ISSN: 2634 - 8853

Journal of Engineering and Applied Sciences Technology

SCIENTIFIC Research and Community

Research Article

Open Access

Assessment of the Effects of Leachates on Groundwater Quality in Igwuruta, Ikwerre Local Government Area of Rivers State, Nigeria

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ABSTRACT

This study focuses on the assessment of the effects of leachates on groundwater quality in Igwuruta, Ikwerre Local Government Area of Rivers State, Nigeria. Ten (10) water samples comprising of five (5) leachate and five (5) borehole water samples were collected and analyzed as well as measurement of static water level (SWL). The sampling was done by using standard techniques. These analyzed parameters were compared with the World Health Organization guidelines for drinking water quality. The analyzed parameters were below the permissible limits of water quality guidelines, except for the leachate samples that were analyzed for chloride which concentrations ranges from 2850 - 3100mg/l below the 250mg/l and sulphate concentration ranges from 170.5 - 289.2mg/l below the 250mg/l. Iron concentration ranges from 3.6 - 4.7 mg/l above the permissible limits of 0.3 mg/l. The high concentrations of iron in the leachate is probably due to the dumping of metal scraps at the dumpsites, which corrodes, leaches out and infiltrates to contaminate the groundwater. The hydrochemical facies of the leachate samples corresponds to the region of saline water type (Na+ -K- Cl-- SO_4^{2-}) as a result of the high concentration of Sodium. The static water level (SWL) of the area ranges from 2.5m to 8.7m. The water level data was determined in different boreholes in the study area. The maximum static water level in the study area occurs around BH4, at 8.4m below ground surface followed by BH2, with 6.2m below the ground surface. Values of static water level decreased in BH5 at 5.7m, BH1, 3.4m and BH3 at 2.5m. These values show shallow water levels which makes the aquifer in the area vulnerable to contamination from leachate and solid wastes. It is recommended that proper waste management practice(s) should be carried out in order to maintain a high level of environmental protection and sustainability as low as reasonably practicable.

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Received: June 21, 2022; **Accepted:** June 27, 2022; **Published:** July 05, 2022

Keywords: Groundwater Quality, Leachates, Waste, Boreholes, Static Water Level, Environmental Protection

Introduction

Water is very vital to all living things hence, its importance cannot be overemphasized. The usefulness of water either for drinking, domestic or industrial purposes are determined by its quality. Groundwater is the water present beneath Earth's surface in soil pore spaces and in the fractures of rock formations. Anthropogenic activities alter the potability of groundwater in its natural state thereby making it contaminated [1,2]. Groundwater is the major source of potable water supply in the study area and Rivers State at large [3].

Waste disposal has now become a global issue especially in developing countries like Nigeria, because of the increasing rate of poverty, rapid growth in population, high rate of urbanization and ineffective funding of waste management by government agencies [4-6]. Leachates are contaminants that contaminate groundwater, it can percolate through the soil depending on the direction of groundwater flow [7].

Waste dumpsites are exposed to rainfall and as such, water percolates through the waste, picks up a variety of inorganic and organic compounds that are leached out of the wastes to accumulate at the subsurface thus, becoming a threat to groundwater. Improper solid waste management is a major environmental problem in the study area, due to indiscriminate disposal of domestic and industrial wastes, which leads to the contamination of groundwater [8]. The threat of groundwater contamination is dependent on the concentration and toxicity of contaminants in leachate, permeability and porosity of the soil, depth of the water table and the direction of groundwater flow [9].

Leachate is a contaminated liquid that is generated from water percolating through a solid waste disposal site, accumulating contaminants and moving into the subsurface to contaminate the aquifer. Leachate from dumpsites contains sufficient concentration of lead (Pb) to cause leachate contaminated groundwater to contain levels of lead (Pb) that impair the use of the groundwater for domestic water supply [10]. The leachate seeps and percolate into groundwater aquifers thus, causing groundwater contamination [11].

