Analysis of Groundwater Quality in a Nigerian Community

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Abstract-**Groundwater is the most accessed freshwater source in Nigeria. However, the groundwater resource sector of Nigeria is confronted with pollution problems arising from both natural causes and human activities. The current study examines the case of a faith-based campus whose water needs are 100 % serviced via groundwater. The campus accommodates about 15,000 full residents and 400, 000 weekly visitors. The campus water supply is sourced from 15 functional boreholes which are pumped directly into elevated tanks. Four replicate water samples were obtained from four tap points which are supplied by four different elevated water tanks within the campus. The water samples were analyzed for physicochemical contaminants using standard methods. This was done to confirm the potability of the water which is being consumed by residents. Results of the analysis of the groundwater in the study area showed that all the water samples met the minimum requirements of the National Standard for Drinking Water Quality (NSDWQ) for pH, sulphate, nitrate, chloride and Total Dissolved Solids (TDS). However, all the water samples exceeded the NSDWQ limit of 400 mg/L for hardness. Cadmium was also found to exceed the NSDWQ limit of 0.003 mg/L in all water samples while 50 % of the water samples slightly exceeded the 0.5 mg/L limit for Iron. The presence of cadmium in most of the water sample suggests that there is high risk in consuming water from these boreholes. Due to the life-threatening effect of cadmium on humans, it was concluded that water from the study area should not be consumed without treatment.**

Keywords- Ground Water; Water Quality; Standards; Ota; Physico-Chemical Parameter

I. INTRODUCTION

More than 60% of the Nigerian population depend on groundwater for domestic water supply [1-2]. This is due to the fact that most homes rely on self-supply of water rather than municipal water supply [3]. Self-supply of water without proper planning and regulations, however, often leads to abuse and chaos [1, 3]. In Ota, Nigeria, improper town planning has created a situation where industries and domestic homes are close by each other [4]. Thus, effluent discharges and other forms of pollution from industrial activities often impact on drinking water sources and other aspects of human life [5]. Groundwater has natural deposits of contamination [6-7]. However, groundwater pollution can also arise from anthropogenic activities and from the surface and groundwater interaction also [6-7]. Pollutants that can affect drinking water sources include heavy metal pollution from manufacturing, metallurgy, paints and chemicals and other similar industrial activities [8-9]. Other pollutants such as nitrates, nitrites and sulphate can affect drinking water sources because of improperly managed wastewater effluents [8]. Therefore, regular water quality monitoring is important to safeguard public health. The current study examines the case of a large faith-based community in Ota, Ogun State, Nigeria whose 15,000 residents and 400,000 weekly visitors, fully rely on groundwater supply. This study, therefore, aims to assess the quality of water in this Ota community, to determine its potability.

II. METHOD AND MATERIAL

The study area is Canaanland in Ota, Ogun State, Nigeria (Fig. 1). It is located between Longitude 3°10' 3" E and Latitude 6°40' 35" N and it is the administrative seat and international headquarters of the Living Faith Church Worldwide (Winners' Chapel), an evangelical mega church located at km 10, Idi-Iroko Road, Ota, Ogun State in the South-Western Nigeria. Canaanland is a 560-acre (2.3 km²) facility that was opened in 1999, and it has since expanded to almost 5,000 acres (20 m²). The rapidly growing city houses the Faith Tabernacle (a 50, 000 seating capacity church building), Covenant University (a full residential tertiary institution with a populace of over 8, 000 students), Faith Academy Secondary School, FA (a full-boarding secondary school), Kingdom Heritage Nursery/Primary School (KHMS) and Covenant University Day Secondary School (CUDSS). A number of business ventures operated by the church are situated within Canaanland including a bottled-water processing plant, a publishing house, bakery, various restaurants, four banks, petrol station, gas-turbine powered electricity generation station, and several residential estates that provide accommodation for over 3,000 church employees. The campus has about 30 boreholes. However, due to constant pumping to meet demand, about half of the total number of wells has failed (Fig. 2). The campus reticulation system was designed in such a way that water pumped from a particular borehole can be channeled to supply different elevated tanks. Similarly, a single elevated tank can be supplied by three to four boreholes. This design was done to ensure water can reach different parts of the campus in case any well fails or in case any elevated tank requires servicing or cleaning. Most of the elevated tanks are one hundred thousand- litre (or 100 m^3) capacity steel tanks set up on 16 m high steel stanchions (Fig. 2). Each of these 100 m^3 capacity elevated water tanks are strategically placed to serve high population residential areas (Fig. 3).

