ASSESSMENT OF CONCENTRATION LEVEL OF SOME HEAVY METALS AND NON - METALLIC IONS IN DUMPSITE SOILS IN THE FEDERAL CAPITAL TERRITORY, NIGERIA

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ABSTRACT

The concentration of heavy metals (Fe, Cd, Cr, Cu, Pb, Mn, Ni and Zn), pH and non-metallic ions (Cl^-, NO_3^- and SO_4^{2-}) in soil samples from dumpsites and soil samples from areas without dumpsites (control) in the study area were determined at depth 0-15cm, 45-60cm and 85-100cm.The digestion of samples was done using concentrated nitric acid. The Atomic Absorption Spectrophotometer (AAS) and titration methods were used to determine heavy metals and non-metallic ions respectively. At depth 0-15cm, heavy metal concentration in the dumpsite soil in both seasons were; Fe (19.8911 and 21.8488 mg/g), Cd (0.0012 and 0.0017 mg/g), Cr (0.7610 and 0.2285 mg/g), Cu (0.3657 and 0.1259 mg/g), Pb (0.5063 and 0.9991 mg/g), Mn (6.3547 and 3.446 mg/g), Ni (0.2549 and 0.1247 mg/g), Zn (1.2057 and 3.2462 mg/g). In both seasons control Fe (18.0275 and 14.5668 mg/g), Cd (0.0078 and 0.0000 mg/g), Cr (0.1768 and 0.2643 mg/g), Cu (0.0308 and 0.0528 mg/g), Pb (0.0201 and 0.3776 mg/g), Mn (0.0824 and 0.1163 mg/g), Ni (0.0256 and 0.0000 mg/g), Zn (0.0695 and 0.8055 mg/g). Heavy metal contents for soil samples across the profile depth at 0-15cm, 45-60cm and 85-100cm were also significantly higher at $P<0.05$ from top down wards as well as between soil and control. Assessed parameters for dumpsite soil samples at depth 0-15cm, 45-60cm and 85-100cm all exceeded the WHO international standards in both seasons. It is therefore concluded that the waste dumpsites have negative impact on the quality of soil the study area. As such, there is need for government to overhaul her approach towards management of waste dumpsites and also to develop better waste management practices with regard to municipal solid waste management to mitigate soil pollution and its attendant implications in the FCT.

Keywords: Soil Pollution, Waste dumpsite, Municipal Solid Waste Management, Sustainable Development.

INTRODUCTION

Among the list of environmental challenges facing urban centres, impact of solid waste dumpsites on the biophysical environment stands out as a serious hazard in the Federal Capital Territory, Nigeria. The Abuja master plan was designed to avoid the challenges which made the former capital city (Lagos) inappropriate for that role, as it became associated with unplanned growth as experienced in many other Nigeria cities. The seat of Government relocated to Abuja in 1991, this relocation and the attendant rapid influx of people which followed, ensured that the growth and development anticipated by the Abuja Master Plan was exceeded fairly quickly by FCT expansion (Imam *et al*, 2008). Population explosion, industrialization and continuous change in consumption pattern have compounded challenges in this area. According to Lenntech, (2004) heavy metal can be defined as any metallic element that has a relatively high density and is toxic or poisonous even at low concentration, it can also be defined as the metals whose density are above $5g/cm^3$ (Pattabhi *et al*, 2008), though Duruibe *et al*., (2007) have shown that heavy metals have little to do with density than chemical properties of the element. Due to the fact that heavy metals are usually persistent and recalcitrant to degradation, they remain in the soil or water body where they are bioaccumulated and moves from one trophic level to the other. For instance, Izah and Angaye (2016) reported that fishes have the ability to bioaccumulates heavy metals origination from waste stream.

Nwaogu *et al*, (2017) in a study aimed at evaluating the impacts of open municipal solid wastes dumps on soil and vegetation near the main roads linking major cities in Nigeria, hypothesized that the metals from the wastes exerted substantial impacts at the dump sites which affect the soil and plants. Data from five dump sites and five control sites revealed that the effects of heavy metals were significant and higher at the dump sites where their concentrations were far above the EU, and Canadian environmental quality permissible limits for agricultural soils and vegetation. Sawyerr *et al*., (2017) assessed impact of dumpsites on quality of soil and groundwater in satellite towns of the FCT, and reported that the pH values of the soil samples from the selected dumpsites were similar, ranging from 7.1 to 7.8 across the study area. According to Amadi *et al.* (2010), dumpsites in most developing countries are usually unlined shallow hollow excavations arising from abandoned burrow-pits and quarry-sites without any environmental impact assessment studies. Consequently, such waste dumpsites become point source for soil pollution as they serve as host for leachate from dumpsites. The composition of solid wastes in FCT comprises Food/organic waste, plastics/nylon, papers, textiles, metals, glass/ceramics and others. (Oluyori, 2018). To address the growing challenge of waste management, the Abuja Environmental Protection Board (AEPB) and Satellite Towns Development Department (STDD), supported by the Federal Capital Territory Administration (FCTA) procured the services of contractors to evacuate and dispose wastes within the FCT to designated waste dumpsites. However, no study has been carried out to show the impact waste management system on soil contamination or otherwise in the entire FCT, part of the gap is the assessment of closed dumpsites in the same vein. It is in this context that the present study was undertaken to assess the concentration of heavy metals, pH and non-metallic ions in 11 government approved dumpsites in the FCT, Nigeria, within the wet and dry seasons, and also compare the obtained results with WHO acceptable standards.

MATERIALS AND METHODS

Study area

The FCT is located between latitude 8^0 25' and 9^0 25' North of the equator and longitude 6^0 45' and 7^0 45' East of Greenwich Meridian (Figure 1). The territory covers approximately an area of 8,000 square kilometres and occupies about 0.87% of Nigeria. The territory is bordered by four states namely; Niger to the West, and North West, Nassarawa to the East, Kogi to the South and Kaduna to the North of the territory (Magaji, 2009).

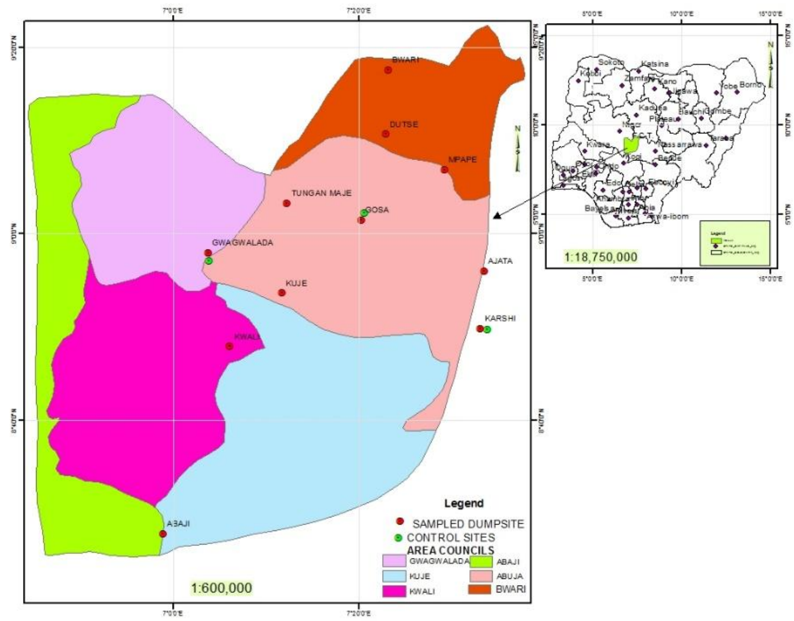

Figure 1: The Study Area (Federal Capital Territory, Abuja, Nigeria indicating the designated Dumpsites and Control Points)

