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Research Article

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Assessment of Groundwater Quality around Isolo Dumpsite Lagos Southwestern Nigeria

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Abstract The groundwater of some areas around the waste dump at Isolo, Lagos, Southwestern Nigeria was assessed for its chemical characteristics.

15 water samples were collected for assessment from 11 wells and 4 boreholes. The samples were analyzed in ACME Analytical Laboratory, Vancouver, Canada using the inductively coupled plasma mass spectrometry (ICP-MS). The physical properties of the samples were determined in the field apart from that of TDS which was carried out in the laboratory.

The results showed that TDS for 10 samples are within normal range while that of 5 samples were above normal. 3 of the 5 samples with high TDS are open wells. The high TDS is a result of pollution. The remaining 2 samples might be from geogenicsouces or contamination through the coating of the inner layer of the pipes. Most of the cations and anions fall within the SON and WHO limit indicating that the water is usable. The SAR is high while salinity hazard classified 10 of the water samples as no hazard with 5 as slightly hazardous and ESP classified the water as slightly sodic. Piper trilinear, Schoeller, Stiff and Durov diagrams were employed to determine the chemical characters of the water samples. They all showed that the water is rich in Na and Cl. It fell in the saline facies (Na + K – Cl) group.

10 of the samples are fresh water while 5 are brackish water. With little treatment and reduction of the salt content, the water will be useful for all purposes.

Keywords Groundwater, Contamination, salinity hazard and brackish water

Introduction

Open dumping of solid waste remains the prevailing form of waste disposal in developing countries like Nigeria. Consideration is hardly given to its effect on human population in such areas. Contamination of water bodies has become an issue of serious environmental concern in recent times. Urban population has been on the increase due to factors like better employment opportunities, concentration of industries and economic activities associated with large population. Generation of waste will also increase accordingly. In spite of the increasing population and waste generation, municipal solid waste management has not received commensurate attention. Consequently, the populace dump their wastes haphazardly. At the best, they find a free place, where they collectively dump their wastes. By so doing, it gets accumulated with time. This is the situation in Isolo waste dump.

Water is an important need of men. Therefore, man must look for water by all means. The most common source of water is groundwater. It is a common source because it is widespread and relatively cheaper to access. In addition, it is assumed to be safe for consumption because it has been filtered through the various layers of soil that it has passed through. However, the innocent consumers are not aware that there are some chemical reactions that could take place between the chemicals in the soil and the groundwater.

Since waste products consist of all kinds of materials leaching through, rain water could affect the chemical attributes of the groundwater. The U.S Environmental Protection Agency declared that hazardous waste sites are one of the principal threats to the environment and living organisms [1]. The quality of groundwater is a function of physicochemical parameters which are influenced by geological and anthropogenic factors [2]. It is therefore necessary to determine the impact of Isolowaste dump on the groundwater within the immediate vicinity. This will create awareness on the effect the groundwater will have on the consumers.

Locations of the Study Area

The study area falls with in latitudes $6^0 31'$ to $6^0 32'$ and longitudes $3^0 19'$to $3^0 20'$ with terrain about 24.4 m. It is located in Isolo, Lagos, Southwestern Nigeria. It is accessible through good major and minor roads. A major stream which has been channeled to become a large drainage way passes through the study area. The area is highly urbanised with only the immediate banks of the channel with light vegetation.

