

IMPACT OF SEASONAL VARIATION ON CHEMICAL PARAMETERS OF GROUNDWATER IN ONE LGA

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ABSTRACT

Groundwater quality in the Niger Delta is increasingly threatened by both natural seasonal cycles and anthropogenic pressures. This study evaluates the impact of seasonal variation on the chemical parameters of groundwater in Ogba/Egbema/Ndoni Local Government Area (ONELGA), Rivers State, Nigeria—a region characterized by intensive hydrocarbon exploration and agricultural activity. Groundwater samples from boreholes were analyzed during wet and dry seasons for chemical parameters. Results indicate significant seasonal fluctuations, with elevated values of Cl, CO₃, DO₂, NO₂, NH during the wet season, except phosphate with high values in BH1/ BH2 (7.01/ 10.7mg\l) and Ca in BH15(4.2mg/l) during dry season. while contamination remains a year-round concern from oil industry and other anthropogenic activities, the overall Concentration of chemical parameters during the wet season indicates that groundwater in the study area is unsuitable for drinking without treatment. This paper recommends seasonal water quality monitoring and improved waste management strategies to safeguard public health.

INTRODUCTION

Background to the Study

Currently, emphasis is not only on how abundant water is but also on whether its quality is good enough to sustain its various uses. Groundwater is the primary source of water for domestic, agricultural and industrial uses in many countries and its contamination has been recognized as one of the most serious problems (Belkhiri et al., 2010). Groundwater moves through pore spaces within rocks and reacts with minerals that make up the rocks in the course of migration (Amadi et al., 2012; Boateng et al., 2016). Groundwater quality in any locality takes after the chemical composition of the aquifer through which it migrates in accordance with the hydrological cycle and flow direction (Offodile 1983; Amadi et al., 2010; Boateng et al., 2016).

Groundwater can become contaminated by pollution at the surface (or at depth), and there are many different anthropogenic (human-caused) sources of contamination.

Vulnerability of aquifers to pollution depends on several/factors, including the depth to water table, the permeability of the material between the surface and then aquifer, the permeability of the aquifer, the slope of the surface, and the amount of precipitation. Confined aquifer tends to be much less vulnerable than unconfined ones, steeper slopes mean that surface water tend to run off rather infiltrate (and this can reduce the possibility of contamination), Contamination risk is also less in dry than in areas with heavy rainfall, (Steven – Earle; 2014).

Climate change for example, major increases in frequency and intensity of exceptional rainfall events in groundwater recharge areas can result in water tables rising to levels higher than previous recorded maxima, causing extensive groundwater flooding and pollution.

To manage a groundwater resource, we should not only concern about the water quantity and what happens to it, but we should also take care of the quality. Deterioration of groundwater quality may result in serious restrictions on its usages especially when it is used for domestic purposes. This is

because poor and contaminated water can be a threat to health, more over to the subsistence. In the study area, owing to the numerous hydrocarbon exploration activities, there is the need for assessment of groundwater quality to ascertain its suitability for domestic purposes. Season is believed to influence the concentration level of the Physico-Chemical and bacteriological loading in water sources. Agbaire and Oyibo (2007) investigated seasonal variability of physico – chemical elements in boreholes in Abraka town. The result shows total dissolved solids were lower in the dry season. Ocheri & Mile; (2010) assessed seasonal variation in nitrate level in Makurdi Metropolis and found 80% of the wells had nitrate concentrations above the WHO limits for drinking water.