Table 1 Dumpsites, control sites with their location attributes

Dumpsite	Classification Remarks	Code	Latitude	Longitude	Elevation (m)
Kuje	+, α	KUJ	8.89392	7.19637	314
Tungan maje	+, α	TGM	9.05452	7.20566	332
Dutse	+, α	DTS	9.17816	7.38310	475
Ajata	*, α	AJT	8.93323	7.56084	416
Karshi	+, α	KSH	8.83053	7.55398	400
Bwari	+, α	BWR	9.29340	7.38813	565
Gosa	+, µ	GSA	9.02511	7.33994	387
Mpape	*, µ	MPP	9.11455	7.48980	568
Kwali	+, α	KWL	8.79805	7.10252	190
Gwagwalada	+, α	GLD	8.96625	7.06330	218
Abaji	+, α	ABJ	8.46129	6.98303	172
Gosa control	-	GSA CONT	9.03797	7.34518	410
Gwagwalada control	-	GLD CONT	8.95181	7.06561	211
Karshi control	-	KSH CONT	8.82879	7.56674	360

Key:

- Status of Dumpsite
  - * = Dumpsites that have been closed, investigation was on post closure impact.
  - + = Dumpsites that are open and active, measured for current impact level.
  - - = Not Available.
- Methods of Waste Dumping
  - α= Open Dumping
  - µ= Controlled Dumping

Table 1 gives a summary of the locational attributes of the dumpsites and the selected research control sites, there are also information about the waste dumping methods implored in the dumpsites as well as the status of the dumpsites.

Each dumpsite location in the study area was divided into four quadrants based on similar work by Nuonamo *et al.,* (2000). Random soil samples were collected from each of quadrants in each of the dumpsites and labelled appropriately. Samples were collected at depth 0-15cm, 45-60cm and 85-100cm (Salami *et al*, 2014). Soil samples were collected in 1 litre plastic bottles which were treated by soaking in 10% nitric acid and rinsed with distilled water. Soil samples were collected for each point for both the wet and dry season (wet season samples were collected in the August, 2017 while dry season samples were collected in January, 2018). Soil samples were also collected from control points located away from the dumpsites (See Figure 1). A total of 264 soil samples and 72 samples from the control points during both seasons. Soil samples were air-dried, mechanically grounded using a stainless-steel roller and sieved through 2mm sieve. Two grammes (2.0 g) of prepared soil sample was digested with 15.0 ml nitric acid, 20.0 ml perchloric acid and 15.0 ml hydrofluoric acid and placed on a hot plate for 3hours. On cooling, the digest was filtered into a 100.0 ml volumetric flask and made up to the mark with distilled water (Opaluwa *et al*, 2012). The metal analysis of digested samples was analyzed for heavy metals (Fe, Cd, Cr, Cu, Pb, Mn, Ni and Zn) using AAS Thermo Scientific iCE 3000 at the National Advanced Laboratories, National Science and Technology Complex, Sheda, Abuja, pH was measured using JENWAY 4590 meter, while non-metallic ions (Cl^-, NO_3^- and SO_4^{2-}) was analyzed by titration. Chloride was determined by titration with $AgNO_3$ solution using potassium chromate as indicator. Soil quality parameters analyzed in the study area was subjected to SPSS Duncan post-hoc to test for significance in seasonal variation.

Results obtained were compared with WHO permissible standards in soils.

RESULT

The seasonal pattern of the soil quality parameters for the wet season in the study are graphically represented in Figures 2 and 3 while seasonal pattern of the soil quality parameters for the dry season in the study are graphically represented in Figures 4 and 5. The graphical illustrations are for Heavy metal, pH and non-metallic ions.

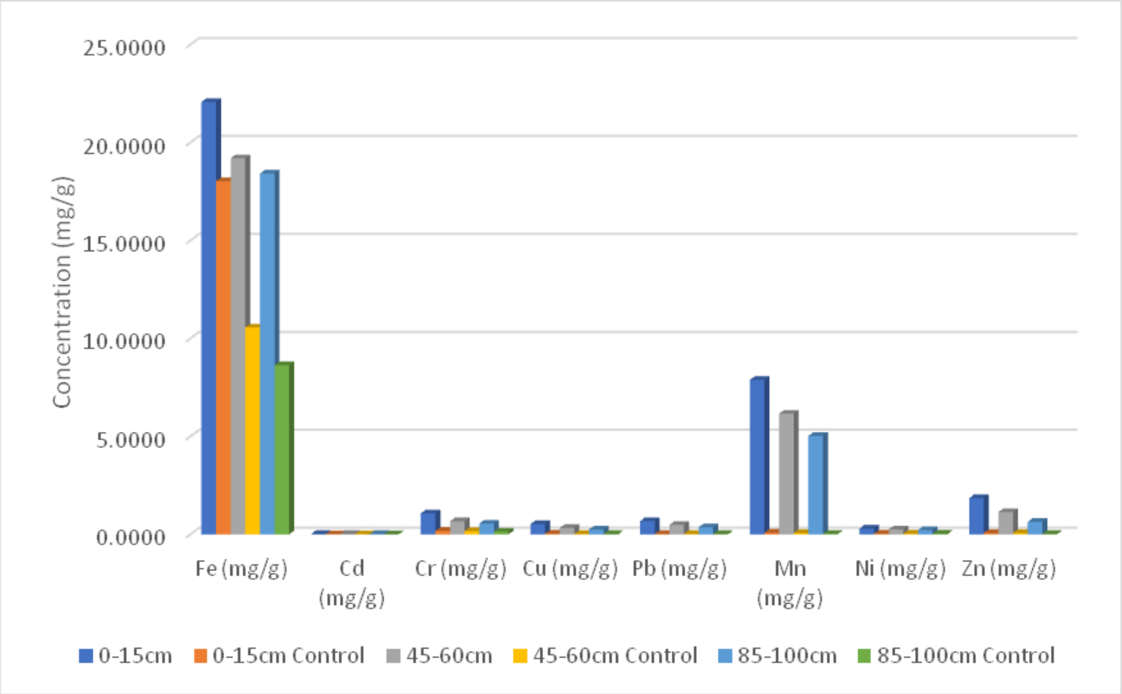

Figure 2 Overall Mean Concentration of Heavy Metals in Soils in the Study Area for Wet Season

Figure 2 shows the relationship between the concentration heavy metals in dumpsite and control sites across the soil profile in the study area during the wet season, mean concentration of Fe, Mn and Zn showed higher nominal value amongst the heavy metals. The highest concentration was recorded at depth 0-15cm while the lowest concentration was at depth 85-100cm, this applies both for soil samples from dumpsites and control sites respectively. Mean value of Cd did not show any difference between the dumpsite and control sites in the wet season. Figure 3, shows that pH values increase with depth in soil profile, the seasonal values during the wet season is lower in the wet season as reported by Salim *et al*, (2015) in a study on characteristics of soil under different land use. Cl^-, NO_3^- and SO_4^{2-} showed most significant nominal value amongst the heavy metals with the highest concentration at depth 0-15cm and the lowest concentration at depth 85-100cm for soil samples from dumpsites and control sites respectively.

