



AN INVESTIGATION INTO GROUND WATER CONTAMINATION IN AGBOR AND
OWA COMMUNITIES IN NIGERIA

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ABSTRACT

Groundwater is the predominant source of water in Ika land without any treatment with questions on its safety. Fifty borehole water sites were sampled divided into five sample areas. Nitrate contents were determined by colorimetric method, and chloride by titration with silver nitrate solution (APHA standard method 4500-Cl-B). From the results obtained, chloride values were consistently low in all the sampled areas. Secondly, very low nitrate values were similarly recorded in the sample areas. Thirdly, a mean value of NO₃⁻/Cl⁻ ratio of 0.003 was observed, an indication of groundwater geochemical evolution. However, both the chloride and nitrate contents of the groundwater fell very far below international guideline values. Microbial analyses reveal that all but one sampled area posted negative results for the presence of E.coli, Salmonella spp. was not detected. It is obvious that the groundwater quality is wholesome with regards to the parameters here analyzed. However, personal hygiene is advised.

Keywords: Ground water, chloride, nitrate, E.coli, and Salmonella spp.

1. INTRODUCTION

Water is essential for human life (Siddiqui *et al.*, 2005). It is a basic natural resource for sustainable living on earth. Although, this resource being one of the most abundant on earth is not immediately available to the teeming human, animal, and agro-plant population the world over. Besides, where water is available its quality is ever always in question (WHO 2010). This is more so, against the backdrop that the quality of water anywhere in the world is subject to natural geographical, human- anthropological, and environmental factors and activities (UNDESA 2001). The benefits of quality drinking water therefore is premium to governments and people all over the world and coordinated by the United Nation; as enshrined in the Millennium Development Goals of the world governing body in 2000. Hence according to the UN Secretary General (2000): “No single measure would do to reduce disease and save lives in the developing world than bringing safe water and adequate sanitation to all.”

Since portable water is a commodity not commonplace, and again, since a myriad of diseases of acute and remote health implications to the continued existence of man are

inherently acquired through poor and unsafe drinking water especially in the a famed third world countries, the benefit of providing, treating, and ascertaining the quality of water available to a community of people cannot be overstated.

In sub-Saharan Africa, Nigeria, and Ika land in particular, the provision of water to the people is froth with its challenges and scarcity as well. In a recent survey, according to Ahaneku and Adeoye (2014) an estimated 65 million Nigerians had no access to portable water. In Ika land and Boji-Boji area in particular, the challenge of portable water has been an interesting one, coming from a period of near absolute absence (after the demise of the now moribund Public Water Works of the then Colonial Government) and over dependence on hand dug wells (merely water reservoirs) and the rather polluted *Orogodo* River (River Ethiopie cutting through the town) to the advent of borehole water now a ubiquitous sight in the community. Provision of borehole was more than a welcome relief as it provides water at the doorstep of the people literally speaking. However, the quality of this commodity was and is assumed to be portable with hardly any questions or doubts raised on its wholesomeness or otherwise.

Ground water is the water that exists underground (The Groundwater Foundation, 2012). Although it can be present as underground lakes beneath the Earth's surface, it commonly lies in the tiny spaces between grains of sand or bits of fractured rock (Australian Academy of Science, 2012). It is part of precipitation that seeps down through the soil until it reaches rock material saturated with water (Roger, 2002). When rain falls to the ground, the water does not stop moving, some sink into the ground (The Groundwater Foundation, 2012). Water is a most valuable resource to man and living things, essential for the sustenance of life on earth as exemplified by its diversified uses (drinking, cooking, washing, irrigation, farming etc.) (Rim-Rukeh *et al.*, 2007). If groundwater is polluted it is no longer safe for drinking. Groundwater can be found almost everywhere. Groundwater supplies are replenished, or recharged by rain and snow melt (The Groundwater Foundation, 2012). According to the National Ground Water Association of the United States, 49% of her population depends on ground water for drinking water supply either from public or private wells (Anon, 2012).

