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An Appraisal of Groundwater Contamination : A Case Study of Shallow Wells In Agbowo Community, Southwestern Nigeria

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ABSTRACT

Abundant as it may seem in Nigeria, access to clean and potable water is a great challenge. Hence the reason for determination of the physico-chemical properties of the groundwater in Agbowo community in Ibadan, Oyo state Southwestern Nigeria for domestic uses. Water samples collected from thirty-four (34) shallow wells with varying depths were subjected to chemical analysis. The water quality parameters were analyzed in accordance to standard methods. The groundwater analysis reviewed includes pH, electrical conductivity, total dissolved solids (TDS), others include Ca^{2+}, Mg^{2+}, K^{+} Na^{+}, Fe^{2+}, NO_3, Cl^{-} SO_4^{2-} and HCO_3^{-} The results indicated that the parameters analyzed have some falling within the limits and some above the maximum permissible limits in accordance to Nigeria Industrial Standard (NIS) and World Health Organization (WHO) guidelines for drinking water. In general, the data revealed that maxima and minima concentrations of the priority physico-chemical water quality parameters examined in the thirty-four (34) water points were mostly within the Target Water Quality Range (TWQR) for domestic use with little exceptions at some points. However, high nitrate concentrations and Total Dissolved Solids (TDS) above the permissible limits in some of the well water sampled are causes for serious concern. Poor construction, lack of maintenance, proximity to sewage tank and stream, as well as indiscriminate dumping of refuse are suggested as the major causes of this development. The overall implication of this observation call for sustenance and improved water resource management strategy for the area in order to prevent the deterioration of the water sources quality, which may pose associated health risks and environmental hazards.

Keywords : Physico-chemical properties, Target Water Quality Range, Health risks, Environmental hazards.

I. INTRODUCTION

Access to clean water is a human right and a basic requirement for economic development. The safest kind of water supply is the use of groundwater, since it normally has a natural protection against pollution by the covering layers of the earth. Thus, only minor water treatment is required (Reinhard Kirsch 2006).

Groundwater occurrence in a Precambrian Basement terrain is hosted within zone of weathering and fracturing which often are not continuous in vertical and lateral extent (Jeff, 2006). The aquifers of the Basement Complex rocks are the regolith and the fractures in the fresh bedrock which are known to be interconnected at depth (Mohammed, 1984; Alagbe, 1987; Adanu, 1987; Uma and Kehinde, 1994). Water can be an instrument for poverty alleviation, lifting people out of the degradation of having to live without access to safe water and sanitation while at the same time bringing prosperity to all (UN-WATER FOR AFRICA, 2004). Oyebade, 1977, noted that the priority accorded domestic water supply by the colonial administration had not been sustained by the post independence governments of the country. Although there was a steady increase in the percentage of the total government expenditure spent on water between 1975 and 1992, however there was a 50% decrease in the total budgetary allocation for water supply between 1992 and 1996 (Areola and Akintola, 1997; Falusi and Gbadegesin, 1998).

After almost sixty years of water supply development in Nigeria, it is regrettable that only 60% of the population has access to safe drinking water, and in rural areas less than 50% of the households have access to good potable water (Nigeria Millennium Development Goal Report, 2005). According to Orebiyi *et al.*, 2010, 52% of Nigerians do not have access to improved drinking water supply. Adequate water resources for future generations are not only regional issue but also a global concern. Just recently, the Federal government of Nigeria declared a state of emergency on Nigeria's water supply, sanitation and hygiene sector while inaugurating the National Action Plan for Revitalization of water supply, Sanitation and Hygiene (WASH). The state of emergency declared has become imperative to reduce the high prevalence of water-borne disease in different parts of the country as Nigeria could not meet the MDG targets for water supply and sanitation that ended in 2015. Besides, the Sustainable Development Goal (SDG) targets for WASH are even more demanding as they require provision of adequate quantity and quality of water at affordable prizes.

In Nigeria, hand-dug wells constitute the largest source of groundwater (Tekwa *et al.*, 2006). Since most of the wells in Ibadan tap their waters from shallow aquifers within the weathered regolith, the examination and determination of their chemical components becomes very important in order to avoid health hazards that may result from the use or consumption of highly polluted water. Ibadan suffers serious water supply problems: cases of dry taps are common in virtually every part of the city. A sight of children/women searching for water is a common experience (Ifabiyi, 2008). Potable water is the water fit for human consumption, it does not contain chemical substances or microorganisms in amount that can cause hazards to health (Alonge, 2005). Water must be substantially free of dissolved salt, plants, animal waste and bacterial contamination to be suitable for human consumption.

