ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25nov1415

Examination of Groundwater Quality within Residential Confines Across Two Selected States of Niger Delta Areas, Nigeria

Dr. Iluyemi Patrick Olorunloba[1]

[1]University of Port Harcourt

Publication Date: 2025/12/05

Abstract: The study on Examination of Groundwater Quality within Residential Confines across two Selected States of Niger Delta Areas, Nigeria focused on possibility of septic tank leachate infiltrating groundwater in Niger-delta region of Nigeria, using two cities in selected States of Rivers and Edo States. The study examined physicochemical characteristics of groundwater, and equally investigated possibility of septic tank leachate infiltrating groundwater, using Student t-Test for the hypothesis testing of a significance level (*p*) of 0.05 and Spearman's Correlation Analysis. The work used thirty communities as study areas. Grouped into areas with distances between soakaway and water borehole less than 30metres and areas with septic tank to water borehole distances higher than 30metres according to WHO standard (5mg/L). Results showed that all groundwater-quality- parameter tests conformed to maximum permissible limits of WHO, DPR and FEPA. The t-test and Spearman's results indicated that there was no statistically significant difference between distance of soakaway to borehole and groundwater quality. However, the Biological Oxygen Demand (BOD) was higher than WHO's criterion. The study recorded highest BOD in Queen's Park estate (7.21mg/L) and Uniben (7.21mg/L). High BOD in a given sample of water is an indication of polluted water. It requires urgent attention. Government through public/private partnership of building central pipe borne water and central sewage treatment plants can prevent the risk or reduce it to manageable level (mitigation).

Keywords: *Pollution, Groundwater, Niger-Delta, Leachate, Contamination*

How to Cite: Dr. Iluyemi Patrick Olorunloba (2025) Examination of Groundwater Quality within Residential Confines Across Two Selected States of Niger Delta Areas, Nigeria. *International Journal of Innovative Science and Research Technology*, 10(11), 2632-2640. https://doi.org/10.38124/ijisrt/25nov1415

I. INTRODUCTION

Having groundwater suitable for domestic consumptions has always been a global challenge requesting multidimensional approach to tackle. This is because majority of households in many developing nations deployed cheap borehole technology to withdraw groundwater in their private residential confines without prerequisite regulations and supervisions (Annapooma, 2015). Most alarming situation is the construction of onsite septic tank systems in the neighbourhood of borehole wellheads in most residential communities without considering possible contamination. This action could singlehandedly trigger likely human health challenge via seepage of septic leachates into the surrounding soil and thereafter to the groundwater through soil pathways, which is the source of drinking water in most localities of developing nations (Arjen, 2008).

Absence of modern central water supply systems to villages, towns and cities of Nigeria has occasioned proliferation of unregulated extraction of groundwater resource (Gbadegesin, 2007). As a result, managing groundwater quality to acceptable global best practices has been a herculean task. Although, many works in the past had assessed groundwater quality, yet further works on examination of groundwater quality in this part of the world to determine its suitability for human consumption in residential confines still beckon for more assessments. To this end, the present work examined physicochemical characteristics of groundwater in the study areas to assess its suitability for drinking, and to investigate possibility of septic tank leachates infiltrating groundwater.

II. METHODOLOGY

The study adopted correlational research design. At the study locations (Port Harcourt metropolis & Benin City), thirty communities were identified fit for the field works in terms of security architecture and ease of communication with the dwellers during data collections. Eighteen communities in Port Harcourt city and its environs, while twelve communities identified in Benin City and its environs. The research adopted purposive sampling technique. To determine suitability of groundwater quality for drinking, the work deployed physicochemical analysis to evaluate chemical properties of water samples across the study areas.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25nov1415

It selected twelve important groundwater quality parameters for the analysis, these included temperatures, Cu, total dissolved solids (TDS), Salinity, pH, electricity conductivity (EC), chloride ion (Cl^-) concentration, total hardness (TH), dissolved oxygen (DO) concentration, BOD & COD (Jirka and Carter, 2010).

All the analyses were carried out and their mean values adopted using basic statistical tools. Data analysis for the relationship between septic tank distance to borehole and groundwater quality done by means of pair comparisons using t-tests for the hypothesis testing. A significance level (*p*) of 0.05 used in testing the alternate hypothesis. Pearson's correlation analysis was equally used to decide if there was any correlation between the occurrences of contaminants in the boreholes and septic tank leachates seepage. The statistical analysis carried out using the IBM SPSS software, version 20.

