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Research Paper

Bacteriological and Physico-Chemical Status of Borehole Water in Abia and Anambra States, Nigeria

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ABSTRACT
As part of the efforts to evaluate the quality of public water supplies in Nigeria, borehole water samples were collected from Anambra, and Abia Statesof Nigeriato ascertain their bacteriological and physico-chemical potability. Membrane filtration technique (MFT) was used for bacterial counts on glucose tryptone agar for heterotrophic counts, Tergitol for total and faecal coliform loads. Physico-chemical parameters were determined by HACH's APHA and AAS techniques. For total heterotrophic and total coliform,samples from Onitsha, Anambra State differed significantly from Abia State. There was no significant variation in their faecal coliform count.Abia Staterecorded the highest number (74.1%) prevalence of the isolateswhile Anambra State had (59.3%). With few exceptions, all samples showed no evidence of undesirable physico-chemical characteristics. Turbidity for Umuahia and Aba significantly varied from those of Onitsha in Anambra State. Chlorine and chloride of the study areas did not differ significantly. Their DO mean values have no significant variation. This research revealed that borehole water supplies in South-Eastern Nigeria have higher physico-chemical quality than bacteriological. Consequently, public water supplies from this source should be adequately treated and stored. This calls for regular monitoring through research.
Keywords: *Underground water, physical, chemical, bacteria, Abia, Imo, Potable, Pollution, Contamination*

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I. INTRODUCTION

Agriculture and trading are the major occupations of the people of these states. Industrial and commercial activities attract people from all parts of Nigeria and other parts of West Africa to these States for business. Human and industrial activities have led to the environmental hazard, as their wastes are indiscriminately disposed. Industrial effluents are discharged into water bodies, thereby contaminating and making them unsafe for human consumption. Erosion has remained the major threat to the environment of these States. Building plans are not properly done [1, 2]. Abia State Economic Empowerment, Development Strategy (ABSEEDS) [1] reported that Abia is among the Nigerian States with the problem of acidic soil and fertility.

Rain, surface and ground water remain sources of drinking water and are polluted mainly due to exposure to human activities, thereby reducing their W.H.O standards for potable water and made them vehicles for the transmission of health risk, due to bacteria and toxic chemicals and simultaneously alter their physical attributes. Report by Ibe and Okpelenye [3] on borehole water in Uli, Anambra State revealed high load of total heterotrophic bacteria mean range of 1.5 x 10^2 – 5.9 x 10^4cfu/ml, 9-136s MPN/ 100ml for total coliform and 4-74MPN/100ml for faecal coliforms. Bacterial community pattern of domestic water sources investigated in the Gogogo and Nkonkobe areas of Eastern Cape Province, South Africa indicated contamination with majorly human pathogens of E*nterobacteriacae* family [4]. Dike and Udebuani [5] noted in Imo State, Nigeria, that water reserved for drinking and domestic purposes was contaminated by atmospheric contaminants, organic matter that are air-borne, as well as other contaminants from run-off flood. Surface water bodies which served as source of pipe-borne water and presently use for domestic and recreational purposes, especially during draught in Imo State, Nigeria, showed the presence of bacteria of public health importance, including: *Chromobacteriumviolaceum*[6]. Physico-chemical quality of Rain, well, and borehole water investigated in

Warri, Delta State, Nigeria, revealed that the minimal and maximal concentration of physico-chemical water quality parameters examined were either on the higher or lower side of Target Water Quality Range (TWQR) or standard for water use for domestic purposes [7].

Many of the chemical substances are toxic. Pathogens can produce water-borne diseases in human or animal hosts.The Health hazards of drinking non-potable water include those due to microbiological and chemical pollutants. However, the risk of contamination with faecal pathogens is much more than the risk due to chemical contamination [8].

The Health hazards of drinking non-potable water include those due to microbiological and chemical pollutants. However, the risk of contamination with faecal pathogens is much more than the risk due to chemical contamination [8]. Water being a potential carrier of pathogens can endanger health and life. Common bacterial pathogens associated with defective drinking water supplies include those responsible for gastro-enteritis such as, diarrhoea due to cholera, typhoid and paratyphoid fever, campylobacteriosis and bacillary dysentery; caused by *Escherichia coli* 0157: H7, *Vibrio cholerae, Salmonella typhi, Samonellaparatyphi*and *Shigelladysentriae* as well as others of other microbial eatiology, which are communicable [9].

