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Full Length Research

An assessment of soil contamination in and around Mpape dumpsite, Federal Capital Territory (FCT), Abuja Nigeria

Magaji J.Y.* and Jenkwe E.D.

Department of Geography and Environmental Management, University of Abuja, Nigeria.

*Corresponding author. Email: john.magaji@uniabuja.edu.ng; johnmagaji6@gmail.com

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ABSTRACT: Landfills are supposed to be the best and safest methods of waste disposal. The Mpape dumpsite was used as landfill for FCT, but did not meet the criteria for landfill construction. Evidences of pollution abound over two decades and now that the site has been closed down, there is need for a study to evaluate the level of pollution with time. This study assessed the level of soil contamination in Mpape dumpsite. The dumpsite was demarcated into six transects, out of which four points were randomly selected and a control for the study. Soil samples were collected at 0 to15 cm and 15 to 30 cm using soil auger. The samples were analysed at Abuja Environmental Protection Board Laboratory. The results show that, there is low variation in the distribution of the analysed parameters within and between the samples. The most common heavy metals found in the study area in order of abundance are Mg>Mn>Hg>Cd>Pb>Cr>CN>Fe>Cu. Correlation results shows that there is a significant positive correlation between pH and K, Pb; NH_4 and Cu^+, Ag; F and Cd, Ag and Pb, Cl- and Cu+, CN and Cr, Humus and K, at ($p \geq 0.05$), while NO_3 and PO_4^2; Mn and NH4, Cd and Br, Hg; Al and Cl-, Cd and Hg; Pb and K, Humus at ($p \leq 0.01$). Statistically, there is no significant variation between the sample points and there is no significant difference between the experimental results and WHO standard, but there is significant difference with the control sample. This shows that the dumpsite has polluted the soils despite the closure of the dumpsite. It is therefore recommended that before siting a landfill, there should be strict compliance with the guidelines for its siting, construction and regular monitoring in order to minimize the menace to the soils.

Keywords: Correlation, heavy metals, leachates, landfill.

INTRODUCTION

The concept of waste generation is as old as mankind, and every society produce one form of waste or another as the societies grow and developed, so the volume, composition and complexity of waste increases. In the primitive era, the composition of the waste is mainly bio-gradable, and the best way of disposal then was to use it as agricultural manure after deposition. With advancement in technology and industrialization, waste composition is now complex, a part from the bio-degradable waste, we have municipal waste, industrial waste, hospital waste, mining waste, nuclear waste among others (Dung-gwom and Magaji, 2007; Amasuomo et al., 2015); and their management has become a global issue. The continuous growing of industrial production and trade in many countries worldwide has accompanied a rapid increase of the production of municipal and industrial waste (Vaverková and Adamcová 2015, Adamović et al., 2018; Alobaid, et al., 2018; Chen, 2018).

The rapid development of industrialization and the increasing application of agrochemicals have led to the accumulation of heavy metals in soils (Yang et el., 2018, Wu et al., 2018, Liu et el., 2018). The volume and quality of leachate are influenced by several factors, such as the composition of the waste, biochemical processes that occur in the degradation stages of the waste, amount of moisture, and the local parameters (Ma et al., 2018). The composition of leachate depends on the biological and chemical reactions on solid waste, the age of the landfill, waste compositions, landfilling technology, and climatic conditions of the area (Kjeldsen et al., 2002; Ziyang et al.,

