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SPATIAL VARIATION IN POLLUTION POTENTIAL OF LEACHATE FROM DUMPSITES IN THE FEDERAL CAPITAL TERRITORY, NIGERIA

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ABSTRACT

Heavy metal, microbiological, physico-chemical and nutrient parameters in leachate samples collected from waste dumpsites in the FCT were analyzed to assess the spatial variation in pollution potential of leachate on the biophysical environment of the study area. The results obtained were compared to NSDWQ standard. The range concentration of heavy metals in leachate are Fe-0.2265mg/L (KUJ) to 10.3971mg/L (GSA), Cd-0.0069mg/L (ABJ) to 0.3857mg/L (MPP), Cr-0.1050mg/L (MPP) to 0.7776mg/L (KWL). Cu-0.0057mg/L (BWR) to 0.5261mg/L (KWL), Pb-0.0672mg/L (AJT) to 1.5071mg/L (KWL) and Mn-0.0408mg/L (TGM) to 1.0026mg/L (GSA). Reported range concentration of Microbiological and Nutrient parameters in leachate samples were: Total coliform-126.33CFU/100mL (KUJ) to 205.33CFU/100mL (KWL), E.coli-122.00CFU/100mL (DTS) to 161.00CFU/100mL (AJT), Cl^--2.83mg/L (KWL) to 560.11mg/L (MPP), NO_3^--0.31mg/L (KSH) to 2.08mg/L (MPP) and SO_4^{2-}-0.26mg/L (DTS) to 728.67mg/L (MPP). Physico-chemical parameters in leachate characterized shows pH values of 6.78 (GSA) to 8.60 (AJT), TS-1.26mg/L (KUJ) to 9.81mg/L (KWL), TSS-1.89mg/L (MPP) to 8.32mg/L (GLD) and EC-512.33µs/cm (BWR) to 1051.33µs/cm (AJT). Results show that leachate has serious potential to impact water resources in the study area since there is currently no plan for collection and treatment in place before discharge into the environment. The paper established spatial variation in concentration of leachate parameters in study area, with waste character, status of dumpsite which is either open or closed as basis. Government needs to overhaul her approach towards management of waste dumpsites.

Keywords: Leachate, Waste dumpsite, Municipal Solid Waste Management, Pollution, Impact.

INTRODUCTION

The symbiotic relationship between man and the environment and the equilibrium between the two is the prime need of the present day's sustainable life. The increasing rate of urbanization and fast lifestyle which man is continuously implementing have led to the formation of various types of toxic compounds within the ecosystem which are less degradable and harmful to living things. Uncontrolled and unscientific garbage or solid waste disposal systems with the associated problem of infiltration of solutes (pollutants) into the soil and accumulation at any particular depth of soil leading to the contamination of the groundwater reserves is a major problem nowadays and it is expected to increase with time if no proper precautions are taken (Abubakar and Adejoh, 2011).

Leachate is extremely polluted wastewater with potent pollution treat on water resources in the environment. Leachate formation is dependent on the water balance of landfill site and it takes place when the moisture content in waste cell exceeds its field capacity, the maximum moisture content that a porous medium is able to hold (Kamaruddin *et al*, 2017).

The Federal Capital Territory 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).