In Ebocha – Obrikom of ONELGA, Raimi and Sabinus (2017) assessed the trace elements in surface and groundwater quality in the Ebocha – Obrikom oil and gas producing area of Rivers State, Nigeria, concluded that while groundwater had higher values of turbidity and iron, the concentration of biological oxygen demand (BOD) are higher in surface water. The pH of groundwater (borehole and well water inclusive) and surface water were acidic and only dissolved oxygen showed a significant negative relationship with distance from gas flaring while other physico-chemical parameters were not statistically significant. Groundwater from dry wells is generally used for domestic purposes in rural area of Ebocha – Obrikom without prior treatment and there are concerns about health implications. The study revealed that both the surface water and groundwater samples collected over Ebocha – Obrikom oil and gas producing community were relatively acidic, contained acidic radicals and may be attributed to emissions from gas flaring and petroleum refining activities which is common in the area. Groundwater constitutes the primary source of potable water for domestic, agricultural, and industrial applications in the Niger Delta region, where public water supply remains inadequate and unreliable. Ogba/Egbema/Ndoni LGA (ONELGA), located approximately 85 km north of Port Harcourt within the Niger Delta flood plains, exemplifies this dependence on groundwater resources, Osigwe et al (2024)

The region's geology consists of unconsolidated fluvial and marine sedimentary rocks, making the aquifer system vulnerable to contamination from both natural processes and anthropogenic activities. ONELGA hosts major oil and gas operations by companies including Nigerian Agip Oil Company (NAOC) now OANDO, Shell Petroleum Development Company (SPDC), and Elf-Total, whose exploration and exploitation activities have raised concerns about groundwater quality degradation. Additionally, agricultural intensification and urbanization further strain water resources, Abam and Nwankwoala (2020).

The Niger Delta experiences distinct wet (April–October) and dry (November–March) seasons, with precipitation patterns significantly influencing groundwater recharge, dilution, and contaminant mobilization. Understanding seasonal variation in chemical parameters is essential for effective water resource management and public health protection.

MATERIALS AND METHODS

The Study Area

The study area is ONELGA, and is located between latitudes 5°13'.92"N and 5° 19'.38"N and longitudes 6° 38'.10"E and 6°38'.75"E. ONELGA is 85km north of Port Harcourt, the capital of Rivers State of Nigeria. Omoku is the headquarters of Ogba/Egbema/Ndoni Local Government Area in Rivers State. The area can be found in the northern part of the Niger Delta Region within the Niger Delta flood plains.

The area is within the coastal rain forest of Nigeria, which is characterized by a long wet and a short dry season. The relief of the study area is generally low-lying plain consisting mainly of unconsolidated

sediments. The area comprises of sedimentary rocks and the sediments that make up the rocks are partly fluvial and of marine origin.

Sample Collection/ Analysis

Groundwater samples were collected from fifteen sampling (15) locations in the Ogba/Egbema/Ndoni Local Government Area. A total of thirty (30) water samples were collected, (15 during wet season and 15 samples during dry season). The samples were analyzed for chemical parameter using the standard laboratory analytical methods by The American Public Health Standard (APHA), 2017.

The study employed a descriptive survey design, collecting primary data through field sampling and laboratory analysis..

Data Analysis

Fourteen analytical parameters were analyzed, and results from the laboratory analysis of groundwater were directly compared with international standards for water quality, WHO (2012) Water Quality Standard were used to ascertain the potability and status of groundwater in both wet and dry season.