Improper waste disposal measures seem to become an essential environmental issue in the study area as a result of inadequate waste management. When rain falls on open waste dumpsite, the leachates which contains organic and inorganic substances percolates through the soil and could contaminate groundwater [7]. Apart from dumping of solid wastes, other potential sources of groundwater contamination are septic tanks and dumping of sewage in borrow pits [12].

Investigations by Nwankwoala and Udom, and Kekwaru and Nwankwoala have proven that infiltration of leachate can contaminate groundwater [1,13]. The impact assessment of leachate on groundwater was therefore carried out in the study area to assess the present quality status of the water. This study will show whether groundwater in the area is affected by leachate.

Brief Geology and Hydrogeology of the Study Area

The study area is located in Ikwerre Local Government Area of Rivers State. It is situated between latitudes 5^0 001N and longitudes $7^0$001E. It is accessible by road. Igwuruta is bounded by Omagwa in the North West, in the North East by Etche Local Government Area and in the South by Rukpokwu (Figure 1). Rainfalls in the study area almost all round the year and generally very heavy. The average annual rainfall is about 3200mm. The mean maximum monthly temperatures are within the range of 28°C to 33°C while the mean minimum monthly temperatures are within 17o to 24°C. The hottest months of the year are February to May. There is a very high relative humidity throughout the year and it decreases minimally during the dry season [14].

The vegetation of the study area consists of an upland area which is dominated by rainforest with economic trees such as palm trees and mahogany. The riverine area is divided into three main hydro-vegetation zones; the beach ridge zone, the saltwater zone and the freshwater zone [15]. The beach zone consists of fresh water swamp trees, palm and shrub on the sandy ridges and mangroves in the tidal flats. The salt water zone consists of the tidal flat vegetation with red stilts rooted mangrove (*Rhizophoraracemose*). The outliers of raised coastal plain terrace within the tidal flat vegetation by tall forest tree species and palm tree. The freshwater zone consists of the Upper and Lower Delta flood plains.

The Relief in the area is consists of freshwater, mangrove swamp and coastal sand ridge zone. The freshwater zone is made up of the flood plain 20m below the sea level. It consists of silts and clay and is prone to perennial inundation by river floods. The southern part is affected by tidal influence. Most water channels in the fresh water zone are bordered by natural levees, which are of topographical interest and of economic importance to the people who settle and cultivate their crops here. The upland is undulating to the hinterland, narrow strip of sandy ridges and beach ridges lie very close to the open sea. The soils of the sandy ridges are mostly sandy loams. Drainage in the study area is poor because of the low lying flood plain with much of the surface covered with water. The study area is drained by two major sources, they are; the freshwater system whose waters originate either outside or wholly from the coastal lowlands including the Bonny and Calabar river systems and other effluent creeks and streams, and a tidal system.

The Tertiary Niger Delta is a sedimentary structure that was formed due to the complex regression overlap sequence of clastic sediments with thickness ranging from 9000-1200meters [16]. Deep wells in the Niger Delta show evidence that there is a lithostratigrphic succession in which the regressive sequence is divided into three main formations [17]. These formations are the continental, transitional and marine environments. The three formations (Eocene to Recent) are designated locally, from bottom to the top as Akata, Agbada and Benin Formations. Of these three formations, the Agbada Formation constitutes the main reservoir of hydrocarbon in the Niger Delta [18].

Etu-Efeotor and Akpokodje, Edet, Edet and Okereke, and Udom et al. have carried out studies on the hydro-geology of the region and have described the Benin formation as the highest yielding water bearing zone in the Niger Delta [16,19-21]. Results of these studies reveals that several irregular, ventricular, and lateral discontinuous layers of clay aquitards, which partially sub-divides the regional aquifer in various units. The depth of water tables decreases seawards with variations from 10 meters (inland) to less than 0.5 meters at the coast [16,22]. A multi aquifer system is developed due to the interactions of sand and shale [23].

