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The Assessment of Drinking Water Sources in Aba Metropolis, Abia State, Nigeria

Agwu A.[1,*], Avoaja A. G.[1], Kalu A. U[2]

[1]Department of Chemistry, Abia State Polytechnic Aba, Abia State, Nigeria
[2]Department of Mathematics, Abia State Polytechnic Aba. Abia State, Nigeria

Abstract The present study is aimed at determining the quality of borehole and packaged(sachet) water consumed in Aba metropolis. Twenty commercial borehole water samples and ten(10) popular sachet water samples were randomly collected from Aba South and Abayi Areas and the physico- chemical and microbial parameters assessed. The physico-chemical parameters of the water samples analyzed were within the World Health Organisation(WHO) standard for drinking water, except for the pH which ranged from 5.20 – 5.80 against the WHO range of 6.5 – 8.5. All the samples were contaminated with different bacteria pathogens(Staphylococcus sp., Streptococcus and E.coli, shigella sp. and Bacillus subtilis) to varying degrees. The total heterotrophic plate count ranged from 1.50 x 102 cfu/ml – 3.90 x 102 cfu/ml for borehole water and 1.60 x 102 – 3.60 x 102 cfu/ml for sachet water. The correlation coefficient for the different parameters and their significance were determined. It is recommended that the borehole and sachet waters be treated to minimize acute problems of water related diseases which are endemic to man.

Keywords Physico - Chemical, Water Quality, Microbial Parameter, Sachet Water

1. Introduction

Water resources have been the most exploited natural system since the world began, and it is used for domestic, industrial and agricultural activities. The usage depends on the quality of the water. However, the quality depends on its origin and history, and many factors produce variation in the quality of water obtained from various sources. Such factors include climatic, geographic and geologic(1).

The quality of water is determined by its physical, chemical and microbiological characteristics.

Drinking water is a major issue in many countries especially in developing countries. Surface water(rivers, streams, lake and dams) and ground water(boreholes and wells) can serve as sources for drinking water. But with the increasing contamination of surface water there is now an increasing reliance on ground water for drinking and domestic purpose since it is believed to be pure through natural purification processes(2).

In Nigeria, borehole and packaged sachet water now serves as the easily assessed and cheap commercial source of drinking water for a greater number of its about 140 million people. And the conformation of these sources of water with microbiological standard is of special interest because of its capacity to spread diseases within a large population. Nearly 90% of diarrhea related cases and deaths have been attributed to unsafe or inadequate water supplies and sanitation conditions(3). The World health Organization in its guidelines for drinking water quality highlighted at least seventeen different and major genera of bacteria that may be found in drinking water sources which are capable of causing disease in man(4).

The increase in the rate of water borne diseases across the world is increasing yearly(5, 6), and even in Nigeria there have been reported cases of cholera and other water related disease in recent years across the states.

In Aba metropolis, in the South eastern part of Nigeria, the majority of it's about 3million populace depends on untreated borehole water and sachet water(aka pure water) as the source of clean and pure drinking water. How "pure" and safe these waters are is a thing of thought by the consumers.

This study therefore seeks to determine how pure and safe these waters are by assessing their physico-chemical and microbiological qualities and comparing them with set regulatory standards(3, 7).

2. Materials and Methods

Water samples from twenty commercial borehole sites within Aba metropolis in Abia State were collected using sterile 1500cm^3 bottles, and also ten popular brands of Sachet water samples(aka pure water) were bought from vendors at different points within the metropolis and taken to

* Corresponding author:
aakenndemics2@yahoo.com (Agwu A.)
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the laboratory for analysis.. Two sachet water packs of the same brand bought at different points were analysed and the average values obtained represented the value for each of the parameter determined in the brand.

The physicochemical and microbiological parameters of each sample were determined immediately on collection.

The physicochemical parameters of the borehole and sachet water samples were determined using known standard methods(8, 9, and 10). The physical parameters analyzed include pH, electrical conductivity and total dissolved solids. The pH was determined using a digital pH meter(model PHS-3C), Conductivity with an Equip-tronics EQ-660A conductivity meter, and total dissolved solids by gravimetric method. Total acidity, total alkalinity and total hardness were determined using titrimetric methods and the chlorides by Mohr's method. Nitrate and Sulphate were determined by colorimetric method using a spectrum lab 752S spectrophotometer.

