ± 0.11	0.47±001	0.41 ± 0.01	0.64 ± 0.11	0.67 ± 0.11	0.43 ± 0.11	0.26±0.15	0.000	0.000
	0 – 15cm	1.05±0.14	1.06 ± 0.19	1.00 ± 0.18	0.90±0.28	0.85±0.16	1.02 ± 0.14	0.97±3.38	1.17±0.18	1.27±0.05	1.39±0.25	0.95±0.08	0.79 ± 0.11	0.000	0.010
Santana market	15 – 30cm	0.46 ± 0.21	0.61 ± 0.10	0.52 ± 0.21	0.50 ± 0.22	0.42 ± 0.12	0.47 ± 0.13	0.44 ± 0.23	0.45 ± 0.10	0.63 ± 0.17	0.52 ± 0.10	$0.34{\pm}0.02$	0.26 ± 0.15	0.600	0.040
(united)	0 – 15cm	$0.54{\pm}0.01$	0.40 ± 0.11	0.43 ± 0.04	0.53 ± 0.23	0.37 ± 0.10	0.45±0.21	0.51 ± 0.26	0.50 ± 0.02	0.57±1.28	0.51±0.21	0.44 ± 0.15	0.38 ± 0.00	0.667	0.955
Control	15 - 30cm	0.28 ± 0.01	0.17 ± 0.11	0.21 ± 0.01	0.26±0.12	0.16 ± 0.00	0.20 ± 0.11	0.24 ± 0.15	0.23±0.01	0.36±0.21	0.28 ± 0.11	0.21±0.10	0.15 ± 0.00	6.667	0.672
	0 – 15cm	:	0.94±2.22	0.88±1.98	1.15±0.14	0.90±0.25	Fungal 1.12±0.52	Counts 1.08±0.56	1.18±2.34	1.23±1.29	1.38±0.21	0.98±1.18	0.63±1.18	0.000	0.000
Edaiken market	15 – 30cm	1	0.38 ± 0.15	0.40±1.12	0.64 ± 0.17	0.38 ± 0.01	0.58±0.14	0.45±0.21	0.37±.19	0.66±0.52	0.62±0.56	0.25±0.23	0.27±0.15	0.000	000.0
	0 – 15cm	0.57±1.23	0.92 ± 0.18	0.89 ± 1.51	0.97 ± 0.10	0.89 ± 0.42	1.15±1.19	1.09 ± 0.24	1.22±1.16	1.25±1.16	1.32 ± 1.13	0.89 ± 0.67	0.64 ± 0.59	3.000	0.040
santana market	15-30 cm	0.27±0.21	0.49 ± 0.11	0.42±1.01	$0.40{\pm}0.13$	$0.40 {\pm} 0.11$	0.58 ± 0.06	0.61 ± 0.11	$0.44{\pm}1.00$	0.70±0.57	0.56 ± 0.50	0.41±0.21	0.25±0.23	0.000	0.000
Control	0 – 15cm	0.56 ± 0.01	0.42 ± 0.21	0.49 ± 1.02	0.47±0.21	0.34 ± 0.32	0.43 ± 2.23	0.43 ± 1.10	0.46 ± 1.11	0.53±0.67	0.54 ± 1.10	0.41 ± 0.68	0.29 ± 0.21	0.000	1.000
COULUI	15 - 30 cm	$0.14{\pm}0.17$	0.16 ± 0.01	0.23±0.51	0.21±0.12	$0.16 {\pm} 0.25$	0.21±1.11	0.21±0.12	0.21±0.09	0.24 ± 0.16	0.23±0.42	0.13±0.29	$0.11 {\pm} 0.19$	21.666	060.0

Table 3: Mean Heterotrophic Bacterial and Fungal counts in Soil samples from Edaiken and Santana Markets Dumpsites (× 1012cfu/g).

X2 = Chi square Value Values are in Mean± standard deviation

NOTE: p > 0.05 = no significant difference, $p < 0.001^{\text{***}} = high$ significant difference

Table 4: Frequency of occurrence of Bacterial isolates from Edaiken and Santana Markets Dumpsites (%).

