OPEN ACCESS

Scholars International Journal of Chemistry and Material Sciences

Abbreviated Key Title: Sch Int J Chem Mater Sci
ISSN 2616-8669 (Print) |ISSN 2617-6556 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: http://saudijournals.com

Original Research Article

Quality Assessment of Groundwater Proximate to Municipal Waste Landfill Site in Owerri, Imo State, Nigeria

A.U. Ezeibe[1]*, A.M. Ekwonu[2]

[1]Department of Chemistry/Biochemistry, Federal Polytechnic Nekede, Owerri, Imo State, Nigeria
[2]Department of Pure and Industrial Chemistry, Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State, Nigeria

DOI: https://doi.org/10.36348/sijcms.2025.v08i05.006 | **Received:** 09.08.2025 | **Accepted:** 07.10.2025 | **Published:** 09.10.2025

***Corresponding author:** A.U. Ezeibe
Department of Chemistry/Biochemistry, Federal Polytechnic Nekede, Owerri, Imo State, Nigeria

Abstract

Poor waste management techniques including the indiscriminate use of poorly constructed landfills as solid waste receptors can lead to the pollution of groundwater in communities. This study examined the physicochemical qualities of groundwater proximate to a major solid waste landfill in Owerri, Imo State during rainy and dry seasons. The determination of the quality of the groundwater samples was carried out in accordance with the standards of the American Public Health Association (APHA). The results obtained from the analysis of the groundwater samples was compared to the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ) standards for drinking water. The values obtained from the analysis of the groundwater samples in both season shows that some of the tested parameters existed in values higher than both WHO and NSDWQ standards for drinking water quality. The results also showed that the concentrations of chromium, copper, iron, and nickel were above the WHO and NSDWQ standards. The Chemical Oxygen Demand, Turbidity and the Total Soluble Solids exceeded the WHO and NSDWQ standards for drinking water quality in both studied seasons. Findings from this study suggest that dumpsite solid waste could impact negatively on some physicochemical qualities of groundwater sited around their vicinity. Therefore, the location of solid waste dumpsites around residential areas should be discouraged.

Keywords: Groundwater, solid waste landfill, water quality, pollutants, leachate.

INTRODUCTION

Water is known to play an indispensable role in the survival of humanity due to its diverse uses to man, plants and other animals as well as the environment. Drinking water quality is of immense concern globally as it is a major health and environmental concern. With rising global population, there is equally increasing pressure on available water resources to sustain life even as the presence of micro-organisms and soluble salts are known to affect quality of water particularly for domestic purposes (Mokuolu *et al.,* 2017).

Groundwater is a major source of water serving both rural and urban societies. It is reported that over 90% of the world's readily available fresh water serving both domestic and industrial purposes is from groundwater (Omofunmi *et al.,* 2020). Groundwater is known to be an important source of water supply for humanity as it provides drinking water for as much as 50% of global population while accounting for 43% of water used for irrigation purposes (Johnson *et al.,* 2022). Despite the rising demand on water resources due to growing global population, groundwater quality is threatened by the activities of man which includes waste generation and management.

Generation of solid waste is an inevitable part of any human society. The solid wastes so generated are linked to several activities that sustain human and infrastructural development in such society. Such generation of solid wastes is traced to the rapid growth in urbanization, agriculture and industrial activities as societies strive to meet the demands of a rapidly expanding population and consumption habits. Huge generation and deposits of solid wastes are therefore associated with both developed and developing countries.

The generation of such high levels of municipal solid waste in developed and developing countries has placed high demands on the proper management of the wastes. Open dumps are the oldest and still the most prevalent system of solid waste disposal. They are located indiscriminately in underdeveloped and developing countries with the availability of open space being the only requirement to establish one. They are usually established without recourse to the health and safety of communities and the adverse environmental implications. The wastes are either carted away periodically, ignited and allowed to burn or leveled and compacted.