The microbiological analyses were carried out using the following media; plate count agar, nutrient agar, Lactose broth, and Eosin methylene blue agar. All the media were prepared according to the manufacturer's specification. A serial dilution method was used for total viable count while the total coliform counts were carried out by the standard plate count technique using MacConkey agar, and faecal coliform was determined using Eosin methylene blue medium using pour plate technique .The Confirmations of the isolates were done using Lactose broth at 44.5^{o}C.

3. Results and Discussion

Tables 1. Mean and Standard Deviation of Physicochemical Parameter of Sachet Water Samples

	Mean	Std. Deviation	WHO Standard limit(1993)
pH	4.7790	.72599	6.5 – 8.5
Conductivity	.78940	.13213	100
TDS	75.9000	5.30094	450
TSS	20.2000	.63246	30
Acidity	16.9560	27.15086	-
Alkalinity	9.2000	3.29309	120 – 600
Total Hardness	.8000	2.52982	100 – 500
Chloride	1.9600	2.84691	250
Sulphate	3.5590	2.66090	250
Nitrate	5.9530	2.62109	45
Total coliform count(cfu/ml)	$2.46X10^{2}$		0

Table 1 and 2 presents the mean results of the physicochemical parameter and microbial analysis of all the sachet water and borehole water samples collected from the selected sites in Aba metropolis. The interrelationship between the physicochemical parameters was determined using the Karl Pearson's correlation analysis. The correlation matrix for the water quality parameters is shown in tables 3 and 4.

The WHO guideline for drinking water recommends that pH range should fall between 6.5 and 8.5, in the current study the pH values fluctuated between 5.26 to 5.80 for boreholes and 4.60 – 5.48 for sachet waters. These values show slightly acidic trend, and because the pH of water is generally influenced by the geology of the catchment area and buffering capacity of water, the low pH values reported for the samples may be due to the geology of the area and also high levels of free CO_2 which may consequently affect the bacteria counts(11). The pH of water is very important in that changes in pH values may affect the toxicity of poisons in the water(12).

The electrical conductivity, total dissolved solids(TDS) and total suspended solids(TSS) range between 0.633 – 0.99us/cm, 68 – 80mg/l and 20 – 22mg/l respectively for sachet water; and 0.20 – 0.73us/cm, 28 – 60mg/l and 15 – 20mg/l respectively for borehole water. Their respective desirable limits(3) are 100µs, 500mg/l and 30mg/l.

The result indicates that values of the electrical conductivity and total dissolved solids are all within the stipulated limits. In natural water, conductivity is always related to the amount of dissolved solids in water

(13). In the study, conductivity shows a significant negative relationship with TSS(r=-0.708, and a significant positive relationship with Acidity(r = 0.716), Total hardness(r=0.903) and chloride(r=0.816) in the borehole samples(Table 4).

The values of total suspended solids are relatively high and this may support the growth of bacteria since suspended solids acts as points of attachment for bacteria.

The hardness of water indicates its calcium and magnesium salt contents. The hardness value ranges from 0 to 8 mg/l for the sachet water samples, and from 20 to 52 mg/l for the borehole water samples. The total hardness of all the borehole and sachet water samples were all within the standard limits of 300mg/l of $CaCO_3$

In the study, Total hardness showed a significant positive relationship with conductivity(r=0.903) acidity(r=0.680) Chloride(r=0.88) in the borehole waters as shown in table 4 while it shows a high significant positive relationship with TSS(table3) in the sachet water.

Low total hardness values have been reported for similar studies carried out in owerri and Nsukka (14, 15) both in south eastern Nigeria. The borehole and sachet water samples are all soft water since their hardness values fall within the stipulated range of 0-75 mg/l for soft water.

The value of chloride ranges between 1.0 and 9.0mg/l for sachet water and between 3.0 and 25mg/l for borehole water. These values are all within the permissible limit of 250mg/l.