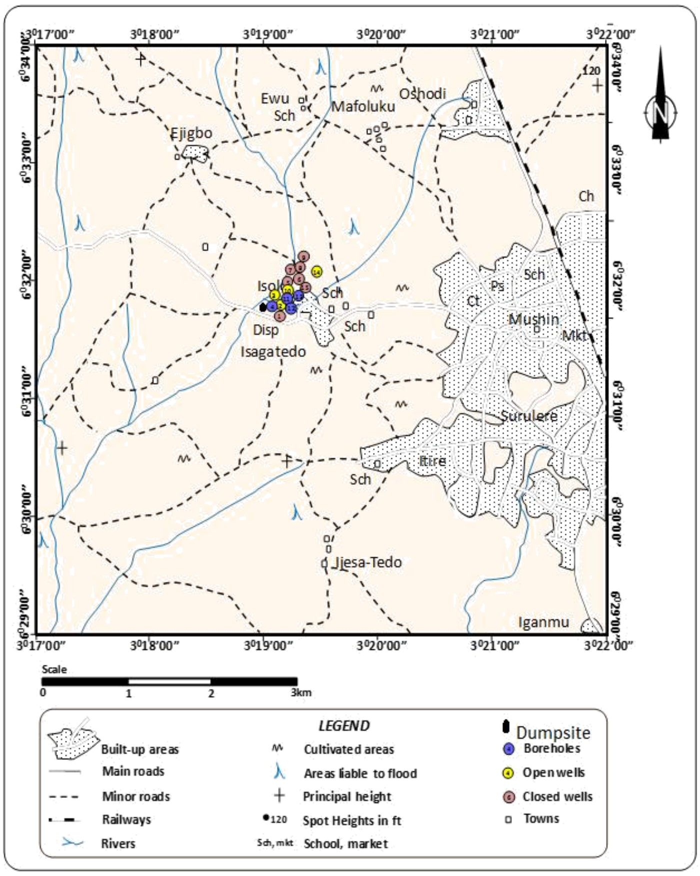


Figure 1: Topographic Map of Isolo, Lagos State (Adapted from Federal Survey Nigeria, 1964)

Geology and Hydrogeology of the study Area

The geological map of Lagos was established using several boreholes drilled for various purposes. These include water supply, foundation construction and hydrocarbon exploration. The study area is underlain by coastal plain sands to the North and then Quaternary alluvial, littoral and lagoonal deposits to the South. The 2 geological units are aquifeous. The stratigraphic relationships of the borehole and their electric logs from the earliest wells (Afowo of Mobil) to most recent (Aje wells of Folawiyo) on the Western frontier with the Benin Republic eastwards to Okitipupa Ridge (IseGraben) were used to decipher the geology of the area at depth [3]. The relationship between the local geology and hydrologic characteristics is the demarcation of the four aquifers that fall within the State. These aquifers are associated with the coastal plain sands of varying thickness. The first aquifer is encountered near the surface and it extends to a depth of 80m.The second aquifer falls between a depth of 80m and 150m, the third rarely has a thickness beyond 25m while the fourth aquifer is deeper than 450m and it is associated with the Ilaro/Abeokuta formation.

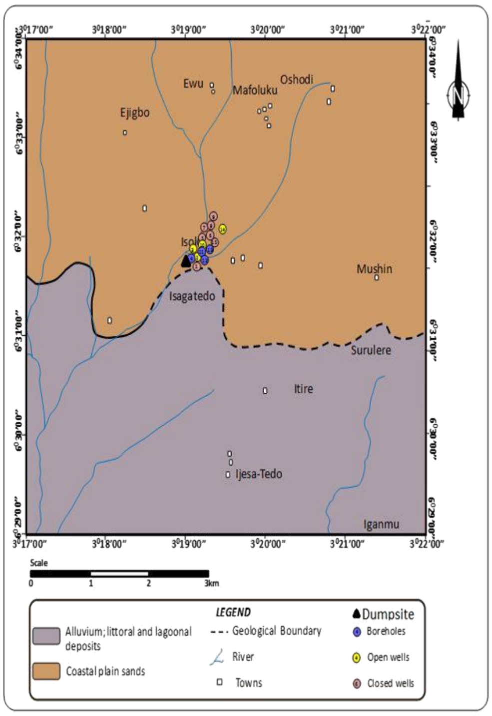


Figure 2: Geological Map of the Study Area

Methodology

Fifteen water samples were collected from wells and boreholes. Four boreholes and eleven wells were sampled. Two samples were taken from each well into a 50 ml plastic bottle. The bottles were washed and a drop of HNO_3 was added into one sample from each well while the other was not acidified. The first set was acidified to prevent the metal ions from reacting with the container. The sterilized containers were properly covered and labeled. The GPS reading of the various sample points were taken and recorded immediately. The pH of the water samples and temperatures were respectively determined in the field with pH meter and thermometer. The taste and odor tests were carried out with the tongue and nose respectively The water samples were dispatched to ACME Analytical Laboratory, Vancouver Canada where the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was used to analyze them for their chemical concentrations. The total dissolved solids (TDS) were determined classically by evaporation to dryness.