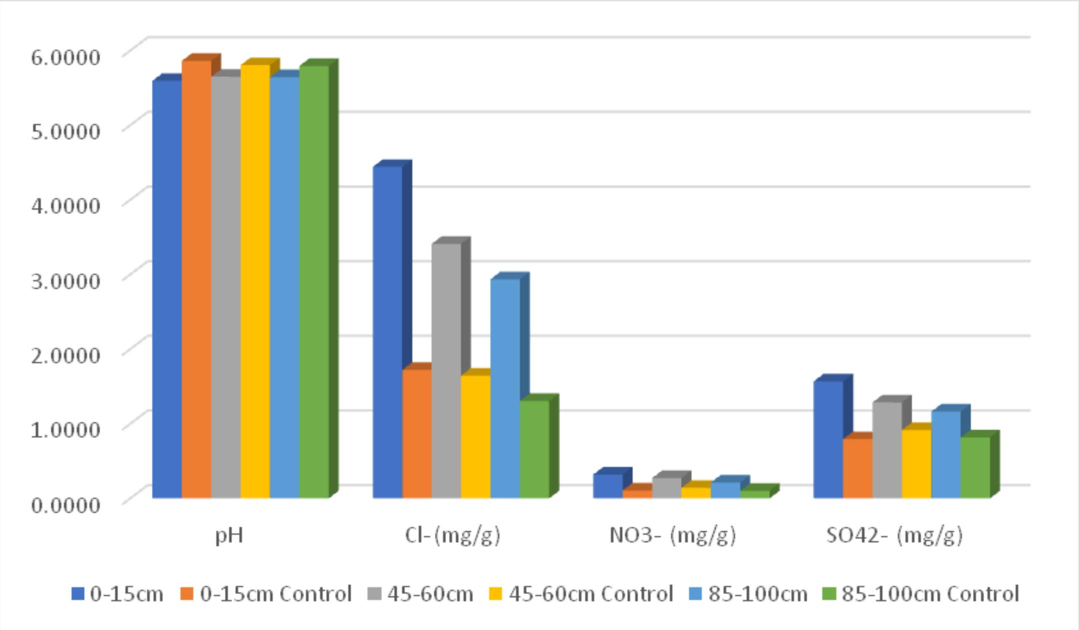

Figure 3: Overall Mean Concentration of pH and Nutrients in Soils in the Study Area for Wet Season

Figure 4 gives a graphical representation of the relationship the concentrations and relationship between the heavy metals in dumpsite and control sites across the soil profile in the study area during the dry season. While Fe, Mn and Zn showed most significant nominal value amongst the heavy metals with the highest concentration at depth 0-15cm and the lowest concentration at depth 85-100cm for soil samples from dumpsites and control sites respectively. From figure 5, it can be seen that pH values increased with depth in soil profile in the soil. The level of presence of heavy metals can be responsible for the acidic nature of the soil as represented by lower pH values as against the neutral to alkaline soil as represented by the higher pH values in the dry season. Cl^-, NO_3^- and SO_4^{2-} showed most significant nominal value amongst the heavy metals with the highest concentration at depth 0-15cm and the lowest concentration at depth 85-100cm for soil samples from dumpsites and control sites.

Findings from this work reveal that the concentration of Pb, Cu, Fe, Ni and Zn exceeds the result of similar study carried out in Lagos Salami *et al*, (2014)

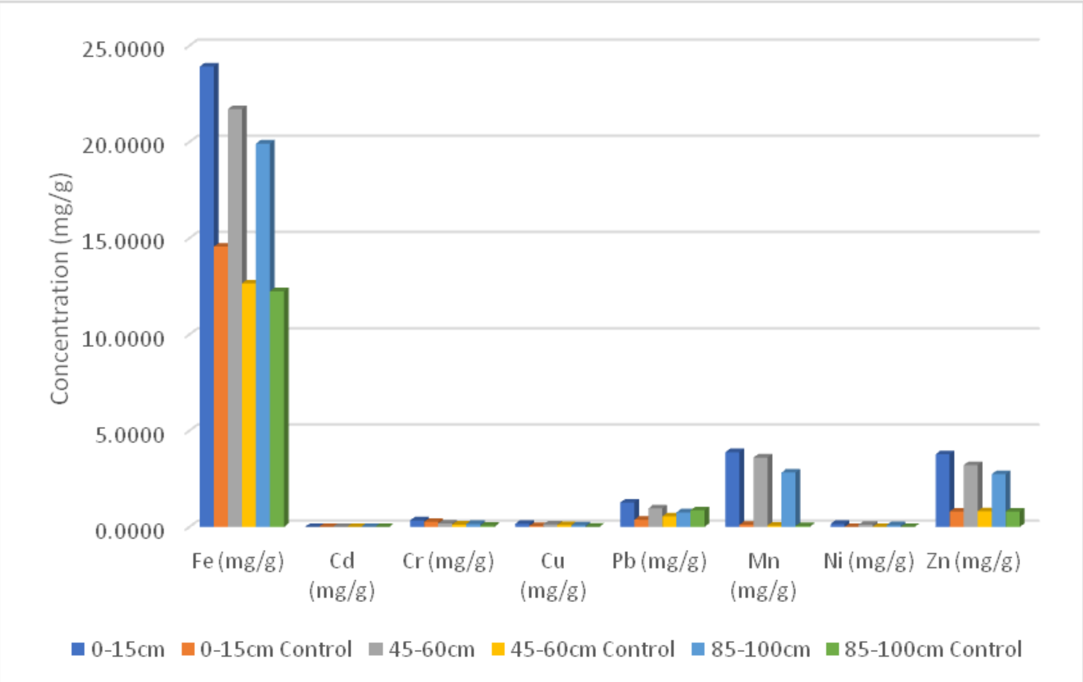

Figure 4 Overall Mean Concentrations of Heavy Metals in Soils in the Study Area for Dry Season

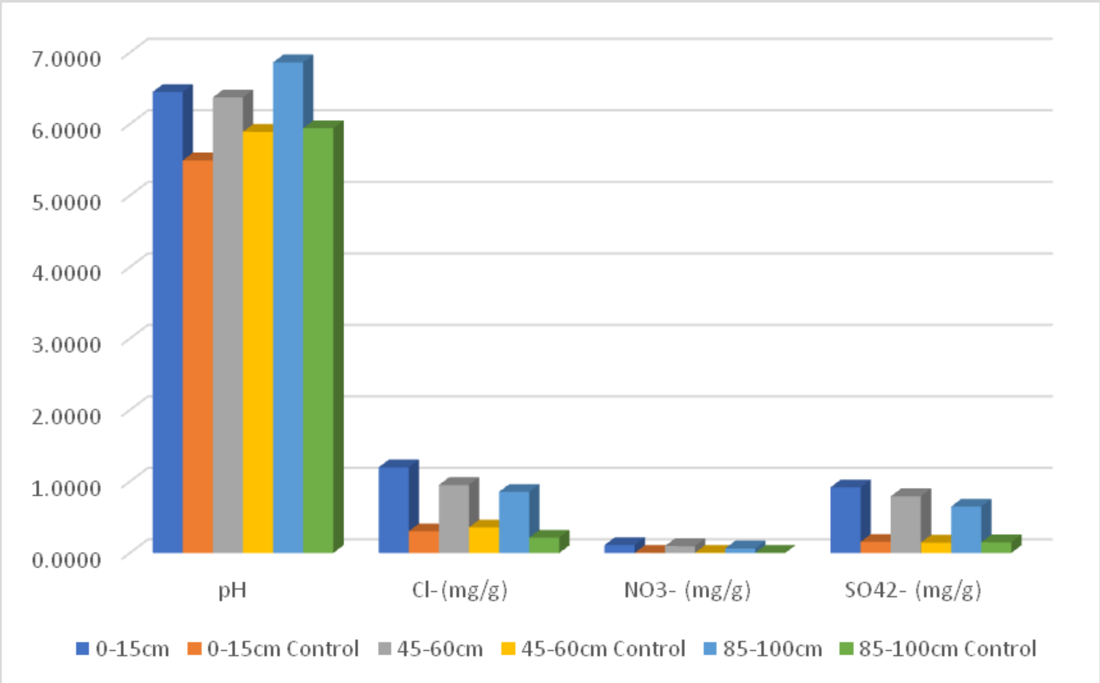

Figure 5: Overall Mean Concentration of pH and Nutrients in Soils in the Study Area for Dry Season