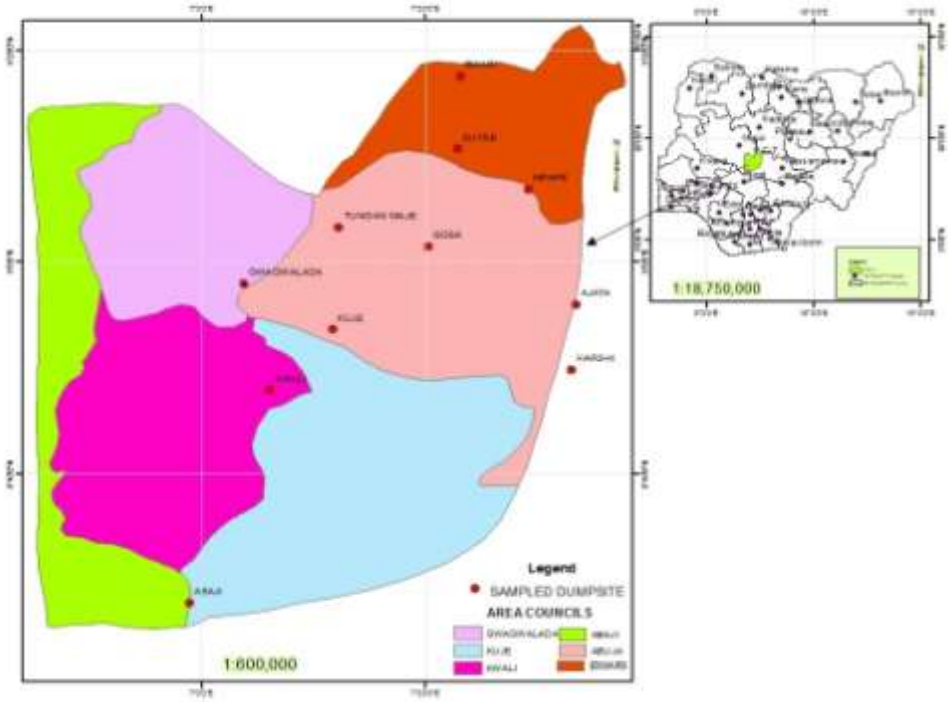

Figure 1: The Study Area (Federal Capital Territory, Abuja, Nigeria indicating the designated Dumpsites)

Pollution occurs when a product added to our natural environment adversely affects nature's ability to dispose it off. A pollutant is something which adversely interferes with health, comfort, property or environment of the people. Leachate, an ecosystem pollutant, has the potential to cause harm to human, plants and animals (Ogundiran and Afolabi, 2008).

Open dumps are the oldest and the most common way of disposing of solid waste, although in recent years thousands have been closed, many still are being used. In many cases, they are located wherever land is available, without regard to safety, health hazard and aesthetic degradation. The waste is often piled as high as equipment allows. In some instances, the refuse is ignited and allowed to burn while in others, the refuse is periodically levelled and compacted. Wastes disposed of in dumpsites can pose several public and environmental health risks including groundwater pollution Oyelami *et al*, (2013). Effective management of waste and the potential risks posed in the context of developing countries is often challenging (Di Bella. and Vaccari 2014).

Leachate corresponds to atmospheric water that has percolated through waste, interacting with bacteriological activity and especially organic substances. Its composition is a function of the nature and the age of the landfill, the type of wastes, the method of burying, the geological nature of the site, the climate (Amina *et al.*, 2004). Leachate varies widely in composition depending on many interacting factors such as the composition and depth of waste, availability of moisture and oxygen, landfill design, operation and age (Reinhart and Grosh, 1998).

This study is aimed at assessing the spatial variation in pollution potential of leachate from government approved and operated dumpsites in the FCT as it relates to water resources component of the environment.

MATERIALS AND METHODS

Eleven (11) government approved and operated dumpsites covering the entire FCT was considered see 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.). The choice of the leachate was based on the view that leachates in dumpsites ultimately leak, percolate, and contaminate the groundwater; hence its analysis can give an indication of a potential for environmental pollution.

Leachate samples were collected from the 11 dumpsites in the May, 2017 from randomly selected leachate drains at the dumpsites as adapted from Uba *et al.* (2008), Adeolu *et al*, (2011). The samples were collected in well-labelled clean polythene bottles rinsed with the

leachates prior to the sample collection. Randomly sampled leachate from different locations within each dumpsite and were thoroughly mixed and composite samples taken for analysis. The samples for microbiological analysis were aseptically taken in 50ml sterile universal containers. Samples were analyzed using standard procedures defined by APHA, (2005).

