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By Adeyi, A. A. & Majolagbe, A. O.
Lagos State University, Nigeria

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Keywords: *physico-chemical, water quality index, correlation coeficiency, dumpsites, water quality parameters.*

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Assessment of Groundwater Quality around Two Major Active Dumpsites in Lagos, Nigeria

Adeyi, A. A. [α] & Majolagbe, A. O.[σ]

Abstract- This paper presents the results of physico-chemical parameter data and water quality index used to assess the groundwater quality around Olusosun and Solus dumpsites in Lagos southwest, Nigeria. Twenty (20) water samples each were collected in wells and boreholes around these two dumpsites, once in two months consecutively for two years. The parameters determined include pH, acidity, alkalinity, conductivity (EC), total dissolved solids (TDS), total hardness (TH), Cl-, $SO4^{2-}$, NO_{3-} and PO_4^{3-} and heavy metals: Pb, Ni, Cd, Zn, Cu, Fe, Mg, Ca, Na and K using standard analytical methods. Descriptive statistics and correlation coefficient were carried out on the data generated. There is strong correlation at $p < 0.05$ in some of the parameters such as TDS versus EC ($r = 0.95$), TDS versus TS ($r = 0.90$), TH versus acidity ($r = 0.73$) in Olusosun while TDS versus EC ($r = 0.93$), TDS versus acidity ($r = 0.82$), TH versus alkalinity ($r = 0.77$) in Solus, suggesting common source. However, very weak chemical associations ($r < 0.30$) were observed in majority of the quality parameters particularly anions and trace metals, indicating multiple anthropogenic sources. Water quality index (WQI) reveal minimal contamination on the groundwater, delineates Solus groundwater as excellent – good – poor and Olusosun groundwater as good – poor – very poor. However, the nitrate level in almost all the groundwater collected around the Olusosun dumpsite reveal is worrisome and portends a great health risk. Therefore, concerted efforts must be put in place to address the situation and ensure sustainable environment.

Keywords: physico-chemical, water quality index, correlation coeficiency, dumpsites, water quality parameters

I. Introduction

Groundwater remains a major source of water supply for drinking, recreation, agricultural and industrial purposes in most part of Nigeria. Lagos state provides about 220 million liters of water daily for domestic and industrial purposes for about 37 % of its population 1. About 8.3 million residents in Lagos (62.6% of the population) and some industries have no access to pipe borne water, thus depend solely on groundwater through privately dug bore holes and shallow wells. This trend could be as a result of either lack of improper planning by government for new residential areas that are emerging in the state, inadequate and erratic water supply by the government water works and or the population - water facility ratio, which is on the high side. Therefore, the ever increasing population will continue to rely on groundwater as a main source of water supply. However, the quality of groundwater assessed by the citizens is doubtful because groundwater resources particularly in Lagos state are under varying degree of threats 2. These threats include various sources of pollution, such as industrial effluents discharges, municipal solid wastes (MSW), residential effluents discharges, agricultural chemicals and fertilizers applied on farms, oil spills and leakages, as well as salt water intrusion and urban surface runoff [3,4].

Landfills have been identified as one of the major threats to groundwater resources [5,6,7]. The volume of wastes generated in Lagos is increasing with time and is presently at about 1000 tons per day apart from the medical wastes which is given separate and special treatment [8]. The quantity and quality of municipal solid waste (MSW) depends upon various factors such as population, life style, food habit, standard of living, industrial and commercial activities in the area9, cultural and tradition of inhabitants, as well as climate[6]. Of the 2.3 million tons of waste generated annually in Lagos since 2008, only about 50% are accounted for by Lagos State Waste Management Authority (LAWMA). The remaining is disposed illegally and haphazardly without regards for environmental consequences. In most open dumpsites across the cities, wastes collected are burnt in the open and ashes abandoned at the site .The practice of burning wastes, destroy the organic component, oxidize metals, thereby enriching the ashes left behind with metal[7]. Wastes in landfills or open dumps are subjected to either groundwater underflow interaction or infiltration from precipitation. The dumped solid wastes gradually release its initial interstitial water (leachate) and some of its decomposition by-products get into water moving through the waste deposit. This leachate accumulates at the bottom of the wastes and percolates through the soil[5] migrate downward and contaminate the groundwater. The leachate sometimes contains mainly organic carbon largely in the form of fulvic acids. It usually contains toxic substances, especially, when wastes are of industrial origin[4]. Such contamination of groundwater resource poses a substantial risk to local resource user and to the natural environment. Each year, about two million people die as a result of poor sanitation and contaminated water, of which ninety percent (90%) are children 10. Various

Author α: Department of Chemistry, University of Ibadan, Ibadan, Nigeria.
Author σ: Department of Chemistry, Lagos State University, P.M.B. 1087, Apapa, Lagos, Nigeria. e -mail: abdulmajss@gmail.com

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studies on the impact of landfill on groundwater quality have been reported using different approaches11,12. These approaches include experimental determination (i.e. physicochemical assessment), estimation through mathematical modeling[13.14,] geophysical method[15,16,17] and the use of water quality indices [18].

Physicochemical assessment of water quality has been extensively used to evaluate the quality status of both surface and groundwater and to suggest possible usage of such water [19,2,20],. A major advantage of physicochemical assessment method of evaluating the quality of water bodies is that the water samples(s) are directly analyzed, thereby generating data that show the true quality or the actual values of the water quality parameters. A large data is usually the results which indicate comprehensive quality assessment. The largeness of the data also helps in revealing possible various trends and patterns that are inherent in the data obtained [21].

Water quality index (WQI) takes the complex scientific information of water quality variables and synthesizes them into a single number, thereby, also reducing the dimensionality of the water data. Various models used in calculating WQI include weighted arithmetic mean, weighted geometric mean, un-weighted harmonic square mean, use of fuzzy logic model and baseline comparative model22. By comparing the mean values of these parameters in the water samples with the maximum permissible limits by various known regulatory bodies such as World Health Organization (WHO), United State Environmental Protection Agency (USEPA) etc., it becomes possible to declare a water body contaminated, polluted or either safe or not for human consumption.

This study therefore, aimed at presenting the use of water quality index and physicochemical assessment of quality of groundwater around two major active refuse dumpsites in Lagos state, thereby evaluating the impact of these dumpsites on the quality of groundwater. The data generated will assist regulatory agencies in formulating policies to ensure sustainable environment and a baseline for further studies.

