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ESTIMATION OF WATER QUALITY INDEX OF HAND DUG WELLS WATER SAMPLES IN PART OF RIVERS STATE

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ABSTRACT

Water Quality Index (WQI) was estimated using physicochemical, heavy metal and microbiological parameters of groundwater samples collected from hand dug wells (HDW) in Ogba, Egbema, Ndoni Local Government Area, Rivers State, Nigeria. Groundwater samples were collected from 15 hand dug wells during the 2023 wet season in order to determine the water quality indices in the study area by comparing with APHA (2017) Rating for WQI and Status of Water. Nine (9) parameters were utilized in calculating WQI for the study area. Each parameter was assigned a given weight (W1) based on the perceived health effect of the importance of the parameter on the overall water quality for drinking purposes. Results obtained, revealed an overall WQI of 118.16mg/l for HDW during wet season denoting poor groundwater quality and are unsuitable for drinking with possible usage being irrigation.

The analysed water samples of hand dug wells were plotted within Na^{+} - Ka – cl^{-} - SO_4^{-2}. The hydrogeochemical facies of the groundwater may be related to Cl – Na dominant water type, this indicates end-point down gradient waters through dissolution.

Keywords: Groundwater, Quality, Hydrogeochemical facies, Parameter

INTRODUCTION

The intensive use of natural resources and increased human activities are posing great threat to groundwater quality (Foster, 1995). 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, owning to the numerous hydrocarbon exploration activities, there is the need for assessment of groundwater quality to ascertain its suitability for domestic purpose. Groundwater is artificially induced by the degradation of natural groundwater quality.

Contaminants can impair the use of water and can create hazards to public health through toxicity or spread of diseases. Numerous agents are responsible for groundwater pollution among which are chemicals, micro-organisms, domestics and industrial wastes and man-made materials. Hand dug wells provide a cheap and low-tech solution to accessing groundwater in semi-urban location. These substances usually persist in the environment, accumulate and leak into the groundwater. Hand dug wells are excavations with diameter large enough to accommodate one or more persons with shovels digging down to below the water table. They can be lived with laid stones or bricks; extending this lining upwards above the ground surface to for around the well serves to reduce both contamination and injuries by falling into the well. They have low operational maintenance costs, in some parts, water can be extracted by hand bailing without a pump. Because they exploit shallow aquifers, the well maybe susceptible to yield fluctuations and possible contamination. surface water including sewage, leachate, etc. Contamination of well water may be from anthropogenic activities, the materials used in the construction of the well and the types of soil in which the well is constructed, or/and non-protection of the well (Ukpong and Abaraogu, 2014). A robust WQI is an important indicator for assessing groundwater quality and its suitability for drinking purposes (Boateng et al, 2016; Avvanavar & Shrihari, 2008; Lumb et al, 2011.

The concept of Hydro chemical facies can be used to denote the diagnostic chemical character of water in hydrologic systems. The facies reflect the effect of complex hydro-chemical chemical processes in the surface (Sajil Kumar, 2013) occurring between the minerals of lithologic formation and groundwater to investigate the spatial variability of groundwater chemistry in terms pf hydro chemical evolution. The chemical composition of groundwater is primarily dependent on the geology as well as on the geochemical processes which takes place within the groundwater system.

The Study Area

The study area is Ogba/Egbema/Ndoni Local Government Area (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, Rivers State, (figure 1). The area can be found in the northern part of the Niger Delta Region within the Niger Delta flood plains. 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.

