



---

## **Chemical characterization of groundwater in Port Harcourt metropolis, Rivers State**

**Okwakpam<sup>1</sup>, Ikechi Omenuihu<sup>1</sup>, Amadi Peace<sup>2</sup>**

<sup>1</sup>Department of Geography and Environmental Studies, Faculty of Social Sciences, Ignatius Ajuru University of Education, Rivers State, Nigeria

<sup>2</sup>Rivers State College of Health Sciences and Management Technology, Oro Owo Rumueme, Port Harcourt Rivers State, Nigeria

---

### **Abstract**

The great threat to the purity of ground water is due to anthropogenic activities: industrial effluents, wastes from fertilizer garbage, chemical dumpsite, poultries and animal husbandries disinfectant, feed formulation, drugs disposed on land surface. These anthropogenic activities through chemical processes affect the unique nature of groundwater. The study therefore analyzed the chemical characterization of groundwater in selected areas of Port Harcourt Metropolis. The study area comprises 14 zones that make up Port Harcourt Metropolis. Two sampling points were purposively chosen in each of the zones, totaling 28 different boreholes sank from different parts of Port Harcourt metropolis. Analysis of p<sup>H</sup>, hardness, and chemical characteristics of groundwater were done using appropriate measures and standard procedures. The finding indicates that pH values of groundwater obtained in the study area is 0.005 which is less than 0.05 level of significance. This revealed that the groundwater in the study area is slightly acidic as all the water samples had a p<sup>H</sup> values that are less than 7 on the P<sup>H</sup> scale. Variation between the chemical properties indicated P-value of 0.000 which is less than 0.05 alpha level. The obtained result shows that there is no significant variation between the chemical properties of groundwater in the study area. The result further reveals that groundwater in the study area contain chemical properties of reasonable quantity. The study concludes that there should be regular monitoring on land to avert the discharge of harmful substances in the environment which might find its way to the groundwater and contaminate it.

**Keywords:** chemical, characterization, groundwater quality, metropolis

---

### **Introduction**

Globally, groundwater is indispensable due to its unique properties. Groundwater has overwhelming significance to every facet of life: used for domestic purpose (drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, watering lawns and gardens, and maintaining pools. Groundwater is also used for animals, ecological functions and industrial uses.

United States Geological Survey, USGS (2018) stated that groundwater is one of our most valuable resources. Waste from industrial effluents, fertilizer and garbage or chemical dumpsite, poultries and animal husbandries disinfectant, feed formulation, and drugs are disposed on land surface which affect the quality of good water. These wastes undergo decay processes with moisture which forms leachates (Yisa & Jimoh, 2020). The leachates migrate through the soil layers to get to groundwater. Leachate migrations pose a high risk of groundwater contamination. It has left some devastating effects on groundwater quality (USGS, 2018).

According to Nijamir and Mim (2017) the impact of chemical processes on groundwater quality is critical. For example, application of agrochemicals impact negatively on the groundwater quality drastically. Parameters such as total dissolved solid and biochemical oxygen demand varied with the spatial position from dumpsite, which impact on soil and groundwater quality (Saidu, 2016). Vulnerability of groundwater contamination has become eminent from direct human activities. Chemical characterization of groundwater varies temporarily and spatially (Grugnaletti Pantini, Verginelli, & Lombardi, 2016; Mor et al 2006).

There is general ignorance of the deleterious effects of groundwater contamination sources on which a number of city dwellers depend (Onyeku & Eludoyin, 2010). Chemical composition of groundwater is a measure of its suitability as a source of water for human and other purposes. The impact has continued to raise concern and have become the subject of recent investigations (Ahmed & Suilman, 2001). Therefore, the study analyzed chemical characterization of groundwater in the different zones of the study area that constitute Port Harcourt metropolis.

