Groundwater Quality of Selected Boreholes in Parts of Lagos, Nigeria

Enovwo Odjegba

Abstract

Inadequacy and poor coverage of public water supply has resulted in heavy reliance on groundwater sources such as boreholes in Lagos State, South-West Nigeria. Groundwater contamination due to industrialization, commercial activities, and saltwater intrusion are challenges facing groundwater use, resulting in water-related diseases. The study's objective was to assess the groundwater quality of selected boreholes in parts of Lagos State, Nigeria, using the rapid assessment approach. Water samples were collected using standard water sample collection methods. They were tested for temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, salinity, chloride, total hardness (TH), calcium (Ca), Sodium (Na), lead (Pb), iron (Fe), and total coliform count using standard water quality assessment methods. The pH levels in water samples from seven out of the ten boreholes were below 6.5, indicating acidic pH levels. Elevated values of EC and TDS were observed in two boreholes, while Six boreholes had high Pb concentrations exceeding 0.01 mg/L. Fe concentrations of five boreholes exceeded the 0.3 mg/L WHO (WHO Guidelines for drinking-water quality: www.who.int/publications/i/item/9789241549950) acceptable limit. Micro-organisms were detected in all water samples tested. Acidic pH levels, elevated EC and TDS values, increased concentrations of Pb and Fe, and the detection of microbial presence indicates possible ingress of contaminants into the boreholes. Since the water is largely consumed untreated, consumers are at risk of disease, hence the need for advocacy of household water treatment.

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Keywords

Groundwater quality · Contamination · Water quality · Borehole

1 Introduction

Inadequacy and poor coverage of public water supply has resulted in heavy reliance on groundwater sources such as boreholes in Lagos State, South-West Nigeria. Groundwater contamination due to industrialization, commercial activities, and saltwater intrusion are some challenges facing groundwater use, resulting in water-related diseases (Alfarrah & Walraevens, 2018). Groundwater quality is also influenced by contamination from geology and anthropogenic sources. The interactions between groundwater and surrounding rocks result in various alterations to groundwater's chemical compositions (Yousif & El-Aassar, 2018). Groundwater quality is altered by the dissolution of ions, thereby increasing concentration levels. Nigeria faces challenges such as poor social amenities in rural settings, which translates to increased rural–urban migration (Momoh et al., 2018). Megacities like Lagos bear the burden of the exploding population, which competes for limited public water supply, housing, healthcare, and employment, amongst others (Anselm, 2019). Residents augment the limited access to public water by depending heavily on groundwater sources for potable water needs. As a result, water is largely consumed untreated, exposing consumers to the risks of water-related diseases. The study's objective was to assess the groundwater quality of selected water sources in Lagos, Nigeria.

Lagos consists of a series of sand and gravel aquifers, interbedded with clay horizons, occurring between the ground surface and a depth of less than 200 m (Healy et al., 2020). It is underlain by sedimentary deposits of the coastal plain sand (Benin Formation) devoid of geological structures such as fractures and lineaments common

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in non-crystalline terrain like Lagos (Akinlalu & Afolabi, 2018). The surface geology of the Island area of Lagos is made up of Miocene to recent, recent littoral alluvial, lagoons, and coastal plain sand deposits. The topography is generally low-lying, indicating susceptibility to periodic flooding. The coastal plain sand is the outcropping in the mainland area overlying the Ilaro, Ewekoro Formation, and the Abeokuta group (Akinlalu & Afolabi, 2018). Also, the location of Lagos as a coastal area predisposes the groundwater to saline water intrusion (Olufemi et al., 2010). The climate of Lagos is a wet equatorial climate with mean annual rainfall above 1800 mm, characterized by two main seasons: the rainy season and dry season, lasting from April to October and October to March, respectively. Swamp forests and wetlands dominate the vegetation cover, and tropical swamp forests comprise fresh waters and mangroves (Soladoye & Ajibade, 2014).

2 Methodology

This study assessed the groundwater quality of ten boreholes in parts of Lagos State. The boreholes were in the Island and mainland areas of Lagos, namely Epe, Victoria Island, Lekki, Ibeju-Lekki, Ikoyi, Apapa, Ikorodu, Mile 2, Ojo, and Badagry. Water samples were collected using standard water sample collection methods. The water samples were tested for temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, salinity, chloride, total hardness (TH), calcium (Ca), sodium (Na), lead, iron (Fe) and total coliform count using standard water quality assessment methods from American Public Health Association. The water quality parameters for this study were selected based on reviewed literature and limited to frequently tested parameters.

