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Original Article

Assessment of Saline Intrusion in Lagos Coastal Aquifer

Adebo Babatunde
Lead City University Ibadan, Nigeria
Email: festy_debo@yahoo.com

ABSTRACT

Groundwater is now heavily relied on in Lagos metropolis as an alternative source of water where surface water is seriously polluted. This is because of the increasing industrialization and population explosions. The continued reliance on ground water has resulted in its decline in quantity and quality. In this study, the coastal aquifers of Lagos metropolis were selected for an assessment of its groundwater quality and impact of saline intrusion

Thirty water samples were collected each from hand dug wells and boreholes in six different locations in the studyareas. These include: Ikeja, Lagos Island, Ajah, Victoria Island, Eti- Osa and Yaba. The chloride concentrations ofall the samples were acquired and then compared with the World Health Organization (WHO) standards for chloridecontent in drinking water. We selectedhand dug well and borehole becausethey are the common source of drinking water in the areaunder consideration. Results show that the average chloride concentrations in all the samples collected from hand dug well in all the six locations exceed the WHO value of 250mg/l (value recommended for safe drinking water) with Ajah havingthe highest Chloride concentration of 606.68mg/l and Ikeja with the least value of 255.37mg/l. For the water samples from boreholes, only one of thesamples showshigh chloride levelabove the WHO standard range.The highest chloride value observed was 343.3mg/l while the lowest was 15.84mg/l.

This indicates thatborehole water in the considered areas is safer for drinking than that of hand dug wells.

Keyword:*Hand dug wells, Boreholes, chloride concentration, W.H.O.*

INTRODUCTION

The definition of water quality is very much depending on the desired use of water. Therefore different uses require different criteria of water quality as well as standard methods for reporting and comparing results of water analysis [2]. Major chemical elements including Na+, K^+, Ca^{2+}, Mg2+, Cl-, HCO^{3-}, and $SO4^{2-}$ play a significant role in classifying and assessing groundwater quality.

Due to massive influx of people from other parts of Nigeria to Lagos metropolis, the population of Lagos has increased from ten to fifteen million in recent times and there is annual population increase of 3% [14].Therefore, there is an increase in the demand of water resulting in concomitant acute water shortage to meet the daily water consumption needs of the people. Most of the residents have resorted to depend on borehole water both for domestic and industrial usage [1].

Saline intrusion into coastal aquifers has become a major concern [3] because it constitutes the commonest of all the pollutants in freshwater, therefore, understanding of saline intrusion is essential for the management of coastal water resources [4]. Various workers around the world have carried out geophysical survey to demarcate the interface between freshwater and saline water. For example,Lee and Song [9] investigated the saltwater intrusion problem in the coastal area of South Korea, they observed that salinization of fresh groundwater is highly associated with groundwater withdrawal. Nowroozi et al [11] mapped the saltwater/freshwater interface in the geological setting of the Eastern Shore of Virginia.

(Frohlich and Urish [6, 7] showed that the deterioration of freshwater quality due to natural seawater infiltration affects the balanced life of the narrow coastal strip of Rhodes Island, USA. In-addition, and Frohlich et al ,also observed that the discharge of a large volume of groundwater may allow saltwater intrusion into the freshwater aquifers, and this potential saltwater contamination poses a threat to the sustainable development and economic well being of any coastal area [8]. In Southeastern Nigeria (Oteri 1988) delineated the depth to the top of the freshwater sands underlying the saline water sands to vary from 77 to 947 m below ground level. [4] reported that saline water intrusions into coastal aquifers have resulted in acute environmental problems in the past. They further confirm that the extent of saline water intrusion is influenced by the nature of

geological formations present, hydraulic gradient, rate of withdrawal of ground water and its recharge.

Owing to massive influx of people from other parts of Nigeria into the coastal cities (rural - to-urban migration), the population of these area has increased greatly. For example, Lagos population has increased from ten to fifteen million in the recent times, and there is annual population increase of 3 % [14]. There is a concomitant acute water shortage to meet the daily demand of the people. Therefore, most of the residents depend on borehole water both for domestic and industrial usage.

According to the estimate of Longe and others, over 10 million gallons of water is extracted from the multi-layer aquifers existing in the area per day [10]. However, most of the boreholes drilled in the coastal area of Lagos were abandoned due to saltwater intrusion into the aquifers. Due to the severe saltwater intrusion into the aquifer, potable water supply to inhabitants in some of the communities in the coastal belt of Lagos has been a major problem.

STUDY AREA

Lagos State lies approximately between longitudes $2^{0}42^{1}$ East and $3^{0}42'$ East and latitudes $6^{0}22^{1}$ North to $6^{0}52^{1}$ North. The southern boundary of the state lies along the Atlantic coastline while its northern and eastern boundaries are shared with Ogun State. On the western side the boundary is bordered by the republic of Benin. Its size is about 3,577 square kilometer which accommodate over nine millions of the national population (2006), Nigeria population census figures). Lagos state is the most urbanized state in Nigeria, though there are still many rural areas within the state which are still very poorly connected with urban places and thus remain undeveloped. Lagos State is located within the low lying coastal zone of south-western Nigeria[1].