### **Methodology**

Port Harcourt metropolis is made of Port Harcourt city local government area and Obio/Akpor local government area. The metropolis is an epicenter and settlement destinations for rural, urban and inter-city migrants, full of

human activities. Many industries and companies are cited within Port Harcourt metropolis. Majority of the residents dumped their waste indiscriminately, anywhere there is available space. These wastes include petrochemical, industrial and fertilizer manufacturing companies, domestic, agricultural if not properly managed, produce waste that can decompose to form liquid substances which migrate into the groundwater through the aquifers, thereby contaminating the groundwater,

The study adopted experimental research design. The sampling points was purposively chosen from the 14 zones that constitute Port Harcourt metropolis. Two sampling points each were selected from each zone, at the end a total of twenty eight (28) sample points (boreholes water from different zones of the study area) were selected to give all the zones an equal chance of being selected for the study. The sample points are shown in table 3.1. The mean values of the groundwater quality parameters in each zone were obtained to represent the 14 zones used for the various analysis. However, for the testing of the hypothesis, the raw values of water quality parameters from the twenty eight (28) sampling points were used. Groundwater samples were subjected to analysis to ascertain their level of  $p^H$ , hardness, and chemical characteristics.

**Table 1:** Groundwater sample location in the Study area

Site Code	Location name	Geographical coordinates	Land-use description
A <sub>1</sub>	Rumuokwurushi	N 04° 52' 05.2", E 007° 04'	Residential area before Nzor hotel, Rumuokwurushi
A <sub>2</sub>	Eneka	N 04° 53' 40.1", E 007° 02'	Model Health Centre, Eneka.
B <sub>1</sub>	Oroigwe	N 04° 52' 21.8", E 007° 02'	Residential area at Oroigwe, Elingbu
B <sub>2</sub>	Rumuodomanya	N 04° 53' 33.4", E 005° 59'	Residential area at Akwaka phase 3, Rumuodomanya
C <sub>1</sub>	Trans-Amadi	N 04° 48' 10.5", E 007° 02'	School premises (Tago Int'l Sch., off Odili Rd, T/Amadi)
C <sub>2</sub>	Woji	N 04° 53' 17.2", E 007° 02'	Residential area at Temple Ejekwe Street, Woji Road
D <sub>1</sub>	Eligbolo Road	N 04° 51' 58.8", E 007° 00'	Residential/school area at Eligbolo road.
D <sub>2</sub>	Rumuagholu	N 04° 53' 21.5", E 006° 58'	Residential/school area, off SARS road, Rumuagholu
E <sub>1</sub>	Rumuigbo	N 04° 50' 25.4", E 007° 00'	Residential area behind PHWC, Psychiatric Rd, Rumuigbo
E <sub>2</sub>	Loretha School	N 04° 52' 26.0", E 005° 58'	Staff quarters at Loretha School, Rumuogholu
F <sub>1</sub>	Old GRA	N 04° 50' 07.3", E 007° 04'	Premises of Braithwaite Memorial Hospital
F <sub>2</sub>	Olumeni Street	N 04° 52' 08.7", E 007° 06'	Residential area Olumeni street
G <sub>1</sub>	Orogbum	N 04° 46' 50.9", E 007° 02'	Nursery school near khana street
G <sub>2</sub>	Nkpoku	N 04° 53' 11.9", E 007° 05'	Nkpoku Estate
H <sub>1</sub>	Timber	N 04° 56' 06.0", E 007° 01'	Timber market/SPDC flow station, PH/Owerri Rd, Rukpoku
H <sub>2</sub>	Gbalajam	N 04° 48' 39.5", E 007° 04'	Residential area at Gbalajam, Woji (close to a creek).
I <sub>1</sub>	Rumuokokwu	N 04° 48' 22.9", E 006° 59'	Commercial area at 4, Nnokam Street (close to RSU gate).
I <sub>2</sub>	Rumuwoji	N 04° 48' 23.9", E 006° 00'	Residential area at Rumuwoji
J <sub>1</sub>	Elioparanwo	N 04° 50' 07.8", E 006° 57'	Residential area at 27, Royal Avenue, Elioparanwo Town
J <sub>2</sub>	Rumuepirikom	N 04° 50' 08.5", E 006° 58'	Commercial area at Rumuepirikom by Ada George Road.
K <sub>1</sub>	Rumuolumini	N 04° 48' 40.4", E 006° 57'	Church Premises (St Mark's Ang. Church, Rumuolumini)
K <sub>2</sub>	Eagle Island	N 04° 47' 00.9", E 006° 58'	Residential area at 38D, Collins Owhonda Str., Eagle Island
L <sub>1</sub>	Ozuoba	N 04° 52' 04.5", E 006° 56'	Residential area opposite Provil School, Ozuoba
L <sub>2</sub>	Rumuokwachi	N 04° 52' 00.6", E 006° 55'	Residential area at 14, Ogbogoro road, Rumuokwachi.
M <sub>1</sub>	MainTown	N 04° 45' 52.6", E 007° 01'	Residential area at 6, Hospital Road, PH Township.
M <sub>2</sub>	Borokiri	04° 45' 01.6", E 007° 02'	Commercial area at UPE, Borokiri.
N <sub>1</sub>	Golf Course Area	N 04° 47' 28.3", E 007° 00'	Residential building near golf course layout
N <sub>2</sub>	Sand fill	N 04° 44' 07.7", E 007° 01'	Commercial area (petroleum) close to Borokiri Sand Fill