III. RESULTS AND DISCUSSIONS

➢ *The Following are the Presentation of the Results:*

- *Groundwater Quality Parameters Test Analyses across Study Fields*

Laboratory tests on water samples collected from different existing sunk private boreholes across thirty study areas were done according to standard methods.

Table 1 Physicochemical Analyses Across the 30 Selected Communities in Rivers & Edo States

Communities	Temp.	Cu	TDS	Salinity	pH	EC	Cl^-	NO_3	Hard	DO	BOD	COD
Nkpor	28.35	0.07	57.85	0.07	6.51	16.76	11.98	0.44	16.99	5.51	4.33	9.28
Mercyland	29.01	0.67	60.34	0.24	6.55	17.01	12.78	1.4	17.62	5.33	4.87	9.33
D-line	28.67	0.55	58.23	1.2	7.23	18.34	12.65	0.55	17.56	5.24	4.50	9.01
Okuruama	27.98	0.86	56.86	0.06	8.12	16.45	12.03	0.33	16.45	5.40	5.01	9.89
Eliogbolo	29.23	0.65	62.34	0.08	6.45	17.43	13.10	0.34	17.43	6.01	4.22	9.99
`Elelenwo	27.63	0.78	58.99	0.12	7.01	17.65	12.33	0.67	17.65	4.52	4.34	9.34
Rukpoku	28.45	0.90	62.03	0.23	6.33	17.98	12.45	0.56	17.98	7.21	4.88	9.45
Rumuigbo	28.66	0.73	60.34	0.22	6.23	16.45	12.87	0.33	16.45	5.55	4.52	8.78
Ayan Waterside	28.03	0.04	58.23	0.09	6.33	16.99	11.89	0.89	16.99	5.45	4.50	1.01
Etete Village	28.35	0.23	56.86	1.3	5.43	17.62	12.02	0.12	17.62	5.99	5.55	9.66
Sakpoba	29.01	0.65	62.34	0.09	7.34	17.56	12.78	2.00	18.32	6.00	4.21	9.76
Ugbowo	28.67	0.55	56.86	0.78	6.45	16.45	12.75	1.09	18.01	5.43	4.43	9.56
Uselu	27.98	0.86	62.34	0.06	7.01	17.43	12.74	0.33	16.99	5.11	4.98	8.76
Ikpoba	28.77	0.65	58.99	0.06	6.33	17.65	12.09	0.34	17.62	5.24	5.19	8.92
Wire Road	27.79	0.78	62.03	0.08	6.23	17.98	13.55	0.67	18.01	5.40	4.01	9.33
Elekhohia	29.56	0.90	60.34	0.12	6.33	16.45	12.67	0.56	17.34	6.01	6.77	9.01
PH Garden Estate	27.98	0.73	61.55	0.23	8.12	16.99	12.76	0.33	17.23	4.52	6.45	9.89
Iboloji Estate	29.23	0.07	57.76	0.22	6.45	17.62	11.89	0.89	17.02	7.21	4.50	9.99
Old GRA	27.63	0.67	58.21	0.09	7.01	18.32	12.02	0.12	17.56	5.55	5.01	9.34
GRA II	28.45	0.55	63.12	1.3	6.33	18.01	12.78	0.33	17.12	5.45	4.22	9.45
GRA IV	28.66	0.86	56.88	0.09	6.23	17.34	12.75	0.34	17.00	5.99	4.34	8.78
Agip Estate	28.03	0.65	57.88	0.07	6.33	17.23	12.74	0.33	17.98	5.24	4.88	1.01
Rumubekwe	28.35	0.78	62.34	0.24	8.12	17.02	11.89	0.34	16.45	5.40	4.52	9.66
Queen Park Estate	29.01	0.90	58.99	1.2	6.45	17.56	12.02	0.67	18.01	6.01	7.21	9.76
Etete	28.67	0.45	62.03	0.06	7.01	17.12	12.87	0.56	17.34	4.52	5.55	9.33
Uniben Campus	29.04	0.97	60.34	0.08	6.33	17.00	11.89	0.33	17.23	7.21	5.45	9.01
GRA- Benin	28.69	0.67	58.23	0.12	6.23	17.98	12.02	0.89	17.02	5.55	5.99	9.89
Airport	28.65	0.88	56.86	0.23	6.33	16.45	12.78	0.12	17.56	5.45	6.00	9.99
Wasota	27.72	0.42	62.34	0.22	8.12	16.99	12.75	0.33	16.45	5.99	6.10	9.34
Adesuwa	28.02	0.04	56.86	0.09	6.11	17.62	12.74	0.34	17.43	6.00	6.77	9.66