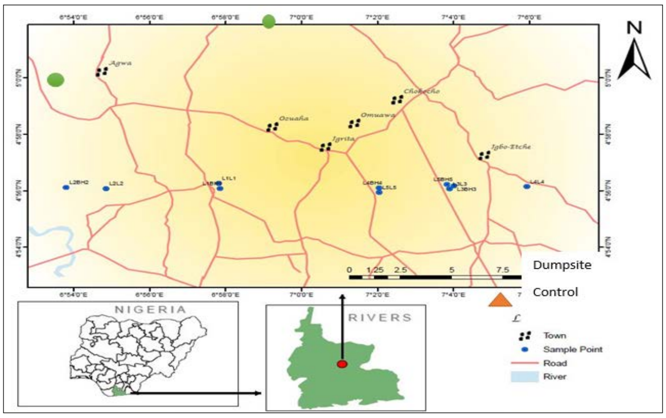

Figure 1: Map of the Study Area Showing Sampling Points

Methods of Study

Sampling Techniques

A total of ten (10) samples were collected for this study, five (5) leachate samples and five borehole water samples. The sampling was done by using standard techniques. Samples were collected in 50cl plastic bottles that were properly rinsed with the samples to be collected before collection. The water samples that were collected from the borehole were collected directly from the well head and not from the water that has passed through the treatment unit to the tank, the borehole was pumped for about 5 - 15 minutes before the samples were collected. The collected samples were filled to its brim and the cover corked, this was done to prevent the water from reacting with oxygen to falsify the result meant for analysis. Physical parameters such as Temperature, Electrical Conductivity and Total Suspended Solids of the water and leachate samples were tested in-situ due to their unstable nature. The samples collected were labeled and packed into a cooler containing ice blocks before transporting them for further analysis in the laboratory.

Static water level (SWL) is the level at which water stands in a well or unconfined aquifer when no water is being removed from it either by pumping or by flow. The static water level (SWL) of existing water boreholes in the study area were measured and recorded with a wetted tape.

In the method used, a lead weight was attached to the end of a measuring tape. Two to three meters of the tape end is dried and coated with marking chalk before each measurement was taken. The tape is lowered into the well until a part of the chalked section is below the water. The foot mark on the tape is taken note of exactly at the top of the casing. Then, the tape is pulled up and the marks were the line is wet is read. The actual depth can also be determined from the top of the casing to water level by subtracting the wetted marked from the mark that was held at the top of the casing.

Table 1: Analytical Results for Leachate Samples

Sample Identity	PH	Temperature (°C)	EC (ms)	Dissolved solids (mg/l)	Total suspended solids (mg/l)	Salinity	Sulphate (mg/l)	Chloride (mg/l)	Nitrite (mg/l)	Phosphate (mg/l)	Bicarbonate (mg/l)	Carbonate (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Sodium (mg/l)	Potassium (mg/l)	Iron (mg/l)
L1	7.3	32.5	20.0	2.4	10.0	23.0	289.2	3100.0	5.9	12.9	0.001	400.1	33.2	21.2	376.7	999.6	4.1
L2	5.6	32.0	21.4	4.6	10.2	12.4	180.4	3000.0	4.0	14.0	0.000	442.2	30.0	20.3	400.1	1000.0	4.0
L3	4.6	29.9	5.15	7.4	7.4	2.5	200.7	2850.0	6.6	10.8	0.005	380.6	35.4	22.6	500.0	857.0	4.7
L4	5.5	31.2	18.6	6.5	2.5	4.9	250.0	3100.0	3.9	10.1	0.001	450.8	31.2	19.7	350.4	1000.0	3.6
L5	6.8	28.7	22.3	4.0	4.8	7.7	170.5	2900.0	6.0	13.4	0.008	400.0	30.9	23.1	365.1	900.5	4.0
Max	7.3	32.5	22.3	7.4	10.2	23.0	289.2	3100.0	6.6	14.0	0.005	450.5	33.2	22.6	500.0	1000.0	4.7
Min	4.6	32.5	5.15	2.4	2.5	2.5	170.5	2850.0	3.9	10.8	0.000	380.6	30.0	19.7	365.1	857.0	3.6
Mean	5.9	30.8	17.5	4.3	6.9	10.1	185.7	2990.0	5.3	12.2	0.003	414.7	32.1	21.4	398.5	951.4	4.1
WHO (2006)	8.5	NA	500	NA	NA	NA	250	250	50	NA	NA	NA	50	7.5	200	200	0.3