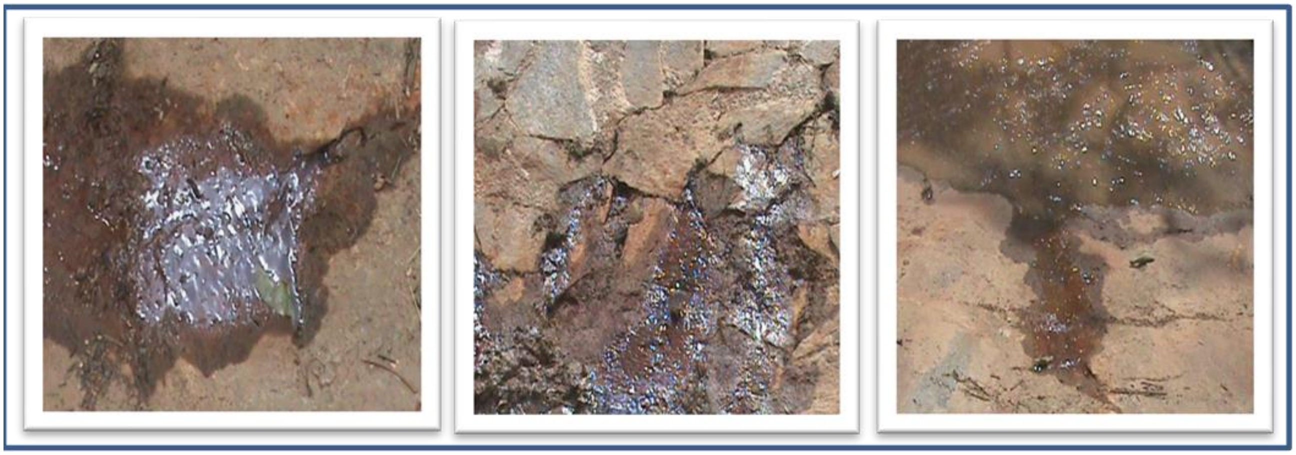

Plate 1. Evidence of leachate coming out from the concreted bank of the dumpsite.
Source: Field survey, 2019

2009).

Apart from the problem of waste evacuation, the major problem facing waste managers is waste disposal. A sanitary landfill is a site where solid wastes are placed on or in the ground at a carefully selected location by means of engineering techniques that minimize pollution of air, water and soil, and their risks to maintained animals. Municipal solid waste landfills are notorious for having adverse impacts on water and soils within their sphere of influence during the active life of the landfill. Environmentalists view soil pollution by heavy metals as a serious problem because the heavy metals tend to persist, circulating indefinitely and eventually bioaccumulating throughout the food chain (Afrifa et al., 2015; Mohseni-Bandpei et al., 2016; Solgi and Khodabandelo, 2016).

The first landfill that served FCT is the Mpape dumpsite. This dumpsite is owned and operated by Abuja Environmental Protection Board (AEPB, 2012). Mpape dumpsite was opened in 1989, and closed in 2005 due to air pollution from and fire outbreaks and foul and awful liquid' (leachate) emanating from the buried waste flowing to the surface as shown in Plate 1 during the raining season that more leachate is produced due to infiltration. There are also cases of the contamination of surface and ground water through the soils within the vicinity of the residential areas around the landfill.

The estimated depth of the waste varies approximately between 15 meters to 30 meters (49.2 feet to 98.4 feet) over an approximate16 hectare area (ISWA, 2008). It is located on a watershed at a former quarry site along the foot of Aso-Bwari hills. The dumpsite was discovered not meeting the standard criteria for a sanitary landfill, and as such has affected the quality of plants grown in the area through the release of leachates into the soils (Aronsson, 2010; Magaji, 2012; Magaji, 2020). The volume of wastes dumped in the area kept increasing until the site was filled up (Table 1).

Heavy metals can also contaminate the food chain and reduce crop yields (Obrador et al., 1997; Wang et al., 2003). The consumption of plants containing high levels of heavy metals might pose a serious risk to human health (Turkdogan et al., 2003; Wang et al., 2003). Depending on the environmental conditions and the rate that heavy metals are added to the soils, these elements can be leach through the soil profile, and consequently, contaminate groundwater.

Wang et al. (2003) investigated heavy metal contamination in soils and plants at polluted sites in China, and reported the problems were associated with the consumption of rice grown in paddy soils contaminated with Cd, Cr or Zn, because 22 to 24% of the total metal content in the rice biomass was concentrated in the grain. Therefore, the risk of soil contamination by heavy metals must be considered when biosolid is applied, and an understanding of the behavior of heavy metals in the soil is essential for assessing environmental risks when these metals are incorporated by the agroecosystem. It is in the light of the aforementioned discussion that this study is set up to investigate the changes in the level of soils contamination over time around the dumpsite in the area.

MATERIALS AND METHODS

Study area

The Mpape dumpsite was the major site used as landfill for the Federal Capital Territory (FCT). It has an approximate depth of 15 to 30 m, and covers about 16 ha of land. This dumpsite was operational from 1989 to 2005 by the Abuja Environmental Protection Board (AEPB) and was formerly a quarry site converted to a dumpsite after its closure. The landfill is 200 m upslope of residential housing, it is located at the Northeastern edge of the Gwagwa plains, along Aso-Bwari hills by the Kubwa expressway near the tipper garage of Mpape, within the watershed of the River Usuma basin. The FCT Abuja is located between latitudes 8°25'

Table 1. Estimated quantity of waste deposited at FCT dumpsites.