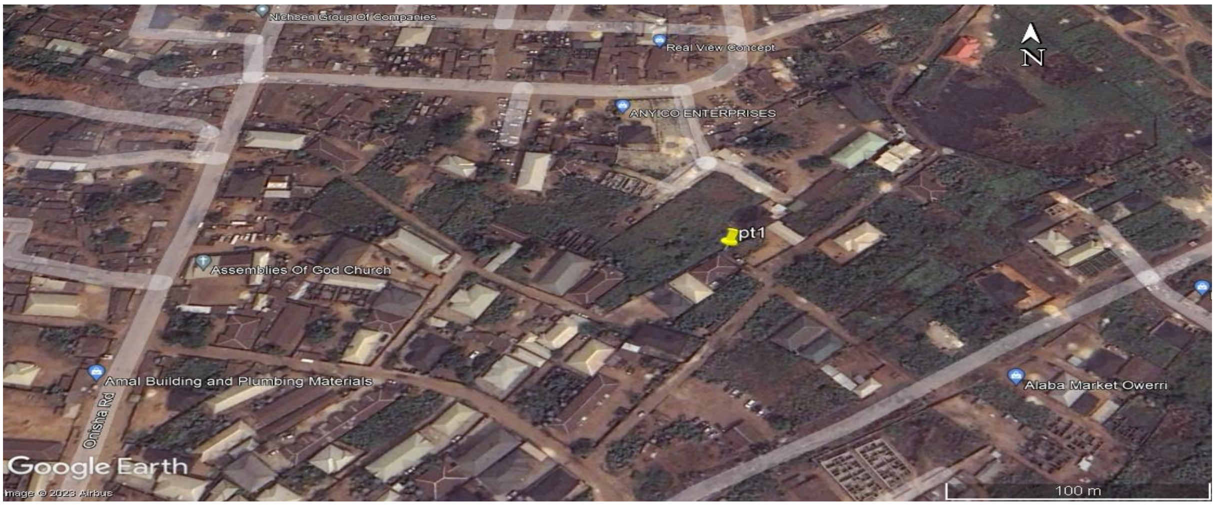
Dumping of wastes in uncontrolled landfills is common in developing countries like Nigeria. The landfills which are seen in different sizes and irregular shapes are receptors of tons of solid wastes generated in cities. Many of the landfills occur naturally while others are created by dredging, mining and other human activities. They are usually deep, open and exist without lining and therefore constitute a huge environmental concern to communities. Due to the fact that these landfills used as receptors of solid waste are open and unlined, the waste is exposed to moisture which penetrates through the waste resulting in the solubulization of organic and inorganic constituents of the wastes leading to the generation of leachates. The leachates also includes as its constituents decomposed organic matter and metallic components (Okunade *et al.,* 2019).

The leachates are generally known to contain significant concentrations of elements like calcium, magnesium, potassium, nitrogen, chromium, nickel, lead and organic compounds like benzene, toluene, chloroform, and phenols etc. The concentrations of these in the leachates and the rate of production of the leachates and migration depends on factors like composition of wastes, particle size, degree of compaction, age of landfill, temperature conditions, available oxygen, hydrology of site and of course moisture (Kanmani and Grandhimathi, 2013). The leachates are reported to contaminate surface soil and water around the environment, moving through the waste dump to the bottom and beneath the soil until it gets to the aquifer by pull of gravity (Igboama *et al.,* 2022).

There are reports of contamination of groundwater in developing cities with similar waste generation and management practices like Owerri. Ezeibe *et al.,* (2024) had reported contamination of groundwater in Aba by seepage from a solid waste disposal site. The waste composition in Aba recorded as 47.3% organic and biodegradable whereas 4.69 -9.90% was recorded as recyclable (Okeke *et al.,* 2023). Ali and Young (2014) documented the significant variations in the physiochemical characteristics of different groundwater samples in their assessment of groundwater contamination around a solid waste disposal site in Kano, Nigeria. Ameloko and Ayolabi (2020) had also reported the pollution of subsurface under a waste dumpsite and by extension the contamination of groundwater aquifer in their study of the geophysical and hydrophysical evaluation of groundwater around Igbenre Ekotedo dumpsite in Ota, Southwest Nigeria. Ferreira *et al.,* (2023) equally highlighted the impairment of water quality collected in the vicinity of a dumpsite in Lagos metropolis, Nigeria noting that drinking water quality standards from both the World Health Organisation and Nigerian government were exceeded more often in the rainy season than the dry season.

In this study, the quality of groundwater from boreholes proximate to a major waste landfill in Owerri located at Nekede Mechanic Village was determined with a view to generating advocacy and policy instruments on appropriate municipal waste management practices in the city.