3 Results

The results of the water quality analysis are presented in Figs. 1, 2, 3, 4, 5, 6 and 7. The pH values ranged from 5.3 to 6.8, with a mean of 6.03 ± 0.55. The pH levels in water samples from seven out of the ten boreholes (Ikoyi, Epe, Ikorodu, Apapa, Mile 2, and Badagry) were below 6.5, indicating acidic pH levels. Electrical conductivity and TDS values ranged between 77–2415 µS/cm and 38.6–1207.5 mg/L, respectively, with respective means of 624.5 ± 671 and 312.3 ± 335.50. Turbidity and salinity values were between 0.1–43.75 NTU and 0.27–1.56 mg/L, with respective means of 10.1 ± 14.8 and 0.67 ± 0.36. The highest salinity value was recorded at Victoria Island, followed by Badagry, Ojo, Ikorodu, and Lekki, while the lowest was recorded at Mile 2. Chloride and total hardness values ranged from 3–168 mg/L to 31–179 mg/L, respectively, with mean of 34.15 ± 49.6 and 86.25 ± 45.2. Calcium and sodium were between 0.02–20.42 mg/L and 0.09–16.13 mg/L with respective means of 4.67 ± 6.8 and 5.2 ± 6.3. The values of Lead and Iron ranged from 0–0.3 mg/L and 0–5.98 mg/L with means of 0.013 ± 0.01 and 0.77 ± 1.75, respectively. Iron concentration in three boreholes (Lekki, Apapa, and Badagry) were above the WHO standard of 0.3 mg/l. Micro-organisms were detected in all water samples tested.