Table 2: Analytical Results for Borehole Samples

Sample Identity	**PH**	**Temperature (°C)**	**EC (ms)**	**Dissolved solids (mg/l)**	**Total suspended solids (mg/l)**	**Salinity**	**Sulphate (mg/l)**	**Chloride (mg/l)**	**Nitrite (mg/l)**	**Phosphate (mg/l)**	**Bicarbonate (mg/l)**	**Carbonate (mg/l)**	**Magnesium (mg/l)**	**Calcium (mg/l)**	**Sodium (mg/l)**	**Potassium (mg/l)**	**Iron (mg/l)**
BHI	5.8	31.3	0.04	6.1	0.02	0.00	0.12	8.0	1.60	0.031	0.001	0.001	0.27	0.07	0.400	ND	0.100
BH2	9.0	30.0	0.08	4.9	0.09	0.00	0.20	8.0	2.00	0.040	0.002	0.000	0.30	0.06	0.500	ND	0.070
BH3	5.7	32.8	0.05	7.6	0.04	0.01	0.10	12.4	1.45	0.030	0.000	0.005	0.38	0.68	0.508	0.000	0.110
BH4	5.9	30.9	0.00	5.5	0.08	0.05	0.70	10.6	1.46	0.040	0.001	0.002	0.25	0.75	0.480	0.003	0.100
BH5	5.6	31.4	0.46	4.7	0.10	0.02	0.15	7.2	2.10	0.058	0.000	0.001	0.29	0.55	0.600	0.001	0.068
Max	9.0	32.8	0.46	7.6	0.10	0.05	0.70	12.4	2.10	0.058	0.002	0.005	0.38	0.75	0.600	0.003	0.110
Min	5.6	30.0	0.00	4.7	0.02	0.00	0.10	8.0	1.46	0.030	0.000	0.000	0.25	0.06	0.400	0.000	0.068
Mean	6.4	31.3	0.13	5.7	0.06	0.02	0.25	9.2	1.72	0.040	0.0008	0.0018	0.30	0.42	0.497	0.0008	0.090
WHO	8.5	NA	500	NA	NA	NA	250	250	50	NA	NA	NA	50	7.5	200	200	0.3

Table 3a: Analytical Results of Heavy Metals in Leachate Samples

Locations	Cd (mgl)	Zn (mg/l)	Pb (mg/l)	Cu(mg/l)
L2	0.451	0.640	0.049	0.003
L3	0.021	0.250	0.035	0.287
L4	0.086	0.481	0.066	0.300
L5	0.063	0.343	0.284	0.415
Max	0.451	0.640	0.284	0.385
Min	0.09	0.250	0.035	0.003
Mean	0.126	0.412	0.325	0.278
WHO (2006)	0.3	3.0	0.01	2.0

Table 3b Analytical Results of Heavy Metals in Borehole Samples

Locations	Cd(mg/l)	Zn(mg/l)	Pb(mg/l)	Cu(mg/l)
BH1	0.008	0.046	0.015	0.037
BH2	0.023	0.534	0.002	0.003
BH3	0.015	0.128	0.280	0.185
BH4	0.048	0.243	0.110	0.018
BH5	0.010	0.057	0.074	0.038
Max	0.048	0.534	0.280	0.185
Min	0.008	0.046	0.002	0.003
Mean	0.021	0.201	0.096	0.250
WHO (2006)	0.03	3.0	0.01	2.0

Table 4: Static Water Level from Existing Water Boreholes in the Study Area

S/no	Location	S.W.L (m)
1	BH1	3.4
2	BH2	6.2
3	BH3	2.5
4	BH4	8.4
5	BH5	5.7
6	BH6	4.5

Discussion of Results of Physical Properties

Temperature

The temperature in the leachate samples analyzed ranges from 28.7°C-32.5°C with a mean value of 30.8°C and analyzed borehole samples ranges from 32.8°C-30.0°C with a mean value of 31.3°C. Temperature alters the physical and chemical parameters of the samples. When the temperature is high, the rate of chemical reaction in the sample and the solubility of gases such as carbon dioxide, nitrogen and oxygen increase while others decreases when the temperature is low.