E1 (0 - 15cm) E1 (15 - 30cm)	17.44 14.63	14.12 16.28	25.58	16.30	14.81	21.97	18.52	20.14	17.97	21.23	17.65	15.04	6.757	0.008
E1 (15 - 30cm)	14.63	16.28	00.65									1.11.21		
			20.22	17.65	18.92	16.67	31.91	21.95	14.06	29.85	18.60	19.23	24.721	0.010
S1 (0 - 15cm)	C2 0C	20.06	23.00	16.67	26.47	22 55	27.77	12 84	05 01	12 05	12.62	12 65	35 578	
(mact - a) to	45.65	04 50	00.50	10.01	12.95	25 25	1010	0000	10.21	20.01	17 60	02 31	010.00	ł
(11306 - 61) 16	C0.0#	60.42	00.02	00.21	1/.00	CC.C2	20.10	20.00	10.01	C7.61	10.11	00.01	4/.110	t
	22.22	20.00	13.95	16.98	21.62	22.22	21.57	18.00	19.30	19.61	15.91	13.16	34,062	ł
· · · ·	14.29	17.65	9.52	14.38	18.75	20.00	25.00	17.39	19.44	25.00	14.29	20.00	63.545	ł
				0.00										
E.2 (0 - 15cm)	10.4/	05.01	10.47	8./0	C0.01	01.21	06.71	91.6	18.1	06-11	the 71	60.11	040.6	0.48
E2 (15 - 30cm)	15.6	11.63	10.67	13.73	13.51	18.75	12.77	9.76	21.88	8.96	9.30	11.54	13.783	0.24
S2 (0 -15cm)	9.52	22.64	11.00	11.11	14.12	9.80	12.37	9.40	11.02	10.79	12.63	11.39	12.137	0.00
S2 (15 – 30cm	0.00	26.23	23.08	16.00	14.29	8.51	11.36	17.78	9.52	11.54	8.82	11.54	23.750	0.00
C2 (0 – 15cm)	7.41	10.00	9.30	13.21	10.81	8.88	9.26	8.00	10.53	11.76	9.09	7.89	3.586	0.00
C2 (0 – 15cm)	3.57	11.76	4.76	11.54	12.50	10.00	8.33	8.69	8.33	10.71	9.52	6.67	12.606	0.24
E3 (0 - 15cm)	31.40	20.00	20.93	32.61	20.98	23.07	25.93	26.53	28.12	18.58	21.76	20.29	9.825	0.00
F3 (15 - 30cm)	29.27	27.91	24.07	33.33	32.43	18.75	21.28	24.39	23.44	23.88	27.91	23.08	37.643	0.00
C2 /0 -16 mil	24 76	16.08	21.00	36 86	21.10	03 40	21 66	20.06	00 00	20 60	32 16	33 70	7 024	0.00
(mact- a) co	01.44	10.70	00.10	00.04	01.12	00.00	20.12	00.72	70.07	00.07	01-07	01.33	ter:	0.00
53 (IS - 30cm)	16.67	11.61	00.62	00.05	C0.61	61.67	00.62	11.16	47.80	40.00	67.00	76.07	224.00	0.00
C3 (0 - 15cm)	27.78	25.00	27.91	32.08	24.32	26.67	29.41	30,00	26.32	19.61	20.45	18.42	8.166	0.06
C3 (0 – 15cm)	28.57	23.53	33.33	23.08	25.00	25.00	25.00	30.43	25.00	21.43	19.05	13.33	167.432	0.00
			000	0 80			10.00		0.00	100			0 800	0.0
E4 (0 - 15cm)	8.14	11.76	0.98	87.6	12.35	6:00	12.96	10.33	8.59	06.1	8.24	10.14	8.400	0.01
E4 (15 - 30cm)	19.51	13.95	37.04	11.76	5.41	8.33	10.64	14.63	9.38	7.47	9.30	11.54	59.792	0.00
S4 (0 -15cm)	14.29	9.43	6.00	3.33	3.53	11.76	12.37	16.24	11.02	10.07	11.58	12.66	17.279	0.0