II. Material and Methods

a) *Description of the study areas*

The study area consists of Olusosun and Solus refuse dumpsites and their environ.

i. *Olusosun refuse dumpsite*

It is a controlled dumpsite located at Ojota, Lagos within longitude 03.372 E to 03.374 E and latitude 06.588 N to 06.595 N. It is the largest government owned dump facility in Nigeria. It is about 18 meters deep and covers close to 42 hectares of land. Olusosun refuse dump was established in 1988 with a life span of 35 years. The dump is surrounded by Oregun industrial layout, Olusosun residential compound, Shangisah residential areas and commercial neighborhood (Fig.1.0). It receives an average of 1.2 million tons of assorted wastes annually and is presently serving as a pilot project for biogas production in Nigeria.

ii. *Solus refuse dumpsite*

The Solus dumpsite is situated between longitude 03.255 E to 03.253 E and latitude 06.569 N to 06.574 N in Igando area of Lagos State. It started operations in 1996. It is of 9 m depth and covers about 3 hectares. Solus refuse dump receives 4000 tons of waste per day and has reached over 70% of its full capacity [23]. The dump is entirely surrounded by residential area (Fig. 2.0). An abattoir and a small fast shrinking Oba stream is located about 2.5 km westward of the dumpsite.

b) *Sampling*

Groundwater samples were collected from twenty (20) locations around each dumpsite determination for physico – chemical parameters and trace metal analyses. Sampling was done once in two months, for two years (January, 2009 -December, 2010). The samples collected around Olusosun dumpsite are represented as OSW 1 – OSW 20, while that of Solus are represented as SWS 1 – SWS 20. The samples were preserved accordingly based on standard methods (APHA/AWWA, 2005). Two samples (1.5 L and 0.75 L for physico –chemical parameters and trace metals respectively) were taken from each location. The 0.75 L water samples were preserved by acidifying with 1.5 ml of concentrated HNO_3 (Analar grade) per liter of water sample. Blank samples were collected (using double distilled water) and treated in the same way as the other water samples 24. The samples were stored in an ice box, transported to the laboratory where they were refrigerated until analysis using standard methods.

c) *Sample chemical analyses*

The pH, electrical conductivity (EC) and temperature of the groundwater samples were determined on sites. Temperature was measured using thermometer, while EC and pH were measured using conductivity meter (Mettler Toledo) and pH meter (pHep HANNA HI 98107) respectively. Alkalinity and acidity were determined titrimetrically [25], total hardness by complexomertry[25], Total suspended solids (TSS), dissolved solids (TDS) and total solids (TS) by gravimetry[25,26] chloride by silver nitrate method[25], sulphate by turbidimetric method [25], phosphate by colorimetric and nitrate by phenol disulphonic acid method [27,28]. Determination of cations Na+, and K+ and trace metals were done with flame photometer and Flame Atomic Absorption Spectrophotometry (Buck scientific 210V model) respectively after acid digestion

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of the samples [29]. Each sample was analyzed in duplicate, so as to ascertain the validity of the method.

d) Statistical Analysis

Descriptive analyses of data generated were carried out using Graph Pad Prism (version 5.00). Correlations coefficiency was performed in a pair wise fashion employing Pearson correlation coefficent.

e) Water Quality Index

Three steps are followed as described by Srinivas and Nageswararao 18, to calculate Water Quality Index (WQI). In the first step each of the parameters has been assigned a weight (w_i) according to its relative importance in the overall quality of the water for drinking purpose. A maximum weight of 5 has been assigned to nitrate due to its major importance in water quality assessment. In the second step, the relative weight is calculated from the following equation

$$W_i =$$

where W_i is the relative weight, w_i is the weight of each parameter and n is the number of parameters. Calculated W_i values of the parameter are given in Table 1.0. In the third step, a quality rating scale (q_i) for each parameter is assigned by dividing its concentration of each water sample by its respective standard according to the WHO guidelines and the result multiplied by 100. $q_i = (C_i - C_{io} / S_i - C_{io}) \times 100$ where Ci is the concentration of each chemical parameter in each water sample in mg/L, Cio is the ideal value of the parameter in pure water and Si is the Indian drinking water standard for each chemical parameter in mg/L according to the guidelines of the WHO. For pH, C_{io} is 7 and $q_i = (C_i - 7)/(S_i - 7) \times 100$. For the remaining parameters the ideal value is 0.

Table 1.0 : Relative Weight of the Chemical Parameters

Chemical parameters	WHO standards	Weight	Relative weight (Wi)
pH	6.5 – 8.5	4	0.1818
Total hardness	300	2	0.0909
Ca	75	2	0.0909
Mg	30		0.0909
Cl	250	3	0.1363
Total dissolved solids	500	4	0.1818
Nitrate	10	5	0.2272

To calculate the WQI, the sub index (SI) is first determined for each parameter, which is used to determine the WQI using the following equations.

$$SI_i = W_i \times q_i,$$

$$W_i =$$

Where SI_i is the sub index of the i^{th} parameter. The calculated WQI values are classified into four types as shown in Table 2.0.

Table 2.0 : Water Quality Classification based on WQI value

WQI	Water quality
< 50	Excellent
50 – 100	Good
100 – 200	Poor
200 – 300	Very poor

III. Results and Discussion

a) Physicochemical Properties Groundwater

The results of physico-chemical analysis and trace metal load of water samples around the two major active controlled dumpsites in Lagos (Olusosun and Solus) are presented in Tables 3.0and 4.0 respectively. The correlation coeficiency between various physicochemical variables are presented in Tables 5.0 and 6.0 for Olusosun and Solus groundwater respectively. The mean and range of pH values for the Olusosun and Solus groundwater were 5.23 ± 0.97 (3.10-7.10) and 5.71 ± 0.75 (4.40-6.90), respectively. All the mean values were in the acidic range and lower than the allowable limits of 6.5 – 8.5 WHO (2006) and Nigerian Standard for Drinking Water Quality [30]. The acidic nature of Lagos water is probably as a result of high volume of CO_2 in atmosphere, an indication of high level of population and industrialisation. Longe et al.[4] however pointed out that acidic status of Lagos groundwater is also a charateristic of coastal water, whose pH is primarily controlled by its hydrological settings. 15% and 20% of Olusosun and Solus water samples collected have the mean value within the WHO

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allowable range. The neutral average pH value observed in samples OWS11and OWS12 could be as a result of the proximity of the location of the wells to a big canal that bound Ketu market, hence infiltration of waste water to the neighbouring water,which results in the pH obtained might be responsible for this. The pH of water controls its solubilty and the rate of reaction of the metal species that is invovlved in corrosion recaction [31].

The temprature of groundwater around Olususun ranges from 24.8 °C and 27.4 °C with mean value of 25.6 ± 0.7 °C, while the mean for Solus was 25.9 ± 0.5 °C and range from 24.9 to 26.9 °C.

Temperature, if high can cause legionellosis, schistomiasis and other related health conditions whose causative organism thrives more in warm water and in the presence of nutrients. Temperature can affects the amount of dissolved oxygen of water.It also control fluoride content which causes dental coloration in childeren and skeletal damage[32]. The mean and range of total alkalinity value were 144 ± 91 (26.2 to 373) and 123 ± 106 (12.3 to 396) mg/L for water around Olususun and Solus dumpsites respectively. Generally, most groundwater tends to be high in alkalinity and Oxygen rich except in high populated and industrialized areas. The larger percentage of the water samples collected around both Olususun and Solus dumpsite had values lower than 100 mg/L. However, going by Ragunath classification of groundwater based on alkalinity [33], only 10% and 25% of the groundwater samples around Olususun and Solus respectively can be said to be good for drinking purpose. Phenolphthalein alkalinity was zero in all water samples analyzed; therefore all alkalinity values were due only to bicarbonate.