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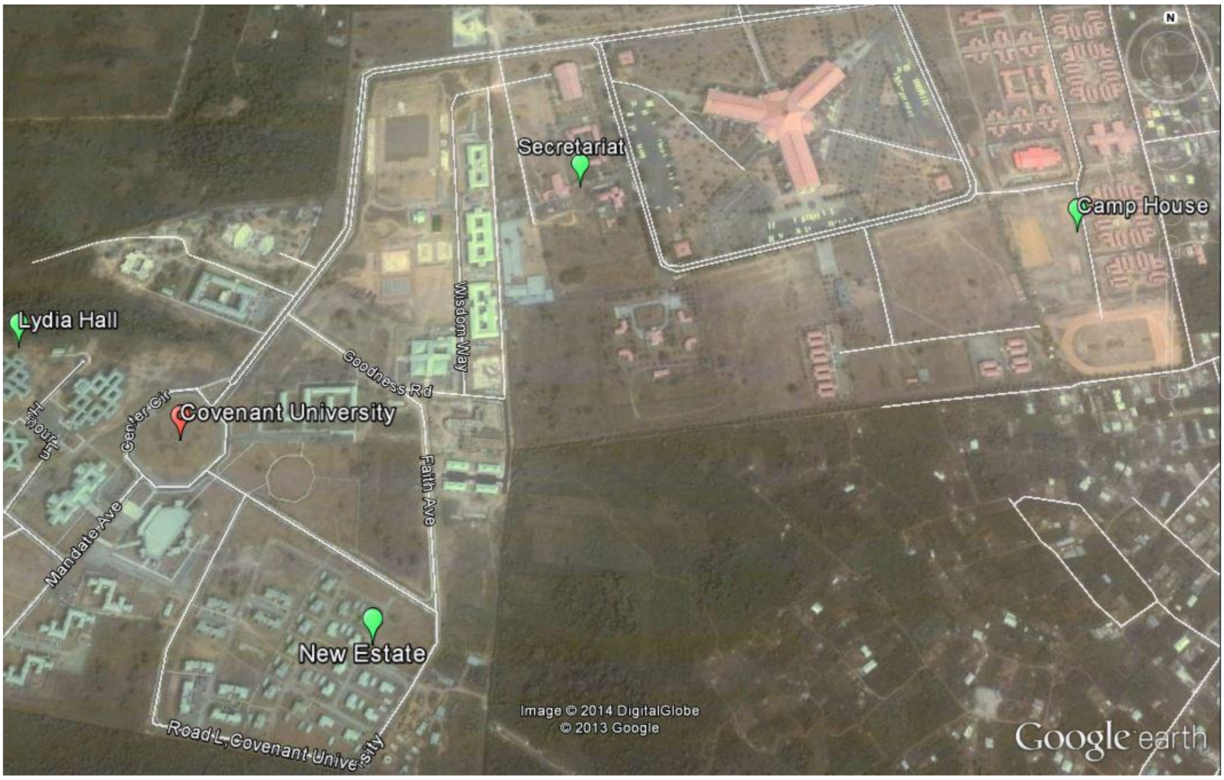

Fig. 1 Satellite image of the study area showing the layout of the church area, university campus, and the four sampled boreholes (green markers)

Fig. 2 A dysfunctional borehole close to an elevated water tank

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Fig. 3 A view of some residential quarters which is serviced by one elevated tank (shown in the background)

The groundwater samples were collected in December 2013 for physicochemical analysis. Sampling was done once but in duplicate. The water samples were collected from four (4) tap points which are supplied by four different elevated water tanks spread within the campus. These tap locations include church secretariat, New Estate, Camp House, and Lydia Hall (Fig.1; Table 1). The samples were collected in 5-litre capacity polyethylene containers. During sampling, several precautions were taken, with respect to standard procedures [10], to avoid possible contamination. The polyethylene containers were properly rinsed with distilled and deionized water prior to usage; and the taps (supplied by the respective tanks) were fully opened and allowed to run for about 2 minutes before samples were collected. The containers were thereafter sealed with fitting corks and stoppers to prevent air bubbles. Subsequently, they were labelled appropriately, and kept in a vacuum cooler with temperature kept constant at 4°C. After collection, samples were transported to the chemistry laboratory of Covenant University, which is not more than ten minutes' drive from any of the sampling locations.

TABLE 1 GPS READINGS OF THE SELECTED TAP LOCATIONS WITHIN THE STUDY AREA

No.	Name	N	E	Elevation (ft.)
1	Camp House	6° 40' 21.4"	3° 10' 15.82"	200
2	Lydia Hall	6° 40' 21.61"	3° 9' 18.97"	144
3	New Estate	6° 39' 56.92"	3° 9' 39.78"	186
4	Secretariat	6° 40' 30.9"	3° 9' 50.58"	177

The water samples were analyzed for parameters such as Turbidity, pH, Salinity, chloride, Total Dissolved Solids, Sulphate (SO_4^{2-}), Hardness, and Nitrate (NO_3) using Waterproof - Eutech pHTestr 10 Pocket Tester. Also, heavy metals such as Cadmium (Cd) and Iron (Fe) were analyzed using Atomic Absorption Spectrophotometer (AA-6650 Model). All samples analyses were done by following standard methods [10].

