Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 7 ~ Issue 10 (2021) pp: 76-82
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Assessment of Physicochemical Characteristics of Groundwater aroundanUnlined Landfillin Aba, Southeastern Nigeria

Ubechu, B. O., Ikoro D. O.,Irefin, M. O.,Israel, H. O., Mohammed,A. T.

ABSTRACT
In this study, the effect of the leachate from an open unlined landfill site in Aba, a commercial city in Southeastern Nigeria on groundwater is investigated. A total of 48 groundwater and 2 leachate sampleswere collected and were analyzed for various physical and chemical parameters and major ions according to standard methodsfor dry and rain seasons using AAs and titrimetric methods. Pearson correlation was used to determine the relationship between two parameters. The results showed that the physicochemical parameters, temperature,electrical conductivity (EC), biochemical oxygen demand (BOD), Cl^-, HCO_3^-, SO_4^{2}, NO_3^-, Ca^{2+}, Mg^{2+}, K^+ and Na^+ in both seasons are below the maximum admissible limits approved by World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality(NSDWQ). Dissolved Oxygen Demand (DO) and Chemical Oxygen Demand (COD) have mean values higher than the permissible limits in rain but lower in dry season. The pH values for rain and dry seasons ranged from 3.38 to 6.95 and 4.47 to 6.25 with mean values of4.86 and 5.21respectively showing acidic condition and are not within the permissible limits set by WHO and NSDWQ standards. Groundwater in the study area is not hard, is fresh and acidic in nature. It falls within safe to tolerable to some extent category in rain and dry seasons respectively. The geo-statistical analysis revealed a perfect association between TDS and EC in both seasons. A very strong positive association was found to exist between COD, DO and BOD in both seasons also. Continuous and uncontrolled accumulation of waste leading to the production of leachate in the landfill will pose a potential risk to the source of water to the communities living around the landfill site. It is recommended that there should be continuous monitoring of groundwater resources in the area.

KEY WORDS: Groundwater . Landfill .Solid waste .Pollution .Leachate . Physicochemical

Received 13 October, 2021; Revised: 25 October, 2021; Accepted 27 October, 2021

I. INTRODUCTION

Unlined landfills have become the choice for the repositories for municipal wastes collected from various parts of the metropolis.This is as a result of the absence of engineered sanitary landfills in many cities in Nigeria. The choice of these unlined pits is often done without proper Environmental Impact Assessments (EIA) on the suitability of such sites as waste disposal sites. Unlined landfills are land from which earth materials have been excavated from for other uses and creating borrow pits which exposes a large portion to the vadose zone bringing the position of the water table very close to the bottom of the pit. Hence leachate can migrate from unlined landfill and can contaminate groundwater around waste dumps. Water because of its polarity and hydrogen bond can dissolve, absorb, adsorb or suspend different substance (Oyelami, *et al.*, 2013, Aderemi, *et al*., 2011, WHO, 2007, Mendie, 2005). Therefore there is need for general measure and specific checks for groundwater constituents. This study was designed to study the effects of the unlined landfill on the water resources being used for drinking and other domestic uses at Aba, southeastern Nigeria by checking for the presence of contaminants to prevent the consumers from harm.

Study Area Description

The study area is located between latitude 5.07°N 7.22°SE and longitude 5.177°N 7.367°E in the South Eastern region Nigeria (Figure 1). Aba as a town is a major economic contributor in the country Nigeria because it is a commercial city and hosts to industries of both small and large scale. Aba lies within the rain forest zone in the Southeastern Nigeria. It has two seasons, the dry season and rainy season in a year. The rainfall regime is bimodal and its peaks are in July and September with little dry season known as August break in-between. The mean annual rainfall of Abia State is between 2550mm and 2890mm. The mean temperature of the city is between 24^{o}C to 34^{o}C and relative humidity of 70% in dry season and 90% in rainy season.

The geology of a place should be well understood before any meaning work on soil and water contamination can be done. This is because the dispersion of contaminants is influenced by the soil porosity as well as the rate of water movement. While some materials may allow contaminants to infiltrate through it to groundwater, others may allow the contaminants to build up around it to a significant level. Sometimes, geology may be the source of contamination. Therefore, the geology of the study area will be understood as this will help in its geo-environmental risk assessment.