- *Table Analyses*

Table 1, reveals the temperature of collected groundwater samples across the study locations. Lowest temperature recorded is 27.63ºC from collected water sample at Elelenwo and the highest at Elekhohia (29.56ºC), in Port Harcourt city. The same table discloses presence of copper level in the collected groundwater samples across study areas. At Ayan waterside, Obio Akpor LGA, Port Harcourt metropolis and Adesuwa community Ore-Edo LGA in Benin City recorded lowest presence of copper level (0.04mg/L), while Uniben campus records the highest (0.97mg/L). Average Total Dissolved Solids (TDS) record shows that GRA II, Port Harcourt has the highest with 63.12mg/L while Nkpor, a marginal land in Port Harcourt Metropolis has a mean value of 57.83mg/L among the locations studied. The lowest average salinity recorded from the sampled water is

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25nov1415

0.06mg/L while the highest is 1.3mg/L in Etete village, suburb of Benin City and GRA II, Port Harcourt. World Health Organisation says 400mg/L, which is international standard and at national level, DPR, it is 300mg/L (Table 2). The result is within allowable standard across study localities.

Average acidity of the water sample collected across research areas almost at par with acceptable values, of WHO which is 6.5, DPR value is 6.5-8.5 and FEPA is 6.5-9.5 (Table2). From table1, the highest across study area is 8.12 in GRA IV, Rumuigbo, Port Harcourt and GRA, Benin City. The lowest record was in Ikpoba (5.43). The lowest Electrical conductivity of water sample tested is 16.45υS/cm in Okuruama, Rumuigbo, Ugbowo, and Elekhohia in Port Harcourt and around Airport Road area of Benin City. The highest value is 18.34υS/cm in D-Line, Port Harcourt. These values are within acceptable limits of international and national standards. Average Chloride across sampled locations suggests is in conformance with WHO standard of 250mg/L. The highest across the study areas is 13.55mg/L in Wire Road, Benin City and lowest is 11.89mg/L in Ayan Waterside, Iboloji estate and Rumubekwe all in Port Harcourt while Uniben campus shares the same value with them. Nitrate level from water samples are within tolerable borders. Having the highest concentration value of 2mg/l in Sakpoba, Benin City, and the lowest of 0.12 in Etete village, fringe of Benin City, Old GRA, Port Harcourt and Airport Road area of Benin City. In all, they are within maximum permissible limits of 50mg/L concentration. Dissolved Oxygen (DO) across the study fields investigated make known that they are within allowable boundaries, although almost at borderline of 6mg/L according to WHO standard. The highest value is 7.21mg/L at Queen Park Estate around Eliozu area, Port Harcourt. The lowest value is 4mg/L from the samples collected in Wire Road, Benin City.

Biochemical Oxygen Demand (BOD) sampled water test discloses that the average (5.74mg/L) across study locations is higher than recommended limit of 5mg/L. The highest value across research location is 7.21mg/L in Uniben campus, Benin City, Iboloji Layout within Rumuigbo and Rukpoku community, Port Harcourt, while the lowest is 4.52 mg/L in Elelenwo, PH Garden estate, Port Harcourt and Etete around Santana Market in Benin City. Average Chemical Oxygen Demand (COD) from the table shows that the presence in sampled water across study fields is within acceptable range prescribed by WHO, an international organisation to be 40mg/L, while from the fieldwork is 9.99mg/L in Eliogbolo, Iboloji estate, Port Harcourt and Airport Road area in Benin. The lowest average is 8.66mg/L in Agip Estate, Port Harcourt.