Month/year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
January	1820.9		3262	1373.2	3298.3	1140	3316.2	2379.6	3920. 6	4706.2	6023	15117	4262	13500
February	1821		3261.2	1012.7	3071.3	970.9	4278.5	2239.2	3654.2	4781.9	6012	106977	3116	123426
March	2233.4		4077.1	1423	2466.5	966.7	4473.4	2756.7	4160.0	5230.5	6991	10193	2967.8	142366
April	2233.4		2261.7	1226.5	2373.1	1267.1	3549.0	3316.4	4844. 4	5666.6	7150	13706	2963.5	102326
May	1820.4	No	4077	1651.4	2854.1	2117.1	4274.1	3597.8	3932.2	6084.3	7765	9835	3212.25	132404
June	2233.4	record	3261.7	1699.4	2625.5	2099.4	4677	4292.8	5364.5	6723.8	7965	9734	4332.25	121383
June	2233.4	for	3262	1565.9	0	2287.9	5585.1	4825.6	5936.8	6549.6	7981	17116	5546	133362
August	1820.9	1999	4077.1	1750.8	0	2193.7	6847.4	5718.6	6333.4	6536.0	7965	9601	10343.5	126676
September	2233.4		3261.7	2105.4	0	3239.4	5211.0	5265.9	5883.1	6943.3	7412	6445	24936.3	128982
October	2233.4		3261.7	2330.1	0	3124	5825.2	5109.4	6333.2	6349.0	6860	5106	24614	135300
November	1821		4077.1	1332.6	0	2953.0	3907.4	3938.5	6276.7	5365.9	6063	5366	20009.8	137397
December	2233.4		3261.7	4363.5	0	2016.1	3663.0	4164.7	5311	5606.6	6218	5235	6461.8	134781
Total (Mj)	24738		41402	21834.5	16688.8	24375.3	55607.3	47605.2	53185.1	70543.7	84405	214431	112765.2	1431903
Total (Tons)	25.083		41.4	22.4	17.1	24.3	55.6	47.7	62.5	71	84.41	99.4	112.88	143.3
Annual Av.	2061.5		3450.2	1819.5	1390.7	2031.3	4633.93	3967.1	5318.5	5878.6	7033.8	17869.3	9397.1	119325.3

Source: Abuja Environmental Protection Board, 2012.

and $9^o25'$ north of the equator and longitudes $6^0 45'$ and $7^o45'$ east of Greenwich meridian. It occupies an area approximately 8,000 km^2 and occupies about 0.87% of Nigeria. The territory is situated within the region generally referred to as the Middle Belt (Mabogunje, 1977), and is bordered on all sides by the four states of Kogi, Niger, Kaduna, and Nassarawa (Figure1).

The Federal Capital consists of basically of two types of distinct physiographic regions, the hills and the plains. The elevations of these hills range from about 100 m to about 300 m in the more rugged areas. The influence of parent materials on the soil of FCT is as a result of the crystalline rocks of the Basement Complex and Nupe Sandstone form the surface from which they are formed. The major soils type of the FCT is tropical Ferruginous. The alluvial complexes of the territory are contained in all the stream channels which are made up of gleysols which are very fertile and occur dominantly in Abaji Area Council of the FCT. The soils of the plains are mostly sandy and sandy-loam. The Federal Capital Territory records the highest temperature during the dry season months, which are generally cloudless. The maximum temperature occurs in the month of March with amounts varying from 37^{o}C in the Southwest to about 30^{o}C in the Northeast. This also coincides with the period of high diurnal ranges of temperature which can drop to as low as 17^{o}C, and by August, diurnal temperature rarely exceeds 7^{o}C.

Soil Sampling and collection procedures

The dumpsite was demarcated into six transects, out of which four were randomly selected for this study. A sampling point was marked along the midpoint of each transect and the coordinates of the points were read using hand held GPS. At each point on the transects, two soils samples were collected at (0-15) cm and (15-30) cm, and a point away from the dumpsite as control, making a total of ten soils samples for the study (Table 2).

The soil samples collected were bagged in black polythene, labeled and taken to Abuja Environmental Protection Board (AEPB) Laboratory for analysis. The following parameters were investigated in the soils at AEPB Laboratory following the APHA guidelines; Soil pH, conductivity NO_3, NH_4 Pb Hg, SO_4^2, F, Ag, PO_4^2, Cl, Br, Cu, Al, Cd, Cn, Mn, K, Ca, Mg, Cr. Fe, and Humus screening. The concentration of these metals present in any type of water may satisfactorily be determined by atomic absorption spectroscopy or colorimetric methods. These two methods are rapid and do not require extensive separation techniques. The two methods were used and procedure for the analysis were adopted after Ademoriti (1996) and APHA (2000). Table 3 presents the parameters, equipment and model used for the analysis.

The Statistical Package for Social Sciences (SPSS) and the Microsoft Excel were used for data analysis.

