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Determination Of Physicochemical Properties Of Groundwater Of Some Shallow Tube-Wells In Abua, Rivers State, Nigeria

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A B S T R A C T

The physicochemical properties of groundwater from shallow tube-wells of four communities designated as locations A-D in Abua Local Government Area of Rivers State were determined following standard procedures. Sampling was carried out twice in each month between March and June, 2015 to determine taste, odour, pH, total dissolved solids (TDS), conductivity, hardness, sulphate, phosphate, nitrate, bicarbonate and iron. There were significant ($p<0.05$) variations with higher values in some wells than others which may signify diffuse factors. Although water samples from the four communities were generally tasteless and odourless, at locations B, C and D, the water was found to be slightly acidic with mean pH values of 5.80±0.19, 4.60±0.05 and 4.20±0.07 respectively, due probably to intrusion from surface water since some of them are close to natural waterbodies. It was also noted that at location A, the water was hard with mean values of 206.64±16.75 and moderately hard at B with mean value of 126.21±45.60. The study concludes that health challenges currently being experienced by the communities living on these water sources, may among other factors, have arisen from the high acidic contents of the water at locations B, C and D, and therefore recommend regular monitoring to mitigate problems implicit in the continuous dependence on these water sources.

Key words: *determination, shallow tube-well, physicochemical properties, groundwater, Abua*

Introduction

Water is the most abundant natural resource, and it makes up about 70% of the earth's total mass. It is the major fluid in living organisms, constituting also about 70% by mass of plants and animals as a body. Pure water is a neutral compound and dissolves many organic and inorganic compounds. It is a good solvent for many substances and is referred to as a universal solvent. However, despite this supporting role played by water in sustaining life generally, it has the potential for transporting diseases and illnesses, if contaminated (Okeola et al., 2010).

Moreover, due to rapid growth in population and increased activities of agricultural irrigation especially in rural areas, the supply of this natural resource by government efforts is gradually being stressed for the sustenance of most human activities that involve use of water. The situation has thus compelled individuals especially in the rural communities to seek or explore other means by which they could provide water to meet its increasing demands. One of such means is the construction of shallow tube-wells with groundwater as their source.

Groundwater is globally important for human consumption and agricultural irrigation. The natural state of groundwater is generally of excellent quality, although harmful concentrations of certain ions such as Na^+, SO_4^{2-} and CI^-, which occur naturally, could lead to problems (Daly, 1994). Groundwater property or quality is a measure of its physical and chemical characteristics which tells it suitability for consumption and irrigation purposes.

The studied area is Abua in Abua/Odual Local Government Area of Rivers State of Nigeria with headquarters at Ayama, Abua Central. It covers an area of 704 sq. km with a population of 282,988 people, as at 2006 census. Abua shares boundary from the East with the lkwerre and Kalabari with Sombrierio River separating them. From the West, Orashi River separates it from Odual and Ogbia. Like other communities in the Niger Delta, Abua has tropical rainfall which is seasonal with wet season beginning in April and ending in December, and the dry season from December to March.

The occupation of the people is mainly fishing, hunting and small-scale farming. The male occupation for most (technologically unskilled) Abuan is palm oil and palm kernel production. Palm oil production generates effluents for every metric ton of palm oil produced. Direct release of these effluents can cause freshwater pollution which affects downstream

biodiversity and people. While palm oil plantations are not large users of pesticides and fertilizers, overall indiscriminate application of these materials can contaminate surface water and groundwater sources (Alagoa, 2005).

Agricultural irrigation is a dominant factor in Nigeria and the state of human health and conservation of surrounding environment has also become issues of strong and constant concern. Generally farmers and rural dwellers are unaware of the far-reaching implications of some of their unwholesome activities with respect to groundwater contamination and pollution. These concerns have evoked studies on groundwater sources in diverse forms in order to create awareness of the dangers implicit in such activities (Singh, 2000; Calson and Ecker, 2002; Benston et al., 2005; Haruna et al., 2008; Obunwo and Bodo, 2014). The present study complements such past workers legacies by characterising water from shallow tube-wells from four communities namely: Ogonokon (A), Agada 1 (B), Ogbemakoku (C), Emoh (D) in Abua, Rivers State.

Materials and Methods

Sample collection and Preservation

Sample containers (plastic cans) were thoroughly washed with detergent, rinsed in distilled water and soaked in 5% HNO_3 for 24hrs. Before the actual collection of sample, the containers were again rinsed in distilled water. Based on availability of wells, about 1.5 Litres of water samples were collected twice each month for four months between March and June, 2015 from four shallow tube-wells of four communities in Abua Kingdom, Rivers State, designated as A, B, C and D for Ogonokon, Agada 1, Ogbemakoku and Emoh respectively. A total of thirty-two (32) samples, eight (8) for each well, were thus collected. Sampling followed the procedure recommended by American Public Health Association (APHA, 1998), transported to the laboratory and refrigerated until the chemical analyses were carried out.