Table 1.1: Results of Chemical Parameters in Borehole Water- Wet Season Samples

Parameters	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8	BH9	BH10	BH11	BH12	BH13	BH14	BH15	WHO (2012)
TA mg/l	3.5	4.0	3.5	4.5	7.5	8	6.5	7.3	7	6.8	2	2	2	2	2	250
CL mg/l	0.02	0.05	0.02	0.04	13.8	16.02	19.31	20.14	7.15	19.31	8.6	10.3	8.53	4.31	8.8	250
CO ₃ mg/l	0.50	1.40	0.75	2.01	1.95	13.1	2.58	1.53	8.61	0.96	2.4	2.6	2.31	2.0	2.0	N/A
DO ₂ mg/l	4.03	4.133	4.31	3.02	3.91	3.7	4.0	3.8	3.01	3.42	3.0	3.3	3.0	3.8	3.0	3
Na mg/l	3.80	3.28	1.48	3.04	13.5	9.0	11.8	4.4	11	12	4.1	4.2	4.0	3.0	4.0	200
HCO ₃ mg/l	0.81	3.01	2.02	0.75	2.5	8.7	2.4	1.9	1.6	1.7	1.80	22	60	2.3	2.0	600
K mg/l	0.76	0.72	1.56	0.67	2	6	3	4	0.6	5	2.80	4.5	2.7	3.20	6.20	55
Oil & Grease mg/l	0.004	0.012	0.011	0.017	0.01	0.011	0.011	0.07	0.03	0.10	0.028	0.008	0.028	0.001	0.007	0.3
SO ₄ ²⁻ 0.015 mg/l	0.360	0.440	0.131	4.11	2.47	0.311	1.48	2.001	124.1	1.32	145.2	106.4	113.9	64.2		500
Phosphate mg/l	0.08	0.06	0.07	0.04	0.03	0.008	<0.005	0.009	0.006	0.003	2.5	3.8	7.6	2.2	6.3	N/A
NO ₂ mg/l	0.06	0.139	0.209	0.103	6.15	13.5	9.00	9.8	5.002	20.1	0.044	0.013	0.011	0.004	0.009	5
NH mg/l	0.003	0.001	0.002	0.002	<0.001	<0.001	0.001	<0.001	0.003	0.002	0.002	0.001	0.001	<0.001	0.001	N/A
Mg mg/l	1.86	1.54	2.91	3.01	0.96	1.44	2.01	0.29	0.04	0.19	0.091	0.012	<0.001	<0.001	<0.023	50
Ca mg/l	0.041	0.021	0.011	1.032	2.028	0.16	0.042	0.20	1.061	1.011	1.42	2.03	3.510	2.031	3.011	75

Key: BH= Borehole

Table 1.2: Results of Chemical Parameters in Borehole Water – Dry Season Samples

Parameters	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8	BH9	BH10	BH11	BH12	BH13	BH14	BH15	WHO (2012)
TA mg/l	2.0	2.0	2.0	2.2	2	2	2	2	3.7	3.4	2.8	2.8	2.4	2.8	2.2	250
CL mg/l	6.2	0.2	1.0	2.6	2	2	NIL	NIL	0.10	0.08	1.0	8.2	8.6	2.1	10	250
CO ₃ mg/l	2.4	2.4	2.2	2.2	2.0	2.6	2.1	3.0	0.6	2.1	0.4	2.8	2.2	86.2	2.0	N/A
DO ₂ mg/l	3.1	3.2	3.0	3.4	3.2	3.3	3.0	1.35	3.2	3.0	3.2	3.0	2.8	2.8	3.2	3
Na mg/l	1.8	2.0	2.0	2.3	2.6	2.0	2.1	2.1	0.1	0.1	0.1	4	4.2	3	3.1	200
HCO ₃ mg/l	1.55	1.80	1.70	1.60	1.44	1.70	1.40	<0.001	2.0	1.80	1.80	2	1.80	1.80	1.80	600
K mg/l	2.0	3.40	2.50	1.80	3.4	2.30	2.2	0.008	0.002	2.1	3.0	4.6	2.80	3.60	2.60	55
Oil and Grease mg/l	0.002	0.002	<0.002	0.001	0.002	0.002	0.001	0.018	0.001	0.001	0.003	0.006	0.023	0.001	0.035	0.3
SO ₄ ² mg/l	32.2	60.7	50.9	29.3	0.022	2.9	0.68	0.87	112	0.02	2.1	76.3	42.1	82.4	52.2	250
Phosphate mg/l	22.4	12.8	15.6	17.3	33.8	76.3	2.2	3.2	2.1	1.0	3.6	3.3	2.2	3.1	5.4	NA
NO ₂ mg/l	0.44	3.40	0.65	0.29	0.016	0.008	0.012	0.022	2.4	2.0	0.47	0.17	0.22	0.30	0.18	0.68
NH mg/l	0.001	0.001	0.003	<0.001	0.001	<0.001	0.001	0.001	<0.001	<0.001	0.001	0.001	0.003	0.001	0.028	0.2
Mg mg/l	7.04	10.7	12.5	5.87	<0.001	0.022	<0.022	0.018	0.032	0.022	0.149	4.22	6.52	2.42	3.54	150
Ca mg/l	0.035	0.034	0.032	0.035	0.022	0.022	0.027	0.047	1.3	1.2	2.6	0.048	1.6	2.5	4.2	75

Key: BH= Borehole

Total Alkaline (TA)

Total Alkaline (TA) values varies from 2 – 10.6mg/l (wet season) and 1.6 – 4.3mg/l (dry season). TA values were found to be highest in wet season (10.6mg/l) W4, and were consistently higher compared to dry season values.