This study is necessitated due to incessant water supply and by the fact that the study area is largely occupied by students and staff of the University of Ibadan and The Polytechnic, Ibadan as well as other local occupants, and thus complement the effort of the Federal Government of Nigeria to achieve the SDG targets for WASH by 2030. The area is one of the largest communities in Ibadan North, southwestern Nigeria (Fig 1). Ibadan North has a population of 306,795 (NPC, 2006) making it densely populated area. Adetunji and Odetokun (2011), while assessing Groundwater conta- mination in Agbowo community, Ibadan Nigeria, observed that Total Aerobic Bacteria Counts (TABC) and Total Coliform Counts (TCC) exceeded the international standard of 0 per 100 mL of potable water and concluded that there is a need to set standards for the siting of wells from septic tanks while considering all possible sources of well contamination.

The present work presents a physico-chemical approach as means of providing additional information on the hydrological investigations and thus assessing the purity variation of the groundwater in the study area, thus ascertaining the source of pollution. The study area is located between latitude

7^{0} 26’ .446^{1} N and 7^{0} 26’ .879^{1}, and longitude 3^{0} 54’ 453^{1} E and 3^{0} 55’ 069^{1}.

Geologic and Hydrogeologic Settings

The study area, Agbowo and its environs, is within the basement complex rock of Ibadan, Nigeria. According to Rahaman (1976), basement complex rocks of Ibadan can be classified into major and minor type. The major rock in the study area is banded gneiss with local schist and quartzite (fig. 2). These rocks in most places are covered by weathered regolith. The banded gneiss covers most places in the study area. The Gneisses are strongly foliated, thus the description ‘banded’, with a general strike of NE, NW-SE direction. The alternating light and dark coloured bands often splits into two or more bands with quartzo-feldspathic minerals alternating with ferromagnesian minerals. Banded gneiss in the study area is predominantly medium grained. It is made up of minerals like quartz, biotite, plagioclase, chlorite and opaque minerals. These rocks are considered unsuitable for accumulation of groundwater unless they are fractured or jointed.

Weathering, especially in the tropic is the dominant process in the development of superficial rocks. The rate of weathering depends on the groundwater flow, which is very effective in the saturated lower part of the weathering profile. The fracture also exposed fresh crystalline surfaces to weathering activities of the basement rocks. Water levels, in the wells fluctuate according to the season. The recharge to the water table is directly from precipitation in the surface and from stream flowing in the area. The non-occurrence of inhomogeneous rock type such as pegmatite and quartz veins in the study area have been observed to be the major reason for low water yield. This is due to fineness of the grain, and the low susceptibility to weathering of some of the components minerals in gneisses.

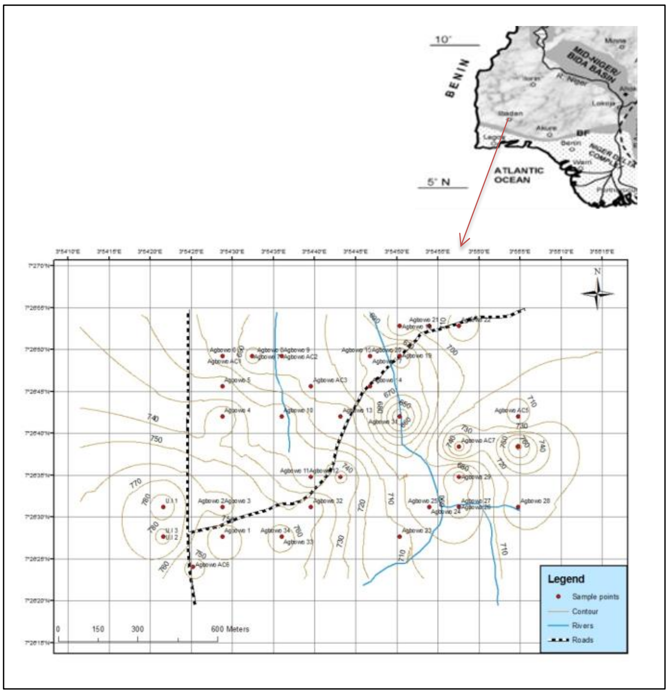

Fig. 1: Location map of the study area. The *insert* shows Southwestern Nigeria

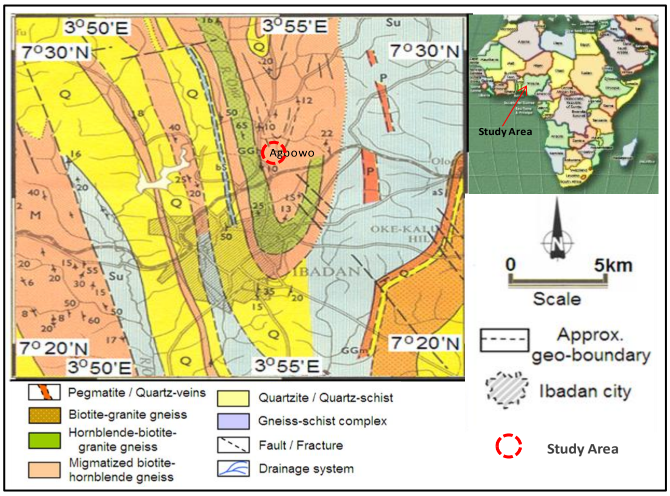

Fig. 2: Geological Map of Ibadan showing the study area (Adapted from NGSA, 2006)