The electrical conductivity (EC) is a quality parameter that describes the ability of water to allow passage of conducting electrons. It is an indication of dissolved inorganic in groundwater [34]. The importance of EC of water is its measure of salinity, which greatly affects the taste consequently; it has a significant impact on the users' acceptance of the water as potable [35]. Water around Olususun dumpsite gave 0.9 mS /cm as the mean value of electrical conductivity. Highest conductivity value were observed from wells OWS5 and OWS6 that were closer (4 m) to the dumpsite. For Solus groundwater sample, values reported were lower, than that of Olususun groundwater samples. This may be probably because of age of the Olususun dumpsite, the geological formations of Olususun area and the depth of wells found around Solus dumpsite. The direction of groundwater flow may also not be unconnected with this finding. About 5% and 10% of water sample collected around Solus in rain and dry season respectively show conductivity values higher than WHO maximum limit of 1.4 mS/cm for drinking water, while all the water collected around Olususun dumpsite, have conductivity values within the acceptable limit. The EC value in Olususun water maintains strong correlation with TDS at $p < 0.05$ ($r = 0.98$), TS ($r = 0.54$) and TSS ($r = 0.90$) (Table 8.0) while strong correlation was observed also between EC and TDS ($r = 0.94$) as well as TS ($r = 0.85$) in water collected around Solus dumpsite.

The average values of total dissolved solids observed in groundwater around Olususun was almost twice of the value in water around Solus dumpsite. The mean and range of values of TDS for water collected around Olususun and Solus were 412 ± 179 (122.0 - 849.0) mg/L and 393 ± 186 (112.0 -1294) mg/L respectively. The TDS of all water collected from Olususun are within fresh water range and lower than the WHO a permissible limit of 1000 mg/L for drinking water. However, 5% of water around Solus had TDS within brackish water range. Total dissolved solid is a measure of amount of dissolved minerals that influences the usability of water. These mineral including inorganic salts (Ca, Mg, K, Na, HCO_3- and SO_4^{2}-) and small amount of organic matter, some of which are dangerous, if ingested at high concentration. TDS varies considerably in different geological regions owing to differences in the solubility of minerals. The palatability of water with TDS value less than 500 mg/L is generally considered good36, while water with TDS value above 1000 mg/L is objectionable to consumer because taste of such water is affected. The TDS in this study correlated with electrical conductivity ($r = 0.93$) and total solids ($r = 0.90$) in Solus groundwater while in Olususun groundwater, TDS correlate strongly with electrical conductivity ($r = 0.98$), total solids ($r = 0.90$) and TSS($r = 0.55$) indicating a common source of the contaminant, while weak association were observed TDS/Cl, TDS/Alkalinity, TDS/Acidity and TDS/ pH.

The mean values of total hardness observed in Solus are almost twice of the TH values in water collected around Olususun. Hardness is an important operational water quality parameter; it defines the suitability of usage of water. Hardness can be caused by Ca and or Mg, these usually prevents formation of lather thereby consuming more soap. Olususun and Solus groundwater have mean and range of TH value 45.6 ± 36 (4.30 - 125) mg/L and 74.0 ± 61 (14.5 - 210) mg/L respectively. These values are higher than the result of similar study in Lagos 37 with 61.3 mg/L. TH as water quality parameter helps in control of corrosion.

Depending on the interaction with other factors such as pH and alkalinity, water with hardness value above 200 mg/L may carry scale of deposition in treatment work. A number of ecological studies have shown a great significant inverse relationship between hardness of drinking water and cardiovascular diseases.

This indicates that, soft water affect the functional behavior of human system. Hardness values in water around Olususun dumpsite(Table 5.0) reveal strong correlation with acidity ($r = 0.73$) and moderate correlation with total suspended solids ($r = 0.52$), while

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it maintains weak correlations with conductivity (r = 0.26), total solid (r = 0.45), alkalinity (r = 0.38), and sulphate (r = 0.23), while water collected around Solus reveal strong correlation between total hardness and acidity (r = 0.81) and alkalinity (r = 0.77) as well as weak associations with pH, nitrate and sulphate as shown in Table 6.0.

The chloride values from Solus groundwater were twice higher than the corresponding chloride values in Olusosun groundwater. This could indicate that bulk of the solid waste received at Solus dumpsite are non industrial, as chloride is major anion from food waste. The mean and range of chloride value in water around Solus and Olusosun dumpsites 146 ± 112 (17.3- 354.0) and 68.2 ± 32 (19.9 – 184) mg/L. The highest chloride values were in wells SWS1, SWS2, SWS 3, SWS 10 and SWS 11, possibly due to their close proximity to the refuse dumpsite. 20% of water collected around Solus dumpsite showed concentration higher than the 250 mg/L permissible chloride limits for drinking water. This may be a pointer to chronic chloride toxicity from Solus groundwater. The values recorded in this study are lower than that reported by Laluraj 38 but higher than Niger delta study19 and Lagos groundwater study by Ikem [37].

The sources of salt water in these areas may be diversified. Tindal et al.39 suggested that it may be due to the retention of ions from salt trapped at the time of deposition, from solution of minerals and constituents or by infiltration of clay and recharge atmospheric precipitation containing ions. Chloride was observed to maintain weak correlations in Olusosun groundwater samples (Table 5.0) with nitrate, sulphate, acidity, alkalinity, EC and TDS with coefficient values ranging from 0.01 to 0.39, and a negative correlation with phosphate. However, in Solus groundwater (Table 6.0), chloride had weak correlation with sulphate, acidity, alkalinity and total hardness and negative correlations with phosphate, nitrate, EC and TDS.

The mean and range of sulphate value in groundwater collected around Olusosun and Solus were 22.4 ± 17 (9.27 - 69.5) mg/L and 12.9 ± 6.4 (3.24 - 25.3) mg/L respectively. Sulphate concentrations in groundwater collected around both dumpsites were generally lower than 250 mg/L limit stipulated by World Health Organization for drinking water. The level of SO_4= in groundwater under investigation could be traced to geological nature of the soil because interlocation of clays, sands and silt could encourage dissolution of sulphite such as pyrite from inter stratified matters percolating water to produce SO_4^{2-} water35. Vehicle emission can also contribute to the SO_4^{2-} concentration in an environment. High level of SO_4^{2-} can cause laxative effect to unaccustomed consumers 31.Excessive intake of SO_4^{2-} can lead to diarrhea, hydration and intestinal irritation, though no health based guideline has been fixed for SO_4^{2-}. Sulphate water collected around Solus dumpsite maintained weak correlation with pH, alkalinity, acidity, total hardness, TDS, TSS, conductivity and all the other anions with coefficient values (r) ranging from 0.004 to 0.48.This shows that the quality parameters are of different sources. However, in groundwater collected around Olusosun dumpsite sulphate maintained negative correlation with EC, TDS and TS, an indication that the higher the sulphate concentration ,the lower the quality parameters mentioned above. A weak chemical association was also observed for SO_4^{2-} versus pH, SO_4^{2-} versus acidity, and $SO_4$2- versus TSS indicating common origin of the paired parameters.