Fig. 1 pH variations in the boreholes

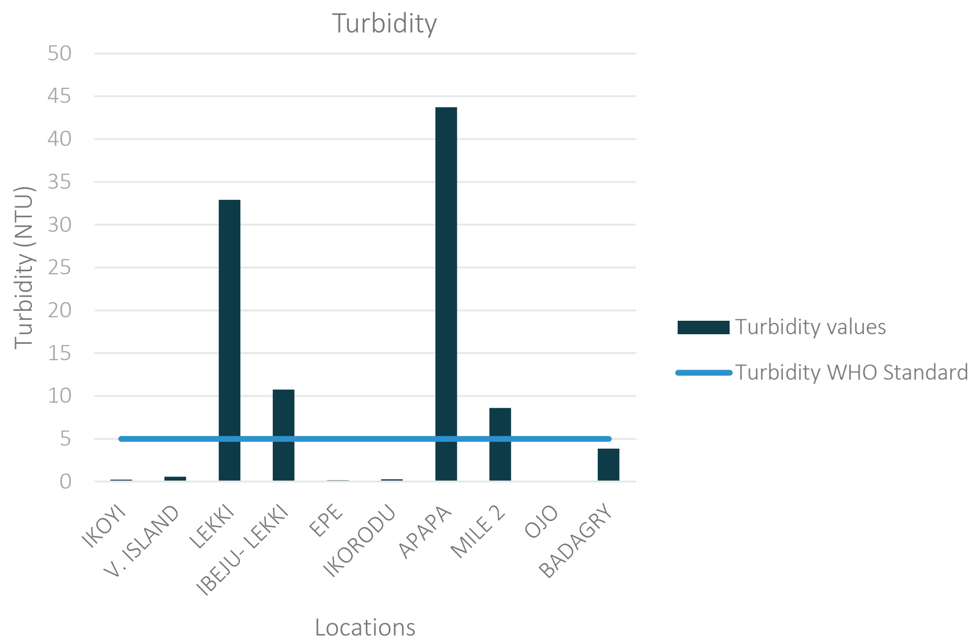

Fig. 2 Turbidity values in the boreholes

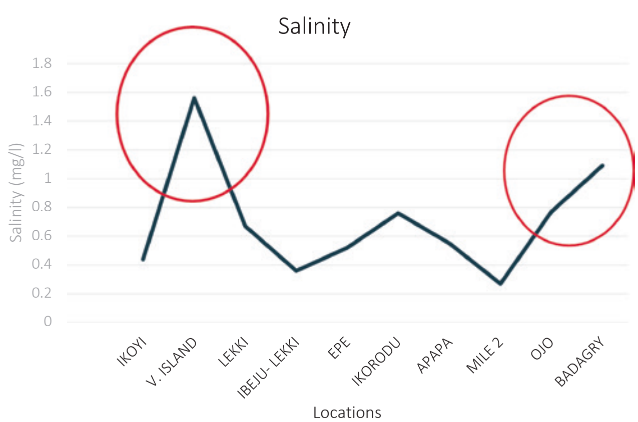

Fig. 3 Salinity trend in the boreholes

4 Discussion

Acidic pH levels recorded in the boreholes are attributed to several factors, such as infiltration from acidic rainwater (Zhou et al., 2015) and dissolution of CO_2 resulting in H_2CO_3 formation (Isa et al., 2012). Elevated values of EC and TDS were observed in two boreholes, while six boreholes had high Pb concentrations exceeding the 0.01 mg/L WHO (2017) acceptable limit. High Fe concentrations of some of the boreholes may be traceable to their mineralogical content of the underlying formation of the borehole locations. Micro-organisms were detected in all water samples tested. Acidic pH levels, elevated EC and TDS values, increased concentrations of Pb and Fe, and the detection of microbial presence indicates possible ingress of contaminants into the boreholes. Acidic pH levels in groundwater may be due to factors such as infiltration from acidic rainwater, dissolution of CO_2, and pyrite oxidation in sediments (Khatri & Tyagi, 2015). Increased EC and TDS values, an indication of water salinity, can be attributed to the proximity of Lagos State to the Atlantic Ocean and the susceptibility of the boreholes to saltwater intrusion (Olufemi et al., 2010). For instance, the salinity level of boreholes was observed to increase with respect to proximity to the ocean Fig. 8. The cause of saline water intrusion is traceable to the shallow depth of the boreholes in coastal areas, their elevations above sea level, or their proximity to Lagoon or sea. High Pb concentrations may be attributed to lead-rich industrial waste effluents and higher volume of leaded gasoline exhausts from motor vehicles in the residential area. In contrast, high Fe concentration could be associated with weathering of minerals and rocks and dissolution of Fe into groundwater bodies via leaching (Popoola et al., 2019). Extensive consumption of drinking water containing high Fe concentration level are haemosiderosis (liver-damage disease), diabetes mellitus, arteriosclerosis and many other neurodegenerative diseases.

5 Conclusion

Acidic pH levels, elevated EC and TDS values increased concentrations of Pb and Fe, and the detection of microbial presence in the samples indicates the ingress of contaminants into the borehole. Since the water is primarily consumed untreated, consumers are at risk of water-related disease, hence the need for advocacy of household water treatment.