II. METHODS AND MATERIAL

The field sampling was carried out during the wet season. Water samples were collected from thirty-four water points, all from shallow hand dug wells. The temperature, total depth of wells, and depths to water level were taken and recorded. The water column thickness was obtained as the difference between the total depth of wells and depth to water level. In order to avoid contamination from the use of reactive or metallic containers, a clean rubber container was used in drawing water from the wells. Samples were stored in clean sterilized plastic water bottles and labeled for easy identification. The raw water samples and control were taken to the International Institute of Tropical Agriculture (IITA), Ibadan laboratory and analyzed for the following components: K^{+}, Na^{2+}, Mg^{2+}, Ca^{2+}, Fe^{2+}, NO_3, HCO_3, SO_4^{2-}, Cl, P^H, TDS, conductivity and Temperature. The anions and the cations in the sample were determined using Atomic Absorption Spectrometer, while the physical parameters measured include pH, TDS, EC and Temperature were determined using Mi 806 MARTINI Combined meter.

Results and Discussion

The average concentrations of analyzed physico-chemical parameters compared to quality standards for drinking water are presented in table 1. The results of the physical parameters conducted in-situ and chemical analysis are presented in table 2, and 3 respectively.

Physical Investigations

The physical parameters examined include temperature (°C), pH, total dissolves solids (mg/l), conductivity (Us/cm), total depth (m), depth to water level (m) and the thickness of water column (m) elevation (ft) and coordinates. There is wide range of values recorded for various physical parameters measured. The total depth of each well represents the level to which it was dug. The shallowest well was Agbowo 022 with total depth of 1.90m, and the deepest well encountered at Agbowo 033 with total depth of 8.82m. The average water well depth in the area is 4.49m. The water level represents the level of water in the wells and this is equivalent to the water table of the environment. The depth to water level ranges from 0.19m (Agbowo 19) to 7.15m at (Agbowo 033) with average of 1.79m. Water column thickness range from 0.35m (Agbowo 30) to 6.04m (Agbowo 003) with average of 2.69m. The appreciable water column thickness obtained is an indication of good recharge rate.

The temperature of the water samples collected in the studied area is fairly constant. It ranges from 26.500C to 28.20C (Agbowo 25 to Agbowo13) with an average of 27.60C. The low temperature value experienced at Agbowo 25 could be related to its shallow depth, since the law of hydrothermal gradient states that temperature increases with depth. Thus the relative high temperature value experienced at Agbowo 13 could also be related to it is relatively deeper depth. The graphical correlation of well depth against temperature is shown in figure 3.

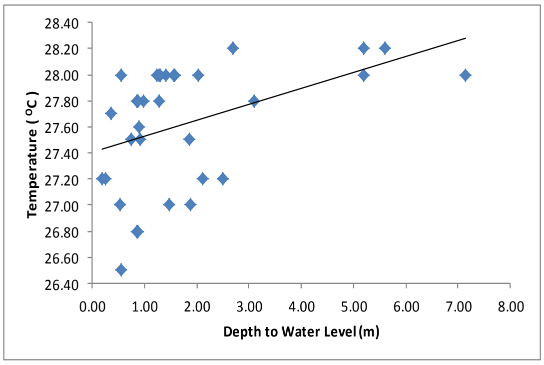

Fig. 3: Well depth against temperature

The pH of water sample collected ranges from 7.6 (Agbowo 30) to 8.8 (Agbowo 13, 15, 20, 28, and 29) with an average of 8.5. The pH value of most groundwater is controlled by the amount of dissolved CO2 gas and the dissolved carbonates and bicarbonates in the mineral salt. The CO2-bicarbonate relation is the principal control of pH in most groundwater (Bollenbach, 1975). Drinking water with pH 6.5 and 8.5 is generally considered satisfactory by WHO 2011; NIS, 2007.

Conductivity gives an indication of amount of ions in the water. The conductivity value ranges from 590us/cm (Agbowo 005) to 1831 us/cm. (Agbowo 27) with an average of 1126.90us/cm. This value is higher when compare to 1000us/cm, the maximum value recommended by WHO, 2011; and NIS 2007 for drinking water. In solution as dilute as most groundwater, the specific conductance varies directly with the amount of dissolved minerals in the water (Bollenbach, 1975). Waters with relatively high specific conductance can cause corrosion of iron and steel (Hem, 1959; Hem and Cropper 1959).