Electrical Conductivity

The electrical conductivity values that were obtained from the analyzed leachate samples ranges from 22.3µS/cm -5.15 µS/cm and a mean value of 17.515 µS/cm and the analyzed borehole samples ranges from 0.46µS/cm- 0.00 µS/cm with a mean value of 0.13µS/cm The electrical conductivity of the samples are directly proportional to the total dissolved solids. The electrical conductivity of the samples are influenced by the concentration and composition of dissolved salts.

Total Dissolved Solids

The leachate samples has a range of 10.2mg/l-2.5mg/l with a mean value of 7.6mg/l and for borehole water samples, it ranges from 0.10mg/l -0.02mg/l with a mean value of 0.06mg/l. The measured values of pH, Temperature, Electrical Conductivity, Dissolved Oxygen, Total Dissolved Solids and Salinity for leachates and borehole samples are presented in Tables 1 & 2).

Chemical Properties

The pH of the samples analyzed for leachate ranges between 4.8 - 7.0with a mean value of 5.9 5.6 - 9.0 with a mean value of 6.4 for borehole samples.

P^H is an expression of the neutrality of acid or alkali in water. The scale between 0-7 implies acidity, 7 neutral and 7-14 alkalinity. Changes in p^H occurs basically due dumping of industrial and domestic wastes that are hazardous to human health and the environment. Hence, making the water not potable for drinking and other purposes. For the leachate samples, the p^H is acidic and for the borehole p^H is alkaline, the results shows that the pH is not within the permissible limits of 6.5 - 6.8 for WHO (2006) for leachate and borehole samples. Leachate samples analyzed for salinity ranges from 2.3 - 2.5 with a mean value of 8.5mg/l and the range for borehole sample is 0.00 - 0.05 with a mean value of 0.016. The dissolved oxygen in the water samples for leachate ranges from 2.4mg/l - 7.4mg/l with a mean value of 4.9mg/l and for the borehole water sample, dissolved oxygen ranges from

4.6mg/l - 7.6mg/l with a mean value of 5.7mg/l.

Concentration of Anions

The concentration of sulphur ranges from 170.5mg/l - 289.2mg/l with a mean value of 182.1mg/l in leachate samples from 0.10mg/l - 0.70mg/l with a mean value of 0.24mg/l for borehole water samples. The concentration of chlorine ranges from 2850mg/l - 3100mg/l with a mean value of 2990mg/l for leachate sample and 7.2mg/l - 12.4mg/l and a mean value of 9.2mg/l for borehole samples. Nitrite concentration ranges from 3.9mg/l - 6.0mg/l with a mean value of 5.2mg/l for leachate sample and 1.4mg/l - 2.1mg/l with a mean value of 1.7mg/l for borehole samples.

The concentration of phosphate ranges from 10.1mg/l - 14.0mg/l with a mean value of 12.2mg/l for leachate concentration and 0.031mg/l - 0.058mg/l with a mean concentration of 0.039mg/l for borehole samples. The concentration of Bicarbonate ranges from 0.000mg/l - 0.008mg/l with a mean value of 0.003mg/l for leachate sample and 0.000mg/l - 0.002mg/l with a mean value of 0.0008mg/l for borehole samples of Carbonates (CO_3) concentration ranges from 380.6mg/l - 450.8mg/l with a mean value of 414.7mg/l for leachate samples and 0.000mg/l - 0.005mg/l with a mean value of 0.42mg/l for borehole samples.