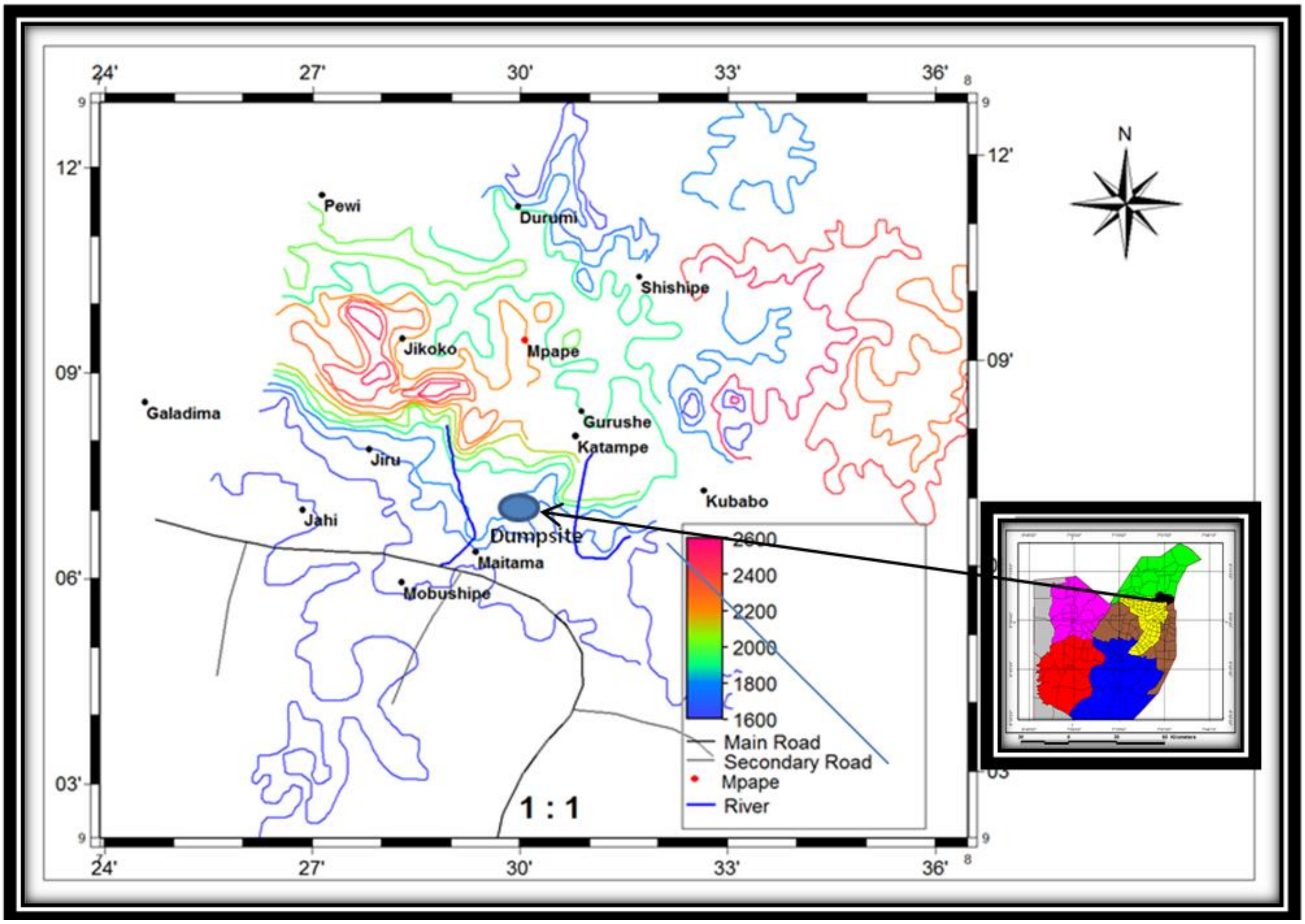

Figure 1. Location of Mpape dumpsite in the Federal Capital Territory, Abuja.
Source: Adapted and Modified from diverse sources by the author, 2018.

Table 2. Sampling frame.

Sampling points	Elevation	Location	No of samples
Soil point A	581m	N 9º 6' 51.7''; E 7º 29' 26''	2
Soil point B	575m	N 9º 6' 42.8''; E 7º 29' 18''	2
Soil point C	562m	N 9º 6' 35.3''; E 7º 29' 11.7''	2
Soil point D	560m	N 9º 6' 29''; E 7º 29' 9.3''	2

Source: Field Survey, 2019.