Physico-chemical parameters like Electrical Conductivity (EC), temperature, total suspended solids (TSS) and pH were measured in-situ with the aid of JENWAY 4590 meter. The composition of parameters such as Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), Total solids, Alkalinity, Total coliform, E coli, Nitrate, Chloride, Sulphate and Heavy metals (Fe, Cu, Cr, Cd, Pb, Zn, Mn and Cu) were determined in the laboratory using AAS Thermo Scientific iCE 3000 at the National Advanced Laboratories, National Science and Technology Complex, Sheda, Abuja.

The evaluation of potential risk of leaching to groundwater and surface water was performed by comparing the pollutant concentrations in the leachate directly to the applicable standards, the Nigerian Drinking Water Standards (SON, 2007), also there is appropriate consideration that dilution of leachate may occur in water resources, thus establishing a pollution potential of leachates from the selected dumpsites.

RESULTS

The physico-chemical characteristics of leachate depend primarily upon the waste composition and water content in the total waste (Mohan and Gandhimathi, 2009). The characterization of leachates (Heavy metals, Microbiological, Nutrient and Physico-chemical parameters) across the dumpsites are presented in Tables 2 to 4. Table 2 shows the mean concentration of Fe in leachate ranged from 0.2265mg/L (KUJ) to 10.3971mg/L (GSA). The ranking order of mean Fe concentration in dumpsite leachate show that GSA > KSH > TGM > BWR > KWL > ABJ > MPP > AJT > DTS > GLD > KUJ. The relatively high value in GSA is attributable to the dumping of iron and steel scraps in large quantities alongside waste stream in this dumpsite, a reasonably evident presence of ‘sharps’ and ‘medication materials were sighted in the raw wastes characterized from this site. The concentration of Cd was undetected in the leachate samples from KWL, while the mean value ranged from 0.0069mg/L (ABJ) to 0.3857mg/L (MPP) in the remaining dumpsites. Mean values for Cr in the leachate samples was between 0.1050mg/L (MPP) and 0.7776mg/L (KWL). The recorded values for Cu were in the range of 0.0057mg/L (BWR) and 0.5261mg/L (KWL). Level of Pb in the leachate samples collected across the dumpsites ranged between 0.0672mg/L (AJT) and 1.5071mg/L (KWL). The recorded values for Cu was in the range of 0.0057mg/L (BWR) and 0.5261mg/L (KWL). The range of mean concentration values for Mn are from 0.0408mg/L (TGM) to 1.0026mg/L (GSA). The Concentration range for Ni in the leachate samples are 0.0051mg/L (GLD) and 0.3646mg/L (KWL). The mean values of Zn are between 0.0024mg/L (KWL) and 0.4897mg/L (KSH).

The mean concentration of Cd, Cr and Pb in leachate from all the dumpsites were all above the permissible level by NSDWQ for either surface or groundwater while Cu and Zn were within the tolerable limit, this is indicative of potential for heavy metal pollution to surface or groundwater through surface runoff or leaching as the case may be. However, Fe, Mn and Ni in leachate showed divergent concentration pattern in which values exceeded NSDWQ guidelines in some dumpsites and were within the guidelines in other dumpsites (Table 2).

Table 3 shows concentration level of Microbiological and Nutrient parameters in leachate samples from the dumpsites. Total coliform was observed to have a minimum concentration value of 126.33CFU/100mL (KUJ) and a maximum concentration value 205.33CFU/100mL (KWL). The concentration of E.coli ranged between 122.00CFU/100mL (DTS) and 161.00CFU/100mL (AJT). Total coliform and E.coli are used as indicators to measure the degree of pollution and sanitary quality of well water, because testing for all known pathogens is a complicated and expensive process. The concentration of Total Coliform and E coli were above the NSDWQ guidelines in leachate from all the dumpsites in the study area. Total coliform bacteria are not likely to cause illness, but their presence indicates that your water supply may be vulnerable to contamination by more harmful microorganisms. E.coli in drinking water indicates the water has been contaminated with fecal material that may contain disease causing microorganisms, such as certain bacteria, viruses, or parasites.