Statistical test of variation in concentration of Heavy Metals, pH and Nutrients at Waste Dumpsites across the depth of soil profile in the Study Area.

Table 2, presents the result post hoc analysis of soil quality parameters in the study area. Mean concentration of Fe was significantly different between the values recorded at the dumpsites against the control sites in the wet and dry seasons at $p<0.05$, there was however no significant difference in concentration of Fe as recorded in the wet and dry season.

Table 2 Seasonal Variation in significance level of concentration in soil parameters

Parameter	Wet	Dry	Control (Wet)	Control (Dry)
Fe	19.89±0.71b	21.62±0.71b	12.18±0.81a	13.30±0.80a
Cd	0.012±0.001c	0.002±0.001a	0.005±0.001b	0.00±0.00a
Cr	0.76±0.05b	0.22±0.05a	0.17±0.06a	0.16±0.06a
Cu	0.37±0.04b	0.12±0.04a	0.02±0.05a	0.06±0.05a
Pb	0.51±0.08b	0.99±0.08c	0.02±0.09a	0.59±0.09b
Mn	6.36±0.39c	3.26±0.40b	0.08±0.04a	0.06±0.02a
Ni	0.26±0.02c	0.12±0.01b	0.03±0.02a	0.001±0.00a
Zn	1.21±0.23b	3.02±0.21c	0.06±0.02a	0.81±0.24b
pH	5.63±0.10a	6.49±0.11b	5.81±0.11a	5.82±0.11a
Cl^-	3.60±0.14d	1.05±0.10b	1.54±0.16c	0.30±0.06a
NO_3^-	0.27±0.02c	0.09±0.00b	0.12±0.02b	0.001±0.018a
SO_4^{2-}	1.34±0.07c	0.78±0.06b	0.87±0.08b	0.15±0.08a

Values with different alphabets along a row are significantly different at $p < 0.05$
Values with more than one alphabet along a row are not significantly different at $p < 0.05$ with respect to similarity in alphabets

Mean concentration of Cr and Cu in dumpsite soils in the study area was observed to show significant seasonal variation between the wet and dry season values at $p < 0.05$. Mn and Ni were observed to show significant difference at $p<0.05$ for concentration values from dumpsite soils in the wet and dry seasons, both parameters showed a similar significance between dumpsite and control site soils in the study area. Concentration of Pb was significantly higher during the dry season over the wet season at $p < 0.05$. In the same vein, the concentration of Cl^-, NO_3^- and SO_4^{2-} at the dumpsite soil was significantly higher during the wet season in comparison with the dry season at 95% confidence level, there was also an observable significant difference between concentration level of NO_3^- and SO_4^{2-} in dumpsite and the corresponding control soils for both seasons. This implies soil pollution as a result of the impact of dumpsite on the environment.

Table 3 Variation in significance level of concentration of soil parameters with depth

Parameters	0-15cm	45-60cm	85-100cm
Fe	19.36±0.65^{c}	16.07±0.65^{b}	14.73±0.67^{ab}
Cd	0.07±0.001^{c}	0.005±0.001^{b}	0.003±0.001^{a}
Cr	0.49±0.05^{b}	0.28±0.05^{a}	0.22±0.05^{a}
Cu	0.21±0.04^{a}	0.15±0.04^{a}	0.10±0.04^{a}
Pb	0.63±0.07^{a}	0.53±0.07^{a}	0.51±0.09^{a}
Mn	3.28±0.36^{b}	2.72±0.40^{ab}	2.13±0.37^{a}
Ni	0.13±0.01^{b}	0.11±0.01^{ab}	0.09±0.02^{a}
Zn	1.75±0.19^{b}	1.40±0.20^{ab}	0.98±0.20^{a}
pH	5.87±0.09^{a}	5.94±0.11^{a}	6.05±0.10^{a}
Cl^-	2.01±0.13^{b}	1.65±0.13^{ab}	1.43±0.13^{a}
NO_3^-	0.14±0.02^{a}	0.13±0.02^{a}	0.10±0.02^{a}
SO_4^{2-}	0.90±0.06^{a}	0.81±0.06^{a}	0.74±0.07^{a}

Values with different alphabets along a row are significantly different at $p < 0.05$

Values with more than one alphabets along a row are not significantly different at $p < 0.05$ with respect to similarity in alphabets

Statistical test of variation in concentration of Heavy Metals, pH and Nutrients at Waste Dumpsites across the depth of soil profile in the Study Area.

The pattern of variation in concentration of soil quality parameters across the depth of soil in the study area can be observed in Table 3. Result showed that mean concentration of Fe at depth 0-15cm was significantly higher than the values observed at 45-60cm and 85-100cm at p<0.05, there was however no significant difference in concentration of Fe as recorded at 45-60cm and 85-100cm.The pattern that was observed for Cd was highest significance at 0-15cm, followed by 45-60cm and 85-100cm at 95% confidence limit. Cr, Mn, Ni, Zn and Cl^- were observed to show significant difference at p<0.05 for mean concentration values at 0-15cm depth, while no significant difference was observed at 45-60cm and 85-100cm at p<0.05 in soils in the study area. Mean concentration of Cu, Pb, pH, NO_3^- and SO_4^{2-} across the profile was observed to show no significant variation in values at 95% confidence interval.

Geo-statistical Analysis of some soil Quality parameters in the Study Area.

Using Arc GIS 10.3, the output grid for mean concentration for Soil Quality parameters measured across the depth of soil profile for the wet and dry seasons in the study area are presented in Figures 6 to 23. The output grid showing the concentration level of Fe in the soil at depth 0-15cm is seen in Figure 6. It shows that the highest emission around GSA and AJT, a higher concentration at the central part of the study area (24.17 – 26.27 mg/g), the output grid for concentration of Fe reduces towards the southern and western parts of the study area with range of 20.03 – 21.69 mg/g, some patches of medium concentration around the north eastern and south eastern sections of the study area with concentration between (21.09 – 22.72 mg/g). The highest concentration range for Fe at depth 0-15cm during the dry season (25.86 – 32.63 mg/g) was observed around the southern part (ABJ), central part GLD, GSA as well as the eastern parts MPP, KSH. Similarly, the lowest concentration of the Fe in the dry season can be seen around AJ and TGM (Figure 7).