Determination of Physicochemical Parameters

Taste and odour were determined through human senses of taste and smell by drinking and smelling. The pH, electrical conductivity and total dissolved solids (TDS) were measured in situ on site using pH/conductivity meters (Hanna brand). Iron contents were determined by Spectrophotometric methods; hardness and bicarbonate by titration; nitrate and phosphate by colorimetric methods and sulphate by photometric method (APHA, 1998).

Results and Discussion

Table 1: Mean Levels of Physicochemical Parameters in Shallow-Tube Water of the Four Communities in Abua, Rivers State

PARAMETERS	SAMPLES				WHO
	A	B	C	D	LIMITS
pH	6.50±0.15	5.80±0.19	4.60±0.05	4.20±0.07	6.50 – 8.50
Hardness (mg/L)	206.64±16.75	126.21±45.60	9.10±1.32	8.06±2.01	100 - 500
Sulphate (mg/L)	26.06±3.40	3.30±1.14	1.10±0.02	1.08±0.07	0 – 250
Bicarbonate (mg/L)	9.26±0.43	9.03±0.13	9.31±0.18	9.18±0.22	100
Iron (mg/L)	<0.001	0.04±0.00	<0.001	<0.001	0.3
Nitrate (mg/L)	10.70±0.94	6.40±0.66	7.20±0.52	1.06±0.11	10 – 45
Phosphate (mg/L)	0.13±0.04	0.64±0.11	0.66±0.01	0.02±0.01	5.0
TDS (mg/L)	332.60±38.62	123.22±16.24	99.28±61.86	10.10±0.73	500
Conductivity (µs/cm)	694.18±13.58	258.13±31.58	29.58±1.27	11.32±0.16	1000

*: A=OGONOKON COMMUNITY; B=AGADA 1 COMMUNITY; C=EMOH COMMUNITY; D = OGBEMAKOKU COMMUNITY

*: WHO = World Health Organization

Table 2: Spearman's correlation coefficient between Physicochemical Parameters in Shallow-Tube Water of the Four Communities in Abua, Rivers State

	pH	Hardness	Sulphate	Bicarbonate	Iron	Nitrate	Phosphate	TDS	Conductivity
pH	1.000								
Hardness	1.000**	1.000							
Sulphate	1.000**	1.000**	1.000						
Bicarbonate	0.00	0.00	0.00	1.000					
Iron	.258	.258	.258	-.775	1.000				
Nitrate	.800	.800	.800	.600	-.258	1.000			
Phosphate	.200	.200	.200	.400	.258	.400	1.000		
TDS	1.000**	1.000**	1.000**	.000	.258	.800	.200	1.000	
Conductivity	1.000**	1.000**	1.000**	.000	.258	.800	.200	1.000**	1.000

**. Correlation is significant at the 0.01 level (2-tailed).

The results of the analyses is presented in Table 1, the Spearman's correlation coefficient between the parameters is presented in Table 2, while the overall picture of the mean level of each parameter at the four wells is shown in Figure 1. All the samples were tasteless and odourless when tested through human senses of taste and smell. Of all the parameters, only bicarbonates recorded somewhat uniform mean values ranging from 9.03±13 – 9.31±0.18 mg/L; others fluctuated. Iron was below detection limits in all the wells except B (Agada 1Community) where it was 0.04±0.00 mg/L with very wide dispersion.