Table 2 National and International Standards of Allowable Limits of Groundwater Quality Parameters from WHO, DPR & FEPA Limits

Parameters	WHO Limits	DPR Limits	FEPA Limits
Temperature	28	35	25-30
Copper	1.5	1.5	-
TDS	500	800	-
Salinity	400	300	-
pH	6.5	6.5-8.5	6.5-9.5
EC	0-40	-	300
Chloride	250	-	-
Nitrate	45	-	-
Hardness	500	800	-
DO	6	-	>5
BOD	5	-	10
COD	40	-	-

- *Water Quality Index (WQI)*

Water Quality Index WQI was calculated using some or all parameters of water quality parameter categories (Brown et al, 1972): Temperature, water clarity (turbidity, etc.), Dissolved Oxygen, Oxygen Demand, Nutrients (Nitrate, Nitrite, Phosphorus, etc.), Bacteria (Total coliform, fecal coliform).

Table 3 Water Quality (WQI) Developed by Brown et al., (1972)

Water Quality Index	Water Quality Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
>100	Unfit for Drinking

Table 4 Results of Water Quality Index/Water Quality Status Across Study Locations

Location	Water Quality Index	Water Quality Status
Nkpor	35.78095	Good
Mercyland	75.44982	Poor

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25nov1415

D-line	67.11236	Poor
Okuruama	89.60709	very poor
Eliogbolo	74.12172	Poor
Elelenwo	79.47635	very poor
Rukpoku	94.9325	very poor
Rumuigbo	78.66592	very poor
Ayan waterside	33.98176	Good
Etete Village	49.50799	Good
Sakpoba	74.90924	Poor
Ugbowo	66.7407	Poor
Uselu	87.79539	very poor
Ikpoba	74.529	Poor
Wire Road	80.20168	very poor
Elekhohia Housing Estate	96.70949	very poor
Port Harcourt Garden City Estate	82.67526	very poor
Iboloji Estate	40.56076	Good
Old GRA	76.75405	very poor
GRA Phase II	66.12333	Poor
GRA Phase IV	87.71719	very poor
Agip Estate	73.73081	Poor
Rumubekwe	83.18828	very poor
Queen Park Estate	100.9054	Unfit for drinking
Etete	61.32158	Poor
Uniben Campus	35.55041	Good
GRA	78.60332	very poor
Airport Road	91.97941	very poor
Wasota	65.57803	Poor
Adesuwa	41.04438	Good

Table 4, applied Water Quality Status Assessment of Brown et al (Table 3) to determine Water Quality Status (WQS) across study areas. This study used Water Quality Index (WQI) formula to compute, from the water quality parameters the suitability of groundwater for drinking across the study locations. Community with the highest WQS is Uniben Campus, Edo State (Table 4) with WQS value of 35.55041, which makes it fit for drinking and other domestic applications. This result justifies the essence of having efficient central borehole system. University of Benin community uses central water supply system, hence, the achievement of this decent result after investigation of the groundwater quality of the locality.

The poorest community is Queen Park Estate in Port Harcourt, Rivers State, with 100.9054 value (Table 4). This reveals groundwater in this community unfit for drinking. As a matter of urgency, the dwellers need sensitisation on high human health risk inherent in the groundwater if consumed untreated.

- ➢ *Investigation of Possibility of Septic Tank Leachates Infiltrating Groundwater*

Laboratory tests on water samples collected from different existing sunk private boreholes across thirty study areas done according to standard practices (Table 1). Samples were taken from land space constrained areas where distances between septic tank to borehole siting were less than 30 metres. Likewise, samples were collected in areas with adequate land space that accommodates accepted distance limit of 30metres (Table 2) between septic tank and borehole water siting. The results of the tests as revealed in table 5 are within acceptable limits when compared with WHO, DPR, and FEPA recommended criteria.

Table 5 Average Physicochemical Results Across Location Fields in Comparison with WHO, DPR & FEPA Limits

Parameters	**Distance>30m**	**Distance<30m**	**WHO Limits**	**DPR Limits**	**FEPA Limits**
Temperature	28.35	28.37	28	35	25-30
Copper	0.07	0.04	1.5	1.5	-
TDS	57.92	63.66	500	800	-
Salinity	0.12	0.08	400	300	-
pH	6.52	6.57	6.5	6.5-8.5	6.5-9.5
EC	16.90	17.21	0-40	-	300
Chloride	12.5	12.78	250	-	-
Nitrate	0.25	0.43	50	-	-
Hardness	15.43	17.05	500	800	-
DO	5.51	5.55	6	-	>5