The Total Dissolve Solids (TDS) concentration in water is a general indication of the overall suitability of water for many uses. The value of TDS ranging from 286mg/l (Agbowo 005) to 908mg/l (Agbowo 027) with an average of 563.21mg/l. This is contrary to 500mg/l maximum value recommended by WHO 2011 and NIS 2007, and this may result in adverse taste effects. It is recommended that water containing more than 500mg/l of dissolved solids not be used if other less mineralized supplies are available. The graphical correlation of TDS against EC, and Calcium concentration against TDS is shown in figure 4 and 5 respectively.

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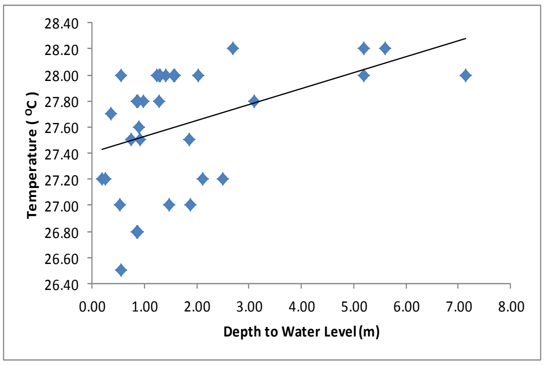

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Chemical Investigations

In order to determine the portability of shallow well water in Agbowo and its environs, major constituents in water such as bicarbonate, sulphate, chloride, calcium, sodium and magnesium are chemically analyzed. The minor constituents also determined include nitrate, potassium and iron. These constituents are analyzed, average concentration were determined and then compared with World Health Organization (WHO) and Nigeria Industrial standards.

Table 1: Showing average concentrations of analyzed physico-chemical parameters compared to quality standards for drinking water.

Chemical Parameters Analysed	**NAFDAC 2007**	**WHO 2007**	**Mean Conc. obtained**
Ph	6.5 - 8.5	...	8.5
Temp. °C	...	...	...
Cond. (us/cm)	1000	1000	1126.9
TDS (Mg/l)	500	500	562.9
Na^+ (Mg/l)	...	200	113
Mg^+ (Mg/l)	...	20	0.66
K^+ (Mg/l)	10	12	2.13
Ca^+ (Mg/l)	75	100	113
Fe^{2+} (Mg/l)	0.3	0.3	0.1
Cl^- (Mg/l)	100	200	38.1
NO_3^{2-} (Mg/l)	10	50	40.19
SO_4^{2-} (Mg/l)	100	100	20.3
CO_3^- (Mg/l)	...	...	34.23

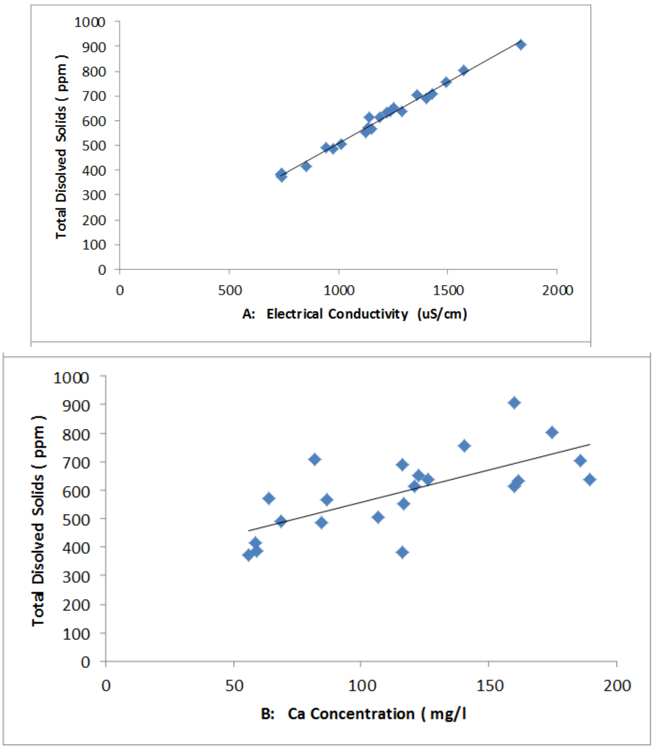

Fig. 4 and 5: Total dissolved solid (ppm) against electrical conductivity and Calcium concentration (mg/l) respectively

Bicarbonate is the most abundant anion in the study area, having concentration ranging from 53.4mg/l to184.6mg/l with an average of 110.59mg/l. The bicarbonate (HCO3-) is the principal alkaline constituent in almost all water supplies. Bicarbonate alkalinity is introduced into the water by CO2 (carbon dioxide) dissolving carbonate containing minerals. Bicarbonate stability in water however, depends on the pH of the water, usually for values between 5 and 7 (Taylor, 1958).