Figure 8 shows that there was higher mean concentration (19.23 – 21.52 mg/g) for Fe at depth 45-60cm during the wet season was observable around MPP, AJT, GSA and GLD. While the concentration range of 17.43 – 18.60 mg/g representing the lowest was observed around KWL and TGM. The highest concentration range for Fe at depth 45-60cm during the dry season (23.60 – 30.58 mg/g) was observed around the southern part (ABJ), central part GLD, GSA as well as the eastern parts MPP, KSH. Similarly, the lowest concentration which ranged between 7.75 – 16.70 mg/g of Fe in the dry season can be seen around AJ and TGM (Figure 9).

Figure 10 shows highest concentration (18.54 – 19.81 mg/g) for Fe at depth 85-100cm during the wet season was observed around BWR, MPP, AJT and GLD. While the concentration range of 14.51

– 16.74 mg/g representing the lowest was observed around GSA. The highest concentration range for Fe at depth 85-100cm during the dry season (21.51 – 28.63 mg/g) was observed around the southern part (ABJ), central part GLD, GSA as well as the eastern parts MPP, KSH. Similarly, the lowest concentration which ranged between 7.27 – 15.15 mg/g of Fe in the dry season can be seen around AJ and TGM (Figure 11).

Output grid showing the concentration level of Mn in the soil at depth 0-15cm is seen in Figure 12. It shows that the maximum concentration around DTS, MPP, GLD, KSH, GSA and AJT of the study area (8.61 – 11.07 mg/g), Minimum concentration was observed around the southern section of the study area with concentration between (2.94 – 7.08 mg/g) as seen in ABJ and KWL. The highest concentration range for Mn at depth 0-15cm during the dry season (6.13 – 10.28 mg/g) was observed around sections of north eastern part (GSA, MPP, BWR, AJT). Similarly, the lowest concentration range (0.47 – 2.36 mg/g) of the Mn in the dry season can be seen around AJ and TGM (Figure 13).

Figure 14 shows that there was higher mean concentration (6.65 – 9.03 mg/g) for Mn at depth 45-60cm during the wet season was observable around DTS, MPP, AJT, RSH and KUJ. While the concentration range of 2.38 – 4.24 mg/g representing the lowest was observed around ABJ and BWR. The highest concentration range for Mn at depth 45-60cm during the dry season (6.08 – 10.27 mg/g) was observed around the patches of north eastern part MPP, AJT, GSA and BWR. Similarly, the lowest concentration which ranged between 0.37 – 2.20 mg/g of Mn in the dry season can be seen predominantly around the southern part which includes ABJ and KWL (Figure 15).

Figure 16 shows highest concentration (5.59 – 7.68 mg/g) for Mn at depth 85-100cm during the wet season was observed around DTS, MPP, AJT, KSH and KUJ. While the concentration range of 1.64 – 3.34 mg/g represents the lowest as observed around BWR and ABJ. The highest concentration range for Mn at depth 85-100cm during the dry season (5.03 – 8.18 mg/g) was seen at GSA, BWR, AJT. Moderate concentration is observed around other northeastern part of the study area (3.15 – 5.03 mg/g). The lowest concentration ranged between 0.30 – 1.73 mg/g of Mn in the dry season can be seen around the southern to the central part of the study area ABJ, KWL and GLD (Figure 17).

Output grid showing the concentration level of pH in the soil at depth 0-15cm is seen in Figure 18. It can be observed that maximum value was recorded around DTS which ranged between 6.34 – 7.11, while the minimum pH value range was observed around the southern to the central section of the study area (5.13 – 5.54) as seen in KUJ, GLD, GSA, BWR, ABJ and KWL. The highest value range for pH at depth 0-15cm during the dry season (6.72 – 7.10) was observed around (DTS, TGM, GLD). Similarly, the lowest value range (5.89 – 6.28) for pH in the dry season can be seen around BWR, MPP, AJT, KUJ and KWL (Figure 19).

Figure 20 shows that there was higher mean pH value range (6.48 – 7.24) at depth 45-60cm during the wet season as observable around DTS. While the lower mean value range of 5.24 – 5.64 was observed around most part of the study area which includes GSA, MPP, ABJ, GLD, KWL, ABJ and BWR. The highest mean value range for pH at depth 45-60cm during the dry season (6.68 – 7.13) was observed around GLD, TGM and DTS. Similarly, the lowest mean pH value range of between 5.89 – 6.19 in the dry season can be seen around the southern part which includes MPP, AJT and KWL (Figure 21).

Figure 22 shows highest pH mean values (6.49 – 7.20) for pH at depth 85-100cm during the wet season was observed around DTS., while the minimum pH value range was observed around the southern to the central section of the study area (5.28 – 5.65) as seen in KUJ, GLD, GSA, BWR, ABJ and KWL. The highest value range for pH at depth 85-100cm during the dry season (7.24 – 8.63) was observed around KUJ and GSA. Similarly, the lowest value range (5.89 – 6.28) for pH in the dry season can be seen around BWR, MPP, AJT, KUJ and KWL (Figure 23).

The output grid shows the overall picture of soil pollution pattern as spatially distributed over the FCT, it can be visualized that across the depth of profile and also amongst the sampling points, the pollution concentration is mostly located at the central to the northern and eastern fringes of the study area (GSA, AJT, BWR, MPP and GLD), this can be attributed to the population density of this section of the FCT as well as the waste component and volume dynamics of the area. Moderate to low level of pollutants are observed in other parts of the study area.