Aba lies within a geological area known as the Niger Delta Basin. Short and Stauble (1967); Adegoke, O.S., (1969); Nwajide, C.S., (2013); geologically, classified the study area into three basic Formations having the Akata Formation at its base, the Agbada Formation at the middle and the Benin Formation which is recent at the top. The Benin Formation is the Formation that outcropped in the study area. It is a fresh water bearing formation consists of coastal plain sand which is unconsolidated and dominantly sandy.

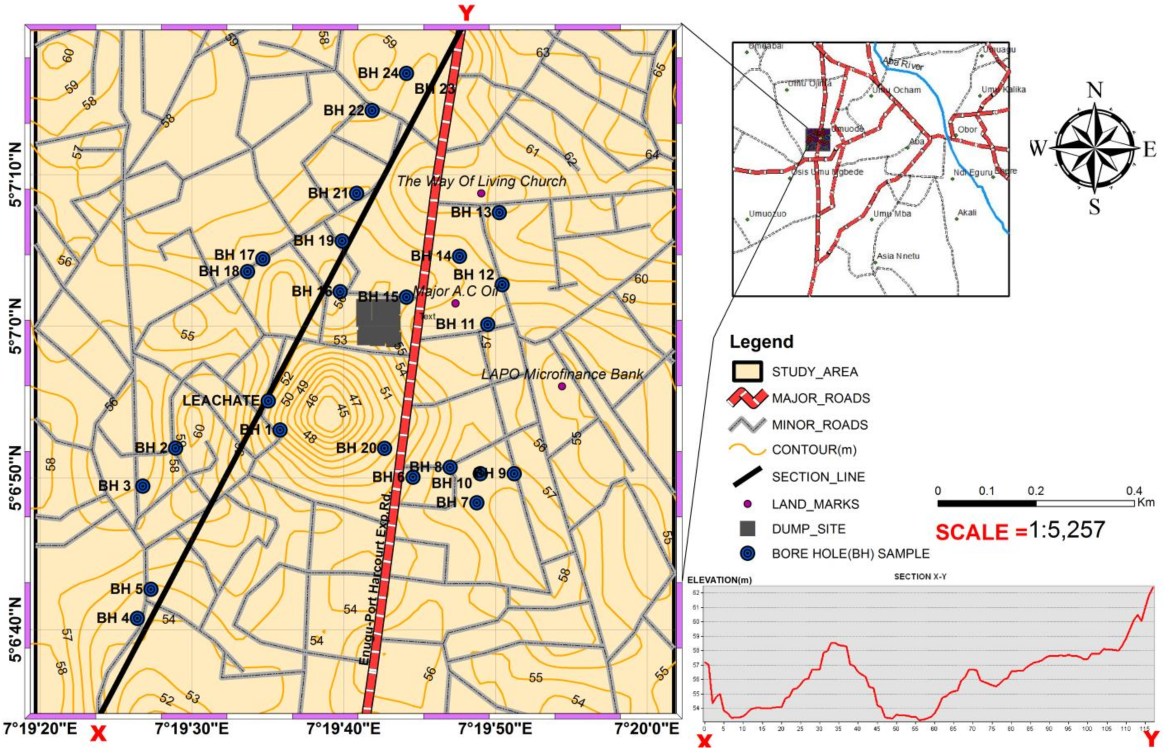

Figure 1: Map of the study area showing the groundwater sampling points.

II. MATERIALS AND METHODS

Sampling was done within the rainy season months of May, June and July while the dry season sampling was done in December, January and February. Water sample were collected to cover industrial, commercial, and residential areas. The water samples were collected directly from boreholes after 5 minutes of pumping from boreholes around the dumpsite. They were collected with labeled polyethylene bottles and kept away from the sun and heat in Styrofoam boxes with ice and then transferred to the laboratory within 12 hrs of collection. Before the bottles were used to collect water samples, they were rinsed with the water sample to be collected to minimize the chance of any contamination. Some of the parameters were recorded in-situ at the point of sampling while the analyses of other various water quality parameters were conductedfollowing standard analytical methods as described by APHA (1998). Results of the laboratory analysis were compared with International standards for drinking water (WHO, 2011) and Nigerian Standards for Drinking Water Quality Guidelines (NSDWQ, 2007) respectively. A total of 50 samples were collected for rain and dry seasons.