Sulphate occurs in almost all natural water. The concentration of sulphate (SO42) in the samples ranges from 11.9mg/l to 40.0mg/l with the average of 20.34mg/l. This value is within the NIS allowable limits. High concentration of sulphate in drinking water causes laxative effect when combined with calcium and magnesium, the two most common component of hardness. The major source of the sulphate ions in the water is believed to be sulphate ions recycled from the atmosphere through rain percolation (Davies and Dewiest, 1966). Sulphates in groundwater may also be derived from dissolution of anhydrite or gypsum, it may also come from the oxidation of pyrite (Bollenbach, 1975)

The chloride concentration in the water sample range from 17.7mg/l to 69.2mg/l with an average of 38.07mg/l. The result of the analysis shows that the average concentration of chloride ions falls within the recommended limits of NIS 2007 which is 250mg/l. Sources of chloride in water often include magmatic rocks, fertilizer human excrement (especially in the area where the wells are very close to the toilets). (Freeze and Cherry, 1979). It is also believed that igneous rocks are generally low in chloride. Water with greater than 250ppm chloride concentration is generally objectionable for municipal purposes. However, chloride content of greater than 350ppm is said to be objectionable for most irrigation or industrial uses by some authors. Water with greater than or equal to 500ppm chloride is found to have disagreeable taste (Bollenbach, 1975). Calcium concentration in the water samples collected ranges from 55.90mg/l to 189.57mg/l with an average of 113.12mg//l. About 79.3% of the sampled water has concentration below the standard of 150mg/l (NIS 2007) which is the maximum allowable limits. About six locations representing 20.7% however contain calcium concentration above the maximum allowable limit. Calcium concentration is found to be higher than other cations analyzed. Calcium and magnesium cause almost all the hardness of water. The metallic calcium and magnesium ions and the corresponding bicarbonate, sulfate, chloride and nitrate from these dissolved compounds will be found in solution. The bicarbonate ions exist in groundwater as the result of dissolved carbon-dioxide.

The CO_2 helps the water to dissolve carbonate minerals with which it comes in contact (Bollenbach, 1975).

Sodium does not contribute to hardness of water. It is however stressed that groundwater containing considerable sodium carbonate or sodium bicarbonate are alkaline and may have pH values of 9 or more. Its concentrations in the samples ranges from 9.98mg/l to 170.33mg/l with average of 112.88mg/l. Its value is within the acceptable limit of the NIS 2007. The possible source of Na^+ in the water are weathered plagioclase feldspars, atmospheric dust washed down by rain, especially wet season, and exchangeable sodium ions from clays.

The concentration of magnesium in the water sample collected ranges from 0.31mg/l to 1.14mg/l with an average value of 0.66mg/l. All the sampled locations have magnesium concentration higher than the allowable limits of 0.20mg/l (NIS, 2007). The probable source of magnesium in water is weathering of feldspar and mica, and other related mineral hosted by the basement rocks in the area. Besides, the role of percolating water especially in the wet season as a participant in the chemical reaction or alteration usually results in the leaching of cations in the silicate minerals (Malomo, 1990). There is no health complication for magnesium except consumer's acceptability.

The safe nitrate limit for domestic water is set at 50mg/l by NIS (2007). The nitrate concentration in the samples collected ranges from 19.21mg/L to 61.98mg/l with the average of 40.19mg. Nitrate in many groundwater appear to be unrelated to any geologic formation. Nitrate is one of the most common groundwater contaminants. However, some authorities believe that Nitrate occurs naturally in soil and water as a result of decaying plant and animal residue. Other common sources of nitrate include human sewage and livestock manure. Nitrate is also a common constituent of chemical fertilizer. The graphical correlation of Nitrate concentration against well depth is shown in figure 6. Nitrate concentration higher than 45ppm is undesirable and toxic on young infants. Nitrate in drinking water causes cyanosis, and asphyxia (blue-baby "syndrome") in infants under 3 months (WHO, 1984; 1997).

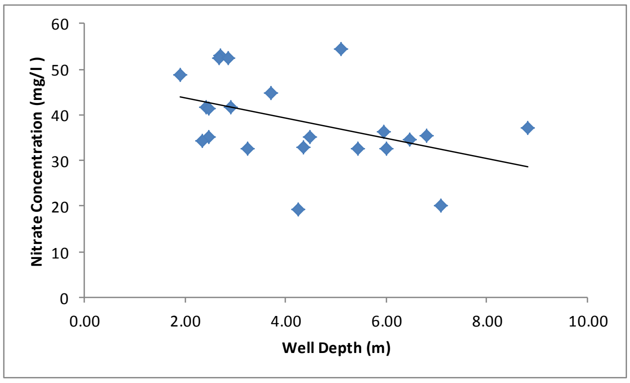

Figure 6: Nitrate concentration (mg/l) against Well Depth (m)

The behaviour of Potassium and Sodium is similar. Nearly all their compounds are soluble so that Sodium leached from rocks or soils remain in solution (Bollenbach, 1975). The water samples analyzed has potassium range from 0.35mg/l to 4.89mg/l with an average of 2.13mg/l. Although excessive intake may have a laxative effect, public health authorities have not established a maximum limits. The major source of Potassium in water is weathered Orthoclase and Microcline feldspar.