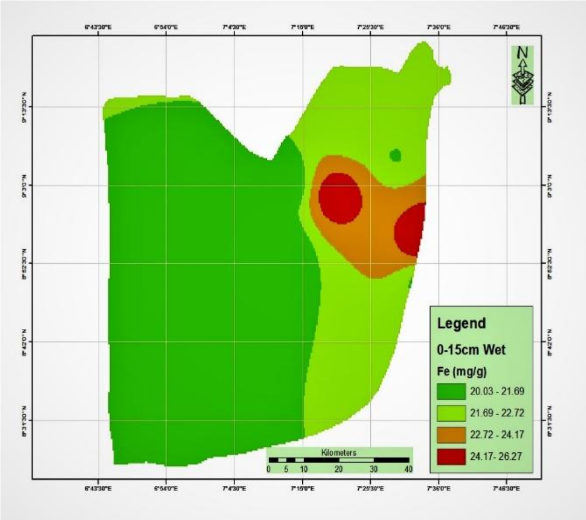

Figure 6 Wet season concentration of Fe in soil at Depth 0-15cm

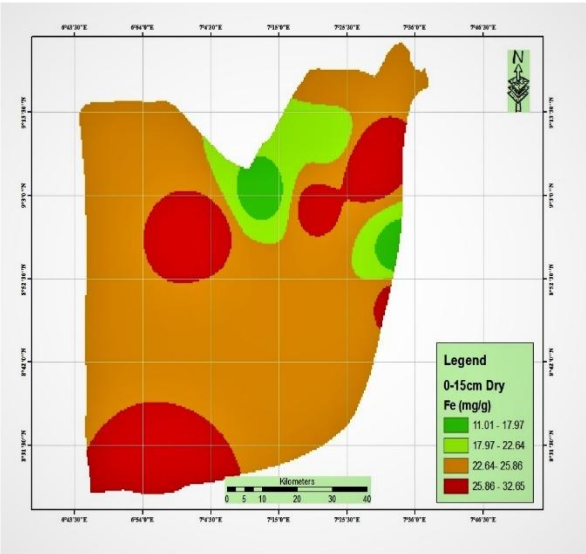

Figure 7 Dry season concentration of Fe in soil at Depth 0-15cm

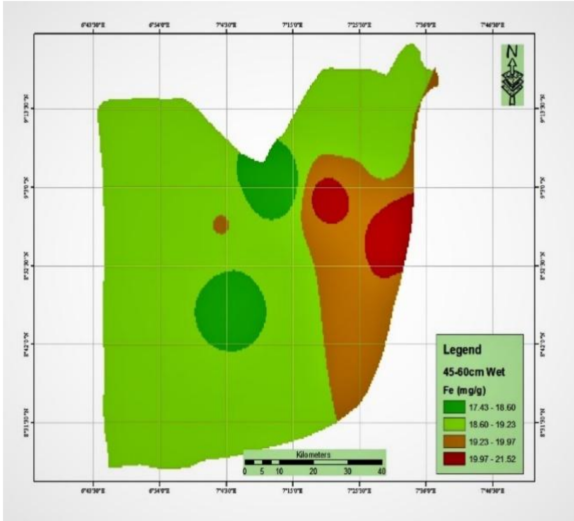

Figure 8 Wet season concentration of Fe in soil a Depth 45-60cm

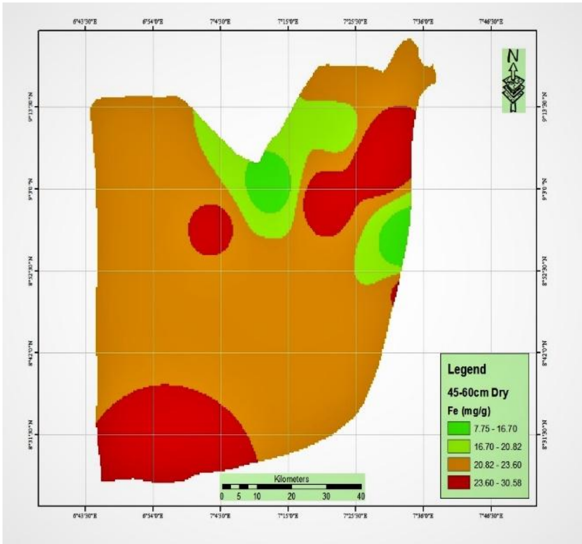

Figure 9 Dry season concentration of Fe in soil at Depth 45-60cm

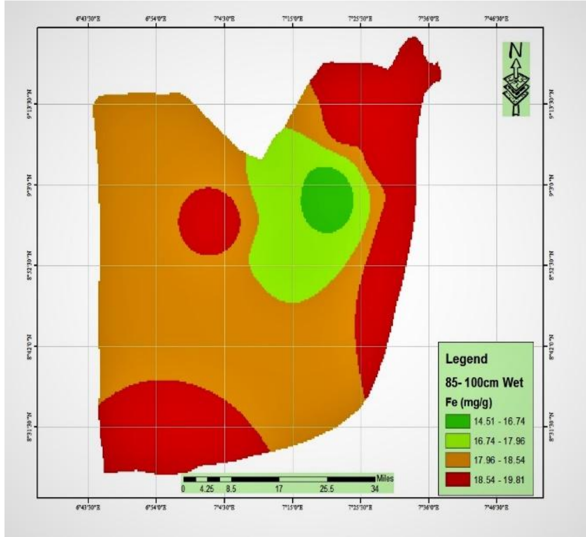

Figure 10 Wet season concentration of Fe in soil at Depth 85-100cm

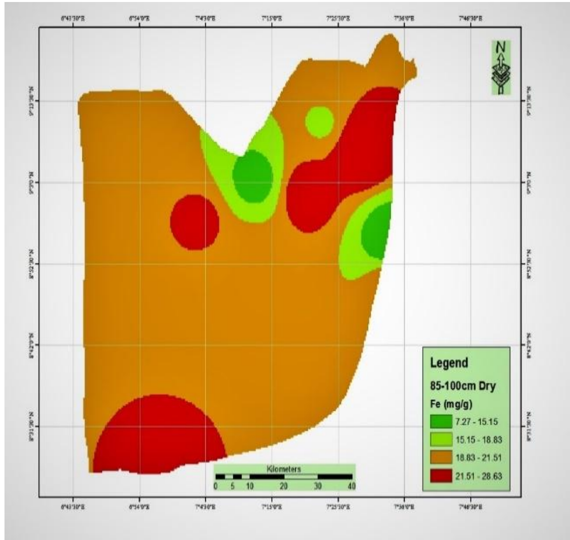

Figure 11 Dry season concentration of Fe in soil at Depth 85-100cm

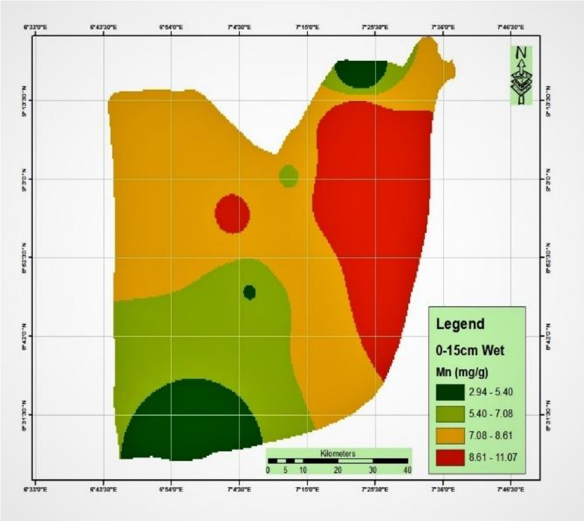

Figure 12 Wet season concentration of Mn in soil at Depth 0-15cm

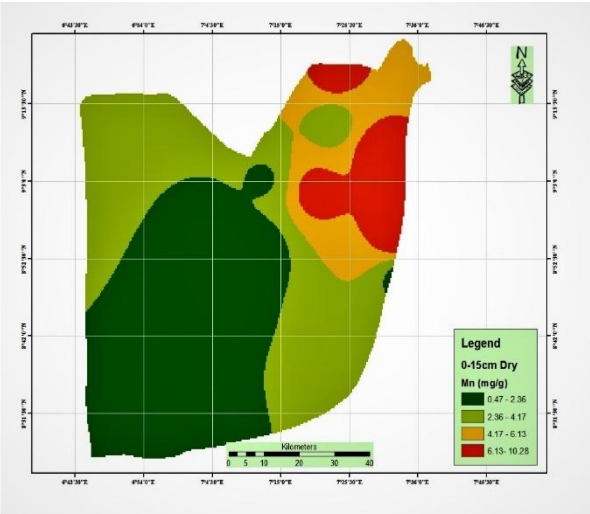

Figure 13 Dry season concentration of Mn in soil at Depth 0-15cm

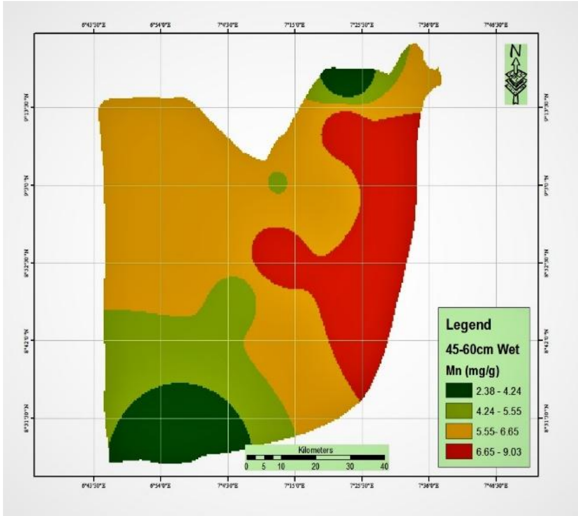

Figure 14 Wet season concentration of Mn in soil at Depth 45-60cm

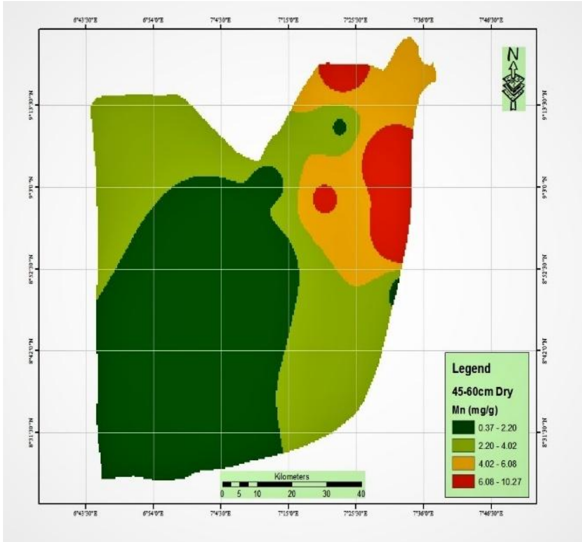

Figure 15 Dry season concentration of Mn in soil at Depth 45-60cm

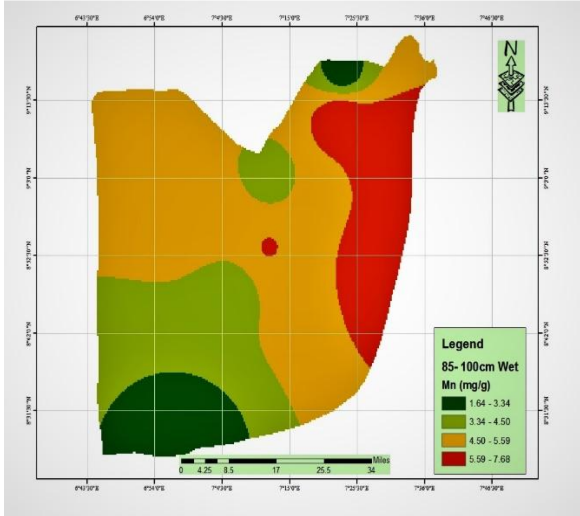

Figure 16 Wet season concentration of Mn in soil at Depth 85-100cm

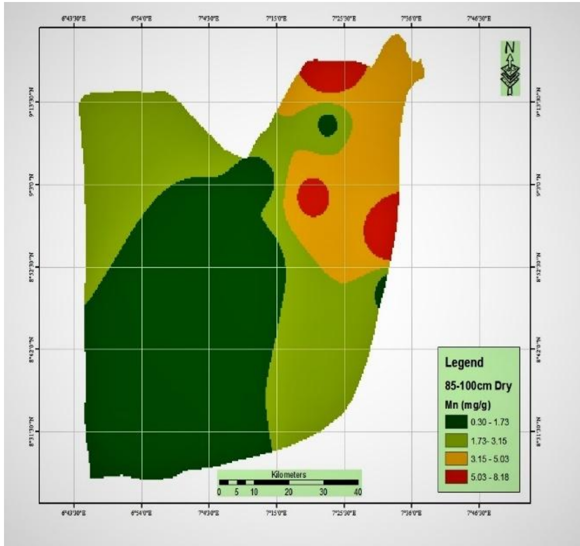

Figure 17 Dry season concentration of Mn in soil at Depth 85-100cm

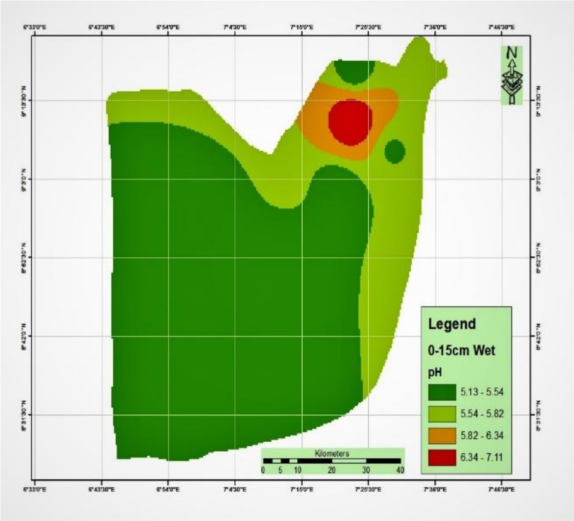

Figure 18 Wet season concentration of pH in soil at Depth 0-15cm

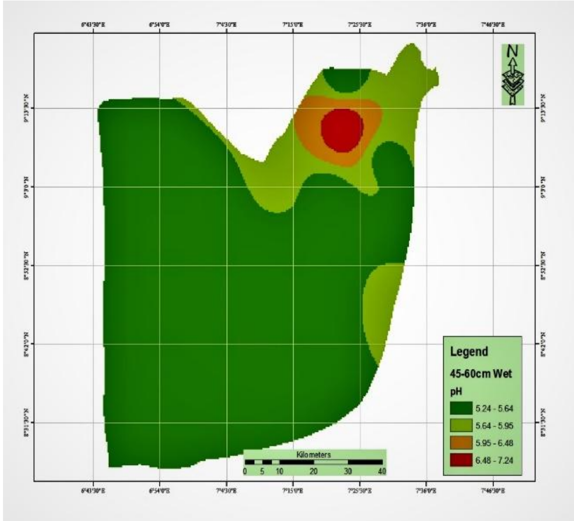

Figure 20 Wet season concentration of pH in soil at Depth 45-60cm

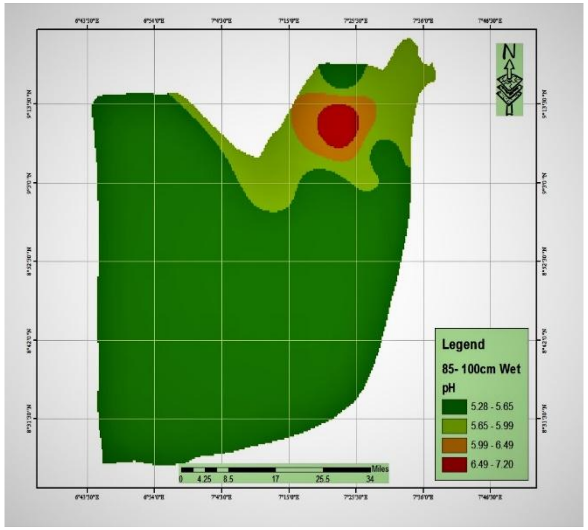

Figure 22 Wet season concentration of pH in soil at Depth 85-100cm

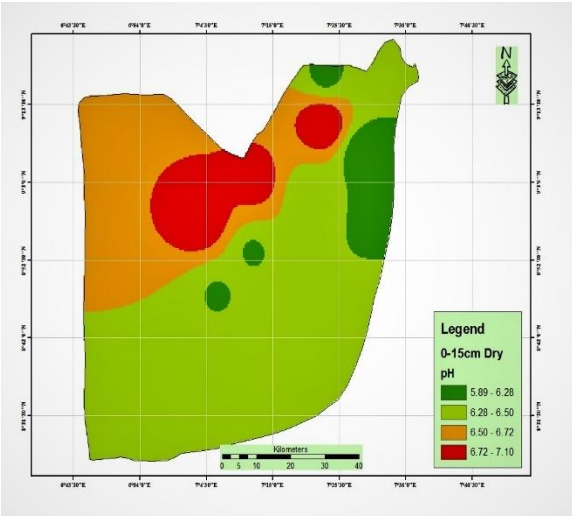

Figure 19 Dry season concentration of pH in soil at Depth 0-15cm

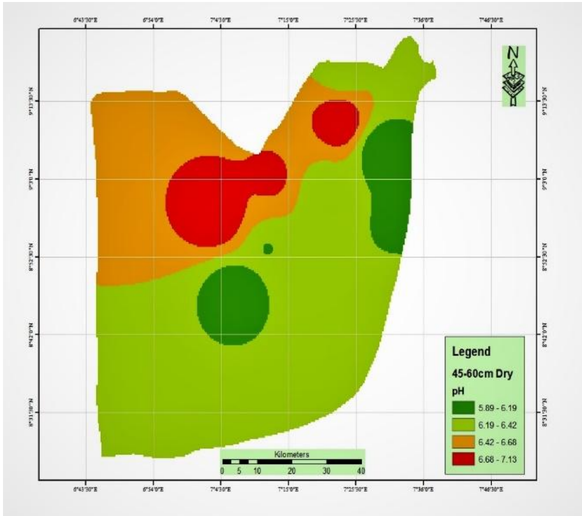

Figure 21 Dry season concentration of pH in soil at Depth 45-60cm

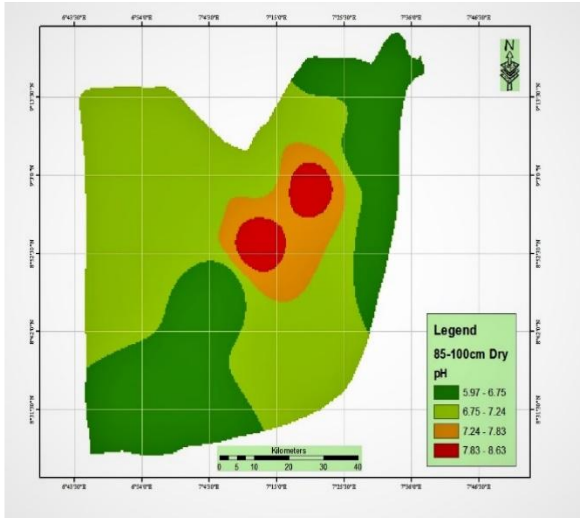

Figure 23 Dry season concentration of pH in soil at Depth 85-100cm

Comparison of Soil Quality Parameters with WHO Guidelines.