III. RESULTS AND DISCUSSIONS

The results of the physicochemical analysis of groundwater around the unlined landfill in rain and dry seasons are presented in Table 1 and Table 2. From the Tables the pH values ranges from 3.38 to 6.95 with a mean value of 4.86 in the rainy season and 4.47 to 6.76 with a mean value of 5.21 in the dry season against the NSDWQ (2007) and WHO (2011) standards of 6.50 – 8.50. These average pH values shows the acidic nature of the groundwater in this area throughout the sampling periods. This indicates the presence of toxic metals in the water (Akinbile and Yussof, 2011). It can also be attributed to landfill gases arising from the unlined landfill as a result of the decay of organic matter from the dumpsite which has percolated through the porous subsurface to the aquifer as well as the quality of leachate from the landfill. This result is in agreement with the findings of Akinbile and Yussof (2011) that discovered that groundwater samples from boreholes around a landfill had an acidic pH values. Aba the study area is a commercial and industrial city that house different types of manufacturing industries of different scales. These industries emits gases containing CO_2, NO_3 and SO_2 which are dissolved in the rain and fall as weak acid that infiltrates into the groundwater causing the groundwater to be acidic (Ojekunle, et al., 2020).

Electrical Conductivity is a measure of the ability of a solution to conduct electric current. This therefore depends on the concentration of ions in water. Therefore the higher the concentration of ions, the higher the electrical conductivity while the lower the ionic concentration, the lower the electrical conductivity implying low inorganic content. The range of the Electrical conductivity values are 10 - 1770 (µS/cm) in the rainy season and 30 – 1000 (µS/cm) in the dry season with an average of (187 µS/cm) in the rainy season and 116.8 (µS/cm) in the dry season. All the samples apart from Leachate sample in the rainy season are below the permissible limit of 1000 (µS/cm). Using salinity classification by Wilcox 1955 (Table 3), it was observed that the water quality in the study area falls within the safe water category apart from leachate in the rainy season which falls in tolerable to some extent category.

Table: 3 Classification of Groundwater (after Wilcox, 1955) EC (µS/cm).

Class	Conductivity Range (Wilcox, 1955)	Quality of water
I	< 1000	Safe
II	1000 – 1500	Tolerable
III	1500 – 2000	Tolerable to some extent
IV	2000 – 2500	Intolerable
V	>2500	Health Hazard

The large variation in EC values may be attributed to the anthropogenic influences in the area.
The total dissolved Solids (TDS), has a range of 6.5 – 1150.5 with an average of 75.92 in rainy season and 19.5 – 650.0 with an average of 121.53 in the dry season. Only the leachate and BH20 samples are >500 the permissible limit. BH 20 is located very close to the dumpsite and it is used as a car wash center. According to TDS classification by Freeze and Cherry in Table 4, the water type is fresh water type because TDS < 1000, (Freeze and Cherry 1979).

Table 4: Simple Groundwater Classification Based on Total Dissolved Solids.(Freez and Cherry, 1979).

Category	Total dissolved solids (mg/l or g/m3)
Fresh water	0-1000
Brackish water	1000-10,000
Saline water	10,000-100, 000
Brine water	More than 100,000

The high concentration of EC and TDS in the leachate and BH20 can be attributed to the presence of inorganic components from the disposal of large quantities of industrial waste within the dumpsite. Maiti et al., (2016) also obtained high level concentration of EC and TDS from leachate sample.