RESULTS AND DISCUSSIONS

Descriptive analysis of the results

Results in Table 3 present the descriptive analysis of the result top and subsoils at depth of 0 to 15 cm and 15 to 30 cm. The mean of the pH level in the soils of the dumpsite are below 7 with low variation, except that of sample 4, implying that the soils are slightly acidic in nature. This might probably be as a result of the location of the sampling point being at a lower elevation where deposition takes place. In sample 1, all the parameters analysed have low variation except fluoride that showed moderate variation while cadmium and lead showed high variation. In sample 2, all the parameters analysed have low variation except fluoride that varied moderately and conductivity showed high variation. In sample 3, all the parameters analysed also have low variation except copper that varied moderately and cadmium which shows high variation. In sample 4 all the parameters analysed have low variation. The control sample also shows that all the parameters analysed have low variation except

Table 3. parameters and their laboratory equipment used for the analyses.

Parameters (Units in Mg/L Except Stated)	Equipment used for the corresponding parameter
pH	pH Reagent/pH Disc
Conductivity (µs/Cm)	Conductivity Meter (Hach Co 150)
Sulphate	Hach Sulphate Colorimetric Test Kit
Chloride	Hanna Chloride Colorimetric Test Kit
Nitrate	Hach Nitrate Colorimetric Test Kit
Fluoride	Ion Meter/Ion Selective Electrode
Magnesium	Hach Magnesium Colorimetric Test Kit
Manganese	Hach Manganese Colorimetric Test Kit
Mecury	Ion Meter /Ion Selective Electrode
Phosphate	Hanna Phosphate Colorimetric Test Kit
Aluminum	Lovibond Aluminum Test Kit
Lead	Ion Meter /Lead Electrode
Cyanide	Ion Meter Cyanide Electrode
Potassium	Ion Meter K Electrode
Bromine	Ion Meter Br Electrode
Silver	Ion Meter Ag Electrode
Ammonium	Ion Meter NH_4 Electrode
Zinc	Ion Meter Zn Electrode
Iron	Hanna Iron Test Kit
Cadmium	Ion Meter /Ion Selective Electrode
Copper	Ion Meter /Ion Selective Electrode

fluoride that varied moderately and cadmium, cyanide and lead that showed high variation.

The most common heavy metals found in the dump site, in order of abundance are Mg, Mn, Hg, Cd, Pb, Cr, Cn, Fe and Cu respectively. The occurrences of these heavy metals slightly differs with that of the reports of USEPA (1996), that the most common heavy metals found at contaminated sites in order of abundance are Pb, Cr, As, Zn, Cd, Cu, and Hg. These metals are important since they are capable of decreasing crop production due to the risk of bioaccumulation and biomagnification in the food chain. This distribution is believed to be controlled by reactions of heavy metals in soils such as (i) mineral precipitation and dissolution, (ii) ion exchange, adsorption, and desorption, (iii) aqueous complexation, (iv) biological immobilization and mobilization, and (v) plant uptake (Levy et al., 1992).

Table 4 presents the results of the correlation coefficient for various heavy metals. The results shows that there is a significant positive correlation between pH and K; pH and Pb; NO_3 and Cu+; NH_4 and Ag; F and Cd; Ag and Pb; Cl- and Cu+; Cn and Cr; Humus and K, at ($p \geq 0.05$) with a correlation coefficients of r = 0.98; r = 0.96; r = 0.99; r =0.98; r = 0.96; r =0.95; r =98; r =0.97 and r = 98, respectively. There is also a significant negative correlation between pH and Cn; NH_4 and F; NH_4 and Hg; Mn and Ag; Hg and Humus; K and Cr at ($p \geq 0.05$) with a correlation coefficients of r = -0.98; r = -0.97; r = -0.99; r = -0.99; r =-0.96 and r=-0.97 respectively.

Statistics also shows that there is a significant positive correlation between NO_3 and PO_4^2; NH4 and Mn; Mn and Cd; Mn and Br; Al and Cl-; Cd and Hg, Cd and Br; Hg and Br; K and Pb; Pb and Humus at ($p \leq 0.01$) with a correlation coefficients of r = 0.99; r = 0.99; r =1.0; r = 1.0; r =1.0; r =1.0; r =1.0; r = 1.0; r = 1.0 and r =1.0 respectively. There exist also a significant negative correlation between pH and Cr; NH_4 and Cd; NH_4 and Hg; NH_4 and Ag; Hg and Humus; K and Cr at $p \leq 0.01$ with a correlation coefficient r=-1.0, r=-1.0, r = -1.0, r = -99, r = -1.0, and r = -1.0 respectively.

There is insignificant positive correlation as well as insignificant negative correlation as shown in the Table 5. Remember that the positive correlation implies that increase in one metal would results to an increase in the other metal and vice versa. Also, a negative correlation signifies that their sources are quite different.