Results and Discussion

The results of physical and chemical analyses of the groundwater are presented in Tables 1 and 2. The results of the physical parameters are as shown below:

Table 1: Results of the Physical and Chemical Analysis of the Well Samples

Name	Unit	WSA1	WSA2	WSA3	BSA4	WSA5	WSA6	WSA7	WSA8	WSA9	
Sample ID		WSA1	WSA2	WSA3	BSA4	WSA5	WSA6	WSA7	WSA8	WSA9	W
Date											
Calcium	mg/kg	10	51.2	37.1	41.6	96.5	58.2	16.7	10.8	25.3	
Magnesium	mg/kg	3.1	7.6	11.9	11.3	12.6	9.2	6.3	3.9	3.1	
Sodium	mg/kg	31.4	113	150	104	87.3	84.9	106	108	46.5	
Potassium	mg/kg	4.3	57.6	55.5	98.4	74	31.9	26.9	24.2	11.6	
Bicarbonate	mg/kg	20.6	42.1	31.2	35.2	142.3	67.1	22.2	16.6	42.4	
Sulfate	mg/kg	1.6	59.5	64.6	24.9	68.1	94.6	13.6	66.8	126	
Chloride	mg/kg	26.9	135	178	169	107	92.2	122	127	59.1	
Dissolved Solids	mg/kg	243	627	710	64	467	518	441	390	397	
Conductivity	µmho/cm	380	980	111C	100	730	810	690	610	620	
pH		6.09	4.52	5.67	6.41	6.91	5.15	4.72	4.75	6.29	
Fluoride	mg/kg	0.1									
Nitrate	mg/kg	17.7									
Bromine	mg/kg	0.08	0.21	0.29	0.76	0.24	0.11	0.22	0.24	0.18	

Name	Unit	WSA8	WSA9	WSA10	WSA11	BSA12	BSA13	WSA14	WSA15
Sample ID		WSA8	WSA9	WSA10	WSA11	BSA12	BSA13	WSA14	WSA15
Date									
Calcium	mg/kg	10.8	25.3	40.3	26.9	2.4	12	0.8	5.8
Magnesium	mg/kg	3.9	3.1	13.8	9.5	1	3.7	0.4	3.1
Sodium	mg/kg	108	46.5	139	112	44	73.2	0.3	72.5
Potassium	mg/kg	24.2	11.6	59.2	43.5	5.1	15.9	0.1	11.8
Bicarbonate	mg/kg	16.6	42.4	67.2	36.9	7.2	17.3	6.9	9.6
Sulfate	mg/kg	66.8	126	93.2	10	60	44	11	64
Chloride	mg/kg	127	59.1	177	171.3	163.4	129.5	53.79	195.3
Dissolved Solids	mg/kg	390	397	697	621	448	166	294	292
Conductivity	μmho/cm	610	620	1090	970	700	260	460	440
pH		4.75	6.29	4.75	4.9	6.43	5.61	4.37	4.94
Fluoride	mg/kg								
Nitrate	mg/kg								
Bromine	mg/kg	0.24	0.18	0.26	0.07	0.26	0.33	0.12	..2

Table 2: Derived Fluid Properties of the Groundwater

Sample WSA15

Fluid Properties

Water Type	Na-Cl		
Dissolved Solids	292 mg/kg	291.2 mg/L	Measured
Density	0.99725 g/cm³		Calculated
Conductivity	440 μmho/cm		Measured
Hardness (as $CaCO_3$)			
Total	27.248 mg/kg	27.173 mg/L	Calculated
Carbonate	15.747	15.704	
Non-Carbonate	11.501	11.469	

Internal Consistency

Primary Tests		
Anion-Cation Balance		
Anions	6.83	
Cations	4	
% Difference	26.105	Not within ± 2%
Measured TDS = Calculated TDS		
Measured	292.000	
Calculated	362.100	
Ratio	0.806	Not within range 1.0 to 1.2
Measured EC = Calculated EC		
Measured	440.000	
Calculated	625.838	
Ratio	0.703	Not within range 0.9 to 1.1
Secondary Tests		
Measured EC and Ion Sums:		
Anions	1.551886	Not within preferred range (0.9-1.1)
Cations	0.909375	Within preferred range (0.9-1.1)
Calculated TDS to EC ratio	0.823	Not within preferred range (0.55-0.7)
Measured TDS to EC ratio	0.664	OK
Organic Mass Balance		
DOC ≥ Sum of Organics		
DOC unavailable		

Carbonate Equilibria

Speciation at pH 4.940

pH

The pH levels of the wells fall within 4.37 to 6.91. The permissible range of pH is 6.5 to 9.5. When it is below 6.5, the water becomes acidic and when above 8.5, the water is said to be alkaline. The two adverse conditions are not good for human consumption. Only one of the wells (well 5) falls within the appropriate range. The other wells contain acidic water which is not good for human consumption. However, it may be treated to become potable.