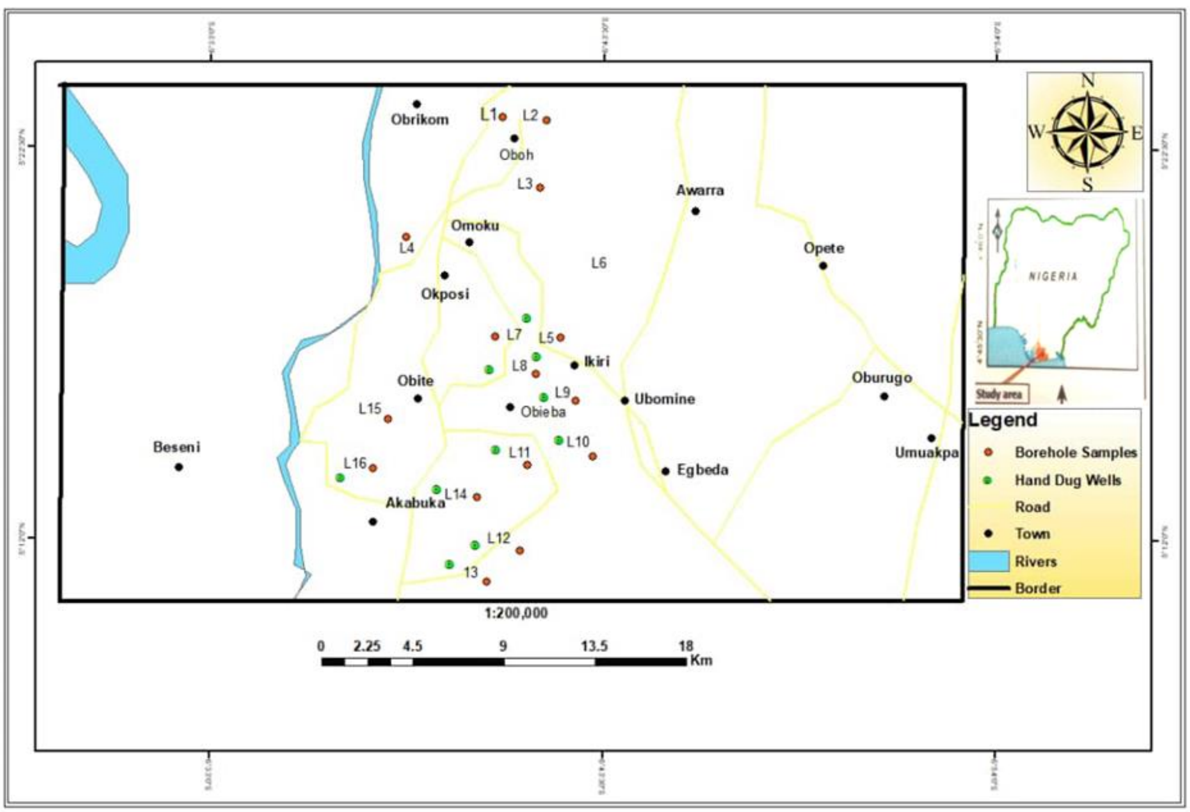

Figure 1. Map of the Study Area Showing Sampling Locations

Geology of the Study Area

The study area is Ogba, Egbema, Ndoni L.G.A of Rivers State (figure 1) located within the Niger Delta region of Nigeria, therefore has same geology as the Niger Delta. The Niger Delta Basin is perhaps the most prolific basin in Sub – Saharan Africa with respect to its petroleum resources (Short and Stauble, 1967). The Niger Delta is composed of marine shale as the base of its stratification, overlying it is an intercalation of sand and shale as the intermediate layer, then the topmost layer is sandstone (Etu–Efeotor & Akpokodje, 1990; Amajor, 1991). The groundwater occurrence is a multi – aquifer system because of the presence of certain clayey strata in formations of various thickness that acts as confining layer between two distinct aquiferous rock strata (Ngah, 1990; Nwakwoala, 2013; Nwakwoala and Ngah, 2014). The present-day Niger Delta was formed during the Tertiary period as a result of the interplay between subsidence and deposition arising from a succession of transgression and regression of the three – tertiary subsurface litho – stratigraphic units of Akata, Agbada and Benin formations (Short and Stauble, 1967). Further studies and evidence from deep wells drilled in the Niger Delta has also proven that the Niger Delta has a three litho–stratigraphic depositional succession (Akata, Agbada and Benin formations) with an approximate average thickness of over 5000m of sediment body (Amajor, 1991; Ngah, 2009).