MATERIALS AND METHODS



Description of Study Area and Sampling Location

Fig. 1: The General Positioning System Map of Owerri Mechanic Village Dumpsite Location in Imo State

The study area was the municipal waste landfill at Nekede mechanic Village, Owerri, Imo State in South Eastern part of Nigeria. The global positioning system (GPS) coordinate of the dumpsite are 5˚27′32′.9° North and latitude 7˚02′16′.8° East. Mechanic village dumpsite is an abandoned mining site located close to residential houses and the Otamiri river. The dumpsite is a major dumping site in Owerri and is maintained by the Imo State Government through the Imo State Environmental Protection Agency (ISEPA). The study period covered both rainy and dry seasons with the months of June and July representing the peak of the rainy season, and December and January representing the peak period of the dry season.

Sample Collection

Groundwater samples were collected pumped fresh from boreholes located in two different residential buildings proximate to the dumpsite. Samples collected in July and June represented rainy season samples, while samples collected in December and January were for the dry season samples. The samples collected within 100 meters from the landfill were taken in clean 1 liter polyethylene bottles and preserved at 4oC with ice pack prior to analysis. Control samples were collected about 3 kilometers away from the landfill.

Determination of Physicochemical Parameters

Parameters determined immediately after sample collection include: Temperature using a mercury in glass thermometer; pH using a portable digital Jenway pH meter; while electrical conductivity and total dissolved solids were determined using a Jenway 4510 conductivity meter. The following parameters were analysed following standard methods in line with APHA 2005: chloride, alkalinity, turbidity, nitrate, sulphide, acidity, dissolved oxygen, phosphate, chemical oxygen demand, and bicarbonate. Equally, the following heavy metals: iron (Fe), chromium (Cr), zinc (Zn), aluminium (Al), cadmium (Cd), nickel (Ni), copper (Cu), and lead (Pb) were analysed using flame Atomic Absorption Spectrophotometer (Apel 3000UV). The results were compared to standards from World Health Organisation (WHO, 2007) and National Standards for Drinking Water Quality (NSDWQ, 2007).

RESULTS AND DISCUSSION

The results of the physicochemical parameters determined from the samples over both rainy and dry seasons is presented in Table 1. Tables 2 and 3 show the results of the descriptive analysis of the parameters determined over both seasons.

Table 1: Results of The Physicochemical Parameters from the Samples in Rainy and Dry Seasons

Physicochemical Properties	Rainy Season			Dry Season			WHO	NSDWQ
	Owerri Control	Owerri 1	Owerri 2	Owerri Control	Owerri 1	Owerri 2		
Temperature (℃)	27	28	28	27.5	28	28.5	22-30	Ambient
pH	4.1	5.0	4.4	5.0	5.0	5.2	6.5-8.5	6.5-8.5
Conductivity (µS/cm)	673	469	187	230	485	201	1000	500
Total Dissolved Solid (mg/l)	190	13	104	38	57	12	500	1000
Alkalinity (mg/l)	5.0	7.5	5.0	15	12.5	12.5	500	NS
Chloride (mg/l)	134	109	78	52	35	28	250	100
Nitrate (mg/l)	9.73	9.64	10.59	4.41	5.02	6.32	50	10
Sulphide (mg/l)	0.041	0.026	0.053	0.490	0.163	0.388		
Sulphate (mg/l)	155.09	93.22	79.66	94.44	92.90	93.12	250	100
Acidity (mg/l)	15	22.5	30	57.50	40.0	45.0		NS
Biological Oxygen Demand (mg/l)	5.35	7.88	9.02	8.20	4.80	3.80	10	NS
Turbidity (NTU)	4.70	3.70	2.80	4.0	7.0	8.4	5	5
Phosphate (mg/l)	6.80	10.40	4.39	8.05	8.22	7.89	NA	100
Total Suspended Solid (mg/l)	1.28	0.89	1.56	0.79	0.78	0.77	3	0.1
Chemical Oxygen Demand (mg/l)	160	192	160	24.0	136	72	10	NS
Bicarbonate (mg/l)	3.0	2.5	3.5	12.50	12.50	22.50	NA	
Aluminium (mg/l)	0.00	0.00	0.01	0.003	0.009	0.10	0.2	0.5
Cadmium (mg/l)	0.02	0.04	0.02	0.005	0.023	0.045	0.003	NS
Chromium (mg/l)	0.05	0.03	0.03	0.079	0.081	0.051	0.05	0.004
Copper (mg/l)	0.01	0.01	0.024	0.031	0.025	0.076	2.0	1.0
Iron (mg/l)	0.026	0.068	0.008	0.224	0.263	0.413	0.3	0.3
Lead (mg/l)	0.055	0.088	0.026	0.006	0.00	0.768	0.05	0.004
Nickel (mg/l)	0.00	0.00	0.026	0.085	0.030	0.056	NS	0.001
Zinc (mg/l)	0.067	0.049	0.089	0.189	0.356	0.298	3.0	5.0

WHO: World Health Organization
NSDWQ: Nigerian Standard for Drinking Water Quality
NS: Not Stated.