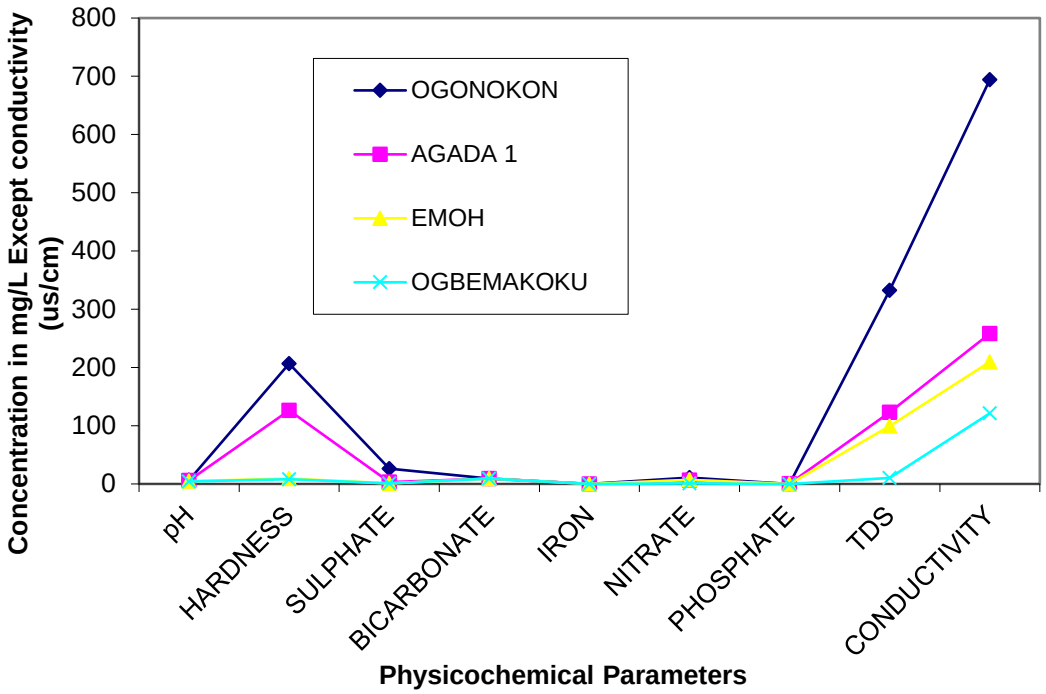

Figure 1: Overall Picture of Each of the Parameters at the four Sample Locations

The values of total hardness and pH are inversely related at wells C and D, while conductivity and TDS are proportional to each other at all locations. Analysis of variance conducted on the results from the 32 samples revealed significant ($p<0.05$) variations which imply that diffuse factors may have been responsible for the variations. From the results, hardness and the pH appear to be the only notable characteristics since others are well within limits set by national (FEPA, 1991) and international (WHO, 1996) standards.

pH is a measure of how acidic or basic the water is. It determines the water solubility and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients and heavy metals. Thus, excessively high or low pH can be detrimental to users of the water. Bitter taste, corrosion, crust formation, etc. are inevitable consequences (United State Geological Survey, 2015). The pH values of 5.80±0.19, 4.60±0.05 and 4.20±0.07 at locations B, C and D respectively are lower than the permissible limits of 6.50-8.50 signifying acidic condition, attributable to surface water intrusion as some of the wells are near natural water sources. The pH values in this study varied from those of Haruna et al. (2008) whose work on evaluation of water quality of shallow tube-wells of some Fadama lands in Zaria city, Nigeria, reported a range of 7.08 - 7.16, but similar to those of a recent study on evaluation of physicochemical characteristics of hand-dug wells in Ogoni Kingdom (Obunwo and Bodo, 2014), who reported mean values of 3.83±0.41 and 5.69±0.29 for low and highland areas respectively, and linked to same factor.

Water hardness is a measure of the amount of calcium and magnesium ions in water. Hard water (though beneficial to an extent because these minerals are needed to stay healthy) forms insoluble scum with soap which makes bathing difficult, can reduce the life of equipment, raise cost of heating water, lower the efficiency of electric water heater and clog pipes (Braide, 1990). The results of this study as shown in Table 1, revealed A (Ogonokon community) as having had the highest value of 206.64±16.75, followed by B (Agada 1 community) which recorded 126.21±45.60. The tolerable limit for hardness in drinking water is 100-500 mg/L (WHO, 2004). Judging however, from the classification of Sawyer and McCarty (1993), which described soft water as containing 0-55 ppm, slightly hard water, 56-100 ppm and moderately hard one, 101-200 ppm, it follows that water from location A is hard and that of B is moderately hard, while locations C and D, Ogbemakoku and Emoh communities whose values fell far below permissible limits can be classified as soft.

Sampling was carried out between March and June in order to investigate seasonal changes in the levels of the parameters and how these changes affect the physicochemical condition of the groundwater. It was generally observed that the well in location A (Ogonokon community) recorded the highest values in most of the parameters, while the lowest were found in C (Ogbemakoku community) – Figure.1. Also, the significant variations in the levels of the parameters especially with lower values of wide dispersion with respect to hardness, sulphate, TDS and conductivity at locations C and D, that is, Ogbemakoku and Emoh communities (Table 1), may be due to dilution brought about by rain in the wet season during which a significant number of the samples were taken.

The spearman's correlation coefficient of the physicochemical parameters in the different wells from different stations showed significant ($P< 0.01$) positive correlation between some of the parameters, pH: hardness, sulphate, TDS, and

conductivity; TDS: hardness, and sulphate; conductivity: hardness, sulphate and TDS. The positive correlation among these parameters indicated close relationship or association amongst the parameters and therefore depicts common origin or source (Inobeme et al., 2014). However, negative correlation was also observed between Iron and bicarbonate and also between nitrate and Iron, which signifies that there is no association between them.

The study also noted that groundwater in the studied area may be under threat by direct consequences of activities leading to palm oil production, a notable occupation of Abua people (SSGPOU, 2015). Moreover, palm oil processing effluents have been identified as notable sources of NO_3^-, PO_4^{3-}, K^+, Na^+, Mg^{2+} and heavy metals (Awotoye et al., 2011). The presence therefore, of some of the parameters most of which, though, within limits set by national and international standards, may be traceable to this occupation of the people.

Conclusion

The determination of physicochemical characteristics of groundwater of shallow tube-wells of four communities in Abua, Rivers State, has revealed that water in some parts of Abua is hard and slightly acidic, while in others it is not. The study opines that this condition is attributable to surface water intrusion at some locations that are close to natural water sources. It also notes that health challenges currently being experienced by the communities living on these water sources, may among other factors, have arisen from the high acidic contents of the water at B, C and D. It is therefore advised that the condition or status of water especially in those communities so noted be monitored regularly to mitigate health problems.

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