Table 1: Dumpsites with their Locational 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

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. Methods of Waste Dumping, α = Open Dumping ; μ = Controlled Dumping*

Table 2 Mean values of Heavy metals in dumpsite leachate and NSDWQ Acceptable Standard

Dumpsites	Fe (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Pb (mg/L)	Mn (mg/L)	Ni (mg/L)	Zn (mg/L)
KUJ	0.2265	0.1386	0.1428	0.0059	0.2390	0.0614	0.0163	0.3158
TGM	8.2612	0.0530	0.1763	0.0824	0.5524	0.0408	0.0078	0.2755
DTS	0.9410	0.0526	0.1451	0.0610	0.4683	0.2879	0.0749	0.2829
AJT	1.4273	0.0348	0.2517	0.3440	0.0672	0.0955	0.0986	0.285
KSH	8.2721	0.0418	0.2011	0.2274	0.3128	0.9627	0.1438	0.4897
BWR	7.3291	0.0784	0.1330	0.0057	0.2519	0.2313	0.1067	0.4053
GSA	10.3971	0.0518	0.1784	0.0243	0.7849	1.0026	0.1353	0.3039
MPP	4.5780	0.3857	0.1050	0.1483	0.2276	0.3036	0.2241	0.1248
KWL	7.2233	0.0000	0.7776	0.5261	1.5071	0.2340	0.3646	0.0024
GLD	0.3515	0.1136	0.2059	0.0158	0.2189	0.1089	0.0051	0.1935
ABJ	6.4288	0.0069	0.6921	0.4683	0.2005	0.1932	0.3245	0.0021
NSDWQ STANDARD	0.3.000	0.0030	0.0500	1.0000	0.0100	0.2000	0.0200	3.0000

Table 3 Mean values of Microbiological and Nutrient parameters in dumpsite leachate and NSDWQ Acceptable Standard.

Dumpsites	Total coliform (cfu/100ml)	E.coli (cfu/100ml)	Cl^- (mg/L)	NO_3^- (mg/L)	SO_4^{2-} (mg/L)
KUJ	126.33	139.00	23.93	0.5587	1.2533
TGM	154.33	125.00	15.43	0.432	2.5667
DTS	131.67	122.00	17.57	0.6147	0.2620
AJT	151.00	161.00	25.83	0.4680	3.1967
KSH	143.67	144.33	19.07	0.3113	1.1433
BWR	128.67	149.67	14.50	0.4187	1.5600
GSA	134.33	145.33	15.30	0.3187	1.3600
MPP	156.33	145.33	560.11	2.0800	728.67
KWL	205.33	158.33	2.83	ND	639.67
GLD	135.67	145.67	15.90	0.8147	1.8833
ABJ	182.77	153.09	2.67	0.1306	569.40
NSDWQ STANDARD	10.00	0.00	250.00	50.0000	100.00

ND = Not Detected

Analysis of Nutrients parameters in leachate showed the following range of values from the waste dumpsites, Cl^- showed a concentration range between 2.83mg/L (KWL) to 560.11mg/L (MPP). The mean levels of NO_3^- was in the range of 0.31mg/L (KSH) and 2.08mg/L (MPP). The concentrations range for SO_4^{2-} was from 0.26mg/L (DTS) to 728.67mg/L (MPP). The concentration of NO_3^- was within the NSDWQ guidelines in leachate from all the dumpsites, while it is similar for Cl^- except in MPP where the value was above the guideline. In the case of SO_4^{2-}, the concentration at KUJ, TGM, DTS, AJT, KSH, BWR, GSA and GLD were within stipulated NSDWQ guideline while the concentration at MPP, KWL and ABJ were outside the NSDWQ acceptable guideline. Physico-chemical parameters that were analyzed are summarized in Table 4, which shows that pH values of the leachates from the various sites range from 6.78 (GSA) to 8.60 (AJT) which generally indicates slight acidic and alkaline conditions of the leachate, with the GSA dumpsite characterized with the most acidic pH value while AJT dumpsite had the most alkaline pH character, the observation at AJT can be attributed to the methane fermentation phase of the dumpsite which has already been closed as observed by Adeolu *et al.*, (2011).