S4 (15 - 30cm)	10.87	11.43	5.77	12.00	2.38	10.64	60'6	13.33	11.11	7.69	8.82	7.69	13.369	0.02
C4 (0 - 15cm)	11.11	15.00	9.30	11.32	10.81	11.11	11.76	16.00	12.30	11.76	15.91	15.79	13.789	0.13
C4 (0 - 15cm)	10.71	11.76	9.52	7.69	6.25	10.00	12.50	13.04	11.11	10.71	14.29	13.33	14.000	0.17
	1.1.0.1		10.00	1011		00101				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			00011	110
ES (0 - 15cm)	23.26	24.71	17.44	20.65	25.93	20.83	13.89	15.31	21.88	24.78	22.35	24.64	8.375	0.07
ES (15 - 30cm)	26.83	30.23	16.67	19.61	22.73	27.08	12.77	21.95	18.75	16.42	18.60	23.08	14.400	0.04
S5 (0 -15cm)	21.90	19.81	4.00	30.00	22 35	23.53	19 59	25.64	25.98	25.90	29.47	27.85	9.571	0.56
S5 (15 - 30cm)	19.57	24 50	15.38	16.00	78 57	21.28	20.45	17.78	14.29	23.08	23 53	26.92	13.211	0.04
C5 (0 – 15cm)	26.50	20.00	18.60	16.98	21.62	16.67	11.76	16.00	21.05	23.53	25.00	31.58	15.056	0.18
CS (0 - 15cm)	32.14	23.53	14.29	19.23	37.50	20.00	16.67	17.40	27.78	21.43	28.57	26.67	9.808	0.45
E6 (0 - 15cm)	9.30	9.41	10.47	6.52	9.88	7.69	9.26	8.16	10.94	12.39	11.76	11.59	16.000	0.10
E6 (15 - 30cm)	0.00	0.00	3.70	0.00	0.00	4.17	4.26	4.88	9.38	11.94	13.95	7.69	14.400	0.04
S6 (0 -15cm)	0.00	0.94	7.00	177	235	3.92	2.06	5.98	7.09	8.63	8.42	10.13	24.129	0.05
S6 (15 - 30cm)	0.00	0.00	3.85	12.00	0.00	4.26	0.00	0.00	4.76	1 92	2 04	7.60	13 211	0.04
C6 (0 - 15cm)	25.93	7.50	11.63	5.77	5.41	6.67	0.80	8.00	2.05	0.80	11.36	7.80	32.200	000
	10.70	11 76	0C V1	2 05	000	10.00	0 2 3	0 60	5 56	114	0 52	12 33	0 606	24.0
	1010		1.411.1	2010	0000	00101	200	6010	10 m m		1 - 1/ W	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	00010	
E7 (0 - 15cm)	0.00	4.71	8.14	4.35	7.41	7.69	6.48	4.08	4.69	3.54	5.88	5.79	3.873	0.95
E7 (15 - 30cm)	0.00	0.00	5.56	3.92	0.00	6.25	6.38	2.44	3.13	1.49	2.33	3.85	7.824	0.45
S7 (0-15cm)	0.00	0.94	8.00	5.56	0.00	3.92	0.00	0.85	2.36	2.16	2.11	2.53	15.000	0.09
S7 (15 - 30cm)	0.00	0.00	1.92	2.00	0.00	0.00	0.00	0.00	1.59	0.00	2.94	3.85	1.400	0.92
C7 (0 – 15cm)	0.00	2.50	9.30	3.77	5.41	6.67	5.88	4,00	3.51	3.92	2.27	5.26	7.811	0.64
C7 (0 - 15cm)	0.00	0.00	14 29	0.00	0.00	5.00	4.16	4.35	2.78	3.57	4.76	6.67	15 217	0.03
(mact - a) /a	0.00	0.00	14:42	w.w	0.00	2000	1.10	E	e 10	1000	0/14	10.0	1.4.4.1.4.4	~~~