Electrical Conductivity

The EC levels of the wells fall within 260 and 1110. The SON standard for EC is a maximum of 1,500 μs/m. All the well water fall below the maximum permissible level hence their electrical conductivity is appropriate. However, wells 3 and 10 are above the WHO limit but within the SON limit.

Total Dissolved Solids

The TDS values range between 64 and 710 while the SON standard for TDS is that it should be below 1,500 mg/l. All the well samples are within this range. However, wells 2, 3, 10 and 11 are relatively higher than others. They are located close to one another and very close to the river. The higher TDS for 2, 3 and 10 is because the well are open and are therefore susceptible to pollution. Well 10 is a borehole. This emphasizes the importance of ensuring wells are closed. Its high TDS level may be from inner corrosion of the pipes. From the TDS values, wells 1,4,5,7,8,12,13,14 and 15 could be classified as fresh water while wells 2,3,6,10 and 11 could be classified as Brackish water.

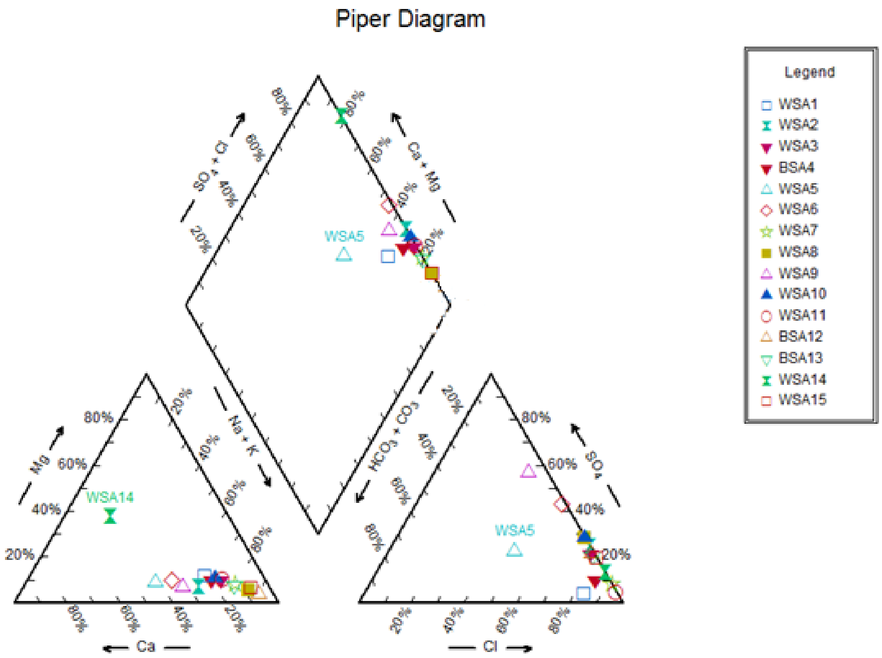


Figure 3: Trilinear Piper Diagram Showing Chemical Characters of the Well Samples

From the Diamond Plot, the water in the study area can be classified as sodium chloride water. This is typical of marine and deep ancient ground water. The study area is very close to the lagoon, therefore, the effect of the lagoon has impacted the salty nature on the water. The dumpsite may have its own contributional influence too.