Non-communicable water-related diseases are those resulting from the chemical quality of drinking water. Typical examples include: methaemoglobinaemia due to high concentration of nitrate, carcinomas like cancer of the lung caused by high level of radon in drinking water, released into the air through taps and boiling [10, 11].

Heavy metals are toxic mainly to the sensitive rapidly developing systems of foetus, infants and young children. Exposure to mercury and lead may result in development of auto-immunity, which can complicate joint diseases [12]. They can easily cross the placenta and damage the foetal brain. Childhood exposure to some heavy metals can cause learning difficulties, memory impairment, damage to the nervous system and behavioral problems like aggressiveness and hyperactivity [13]. At higher doses, heavy metal can lead to irreversible brain damage [14]. Some are evident that there may be a loss of up to 2 IQ point for a rise in blood lead level from 10-20µg/dl in young children [15, 16, 17]. Due to the minamata epidemic of methyl mercury poison in late 1950s in Japan, methyl mercury has remained one of the most dramatic and best recorded case of bio-accumulated toxins in the environment, mainly in aquatic food chain [18]. Exposures to pregnant women are of great public health concern since methyl mercury can cross the placenta and enter foetal brain and even at low concentration of mercury before birth, children can suffer serious neurological and developmental deficits [19].

Accumulation of cadmium in the body can cause serious health effects like lung diseases, kidney damage and cancer in human. Even at low levels it has serious effects on foetus, infants and young children. Long-term exposure of cadmium on man has been associated with renal dysfunction. Cadmium may cause bone defects such as osteomalacia/osteoporosis in human and animals. Observations also recorded decreased reproduction and testicular damage in exposed animal [13]. Arsenic is among toxic elements that can be found in our environment. Human exposure to inorganicarsenics results in different kinds of health effect [17]

II. MATERIALS AND METHODS

Sample collection

Borehole water samples were randomly and aseptically collected from different borehole taps in the study areas [20].

Laboratory Processing and Analysis

Bacteriological investigation was done by Membrane Filtration technique (MFT) as reported by Cheesbrough [20].Total bacteria counts were determined by filtering 1ml of water sample through 0.45nm sterile membrane filter (Sartorius) in a sterile filtration unit in an inoculation hood, covered and vacuum applied. The filter was aseptically transferred to a plate of Glucose Tryptone medium in duplicate, incubated at 37^{o} C for 24hrs. Bacteria colonies were counted 24 hourly and means reported as organisms (cfu)/ml of water. Total coliform and faecal coliform counts were determined by filtering 100ml of sample through membrane filter in duplicate as above. These were aseptically placed different on two plate of Tergitol medium, incubated one at 37^{o}C for coliforms and the other at 44^{o}C for faecal coliform.Colonies were enumerated and expressed as cfu/100ml.

Physico-chemical assessment of samples

Water samples were analyzed by photometric method as stipulated by APHA [21] and NWRI [22] for physical and chemical parameters, while heavy metals were assessed using Buck scientific Atomic Absorption Spectrophotometer (205) using appropriate filters after proper treatment and strict adherence to quality assurance measures.

Data Analysis: Statistical analysis was by ANOVA using the least significant difference (LSD).

III. RESULTS AND DISCUSSION

The Analysis of Variance of the bacterial loads/counts of borehole water samples from the different study areas

The mean value of microbiological characteristics of borehole water samples from different locations in different States, as presented in Table 1, showed that there was significant difference in the total heterotrophic (TH) bacterial counts/ml, among the various locations. Onitsha in Anambra State had the highest heterotrophic bacterial count mean value of 238.9/ml although not significantly different from that of Aba in Abia State with 103.54 mean count/ml.For total coliform/100ml, Onitsha presented the highest mean count of 205.7/100ml, which was significantly different from those observed Aba in Abia State with 111.82mean count values/100ml. The mean faecal coliform counts/100ml showed no significant difference among the different areas , Umuahia ranked highest with 5.82 mean count/100ml, Onitsha has 2.9 mean count/100ml and Aba with 1.87 mean count/100ml.