In analysing the impact of the waste dump on the quality of soils, the result of the dumpsite soils were compared with the results of the soils of the controls points. Results shows that apart from pH values that was higher than those of the dumpsite soils, all the parameters analysed in the soils of the waste dump are higher than those of the control.

The result in Table 6 shows that the soil pH all fall within the WHO except that of sample 1 which falls slightly below the minimum value set by WHO. Almost all the sampled soils have higher conductivity compared with the standard value set by the WHO, while NO_3 and fluoride values are within the limit though fluoride was higher in sample 1 (WHO, 2011).

Table 4. Temporal analysis of the results of surface water.

Parameter (mg/L except stated)	Sample Point 1		Sample Point 2		Sample Point 3		Sample Point 4		Control Point	
	x̄±STD	COV	x̄±STD	COV	x̄±STD	COV	x̄±STD	COV	x̄±STD	COV
pH	6.25±0.42	6.0	6.65±0.49	7.44	6.75±0.4	5.24	7.2±0.7	9.82	7.1±0.42	5.98
Conductivity (µs/cm)	1434±55.2	4.4	759±878.2	115.7	1232±1.4	0.11	1685±82.0	4.86	830.2±110.9	13.4
Nitrate (NO_3^-)	7.7±0.50	6.5	6.40±0.01	0.09	10.4±0.1	0.68	10.4±0.01	0.08	6.41±0.0	0.06
Ammonia (NH_4)	2.4±0	0.0	10.2±0	0	9.4±0.85	9.03	9.4±0.06	0.67	0±0	0
Magnesium (Mg)	12.5±0.7	1.6	45.1±0.57	1.25	75.3±0.4	0.5	84.7±0	0	45.1±0.7	1.57
Manganese (Mn)	31.5±0.3	1.0	2.40±0.13	5.61	1.41±0.1	9.6	4.5±0	0	2.4±0.09	3.78
Aluminum (Al)	1.25±0.01	0.4	2.01±0.01	0.35	34.1±1.1	3.12	50.4± 0.49	0.98	2.0±0.01	0.35
Sulphate (SO_4^{2})	109±4.9	1.4	341±4.24	1.24	552±2.1	0.38	578±12.0	2.07	344±5.0	1.44
Fluoride (F^-)	6.1±0.22	17.5	1.29±0.22	17.1	1.9±0.04	1.83	3±0	0	1.3±0.23	17.5
Cadmium (Cd)	7.9±3.1	39.2	0.1±0.01	14.14	0.51±0.7	138.6	3.4±0.13	3.92	0.1±0.03	35.4
Mercury (Hg)	23.7±0.0	0.0	6.31±0	0	6.88±0.2	2.16	5.1±0.01	0.28	0.0±0	0
Phosphate (PO_4^{2})	5.36±0.03	3.5	0.99±0.02	2.2	71.04±0	0	71.1±0	0	1.01±0.0	3.5
Silver (Ag)	0.04±0	0.0	5.33±0.01	0.1	5.88±0.5	7.9	6.0±0.08	1.28	0±0	0
Chloride (Cl^-)	120.2±8.5	7.1	98.5±16.3	16.5	415±0	0	616±0	0	94±8.5	9.03
Bromide (Br)	2.215±0	0.0	0.0±0.0	0.0	0.01±0	0	0.01±0	0	0±0	0
Copper (CU^+)	1.5±.0.4	27	1.03±0.01	1.4	3.54±0.7	19.8	4.1±0.03	0.69	1.03±01	0.7
Ferric Iron (Fe)	4.1±0.28	6.9	2.06±0.01	0.7	4.19±0	0	4.1±0	0	2.08±0.1	0.7
Potassium (K)	3.6±0.71	0.7	135.5±0.7	0.5	143±0.7	0.5	226.5±6.4	2.81	101±0.7	0.7
Calcium (Ca)	323.7±3.5	1.1	237.5±7.8	2.4	255±21	8.2	362±14.8	4.1	213±0.7	0.03
Cyanide (CN^-)	4.3±0.01	0	3.64±0	0	3.58±0.0	0.0	3.2±0.13	4.15	0.02±0.01	47.1
Chromium (Cr)	4.4±0.6	14.2	3.8±0.01	0.2	3.8±0	0	3.02±0.1	3.3	0±0	0
Lead (Pb)	0.0±0.0	0.0	4.02±0.02	0.5	4±0	0	5.9±0.01	0.2	0.0±0.0	0
Humus Screening test (%)	118.5±2.1	1.79	155±7.07	4.6	149±12.7	8.5	167±0	0	118±2.1	1.8

Source: Field survey, 2019.