Table 2. Mean and Standard Deviation of Physico-chemical Parameters of Borehole Water Samples

	Mean	Std. Deviation	WHO Standard limit(1993)
pH	5.5180	.14343	6.5 – 8.5
Conductivity	.4321	.22126	100
TDS	45.6000	13.75338	450
TSS	18.7000	1.88856	30
Acidity	64.6710	19.08013	-
Alkalinity	7.2000	3.67575	120 – 600
Total Hardness	34.0000	25.56039	100 – 500
Chloride	13.6000	8.59199	250
Sulphate	7.3860	.43079	250
Nitrate	1.9300	.79589	45
Total coliform count(cfu/ml)	1.90x 102		0

Table 3. Correlations Between Different Physico-chemical Parameters of Sachet Water Samples

		pH	Conductivity	TDS	TSS	Acidity	Alkalinity	Total Hardness	Chloride	Sulphate	Nitrate
pH		1	.165	.447	-.091	-.854**	.173	-.091	-.834**	.114	-.203
	Sig.(2-tailed)		.649	.195	.802	.002	.632	.802	.003	.754	.573
Conductivity		.165	1	-.457	-.111	-.118	.299	-.111	-.242	-.259	.178
	Sig.(2-tailed)	.649		.184	.760	.746	.402	.760	.501	.471	.623
TDS		.447	-.457	1	.272	-.517	-.018	.272	-.277	-.063	.045
	Sig.(2-tailed)	.195	.184		.448	.126	.961	.448	.438	.863	.903
TSS		-.091	-.111	.272	1	-.098	-.128	1.000**	.252	.491	-.463
	Sig.(2-tailed)	.802	.760	.448		.789	.724	.000	.483	.149	.178
Acidity		-.854**	-.118	-.517	-.098	1	-.128	-.098	.874**	-.126	.229
	Sig.(2-tailed)	.002	.746	.126	.789		.725	.789	.001	.729	.525
Alkalinity		.173	.299	-.018	-.128	-.128	1	-.128	-.222	-.197	.230
	Sig.(2-tailed)	.632	.402	.961	.724	.725		.724	.538	.586	.523
Total Hardness		-.091	-.111	.272	1.000**	-.098	-.128	1	.252	.491	-.463
	Sig.(2-tailed)	.802	.760	.448	.000	.789	.724		.483	.149	.178
Chloride		-.834**	-.242	-.277	.252	.874**	-.222	.252	1	.091	.043
	Sig.(2-tailed)	.003	.501	.438	.483	.001	.538	.483		.802	.906
Sulphate		.114	-.259	-.063	.491	-.126	-.197	.491	.091	1	-.979**
	Sig.(2-tailed)	.754	.471	.863	.149	.729	.586	.149	.802		.000
Nitrate		-.203	.178	.045	-.463	.229	.230	-.463	.043	-.979**	1
	Sig.(2-tailed)	.573	.623	.903	.178	.525	.523	.178	.906	.000	

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

The presence of high amounts of chlorides may indicate the contamination of ground water by waste water. The relatively higher amount of chloride(> 20mg/l) in some of the borehole samples may be an indication of pollution from domestic waste and sewage.(2). In the study chloride shows a significant positive relationship with acidity(r =0.874) and a significant negative relationship with PH(r = - 0.834) in the sachet water samples(tables 3) while it showed significant positive relationship with conductivity(r = 0.816), Acidity(r =0.680) and Total hardness(r = 0.688); and a significant negative relationship with TSS(r = 0.645) in the borehole water samples(Table 4).

The alkalinity values recorded for the sachet and borehole samples both ranged from 4.0 to 16.0mg/l. these values are

well below the maximum acceptable limits in drinking water of 120mg/l. The alkalinity values gives an idea of the level of natural salts present in the water.

The sulphate and Nitrate values recorded are low when compared to the standard recommended limits(Tables 1 and 2). The sachet water values were between 7.00 – 8.29mg/l for Nitrate and 1.1 – 16mg/l for Sulphate. The values of 1.70 – 3.50mg/l and 3.0 – 10.0mg/l were recorded for Nitrate and Sulphates in the borehole water. Nitrate is the most highly oxidized of Nitrogen compounds commonly present in natural water and it is the product of aerobic decomposition of organic nitrogenous matter(16). Significant sources of Nitrate include fertilizer, decayed vegetation, animal matter, domestic and industrial effluents. And unpolluted natural water usually contain only small amount of nitrate.

In the study, Nitrate shows a significant negative relationship with sulphate($r = -0.979$) in sachet water samples(tables 3) and positive relationship with alkalinity($r = 0.647$) in the borehole samples, (Table 4).