Hydrogeology of study area

Studies of groundwater resources and aquifers underlying Lagos metropolis have been made. This is based on well-logs, pumping tests, well production as well as water quality data.

The sub-surface geology indicates a complex lithogy of alternating sequence of sand and clay deposits. Three aquifer horizons were delieanated. The first, a water table aquifer (average thickness of 10^{-25} and 10^{-35}m respectively), are harnessed through boreholes.

Average values of transmissivity T and storage coefficient(s) are 3.53×10^{-3} m^2s^{-1} and 2.95×10^{-4} respectively for the first and second and $17.44 \times 10^{-3}m^2s^{-1}$and 3.29 for the third.

The range of transmissivity, the storage coefficient and also the permeability indicate considerable inhomogenity in the aquifers.

Lagos state lies between latitude 8^{o} 15^{1} and 8^{o} 45^{1} and longitude 2^{o} 30^{1} and 4^{o} 30^{1}. Two major climate seasons are recognized; the dry season which is between November and march, and the wet season which starts in April and then end in october with a short break in mid- August. The average annual precipitation is above 1700mm and serves as a major source of groundwater replenishment. The temperatures range from 32^{o}C to 37^{o}C.

The surface geology is made up of the Benin formation (Miocene to recent) and the recent littoral alluvial deposits. The Benin formation consists of thick bodies of yellowish (ferruginous) and white sands .It friable, poorly sorted with intercalation of shale, clay lenses and sandy clay with lignite.

Lagos metropolis is located within the Western Nigeria coastal zone; a zone of coastal creek and lagoons [13]. The metropolis is the area of land around the only inlet of the sea into the extensive lagoon system. It includes such areas as the Islands (Lagos, Ikoyi, Victoria Island).

METHODOLOGY

The methods employed for this study are field investigation/sampling and laboratory analysis. Thirty water samples each from hand dug-wells as well as from boreholes were collected in 6 different locations in Lagos state namely Ajah, Victoria Island, Lagos Island, Yaba, Ikeja and Eti-Osa.

A detailed field sampling exercise was carried out, while analysis of the water samples was carried out afterwards in the water laboratory.

For chloride determination, AgNO3 solution is standardize against standard sodium chloride solution.30 ml of sample is taken in a conical flask. Then added 1 ml H_2O_2 30% and 1ml K_2CrO_4, then titrate against 0.014 N $AgNO_3$ to a pinkish yellow end point. The chloride is then found as follows: Chloride mg/L = (A – B) x N x 1000 / ml of sample.
A = ml of titrant used B= ml of titrant for blank N= normality of AgNO3. PH was analyzed using a pH meter. Cations were analyzed using an atomic absorption spectrophotometer (Perkin – Elemer AAS3110), while anions were analyzed using the colorimetric method with UV, spectrophotometer (WPAS110). Total dissolved solids (TDS) were analyzed using the gravimetric method.

RESULTS AND DISCUSSIONS

For hand dug wells, the pH of all the samples taken range between 9.88 – 7.07 while that of borehole 6.04 – 8.45. This shows that all the samples taken from hand dug wells are alkaline. Few of the borehole sample show slight acidic level while most of them are alkaline. With the exception of the pH of hand dug well Samples from Victoria Island and that of Yaba that exceed the WHO value of 8.5, the pH values for all other samples from both boreholes and hand dug wells were found to be within the acceptable range. Table 1 shows average chloride concentration of each of the samples collected from hand dug wells in five locations in Lagos. The highest average value for the chloride concentration was observed in samples collected from Ajah. This may be due to its proximity to the Lagoon. The least value was obtained in one of the samples from Ikeja. The average chloride concentration of all samples collected from boreholes is shown in Table 2. Figure 1 is a bar chart showing the variation of chloride concentration of the hand dug sampled water while figure 2 is that of borehole water samples. Figure 3 gives a graphical comparison between variations of chloride in both hand dug well and boreholes.
It can be deduced from the tables that there is very high chloride content in the samples analyzed Eti - Osa.
The average chloride content here is 530.87 mg/l for hand dug well and 111.2mg/l for boreholes. Six water samples were collected at Ajah, 4km from the Atlantic Ocean and the average chloride concentration observed in hand dug samples is 608.68 mg/l while that of borehole is 258.72mg/l . Five water samples were also collected at Ikeja and the average chloride concentration for hand dug well is 255.37 mg/l, while borehole is 56.87kg/l. Ikeja is about 30 km from the Atlantic Ocean.
At Lagos Island which is about 18km from the Atlantic Ocean, the average chloride concentration in hand dug and borehole samples are 322.95 mg/l and 122.40mg/l respectively.. At Victoria Island, the five samples collected give an average chloride concentration of 344.53 mg/l and 100.05 respectively for samples from hand dug wells and boreholes respectively.