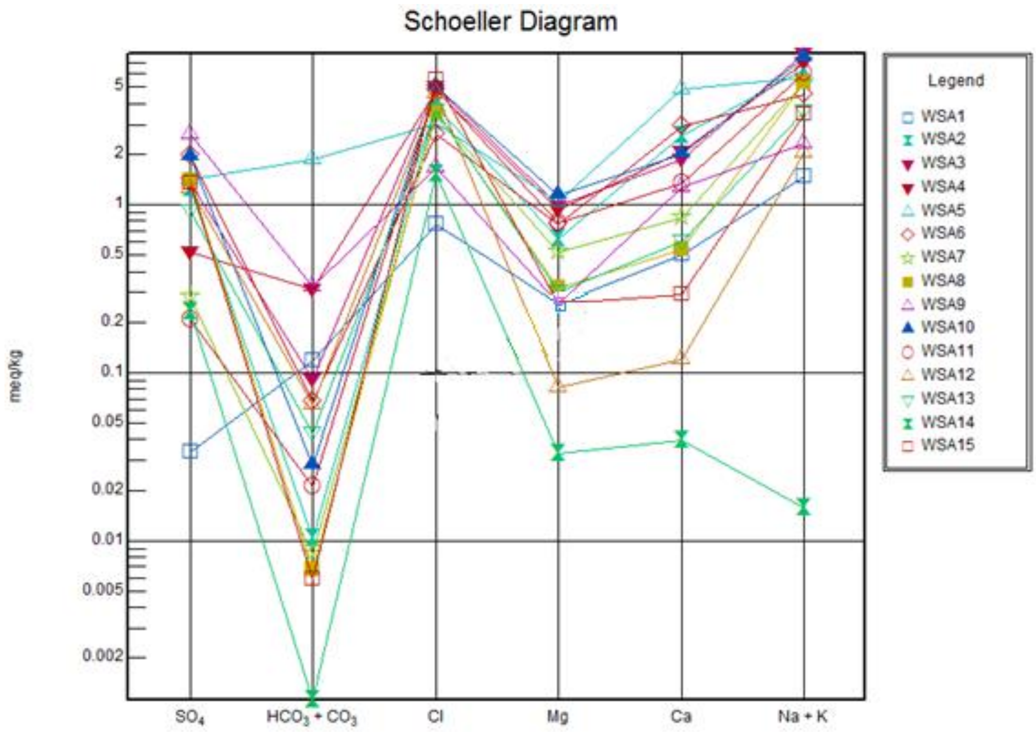


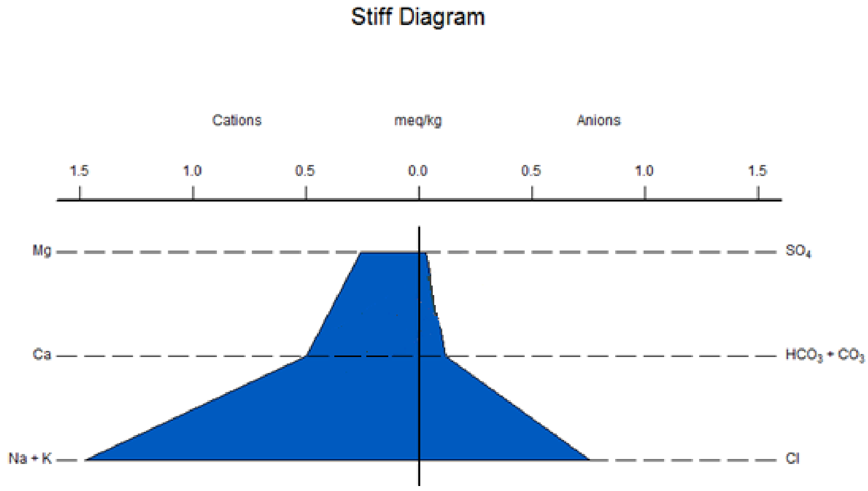
Figure 4: Schoeller Diagram of the Sampled Waters