Water in its natural state may not be pure since it is a universal solvent with the ability to dissolve numerous chemicals and thus carry a lot of impurities that can be injurious to health if it exceeds tolerable limits (WHO, 1984). The quality of any water source depends on its physico-chemical and bacteriological parameters (WHO, 1984). Metallic contaminants and microbial pollution are serious concerns in many water bodies around the world (UNEP GEMS, 2007). The largest concern about microbial pollution is the risk of illness or premature death to humans and livestock after exposure to contaminated water (UNEP GEMS, 2007). Indicator organisms, such as faecal coliforms, can be used to detect the presence of faecal contaminants in water resources (UNEP GEMS, 2007).

In this paper, among the many parameters of portable water quality, chloride, nitrate, faecal coliforms, and *Salmonella spp.* will be studied. Arising from the notion of a water- scarce area with sanitation and waste disposal problems occasioned with an increase and prevalence in the spate typhoid disease and sicknesses associated with contaminated food and water from faecal sources in recent past.

This research exercise studied the groundwater characteristics of Boji-Boji Agbor/Owa town and its immediate suburbs of Alihame and Owa Alero communities with the intention of finding out the wholesomeness or otherwise of the bore hole water widely and variously used by inhabitants of the area. Besides, there is scarcely any data published on the groundwater quality of Ika area.

2. MATERIALS AND METHODS

The study area (Agbor/Owa town commonly referred to as *Boji-Boji*) found within longitudes 6° - 6° 30' E and latitudes 6° - 6° 30' N, was mapped out in to five (5) sub-areas of

Agbor Obi, Boji-Boji Agbor, Boji-Boji Owa, Alihame, and Owa Alero. The latter two areas (Alihame and Owa Alero) being classified as suburban towns for the purpose of this exercise on the basis of socio-economic stratification and population density. The geology of the area is mainly of the recent tertiary sedimentary sand stone, with the Bini formation as a typical example. This indicates a lee way for easy passage of leachate through to the ground water in the underlying aquifer. The climate of the study area exhibits the characteristics of a sub-equatorial climate with an annual mean air temperature of 27.0°C (Odjugo 2008). The rainfall pattern is that of double peaks or maximal with mean annual rainfall of 2,255mm; while the mean relative humidity is 81%, and the soil type is red-yellow ferralsols (Avwunudiogba 2000).

A total of 50 borehole water sources were sampled in all from these areas, with an average of about 12-15 per area for Agbor Obi, Boji-Boji Agbor and Owa areas, and five (5) for Owa Alero and Alihame communities on the grounds of fewer wells per unit area. Samples were collected in clean new 300ml sterile bottles with corks (Burubai *et al.*, 2007). Borehole water points were randomly spaced and collected in these bottles filled to the brim, put in dark ice bag and immediately taken to the laboratory for analysis.

At the laboratory, the samples were carefully transferred in to a clean and larger container of 4L in capacity previously sterilized, and a composite sample was thus formed per sample area. Samples were collected on different days and in the mornings between the 4th and 18th of August, 2013. These composites were then shared in to two (2) portions for chemical and bacteriological analyses.

Nitrate concentrations of the samples were determined by colorimetric method using visible spectrophotometer model 712; and chloride, by titration with silver nitrate solution (APHA 2005). Blank analyses were done using freshly prepared distilled water in place of the samples. All determinations were done in triplicates and the average values taken. Bacterial analyses were done with specific reference to *E.coli* to determine faecal contamination and for *Salmonella typhi*, by culturing samples in Mac Conkey and bile Salt Lactose peptone water respectively at 37° C after 48 hours incubation.



Figure 1: Map of Nigeria showing Delta State (Source: Google Map)

3. RESULTS AND DISCUSSIONS

Table 1: The Concentrations Of The Anions Analyzed For In The Study Area In Milligrams Per Litre.