The variations for Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Dissolve Oxygen (DO), 0.2 - 12.6 and 0.1 – 2.50, 0.32 – 12.8 and 0.06 – 1.00, 2.1 – 9.60 and 0.6 - 4.90 for rainy and dry season respectively. Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} varied as follows 1.68 – 151.39 and 4.21 – 42.89, 0.59 – 72.85 and 1.18 -21.95, 3.40 – 80.00 and 0.19 – 5.34, 0.334 – 80.50 and 35.00 – 115.00 in rainy season and dry season. SO_4^{2-} varied from 0.00 – 5.00, in rainy season to 0.00 – 35.00 in dry seasons. These are within the range as described by Akobundu and Nwankwoala, (2013), which shows that the groundwater around the study area is free from possible sulphate toxicity which includes gastrointestinal irritation. The low level of SO_4^{2-}could be as a result of sulphate reducing bacteria (SRB) present in the water which is capable of reducing sulphates (SO_4^{2-}) to sulphides (S^-) (Oyelami*et al,* 2013, Abdurafui*et al*., 2011). The bicarbonate (HCO_3^-) concentrations in both seasons ranged from 0.00-3892.00mg/L for rain with an average value of 155.70mg/L, and from 40.00-228.00mg/L and a mean value of 88.00mg/L for dry season. Only the leachate sample recorded HCO_3^- concentration in rain season. The high concentration of bicarbonate in the leachate sample may be as a result of the decomposition of organic matter in the unlined landfill (Khashogji and El Maghraby 2013, Saha, *et al*., 2019).Nitrate (NO_3^-) values ranged from 4.80-83.00mg/L with an average value of 18.26 mg/L in rain season and ranged from 8.00-52.00mg/L with an average value of 21.82mg/L. The mean values of all the physicochemical parameters were below the permissible limits in both seasons except DO and COD in rain season values which were slightly higher. In a similar analysis carried out by Giadom et al., 2014, in Ariaria dumpsite in Aba, similar results were also obtained.

The low levels of BOD and COD concentrations values indicate low organic content which means that the waste dumpsite receives little waste of organic origin. Hence low deamination process of amino acids during decomposition of organic compounds leading to low concentration of Nitrogenous compounds like Nitrites and Nitrates (Crawfor and Smith, 1985).

Seasonal Correlation of Hydrochemical Parameters

Table 5 and Table 6shows the correlation relationship between parameters. In both seasons, water temperature showed no correlation with other parameters. Positive correlation were found to exist between pH and Cl^- , Ca^{2+}, Na^+, K^+, in rain with high negative correlation with DO. In addition, in dry seasongood correlations also occurred with pH and Cl^-, HCO_3^- and Na^+. Although K^+ had high positive correlations with Na^+, Cl^-, and pH in rain season, such correlation became very poor in dry season. It is interesting to note that TDS had a perfect positive with EC in both seasons. This shows the fact that EC depends on the amount of dissolved ion in water at a larger extent (Ganiyu, *et al*., 2018). This result agrees with the earlier work reported by (Mokuolu, *et al*., 2017, Ojekunle, *et al*., 2020). Positive correlations were observed between HCO_3, EC, TDS, BOD, Ca^{2+}, Mg^{2+}, NO_3^-, Cl^- and pH in rain and dry seasons. Na^+ had a highpositive correlation with Cl^-, and pH in rain season, while in dry season it had a positive correlation with Mg^{2+} and pH. This means that the association of Na^+ with other parameters is affected by the acidic nature of the groundwater. NO_3^-, Mg^{2+} and Cl^- had a positive correlation in rain season with EC, TDS and BOD than in dry season where Mg^{2+} andNO_3^- had no correlation with any parameter. High positive correlation also exist between COD, BOD and DO in both seasons.