Potassium migration is not stable in groundwater due to it is ready exchange with sodium in clays (freeze and cherry 1979). This is an important contributor to water hardness. When water is heated, it breakdown and precipitate out of solution, forming scale.

Iron is common in many igneous rocks and it is found in trace amounts in practically all sediments and sedimentary rocks. The specific form of iron intake in water depends on the amounts of oxygen concentration in the water, and the pH. Iron has concentration ranging from 0.04mg/l to 0.12mg/l with the average 0.1mg/l. The source of iron may be related to the production of iron oxides alongside with clay minerals. Iron in concentration greater than 0.3mg/l which is the maximum value permitted by NIS 2007, may cause brown and black stains in laundry, plumbing fixtures and sinks. USPHS suggests that the iron content in groundwater should not be greater than 0.3ppm. Water standing in a well that has been idle will have higher iron content than the natural water in the aquifer (Bollenbach, 1975).

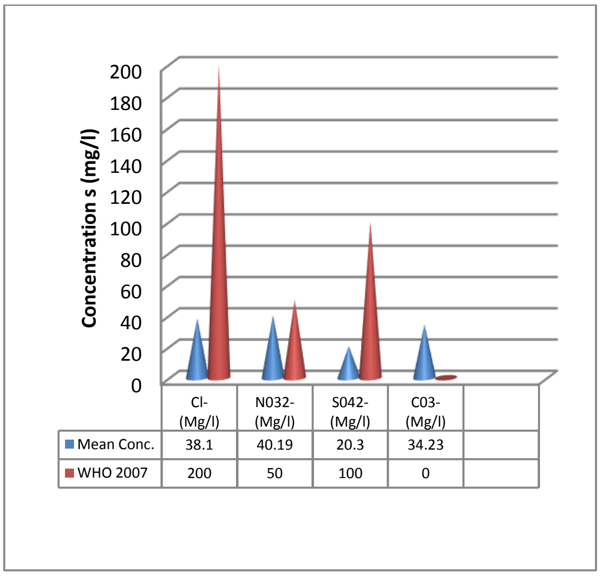

Figure 7: Histogram depicting mean concentration of cations compared to WHO standards

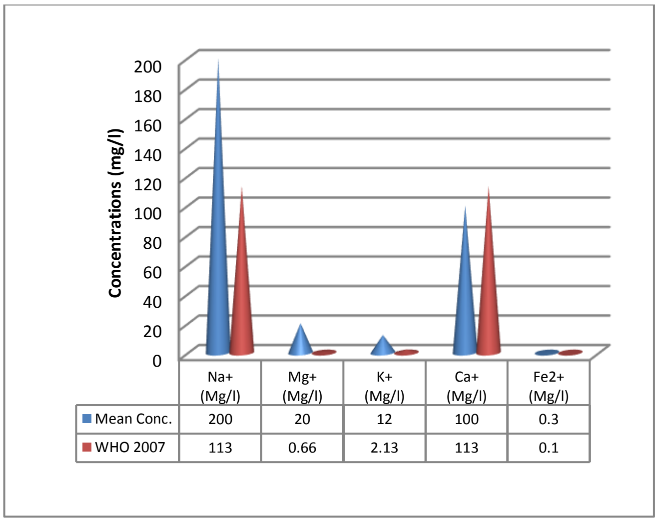

Figure 8: Histogram depicting mean concentrations of anions compared to WHO standards

IV. CONCLUSION

There primary purpose of a water analysis is to determine the suitability of water for a purposed use. The three main classes of use are domestic (household), agriculture and industrial. Agbowo and its environs in the Ibadan north local government is dominated by staff and students of both university of Ibadan and the Polytechnic, Ibadan as well as other community members. Thus, the use of water in this area is strictly domestic. Since there is no public water system, a system for the provision of the public of piped water for human consumptions, people living in the area depend on groundwater through construction of shallow wells and occasionally deep water boreholes.

The physico-chemical investigation of shallow well water in the area shows that some shallow wells in the environs are unkempt and wrongly positioned and this has resulted in concentrations of some major parameters above the allowable limits and thus rendered the well water not suitable for drinking and household use. Only few locations met up with the standards. High concentration of nitrate, magnesium, as well as total dissolved solids and electrical conductivity in many of the sampled locations are major cause for concern.

Poor construction, lack of maintenance, proximity to sewage tank and stream are some of the major causes of this development. In conclusion, government intervention in collaboration with the inhabitants of the area is highly necessary to provide clean and safe water for household use. Proper dissemination of information on construction of shallow wells and water treatment should be given a priority to prevent outbreaks of epidemic in the area.