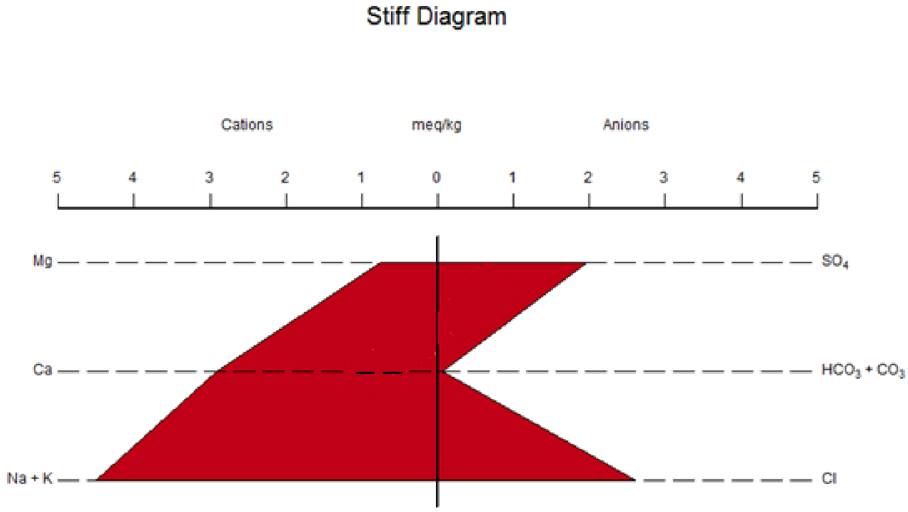
Schoeller Diagram

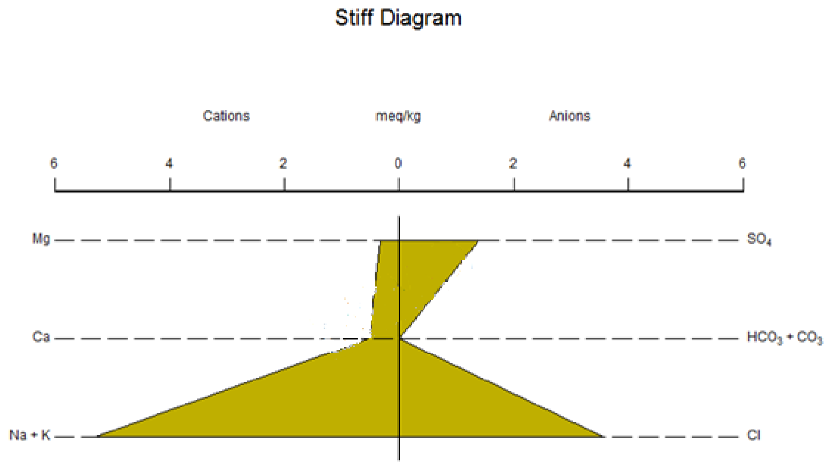
From the Schoeller diagram, Na+ K and Cl have the highest values indicating high salt content. The water is therefore saline. This is followed by Ca+ Mg and SO_4 while CO_3 + HCO_3 have the lowest values.

Stiff Diagram

From the Stiff diagram, all the wells, except well 9, have Na + K and Cl to be much higher than other ions. Well 9 has SO_4^{2-} to be highest, followed by Na + K and Cl, the far distance from the dumpsite may be responsible for the high SO_4^{2-} content.