MATERIALS AND METHODS

The study is descriptive survey design, descriptive studies are those that observe and describe events without any manipulation or application of treatments or treatment of variables. The data for this study were purely primary data that were collected from 15 hand dug wells groundwater sample showing various Physicochemical, heavy metal, PAHs (poly-cyclic aromatic hydrocarbon) and Biological Parameters and their characteristics to WHO 2012 reference standards.The WQI was calculated by assigning a weight (Wi) to each water quality parameter according to its relative importance in the overall quality of groundwater for drinking purposes. The assigned weight (Wi) and relative weight (RWi) for each

$$\mathrm{RWi} = \frac{Wi}{\sum_{i}^{n}=1} \mathrm{Wi} \quad (1)$$

$$\mathrm{Qi} = \frac{Ci}{Si} \times 100 \quad (2)$$

$$\mathrm{Sli} = \mathrm{Wi} \times \mathrm{Qi} \quad (3)$$

$$\mathrm{WQI} = \sum Sli \quad (4)$$

parameter are used. The WQI was calculated as follows:
Where Qi is the quality rating, Ci is the concentration (mg/l) of each quality parameter, Si is the water quality standard for each water quality parameter and Sli is the sub-index of the i parameter.

WQI values are usually classified into five categories:

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Table 1. Rating for WQI and Status of Water

Class	WQI	Category of Water and Quality
1.	<50	Excellent
2.	50 - 100	Good
3.	100 - 200	Poor
4.	200 - 300	Very poor
5.	>300	Unsuitable

Source: APHA, (2017)

Table 2. Standard Water Quality Classification Scheme (Minakshi and Dulal, 2017).

WQ Values	WQI Values/quality status	Possible Usage
0-20	Excellent for drinking	Irrigation and Industrial
26-50	Good for drinking	Irrigation and Industrial
51-72	Poor	Irrigation and Industrial
76-100	Very poor	Irrigation
>100	Unsuitable for drinking	Proper treatment required before use

RESULTS AND DISCUSSION

WQI is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers. Nine (9) parameters were utilized in calculating WQI for the study area. Each parameter was assigned a given weight (W1) based on the perceived health effect of the importance of the parameter on the overall water quality for drinking purposes.

Parameters	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	WHO (2012)
TA mg/l	6.7	8.3	8	10.6	8.1	7.2	6.8	7.4	8.3	8.6	9	2	2	2	2	250
Cl mg/l	9.94	10.51	10.22	10.22	10.25	15.05	11.08	9.54	4.03	7.21	4.63	4.21	7.3	9.12	5.4	250
CO_3 mg/l	0.21	0.52	1.71	202	1.06	6.72	2.61	1.04	6.78	1.01	2.3	2.1	1.10	1.98	2.1	N/A
DO_2 mg/l	5.81	5.1	4.93	3.6	4.21	4.01	4.72	4.5	3.63	4.2	3.9	4.5	3.86	4.43	4.10	3
Na mg/l	10	10	448	45.7	13.5	3.45	7.3	13.8	3.06	11.3	10.4	5.02	4.5	3.9	5.6	200
HCO_3 mg/l	12.4	13.5	2.9	0.06	1.07	7.2	15	4.1	3.2	2.5	3.2	6.1	4.5	2.7	2.1	600
K mg/l	2.01	2	3.2	1.6	8	7	8	5	8	7	3.4	4.3	3.2	2	2.8	55
Oil and Grease mg/l	0.005	0.016	0.013	0.13	0.03	0.015	0.15	0.018	0.08	0.16	0.01	0.013	0.101	0.006	0.018	0.3
SO_4^2 mg/l	1.48	45.07	3.45	1.21	2.3	2.62	2	3.01	2.47	0.76	105.3	115.2	116.2	66.3	156.3	500
Phosphate mg/l	0.2	0.02	0.06	0.05	0.06	0.02	0.01	0.9	0.6	0.04	2.1	3.2	3.3	3.1	6.5	N/A
NO_2 mg/l	18	12.3	5.102	17.4	15.4	15.7	13	10	12	10.5	2.08	6.13	9.8	10	12	5
NH mg/l	0.001	<0.001	0.001	<0.001	<0.001	0.001	0.001	0.001	0.002	0.001	0.001	<0.001	<0.001	0.001	<0.001	N/A
Mg mg/l	0.58	0.68	2.11	1.06	1.08	0.58	0.02	0.4	2.4	1.21	1.62	0.015	0.027	0.002	0.02	50
Ca mg/l	0.72	1.021	0.08	3.01	1.051	0.107	1.01	2.905	1.54	1.20	1.12	4.07	6.17	4.41	5.06	75