Table 1: Mean ± Standard deviation values bacterial counts of borehole water samples from different zones.

Zone	THC (/ml)	TCC (/100ml)	FCC (/100ml)	PC (/100ml)
Onitsha	238.9 ±129.58a	205.7 ±119.20a	2.9 ±1.71a	0.0 ±0.0a
Umuahia	106.12 ±116.98b	72.76 ±100.80b	5.82 ±8.44b	2.5 ±4.33a
Aba	103.54 ±91.59b	111.82 ±139.33ab	1.87 ±1.81a	0.0 ±0.0a

Legend:
THC: Total Heterotrophic bacterial count / ml
TCC: Total Coliform Count / 100 ml
PCC: Faecal Coliform Count / 100 ml
*Means on the same column with the same letter(s) are not significantly different at P = 0.05, according to the Least Significant Difference (LSD)

Analysis of Variance of the Physical characteristics of borehole water samples from different study areas

The physical characteristics of borehole water samples from Onitsha in Anambra State, Umuahia and Aba in Abia state are presented in table 2. For Turbidity, Aba recorded the highest mean value of 1.86mg/l, which was significantly different from that observed in Onitsha with the lowest mean. There was no significant difference in the mean temperature values among the study areas. The highest mean value of 30.26^{0}C observed in Umuahia was not significantly different from the lowest, 29.5^{0}C observed in Aba.The mean value for conductivity from Onitsha samples (71.3mg/l), ranked the highest, Aba ranked the second with mean conductivity value of 44.8mg/l, but was significantly different from that of Umuahia which is 31.28mg/l. For TDS, there was no significant difference among the different zones. However, Onitsha recorded the highest mean value of 36.12mg/l, seconded by Aba with 24.46mg/l then Umuahia with 16.26mg/l

Table 2: Mean ± Standard Deviation Value of Physical Characteristics of borehole water samples from different zones

Zone	Turbidity (mg/L)	Temperature (°C)	Conductivity (mg/L)	TDS (mg/L)
Onitsha	0.041 ±0.09b	29.94 ±0.36a	71.38 ±63.14a	36.12 ±32.52a
Umuahia	1.68 ±0.96a	30.26 ±1.82a	31.28 ±31.59ab	16.26 ±16.78a
Aba	1.862 ±1.37a	29.5 ±1.73a	44.84 ±56.63ab	24.46 ±29.69a

*Means on the same column with the same letter(s) are not significantly different at P = 0.05, according to the Least Significant Difference (LSD)

Analysis of Variance of the chemical characteristics of borehole water samples from different study areas

The mean values of chemical parameters presented in Table 3 revealed significant variations in the mean pH of the borehole water samples from the different zones. Mean alkalinity values showed significant difference. Onitsha had the highest mean value of 6.0mg/L and this significantly differed from that of Umuahia with the lowest mean value of 2.54mg/L and Aba with 2.6mg/L. acidity mean values also showed significant difference among different locations. Although Umuahia recorded the lowest mean acidity, it was not significantly different from those of Onitsha but significantly different from what was observed from Aba. There was significant difference in the mean value of iron in the study areas. The highest mean value of 1.62mg/L was recorded in Umuahia and showed no significant difference from values observed in Onitsha and Aba. All the water samples from the different locations recorded zero (0mg/L) mean value for chlorine, meaning no variations among them. The mean chloride varied in this sequence; Umuahia 37.2mg/L, Onitsha 36.88mg/L and Aba 29.72mg/L. Total hardness values showed significant differences among the water samples from different ecological settings. Umuahia recorded the lowest mean total hardness value of 14.48mg/L and this did not vary significantly from the value obtained in Aba 17.34 mg/L but varied significantly from that obtained in Onitsha 97.5mg/L. There was also significant difference in the mean values of calcium hardness of samples from different locations. The least mean value was obtained from Aba 5.68mg/L and did not vary from that obtained from Umuahia 6.48mg/L but varied significantly from that obtained in Onitsha which was the highest value 56.56mg/L. Magnesium hardness sampling recorded some variations among different locations but these difference are not statistically significant. Mean values of nitrate from different zones were variant. Values recorded for Onitsha samples in Anambra state took the lead of 33.94mg/L and showed no significant variations from the mean value of samples from Umuahia 16.48mg/L and Aba 16.51mg/L.