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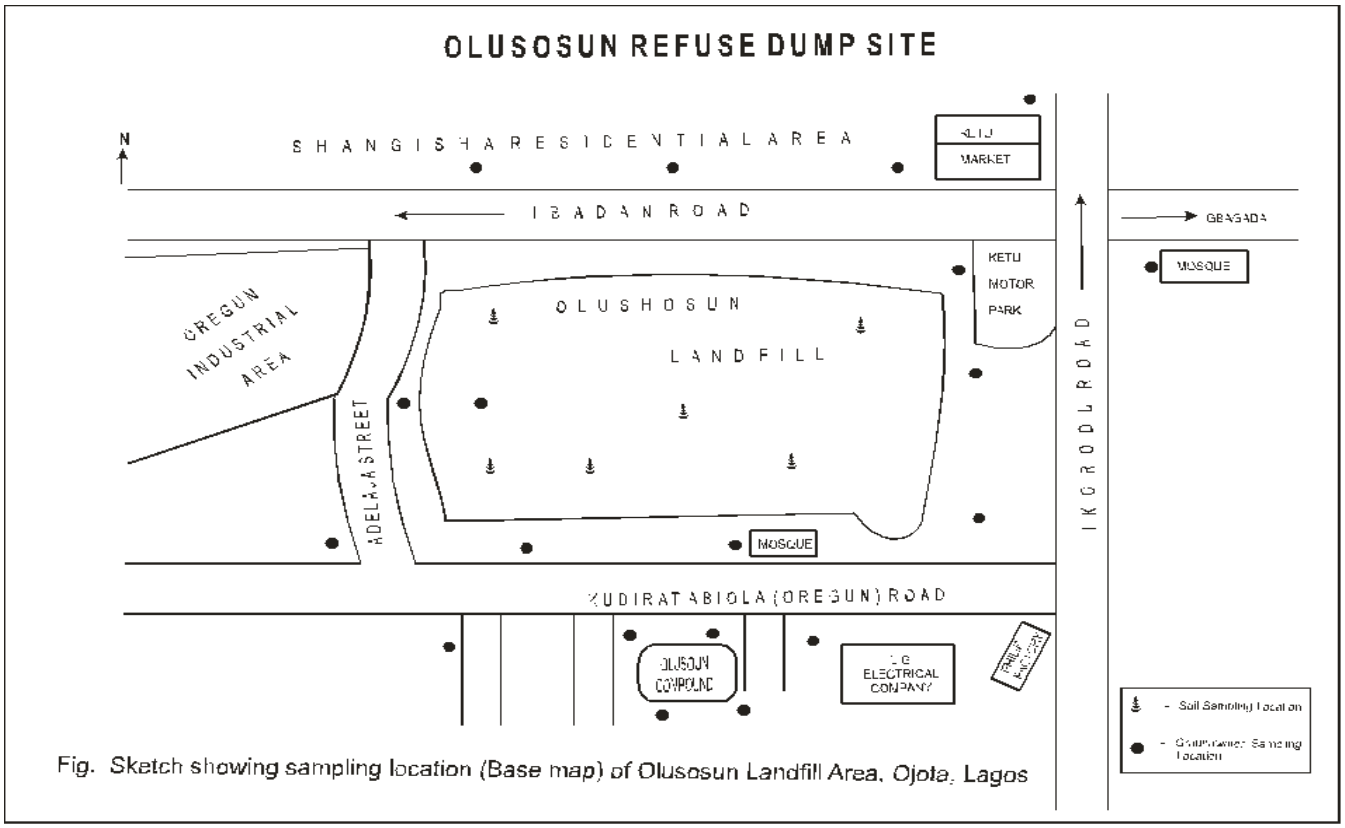

Fig. Sketch showing sampling location (Base map) of Olusosun Landfill Area, Ojota, Lagos

Fig. 1.0 : Sampling locations of Olusosun dumpsite area, Ojota, Lagos

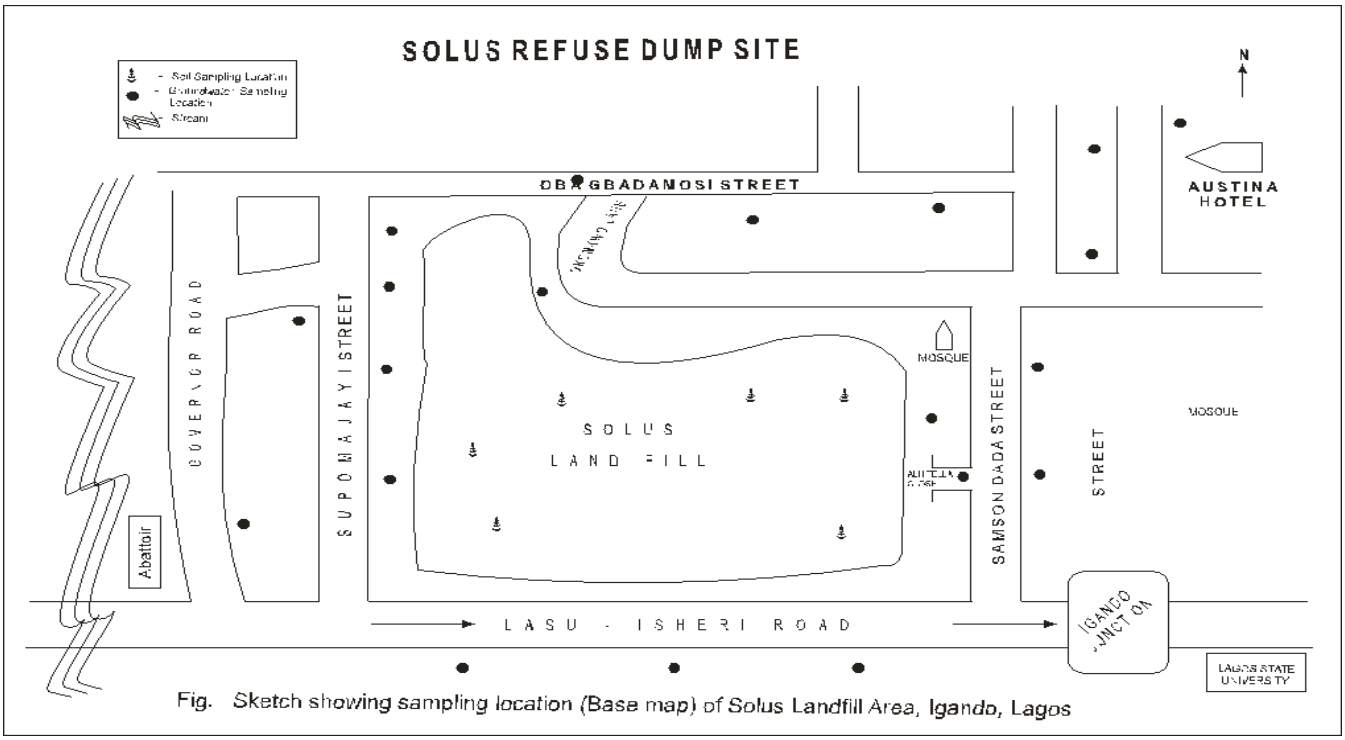

Fig. Sketch showing sampling location (Base map) of Solus Landfill Area, Igando, Lagos

Fig. 2.0 : Sampling locations of Solus dumpsite area, Igando, Lagos

The average concentration of nitrate in groundwater around Olusosun was almost ten times that of nitrate value in Solus groundwater. The mean and range of nitrate values in water around Olusosun and Solus were 14.1 ± 6.4 (7.5 -35.3) mg/L and 1.47 ± 1.1 (7.4 - 35.3) mg/L respectively. The nitrate concentration

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in over 85% of the water from Olusosun area exceeded the 10 mg/L permissible limit by WHO[31] and Nigeria Standard drinking quality water[30]. This portends great danger. However, all samples analysed in Solus dumpsite area are safer from nitrate toxicity. The health effect of excess nitrate concentration beyond acceptable limit includes death of infant of about age six, while shortness of breath and blue-baby syndrome has also been identified. Generally, the sources of nitrate in groundwater include domestic sewage, runoff from urban on agricultural field and leachate from landfill site[34]. The leachate from the refuse dump is suspected to be responsible for the high nitrate level observed. The low value of NO_3- level observed in the Solus refuse dumpsite unlike most of the Olusosun samples investigated, could be as a result of age of Olusosun dumpsite, the nature and volume of the solid waste received and the level of clay soils in the Solus area. Tindas 39 also pointed out that low level of nitrate in an area indicate low level of nitrifying bacteria which convert nitrogen to nitrate under aerobic condition. Phosphate, total hardness and acidity were observed to have weak correlation with nitrate in Solus as shown in Table 6.0.