Table 1: Rain Season Physicochemical Parameyeters

Rain Season	Temp.^{0}C	pH	EC, µS/cm	DO, mg/L	TDS, mg/L	BOD, mg/L	COD, mg/L	Total Cl, mg/L	Ca2+, mg/L	Mg, mg/L	N03, mg/L	HCO3, mg/l	Na mg/L	K, mg/L	SO4, mg/L
BH1	28.4	5.39	40	2.5	26	1.7	2.72	22.46	4.21	0.59	26.4	0	7.36	0.556	5
BH2	29.4	4.86	20	9.0	13	5.8	9.28	16	3.36	1.18	33.9	0	6.54	1.203	ND
BH3	28.5	4.8	10	8.6	6.5	4.2	4.2	9.24	5.05	1.19	28.1	0	5.89	0.403	ND
BH4	30.3	4.62	10	8.5	6.5	3.9	6.24	15.3	3.36	1.18	20.2	0	7.22	0.501	ND
BH5	30.5	4.55	10	4.8	6.5	0.2	0.32	18.2	5.89	0.59	23.9	0	6.1	0.334	ND
BH6	30.6	3.38	110	7.1	71.5	3.1	4.96	60.34	5.89	1.78	18.4	0	6.74	0.448	ND
BH7	28.2	3.75	80	7.9	52	3.1	4.96	48.28	8.41	1.19	13	0	5.36	5.36	0.039
BH8	29.0	3.61	110	8.0	71.5	4.2	6.72	64.27	7.57	2.97	18.4	0	4.18	4.18	ND
BH9	29.7	4.39	30	8.7	19.5	4.6	7.36	18.3	2.52	1.78	13.8	0	3.84	3.84	0.003
BH10	28.9	4.43	10	7.5	6.5	2.8	4.48	32.21	3.36	1.78	13.3	0	5.1	5.1	0.154
BH11	30.6	4.2	10	7.7	6.5	7.0	11.2	20.31	4.21	1.19	13.7	0	3.4	3.4	ND
BH12	29.0	4.96	10	7.0	6.5	4.0	6.4	16.38	2.52	0.59	10.9	0	4.48	4.48	0.031
BH13	29.7	5.76	10	7.6	6.5	3.6	5.76	26.13	1.68	1.19	14.4	0	4.28	4.28	0.073
BH14	30.7	4.26	20	6.0	13	0.8	1.20	28.81	3.36	1.78	14.9	0	3.76	3.76	ND
BH15	28.2	4.01	30	9.0	19.5	5.0	8.02	24.12	4.21	1.78	11.8	0	5.53	5.53	0.034
BH16	30.2	4.92	10	9.2	6.5	4.9	7.84	34.82	1.68	2.37	11.9	0	5.29	5.29	0.039
BH17	27.5	3.95	20	9.5	13	6.3	10.08	42.74	3.36	2.37	10.6	0	4.12	4.12	0.029
BH18	28.7	3.99	20	9.6	13	5.5	8.8	38.42	2.52	2.37	13.5	0	3.97	3.97	ND
BH19	29.0	3.87	30	9.5	19.5	5.7	9.12	243.68	4.21	2.97	16.3	0	32.53	32.53	0.16
BH20	29.0	6.95	260	8.5	169	8.0	12.8	286.93	84.11	4.75	22.8	0	46.97	46.97	0.071
BH21	28.3	6.52	30	3.8	19.5	0.5	0.8	692.41	3.364	0.921	4.8	0	34.33	34.33	ND
BH22	29.4	5.32	60	4.3	39	0.9	0.54	783.52	2.523	6.171	5.0	0	74.58	74.58	ND
BH23	28.9	6.21	80	4.2	52	0.8	1.28	2241.22	4.21	3.37	8.4	0	69.32	69.32	ND
BH24	28.8	6.02	130	4.4	84.5	0.5	0.8	561.22	5.89	1.76	5.2	0	80.5	80.5	ND
Leachate	29.3	6.85	1770	2.1	1150.5	12.6	12.46	759.84	151.39	72.85	83	3892	72.23	72.23	0.035
Mean	29.2	4.86	116.8	7.0	75.92	3.98	5.93	244.21	13.154	4.83	18.3	155.68	20.14	18.69	0.472
STDEV.	0.8712	1.024677	349.08	2.3022	226.9	2.8316	3.818	486.47	32.99	14.23	15.3	778.4	26.51	27.40	1.427