III. RESULTS AND DISCUSSION

Sampling locations 1 and 4 are situated in the church area while locations 2 and 3 are located within the university. The sampled tap at Location 1 is situated at the Church Guest house. This tap is serviced by an elevated tank which also supplies water to other adjoining buildings in the area such as Green Pastures cafeteria, and WOFBI Complex. The sampled tap at location 4 is situated at the Church office. This tap is serviced by an elevated tank which also supplies water to the main church building, and the Bishop's court. The sampled tap at location 2 is situated at Lydia hall (student hall of residence). This tap is serviced by an elevated tank which also supplies water to four other halls of residence. The sampled tap at location 3 is situated at one of the staff residential areas of the university. Results of physical and chemical parameters obtained from the analysis of the water samples are shown in Table 2.

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TABLE 2 PHYSICOCHEMICAL PARAMETERS OF WATER SAMPLES

Parameters	Camp House	Lydia Hall	New Estate	Secretariat	SON Standard
Turbidity (NTU)	0	0	0	0	5
pH	6.08	6.74	6.26	5.77	6.5-8.5
Chloride (mg/l)	20.0	1.50	25.0	20.0	250
Sulphate (mg/l)	5.15	4.24	7.27	6.36	100
TDS (mg/l)	10.0	10.0	10.0	10.0	500
Hardness (mg/l)	520.0	560.0	520.0	550.0	150
Nitrate (mg/l)	4.48	3.76	3.85	1.82	50
Cadmium (mg/l)	0.0113	0.0524	<0.01	0.0260	0.003
Iron (mg/l)	0.3081	0.5406	0.0523	0.4098	0.3

None of the water from the study area had any objectionable appearance, colour, taste or odour. When compared to Standards Organization of Nigeria (SON) limits [11], results indicated that the turbidity value in all the samples of the study area was negligible (Table 2).

Nearly all the pH and chloride values for the four locations were within permissible limits (Table 2). At Secretariat, however, the pH level indicated acidity at 5.77.

Chloride in drinking water is comparatively harmless. However, chloride content affects metallic pipes as well as growing plants and excessive presence of it indicates sewage pollution 6]. The chloride limit recommended by the SON is 250 mg/l [11]. Thus, all four wells in Canaaland meet the SON limit for chloride.

Likewise, none of the water samples had values above the SON limit for sulphate (Table 2). Higher values of sulphate could cause intestinal disorder and odour under aerobic condition [12].

Total Dissolved Solids in drinking water could originate from natural sources, sewage and industrial wastewater. Since the TDS values of the water samples are less than 500 mg/l (Table 2), all the water samples were considered acceptable for TDS (SON, 2007).

Table 2 further indicates that none of the water samples met the SON standard of drinking water for hardness. Hardness in water may be caused by carbonates of calcium and/or magnesium, which usually results to inadequate soap lather and successive “scum” formation [8].

The nitrate contents of the water samples ranged from 1.82 - 4.48 mg/l (Table 2), which is below the SON standard for drinkable water (SON, 2007). Nitrates are naturally present in soils and water. They may get in contact with water sources through chemical fertilizers, surrounding soil, and leaching from natural vegetation or domestic wastewater.

Table 2 also indicates that none of the water samples met the SON standard of 0.003 mg/l. The source of cadmium in drinking water includes corroded galvanized pipes, runoff from waste battery, discharge from metallurgical activities etc. [8]. Cadmium is a very toxic metal which bio-accumulates in the body. This leads to neurological problems as well as organ failure which ultimately lead to death [8]. The presence of cadmium, therefore, makes the water from all the sampled well unfit for human consumption in its raw state.

The Iron concentrations for the four samples ranged between 0.0523 - 0.5406 mg/l (Table 2). Camp house, Lydia hall and Secretariat had iron contaminant levels higher than the specified national limit. Although, Iron has no hazardous effect on human health as it is considered as a secondary contaminant but it can be deposited in cooking utensils, toilet bowls and water pipes, thereby causing discoloration and sediment deposits [8].

IV. CONCLUSIONS

The study has shown that water from some of the wells in Canaaland is contaminated with cadmium and iron, two heavy metals with adverse impact on human health and domestic vessels, respectively. Although the water samples appear potable to the naked eyes, chemical analysis suggested otherwise. Therefore, it is recommended that further comprehensive water quality analysis should be conducted on all the borehole supplied elevated tank water sources within the campus to ascertain their degree of potability. Although, some previous studies show that Cadmium and Iron are commonly found in water samples in Ota and environ [13-15], further studies is required in order to determine the sources of the contamination, be it natural soil deposits or human-induced. Findings from these future studies will guide scientists on the course of remedial actions to safeguard public health.

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