The mean and range of phosphate value water collected around Olusosun were 0.39 ± 0.27(0.07 - 0.84) mg/L while that of Solus groundwater were 0.44 ± 0.22(0.22 - 0.96). Generally, the phosphate concentration in Solus observed was relatively higher than that of Olusosun. The result is similar to Ibadan and Lagos studies by Ikem [37]. However, it is lower than the values reported in Lebanon Basins [40]. This indicates low level of detergent pollutant from the landfills. The mean and range of Cu value water around Olusosun and Solus were 0.12 ± 0.17(0.01 to 0.23) mg/L and 0.08 ± 0.03 (0.03 to 0.15) mg/L respectively. Copper is an essential nutrient as well as a toxic element, depending on the level of its concentration. It acts as aco-factor in specific cupro- enzymatic reaction. High concentration of copper can cause gastrointestinal irritation in man. The sources of copper in groundwater include leachate from landfills, runoff from agricultural field and geochemical composition of the soil/rock holding the water.

The mean and range of iron values in water around Olusosun and Solus dumpsites 12.9 ± 7.0(4.12 – 31.2) mg/L and 11.7 ± 7.7 (0.36 – 20.1) mg/L. The rusting of water pipes often resulted in unnecessary high level of iron "red water". Other major sources of iron include nature of rock and soil which house the groundwater particularly the igneous rock, leachate from refuse dumps, industrial waste, and seepage from septic tank in residential areas. Iron is an essential element in human nutrient; it helps in the formation of hemoglobin which is important during pregnancy and lactation. Zinc is an essential trace element found virtually in all food and potable water. It is necessary in minimal quantity for animal and plant metabolism. However, high levels of zinc often result in zinc toxicity, which may cause cancer in the body system. 0.59 ± 0.58(0.12 – 1.90) mg/L and 0.86± 0.78(0.18 – 2.24) mg/L were mean and range of zinc values in the groundwater collected around Olusosun and Solus dumpsites respectively.

Sodium, Calcium, Potassium and Magnesium are of nutritional importance to life, so they are referred to as essential metals. They help in various metabolic activities in the human body system. The mean of sodium (Na) Sodium, in water around Olusosun and Solus were 171 ± 128 mg/L and 143 ± 109 mg/L respectively; potassium, 24.3 ± 8.8 mg/L and 20.3 ± 11 mg/L respectively; calcium, 59.0 ± 41 mg/L and 57.9 ± 48 mg/L and magnesium,10.5 ± 8.6 mg/L and 13.9 ± 7.0 mg/L. These minerals (K, Na, Mg and Ca) are probably derived from chemical weathering of feldspars as micas which are some of the minerals characterizing the plain sands. The three cations Na+, Ca2+ and Mg2+ are among the species that are constantly involved in cations exchange process and interactions with the aquifer materials. The concentration of these quality parameters were mainly compared to (WHO) guidelines for drinking water.

The extents by which some of the parameters exceed the WHO guidelines are expressed as exceedance level. This level is calculated as ratio of mean concentration of each water quality variable to respective guideline values and expressed with no unit41. exceedance level of variables such as nitrate, lead, iron, cadmium and magnesium are presented in Table 7.0.

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Table 3.0 : Concentration of physicochemical parameters and trace metals in groundwater around Olusosun dumpsite

Sample Code	pH	Tem	Alk	Acid	TH	EC	TDS	TSS	TS	Cl^-	PO_4^{3-}	NO_3^-	SO_4^{2-}	Cu	Ni	Pb	Cd	Fe	Zn	Mg	Ca	Na	K
OWS1	4.1	25.4	120	45.4	20.4	0.49	240	215	455	47.5	0.93	10.5	21.4	0.08	0.07	ND	0.01	10.1	0.22	8.13	10.3	190	31.1
OWS2	4.9	25.6	102	18.5	37.5	0.42	201	258	459	30.2	0.62	13.7	13	0.08	0.04	ND	ND	0.61	0.3	3.53	9.8	200	31.1
OWS3	3.9	25.2	373	21.7	43.4	1.13	483	509	992	132	0.15	23.8	19	0.07	0.03	ND	ND	3.99	0.34	4.34	9.48	175	43.2
OWS4	5.1	25.5	60.2	22.9	15	0.82	400	128	523	76.2	0.33	21.2	9.6	0.08	0.05	ND	0.01	9.04	0.27	3.97	10.1	200	30.7
OWS5	6.3	25	98.6	65.3	20.7	1.77	849	426	1245	62.8	0.18	17.5	13.1	0.11	0.02	ND	ND	15	0.12	4.2	9.01	123	25.1
OWS6	6.6	25.1	80.3	62.2	32.5	1.59	758	475	1423	59.9	0.07	10.6	12.9	0.1	0.06	ND	0.01	0.36	0.13	6.19	26.9	11.7	33
OWS7	5.4	25	24.5	41.5	42.5	0.52	209	114	323	100	0.23	35.3	22.4	0.11	0.03	ND	0.01	19.7	0.25	10.8	101	38.1	31.4
OWS8	4.8	25.4	218	25.4	20.6	0.91	311	123	434	23.9	0.36	14.4	11.7	0.23	0.02	ND	ND	21.3	0.22	6.12	118	26.2	25.5
OWS9	5.1	26.5	126	15.4	6.7	0.42	213	155	368	19.9	0.35	12.6	12.4	0.03	0.07	ND	ND	2.76	0.15	7.31	231	134	17.6
OWS10	5.2	26.4	132	13.5	4.8	0.41	214	223	475	89	0.84	10.7	17.3	0.08	0.03	ND	0.02	2.01	0.21	31.2	130	22.2	25.3
OWS11	6.7	24.8	119	88.4	27.3	0.82	321	247	568	75.9	0.65	12.9	21.5	0.11	0.06	ND	0.01	1.11	0.22	28.2	141	376	10.8
OWS12	7.1	25.1	122	73.4	20.6	1.0	421	337	758	91.1	0.53	11.8	20.5	0.13	0.05	ND	0.01	17.1	0.28	30	176	429	10.2
OWS13	4.6	25	219	60.5	108	1.03	541	363	904	86.3	0.07	7.7	12.5	0.05	0.05	ND	ND	20	0.25	8.02	40.1	304	30.2
OWS14	4.0	25.7	240	152	125	1.21	529	446	989	105	0.74	7.4	10.7	0.06	0.01	ND	ND	20.1	1.9	4.11	71.5	426	32.1
OWS15	4.3	25.2	223	56.7	65.6	1.09	529	484	1103	118	0.15	9.6	17.6	0.08	0.01	ND	ND	18.2	1.41	9.17	49.5	152	20.8
OWS16	5.2	25.5	141	100	116	1.26	621	542	1164	32.9	0.16	14.5	21.4	0.08	0.02	ND	ND	15.2	1.24	9.03	6.03	20	22.2
OWS17	4.5	27.4	94.2	22.4	34.1	1.38	610	515	1125	31.8	0.64	12.6	25.7	0.08	0.01	ND	ND	10.9	1.74	9.84	7.99	170	21.1
OWS18	4.4	26.5	71.1	33.3	23.3	0.72	331	468	799	36.1	0.57	12.8	23.6	0.06	0.01	ND	ND	14.2	0.94	8.39	22.1	100	20.1
OWS19	6.1	26	302	99.5	79.6	0.72	327	417	744	67.2	0.24	12.4	69.5	0.04	0.02	ND	ND	15.2	1.2	8.91	12.1	157	13.8
OWS20	6.4	25	152	43.8	22.6	1.41	697	429	1275	66.2	0.428	18.3	18.5	0.01	0.01	ND	ND	17.1	0.35	8.28	8.02	166	11.4
Mean	5.23	25.6	144	55.8	45.7	0.9	412	349	775	68	0.38	14.1	22.4	0.12	0.03	0	0.01	11.7	0.59	10.5	59	171	24.3
SD	0.97	0.7	91	37	36.4	0.42	179	151	327	32.7	0.27	6.4	17	0.17	0.02	0.01	0.01	7.7	0.58	8.6		128	8.8
WHO	6.5-8.5		1000		500	1.4	1000			250		10	250	1.5	15	10	3	2.5	3	50		200	