Table 3: Mean ±Standard deviation of chemical characteristics of borehole water samples from different study area

Parameter	Onitsha	Umuahia	Aba
Ph	6.5±0.86ab	5.7±0.31bc	5.2±0.48c
Alkalinity (mg/L)	6.0±2.09a	2.54±1.04b	2.6±1.48b
Acidity (mg/L)	23.9±8.72bc	14.48±5.84c	34.22±11.9a
Iron (mg/L)	0.04±0.09ab	1.62±2.91a	0.86v0.59bc
Chlorine (mg/L)	0.0±0.0a	0.0±0.0a	0.0±0.0a
Chloride (mg/L)	36.88±11.81a	37.2±33.13a	29.72±16.87a
Total Hardness (mg/L)	97.5±79.69ab	14.48±4.41b	17.34±5.55b
Calcium Hardness (mg/L)	56.56±48.58ab	6.48±1.82c	5.68±1.64c
Magnesium Hardness (mg/L)	40.94±34.07abc	8.0±3.72c	11.68±4.32c
Nitrates (mg/L)	33.94±28.86a	16.48±12.16ab	16.51±20.75ab

*Means on the same column with the same letter(s) are not significantly different at P = 0.05, according to the Least Significant Difference (LSD)

Analysis of Variance of the Heavy metal content of water samples from different study areas

The mean values of heavy metals in borehole water samples in the different states are displayed in table 4 below. There was no significant variation in mean values of lead among the different places. However, while data from Onitsha in Anambra State and Aba in Abia State recorded mean lead value of 0.0008mg/L each, there was no significant variation from other areas that had zero (0mg/L) mean value. Mean value for mercury was also zero (0mg/L) in all the samples from the different zones and states. The mean cadmium value of the water samples from the different zones showed no significant variation. However, samples from Onitsha in Anambra State ranked first with mean value of 0.0048mg/L, followed by Umuahia with 0.0018mg/L and Aba with 0.00022mg/L. For Arsenic, there was no variation. All zones and states recorded zero (0mg/L) mean value. Mean value of copper showed no significant variation among the two states. Mean cobalt of 0.003mg/L recorded in Onitsha showed significant variation from those recorded in Umuahia 0.0006mg/L and Aba 0.00056mg/L. Mean values for Nickel (0mg/L) were the same in all the locations.

Table 4: Mean ±Standard deviation of heavy metals of borehole water samples from different zones

Zone	Lead (mg/mL)	Mercury (mg/mL)	Cadmium (mg/mL)	Arsenic (mg/mL)	Copper (mg/mL)	Cobalt (mg/mL)	Nickel (mg/mL)
Onitsha	0.0008±0.002a	0±0a	0.0048±0.009a	0±0a	0.0118±0.016a	0.003±0.0019a	0.0±0.0b
Umuahia	0±0a	0±0a	0.0018±0.0035a	0±0a	0.002±0.0014a	0.0006±0.0009b	0.0±0.0b
Aba	0.0008±0.002a	0±0a	0.00022±0.0035a	0±0a	0.001±0.0094a	0.00056±0.0005b	0.0±0.0b

*Means on the same column with the same letter(s) are not significantly different at P = 0.05, according to the Least Significant Difference (LSD)

Analysis of Variance of Dissolved Oxygen (DO) and 5-day Biochemical Oxygen Demand (BOD_5) of samples from different Locations

The mean values for Dissolved Oxygen (DO) and 5-day Biochemical Oxygen Demand (BOD_5) of the borehole water samples of the two states are shown in table5 below. Both the Do and theBOD_5revealed variations in the mean values among the different locations. For DO, the highest mean value was recorded in Umuahia, but it was not significantly different from the values in other areas. Umuahia recorded the highest mean value (16.84 mg/L) in 5-dayBiochemical Oxygen Demand (BOD_5) but this showed no significant difference from the mean values from other locations.