A comparison between obtained results of analyzed soil quality parameters and WHO (1993) acceptable guidelines for soil quality during the wet and dry season in the study area can be seen in Table 4, it shows that the mean values of Fe, Cd, Cr, Pb, Ni, Mn, Zn and NO_3^- exceeded their permissible limit in the soil during both the wet and dry season. Other analyzed parameters could not be compared with standard by WHO because they were not available. This implies that the soil is polluted by heavy metals and can have implications for cropping in the study area.

Table 4. Comparison of Soil Quality Parameters in wet and dry seasons with WHO Acceptable guidelines

Parameters	Obtained Results (wet season) (mg/g)	Obtained Results (dry season) (mg/g)	WHO Standard (mg/g)	Variation (wet season) (mg/g)	Variation (dry season) (mg/g)
Fe	19.8911	21.8488	0.003 to 0.25	19.6411	21.5988
Cd	0.012	0.0017	0 to 0.00003	0.01197	0.00167
Cr	0.761	0.2285	0 to0.000085	0.760915	0.228415
Cu	0.3657	0.1259	NA	NA	NA
Pb	0.5063	0.9991	0.000015 to 0.000025	0.506275	0.999075
Mn	6.3547	3.4406	0.0002 to 0.009	6.3457	3.4316
Ni	0.2549	0.1247	0 to 0.0001	0.2548	0.1246
Zn	1.2057	3.2462	0.00002 to 0.0003	1.2054	3.2459
pH	5.6287	6.5608	NA	NA	NA
Cl^-	3.595	1.0005	NA	NA	NA
NO_3^-	0.2677	0.0890	0.000045	0.267655	0.088955
SO_4^{2-}	1.3383	0.7863	NA	NA	NA

NA = Not Available, pH has no unit

DISCUSSION

Soil is an important component of the urban environment and its management is very central to the quality. The observed decrease in concentration of heavy metals with depth is as a result of leaching. Concentration of Cr, Cu, Pb and Zn showed a similar pattern during the wet season in the study area, heavy metals were detected among the soil samples examined; this is an indication that industrial and hazardous materials were dumped on the dumpsites (Salami *et al*., 2014). The decreasing pattern in concentration of heavy metals at the three (3) sampling depths is similar to results from control sites, however, an inverse relationship is observed between concentration of heavy metals and pH with depth, this can be attributable to presence of heavy metals having a lowering effect on pH value and hence, the acidic soil in the study area during the wet season Kazlauskaitė-Jadzevičė, *et al*, (2014). During the dry season Cr, Cu, Pb and Zn was observed to show a similar pattern though with lower nominal values. Cd showed no difference between the dumpsite and control sites in the dry season. It can be generally