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25nov1415

BOD	4.36	5.74	5	-	10
COD	7.81	9.28	40	-	-

Table 5, presents average physicochemical properties of groundwater samples collected across the study locations. The parameters cover groundwater temperature, copper, TDS, salinity, PH, EC, chloride, Nitrate, hardness, DO, BOD, COD. Results are as follows: areas where distances between septic tanks to water boreholes are less than 30 metres recorded temperature (28.35ºC), copper (0.07mg/L), TDS (57.92mg/L), salinity (0.12), PH (6.52), EC (16.90), Chloride (12.5mg/L), Nitrate (12.5mg/L), Total hardness (15.43mg/L), DO (5.51mg/L), BOD (4.36mg/L), COD (7.81mg/L). Areas where distances between borehole wellheads and septic tanks are more than 30 metres, temperature (28.37ºC), copper (0.04mg/L), TDS (63.66mg/L), salinity (0.08), PH (6.57), EC (17.21), Chloride (12.78mg/L), Nitrate (0.43mg/L), Total hardness (17.05mg/L), DO (5.55mg/L), BOD (5.74mg/L), COD (9.28mg/L). The results of both locations when compared with the standard permissible limits of WHO, DPR and FEPA are within allowable limits.

The following represent data presentation of calculated Water Quality Index (WQI) against measured distances between septic tanks and water borehole locations.

Table 6 Results of WQI Versus Distances in <30 Metres Areas and their WQS

Location	Distance	Water Quality Index	Water Quality Status
Nkpor	9	35.78095	Good
Mercyland	8	75.44982	Poor
D-line	5	67.11236	Poor
Okuruama	24	89.60709	very poor
Eliogbolo	13	74.12172	Poor
Elelenwo	17	79.47635	very poor
Rukpoku	7	94.9325	very poor
Rumuigbo	14	78.66592	very poor
Ayan waterside	18	33.98176	Good
Etete Village	19	49.50799	Good
Sakpoba	12	74.90924	Poor
Ugbowo	8	66.7407	Poor
Uselu	10	87.79539	very poor
Ikpoba	18	74.529	Poor
Wire Road	6	80.20168	very poor

Table 7 Results of WQI Versus Distances in >30 Metres Areas and their WQS

Location	Distance	Water Quality Index	Water Quality Status
Elekhohia Housing Estate	35	96.70949	very poor
Port Harcourt Garden City Estate	33	82.67526	very poor
Iboloji Estate	28	40.56076	Good
Old GRA	45	76.75405	very poor
GRA Phase II	28	66.12333	Poor
GRA Phase IV	34	87.71719	very poor
Agip Estate	50	73.73081	Poor
Rumubekwe	33	83.18828	very poor
Queen Park Estate	60	100.9054	Unfit for drinking
Etete	34	61.32158	Poor
Uniben Campus	65	35.55041	Good
GRA	42	78.60332	very poor
Airport Road	29	91.97941	very poor
Wasota	32	65.57803	Poor
Adesuwa	40	41.04438	Good

Water Quality Index (WQI) results calculated from the water quality parameters were placed against measured average distances (<30 metres and >30 metres) between septic tank and water boreholes to verify possible infiltration of septic tank leachates into groundwater (Table 6 and 7), after being subjected to hypothesis testing. The test serves as final analysis in finding if proximity of septic sewage to borehole plays statistical significance in groundwater pollution in the areas studied. In this category (<30metres distance), the mean of community with lowest distance (5metres.) is D-Line, Port Harcourt, while Okuruama has the highest distance (24metres). WQI in the category has highest value of 94.3 in Rukpoku, while the lowest is Ayan Waterside with WQI of 33.98. Communities with highest Water Quality Status (WQS) based on assessment are, Nkpor (Good), Ayan waterside (Good) and Etete Village (Good).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25nov1415

In the study areas where the distances of septic tanks to boreholes are more than 30metres, the least measurement was in Iboloji estate with mean value of 28metres. While the highest measured, distance was in Queen Park estate (65metres), Port Harcourt. Regarding the Water Quality Status (WQS), only Iboloji estate (Rumuigbo), Port Harcourt has good water for drinking based on the analysis. While three communities are classified "Poor", 6 communities, (Very Poor) and only water samples from one community (Uniben campus) considered "safest for drinking" (Table 7)

➢ *Alternate Hypothesis:*

- H_1: There is a statistically significant difference in the relationship between septic tank distance to borehole and groundwater quality across the study locations
- Ho: There is no statistically significant difference in the relationship between septic tank distance to borehole and groundwater quality across the study locations