Table 3: Results of Chemical Parameters in Hand Dug Well Water – Wet Season Samples

Keys: HDW=Hand Dug well
Source: Researchers Field work

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Table 4a: Estimation of WQI for Hand dug Well Water (Wet season samples)

WQI PARAMETERS FOR W DRY																		
SN	PARAMETER	BH 1	BH2	BH3	BH4	BH5	BH6	BH7	BH8	BH9	BH10	BH11	BH12	BH13	BH14	BH15	MEAN VALUE	WHO MAX LEVEL
1	pH	6.2	6.6	6.1	6	6.6	6.2	6.2	6.4	7.6	6.2	7.2	4.91	5.15	6.1	5.66	6.21	7.5
2	Total Hardness mg/l	80.9	110	132	108	130	115.6	135	125	142	147	85.2	134	109	8.6	108.6	111.39	150
3	TDS mg/l	39	54	65	53	64	71	65	62	71	71	58	56	73	39	61	60.13	500
4	BOD	0.4	0.18	0.54	0.32	0.12	0.26	0.046	0.54	0.22	0.23	0.4	0.95	0.5	0.61	0.57	0.39	200
5	TA mg/l	1.6	2.1	2.2	2	2	2	4	4	43	2.4	3.8	3.9	3.6	4.1	3.5	5.61	250
6	DO2 mg/l	3.3	3.4	3.2	3.1	3.4	3.6	3.4	3.6	3.1	3.1	2.32	3.6	3.3	3.1	3.8	3.29	3
7	Mg mg/l	6.09	9.05	8.08	<0.001	0.026	0.006	0.028	0.032	<0.001	11.8	0.121	3.91	12.1	3.61	21.5	5.09	150
8	Ca mg/l	0.031	0.037	0.036	4.042	0.04	0.033	0.033	0.027	2.6	0.024	2.5	2.7	3.17	6.61	5.45	1.82	200

Table 4b: Estimation of WQI for Hand dug Well (Wet season samples)

WQI W DRY							
SN	PARAMETER	MEAN CONC. (Ci)	Si	qi	Wi	qiWi	
1	pH	6.208	7.500	82.773	0.133	11.036	
2	Total Hardness	111.393	150.000	74.262	0.007	0.495	
3	TDS mg/l	60.133	500.000	12.027	0.002	0.024	
4	BOD	0.392	200.000	0.196	0.005	0.001	
5	TA mg/l	5.613	250.000	2.245	0.004	0.009	
6	DO2 mg/l	3.288	3.000	109.600	0.333	36.533	
7	Mg mg/l	5.090	150.000	3.393	0.007	0.023	
8	Ca mg/l	1.822	200.000	0.911	0.005	0.005	**OVERALL WQI**
	SUMMARY	**24.24**	**182.56**	**35.68**	**0.06**	**6.02**	**97.03**

The Water Quality Index for Hand Dug well during wet season (tables 3) presents 118.16 as the WQI value which reveals that the groundwater samples are unsuitable for drinking based on the WQI standard (Minakshi and Dulal, 2017). Water sample has very poor and unsuitable water quality status. Hence, proper treatment is required before any possible use (Akakuru et al., 2015).