Table 4 Mean values of Physico-chemical parameters in dumpsite leachate and NSDWQ Acceptable Standard.

Dumpsites	pH	DO_2 (mg/L)	BOD (mg/L)	TS (mg/L)	TSS (mg/L)	Alkalinity (mg/L)	Conductivity (µs/cm)	Temperature ^oC
KUJ	7.49	5.02	5.66	1.26	5.58	2.05	844.67	28.67
TGM	8.14	4.27	6.31	2.06	6.47	2.16	907.33	28.03
DTS	6.84	5.52	8.09	2.45	4.72	3.07	961.33	28.13
AJT	8.6	5.92	8.27	2.11	5.12	2.52	1051.33	27.80
KSH	7.33	5.36	7.23	2.55	4.24	2.47	706.67	27.43
BWR	7.23	5.12	6.89	2.49	4.76	2.20	512.33	27.67
GSA	6.78	5.81	7.15	3.10	5.23	2.33	905.67	28.83
MPP	7.11	5.02	3.15	6.24	1.89	1.04	1038.33	27.03
KWL	7.49	5.94	3.02	9.81	6.81	2.94	1023.33	27.23
GLD	6.84	5.52	5.09	1.89	8.32	2.72	965.67	28.60
ABJ	7.01	5.36	2.85	8.73	6.06	2.73	910.77	24.24
NSDWQ Standard	6.5 – 8.5	NA	NA	N/A	500	N/A	1000	Ambient