Chloride (CL)

Chloride concentration of groundwater sample during wet and dry seasons ranged from 0.02 – 19.31mg/l and 0.08 – 10mg/l respectively. Chloride values were found to be higher in wet season than in dry season.

Carbonate (CO₃)

Carbonate (CO₃) concentration in groundwater for wet and dry seasons varies from 0.21 – 13.1mg/l and 0.4 – 88mg/l. highest value of carbonate (88mg/l) W14 was observed during dry season, carbonate values were also observed to be slightly higher during dry season than in all the wet season values.

Dissolved Oxygen (DO)

Dissolved oxygen (DO) values of water samples during wet and dry seasons sampling periods ranged from 3 – 5.81mg/l and 1.35 – 3.8mg/l. Seasonal changes showed the highest values during the wet season and the lowest during the dry season.

Sodium (Na)

Sodium (Na) concentration in groundwater ranged from 1.48 – 448mg/l and 0.1 – 5.1mg/l during wet and dry season period. Sodium values were found to be higher during wet season than during dry season.

Biocarbonate (HCO₃)

Seasonal variation of Biocarbonate in groundwater showed ranges of 0.06 - 15mg/l and <0.001 – 2.8mg/l. Biocarbonate values were higher in dry season compared to wet season even though all samples for both seasons at all sampling location lie within the specified standard limits.

Potassium (K)

The Potassium (K) concentration in groundwater samples during wet and dry seasons ranged from 0.6 – 8mg/l and 0.002 – 5.1mg/l respectively. The observed value for potassium is found to be slightly higher in wet season than in dry season even though the values fall within the permissible limit.

Oil and Grease

Oil and Grease concentration in groundwater samples during wet and dry seasons varies from 0.001 – 0.16mg/l and <0.001 – 0.051mg/l respectively. Oil and Grease values observed were found to be slightly higher during wet season compared to dry season. The low concentrations for oil and grease value for the study area during both sampling periods were found to be within the limits of 0.3mg/l (WHO, 2012).

Sulphate (SO₄)

The concentration of Sulphate (SO₄) varies from 0.095 – 156mg/l and 0.02 – 137mg/l during wet and dry seasons respectively. Highest values of SO₄ (156.3 and 145.2mg/l) were observed in W15 and B15. Sulphate concentration was found to be higher in wet season compared to dry season.

Phosphate (PO₄)

Phosphate (PO₄) concentration in groundwater varies from 0.003 – 7.6mg/l and 0.032 – 97.3mg/l during wet and dry seasons in the study area. PO₄ values were consistently higher in dry season than wet season with the highest values (97.3mg/l) W6 during dry season.

Nitrate (NO₃)

Nitrate concentration in groundwater study area ranges from 0.009 – 20.1mg/l for wet season and 0.008 – 3.46mg/l for dry season. The concentration of nitrate in wet season is higher than that in dry season with its highest values in BH10 (20.1mg/l) which also show possible source of contamination of groundwater in the area since nitrate concentration exceeded the regulatory limit of 5.00mg/l (WHO, 2012).

Ammonia (NH₃)

The Ammonia (NH₃) values of groundwater samples during wet and dry season sampling period ranged from <0.001 – 0.003mg/l and <0.001 – 0.041mg/l respectively. The result did not vary significantly in both seasons. All Ammonia values for both seasons lie within the permissible limit.

Magnesium (Mg)

Magnesium (Mg) concentration for both wet and dry seasons varies from <0.001 – 2.11mg/l respectively. Seasonal changes showed the highest value (21.5mg/l) W15 during dry season and also consistently higher in dry season than in wet season, but the observed values are within the permissible limit.