Table 5: Frequency of occurrence of fungal isolates from Edaiken and Santana Markets Dumpsites (%).

Fungal Isolate	Jan	Feb	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	X*	p-value
E1 (0 - 15cm)	21.43	11.70	18.18	22.61	11.11	14.29	14.81	12.71	21.14	15.94	16.33	14.29	15.227	0.124
E1 (15 - 30cm)	0.00	15.79	27.08	26.56	13.16	22.41	15.56	16.22	25.76	11.30	16.00	14.81	18.059	0.054
S1 (0 - 15cm)	0.00	15.22	19.10	24.74	11.24	10.43	18.35	15.57	17.60	17.42	15.73	17.19	9.593	0.477
S1 (15 - 30cm)	0.00	16.33	19.05	25.00	10.00	6.90	18.03	9.09	14.29	17.86	14.63	20.00	18.187	0.052
1	19.64	14.29	18.37	23.40	11.76	16.30	20.93	19.56	16.98	6.67	14.63	17.28	6.114	0.006
	14.29	6.25	17.40	19.05	6.25	19.05	19.05	19.05	16.67	17.39	15.38	18.18	137.957	0.000
E2 (0 - 15cm)	12.86	11.70	12.50	13.04	12.22	8.93	9.26	15.25	14.63	14.49	25.51	17.46	15.429	0.164
E2 (15 - 30cm)	12.90	0.00	0.00	12.50	0.00	0.00	0.00	16.22	16.67	24.19	20.00	18.52	5.377	0.496
S2 (0 - 15cm)	10.30	18.48	16.95	22 68	10.10	13.04	10.00	16.30	15.20	14 30	13.48	12 50	0.021	0.638
(mper - 0) 70	00.01	01.01	00.01	00.77	15.00	10.01	60.01	10.01	07.01	N1 L	01.01	02.21	170.00	100.0
(mone - el) 76	700	47.71	00.0	00.71	00.01	06.0	00.0	16.01	C4-11	1.14	70.1	00.71	170.07	100.0
C2 (0 - 15cm)	06 70	10.01	8 70	17.71	18.75	0 50	C6.C1	0 57	12 50	13.04	15.38	18 18	70 177	0.010
(maga = 0) 70	(71-L)	14:00	0/10	0C*LT	C1.01	40.0	40.0	7.04	14:00	10.01	00001	01-01	111.07	010.0
E3 (0 - 15cm)	35.71	23.40	20.45	19.13	24.44	16.96	27.78	15.25	21.14	26.09	17.35	14.29	19.785	0.048
E3 (15 - 30cm)	41.94	39.47	22.92	9.38	44.74	13.79	26.67	18.92	21.21	17.74	32.00	11.11	64.640	0.000
S3 (0 - 15cm)	47.37	2.17	21.35	17.53	23.60	27.83	19.27	17.21	20.00	19.69	15.73	12.50	59.310	0.000
S3 (15 - 30cm)	40.74	28.57	33.33	15.00	35.00	31.03	29.51	27.27	25.71	22.22	17.07	20.00	23.693	0.014
C3 (0 – 15cm)	21.43	11.90	14.29	17.02	23.53	14.00	16.28	15.22	15.09	18.52	17.07	17.24	7.179	0.784
C3 (0 – 15cm)	42.86	12.50	17.40	14.30	25.00	9.52	19.05	14.29	16.67	21.74	15.38	60.6	49.743	0.000
E4 (0 - 15cm)	30.00	28.72	27.27	31.40	26.67	35.71	28.70	40.67	24.39	25.36	21.43	28.57	10.691	0.470
E4 (15 - 30cm)	45.16	28.95	37.50	4.38	34.21	44.83	40.00	29.73	28.79	35.48	4.00	37.03	66.476	0.000
S4 (0 - 15cm)	33.33	26.09	23.60	20.62	26.97	35.65	31.20	33.61	28.80	24.24	32.58	32.81	8.624	0.657
S4 (15 - 30cm)	40.74	32.65	38.57	27.50	35.00	41.38	31.15	31.82	34.29	28.57	3.90	28.00	49.836	0.000
C4 (0 - 15cm)	25.00	30.95	22.45	27.66	29.41	34.88	27.91	28.26	32.08	25.93	29.27	34.48	5.219	0.920
C4 (0 – 15cm)	28.57	43.75	34.78	33.33	31.25	42.86	33.33	38.10	37.50	26.09	30.77	36.36	31.151	0.001
E5 (0 - 15cm)	0.00	9.57	10.23	6.06	10.00	8.93	9.26	7.63	8.13	7.25	8.16	11.11	2.542	066.0
ES (15 - 30cm)	0.00	15.79	8.33	3.13	7.89	13.79	11.11	8.11	3.03	4.84	16.00	7.41	24.667	0.006
S5 (0 - 15cm)	0.00	7.61	12.36	10.00	7.87	7.83	11.93	7.38	8.80	10.61	11.24	14.06	5.776	0.834
S5 (15 - 30cm)	0.00	10.20	11.90	7.22	5.00	6.90	8.19	4.55	8.57	14.29	9.76	12.00	8.863	0.545
C5 (0 – 15cm)	25.00	16.67	14.29	10.64	11.76	11.63	11.63	8.69	15.09	11.11	12.20	10.34	20.262	0.027
C5 (0 – 15cm)	0.00	18.75	13.04	9.52	12.50	9.52	9.52	4.76	8.33	13.04	15.38	9.09	35.064	0.000
E6 (0 - 15cm)	0.00	14.89	11.36	7.84	15.56	15.18	10.19	8.47	10.57	10.87	11.22	14.29	6.569	0.765
E6 (15 - 30cm)	0.00	0.00	4.20	4.69	0.00	5.17	6.67	10.81	4.55	6.45	12.00	11.11	10.636	0.223
S6 (0 - 15cm)	0.00	10.87	6.74	10.00	11.24	5.22	9.17	9.84	9.60	13.64	11.24	10.094	19.094	0.024
S6 (15 - 30cm)	0.00	0.00	7.14	7.22	0.00	6.90	6.56	11.36	5.71	10.71	12.20	4.506	4.506	0.809
C6 (0 - 15cm)	0.00	9.52	12.24	8.51	8.82	9.30	9.30	10.86	9.40	12.96	9.76	6.89	7.741	0.560
C6 (0 - 15cm)	0.00	6.25	8.70	9.22	6.25	9.52	9.52	14.29	8.33	8.69	7.69	9.09	31.182	0.000