Concentrations of Cations

The concentration of magnesium in the analyzed samples ranges from 30.0mg/l - 35.4mg/l with a mean value of 25.1mg/l for leachate samples from 0.25mg/l - 0.38mg/l with a mean value of 0.29mg/l for borehole water samples. The concentration of calcium ranges from 23.1mg/l-19.7mg/l with a mean value of 21.3mg/l for leachate concentration 0.06mg/l - 0.75mg/l with a mean value of 0.37mg/l for borehole samples. The concentration of sodium in the analyzed samples ranges from 350.4mg/l - 500.0mg/l with a mean value of 398.4mg/l for leachate samples 0.427mg/l - 0.550mg/l with a mean value of 0.493mg/l for borehole samples. The concentration of potassium ranges from 857mg/l - 1000mg/l with a mean value of 951mg/l for leachate samples from 0.000mg/l - 0.003mg/l with a mean value of 0.008mg/l for borehole samples. The concentration of iron in the analyzed samples ranges from 3.6mg/l - 4.7mg/l with a mean value of 4.1mg/l for leachate samples from 0.074mg/l - 0.110mg/l with a mean value of 0.09mg/l for borehole water sample.

Heavy Metals Concentrations

The concentration of cadmium in the analyzed leachate samples ranges from 0.09mg/l - 0.451 with a mean value of 0.126 mg/l and 0.008mg/l - 0.048mg/l with a mean value of 0.021mg/l for borehole samples. The concentration in leachate sample is higher than that of borehole sample when compared with permissible limit of 0.03mg/l of WHO [24].

Zinc ranges in concentration between 0.250mg/l - 0.640mg/l with a mean value of 0.412mg/l for leachate and 0.046mg/l - 0.243mg/l with a mean value of 0.201mg/l for borehole samples. They both have a low concentration when compared with the WHO standard which permissible limit is 3.0mg/l [24].

The concentration of lead ranges from 0.035mg/l to 0.284mg/l with a mean value of 0.325mg/l for leachate samples and 0.002mg/l to 0. 280mg/l with a mean value of 0.096mg/l for borehole samples. The leachate and borehole samples have lower concentrations when compared with the WHO limit of 2.0mg/l [24].

The concentration of lead ranges from 0.003mg/l to 0.385mg/l with a mean value of 0.278mg/l for leachate samples and 0.003mg/l to 0.185mg/l with a mean value of 0.250mg/l for borehole samples. The leachate and bore samples have higher concentrations when compared with the WHO limit of 0.01mg/l. Figure 2 is the heavy metal readings in the Leachate samples at different locations [24].

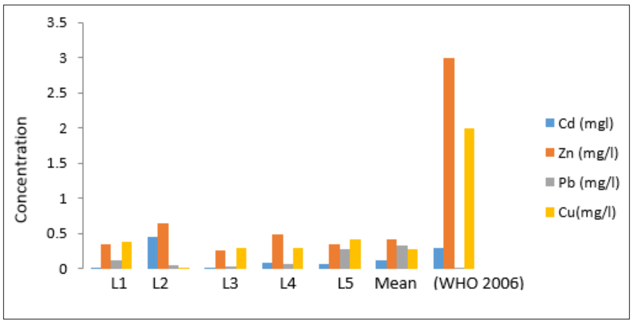

Figure 2: Heavy Metal Readings in the Leachate Samples at Different Locations

Hydrochemical Facies

Hydrochemical facies is used to determine the diagnostic chemical aspect of groundwater solutions occurring in hydrologic systems. The facies reflect the response of chemical processes operating within the lithologic framework and also the pattern of flow of the water.

The Piper trilinear diagram is used in the classification of the hydrochemical facies present within the analyzed water samples [25]. The geochemical evolution of groundwater in the study area can be understood by plotting the concentration of major cations and anions in the Piper trilinear diagram. It is a combination of cations and anions triangle that lies on a common base line, the position of the analyzed sample that is plotted on the Piper diagram is used to make a tentative conclusion of the origin of the water represented by the analysis. Four basic conclusions can be driven from the multiple analysis plotted on the Piper diagram. These are water type, precipitation or solution, mixing and ion exchange.