N.B : All units are mg/L except EC (mS/cm) and Temperature (°C) and pH with no unit

Table 4.0. Concentration of physicochemical parameters and trace metals in groundwater around Solus dumpsite

Sample Code	pH	Tem	Alka	Acid	TH	EC	TDS	TSS	TS	Cl^-	PO_4^{3-}	NO_3^-	SO_4^{2-}	Cu (mg/L)	Ni	Pb	Cd	Fe	Zn	Mg	Ca	Na	K
SWS1	4.80	26.9	59.6	37.5	15.9	0.44	598	243	842	299	0.260	0.840	8.37	0.10	0.08	ND	ND	5.43	1.67	31.2	40.3	95.0	5.43
SWS2	5.40	25.6	195	43.4	14.5	0.41	261	242	517	261	0.760	0.690	6.08	0.08	0.02	ND	ND	4.11	1.21	22.5	10.2	125	4.11
SWS3	6.90	25.7	310	167	108	1.01	1294	521	1872	378	0.380	1.55	25.3	0.07	0.02	ND	ND	6.86	0.89	11.1	19.0	19.9	6.86
SWS4	4.60	25.7	41.8	26.6	30.4	0.71	120	139	256	25.2	0.240	1.57	14.1	0.09	0.03	ND	ND	9.00	0.18	23.0	16.1	23.9	9.00
SWS5	5.30	25.3	10.5	6.60	13.5	1.62	802	411	1213	354	0.280	0.29	5.95	0.08	0.01	ND	ND	15.0	0.18	10.2	21.0	210	15.0
SWS6	5.90	25.8	29.3	62.8	24.7	1.41	724	425	1235.	107	0.360	1.59	22.0	0.11	0.06	ND	ND	2.00	0.32	10.0	26.2	103	2.00
SWS7	6.80	25.6	110	98.5	90.6	0.38	209	140	347	158	0.340	2.85	12.9	0.12	0.03	ND	ND	27.0	0.22	10.1	102	38.1	27.0
SWS8	6.60	25.7	291	96.8	202	0.64	300	167	478	34.9	0.270	2.92	16.6	0.05	0.01	ND	ND	21.3	0.39	8.21	116	126	21.3
SWS9	6.10	24.9	221	110	181.8	0.39	209	184	417	241	0.220	2.64	24.1	0.03	0.07	ND	ND	31.3	0.09	11.0	14.0	152	31.3
SWS10	5.80	26.3	376	157	210.4	0.33	211	243	452	235	0.440	1.96	11.1	0.09	0.03	ND	0.01	21.9	0.20	11.2	85.6	203	21.9
SWS11	5.90	26.7	65.8	17.4	44.50	0.71	302	269	670	139	0.340	0.820	3.24	0.12	0.07	ND	0.01	10.2	0.01	21.1	55.0	347	10.2
SWS12	4.70	26.2	12.9	39.1	61.80	1.00	397	364	769	138	0.320	3.80	9.35	0.15	0.02	ND	0.01	16.1	2.23	22.0	24.0	420	16.1
SWS13	5.80	25.7	125	86.9	72.60	1.02	517	365	883	43.0	0.390	3.44	8.37	0.05	0.05	ND	0.01	21.1	0.25	12.0	41.0	304	21.1
SWS14	6.10	25.8	14.5	27.5	36.40	1.09	511	473	985	135	0.850	1.65	14.2	0.06	0.02	ND	ND	20.0	1.87	8.22	74.1	22.0	20.0
SWS15	6.30	25.6	21.3	13.4	31.30	1.22	501	452	982	21.2	0.960	0.760	20.2	0.06	0.01	ND	ND	18.1	1.32	12.0	50.4	152.	18.1
SWS16	6.90	25.7	124	72.6	94.70	1.13	609	598	1206	17.4	0.700	0.180	11.4	0.04	0.01	ND	ND	15.5	2.24	4.12	125	20.0	15.5
SWS17	5.70	25.8	65.4	27.6	57.98	1.14	581	583	1070	75.6	0.540	0.47	14.7	0.07	0.01	ND	ND	4.10	1.99	9.00	28.0	112	4.10
SWS18	4.70	25.9	126	65.7	71.70	0.13	317	423	738	67.4	0.520	0.390	3.54	0.07	0.01	ND	ND	2.29	0.34	6.13	177	120	2.29
SWS19	4.80	25.8	143	71.4	56.40	0.60	314	465	772	112	0.360	0.260	14.4	0.05	0.01	ND	ND	2.00	1.11	18.0	112	155	2.00
SWS20	5.25	26.4	113	73.2	61.60	0.23	112	549	669	81.1	0.250	0.760	12.4	0.08	0.02	ND	ND	4.21	0.30	16.9	98.0	115	4.21
Mean	5.71	25.9	123	65.1	74.04	0.78	393	362	763	146	0.440	1.47	12.9	0.08	0.03	0.0	0.01	12.9	0.86	13.9	57.9	143	12.9
SD	0.75	0.5	106	44	60.03	0.42	186	149	289	112	0.22	1.1	6.4	0.03	0.02	0.0	0.01	9.0	0.78	7.0	48	109	9.0
WHO	6.5-8.5		1000.0		500.0	1.4	1000			250		10	250	1.5	15	10	3	2.5	3.0	50		200	

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Table 5.0: Correlation coefficient between physicochemical parameters in groundwater of Olusosun area

Temp	-0.21718	1.0									
Alkalinity	-0.40342	0.066897	1.0								
Acidity	0.268037	-0.4445	0.159297	1.0							
TH	-0.21486	-0.30143	0.382054	**0.732725**	1.0						
EC	0.060558	-0.21612	0.189625	0.249704	0.245912	1.0					
TDS	0.03774	-0.20213	0.185418	0.240107	0.263872	**0.985504**	1.0				
TSS	-0.05724	0.019458	0.235771	0.452321	**0.524919**	**0.537175**	**0.554534**	1.0			
TS	-0.02186	-0.12031	0.241032	0.379682	0.45227	**0.90107**	**0.906597**	**0.834783**	1.0		
Cl	-0.05185	-0.34861	0.393472	0.255431	0.256245	0.137506	0.131044	0.176222	0.151613	1.0	
PO_4	-0.07713	0.178037	-0.18431	-0.05344	-0.32311	-0.37861	-0.41783	-0.32448	-0.44323	-0.1604	1.0
NO_3	0.04809	-0.17466	-0.18086	-0.32171	-0.23698	-0.0617	-0.12299	-0.35315	-0.19063	0.199378	0.29723	1.0
SO4	0.300221	0.094885	0.015351	0.357699	0.227248	-0.33853	-0.34706	0.332921	-0.04984	0.013524	0.14355	0.08608	1.0