Table 1: Average Chloride concentration in water sample from selected hand dug Wells

Locations	V.I	EO	A	IK	LI	YB
Chloride Conc.(mg/l)	344.53	530.35	608.68	255.37	322.96	271.36

Table 2: Average Chloride concentration in water sample from Boreholes

Locations	V.I	EO	A	IK	LI	YB
Chloride Conc.(mg/l)	100.05	111.2	258.72	56.85	122.40	45.23

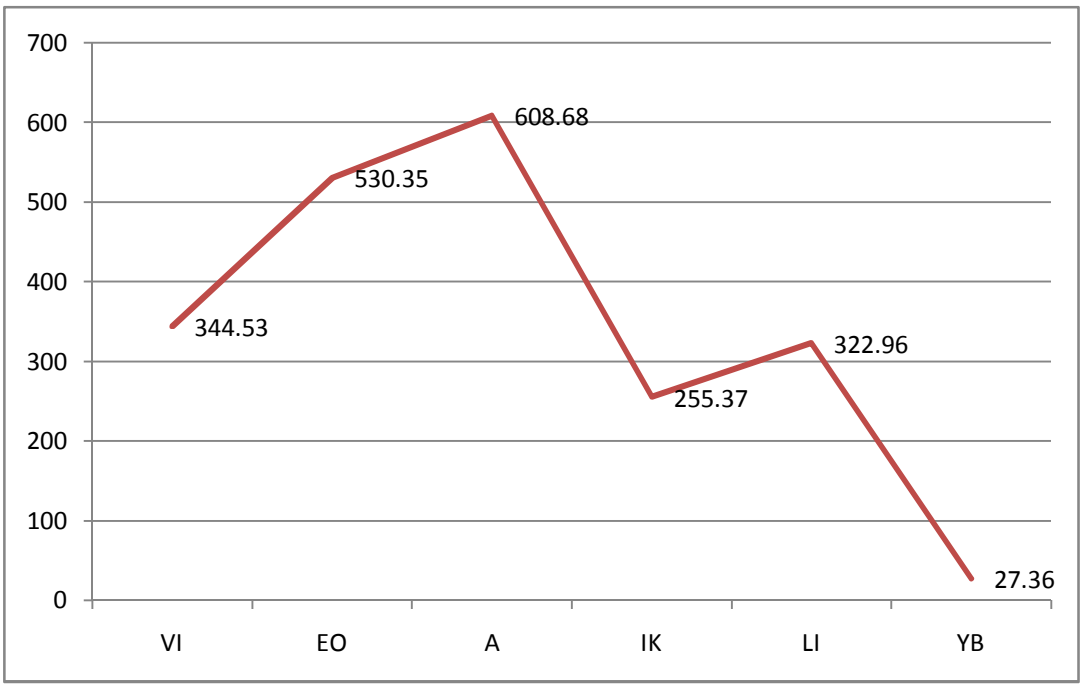

Figure 1: Barchat of the Chloride concentration in samples from Hand dug wells

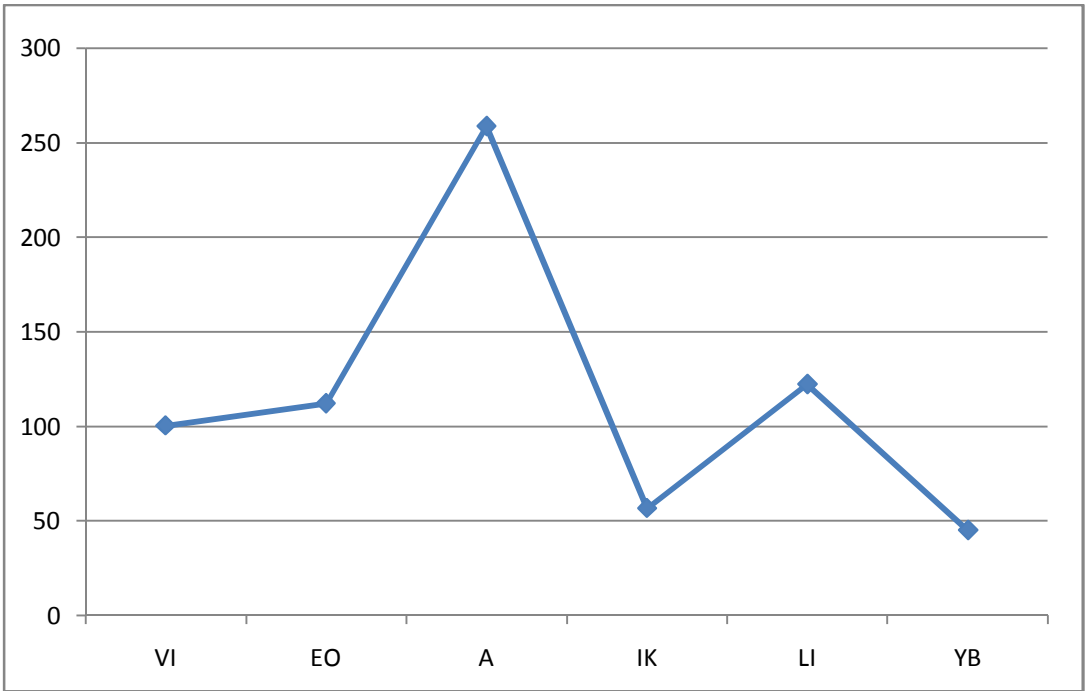

Figure 2: Graph of Chloride concentration in samples from Boreholes

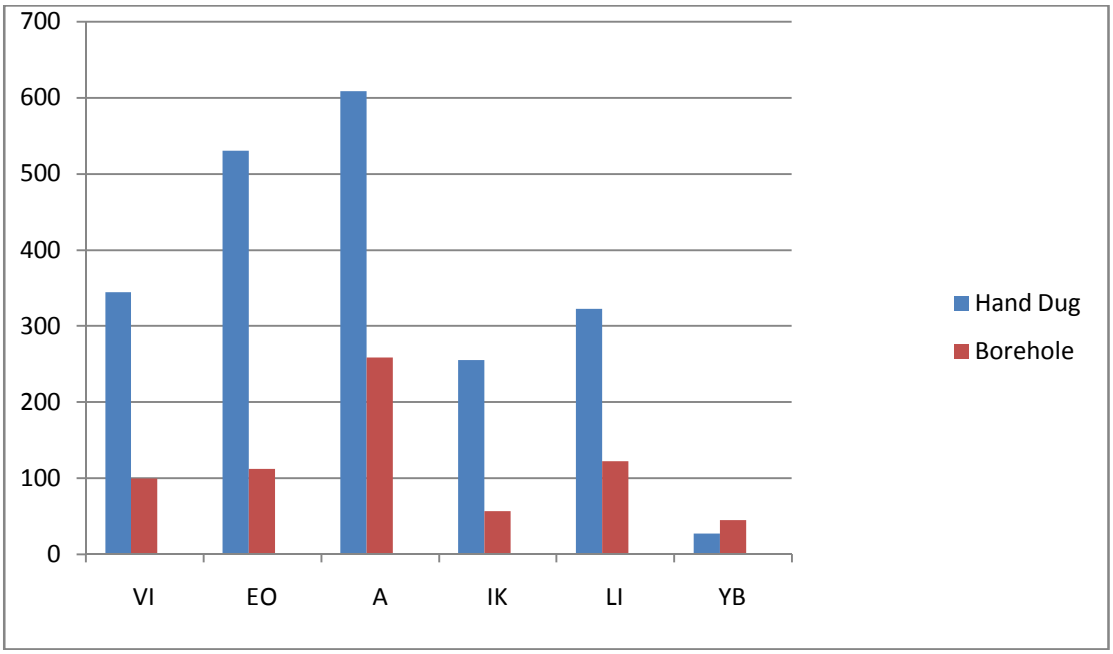

Figure 3: Comparison between the chloride concentration of samples from hand dug wells and Boreholes

The four samples collected at Yaba, give an average chloride concentration of 271.36 mg/l and 45.23 for hand dug and boreholes in that order.. The average chloride concentrations in all the samples from hand dug wells from all the six locations are above the WHO value of 250mg/l (value recommended for safe drinking water) with Ajah having the highest average Chloride concentration of 606.68mg/l and Ikeja with the least average value of 255.37 mg/l, while only the borehole sample collected from Ajah slightly exceed the WHO standard for drinking water, all other samples fall within the safe range.

Since for the hand dug well, all the 30 values of chloride exceed 250 mg/l and only 6 out of 30 in the borehole sample slightly exceed this threshold, it can be said in the limit of the domain of this research that taking borehole water is safer than hand dug well. The shallow depth of this hand dug wells may also be responsible for the high chloride content. Finally observation was also made that the chloride concentrations decreases as we move away from the coast.

CONCLUSION

The study also reveals that the problem of saltwater intrusion in the area under study is caused majorly by in increased abstraction of groundwater which disturbs the natural freshwater/saline water equilibrium. This study also reveals the extent of salinisation of available water for domestic purposes which are higher that the stipulated W.H.O standard for safe drinking water. The government must rise up to its responsibility and become proactive in the provision of clean and quality water to its citizens otherwise the health of the people would be adversely affected.

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