Piper diagram divides water into four basic types according to their placement near the four corners of the diamond. Water that plots at the top of the diamond is high Ca^{2+} + Mg $^{2+}$ and Cl- +SO_4^{2-} which results in an area of permanent hardness. The water that plots near left corner is rich in Ca^{2+} +Mg^{2+} and HCO_3^- is the region of water of temporary hardness. The water that is plotted at the lower corner of the diamond is primarily composed of alkali carbonates (Na^+ +K^+ and HCO_3^- +CO_3^-), water lying near the right hand side of the diamond may be considered saline (Na^+ +K^+ and Cl- +SO_4^{2-}) The borehole data of the study area is plotted on the Piper trilinear diagram in figures 3 & 4.

The results that were generated from the analysis of leachate and borehole samples are discussed on the bases on its suitability of water quality for drinking and domestic usage. The variation of the hydrochemical facies of leachates and borehole samples are only suitable for irrigation purposes. The results shows that all the analyzed parameters for leachate concentration exceeded the WHO guidelines for drinking water quality expect sulphate concentration for L4 which meets the permissible limit of WHO drinking water quality guidelines (Tables 5 & 6). While the parameters that were analyzed for borehole samples are all below the permissible limits of WHO drinking water quality guidelines [24]. The static water level of the area ranges from 2.5m to 8.7m. The water level data was determined in different boreholes in the study area. The maximum static water level in the study area occurs around BH4, at 8.4m below ground surface followed by BH2, with 6.2m below the ground surface. Values of static water level decreased in BH5 at 5.7m, BH1, 3.4m and BH3 at 2.5m. These values show shallow water levels in the study area which makes the aquifer in the area vulnerable to contamination from leachate and solid wastes.

Table 5: Analytical Results for the Leachate in Milliequivalents per Litre

	Leachate Cations								Leachate Anions								
Sample Identity	Mg		Ca		Na		K		Na+k		$SO;^{2}_{4}$		Cl		HCO3		CO_3
	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)
L1	33.2	3.32	21.2	2.12	376.7	37.67	999.6	99.96	137.63	289.2	28.92	3100	31.00	0.001	0.0001	400.1	40.01
L2	30.0	3.00	20.3	2.03	400.1	40.01	1000	10.00	50.01	180.4	18.04	3000	30.00	0.000	0.000	442.2	44.22
L3	35.4	3.54	22.6	2.26	500.1	50.01	857.0	85.7	135.71	200.7	20.07	2850	28.50	0.005	0.0005	380.6	38.06
L4	31.2	3.12	19.7	1.97	350.4	35.04	1000	100	135.04	250	2.50	3100	31.00	0.001	0.0001	450.8	45.08
L5	30.9	3.09	23.1	2.31	365.1	36.51	900.5	90.05	126.56	170.5	17.05	2900	29.00	0.008	0.0008	400.0	40.00

Table 6: Analytical Results for Borehole Water Samples in Milliequivalents per Litre

	Borehole Cations								Borehole Anions								
Sample Identity	Mg		Ca		Na		K		Na+k		$SO;^{2}_{4}$		Cl		HCO3		CO_3
	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)	Conc. (mg/l)	Conc. (meq./l)
BH1	0.27	0.027	0.07	0.007	0.400	0.04	0.000	0.000	0.04	0.12	0.012	8.0	0.8	0.001	0.0001	0.001	0.0001
BH2	0.30	0.03	0.06	0.006	0.500	0.05	0.000	0.000	0.05	0.20	0.002	8.0	0.8	0.002	0.0002	0.000	0.000
BH3	0.38	0.038	0.68	0.068	0.480	0.048	0.003	0.0003	0.0483	0.10	0.01	12.4	1.24	0.000	0.0000	0.005	0.0005
BH4	0.25	0.025	0.75	0.075	0.600	0.06	0.001	0.0001	0.0601	0.70	0.07	10.6	1.06	0.001	0.0001	0.002	0.0002
BH5	0.29	0.029	0.55	0.055	0.600	0.06	0.003	0.0003	0.0603	0.15	0.015	7.2	0.72	0.002	0.0002	0.005	0.0005