ND- not dictated

Table 2: Dry Season Physicochemical Parameters

Dry Season	Temp. °C	pH	EC µS/cm	TDS mg/L	DO mg/L	BOD mg/L	COD mg/L	Cl mg/L	Ca mg/L	Mg mg/L	N03 mg/L	HCO3 mg/L	N mg/L	K mg/L	SO4 mg/L
BH1	29.1	5.87	300	195	1.4	0.8	0.32	208.3	9.25	21.95	9.8	120	5.39	70	ND
BH2	28.4	5.75	100	65	0.8	0.4	0.24	55.87	6.73	14.24	30.1	76	2.98	115	ND
BH3	27.1	6.21	70	45.5	2.0	0.9	0.36	52.32	9.25	5.34	9.6	120	5.25	35	ND
BH4	27.8	5.73	100	65.0	0.6	0.2	0.12	48.78	6.73	6.53	35.5	76	2.75	35	ND
BH5	28.5	5.43	60	39.0	1.8	0.7	0.42	39.56	5.89	7.12	25.8	68	2.39	70	ND
BH6	28.2	5.84	500	325	1.6	1.3	0.52	276.37	14.29	3.56	39.8	104	2.47	90	ND
BH7	28.5	4.99	290	188.5	1.5	1.0	0.4	100.54	8.41	10.08	19.0	84	2.28	85	ND
BH8	29.2	4.52	380	247	1.9	0.7	0.42	105.5	17.66	9.81	30.9	84	2.84	70	5
BH9	28.8	5.14	160	104	0.7	0.2	0.12	67.21	10.93	2.37	18.2	92	1.38	90	ND
BH10	28.2	4.75	250	162.5	3.0	1.4	0.56	86.36	11.77	5.34	38.9	92	1.38	105	ND
BH11	29.9	5.22	70	45.5	0.8	0.2	0.12	44.53	16.82	1.78	16.2	116	1.18	90	ND
BH12	31.1	5.95	30	19.5	0.8	0.1	0.06	45.23	7.56	5.93	16.9	124	1.74	75	ND
BH13	28.2	5.4	30	19.5	1.9	0.4	0.24	49.49	5.89	7.71	22.2	52	2.42	90	ND
BH14	33.4	5.04	110	71.5	1.4	0.2	0.12	59.41	5.89	9.49	21.5	76	2.56	70	5
BH15	28.9	4.69	120	78	0.9	0.8	0.32	78.56	4.21	7.12	31.6	72	1.99	75	ND
BH16	29.0	4.95	90	58.5	2.5	1.4	0.56	53.03	12.62	3.56	13.3	112	2.13	75	ND
BH17	29.0	4.71	180	117	1.8	0.2	0.12	66.5	11.77	1.18	15.3	60	0.34	65	ND
BH18	29.7	4.47	200	130	2.7	2.5	1.00	74.3	10.09	7.12	18.6	44	1.46	70	ND
BH19	30.4	4.66	210	136.5	2.5	2.5	1.00	89.19	11.77	7.71	18.3	40	3.48	75	ND
BH20	27.6	6.76	1000	650	4.9	0.8	0.32	503.96	42.89	12.46	13.1	228	3.85	60	35
BH21	29.2	5.16	40	26	0.9	0.1	0.06	73.59	11.77	2.96	52	52	1.94	65	ND
BH22	29.5	4.76	45	29.25	1.0	0.4	0.24	88.48	10.93	8.89	18.4	48	2.08	65	ND
BH23	29.4	4.51	80	52	2.7	0.9	0.36	89.19	14.29	4.75	8	92	2.22	75	ND
BH24	29.0	5.08	60	39	0.8	0.2	0.12	87.77	14.29	6.53	11.8	96	2.67	65	ND
Leachate	28.8	4.55	200	130	2.6	0.5	0.3	102.66	13.46	9.49	10.8	72	0.19	90	ND
Mean	29.08	5.21	187	121.6	1.74	0.75	0.34	101.87	11.81	7.32	21.82	88	2.37	74.8	15
STDEV	1.25	0.61	206.4	134.2	0.99	0.66	0.25	98.67	7.39	4.44	11.15	38.3	1.22	17.9	17.32
WHO		6.5-8.5	600	5	500	5	6	250	75	30	50	250	200		200
NSDWQ		6.5-8.5	1000		500			250		20		250			100

Note: WHO: World Health Organization
NSDWQ: Nigerian Standard for Drinking Water Quality