The values of Mg, Mn, and SO_4^{2} ranged between 12.5 to 84.7mg/L, 2.14 to 31.5 mg/L, and 109 to 578 mg/L respectively, which are grossly above WHO standard (WHO, 2011). Others that also exceeded the WHO limits are Cd, Hg, Br, Cu, Fe, Ca, Cn, and Pb. In another research work by Purohit et al. (2001), Ni and Cr exceeded the critical threshold value in the Doon valley soils of outer Himalayas, India. Srinivasarao et al. (2014), in their study on "heavy metals concentration in soils under rain fed agro-ecosystems and their relationship with soil properties and management practices, in Ghana" also observed that Ni, Cr and Mn concentrations exceeded the maximum allowable limits in soils set by WHO, while Cd, Co, Cu and Zn concentrations in the studied sites were within the maximum allowable limit (WHO, 2011).

There were no mentions of some parameters' limits by WHO, such parameters as ammonium, phosphate and silver. In summary, about 52.2% of the parameters under investigation have values above the WHO limit. To verify if the impact is significant, the results were further subjected to inferential statistics; Analysis of Variance (ANOVA) for spatial variation and student t-test to compare with WHO standard, the results are presented in Table 7 and Table 8.

Table 7 presents the result of spatial analysis comparing the soils quality of different samples. It shows that the calculated F-ratio is 1.074 and F-

Table 5. The results of Pearson Correlation Matrix of the analysed parameters in the soils.

	pH	Cond.	NO_3^-	NH_4	Mg	Mn	Al	SO_4^2	F^-	Cd	Hg	PO_4^2	Ag	Cl^-	Br	CU^+	Fe	K	Ca	CN	Cr	Pb	Humus
pH	1																						
Cond	0.34	1																					
NO_3^-	0.69	0.65	1																				
NH_4	0.75	-0.35	0.33	1																			
Mg	0.93	025	0.82	0.80	1																		
Mn	-0.74	0.32	-0.41	0.99**	-0.83	1																	
Al	0.88	0.63	0.95	0.48	0.91	-0.53	1																
SO_4^2	0.90	0.20	0.81	0.82	1.0	-0.86	0.88	1															
F^-	-0.55	0.57	-0.17	-0.97*	-0.65	0.96*	-0.28	-0.69	1														
Cd	-0.76	0.30	-0.41	-1.0**	-0.84	1.0**	-0.54	-0.86	0.96*	1													
Hg	-0.83	0.21	-0.44	-0.99*	-0.87	0.99*	-0.60	-0.88	0.92	0.99**	1												
PO_4^2	0.76	0.57	0.99**	0.45	0.89	-0.52	0.96*	0.88	-0.29	-0.52	-0.55	1											
Ag	0.83	-0.17	0.52	0.98*	0.90	-0.99*	0.65	0.92	-0.91	-0.99**	-0.99	0.62	1										
Cl^-	0.87	0.68	0.94	0.43	0.88	-0.47	1.0**	085	-0.22	-0.48	-0.55	0.94	0.60	1									
Br	-0.79	0.27	-0.42	-1.0**	-0.85	1.0**	-0.56	-0.88	0.95	1.0**	1.0**	-0.54	-1.0**	-0.51	1								
CU^+	0.78	0.68	0.99*	0.37	0.85	-0.43	0.98	0.83	-0.18	-0.43	-0.49	0.99*	0.55	0.98*	-0.46	1							
Fe	0.11	0.86	0.72	-0.41	0.21	0.33	0.55	0.18	0.53	0.53	0.20	0.63	-0.22	0.58	0.32	0.68	1						
K	0.98*	0.15	0.61	0.86	0.94	-0.85	0.80	0.92	-0.70	-0.70	-0.93	0.70	0.92	0.78	-0.89	0.69	-0.06	1					
Ca	0.31	0.92	0.38	-0.39	0.09	0.41	0.46	0.24	0.62	0.62	0.26	0.30	-0.26	0.53	0.34	0.46	0.62	0.12	1				
CN^-	-0.98*	-0.14	-0.62	-0.87	-0.94	0.87	-0.81	-0.93	0.72	0.72	0.93	-0.71	-0.93	-0.78	0.90	-0.70	0.52	-1.0	-0.10	1			
Cr	-1.0**	-0.34	-0.63	-0.73	-0.89	0.71	-0.84	-0.86	0.52	0.52	0.82	-0.70	-0.81	-0.84	0.77	-0.73	-057	-0.97*	-0.35	0.97*	1		
Pb	0.96*	0.05	0.56	0.91	0.93	-0.90	0.75	0.92	-0.77	-0.77	-0.96	0.66	0.95*	0.73	-0.93	0.63	-0.13	1.0**	0.03	-1.0**	-0.95	1	
Humus	0.93	-0.02	0.46	0.92	0.87	-0.90	0.68	0.87	-0.92	-0.79	-0.96*	0.56	0.94	0.65	-0.93	0,54	-0.24	0.98*	-0.01	-0.98	-0.93	1.0**	1

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Table 6. Mean concentration of the parameters analysed.