Table 2: Descriptive Statistics of Physicochemical Properties for Owerri During Rainy Season

Properties	MEAN	SD	MEAN-SD	MEAN+SD	SEM
Temperature (°C)	27.667	0.577	27.089	28.244	0.1925
pH	4.867	0.416	4.450	5.283	0.1388
Conductivity (µS/cm)	244.667	201.778	42.889	446.445	67.2593
Total Dissolved Solid (mg/l)	46.333	50.143	-3.810	96.476	16.7144
Alkalinity (mg/l)	5.833	1.443	4.390	7.277	0.4811
Chloride (mg/l)	107.000	28.054	78.946	135.054	9.3512
Nitrate (mg/l)	9.986	0.526	9.460	10.512	0.1754
Sulphide (mg/l)	0.040	0.014	0.026	0.054	0.0045
Sulphate (mg/l)	109.322	40.208	69.114	149.530	13.4025
Acidity (mg/l)	22.500	7.500	15.000	30.000	2.5000
Biological Oxygen Demand (mg/l)	7.417	1.878	5.538	9.295	0.6261
Turbidity (NTU)	3.733	0.950	2.783	4.684	0.3168
Phosphate (mg/l)	7.194	3.023	4.171	10.218	1.0078
Total Suspended Solid (mg/l)	1.243	0.337	0.907	1.580	0.1122
Chemical Oxygen Demand (mg/l)	170.667	18.475	152.191	189.142	6.1584
Bicarbonate (mg/l)	3.000	0.500	2.500	3.500	0.1667
Cadmium (ppm)	0.026	0.012	0.014	0.038	0.0040
Lead (ppm)	0.056	0.031	0.025	0.087	0.0103
Copper (ppm)	0.016	0.007	0.008	0.023	0.0025
Chromium (ppm)	0.032	0.011	0.021	0.043	0.0037
Zinc (ppm)	0.068	0.020	0.048	0.088	0.0067
Nickel (ppm)	0.009	0.015	-0.006	0.024	0.0050
Aluminum (ppm)	0.002	0.004	-0.002	0.006	0.0013
Iron (ppm)	0.034	0.031	0.003	0.065	0.0103

Table 3: Descriptive Statistics of Physicochemical Properties for Owerri During Dry Season

Properties	MEAN	SD	MEAN-SD	MEAN+SD	SEM
Temperature (°C)	28.000	0.500	27.500	55.500	0.2887
pH	5.067	0.115	4.951	10.018	0.0667
Conductivity (µS/cm)	305.333	156.270	149.063	454.397	90.2226
Total Dissolved Solid (mg/l)	35.667	22.591	13.076	48.743	13.0427
Alkalinity (mg/l)	13.333	1.443	11.890	25.223	0.8333
Chloride (mg/l)	38.333	12.342	25.991	64.324	7.1259
Nitrate (mg/l)	5.251	0.976	4.275	9.526	0.5633
Sulphide (mg/l)	0.347	0.167	0.180	0.527	0.0966
Sulphate (mg/l)	93.489	0.831	92.659	186.148	0.4796
Acidity (mg/l)	47.500	9.014	38.486	85.986	5.2042
Biological Oxygen Demand (mg/l)	5.600	2.307	3.293	8.893	1.3317
Turbidity (NTU)	6.467	2.248	4.219	10.685	1.2979
Phosphate (mg/l)	8.052	0.169	7.883	15.935	0.0976
Total Suspended Solid (mg/l)	0.779	0.012	0.767	1.545	0.0070
Chemical Oxygen Demand (mg/l)	77.333	56.190	21.143	98.477	32.4414
Bicarbonate (mg/l)	15.833	5.774	10.060	25.893	3.3333
Cadmium (ppm)	0.024	0.020	0.004	0.029	0.0116
Lead (ppm)	0.258	0.442	-0.184	0.074	0.2550
Copper (ppm)	0.044	0.028	0.016	0.060	0.0160
Chromium (ppm)	0.070	0.017	0.054	0.124	0.0097
Zinc (ppm)	0.281	0.085	0.196	0.477	0.0490
Nickel (ppm)	0.057	0.027	0.030	0.086	0.0157
Aluminum (ppm)	0.007	0.004	0.004	0.011	0.0022
Iron (ppm)	0.300	0.100	0.200	0.499	0.0576

The temperature of the ground water was within the range of 27 to 28.5 for both seasons. Maximum temperature reading of 28.5 was recorded during the dry season while the lowest temperature readings for each season was recorded at the control locations: 27 and 27.5 for the rainy and dry seasons respectively. However, the readings were all within the limits of the WHO and NSDWQ. The slightly higher values recorded in the dry season can be attributed to the higher rates of evaporation seen during dry seasons.