All the physico-chemical parameters were within the standard limits recommended by WHO and USEPA. The result is similar to results obtained in identical studies in Owerri, Nsukka and Lagos, cities all in Nigeria(14, 15, and 17).

High levels of Coliform bacteria were present in both the borehole and sachet water samples. The values of 1.5×10^2 – 3.9×10^2cfu/ml and 1.0×10^2 – 2.9×10^2cfu/ml were recorded for the boreholes and sachet waters respectively. These are well beyond the WHO recommended limits of 0(Tables 1 and 2), and most of the samples had more than three coliform organisms present in them which is against WHO stipulation. The Coli forms detected include Bacillus subtilis, Escherichia coli, Streptococci faecalis, Staphylococcus sp., Streptococcus sp. and Shigella sp. . These bacteria has been implicated in water related disease which has been reported to cause high death rate among children especially in the under developed countries(3).

The presence of coliform in water is indicative of pollution. The presence of coliform in the present study may be due to the unhygienic environment of the boreholes and factories where the sachet water is packaged. Most of the boreholes were sited close to septic tanks, and the points of collection of the water were not kept clean. Similar results have been reported for microbial analysis in sachet water sold in Nnewi, Ibadan, Oyigbo Lagos, and Ogbomosho(18, 19, 21 and 22) in Nigeria. The presence of coliforms in these towns were attributed to poor water treatment and handling methods of the producers such as poor sanitary conditions of the packaging environment, inadequate sterilization of the packaging material and contamination by the sealing machine used.

Table 4. Correlation Between Different Physico-chemical Parameters of Borehole Water Samples

		pH	Conductivity	TDS	TSS	Acidity	Alkalinity	Total Hardness	Chloride	Sulphate	Nitrate
pH		1	.475	-.167	-.765**	.237	.890**	.205	.611	-.165	.534
	Sig.(2-tailed)		.166	.644	.010	.510	.001	.570	.061	.649	.112
Conductivity		.475	1	-.459	-.708*	.716*	.575	.903**	.816**	-.280	.414
	Sig.(2-tailed)	.166		.182	.022	.020	.082	.000	.004	.433	.234
TDS		-.167	-.459	1	.329	-.158	-.077	-.590	-.363	.169	-.242
	Sig.(2-tailed)	.644	.182		.354	.663	.832	.072	.303	.640	.500
TSS		-.765**	-.708*	.329	1	-.341	-.679*	-.608	-.645*	.058	-.385
	Sig.(2-tailed)	.010	.022	.354		.335	.031	.062	.044	.873	.272
Acidity		.237	.716*	-.158	-.341	1	.284	.679*	.680*	-.129	-.175
	Sig.(2-tailed)	.510	.020	.663	.335		.427	.031	.030	.723	.628
Alkalinity		.890**	.575	-.077	-.679*	.284	1	.255	.495	-.440	.647*
	Sig.(2-tailed)	.001	.082	.832	.031	.427		.476	.145	.203	.043
Total Hardness		.205	.903**	-.590	-.608	.679*	.255	1	.688*	-.106	.208
	Sig.(2-tailed)	.570	.000	.072	.062	.031	.476		.028	.772	.565
Chloride		.611	.816**	-.363	-.645*	.680*	.495	.688*	1	-.106	.309
	Sig.(2-tailed)	.061	.004	.303	.044	.030	.145	.028		.770	.385
Sulphate		-.165	-.280	.169	.058	-.129	-.440	-.106	-.106	1	-.162
	Sig.(2-tailed)	.649	.433	.640	.873	.723	.203	.772	.770		.655
Nitrate		.534	.414	-.242	-.385	-.175	.647*	.208	.309	-.162	1
	Sig.(2-tailed)	.112	.234	.500	.272	.628	.043	.565	.385	.655	

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

*. Correlation is significant at the 0.05 level(2-tailed)

4. Conclusions

In general, the qualities of the borehole water and satchet water samples with respect to the determined physicochemical parameters are within the WHO permissible limit. But in terms of the microbial quality, the samples do not meet the set standards. Hence it is necessary to treat both the borehole waters and the water sources(usually boreholes) from which the sachet water are packaged before consumption, and also awareness should be created by the government sanitation agencies on the effects of siting drinking water sources in unhygienic environments and areas close to waste disposal systems.

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