Table 6.0: Correlation coefficient between physicochemical parameters in groundwater of Solus area

pH	1.0											
Temp	-0.33669	1.0										
Alkalinity	0.344473	-0.10326	1.0									
Acidity	0.434588	-0.12313	**0.869089**	1.0								
TH	0.412146	-0.18854	**0.816777**	**0.770859**	1.0							
EC	0.247354	-0.28313	-0.46869	-0.36718	-0.36674	1.0						
TDS	0.147805	-0.34406	-0.4795	-0.37336	-0.3696	**0.93467**	1.0					
TSS	0.108837	0.024777	-0.23197	-0.10425	-0.28894	0.451343	0.482027	1.0				
TS	0.167952	-0.19255	-0.44806	-0.30514	-0.40398	**0.851505**	**0.901455**	**0.796885**	1.0			
Cl	0.01982	-0.0109	0.28214	0.262232	0.010354	-0.01232	-0.10794	-0.14883	-0.14586	1.0		
PO_4	0.294353	-0.15374	-0.15364	-0.2637	-0.24819	0.246632	0.241836	0.398825	0.35071	-0.23463	1.0	
NO_3	0.165828	-0.13376	0.196807	0.36781	0.453334	-0.06226	-0.17714	-0.48943	-0.35521	-0.05891	0.32869	1.0
SO_4	0.4809	-0.4529	0.246798	0.421234	0.325313	0.220085	0.102509	0.109578	0.128819	0.028624	0.00475	0.213417	1.0

This approach according to Saroj42 has effectively visualized the levels. The order concentration levels of different water quality parameters in relation to the non-uniform increase in exceedance value in Olusosun groundwater sample was Mg > Fe > Cd > NO_3- -N >Pb, while in that of Solus groundwater, order concentration levels of different water quality parameters was Mg > Fe > Cd > Pb > NO_3- -N. Apart from the leachate as a major probable source of these pollutants in groundwater, there are other possible sources. The major source of magnesium (Mg) in the groundwater for instance, is due to ion exchange of minerals in rocks and soils by water[41].

Table 7.0: Exceedance levels of groundwater parameters with respect to WHO

Dumpsite	NO_3^-	Cd	Pb	Mg	Fe
Olusosun	1.57	1.8	1.0	21.1	11.5
Solus	-	1.85	1.0	20.7	13.4

b) Assessment of the water quality

The quality of groundwater under consideration in respect of drinking purpose has been established based on the WHO guidelines for drinking water. The calculated WQI values of these water samples put them water in excellent - good – poor class for Solus water and good - poor – very poor class for Olusosun using classification shown in Table 2.0. WQI vales ranged from

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39.1 to 126 mg /L and from 61.8 to 205 mg /L respectively for Solus and Olusosun water. The spatial variations revealed that about 10% of the samples collected around Solus are in excellent grade; 65%, good and 25%, poor for Solus water, while in Olusosun, it is 35% good, 55% poor and 5% very poor. Some sampling locations are critical to human health and need urgent attention. These locations include OWS 3, OWS 4, OWS 8, OWS 14, OWS 17 and OWS 18 around Olusosun area and SWS1 and SWS 12 around Solus area.

IV. Conclusion

The level of physico-chemical parameters in groundwater around Olusosun dumpsite was observed to be higher than the corresponding groundwater around Solus area. Age of Olusosun dumpsite, nature and volume of solid waste deposited as well as the percentage of clay content in the soil from the sampling area could be some of the factors responsible for the observation. All groundwater samples analyzed from the study area are acidic in nature. This might be as a results of high population density and industrialization in the area, consequently, the high level of CO2 in the atmosphere can result in acidic nature of water that percolates into aquifer. Very low pH in water is a form of health treats to human. Correlation coeficiency applied shows possible contribution of contaminant from diverging multiple sources. Water quality index (WQI) further revealed that the impact of the dumpsites is still minimal in groundwater around Solus dumpsite compared to Olusosun dumpsite. WQI delineate water samples around Solus dumpsite as excellent – good – poor and that of Olusosun dumpsite as good – poor – very poor. The level of Chloride in groundwater around solus dumpsite demonstrates a buildup of the anion in the aquifer and this may continue as the dumpsite matures. Almost all the groundwater collected around Olusosun dumpsite showed level of nitrate higher than that WHO permissible limit of 10 mg/L. This situation is of great health risk as nitrate pollution has been linked to mith and sometimes death. Some sampling locations in both dumpsites with very poor quality water samples require some treatment measures to make the water therein potable.

References Références Referencias

1. Lagos Organization Review, 2008. "A tale of Two kinds of cities". 5:115-128.
2. Osibanjo, O. and Majolagbe, A. O. 2012.physicochemical quality assessment of groundwater based on land use in Lagos city, southwest, Nigeria. *Chemistry Journal*, 2 (2): 79-86.
3. Okoronkwo, N. E., Odemelam, S.A. and Ano, A.O. 2006.Levels of Toxic elements in soil of abandoned dumpsite. *African Journal of Biotechnology*. 5:1241 – 1244.
4. Longe, E. O. and Enekwechi, L. O. 2007. Investigation on potential groundwater impacts and influence of local hydrogeology on natural attenuation of leachate at a municipal landfill . *Int. J. Environ. Sci. Tech.*, 4 (1): 133-140.
5. Mor, S., Ravindra, K., Vischher, A. R. P. Dahiya and A. Chandra, 2005. Municipal Solid Waste Characterisation and its assessment for potential methane generation at Gazipur Landfill Site, Delhi: A case study. Bioresource Technology, Communicated.
6. Singh, U.K, Kumar M, Chauhan HYPERLINK "http://www.ncbi.nlm.nih.gov/pubmed?term=Chauhan%20R%5BAuthor%5D&cauthor=true&cauthor_uid=17899419" R, Jha HYPERLINK http://www.ncbi.nlm.nih.gov/pubmed?term=Jha%20PK%5BAuthor%5D&cauthor=true&cauthor_uid=17899419 PK, Ramanathan HYPERLINK http://www.ncbi.nlm.nih.gov/pubmed?term=Ramanathan%20A%5BAuthor%5D&cauthor=true&cauthor_uid=17899419 A, Subramanian V. 2008. Assessment of the impact of landfill on groundwater quality: a case study of the Pirana site in western. India. *Environ HYPERLINK "http://www.ncbi.nlm.nih.gov/pubmed/17899419"nit HYPERLINK"http://www.ncbi.nlm.nih.gov/pubmed/17899419" Assess*. 2008 Jun; 141 (1-3):309-21.
7. Majolagbe, A.O., Kasali, A.A., and Ghaniyu, L.O. 2011.Quality assessment of groundwater in the vicinity of dumpsites in Ifo and Lagos, Southwestern Nigeria. *Advances in Applied Science Research,* 2 (1):89-29.
8. Lagos state Waste Management Agency (LAWMA). 2008. Assessment Report, 1, Lagos.
9. Amusan, A.A., Ige, D.V. and Olawale, R. 2005.Characteristics of soils and Crops uptake of metals in Municipal waste dumpsites in *Nigeria. J. Hum.* Ecol. 17(3):167 – 171.
10. Okoli, C.C., Cyril, A. and Itiola, O.J. 2013. Geophysical and Hydrogeochemical Investigation of Odolomi Dumpsite in Supare-Akoko, Southwestern Nigeria. The Pacific Journal of Science and Technology. 14:1,492 _ 504.
11. Abu-Rukah Y, and Al-Kofahi O. 2001. 'The assessment of the effect of landfill leachate on groundwater quality – a case study', El-Akader Landfill Site – North Jordan, Arid *Environ.* 4: 615-630.
12. Sarela, J. 2003. Pilot investigations of surface parts of three closed landfills and factors affecting them. *Environ. Monit.* Assess. 84:183-192.
13. Magnus. U. Igboekwe, N. J. and Achi A. 2011.Finite Difference Method of Modelling Groundwater Flow *Journal of Water Resource and Protection,* 3:192-198. doi: 10.4236/jwarp.2011. 33025.