The pH recorded between 4.1 and 5.2 across the two seasons showed that the samples were acidic falling below acceptable limits set by WHO and NSDWQ. However, it is unlikely that the acidic nature of the samples is influenced by the landfill as the control samples were even more acidic in both seasons.

Values obtained for turbidity (2.80 to 8.4 mg/l), total suspended solids (0.77 to 1.56 mg/l), bicarbonate (2.5 to 22.50 mg/l), conductivity (201 to 673 us/cm), alkalinity (5.0 to 12.5 mg/l), sulphide (0.026 to 0.163 mg/l), sulphate (79.66 to 155.09 mg/l), and acidity (15 to 57.50 mg/l) were higher in the dry season compared to the rainy season. Values for total dissolved solids (12 to 190 mg/l), chloride (35 to 134 mg/l), nitrate (4.41 to 9.73 mg/l), biochemical oxygen demand (3.80 to 9.02 mg/l), phosphate (4.39 to 10.40 mg/l), and chemical oxygen demand (24.0 to 192 mg/l) were higher in the rainy season compared to the dry season. The values obtained were generally within acceptable limits for WHO and NSDWQ except for total suspended solids and chemical oxygen demand with values recorded above NSDWQ and WHO respectively.

The high value of total suspended solids observed which exceeded threshold values might be because of infiltration of contaminated surface water or leaching from contaminated sites which is expected. Chemical Oxygen Demand is the measure of the amount of oxygen needed for complete oxidation of carbon (IV) oxide and organic matter present in water. It is a vital water quality parameter that indicates the extent of organic pollution in water (Yakubu and Omar, 2019). The values for chemical oxygen demand which an exceeded threshold value is therefore of major concern as it have direct impact on the quality of the groundwater.

For the metals, chromium (0.03 to 0.081 mg/l), copper (0.01 to 0.076 mg/l), and iron (0.008 to 0.413 mg/l) recorded higher values in the dry season compared to the rainy season; while cadmium (0.005 to 0.02 mg/l), lead (0.00 to 0.088 mg/l), nickel(0.00 to 0.085 mg/l), and zinc (0.049 to 0.356 mg/l) recorded higher values in the rainy season compared to the dry season. Values obtained for iron chromium and nickel were above recommended thresholds.

The metals with values still within permissible limits may not have accumulated appreciably in the groundwater while the values for iron, chromium and nickel which exceeded threshold values indicate concerns of toxicology to the community and environment.

Table 4: The physical component matrix of ordination of physicochemical parameters and metals from Owerri during rainy season

	Component	
Variable	**1**	**2**
Temperature	0.071	0.336
pH	-0.223	-0.161
Conductivity	-0.117	0.31
TDS	0.248	0.051
Alkalinity	-0.173	0.254
Chloride	-0.192	-0.225
Nitrate	0.248	0.055
Sulphide	0.236	-0.121
Sulphate	-0.111	-0.315
Acidity	0.182	0.241
BOD	0.141	0.29
Turbidity	-0.177	-0.249
Phosphate	-0.231	0.137
TSS	0.233	-0.131
COD	-0.173	0.254
Bicarbonate	0.241	-0.099
Cadmium	-0.207	0.199
Lead	-0.238	0.112
Copper	0.25	0.026
Chromium	-0.071	-0.336
Zinc	0.244	-0.08
Nickel	0.244	0.082
Aluminium	0.244	0.082
iron	-0.219	0.173

Table 5: The size, percentage total variation and cumulative percentages of co-relation matrix of the first two components in the original data set of scree plots composition of groundwater from Owerri during rainy season.