NOTE: $p > 0.05 = no significant difference, <math>p < 0.001^{\text{ssst}} = high significant difference. X2 = Chi square Value valu$ E5 and S5 = Candida albicans, E6 and S6 = Saccharomyces cerevisiae, C1 - C6 = control.

The mean pH values of the soil samples collected from solid waste dumpsites hover around slightly acidic to neutral which was in consonance 6.61 to 8.08 recorded by Osunwoke and Kuforiji (2012) and 6.5 - 9.4 recorded in municipal solid wastes dumpsite soils in Abuja as reported by Utpal and Sarma (2008). The results of electrical conductivity in this study ranged from 111±0.11 to 956±0.11mg/kg in the top soils and 109±0.11mg/kg to 729±0.31mg/kg in sub soils. Osazee et al., (2013) reported a range of values between 164 to 540us/cm in top soils from dumpsites in Benin City. Mshelia et al., (2014) reported a range of between 1228 to 1438µs/cm in soils from an Industrial area in Maiduguri Metropolis. The pH and electrical conductivity values reported could be due to the continuous dissolution of organic materials which is a store house for them (Alasohty et al., 2011; Schlecht et al., 2006; Fatubarin and Olojugba, 2014). The increase in soil sulphate ions recorded may be because of increased remains of animals being deposited in these solid waste dumpsites (Chinyere et al., 2013). Soil microorganisms need nitrate for the formation compounds containing nitrogen. The organic forms are mostly found in humus while inorganic forms are in various combinations with other metals (Ogunmodede et al., 2014).

The cations (sodium, potassium, calcium and magnesium) concentrations of the soils differ across soil depths, time and dumpsites. This may be because the waste are heterogeneous in nature, which impacted differently on the various soils properties.

Sodium and Potassium values were higher compared to calcium. This submission agreed with that of Brady, (1984) which asserted that the more a cation increases, the more the other reduces.

The total hydrocarbon content recorded in this study may be due to pollution from human inputs especially through discharges from clusters of auto mechanic workshops, condemned oils and hydrocarbon wastes from petrol stations around the studied area.

This total organic carbon (TOC) reported in this study ranged from 0.11 ± 0.001 to $8.17\pm0.14\%$. Badmus *et al.*, (2014) reported a total organic carbon range of between 1.39 to 5.30%. Essien and Hanson (2013) reported a range of 2.10 to 5.76% in soils from dumpsites in Uyo. This high could be attributed to the fact that the dumpsites studied receives loads of solid wastes on a daily basis which directly impacted on the total organic carbon values recorded.

The increased nitrogen concentration particularly in the Months of May and June could be due to the increased protein rich content of the solid wastes. Fatubarin and Olojugba, (2014) reported increased biological nitrogen fixation along with increased mineralization rates occurred more during the rainy season which may had resulted in the increased nitrogen content recorded in this study during the rainy season.

Iron values recorded ranged from 2.14 ± 0.59 in March to $31.55\pm$ in July at upper depths and 0.15 ± 0.11 to 10.10 ± 0.51 mg/kg at the lower depths at Edaiken market. There was high significant difference at both sampled depths (p<0.001). Salami et al. (2014) reported a range of 39.95 - 40.07mg/kg on studies of closed dumpsites on Oke - Afa Dumpsite in Lagos. The concentration reported is this study may be linked to its availability in almost every home in the studied area which found their way to these dumpsites. It is important for microbial growth at low concentration, but with increased concentration, it negatively affects microbial growth.