V. RECOMMENDATION

The following recommendation could be useful to proffer a long-lasting solution to the common lack of potable water in the area if given a cognizance:

- Infiltration of surface water should be prevented while constructing water wells. The last 3ft to the surface should be cased off with concrete plugs.
- Water wells should always be properly covered with wells lids. This will prevent settling of dust and other contaminants in well water.
- The inhabitants of the Ibadan North Local Government should be sensitized on the possible side effects of unhygienic condition of living.
- People should also be educated on the merits of regular water treatments, and hence the prescription of necessary treatment measure.
- There is a need to set standards for the siting of wells from septic tanks while considering all possible sources of well contamination.

Table 2: Field Measurements

Sample No	Coordinates	Elev. (ft)	DWL (bgl)m	DW (bgl)m	WCT (m)	Temp. (^{0}C)	Sample No	Coordinates	Elev. (ft)	DWL (bgl)m	DW (bgl)m	WCT (m)	Temp. (^{0}C)
Agb 001	Not Taken	742	0.85	4.38	3.53	27.80	Agb 018	N $07^{0}26.852^{1}$ E $003^{0}54.830^{1}$	709	1.24	5.11	3.87	28.00
Agb 002	N $07^{0}26.546^{1}$ E $003^{0}54.453^{1}$	765	2.03	4.58	2.55	28.00	Agb 019	N $07^{0}26.844^{1}$ E $003^{0}54.819^{1}$	667	0.19	2.70	2.51	27.20
Agb 003	N $07^{0}26.546^{1}$ E $003^{0}54.453^{1}$	767	0.98	7.02	6.04	27.80	Agb 020	N $07^{0}26.824^{1}$ E $003^{0}54.851^{1}$	682	0.87	2.41	1.54	26.80
Agb 004	N $07^{0}26.678^{1}$ E $003^{0}54.460^{1}$	749	0.88	4.70	3.82	27.80	Agb 021	N $07^{0}26.868^{1}$ E $003^{0}54.906^{1}$	703	1.55	5.45	3.90	28.00
Agb 005	N $07^{0}26.758^{1}$ E $003^{0}54.464^{1}$	724	1.40	4.62	3.22	28.00	Agb 022	N $07^{0}26.879^{1}$ E $003^{0}54.969^{1}$	716	0.75	1.90	1.15	27.50
Agb 006	N $07^{0}26.787^{1}$ E $003^{0}54.503^{1}$	708	2.70	7.50	4.80	28.20	Agb 023	N $07^{0}26.469^{1}$ E $003^{0}54.860^{1}$	712	1.48	5.95	4.47	27.00
Agb 007	N $07^{0}26.795^{1}$ E $003^{0}54.525^{1}$	686	2.50	6.15	3.65	27.20	Agb 024	N $07^{0}26.516^{1}$ E $003^{0}54.898^{1}$	690	1.30	3.70	2.40	28.00
Agb 008	N $07^{0}26.794^{1}$ E $003^{0}54.604^{1}$	693	0.85	5.70	4.85	26.80	Agb 025	N $07^{0}26.544^{1}$ E $003^{0}54.923^{1}$	688	0.55	2.46	1.91	26.50
Agb 009	N $07^{0}26.820^{1}$ E $003^{0}54.604^{1}$	693	1.29	3.35	2.06	28.00	Agb 026	N $07^{0}26.537^{1}$ E $003^{0}54.946^{1}$	686	0.25	2.35	2.10	27.20
Agb 010	N $07^{0}26.728^{1}$ E $003^{0}54.614^{1}$	727	0.90	2.89	1.99	27.60	Agb 027	N $07^{0}26.546^{1}$ E $003^{0}54.975^{1}$	716	1.87	2.67	0.80	27.00
Agb 011	N $07^{0}26.590^{1}$ E $003^{0}54.670^{1}$	720	0.87	2.95	2.08	27.80	Agb 028	N $07^{0}26.546^{1}$ E $003^{0}55.069^{1}$	727	0.53	3.24	2.71	27.00
Agb 012	N $07^{0}26.605^{1}$ E $003^{0}54.704^{1}$	742	1.58	4.33	2.75	28.00	Agb 029	N $07^{0}26.584^{1}$ E $003^{0}54.934^{1}$	676	1.86	2.87	1.01	27.50
Agb 013	N $07^{0}26.695^{1}$ E $003^{0}54.741^{1}$	705	5.60	6.00	0.40	28.20	Agb 030	N $07^{0}26.659^{1}$ E $003^{0}54.943^{1}$	761	2.12	2.47	0.35	27.20
Agb 014	N $07^{0}26.745^{1}$ E $003^{0}54.766^{1}$	678	5.20	6.82	1.62	28.00	Agb 031	N $07^{0}26.703^{1}$ E $003^{0}54.826^{1}$	644	0.55	4.25	3.70	28.00
Agb 015	N $07^{0}26.791^{1}$ E $003^{0}54.805^{1}$	678	1.27	4.48	3.21	27.80	Agb 032	N $07^{0}26.528^{1}$ E $003^{0}54.666^{1}$	758	3.10	6.48	3.38	27.80
Agb 016	N $07^{0}26.823^{1}$ E $003^{0}54.828^{1}$	661	0.92	2.90	1.98	27.50	Agb 033	N $07^{0}26.476^{1}$ E $003^{0}54.607^{1}$	764	7.15	8.82	1.67	28.00
Agb 017	N $07^{0}26.842^{1}$ E $003^{0}54.824^{1}$	666	0.35	4.35	4.00	27.70	Agb 034	N $07^{0}26.446^{1}$ E $003^{0}54.627^{1}$	750	5.20	7.08	1.88	28.20