➢ *Testing the Hypothesis*

Testing for the relationship between septic tank distance to borehole and groundwater quality handled by means of pair comparisons using t-tests for the hypothesis testing of a significance level (p) of 0.05. Spearman's correlation analysis further deployed to decide if there was any correlation between the occurrences of contaminants in the water borehole and the proximate distance from onsite septic tank systems. From table 8, the p value of Levine's test is 0.787; therefore, we conclude that the variance in WQI in both <30metres and >30metres distances between septic tank and water borehole wellheads is not statistically significant. Therefore, we reject the alternate hypothesis that states, "There is a statistically significant difference in the relationship between septic tank distance to borehole and groundwater quality across the study locations". We now accept the Null Hypothesis that states," There is no statistically significant difference between water quality across the study areas and the distance from water borehole to soak away. In addition, on Table 9, there is a weak relationship (0.286) between water quality index and septic tank distance to borehole. Again, Table 10, shows there is weak correlation (0.04) between WQI and septic tank distances that are >30metres. In the final analysis on WQI against distance shows, there is a weak correlation (0.2) between WQI and septic tank distance to borehole where septic tank distance to borehole wellheads are less than 30metres.

Table 8 T. Test Testing for Difference in WQI between High-Density and Low-density Areas

Group Statistics					
	Density	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Water Quality Index	High	15	70.8542	18.08554	4.66967
	Low	15	76.3231	18.76629	4.84543

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	
Water Quality Index	Equal variances assumed	.074	.787	-.813	28	.423	-5.46891	6.72934	-19.25334
	Equal variances not assumed			-.813	27.962	.423	-5.46891	6.72934	-19.25419

Table 9 Correlation Between WQI and Distance Between Septic Tank and Water Borehole

			Water Quality Index	**Septic Tank Distance to Borehole**
Spearman's rho	Water Quality Index	Correlation Coefficient	1.000	.201
		Sig. (2-tailed)	.	.286
		N	30	30
	Septic Tank Distance to Borehole	Correlation Coefficient	.201	1.000
		Sig. (2-tailed)	.286	.
		N	30	30

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25nov1415

Table 10 Correlation Between WQI and Septic Tank Distance to Borehole in Low-Density Areas

			Water Quality Index	Septic Tank Dist. to Borehole in Low Density Location
Spearman's rho	Water Quality Index	Correlation Coefficient	1.000	.043
		Sig. (2-tailed)	.	.879
		N	30	15
	Septic Tank Dist. to Borehole in Low Density Location	Correlation Coefficient	.043	1.000
		Sig. (2-tailed)	.879	.
		N	15	15

Table 11 Correlation between WQI and Septic Tank Distance to Borehole in High-density Areas

			Water Quality Index	Septic Tank Distance to Borehole
Spearman's rho	Water Quality Index	Correlation Coefficient	1.000	.201
		Sig. (2-tailed)	.	.286
		N	30	30
	Septic Tank Distance to Borehole	Correlation Coefficient	.201	1.000
		Sig. (2-tailed)	.286	.
		N	30	30

IV. CONCLUSION AND RECOMMENDATION

- *Conclusion*

The research on groundwater pollution assessment across selected urban Cities of two States in Niger Delta region of Nigeria has shown that there is no statistical significance in distance between soakaway to water borehole source and groundwater quality. However, certain parameter indicates that mean values across some study areas are higher than maximum allowable criteria. In as much as this should not be considered unilaterally by standards, it portents probability of occurrence of groundwater pollution, particularly in the communities where fieldworks were conducted.

Lack of central water supply system and sewage treatment plants, poor urban planning, population explosion, birth control and many more are the root courses of groundwater vulnerability and pollution. Having boreholes in every residential area without considering locations of soakaway in the adjoining properties is another level of groundwater vulnerability. Allowing property to be developed on a given land space above statutory limit is another issue affecting proper planning of facilities within residential confines, particularly in the spacing of onsite septic tank from water borehole source. It is equally obvious that monitoring of approved plans to see to appropriate positioning of septic tank and water boreholes is lacking in most of the communities where we carried out survey. Worst hit is the high-density areas. Total disregard to urban rules and regulations in the area of depth of borehole, design of soakaway and spacing are the order of the day in these locations.