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14. Moo-Young, H., Johnson, B., Johnson. A., Carson, D., Lew, C., Liu, S, and Hancock, K. 2004. Characterization of infiltration rates from landfills: Supporting groundwater modeling efforts. *Environ. Monit.* Assess. 96:283-311.
15. Abdul Nassir, S.S., Loke, M.H., Lee, C.Y., Nawawi, M.N.M. 2000. Salt-water Intrusion Mapping by Geoelectrical Imaging Surveys. *Geophys.* Prospect 48:647-661.
16. Adepelumi, A.A., Ako, B.D., Ajayi, T.R., Afolabi, O., Ometoso, E.J., (2008). Delineation of saltwater intrusion into the freshwater aquifer of Lekki. Penninsula, Lagos, Nigeria. *Environ Geol.* 56: 927-933.
17. Adegbola R.B, Oseni S.O, Anyanwu V.C, Majolagbe A.O and Sovi S.T. 2012.Application of electrical resistivity and hydrochemical methods to investigate agricultural pollution in some parts of Ojo, Lagos, Southwest, Nigeria. *International Journal of Innovative Research & Development,* 1 (4):398 – 413.
18. Srinivas, G. R. and Nageswarara, G. 2013.Assessment of Groundwater quality using Water Quality Index. Arch. Environ. Sci. 7, 1-5.
19. Edet, A.E. 1993. Groundwater quality assessment in parts eastern of Niger Delta. *Environmental Geology,* 22: 41-46.
20. Oketola, A.A., Adekolurejo, S. M. and Osibanjo, O. 2013. Water Quality Assessment of River Ogun Using Multivariate Statistical Techniques. Journal of Environmental Protection, 2013, 4, 466-479 .doi:10.4236/jep.2013.45055.
21. Halkidi, M., Batistakis, Y. and Vazirgiannis, M 2001. On Clustering Validation Techniques. Journal of Intelligent Information Systems, 17:2/3, 107–145.
22. Bharti N, and Katyal, D. 2011. Water quality indices used for surface water vulnerability assessment. International Journal of Environmental Sciences. 2:1.
23. Aboyade, A. 2004. The potential for climate change mitigation in Nigeria solid waste disposal sector. A case study of Lagos. MSc thesis, Lund University, Sweden. pp1- 47.
24. Protano, G., Riccobono, F., and Sabatini, G. 2005. Does Salt Intrusion Constitute a mercury contamination risk for coastal fresh water aquifers? *Environmental Pollution,* 110: 451- 458.
25. APHA / AWWA / WPCF. 2005. Standard Methods for the Examination of Water and Wastewater. 21st ed. Washington, APHA / AWWA / WPCF.
26. Department of Environmental (DOE). 1972. Analysis of Raw, Portable and Wastewaters. London, Department of Environmental, 12-16.
27. Taras, M.J.1964. Phenoldisulfonic Acid Method. *Analytica. Chemical*. 36: 3. pp 6-10.
28. Aluko, O.O., Srinda, M.K.C and Oluwande, P. A. 2003. Charaterisation of leachate from municipal solid wastes landfill site in Ibadan, Nigeria. J. *Environm. Health Research* 2(10):32-37.
29. America Society for Testing and Materials (ASTM). 1982. Water; Annual Book of ASTM Standards. Part 31, Washington, America Society for Testing and Materials (ASTM).
30. NSDQW. 2007. *Nigerian Standard for Drinking Water Quality*. Nigerian Industrial Standard NIS 554, Standard Organization of Nigeria: Lagos, Nigeria.
31. World Health Organization (WHO). 2006. Guidelines for Drinking-Water Quality. First addendum to 3rd ed. 1, Recommendation. *J. Hydrol* Geneva, WHO (World Health Organization), p. 595.
32. Paul, R. 2003. Hunter Drinking water and diarrheal disease due to Escherichia coli.*Journal of Water and Health,* 1: 2.
33. Ragunath, H.M. 1987.Groundwater. New Delhi, Wiley Eastern Ltd., p. 563.
34. Sanjay, S., Kale, Ajay K., Kadam, K. A ., Kumar,S. and Pawar, N. J. 2010. Evaluating pollution potential of leachate from landfill site, from the Pune metropolitan city and its impact on shallow basaltic. *Enviromental Monitoring Assessment.* 162:327– 346 DOI 10.1007/s10661-009-0799-7.
35. Olabaniyi, S.B. and Owoyemi, F.B. 2006. Characterization by factor analysis of the Chemical facies of groundwater in the Deltaic plain Sands Aquifer of Warri, Niger Delta, Nigeria. AJST *Science and Engineering Series* 2. 7 (1):73-81.
36. Langeneggar, O. 1990. Groundwater quality in rural areas of western African UNDP project, 81(26): 10.
37. Ikem, A., Osibanjo, O., Shridar, M.K.C., and Sobande, A.2002. Evaluation of ground water quality characteristics near two waste sites in Ibadan and Lagos, Nigeria. *Water, Air, and Soil Pollution,* 140: 307-333.
38. Lahluraj, S.M. 2005. Groundwater Chemistry of shallow aquifer. *Applied Ecology and Environmental Research,* 3(1): 133-199.
39. Tindasl, J.A., Petrusak, R.L., and McMonan, P.B. 1995. Nitrate transportation and transformation process in unsaturated vacuous media. *J. Hydrol* 169: 51-94.
40. Brian, D. 2001. Evaluation of water quality of the Qaraoun reservoir, Lebanon and suitability for multipurpose usage. *Environmental Monitoring and Assessment.* 77: 11- 30.
41. Aghazadeh, N., Asghari, A. and Mogaddam, A. 2010. Assessment of Groundwater Quality and its Suitabilityfor Drinking and Agricultural Uses in the Oshnavieh Area, Northwest of Iran *Journal of Environmental Protection*, 1:30-40.doi:10.4236/-jep.201011005.
42. Saroj K. C., Pandey, Vishnu V.P., Shrestha, S., Nakamura,T. and Futaba K.2010.Assessment of

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Deep Groundwater Quality in Kathmandu Valley Using Multivariate Statistical Techniques. Water Air Soil Pollut 210:277–288.

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