Table 2 : Results of Chemical Analysis of the Water Samples

Sample No	PH	ect. Con (uS/cm)	TDS ppm	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	Fe mg/l	NO_3-N mg/l	Cl^- mg/l	SO_4^- mg/l	HCO_3^- mg/l
Agw 01	8.2	843	325	98.9	0.42	2.28	83.7	0.1	55.58	56.4	40	120.9
Agw 02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Agw 03	8.6	1009	490	138	0.83	2.78	78.1	0.1	61.98	41.2	15.1	98.4
Agw 04	8.6	823	404	89.3	0.73	0.96	84.1	0.1	33.31	20.7	12.6	100.2
Agw 05	8.5	590	286	71.5	0.31	1.76	64.1	0.1	29.23	35.1	14.1	70.4
Agw 06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Agw 07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Agw 08	8.6	1186	573	117	0.69	1.63	130	0.1	48.81	31.2	27.9	75.8
Agw 09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Agw 10	8.6	1178	580	119	0.58	2.37	134	0.1	49.08	47.2	24.6	180.2
Agw 11	8.6	1211	590	87.4	0.39	3.42	144	0.1	39.25	61.4	28.9	110.1
Agw 12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Agw 13	8.8	1431	709	81.8	1.14	1.28	156	0.1	32.66	26.6	12.4	53.4
Agw 14	8.4	975	484	84.6	0.92	1.28	85.2	0.1	35.35	56.7	19.3	72.5
Agw 15	8.8	1289	639	190	1.03	1.77	113	0	35.08	40.3	18.7	154
Agw 16	8.6	1015	504	107	0.47	2.32	112	0	41.57	32.3	19.4	130
Agw 17	8.5	1255	652	123	0.61	3.02	10.4	0	32.85	69.2	24.6	166.1
Agw 18	8	1126	551	117	0.63	1.18	131	0	54.47	31.4	23.9	149.2
Agw 19	8.5	1189	615	121	0.58	2.76	135	0	53.07	29.6	21.6	130.6
Agw 20	8.8	1494	755	141	0.65	3.83	154	0	41.76	23.4	18.1	98.1
Agw 21	8.3	1401	689	116	0.61	2.02	147	0	32.43	32.8	20.4	112.2
Agw 22	8.3	1153	566	86.9	0.54	3.2	134	0	48.71	17.7	15.6	93.3
Agw 23	8.5	855	414	58.8	0.6	1.73	108	0	36.19	56.1	14.8	92.7
Agw 24	8.4	740	386	59.2	0.82	0.35	76.9	0	44.91	28.3	11.9	60.6
Agw 25	8.6	1133	572	64.2	0.56	1.91	145	0	35.26	32.6	19.1	74.1
Agw 26	8.7	1223	631	162	0.69	1.89	140	0	34.15	26.1	15.4	74.6
Agw 27	8.6	1831	908	160	0.72	3.86	170	0	52.42	46.1	24.6	114.7
Agw 28	8.8	737	381	116	0.37	1.08	82	0	32.57	59.6	21.2	117.8
Agw 29	8.8	1237	636	126	0.6	2.69	137	0	52.42	38.1	18.7	119.2
Agw 30	7.6	1573	804	175	0.64	4.89	160	0	41.48	32.6	15.1	98.9
Agw 31	8.5	1361	703	186	1	2.66	127	0.1	19.21	30.8	16.6	92.4
Agw 32	8.6	1140	613	160	0.64	1.82	126	0	34.61	28.8	21.8	130.6
Agw 33	8.3	742	375	55.9	0.58	0.64	95.9	0.1	37.02	36.7	27.4	131.4
Agw 34	8.4	941	489	68.9	0.67	0.46	9.98	0.1	19.95	34.9	26.1	184.6
Sum	246.5	32681	16324	3280	19	61.8	3274	1.8	1165	1104	590	3207
Minimum	7.6	590	286	55.9	0.31	0.35	9.98	0	19.21	17.7	11.9	53.4
Maximum	8.8	1831	908	190	1.14	4.89	170	0.1	61.98	69.2	40	184.6
Mean	8.5	1126.9	562.9	113	0.66	2.13	113	0.1	40.19	38.1	20.3	110.6
Standard Deviation	0.2591	280.49	146.6	39	0.19	1.08	40.3	0	10.44	13.2	6.17	34.23

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