Calcium (Ca)

The Calcium concentrations during both sampling periods ranged from 0.021 – 6.17mg/l for wet season and 0.022 – 6.61mg/l for dry season. There is no significant seasonal variation of calcium. The lowest and highest concentration values in both seasons are barely the same. The concentration of calcium in all analyzed water samples lie within the specified limit of WHO.

CONCLUSION

Looking at the seasonal variation of parameters, there were significant changes of parameters from wet season than dry season. Most parameters had higher values during wet season compared to their dry season values e.g. TDS, TA, Cl, DO, Na, K, SO₄, and vice versa. Most parameters studied had concentrations above the WHO limits for drinking water which could be due to exceptional rainfall, causing extensive groundwater flooding and pollution. Seasonal variation significantly influences groundwater chemical parameters in Ogba/Egbema/Ndoni LGA, with the associated elevated values of chemical parameters during wet season. The groundwater is classified as Cl–Na dominant water type, reflecting end-point dissolution processes.

RECOMMENDATIONS

Recommendations include seasonal monitoring programs to track water quality fluctuations and inform treatment strategies, proper waste management system must be implemented. Regulatory enforcement should be strengthened for oil companies to minimize environmental contamination from exploration activities, necessary community water treatment and public health education regarding water treatment practices and sanitation which is essential for disease prevention.

REFERENCES

- Abam, T. K. S., & Nwankwoala, H. O. (2020). Hydrogeology of Eastern Niger Delta: A review. *Journal of Water Resource and Protection*, 12(9), 741–777. <https://doi.org/10.4236/jwarp.2020.129045>
- Agbaire, P. O. & Oyibo, P. (2007). Seasonal Variation of Some Physico-Chemical Properties of Boreholes in Abraka, Nigeria. *African Journal of Pure and Applied Chemistry* 3(6), 116-118.
- Amadi, A.N., Olasehinde, P.I., Yisa, J. Okosun, E.A., Nwankwoala, H.O. & Alkali, Y.B. (2012). Geostatistical Assessment of Groundwater quality of coastal aquifers of Eastern Niger Delta. *Geosciences*, 2(3), 51-59.
- Amadi, A.N., Yisa, J., Okoye, N.O. & Okunlola I.A., (2010). Multivariate statistical evaluation of the hydro chemical facies in Aba, South-eastern Nigeria. *International Journal of Biology and Physical Science*, 15 (3), 326-337.
- Belkhiri, L., Boudoukha, A. & Mouni, L. (2010). Groundwater quality and agricultural use in AinAzel plain, Algeria, *Journal of Geography and Regional Planning*, 3(6), 151-157.
- Boateng, T.K., Opoku, F., Acaquaah, S.O. & Akoto, O. (2016). Groundwater Quality assessment using statistical approach and water quality index in Ejisu – Juaben Municipality, Ghana. *Environmental Earth Science*, 75, 489.
- Ocheri, M. I. (2006). Analysis of Water Consumption Pattern in Makurdi Metropolis. *Journal of Geography and Development*, 1(1), 71-83.
- Offodile, M.E. (1983). The occurrence and exploitation of groundwater in Nigeria, Mecon Eng. Service Ltd, Jos, Nigeria. 239-255.
- Osigwe, O. W., Abam, T. K. S., & Yondeowei, P. O. (2024). Assessment of heavy metal levels and microbiological parameters in hand dug wells and water boreholes in Ogba Egbema Ndoni Local Government Area, Rivers State, Nigeria. *BW Academic Journal*, 1(2), 130–140. Retrieved from <https://mail.bwjjournal.org/index.php/bsjournal/article/view/2065>
- Raimi, M.O. & Sabinus, C.E. (2017). An assessment of Trace Elements in Surface and Groundwater Quality in the Ebocha - Obrikom Oil and Gas Producing Area of Rivers State, Nigeria. *International Journal of Scientific and Engineering Research*, 8(7),
- Steven Earle (2014) *Physical Geology*. Enugu: Pef Publisher