Table 5: Correlation Coefficients ofRain SeasonSampled Groundwater Parameters

	Temp	pH	EC	DO	TDS	BOD	COD	Cl	Ca	Mg	N03	HCO3	Na	K	SO4
Temp	**1.000**														
pH	-0.124	**1.000**													
EC	-0.004	0.455	**1.000**												
DO	-0.026	-0.591	-0.453	**1.000**											
TDS	-0.004	0.455	*1.000	-0.453	**1.000**										
BOD	-0.062	0.084	*0.640	0.298	*0.640	**1.000**									
COD	-0.061	-0.066	0.372	*0.525	0.372	*0.941	**1.000**								
Cl	-0.152	*0.560	0.260	-0.533	0.260	-0.177	-0.296	**1.000**							
Ca	-0.020	*0.553	*0.926	-0.336	*0.926	*0.703	0.492	0.206	**1.000**						
Mg	0.009	0.419	*0.990	-0.439	*0.990	*0.640	0.363	0.258	*0.889	**1.000**					
N03	0.097	0.297	*0.870	-0.295	*0.870	*0.670	0.430	-0.001	*0.821	*0.865	**1.000**				
HCO3	0.016	0.404	*0.987	-0.443	*0.987	*0.634	0.356	0.221	*0.873	*0.996	*0.881	**1.000**			
Na	-0.145	*0.689	0.480	-0.592	0.480	-0.002	-0.173	*0.771	0.470	0.459	0.168	0.409	**1.000**		
K	-0.166	*0.681	0.478	-0.564	0.478	0.015	-0.147	*0.771	0.469	0.459	0.139	0.407	*0.996	**1.000**	
SO4	-0.208	0.106	-0.044	-0.396	-0.044	-0.158	-0.163	-0.101	-0.051	-0.060	0.112	-0.040	-0.102	-0.138	**1.000**

Correlation is significant at 0.05 level (2-tailed)

Table 6: Correlation Coefficients of Dry Season Sampled Groundwater Parameters

	Temp	pH	EC	DO	TDS	BOD	COD	Cl	Ca	Mg	NO3	HCO3	Na	K	SO4
Temp	**1.000**														
pH	-0.340	**1.000**													
EC	-0.281	0.391	**1.000**												
DO	-0.221	0.064	*0.665	**1.000**											
TDS	-0.282	0.391	*1.000	*0.665	**1.000**										
BOD	-0.049	-0.258	0.250	*0.529	0.250	**1.000**									
COD	-0.052	-0.302	0.228	*0.523	0.228	*0.987	**1.000**								
Cl	-0.279	*0.515	*0.938	*0.599	*0.938	0.144	0.104	**1.000**							
Ca	-0.234	0.323	*0.818	*0.675	*0.818	0.068	0.048	*0.821	**1.000**						
Mg	-0.001	0.282	0.320	0.129	0.320	0.061	0.083	0.366	0.068	**1.000**					
NO3	-0.112	-0.023	-0.018	-0.270	-0.019	-0.061	-0.048	-0.070	-0.198	-0.194	**1.000**				
HCO3	-0.244	*0.697	*0.666	0.432	*0.666	-0.130	-0.192	*0.719	*0.734	0.201	-0.306	**1.000**			
Na	-0.206	*0.591	0.255	0.109	0.255	0.161	0.132	0.346	0.1230	*0.586	-0.152	0.377	**1.000**		
K	0.082	-0.239	-0.006	-0.020	-0.006	0.074	0.100	-0.065	-0.103	0.055	0.160	-0.131	-0.403	**1.000**	
SO4	-0.139	0.489	*0.831	*0.653	*0.831	-0.011	-0.029	*0.830	*0.870	0.270	-0.138	*0.742	0.265	-0.186	**1.000**

Correlation is significant at 0.05 level (2-tailed)

IV. CONCLUSION AND RECOMMENDATION

The study of the physicochemical characteristics of groundwater samples around an unlined landfill in Aba Southeastern Nigeria were analyzed for Temperature, pH, COD, TDS, BOD, EC, Cl^-, HCO_3^-, SO_4^{2-}, NO_3^-, Ca^{2+}, Mg^{2+}, Na^+, K^+. Although the physicochemical characteristics results showed no significant deviation from world health organization(WHO) and Nigeria standard for drinking water quality (NSDWQ) standards, it wasobserved that the pH values of all sampled sites in rain and dry seasons were found to be below the standards limit of the WHO and NSDWQ. Pearson correlation coefficient was performed in order to ascertain possible relationship between analyzed parameters.A very strong positive correlation was found between EC and TDS as well as between Na^+, pH and Mg^{2+} in both seasons. The study also revealed that anthropogenic activities from industries impact negatively on the physicochemical characteristics of groundwater samples under consideration. This implies a future threat on the groundwater in the study area which is the source of drinking water and other domestic purposes. This therefore calls for constant monitoring of the quality of groundwater resources in the area.