N/A = Not Available

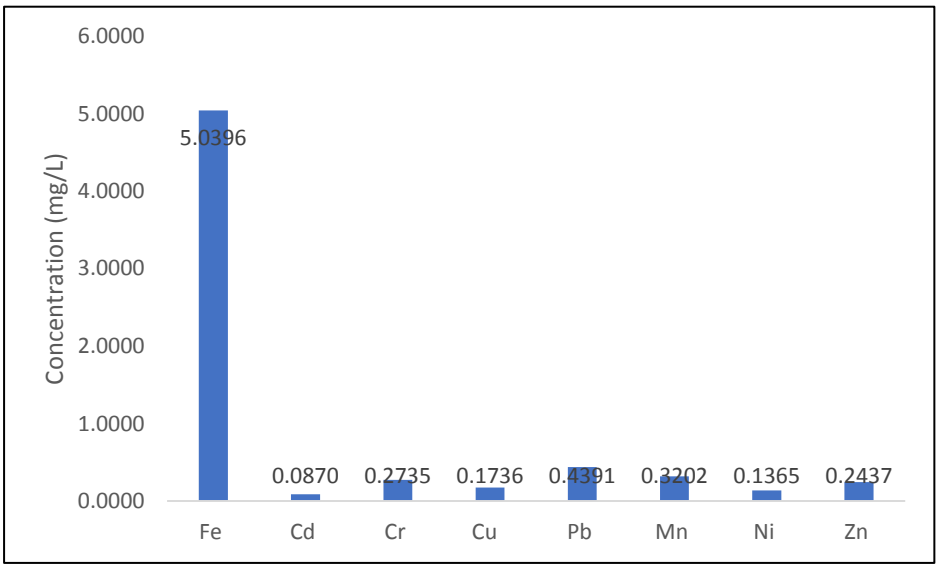

Figure 2: Overall picture of Heavy Metal in Leachate in the study area

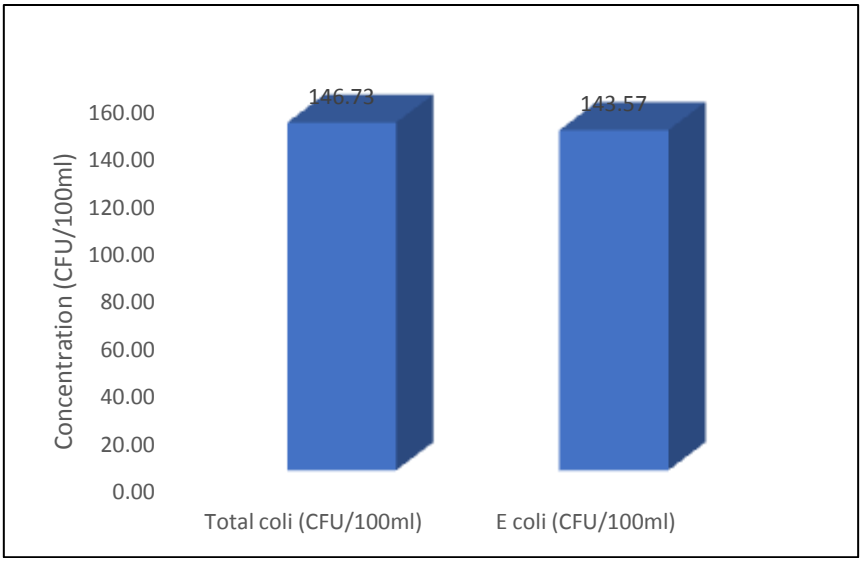

Figure 3: Overall picture of Microbial Parameter in Leachate in the study area

Microbial Parameters showed that average concentration of Total Coliform was 146.73 cfu/100ml and E.coli was 143.57 cfu/100ml (Figure 3). Average concentration of both microbiological parameters in the study area falls outside the allowable limit prescribed by NSDWQ guidelines, hence the pollution potential of microbiological parameters is highly probable. The mean values for physico-chemical parameters are as follows: - pH (7.35), DO (5.35 mg/L), BOD (6.09 mg/L), TS (3.39 mg/L), TSS (5.31 mg/L), Alkalinity (2.35mg/L), Electrical Conductivity (891.67 us/cm) and Temperature (27.94^{o}C) as seen in Figure 4. Nutrients recorded overall mean values of Chloride, 71.05 mg/L, Nitrate, 0.6017 and Sulphate, 138.16 mg/L (Figure 5). Average mean values when compared with available standard benchmark for physico-chemical and nutrient parameters were observed to be within allowable limits.

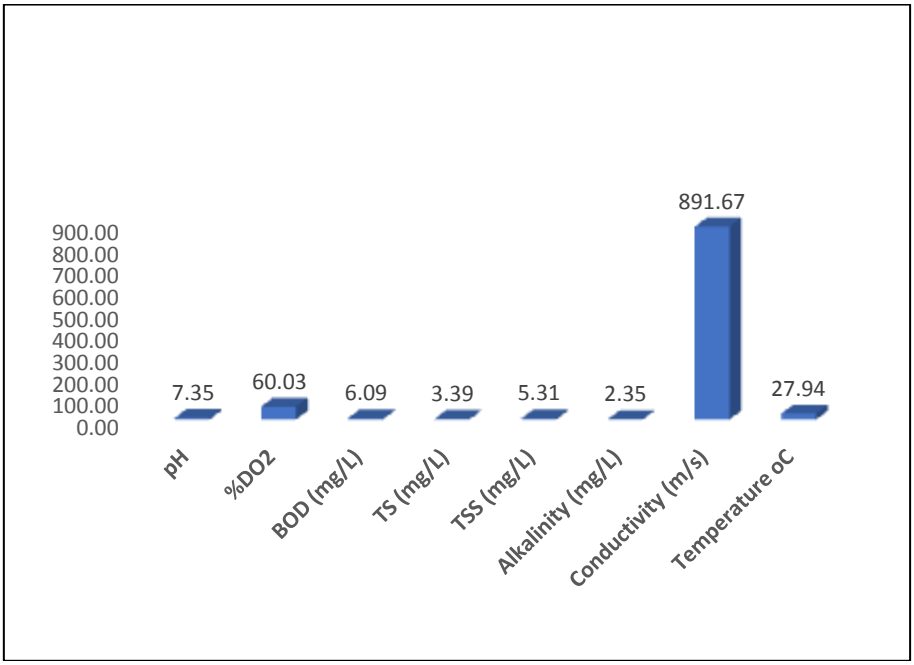

Figure 4: Overall picture of Physico-chemical Parameters in Leachate in the study area