**Source:** Researchers' fieldwork, 2021

### Results and Discussion of Findings

Table 2 reveals a mean value ( $\bar{x}$ ) of 4.51mg/l for level of hardness of groundwater in the study area. The generation of mean score of 4.51mg/l from the water samples collected show the presence of bicarbonates and carbonates of calcium and magnesium which are the principal causes of hardness of water.

**Table 2:** Zonal Mean values for level of Hardness of Groundwater in the study area

Zone	P1	P2	Sum	T.Hard(mg/l)	SD	Remark
Zone A	6.06	5.20	11.26	5.63	0.61	Hard
Zone B	6.01	5.62	11.63	5.82	0.28	Hard
Zone C	4.30	4.15	8.45	8.45	0.11	Hard
Zone D	2.00	1.80	3.80	1.9	0.14	Hard
Zone E	4.00	3.40	7.40	3.7	0.42	Hard
Zone F	5.34	5.10	10.44	5.22	0.17	Hard
Zone G	6.60	5.80	12.40	6.2	0.57	Hard
Zone H	5.80	5.30	11.10	5.55	0.35	Hard
Zone I	3.22	3.06	6.28	3.14	0.11	Hard
Zone J	4.40	4.18	8.58	4.29	0.16	Hard
Zone K	2.81	2.68	5.49	2.75	0.09	Hard
Zone L	3.90	3.82	7.72	3.86	0.06	Hard
Zone M	5.04	5.01	10.05	5.03	0.21	Hard
Zone N	6.02	5.76	11.78	5.89	0.18	Hard
	4.68	4.35	9.02	4.51 mg/l	1.31	Hard

Source: Researchers' Fieldwork 2021

### Test of Hypotheses

#### Hypothesis one states

“The acidity value of groundwater in the study area is the same”. In table 3 a mean ( $\bar{x}$ ) value of 4.76 for the acidity of groundwater sample in the study area expresses the level of concentration of hydrogen ion ( $H^+$ ). In table 5 the sig. p-value for the acid level of groundwater in the study area = (0.005) < the alpha level (0.05). Since the generated sig. p value is less than the alpha level, the null hypothesis which states that the acidic values of groundwater in the study area is the same is hereby rejected. This implies that the acid values of groundwater in the study area are not the same hence, the alternate hypothesis.

**Table 3:** Zonal Mean Values for acidic characteristics of Groundwater in the study area

Zones	P1	P2	Sum	P <sup>H</sup>	SD	Remark
Zone A	5.8	4.3	10.10	5.05	1.06	Acidic
Zone B	5.9	5.1	11.00	5.50	0.57	Acidic
Zone C	6.1	4.9	11.00	5.50	0.85	Acidic
Zone D	4.7	4.1	8.80	4.40	0.42	Acidic
Zone E	4.5	3.7	8.20	4.10	0.57	Acidic
Zone F	5.3	4.9	10.20	5.10	0.28	Acidic
Zone G	4.9	4.1	9.00	4.50	0.57	Acidic
Zone H	4.8	3.9	8.70	4.35	0.64	Acidic
Zone I	4.5	4.2	8.70	4.35	0.21	Acidic
Zone J	5.5	5.0	10.50	5.25	0.35	Acidic
Zone K	5.7	5.3	11.00	5.50	0.28	Acidic
Zone L	4.3	4.1	8.40	4.20	0.14	Acidic
Zone M	4.2	4.0	8.20	4.10	0.14	Acidic
Zone N	5.1	4.4	9.50	4.75	0.49	Acidic
	5.09	4.43	9.52	4.76	0.66	Acidic