- *Recommendations*

Reducing numbers of On-site Septic Tank Systems (OSTSs) in densely populated residential community in terms of density per unit land area will help lessen inputs of septic tank leachates such as faecal coliforms, total coliform and other pollutants to the groundwater, particularly in the suburb of the cities. By implication, it could mean adopting communal modular septic tank system within the neighbourhood, capable of serving many residences better without compromising World Health Organization's standard of minimum of thirty metres distance away from sources of portable water.

Capacity of centrally located OSTS in terms of size will be dependent on population of the area and the efficiency level of the sanitary wares such as water cisterns (black wastewater), bathing systems, kitchen plumbing system (green wastewater), etc. Since the areas in focus also include landfilled that could allow flow of treated wastewater to the neighbouring rivers, ponds, sea tributaries, as so on, makes final destination of treated waste safe. The intended modern septic tank system should have a design capable of accommodating changes in water saturation level because of high precipitations. Septic tank leachates' transport and fate, system performance, resultant environmental impacts; interaction of the planning design, siting, maintenance, and management function, cost effectiveness, system reliability and proper management should be community-based.

Financing the proposed modular/communal septic tank systems could come handy through contributions, donations, borrowing, and partnership among other sources of raising funds. The essence of this is to guide against endless waiting for government funding. As well as regulating commercial activities of the professional, company responsible for the construction and maintenance of the facility. The community's involvement equally gives room for sustainable management of the projects through utility bill payments. Arriving at the cost of project is dependent on the following factors: population density of a given residential community, site selection & cost of siting, soil investigation/EIA, engineering design/ construction cost and the management, while total cost of doing this could be among the dwellers and the professional company chosen to construct and manage it.

Again, determining population density and the spread of the community proposed for the scheme will help to decide capacity of septic tanks and ultimately number of modular septic tank systems that will be required. Knowing distance from the source of drinking water is equally important. This guides the mapping of sewer lines to the facility and maintenance culture to adopt within the neighbourhoods. Site selection and acquisition of land for the scheme is of importance too. It should be a topmost consideration as to meet WHO's standard of thirty metres minimum distance from the community source of drinking water which should also be centrally provided. For instance, an average plot of land required for this purpose per community of 250 houses based on estimation is about 1256.35m².

Geological Survey/Environmental Impacts Assessment of the site for the envisioned community-based modular septic tank system should be a contributory factor in determining structural suitability of the tank, impacts on the livelihoods of the dwellers, socio-cultural heritage areas, biodiversity, and the physical environment in general. The cost of doing all these should be in the overall design cost.

Septic tank capacity of an average household of three-bedroom apartment with four toilet facilities is about 1000 gallons (4000 litres) of water (Nnaji, 2012). This translates to constructing septic tank of the following dimensions: 3.0-metre length, 1.7metre width, and 1.5metre height, which equals 7.2m³ capacities. This could be in use for close to ten years without evacuation, all things being equal. With this calculation, it can be projected that a typical residential area with about 250 houses, given that a three-bedroom apartment with average of ten users are predominantly dwellers of the community. It implies 2500 residents can comfortably use septic tank with a capacity of about 1800m³ with one-third of the size meant for open drain field. This in turn means average of 1256.25m² size of land (about three plots of land) will be required to take care of effluents generated by this population.

Conversely, connecting all sewer lines in such community to a single On-site Disposal of Septic Tank effluent will not be advisable in the sense that; it makes construction process difficult and management of facility laborious. As a result, two of this facility can be in different sites. This reduces connection issues and yet serving purpose of taking septic system technically away from source of portable water (borehole sources) to allowable distances.

This proposition conforms to the theoretical framework of the current study - waste management theory. If stakeholders could shore up this arrangement, septic waste transported to the facility through sewer line would be another source of manure for agricultural purposes. In addition, green architecture, which is conversion of the septic waste into source of electricity supply, will help ameliorate incessant power outage in our communities. Nevertheless, this proposition could be an ideal and or a long-term arrangement. As a result, deployment of affordable community-based measures capable of reducing risk factors and level of vulnerability of groundwater pollution will be an additional recommendation.

If ensuring drilling of water borehole in the residential vicinities to get required depth based on professional advice and with opportunity for regularly treatment based on prescription, groundwater pollution risk may witness prevention or reduction as the case may be in the communities. Likewise, adequate urban planning could curb some of the lapses ensuing during property development. By ensuring developers adhere strictly to building codes, allowable building setback, observance of tolerable distance between septic tank system, water borehole and many more, could reduce groundwater pollution risk. Again, making sure contravention of rules and regulations meet prerequisite consequences, will curtain excesses on the part of property developers.