Parameter (mg/L except stated)	Sample Point 1	Sample Point 2	Sample Point 3	Sample Point 4	Control Point	FME
pH	6.25	6.65	6.75	7.2	7.1	6.5-8
Conductivity (µs/cm)	1434	759	1232	1685	941	1000
Nitrate (NO_3^-)	7.28	6.40	10.4	10.4	6.41	10
Ammonia (NH_4)	2.4	10.2	9.4	9.4	0	NM
Magnesium (Mg)	12.5	45.1	75.3	84.7	45.1	0.3
Manganese (Mn)	31.5	2.40	1.41	4.5	2.4	0.4
Aluminum (Al)	1.25	2.01	34.1	50.4	2.0	250
Sulphate (SO_4^2)	109	341	552	578	344	100
Fluoride (F^-)	6.1	1.29	1.9	3	1.3	1.5

Table 6. Contd.

Cadmium (Cd)	7.9	0.1	0.51	3.4	0.1	0.003
Mercury (Hg)	23.7	6.31	6.88	5.1	0.0	0.001
Phosphate (PO_4^{2})	5.36	0.99	71.04	71.1	1.01	NM
Silver (Ag)	0.04	5.33	5.88	6.0	0	NM
Chloride (Cl^-)	120.2	98.5	415	616	94	250
Bromide (Br)	2.22	0.0	0.01	0.01	0	0.001
Copper (CU^+)	1.5	1.03	3.54	4.1	1.03	1.0
Ferric Iron (Fe)	4.1	2.06	4.19	4.1	2.08	0.3
Potassium (K)	3.6	135.5	143	226.5	101	
Calcium (Ca)	323.7	237.5	255	362	213	200
Cyanide (CN^-)	4.3	3.64	3.58	3.2	0.02	0.01
Chromium (Cr)	4.4	3.8	3.78	3.02	0.0	
Lead (Pb)	0.0	4.0	4.0	5.9	0.0	0.01
Humus Screening test (%)	118.5	155	149	167	118	NM

Table 7. Results of spatial analysis (ANOVA).

Source of Variation	SS	df	MS	F	P-value	F-crit.
Between Groups	80223.4	4	20055.9	1.0474	0.3882	2.4859
Within Groups	1531855	80	19148.2			
Total	1612078	84				

Table 8. Results of analysis comparing the experimental results and WHO standard (t-test).

Parameter	Mean difference	df	T	t- Critical two –tail	Remark
Dumpsite soils vs the control soils	29.2	16	2.25	0.039	Significant
Dumpsite soils vs the WHO limits	3.38	12	0.10	2.179	Not significant

critical is 2.4859. Here F-calculated is less than the F-critical, implying that there is no significant variation between and within the physiochemical properties of the soils at different sampling points. This does not mean that there is no difference, but that the difference is not significant.

Table 8 presents the comparison between the soils' quality of the dumpsite and the control soils. The result of the analysis shows that the calculated t-cal. is 2.25 and t-critical is 0.039 at α=0.05 level of confidence. Here t-calculated is more than the t-critical, implying that there is significant impact of the waste dump on the surrounding soils. Comparing these results with WHO, the results in Table 8 shows that the calculated t-cal. at α=0.05 level of confidence is 0.102 and t-critical is 2.179. Here t-calculated is less than the t-critical, implying that there is no significant difference between the values of the parameters of the dumpsite soils and the values set by WHO (WHO, 2011). This result did not mean that the values are the same, rather the difference is not significant.

Conclusion and recommendations

This study finds out how the dumpsite has polluted the soils as clear evidences revealed continues emission of leachates even as the dumpsite was closed up. This has brought to the understanding of the nature and distribution of metals and compounds in the soils of the dumpsite. On this basis, it can be concluded that though opened dumping remains a dominant method of waste disposal in the management of solid waste in the FCT. This continues to be one of the main methods of waste disposal despite their relative high potentials in land, water, and air pollution. It is therefore recommended that before siting a landfill, there should be strict compliance with the guidelines for siting and construction of landfill, and also have regular monitoring in order to mitigate the menace of leachates on soil quality.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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