Components	Initial eigen value		
	Total	% Proportion	% Cumulative
1	15.865	66.10	66.10
2	8.135	33.90	100.00

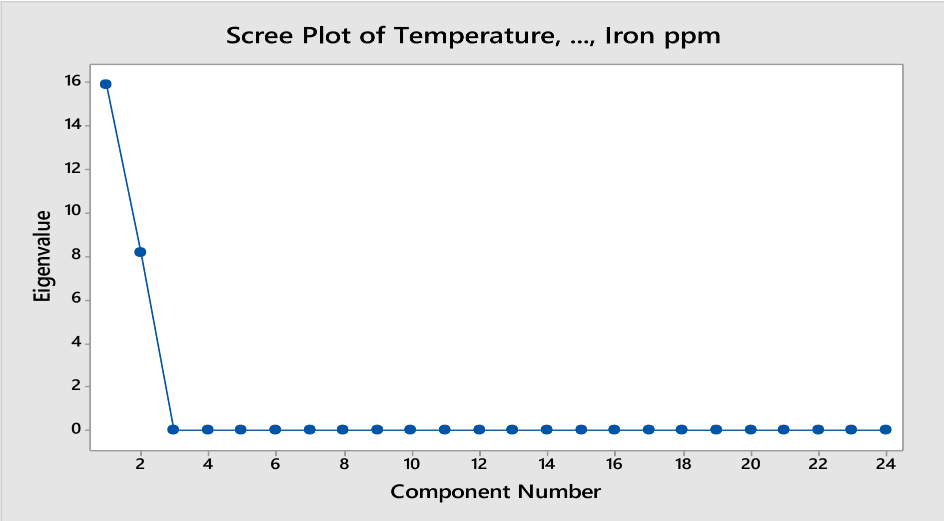


Figure 2: Ordination graph showing principal components of groundwater from Owerri during Rainy season

Table 6: The physical component matrix of ordination of physicochemical parameters and metals from Owerri during dry season

	Component	
Variable	**1**	**2**
Temperature	0.255	0.002
pH	0.22	0.172
Conductivity	-0.023	-0.34
TDS	-0.146	-0.28
Alkalinity	-0.221	0.169
Chloride	-0.248	0.078
Nitrate	0.249	0.071
Sulphide	-0.079	0.325
Sulphate	-0.202	0.207
Acidity	-0.177	0.245
BOD	-0.243	0.101
Turbidity	0.249	-0.069
Phosphate	-0.12	-0.301
TSS	-0.242	-0.107
COD	0.11	-0.308
Bicarbonatel	0.22	0.172
Cadmium	0.254	0.021
Lead	0.219	0.174
Copper	0.205	0.202
Chromium	-0.212	-0.189
Zinc	0.165	-0.26
Nickel	-0.138	0.287
Aluminium	0.236	-0.129
Iron	0.241	0.111

Table 7: The size, percentage total variation and cumulative percentages of co-relation matrix of the first two components in the original data set of scree plots composition of groundwater from Owerri during dry season

Components	Initial eigen value		
	Total	% Proportion	% Cumulative
1	15.417	64.20	64.20
2	8.583	35.80	100.00

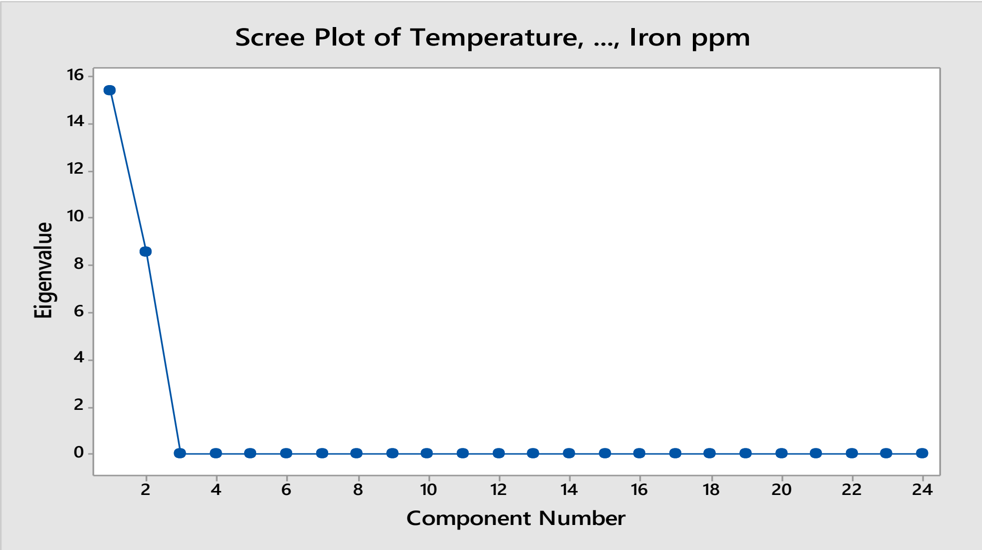


Figure 3: Ordination graph showing principal components of groundwater from Owerri during dry season