S/No.	Place (Sample area)	Chloride (mg/L)	Nitrate (mg/L)
1	Agbor Obi	8.8	0.015
2	Boji-Boji Agbor	9.64	0.02
3	Boji-Boji Owa	7.1	0.012
4	Owa Alero	6.63	0.019
5	Alihame	7.26	0.023

3.1 Chloride

Table 1.0 displays the chloride contents of borehole water sample from the five sampled areas. The smallest chloride value of 6.63mg/L was recorded for Owa Alero; while Boji-Boji Agbor had the highest chloride value of 9.64mg/L suggesting the highest saline area. Agbor Obi and Alihame were second and third respectively with 8.80 and 7.26mg/L chloride values. Furthermore, an average chloride value of 6.29mg/L is recorded for the area under study. Chloride, like sodium is principal component of TDS, either ion can give water an unpleasant salty taste (salinity) at elevated concentrations (Apps 2012) (above 200-300mg/L). The comparatively low values obtained in this study are indicative of good water quality especially falling very far below guideline value of 250mg/L according to the Nigerian water standards, WHO, USEPA and the EU. This low chloride content of the groundwater suggests no fresh water infiltration. However, from geochemical point of view, the NO_3/Cl^- ratio of 0.003 determined for this area infer the dominance of halite. Bacteriological contamination is unlikely to occur if free chlorine levels are kept around 0.4 – 0.5 mg/l (Apps 2012).

3.2 Nitrate

The source of nitrate in water bodies is through fertilizers and human or animal waste; including septic tank. As a tracer, nitrate provides information on the rate of water movement, agricultural use and environment (Al-Harbi *et al.* 2006). Bacteria converts nitrate to nitrite in surface and groundwater. Nitrate is therefore a primary priority chemical contaminant (UNICEF 2008; WHO 2010). Nitrate values range from 0.012-0.023mg/L for the five sampled areas; the biggest value of 0.023mg/L being recorded for Alihame, with 0.020 and 0.019mg/L (2nd and 3rd) for Boji-Boji Agbor and Owa Alero in this order. Boji-Boji Owa had the smallest 0.012mg/L. Whereas, nitrite and ammonia in water are toxic, nitrate is virtually harmless, with direct effects typically not observed until concentrations greater than 1000mg/L (Yilmaz and Koc, 2013). Average nitrate value for the study area is 0.020mg/L. Al-Harbi *et al.* (2006), contend that high nitrate concentration in water usually creates health hazards such as nitrate toxicity and physiological disorder. However, results obtained from this study fall far below the 50mg/L guideline value for Nigerian, WHO, European Union (EU), and United States Environmental Protection Agency (USEPA)'s 44.3mg/L limit, inferring good water quality; more so, according to Jaji *et al.*, (2007) unpolluted water usually contain only minute amount of nitrate. In unpolluted water, nitrate is rarely above 1 mg/l so higher levels may indicate contamination (Apps, 2012). Furthermore, nitrates are very soluble in water and adhere weakly to soils so are often quickly leached (Apps, 2012).

3.3 *Escherichia coli* and *Salmonella* spp. analyses of Groundwater samples in the study area

Table 2.0: The results of *Escherichia coli* and *Salmonella* spp. analysis of the groundwater samples collected from the five sample areas of the study area.

S/No	Sample Area	<i>E.coli</i>	<i>Salmonella</i> spp.
1	Agbor Obi	FFP	ND
2	Boji-Boji Agbor	PFEC	ND
3	Boji-Boji Owa	FFP	ND
4	Owa Alero	FFP	ND
5	Alihame	FFP	ND

Notes: FFP: Free of Faecal Pollution; PFEC: Presence of Faecal *E.Coli*; ND: Not Detected

By far the most serious public health risk associated with drinking water supplies is microbial contamination (UNICEF 2008). Since it is impractical to analyze water for every individual pathogen, some of which can cause diseases at very low doses, it is rather more practical to analyze water for indicator species that are also present in faecal matter (UNICEF 2008). The most specific indicator of faecal contamination is *Escherichia coli* (*E. coli*) (UNICEF 2008). Serious ill-health and death are associated with *E.coli* (HSE 2008). Most faecal coliforms are *E. coli* so *E. coli* tests are used as an indicator of faecal coliforms. Only some relatively uncommon strains of *E.coli* are actually harmful but its presence is an alert that other human disease organisms may be present (Apps 2012). It is, therefore, recommended that the bacteriological classification scheme should be based on thermotolerant (faecal coliform) bacteria or *E. coli* (WHO 1992).