Table 5: Mean±Standard deviation of Dissolved Oxygen (DO) and 5-day Biochemical Oxygen Demand (BOD_5) of samples from different Zones

Zone	DO (mg/L)	BOD_5 (mg/L)
Onitsha	25.56±19.42a	16.12±13.99ab
Umuahia	28.84±6.15a	16.84±6.13a
Aba	22.68±8.35a	11.22±2.90ab

*Means on the same column with the same letter(s) are not significantly different at P = 0.05, according to the Least Significant Difference (LSD)

IV. DISCUSSION

The level of bacterial contamination of various borehole water samples were investigated, with a view to highlighting the public health implications of the total dependence on borehole as the cheapest source of table water in Abia and Anambra States of Nigeria. Borehole water is regarded as a safe source of public water supply because it undergoes some level of filtration processes, while passing through layers of soil by which suspended particles and microorganisms are removed to some extent [9, 23].

These high bacteria counts in the borehole water samples analyzed, indicates pollution and source of public health risks. Since these borehole are installed within residential houses, hospitals, along roads, besides petrol stations, industries and even refuse dumps, the source of contaminations are not far-fetched. Pollution may results by contaminated water (sewage) seepage into them through crevices in the rocks or those drawn into them through pumping [9].This refutes the historical belief that ground water is free from microbial contamination [23].

Since borehole is sited within human residence, near septic tanks, drainage systems and landfills, they can be contaminated by effluent seepage from these sources [24]. The great risk from microbes in the water is associated with the consumption of drinking water that is contaminated with human and animal excreta, although other source and routes of exposure may also be significant [25].

The high level of heterotrophic bacterial,coliform and faecal coliform counts recorded in borehole water sample are indicative of pollution and agrees with the report of Ibe and Okpelenye [3]. These high heterotrophic counts can indicate lack of treatment breakthrough, post-treatment contamination, growth within the water conveyed by the distribution system or the presence of deposits or biofilms in the system [26].

The total coliform records can indicate deterioration of water quality through distribution system. Their presence in borehole water can reveal microbial growth and possible bio-film formation, as well as ingress of foreign materials such as soil. The detection of faecal coliform in the majority of the borehole sampled evident contamination from human and animal faeces which agrees with the report of Zamxaka*et al.*,[4]. The detection of these faecal coliforms which are indicators of faecal contamination should denote the possible presence of all relevant pathogens [26].

Majority of the borehole samples deviated from standards for microbiological quality for drinking water of not greater than $1.0 \times 10^2/ml$ [100cfu/ml] for total bacterial counts, zero [0.0] cfu/$100ml$ for coliform and faecal coliform organism/100ml and not more than 3 coliform organisms in $100ml$ of any 2 consecutive samples as stipulated by NAFDAC, [27] and W.H.O. [25]. From the specifications faecal*Streptococci* should also be nil/100ml of water sample, other parasites$= nil/100ml$ [27] or not more than $10cfu/100ml$ for coliform, zero [$0cfu/100ml$] for faecal coliform and other parasites [28].

V. CONCLUSION

The results of this research reveal that this source of potable water in these study areas is grossly contaminated bacteriologically and chemically although with few exceptions. The highest contamination with total heterotrophic and coliform bacteria was observed in Anambra State which differs significantly from Abia State. Isolations of organisms of public health concern predicts health risk that can be encountered by the users. This means that water from the majority of the sources is not potable without treatment.Physico-chemical parameters are within the acceptable limit with the exception of a few. The total absence of detectable chlorine residuals in all the samples assessed is a proof for this level of contamination and adequate treatment before distribution. It can be concluded that the historical and the theoretical attribute of borehole is no longer strictly right owing to urbanization, increased population and human activities. The methods of waste management play an important role in the people's water supply both in the developing and developed countries.

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