Finally, sanitation ministry should receive boost in terms of capacity development training for its personnel, adequate equipment for effective operation in terms of monitoring and inspection, among other activities, in order to safeguard availability of portable water across communities in Nigeria.

REFERENCES

[1]. Adegoke, A. and Stenstrom. T. (2019). Septic systems. Global water

[2]. Akinbile, O., Yusoff, S. (2011). Environmental impact of leachate pollution on groundwater supplies in Akure, Nigeria. International journal of environmental science and development, 2(1), p. 81-86. 17.

[3]. Agbalagba, E., Agbalagba, H., Ononugbo, P., Alao, A. (2011). Investigation into the physicochemical properties and hydro chemical processes of groundwater from commercial boreholes in Yenagoa, Bayelsa State, Nigeria. African journal of environmental science and technology, 5(7), p. 473-481.

[4]. Akoteyon, S. (2019). Factors affecting household access to water supply in residential areas in parts of Lagos metropolis, Nigeria. Bulletin of Geography. Socio-economic Series, *43(43), 7-24. http://doi.org/10.2478/bog-2019-0001*

[5]. Annapooma, H., Janardhana, M. (2015). Assessment of groundwater quality for drinking purpose in rural areas surrounding a defunct copper mine. Elsevier. B.V

[6]. Arjen, V. (2008). Understanding groundwater and wells in manual drilling. Practical foundation

[7]. Ayeni, O., Omojola, S., and Fasona, M. (2008). Urbanization and water supply in Lagos state, Nigeria: The challenges in a climatic change scenario. *aayeniao@unilag.edu.ng, ayeniao2000a@yahoo.com*.

[8]. Convery, M. (2013). Infant methemoglobinemia in Minnesota due to nitrate in well water. Personal communication.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25nov1415

[9]. Deepanjan, M. (2003). The blue baby syndrome: Nitrate poisoning in human. National environment research institute.

[10]. Ele, S. (2013). Challenges of water supply in Nigeria since 1999 and its consequences on economic development. International journal of economic development research and investment, volume 4, number 4.

[11]. Eneji, C. (2015).Water, Sanitation and hygiene (WASH) in community disease control in cross RiverState,Nigeria.InternationalInventionJournals.*http://www.internationalinventjournals.org/journals/IJESTR*

[12]. Eze, C. and Eze, E. (2015). Investigation of possible groundwater contamination from septic system in Port Harcourt, Nigeria. Journal of natural science research

[13]. Fewtrell, L. (2004). Drinking -water nitrate, methemoglobinemia, and global burden of disease: a discussion. Environmental health perspective, 112 (14): 1371-1374

[14]. Gbadegesin, N and Olorunfemi, F. (2007). Assessment of Rural Water Supply Management in Selected Rural Areas of Oyo State, Nigeria. ATPS working paper series no. 49

[15]. Greenwood, E., Nikulin, S. (1996). A Guide to chi-squared testing. New York: Wiley. ISBN0-471-5579-X

[16]. Ibiang, E., Ebaye, B and Ekeng, E. (2016). The effect of distances between soak away and borehole on groundwater quality in Calabar, South-south, Nigeria. International research journal of advanced engineering and science

[17]. Kulikowska, D. (2012). Nitrogen removal from landfill leachate via the nitrite route. Brazilian journal of chemical engineering

[18]. Mmom, P and Iluyemi, P. (2017). Disaster Risk of Property Development on Floodplains in Port Harcourt, Nigeria. *www.iaia.org*

[19]. Muhibbu-Din, I., Aduwo, O, Adedeji, A. (2011). Study of physicochemical parameter of effluent impacted stream at Obafemi Awolowo University Ile-Ife, Nigeria. A Dissertation submitted to the Department of Zoology, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria. 2011 (unpublished).

[20]. Musa, J. (2014). Effect of Domestic Waste Leachates on Quality Parameters of Groundwater. Leonardo journal of sciences

[21]. Musa, J., Adewumi, K., Adeoye, A., Mustapha, H. and Adebayo, S. (2011). Physicochemical assessment of groundwater as a source of domestic water use in some selected settlements in Minna, Niger State. IUP journal of science & technology, 7(2), p.35-44.