The concentration of Zn observed may be from the auto mechanic clusters (Abenchi *et al.*, 2010). However, the concentration of Zn in this study was low compared with many other studies (Nwachukwu *et al.*, 2011 and Shinggu *et al.*, 2007). Manganese is among the most easily found metal which is widely distributed in soils, sediments, rocks and water (Shrivastava and Mishra, 2011). However, the corrosion of metal scraps from automobile wastes contained in electrical and electronic parts such as copper wires, electrodes, copper pipes and alloys from corroding vehicle scraps which had littered the vicinity for a long time and gradually leached into the soil may be responsible for its present load (Nwachukwu *et al.*, 2011).

This corroborates with the findings of Madrid *et al.*, (2007) where they observed that soils treated with municipal solid wastes had increased extractable forms of heavy metals especially in the 0 - 20cm layer of soils compared to the control.

Cadmium in the body is known to affect several enzymes including those responsible for reabsorption of proteins in kidney tubules. It also reduces the activity of delta aminolevulinic acid synthetase and alcohol dehydrogenase (Wuana and Okieimen, 2011). The major anthropogenic point sources of atmospheric emission are through burning of crude or residual oil, coal and residual-fuel combustion. This finding agreed with the works of Perez et al., (2007) and Alashty et al., (2011) where they reported that increased municipal solid wastes level, years of application, amount of available and absorbable heavy metals in soil. The anthropogenic inputs may have originated from plastic shopping bags, empty paint containers and waste containing Pb - Cr batteries as reported by (Parth et al., 2011).

Lead concentrations were in consonance with those reported by Udousoro et al. (2010) in *FULafia Journal of Science & Technology Vol. 5 No.2 June 2019* South-South Nigeria and Industrial areas of North-West Nigeria, but below the range of 283 – 665mg/kg reported by Pam *et al.*, (2013) in North - Central Nigeria. It is possible that these levels of lead could be traced to the amount of waste oil, expired motor batteries and automobile emissions in these dumpsites.

Soil Hg is toxic especially on the surface horizons. Mbe *et al.*, (2013) reported that most heavy metals and trace-element become more available and biotoxic at low pH values, but since the pH reported in this study varied from slightly acidic to neutral, it may have accounted for the relatively non – toxic and low immobility observed by Hg in this study.

Anthropogenic sources in soils included solid wastes incineration, pesticide application and wood combustion (Budavari *et al.*, 2001). These may have been responsible for their presence in soils from these dumpsites. However, arsenic undergoes a variety of reactions in the environment, including precipitation, oxidation-reduction reactions, ligand exchange and biotransformation which released it from the solid phase, resulting in soluble mobile forms. However, these reactions could be influenced by pH, metal sulphide, ion concentrations, temperature, salinity, distribution and composition of the biota (Pongratz, 1998; Welch *et al.*, 1988).

The total viable heterotrophic aerobic bacterial counts for Edaiken market values ranged from 0.81±0.24 in May to 1.28±0.59 cfu/g in September at the upper depths and 0.26 ± 0.15 to 0.67 ± 0.11 cfu/g in October at the lower depths for bacterial counts. Also, the same market had fungal counts which ranged from 0.63±1.18 in December to 1.38±0.21 cfu/g at the upper depths and 0.25 ± 0.23 in November to 0.66±0.52 cfu/g in September. Santana market dumpsite soils had a high significant difference in the fungal counts with values ranging from 0.25 ± 0.23 in December to 0.70v0.57 cfu/g in September. This phenomenon may have resulted from the increased availability of biodegradable and inorganic substrates from the variety of solid wastes which made it an ideal enrichment medium that supported the growth and proliferation of numerous microorganisms, hence such high counts in the dumpsites contaminated soils (Osazee et al., 2013; Saha and Santra, 2014). There bacterial and fungal count was inversely related to the soil depth. This could be attributed to the decrease in the quantity of oxygen and organic matter and inorganic matter (Odevemi, 2012; Taiwo and Oso, 2004). The results obtained in this study correlated with those of other authors (Noel et al., 2008; Odeyemi, 2012; Osunwoke and Kuforiji, 2012). However, most of the bacterial and fungal isolated in this study reside in soil. The dumping of human and animal excreta in these dumpsites could also be responsible for the

enrichment of the soil with pathogenic organisms which indicated poor sanitary condition of the studied area (Tijani, 2004).