Source: Researchers' Fieldwork 2021

**Table 4:** Chemical properties of groundwater in the study area

Zones	Chemical Properties mg/l						Sum	mg/l
	Samples	SO <sub>4</sub> mg/l	NO <sub>3</sub> mg/l	Cl mg/l	PO <sub>4</sub> mg/l			
Zone	A	0.24	2.90	32.0	Nil	34.14	11.71	
Zone	B	0.12	2.80	30.0	Nil	32.92	10.97	
Zone	C	0.72	1.60	8.6	Nil	10.92	3.64	
Zone	D	0.12	0.86	4.0	Nil	4.98	1.66	

Zone	E	0.60	2.63	24.0	Nil	27.23	9.08
Zone	F	0.46	2.02	26.2	Nil	28.68	9.56
Zone	G	0.62	1.80	18.6	Nil	21.02	7.01
Zone	H	0.84	1.76	22.2	Nil	24.80	8.27
Zone	I	0.70	0.96	16.0	Nil	17.66	5.89
Zone	J	0.54	1.22	20.8	Nil	22.56	7.52
Zone	K	0.44	1.66	28.0	Nil	30.10	10.03
Zone	L	0.32	1.28	24.2	Nil	25.80	8.60
Zone	M	0.26	2.74	12.4	Nil	15.40	5.13
Zone	N	0.28	2.10	9.6	Nil	11.98	3.99
	Mean( $\bar{x}$ )	0.45	1.88	19.76	Nil	22.09	7.36

Source: Researchers' Fieldwork 2021

**Table 5:** The acidity value of groundwater in the study area is the same.

Model	SS	Df	MS	F	Sig. P	P	Decision
Between groups	3.089	1	3.089	9.429	0.005	0.05	Rejected
Within groups	8.518	29	0.328				
Total	11.607	30					

### Hypothesis two states

“There is a significant variation between the chemical properties of groundwater in the study area”. As indicated in table 4, the grand mean generated were 0.45mg/l, 1.88mg/l, 19.76mg/l and 0mg/l for NO<sup>4</sup>, SO<sup>3</sup>, Cl<sup>-</sup> and PO<sup>4</sup> respectively for all the groundwater samples collected in different parts of the study area. Table 4 also indicate a mean ( $\bar{x}$ ) value of 7.36 for variation between the chemical characterization of groundwater sample in the study area. Table 6 indicate the sig. p-value for chemical properties of groundwater in the study area = (0.000) which is less than the alpha level (0.05). Since the generated sig. p value is less than the alpha level, the null hypothesis which states that there is a significant variation between the chemical properties of groundwater in the study area is hereby rejected. This implies that the chemical properties of groundwater in Port Harcourt Metropolis are the same hence, the hypothesis which states that there is a significant variation of chemical properties of groundwater in the study area is rejected.

**Table 6:** Variation between the chemical characteristics of groundwater in the Study area

Model	SS	Df	MS	F	Sig. P	P	Decision
Between groups	3240.99	1	1620.50	65.74	0.000	0.05	Rejected
Within groups	961.35	29	24.65				
Total	4202.34	30					

The findings in hypothesis one revealed that the groundwater in the study area is slightly acidic as all the water samples had a p<sup>H</sup> values that are less than 7 on the P<sup>H</sup> scale. This finding is in agreement with the submission of Adesuji et al (2015) who stated that the pH of groundwater samples around Elioizu in Obio/Akpor local government area of Rivers State ranges from 5.5 –8.0, indicating slight acidity in some of the water samples. The obtained result in hypothesis two shows that there is no significant variation between the chemical properties of groundwater in the study area. The result further reveals that groundwater in the study area contain chemical properties such as NO<sup>4</sup>, SO<sup>3</sup>, and Cl, in reasonable quantity that makes it polluted as a result of spatial activities on land within the metropolis. The findings further reveals that the P-value generated from the analysis in table 6 is 0.000 which is less than 0.05 alpha level, therefore, the hypothesis is rejected while the alternate hypothesis is retained. This result is in tandem with the findings of (Chenini & Khamiri, 2009) who argued that the impact of human activities and the environmental parameters affect the geochemical mobility of certain constituents in groundwater. Also in conformity with Integrated Publishing report of 2019, which state that the most important chemical characteristics of water are its acidity, alkalinity, hardness and corrosiveness and that chemical impurities can be either natural, manmade (industrial), or be deployed in raw water sources by enemy forces.