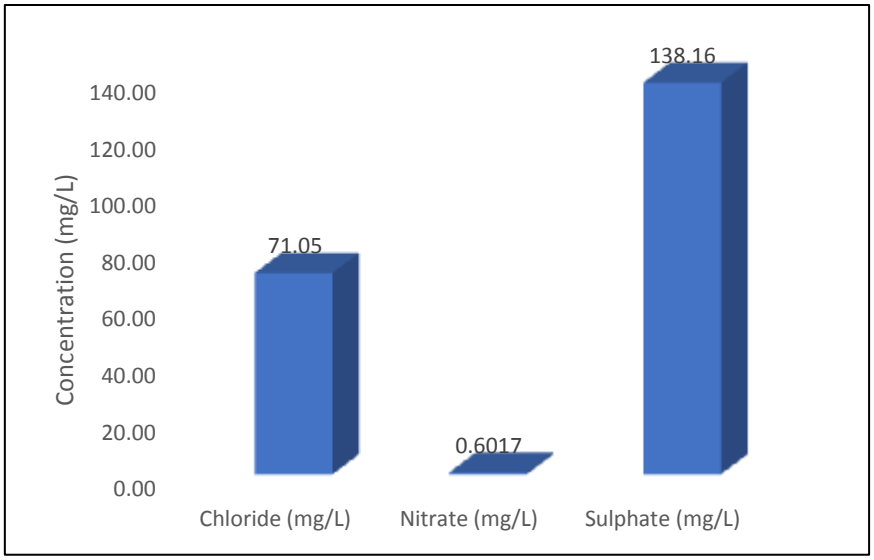

Figure 5: Overall Picture of Nutrient in Leachate in the study area

DISCUSSIONS

As landfill age increases, the biodegradable faction from organic pollutants in leachate decreases due to anaerobic decomposition occurring in the landfill site. The minimum concentration of DO was 4.27mg/L at TGM while the maximum concentration was 5.94mg/L at KWL. The concentration level of BOD ranged from 3.02mg/L (KWL) to 8.27mg/L (AJT). The mean value of TS was reported to range from 1.26mg/L (KUJ) to 9.81mg/L (KWL). TSS reported a value in the range of 1.89mg/L (MPP) to 8.32mg/L (GLD). Alkalinity ranged from 1.04mg/L (MPP) to 3.07mg/L (DTS). EC showed variation in sites though the range 512.33µs/cm (BWR) to 1051.33µs/cm (AJT). A pattern of decrease in the level of conductivity as observed was AJT > MPP > KWL > GLD > DTS > TGM > GSA > KUJ > KSH > BWR. Temperature range was from 27.03^{o}C (MPP) to 28.83^{o}C (GSA).

The value of pH in leachate from all the dumpsites was within the NSDWQ guideline except in the case of AJT which was above the permissible range for pH. The concentration of TS in leachate from all dumpsites was within prescribed limits, while the concentration of EC in leachate from KUJ, TGM, DTS, BWR, KSH, GSA, GLD and ABJ were with the permissible limit the concentration of EC in leachate from MPP, KWL and AJT was above the threshold level.

The relatively high concentration of Pb, Cu, Cr in KWL shows that the dumpsite receives waste streams from batteries, florescent tubes as well as the location of the site in the proximity of right of way of a recently constructed power transmission line with part of the metallic construction waste still in place. AJT recorded maximum mean values for E. coli, pH, BOD and Electrical Conductivity, this could be adduced to the operational state as a recently closed dump site with significant reduction in the concentration of hydrogen ions. MPP recorded the highest mean value for all the nutrients analyzed in this study (Cl^-, NO_3^- and SO_4^{2-}), this dumpsite was closed in 2005 is still actively releasing the water-soluble salts to the environment as a result of surface water ingression and age. GSA reported maximum mean values for Fe, Mn and Temperature, while also recording the lowest pH value of all the dumpsites which is tending toward acidity.