Principal Component Analysis was deployed in the analysis of the groundwater samples in the rainy and dry seasons to check patterns in the data set obtained by transforming the data obtained into a new set of uncorrelated variables. The principal component analysis of physicochemical parameters, size percentage proportion and cumulative variance on the two principal components are shown in Tables and; and Figures 1 and 2. The ordination of 16 physicochemical parameters and 5 heavy metals extracted two principal components (Figure 1 and 2) in ground water from the studied locations in both seasons. The components of the rainy season were as follows:

Component 1: The component had the highest Eigen value of 15.865 and 15.417 with 66.10 % and 64.20 %, of data variation during rainy and dry seasons respectively. The PCA values indicated that the variation in the data set should be ignored. The data revealed that all the physicochemical and heavy metal parameters showed very low loading.

Component 2: with Eigen value of 8.135 and 8.583 with 33. 90% and 35.80% variation in rainy and dry seasons respectively. Component 2 was not influenced by any physicochemical parameters and heavy metals.

The principal component analysis shows that the water quality is not affected by the waste dump activities in the study area.

Table 8: Test for Differences between Dry and Rainy seasons Physicochemical Properties at Owerri

Physicochemical Properties	Season	Mean	SD	SEM	CI	t-value	P-value
Temperature	Dry Rainy	28.000 27.667	0.5 0.557	0.289 0.333	(-0.385, 1.050)	2	0.184
pH	Dry Rainy	5.067 4.867	0.115 0.416	0.067 0.240	(-0.794, 1.194)	0.87	0.478
Conductivity	Dry Rainy	305 245	156 202	90 116	(-669, 791,)	0.36	0.755
TDS	Dry Rainy	35.7 46.3	22.6 50.1	13 29	(-91.6, 70.3)	-0.57	0.628
Alkalinity	Dry Rainy	13.333 5.833	1.443 1.443	0.833 0.833	(1.29, 13.71)	5.20	0.035
Chloride	Dry Rainy	38.3 107	12.3 28.1	7.1 16.2	(-123.9, -13.4)	-5.35	0.033
Nitrate	Dry Rainy	5.251 9.986	0.976 0.526	0.563 0.304	(-7.796, -1.675)	-6.66	0.022

Physicochemical Properties	Season	Mean	SD	SEM	CI	t-value	P-value
Sulphide	Dry Rainy	0.347 0.040	0.167 0.101	0.097 0.008	(-0.130,0.744)	3.02	0.094
Sulphate	Dry Rainy	9.35 109.30	0.8 40.2	0.5 23.2	(-113.7, 82)	-0.70	0.558
Acidity	Dry Rainy	47.5 22.5	9.01 7.50	5.20 4.33	(-15.72,65.72)	2.64	0.118
DO	Dry Rainy	5.60 7.42	2.31 1.88	1.33 1.08	(-11.86, 8.22)	-0.78	0.518
Turbidity NTU	Dry Rainy	6.47 3.73	2.25 0.95	1.30 0.55	(-4.68, 10.15)	1.59	0.253
Phosphate	Dry Rainy	8.05 7.19	0.17 3.02	0.10 1.75	(-7.07,8.78)	0.47	0.687
TSS	Dry Rainy	0.779 1.243	0.012 0.337	0.007 0.194	(-1.227, 0.347)	-2.46	0.133
COD	Dry Rainy	77.3 170.7	56.2 18.5	32.4 10.7	(-243.8, 57.1)	-2.67	0.116
Bicarbonate	Dry Rainy	15.83 3	5.77 0.50	3.33 0.29	(-2.60, 28.26)	3.58	0.070

Table 8 showed the result of the test of difference between the results obtained across the seasons. From the table, results obtained showed little variations as many of the physicochemical parameters were not greatly affected across the seasons. Only three physicochemical parameters differed significantly between the two seasons. The parameters that showed variations were alkalinity ($t = 5.20$, $P = 0.035$), chloride ($t = 5.35$, $P = 0.033$), and nitrate ($t = -6.66$, $P = 0.022$), respectively.