REFERENCES

[1]. Abdulrafiu, O. M., Kasali, A. A., &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), 289-298.

[2]. Adegoke, O. S. (1969). Eocene Stratigraphy of Southern Nigeria, Bulleting Bureau de Research Geologic ET Miners Memoirs.

[3]. Aderemi, A. O., Oriaku, A. V., Adewumi, G. A., &Otitoloju, A. A. (2011). Assessment of groundwater contamination by leachate near a municipal solid waste landfill. *African Journal of Environmental Science and Technology*, *5*(11), 933-940.

[4]. Akinbile, C. O., &Yusoff, M. S. (2011). Environmental impact of leachate pollution on groundwater supplies in Akure, Nigeria. *International Journal of Environmental Science and Development*, *2*(1), 81.

[5]. Akobundu, A. N., &Nwankwoala, H. O. (2013). Evaluation of heavy metal in soils from Enyimba dumpsite in Aba, southeastern Nigeria using contamination factor and geo-accumulation index. *Energy and Environment Research*, *3*(1), 125.

[6]. APHA (1998). Standard method for examination of Water and wastewater, *American PublicHealth Association*, 20th Edition, New York

[7]. Crawford, J. F., & Smith, P. G. (1985). Landfill Technology (UK)

[8]. Freeze, R. A., & Cherry, J. A. (1979). Groundwater Prentice-Hall Inc. *Eaglewood Cliffs, NJ*.

[9]. Ganiyu, S. A., Badmus, B. S., Olurin, O. T., &Ojekunle, Z. O. (2018). Evaluation of seasonal variation of water quality using multivariate statistical analysis and irrigation parameter indices in Ajakanga area, Ibadan, Nigeria. *Applied water science*, *8*(1), 1-15.

[10]. Giadom, F.D. and Abam, T.K.S. (2014), The contaminant status of Ariaria west dumpsite: *Journal of Nigerian Environmental society* (JNES) (1)2, 1-8.

[11]. Khashogji, M. S., & El Maghraby, M. M. (2013). Evaluation of groundwater resources for drinking and agricultural purposes, Abar Al Mashi area, south Al Madinah Al Munawarah City, Saudi Arabia. *Arabian Journal of Geosciences*, *6*(10), 3929-3942.

[12]. Maiti, S. K., De, S., Hazra, T., Debsarkar, A., &Dutta, A. (2016). Characterization of leachate and its impact on surface and groundwater quality of a closed dumpsite–a case study at Dhapa, Kolkata, India. *Procedia Environmental Sciences*, *35*, 391-399.

[13]. Mendie, U. (2005). The nature of water. *The Theory and Practice of Clean Water Production for Domestic and Industrial Use. Lagos: Lacto-Medals Publishers*, *1*, 21.

[14]. Mokuolu, O. A., Jacob, S. O., &Ayanshola, A. M. (2017). Groundwater quality assessment near a Nigerian dumpsite. *Ethiopian Journal of Environmental Studies and Management*, *10*(5), 588-596.

[15]. NSDWQ (2007). Nigerian Standard for Drinking Water Quality. *vol. NIS*, *554*, 15-22.

[16]. Nwajide, C. S. (2013). *Geology of Nigeria's sedimentary basins*. CSS Bookshop Limited.

[17]. Ojekunle, Z. O., Adeyemi, A. A., Taiwo, A. M., Ganiyu, S. A., & Balogun, M. A. (2020). Assessment of physicochemical characteristics of groundwater within selected industrial areas in Ogun State, Nigeria. *Environmental Pollutants and Bioavailability*, *32*(1), 100-113.

[18]. Saha, S., Reza, A. S., & Roy, M. K. (2019). Hydrochemical evaluation of groundwater quality of the Tista floodplain, Rangpur, Bangladesh. *Applied Water Science*, *9*(8), 1-12.

[19]. Short, K. C., &Stäuble, A. J. (1967). Outline of geology of Niger Delta. *AAPG bulletin*, *51*(5), 761-779.

[20]. Wilcox, L. (1955). *Classification and use of irrigation waters* (No. 969). US Department of Agriculture.

[21]. World Health Organization (W.H.O). Guidelines for drinking-water quality, Fourth edition. 2011. ISBN 97892 4 154815 1