CONCLUSION

This study revealed the presence of several bacteria and fungi. Moreso, most of these microorganisms have been associated with solid wastes and its biodegradation (Obire et al., 2002). Other studies have reported variable results in relation to bacteria and fungi in soils contaminated with solid wastes. Oviasogie et al., (2010) and Achudume and Olawale, (2007) reported some of the organisms isolated in this study in addition to others such as Aeromonas. Neisseria, Klebsiella, Escherichia coli and Serratia species. However, Alcaligens faecalis and Bacillus sp. were the most prevalent bacterial isolate identified. The most predominant pathogens in solid wastes contaminated soils include the genus Bacillus (80-90%) with Staphylococci and Streptococci varying between 5 and 10% (Oyeleke and Istifanus, 2009). However, this study reported the presence of Myroides odoratimimus, Providencia vermicola and Providencia rettegeri in soils from solid waste dumpsites in Benin City which have never been reported in earlier studies. The high count in soil may be attributed to the fact that it inhabits and proliferate in soil environment. Alcaligens faecalis is used in bioremediation of polycyclic aromatic compounds and other high molecular weight compounds (Lakshmi and Velan, 2011). Bacillus cereus is a ubiquitous soil bacterium and an opportunistic pathogen that is a common cause of food poisoning (Helgason et al., 2000). The possession of this spore increases its power of uptake and aid in bioremoval which makes it being able to survive harsh environmental conditions such as these solid wastes dumpsites that contained variety of contaminants (Odokuna and Abah, 2003). Pseudomonas aeruginosa known for biodegradative capabilities is also responsible for a number of infections which can proceed to septicemia and mortalities in the form of secondary infections (Achudume and Olawale, 2007; Oviasogie et al., 2010).

Myroides odoratimimus, Providencia rettgeri and *Providencia vermicola* were also isolated in relative low percentage. *Myroides* sp. are rare clinical isolates and are often not considered pathogenic (Elantamilan *et al.*, 2015). It has been suggested that their wide distribution in the environment as well as their ability to auto aggregate and coaggregate to form biofilms, might explain the ability to infect debilitated or immunosuppressed hosts. *Providencia rettgeri* and *Providencia vermicola* can cause human diseases such as traveller's diarrhoea, urinary tract infections and others external to the intestinal tract as well as many outbreaks in hospitals (Zhang, 2003). Foods easily contaminates with these bacteria during processing, transportation and sales (Zhang *et al.*, 2013).

All the fungal isolated in this study are known to cause a lot of infections which are of public health concern. *Aspergillus* sp. is known for Aflatoxin production which is primarily destroys the liver by inducing fatty acid metamorphosis of its cells. This leads to decrease in Ribosomal Nucleic acid (RNA) polymerase activity with subsequent impairment in the synthesis of nucleic acid. It also weakens the body and is associated with inhibition of libido in males and ovulation in females (Enerijiofi and Ajuzie, 2012). Among the fungal isolated, *Rhizopus* and *Mucor* were the most frequently encountered. They are saprophytes which feed on dead organic remains thereby removing them by decomposition (Osunwoke and Kuforiji, 2012).

The analyses of soils samples collected from the different solid wastes dumpsites showed variability in soil physicochemical parameters and microbial diversity with time, depths and dumpsites. Although the values of the various parameters studied decreased with increased depth, there were however some inconsistencies across the sampling depths and periods. The heavy metals concentrations reported in this study were generally above the control and the set limit by Federal Environmental Protection Agency (FEPA). This study revealed that the open solid wastes dumpsites potentially have environmental and public health implications on the receiving soil environment due to the pathogenic microorganisms and the high concentrations of physico- chemicals and heavy metals. However, by the result of this study, there is need for monitoring to prevent substantial building up in the soils or prevent any further increase.

Edo State Government should encourage more citizenries to enroll with the State Waste Management Board for proper solid waste disposal. Edo State Government in particular should create a conducive environment for interested companies or enter into functional public-private partnerships on a large scale into the management of solid wastes for environmentally friendly processes.

REFERENCES

Association of Official Analytical Chemists (2005). Method of Analysis, Washington D.C.