### Conclusion and Recommendations

Vulnerability of groundwater contamination is eminent in the study area. Chemical characterization of groundwater varies spatially. Therefore, there should be regular monitoring on land to avert the discharge of harmful substances in the environment which might find its way to the groundwater and contaminate it. Also, there should be stringent, stiffer penalties to discipline and punish those who pollute the groundwater.

Individuals, and cooperate bodies that rely on groundwater for domestic, agricultural and industrial use should adequately treat the water before use to eliminate the impurities contained in groundwater in the study area.

## References

1. Adesuji AA, Nnodi VC, Akinola MO, Njoku KL, Jolaoso AO. Groundwater quality assessment in Elioju community, Port Harcourt, Niger Delta, Nigeria. *International Journal of Scientific & Technology Research*,2015:4(12):149-156.
2. Ahmed AM, Sulaiman WN. Evaluation of groundwater and soil pollution in a landfill area using electrical resistivity imaging survey. *Journal of Environmental Management*,2001:28:655-663.
3. Aiman U, Mahmood A, Waheed S, Malik RN. Enrichment, geo-accumulation and risk surveillance of toxic metals for different environmental compartments from Mehmood biotic dumping site, Lahore City, Pakistan. *Journal of Chemosphere*,144:2229-2237. Retrieved from [www.elsevier.com/locate/chemosphere](http://www.elsevier.com/locate/chemosphere). Downloaded on 2/9/2021.
4. Babiker SI, Mohammed AA, Mohamed TH. Assessing groundwater quality using GIS. *Journal of Water Resource Management*,2007:21:699-715.
5. Chenini I, Khamiri S. Evaluation of groundwater quality using multiple linear regression and structural equation modeling. *International Journal of Environmental Science and Technology*,2009:6(3):509-519.
6. Grugnaletti M, Pantini S, Verginelli J, Lombardi F. An easy-to-use tool for the evaluation of leachate production at landfill sites. *Journal of Waste Management*,2016:55:204-219.
7. Integrated Publishing. Chemical characteristics of water, 2019. Available online at [www.TBUB.com](http://www.TBUB.com). Retrieved on 10/8/2021.
8. Mor S, Ravindra K, Dahiya RP, Chandra A. Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site, 2006. Available online at <http://www.ncbi.nlm.nih.gov/pubmed>. Retrieved on 10/4/2020.
9. Nijamir K, Mim K. The impact of agricultural practices on groundwater quality: a critical study based on Nauthanveli DS District in Ampara District in Sri Lanka. *International Journal of Research-Granthaalayah*,2017:5(9):36-43.
10. Oyekun OT, Eludoyin AO. Heavy metal contamination of groundwater resources in a Nigerian urban settlement. *African Journal of Environmental Science and Technology*,2010:4(4):201-214.
11. Saidu S. Assessment of dumpsite impact on soil and groundwater quality in Tundun Wada,Kaduna. Available online at [www.kabunni.abu.edu.ng/jspui/bitstream/assessment-of-dumpsite,impact-on-groundwater-quality-in-tudun-wada-kaduna](http://www.kabunni.abu.edu.ng/jspui/bitstream/assessment-of-dumpsite,impact-on-groundwater-quality-in-tudun-wada-kaduna). Downloaded on 10/06/2020
12. USGS (2016). Quality of groundwater, 2016. Available online at <https://pubs.usgs.gov/gip/gw/index.html>. Downloaded on 05/07/2021.
13. USGS. Groundwater quality, 2018. Available online at <https://www.usgs.gov/special-topic/water-science-school/science/groundwater-quality>. Downloaded on 2/12/2020.
14. Wikipedia. Properties of water, 2021. Available online at <https://en.wikipedia.org/w/index.php?title=properties-of-waters&oldid=947664715>. Downloaded on 12/8/2021.
15. Wikipedia. Water quality. Available online, 2021. at <https://en.wikipedia.org/w/index.php?title=water=quality&oldid=948533492>. Downloaded on 12/9/2021.
16. Yisa J, Jimoh TO, Oyibo OM. Underground water assessment using water quality index. Available online at <http://www.researchgate.net/publication/286286617>, 2020. Downloaded on 13/8/2021.