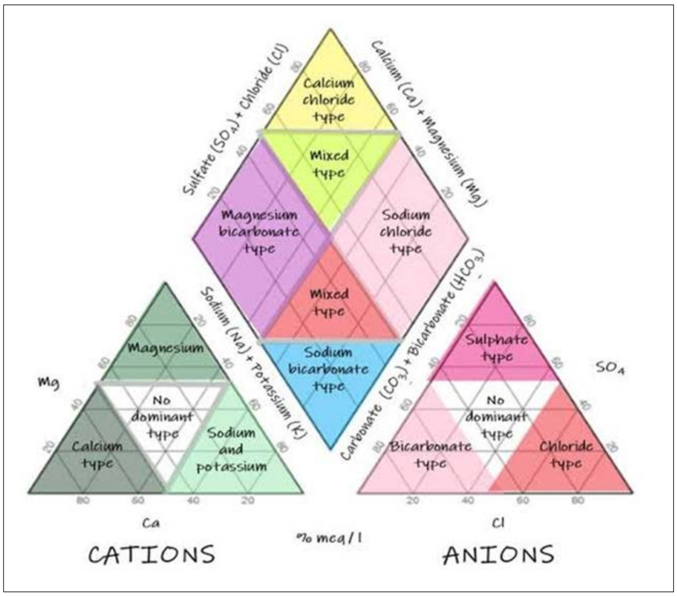

Figure 3: Hydrochemical Facies Classification after Piper (1944)

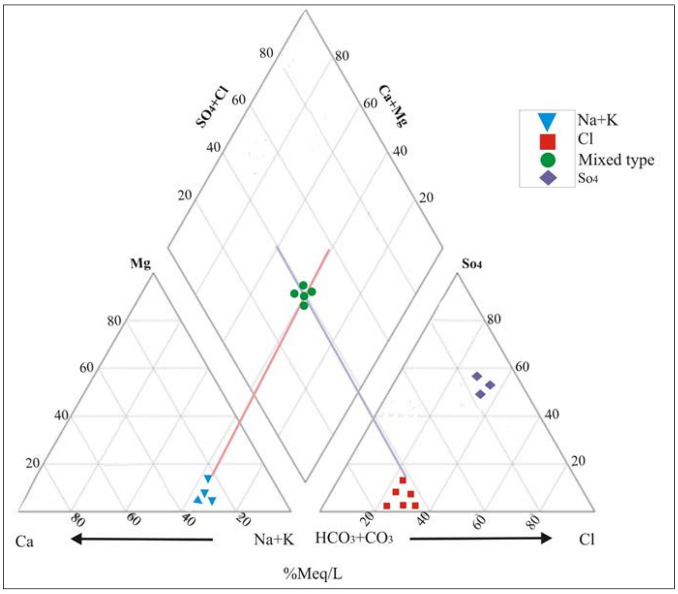

Figure 4: Classification of Borehole Water Sample Using Piper Diagram

Conclusions

This study assess the impact of leachate on groundwater in Igwuruta in Ikwerri Local Government Area of Rivers State. Using physico- chemical analyses of leachate and borehole samples and comparing the laboratory results with internationally acceptable standards. Measurement of static water level (SWL) and borehole logs to delineate the lithology of the area. The analyzed samples for leachate shows that chloride, calcium, sodium and potassium are all above the permissible limits of the World Health Organization guidelines for drinking water quality. While PH, Electrical conductivity, nitrite, magnesium and iron are below the permissible limits of the Health Organization guidelines for drinking water quality. All the analyzed borehole samples were below the stipulated requirements that were set up by the World Health Organization guidelines for drinking water quality except for PH in BH2 that is slightly alkaline [24].

The hydrochemical facies analyses for the samples shows that the leachate sample which is classified as a type two (2) water which corresponds to the region of saline water. This suggest that the water is not really adequate for drinking because of the shallow nature of the groundwater which makes it susceptible to contamination from leachate and solid wastes.

Results revealed that chloride, sodium and potassium were above the recommended standard. It is therefore recommended that these parameters should be treated and proper engineered landfill system be practiced in the dumpsites to reduce the infiltration rate of leachate, hence contaminating groundwater. And also, proper waste management practices such as burying of biodegradable and combusting or recycling of non-biodegradable wastes should be adhered to in order to maintain a high level of environmental protection and sustainability.

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