- Chinyer, G. C., Obisike, E. S., Ugbogu, A. E. and Osuocha, K. U. (2013). Studies on municipal solid wastes dumping on soil anions, cations and selected enzymes activities at Njoku sawmill waste dumpsite, Owerri Municipal, Imo State, Nigeria. *Ethiopian Journal of Environmental Studies and Management* 6: 774-783.
- Edori, O. S. and Edori E. S. (2012). Effect of automechanic works on lead and Iron content in two mechanic villages in Port Harcourt, Rivers State Nigeria. *Journal of Applied Science and Environmental Management 16 (4)* 317 - 321.
- Eja, M. E., Alobi, N. O., Ikpeme, E. M., Ogri, O. R. and Inyang, A. O. (2010). Environmental and public health - related assessment of solid waste management in Uyo, Akwa Ibom State, Nigeria. *World Journal of Applied Science and Technology 2:* 110 - 123.
- Enerijiofi, K. E. and Ajuzie, C. U. (2012). Health Impact of Some Heavy Metals Resistance in Microbes Isolated from Ikhueniro
- Refuse Dumpsite, Benin City. Nigerian Journal of Microbiology 26: 2593 2599.
- Fawole, M. O. and Oso, B. A. (2001). Laboratory manual of Microbiology: Revised edition Spectrum books Ltd Ibadan.
- Momodu, M. and Anyakora, C. (2010). Heavy metal contamination of groundwater: Thesurulere case study. *Research Journal of Environmental Earth Science 2(1)*: 39-43.
- Odeyemi, O. (2004). Biogas generation from cassava leaves compared with two animal manures and sewage sludge. Review In: Energies in Biogas industries. Pergamon Press, Oxford.
- Ogbeibu, A. E. (2005). Biostatistics: A Practical Approach to Research and Data Handling. Mindex Publishing Company Limited.
- Ogbonna, D. N. and Igbenijie, M. (2006). Characteristics of microorganisms associated with waste collection sites in Port-Harcourt City, Nigeria. *Nigerian Journal of Microbiology 20(3):* 1427 1434.
- Osakwe, S. A. (2012). Effect of cassava processing mill effluent on physical and chemical properties of soils in Abraka and environs, Delta State, Nigeria. *Chemistry and Materials Research 2 (7)*: 27 40.
- Osunwoke, J. I. and Kuforiji, O. O. (2012). Health impact of microorganisms associated with waste dump sites in a private university. Journal of Sustainable Development and Environmental Protection, 2: 59 56.
- Oviasogie, F. E., Ajuzie, C. U. and Uyiosa, G. I. (2010). Bacterial analysis of soil from waste dumpsites. Archives of Applied Science Research 2 (5):161 - 167.

- Okechukwu, O. I., Okechukwu, A. A., Noye-Nortey, H. and Owusu-Agyei, L. (2012). Health perception of indiscriminate waste disposal a Ghanaian case study. *Journal of Medicine and Medical Sciences* 3(3): 146-154.
- Saha, A. and Santra, S. C. (2014). Isolation and characterization of bacteria isolated from municipal solid waste for production of industrial enzymes and waste degradation. *Journal of Microbiology and Experimentation 1 (1): 1-8.*
- Ujowundu, C. O., Kalu, F. N., Nwaoguikpe, R. N., Kalu, O. I., Ihejirika, C. E., Nwosunjoku, E. C. and Okechukwu, R. I. (2011). Biochemical and physical characterization of diesel petroleum contaminated soil in Southeastern Nigeria. *Research Journal of Chemical Sciences 1(18):* 57 62.
- Yahaya, M. I., Ezeh, G. C., Musa, Y. F., Mohammad, S. Y. (2010). Analysis of heavy metals concentration in roadside soil in Yauri, Nigeria. *African Journal of Pure and Applied Chemistry* 4(3):22-30.
- Zaved, H. K., Mizanur Rahman, M., Mashiar Rahman, R., Arafat, S. M.Y. and Rrahman, M. S. (2008). Isolation and characterization of effective bacteria for solid waste degradation for organic manure. *KMITL Science and Technology Journal 8 (2):* 44 - 55.
- Zhang, J., Shen, Z. Y., Tang, X. D., Xu, L. and Zhu, F. (2013). Isolation and identification of a pathogen, Providencia rettgeri, in Bombyx mori. *Journal of Bacteriology Research* 5(2): 22-28.