Hydrogeochemical Analysis of Groundwater from Hand Dug Wells

Groundwater Classification in the study area was achieved using piper, (1944). Piper Tri-linear diagram is most widely used to understand the hydrochemistry of any area, it is a major key to the identification and classification of rock-water interaction, solution kinetics, geology and sources of contamination in groundwater (Kaur *et al.*, 2019).

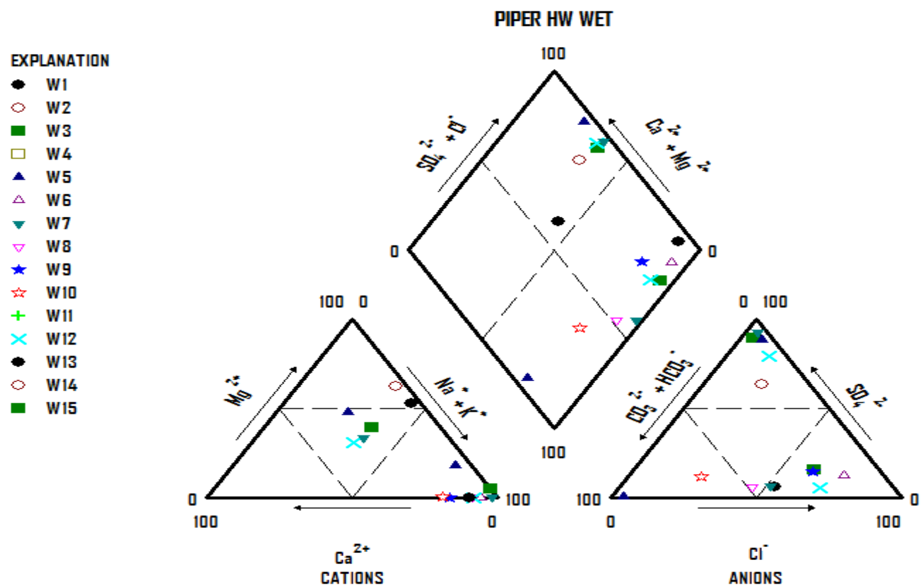

Figure 2:
Piper Tri-Linear diagram showing groundwater facies for hand dug well during wet season in the area

Interpretation of Piper Tri-linear diagram for Hang Dug Well Water – Wet Season

W1-W15cover diverse geological settings, indicative of different hydro-geochemical constitutions. The piper diagram showed that the water classification across section W1, W2, W3, W5, W7, and W12, are of Ca-SO_4 water type and is ans indication of gypsum ground waters and mine drainage. W6, W8, W9, W13 and W15 belongs to Na-Cl waters type which is often characterized by of marine and deep ancient ground waters. W10 is of Na-HCO_3 water class and is typical of deeper ground waters influenced by ion exchange (Figure 4.13).

CONCLUSION

Based on the result of the WQI for hand dug wells during wet season in the study area which showed WQI of 118.16mg/l, denoting very poor groundwater quality which makes it unsuitable for drinking with possible usage being irrigation. The hydrogeochemical facies shows indications of end-point down gradient waters through dissolution and is influenced by ion exchange of Ca-SO^{2+} indicating gypsum groundwater and mine drainage. The Piper Tri-linear diagram shows that Ca-Mg-HCO_3 and Ca-Cl are the types of groundwater hydrogeochemical facies with the Na-Cl ions as the document water type.

RECOMMENDATIONS

Among the recommendation includes; proper town planning, creating awareness for groundwater quality protection, the need for improved regulations, among the identified needs are, improvements in drinking water standard, improved handling of special waste.

Contributions to Knowledge

1). The main innovative contribution of this study is that Water Quality Index (WQI) of hand dug well has been used which ultimately help us to understand the water quality status in the surrounding area

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