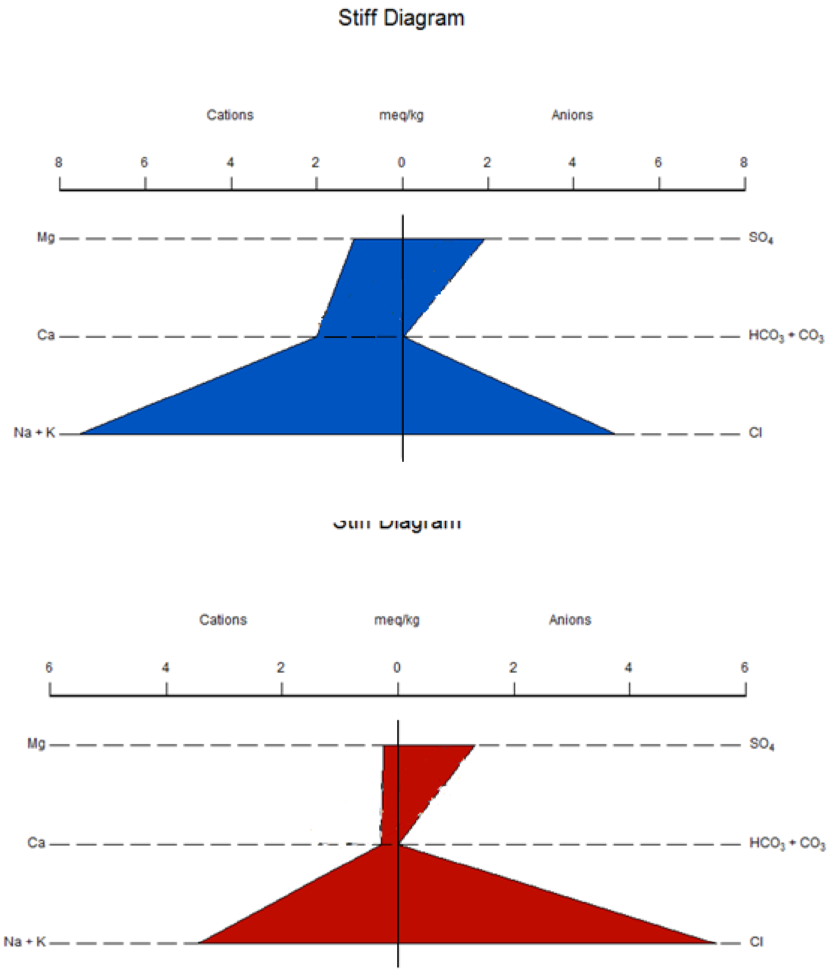


Figure 5: Stiff Diagrams of 5 of the Sampled Waters

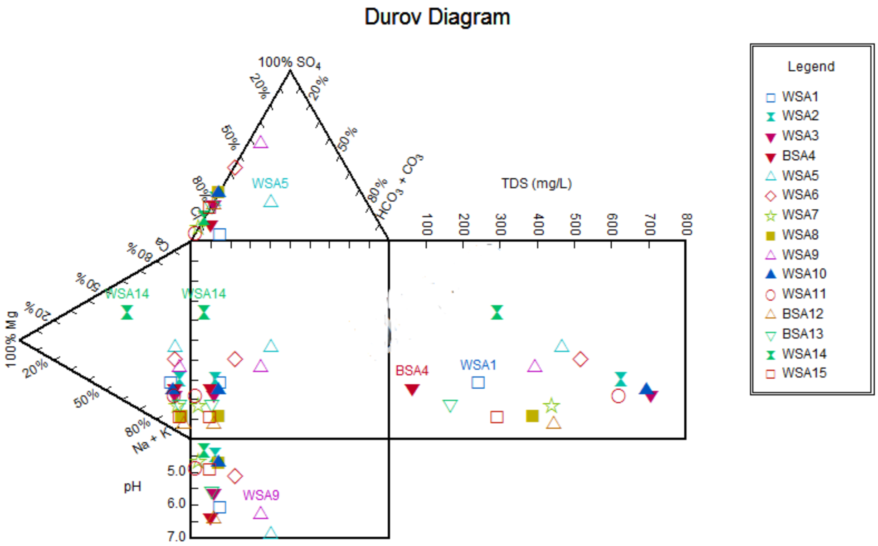
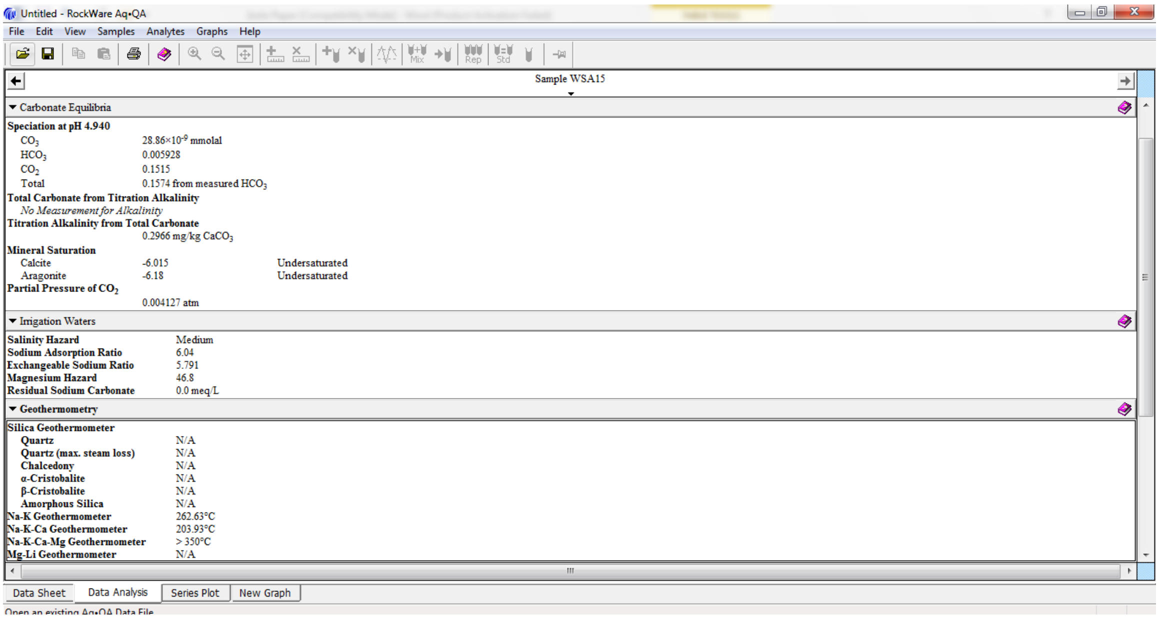


Figure 6: Durov Diagram Showing the Parameters of the Groundwater Samples

From the Durov diagram in Fig 6, all the TDS values fall within acceptable limit and the pH values reflected acidic water since they fall mostly below 6.5. The cations and anions showed high concentration of Na + K and Cl, respectively. This is in agreement with the Piper, Stiff and Schoeller diagrams which classified the waters as saline.