CONCLUSION

This study was carried out to determine the impact of solid waste dumped in a landfill on the physicochemical qualities of groundwater during both rainy and dry seasons in Owerri, Imo State, Nigeria. The results from the study revealed that the groundwater collected from the study areas showed that some of the parameters did not align with water quality standards which in turn undermines human health. The study also revealed that the quality of the groundwater as seen in most of the parameters varies with the seasons. Some of the parameters were however still within the WHO and NSDWQ permissible limit as at the period the study. The study also showed that the parameters in the studied samples were also influenced by geophysical factors apart from the waste dumpsite. There is therefore a need for the location of solid waste dumpsites/landfills to be sited away from residential areas as it is expected that over time, the impact of the waste dumpsite will be felt in more significant terms on the quality of groundwater in the area studied.

Acknowledgement: The authors are grateful to the Tertiary Education Trust Fund (TETFund) for their financial support and Federal Polytechnic Nekede, Owerri, Imo State, Nigeria.

Funding: This research was funded by grant from the Tertiary Education Trust Fund (TETF/DR&D/CE/POLY/NEKEDE/IBR/2024/VOL.1).

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

- APHA. (2005). Standard methods for the examination of water and wastewater. American Public Health Association: Washington D.C., 23-29.
- Ali F.M., and Young Y. (2014). Community Perception and Adaptation to Safe Drinking Water Scarcity. Water Policy Vol.5 pg 110 - 124.
- Ameloko A.A, and Ayolabi E.A. (2020). Geophysical and Hydrophysical Evaluation of Groundwater Around the Igbenre Ekotedo Dumpsite, Ota, South West Nigeria Using Correlation and Regression Analysis. Arabian Journal of Geosciences Vol.13, 896.
- Ezeibe A.U., Ekwuonu A.M., Nwadiogbu J.O., Nleonu E.C. (2024). Physicochemical Qualities of Groundwater Near Solid Waste Disposal Site in Aba, Abia State Nigeria. Scholars International Journal of Chemistry and Material Sciences 7(12): 178 - 189
- Ferreira C.S, Adan- Ajonye O., Anosike E.I, and Zahra K.(2023). Groundwater Quality in the Vicinity of a Dumpsite in Lagos Metropolis, Nigeria. Geography and Sustainability Vol. 4 Issue 4, pp 379 - 390.
- Igboama, W. N., Hammed, O. S., Aroyehun, M. T., and Ehiabhill, J. C. (2022). Review article on impact of groundwater contamination due to dumpsites using geophysical and physicochemical methods. Applied Water Science, 12(130), 1-14.
- Johnson G.R., Brusseau M.L., Carroll K.C., Tick G.R., and Duncan C. M. (2022). Global Distributions, Source Type, Dependencies and

Concentration Ranges of Per and Polyflouroalkyl Substances in Groundwater. Science of The Total Environment Vol.841.

- Kanmani S. and Gandhimanthi R. (2013). Investigation of Physicochemical Characteristics and Heavy Metal Distribution Profile in Groundwater System Around the Open Dump Site.
- Mokuolu, O. A., Jacob, S. O., & Ayanshola, A. M. (2017). Groundwater quality assessment near a Nigerian dumpsite. Ethiopian Journal of Environmental Studies & Management, 10(5), 588-596.
- NSQWQ. (2007). Nigerian standard for drinking water quality. Ministry of Water Resources, Nigeria, 1-2
- Okunade, E. A., Awopetu, M. S., & Bolarinwa, A. (2019). Groundwater quality assessment near an open dump municipal solid waste disposal site in Ekiti State, Southwestern Nigeria. Journal of Geography, Environment and Earth Science International, 23(3), 1-18.
- Omofumi, O., Satimehin, A., Oloye, A., & Umego, O. (2020). Effect of landfill leacheates on some water quality indicators of selected sueface water and groundwater at Ilokun, Ado-Ekiti, Nigeria. Makara J Technol, 24(2), 72-78.
- Okeke, P. I., Nwugha, V. N., Nleonu, E. C., Okore, G. J., & Okeke, P. O. (2023). Assessment of groundwater quality in owerri and its environments, Southeast Nigeria. Science View Journal, 4(3), 334-338
- WHO. (2011). World Health Organization guidelines for drinking water quality, 4th Edition, WHO Press, USA, 564.
- Yakubu, M. T., & Omar S. A. (2019). Physicochemical characteristics of groundwater samples and leachate from Gbagede dumpsite, Amoyo, Kwara State, Nigeria. Al-Hikmah Journal of Pure & Applied Sciences, 7, 31-37.