Figures 2 to 5 indicates the overall pattern of leachate characterization within the study area. Average characterization of leachate quality of Heavy metals shows the following values: - Fe (5.0396 mg/L), Cd (0.0870 mg/L), Cr (0.2735 mg/L), Cu (0.1736 mg/L), Pb (0.4391 mg/L), Mn (0.3202 mg/L), Ni (0.1365 mg/L) and Zn (0.2437 mg/L) as seen in Figure 2. When compared with the NSDWQ guidelines for drinking water, the overall concentration of Fe, Cd, Cr, Pb and Mn in leachate of the study area were above the threshold limit while the concentration values of Cu, Ni and Zn were within tolerable limits. On the whole Fe, Cd, Cr, Pb and Mn are characterized as toxic for the water resources in the study area.

CONCLUSION AND RECOMMENDATIONS

The concentration level of leachate quality parameters in the dumpsites within the study area was found to vary spatially over locations. Heavy metals (Cr, Pb and Ni) were highest at KWL dumpsite while (Fe and Mn) were maximum at GSA dumpsite. A closed dumpsite, MPP recorded

the highest concentration of Cd in the leachate sample. Metals and Microbiological content in leachate from all the dumpsites in the study area exceeded the permissible limit allowed by NSDWQ standard. The high concentrations of the pollutants in the leachate have potential to reach and contaminate water resources within the study area and thus threatening sustainable development. Therefore, there is an urgent need for strategy to be put in place for leachate collection and treatment as part of dumpsite management strategy to deal with active and post closure impact of dumpsite leachate to mitigate potential impact water resources.

REFERENCES

Abubakar, B. S. and Adejoh, B. (2011). Pollution Potential of leachate from selected soil waste dumpsites in Kakuri, Kaduna, Nigeria. *Journal of engineering and applied sciences*, 3, 45-51

American Public Health Association, APHA (2005). American Water works Association and Water Pollution Control Federation, Standard Method for Examination of Water and Wastewater, APHA, AWWA and WPCF, 46, New York.

Amina, C., Abdekader, Y., Elkbri, L., Jacky, M. and Alain, V. (2004). Environmental impact of an urban landfill on a costal aquifer (El Jadida, Morocco). *Journal of African Earth Science*, 39: 509-516.

American Public Health Association, APHA (2005). American Water works Association and Water Pollution Control Federation, Standard Method for Examination of Water and Wastewater, APHA, AWWA and WPCF, 46, New York.

Di Bella, V. and Vaccari, M. (2014). Constraints for solid waste management in Somaliland. *Waste Resources Management*, 167, 62–71.

Kamaruddin, M. A., Yusoff, M. S., Rui, L. M., Isa, A.M., Zawawi, M. H. and Alrozy, R. (2017). An overview of municipal solid waste management and landfill leachate treatment: Malaysia and Asian perspectives. Environ. Sci. Pollut. Res. 2017, 24, 26988–27020.

Nigerian Standard for Drinking Water Quality (NSDQW) (2007). Nigerian Industrial Standard NIS 554, Standard Organization of Nigeria, pp15-30.

Ogundiran, O. O. and Afolabi, T. A. (2008): Assessment of the Physiochemical Parameters and Heavy metal Toxicity of Leachate from Municipal Solid Waste Open Dumpsite; *International Journal of Science Technology*, 5(2) 243-250.

Oluyori, A. O. (2018). Effect of Waste Dumpsite on the Biophysical Environment in the Federal Capital Territory, Nigeria. Part of Unpublished PhD Post Field Report presented to Department of Geography, Federal University of Technology, Minna, Nigeria.

Oyelami, A. C., Aladejana, J. A.and Agbede, O. O. (2013). Assessment of the impact of open waste dumpsites on groundwater quality: A case study of the Onibu-eja dumpsite, Southwestern Nigeria. *Procedia Earth and Planetary Science*. 7, 648–651.

Reinhart, R.D. and Grosh, C. J. (1998). Analysis of Florida Municipal Solid Waste Landfill Leachate Quality, Report #97-3, *Florida Center for Solid and Hazardous Waste Management.*