deduced that concentration of heavy metals decreases down the soil profile with increase in depth during the dry season, it is expected that concentrations of heavy metals to decrease as move downward the soil profile if sorption, natural attenuation, dilution and chemical transformation occur (Yadav and Jaiswal, 2011; Adjia *et al*., 2008), The pattern of Cd is based on the effect of pH on the leaching of Cd Zhang *et al*, (2018). Results obtained were compared with WHO permissible standards in soils Fe, Cd, Cr, Pb, Ni, Mn, Zn and NO_3^- exceeded their permissible limit in the soil during both the wet and dry season. These parameters could therefore be used as indicators of inorganic soil pollution. Further studies on the geology and the hydrogeology of the study area need to be carried out in order to corroborate these findings and confirm leaching contamination of soil in the study area.

CONCLUSION

The concentration level of soil quality parameters in the dumpsites within the study area was found to vary over locations (spatially) and seasons (temporal). Heavy metals parameters (Fe, Cd, Cr, Pb, Mn, Ni and Zn) and NO_3^- content in soil quality parameters from all the dumpsites in the study area exceeded WHO guidelines in study area during both seasons. The high concentrations of the pollutants in the soil have potential to reach and contaminate water resources, agricultural processes within the study area and thus threatening sustainable development. Pollution of dumpsite soil could be a threat to the health of members of the public who consume plants that are usually grown on the dumpsite soils. Most of the dumpsites were observed to be a source of pollutants of public health importance, it is therefore recommended that environmental education and awareness on the inherent dangers of cultivating plants on dumpsite soils is required for dumpsite workers and nearby residents, so they can understand the likely effects of polluted dumpsites soil on the food chain on their health and that of the general consuming public as well as remediation strategy to deal with post closure impact of dumpsites is necessary to mitigate continuing impact from closed dumpsites.

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