Of the five sampled areas, all but one (BB Agbor) posted negative results for the presence of *E.coli*. That is, Agbor Obi, BB Owa, Owa Alero, and Alihame returned “free of faecal pollution” (FFP) results with the exception of BB Agbor which had a “presence of faecal *E.coli*” result. Meanwhile, the general picture from the study suggests very clearly, that the groundwater is not infiltrated by septic tank waste and other means of microbial contamination. Furthermore, it is apparent that borehole water points are situated away from septic tanks and other point sources of microbial contamination.

Nonetheless, it is safe to infer that the groundwater in the study area is safe from faecal contamination. Furthermore, since *E.coli* is generally a reliable indicator for salmonella spp. in drinking water supplies (WHO 2010), and *Salmonella* was not detected (ND) in all the sampled areas (Table 2.0), it is informative therefore that the “presence of faecal *E.coli*” declared in BB Agbor is a confirmation of the suspicion of contamination.

Salmonella is the parasite responsible for causing typhoid fever—a disease which ravaged the study area prior to the advent of borehole water system. Due to the isolated rare cases of typhoid fever recently, it became necessary to screen the water samples for traces of *salmonella*; especially since *S. typhimurium* has been associated with the consumption of contaminated ground water and surface water supplies (WHO 2010).

The results of the analysis of the water samples for *Salmonella* pathogen are expressed in table 2.0 as well. In all the sampled areas (study area), there was no detectable trace of *Salmonella* parasite in the water samples analyzed. They all returned a *not detected* verdict, suggesting very strongly that the groundwater was safe from pollution.

4. CONCLUSION

Chloride, nitrate, *E. coli*, and *Salmonella spp.* content of groundwater in Boji-Boji area and immediate environ, of Ika land, Delta state, Nigeria was studied. From results obtained, chloride values were consistently low in all the sample points. The low chloride concentration is an indication of very little or no freshwater deposition in the study area's aquifer. Very low nitrate values were similarly recorded for the sample sites, suggesting that the groundwater is free of septic waste infiltration and agricultural leachate arising from increasing fertilizer use. However, both the chloride and nitrate contents of the groundwater fell very far below international guideline values. Meanwhile, a mean value of $\text{NO}_3^-/\text{Cl}^-$ ratio of 0.003 was observed, an indication of groundwater geochemical evolution. This portrays mineral precipitation. The nitrate/chloride ratio obtained means a relatively higher Cl^- to NO_3^- concentration and hence dryer recharge period.

Microbial analysis of *E.coli* and *Salmonella spp.* of the groundwater reveals that the studied aquifer is not inundated by faecal pollutants as results indicate. This position is further emphasized by the low nitrate content of the water since faecal and fertilizer seepage would have caused a rise and indeed a high nitrate composition. The chloride content observed in this study being far higher by proportion to nitrate, translates to the provision of aseptic environment to microbial growth; thereby preventing and indeed controlling the possible growth of microorganisms. This could be adduced as a potent explanation for the near total absence of microbial contaminants in the groundwater apparently indicated in the results above. These are supported by the pleasantly portable (fresh) taste of the water, and could be considered a credible indication of absence of unpleasant odour-causing bacteria (actinomycetes).

Going by these variables therefore, it becomes very obvious that the groundwater quality of this study area is wholesome with regards to the parameters here analyzed; although caution is emphasized in terms of personal hygiene.

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