Table 3: Derived Water Parameters



Carbonate Equilibria		
Speciation at pH 4.940		
CO_3	28.86×10^{-9} mmolal	
HCO_3	0.005928	
CO_2	0.1515	
Total	0.1574 from measured HCO_3	
Total Carbonate from Titration Alkalinity		
No Measurement for Alkalinity		
Titration Alkalinity from Total Carbonate		
	0.2966 mg/kg $CaCO_3$	
Mineral Saturation		
Calcite	-6.015	Undersaturated
Aragonite	-6.18	Undersaturated
Partial Pressure of CO_2		
	0.004127 atm	
Irrigation Waters		
Salinity Hazard	Medium	
Sodium Adsorption Ratio	6.04	
Exchangeable Sodium Ratio	5.791	
Magnesium Hazard	46.8	
Residual Sodium Carbonate	0.0 meq/L	
Geothermometry		
Silica Geothermometer		
Quartz	N/A	
Quartz (max. steam loss)	N/A	
Chalcedony	N/A	
α-Cristobalite	N/A	
β-Cristobalite	N/A	
Amorphous Silica	N/A	
Na-K Geothermometer	262.63°C	
Na-K-Ca Geothermometer	203.93°C	
Na-K-Ca-Mg Geothermometer	> 350°C	
Mg-Li Geothermometer	N/A	

Sodium Absorption Ratio

The SAR for the water in the study area is 6.04. This is an indication of high salt content. The SAR should not be more than 12 for water for irrigation. The SAR value is 6.04 which is less than 12 hence the water is adequate for irrigation. However, for consumption, efforts should be made to reduce the salt content.

Salinity Hazard

From the TDS values, 10 of the wells with TDS values below 500mg/l fall within NO HAZARD zone while 5 wells whose value are above 500mg/l fall within SLIGHTLY HAZARDOUS zone. The high values for 2, 3 and 10 is because of the fact that the wells are open. The other 2 wells may be caused by geogenic factors or contamination from pipes.

Exchangeable Sodium Percentage

The exchangeable sodium percentage is 5.791 which can be approximated to 6. When the percentage is 6 and above, it is regarded as SODIC. The water in the study area could be regarded as SODIC.

Water Quality and Usability

Water quality is derived from the chemical and physical characteristics of the water. Biological characteristics also play its own part on the quality. The physical parameters of the groundwater in the study area indicate that the water has high usability after treatment. However, the pH of most of the wells is low indicating high acidity. Considering the environment, which is not too far from the lagoon, the acidity may be as a result of the dump site. The TDS values classified 10 of the wells as fresh water while 5 of the wells are brackish water. The SAR indicated that the water is good for irrigation and can easily be treated for drinking. The 10 wells that are fresh water have no hazard implication while the remaining 5 are slightly hazardous. The exchangeable sodium percentage indicated that the groundwater of the study area is very close to sodic.

From the Piper diagram, the water facies is sodium chloride water which is Na-K-Cl facies. This falls in line with that of Schoeller and Stiff diagram which indicated that Na + K and Cl are most abundant in the water. The usability of the groundwater is therefore very high but if it will be consumed, it must be treated to make it potable.

Conclusion

An assessment of the quality of groundwater around Isolo Waste Dump was carried out. The physical characteristics showed that the water is good for use after some treatment. The water is acidic, while the electrical conductivity falls within SON limit and the TDS classified 10 of the water samples as fresh while 5 are brackish water. The Piper trilinear diagram classified the water as Na-K-Cl facies. This is supported by

Schoeller and Stiff diagrams which indicated that the water is rich in Na and Cl. The Durov diagram fits in with Piper, Schoeller and Stiff diagrams results. The sodium absorption ratio indicates that the water is good for irrigation since its value of 6.04 is less than 12 which is the upper limit. From the TDS, the salinity hazard for 10 wells described them as ‘no hazard’ while 5 of the samples described them as ‘slightly hazardous’. The exchangeable sodium percentage is slightly sodic. However, there is need to treat the water for it to be potable.

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