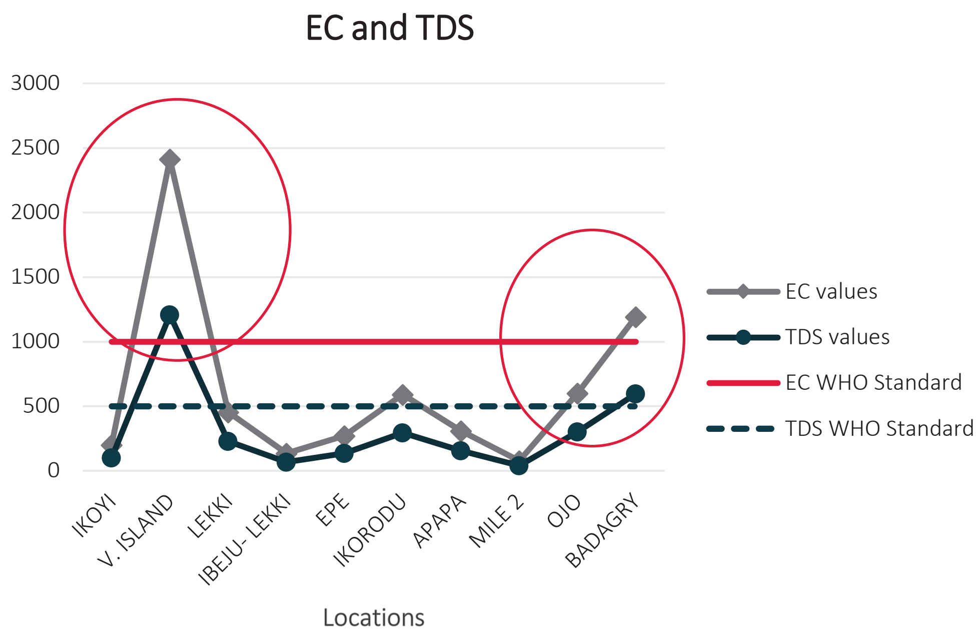

Fig. 4 EC and TDS values in the boreholes

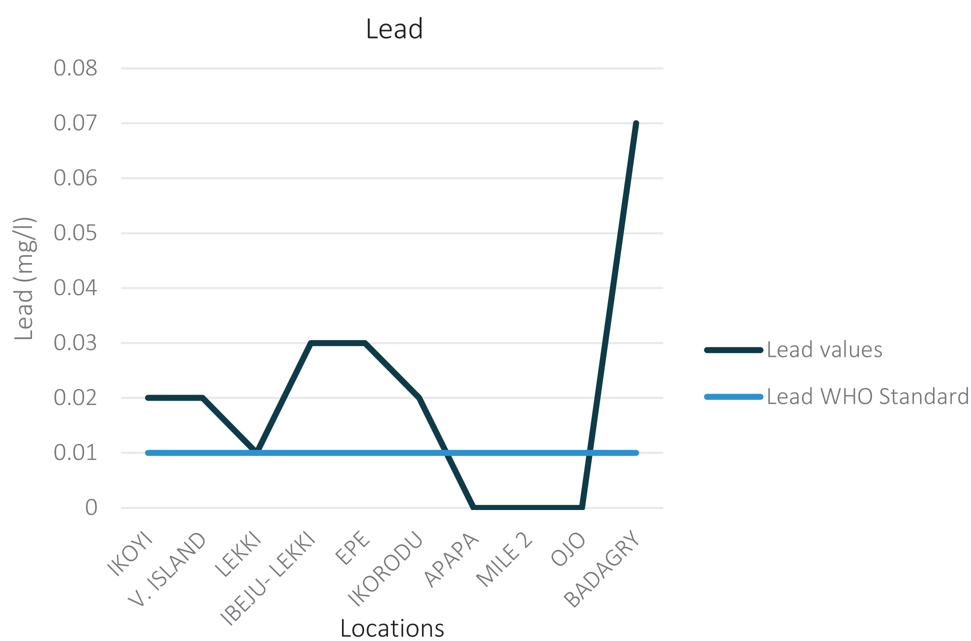

Fig. 5 Lead variations in the boreholes

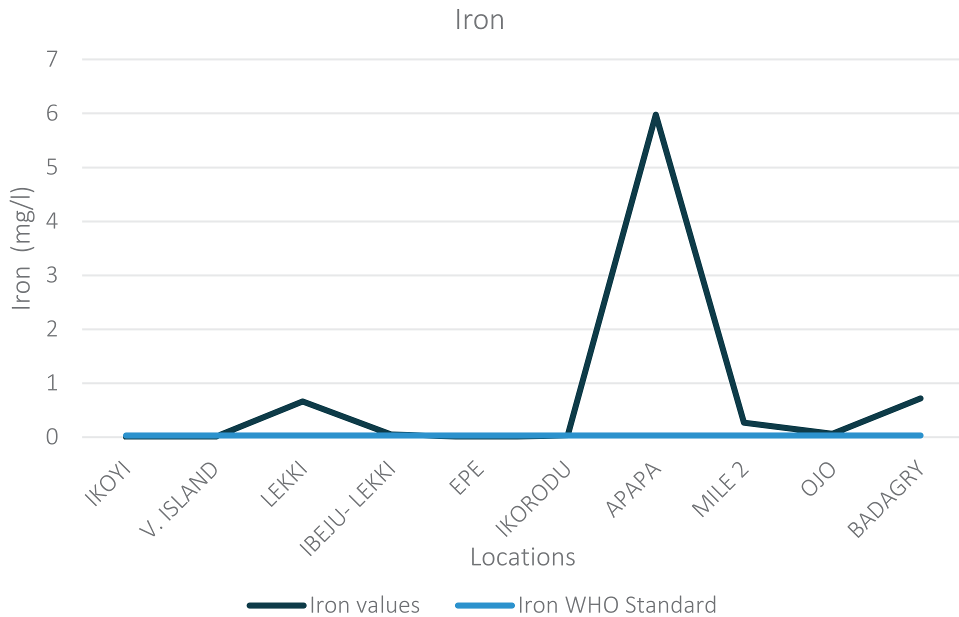

Fig. 6 Iron values in the boreholes

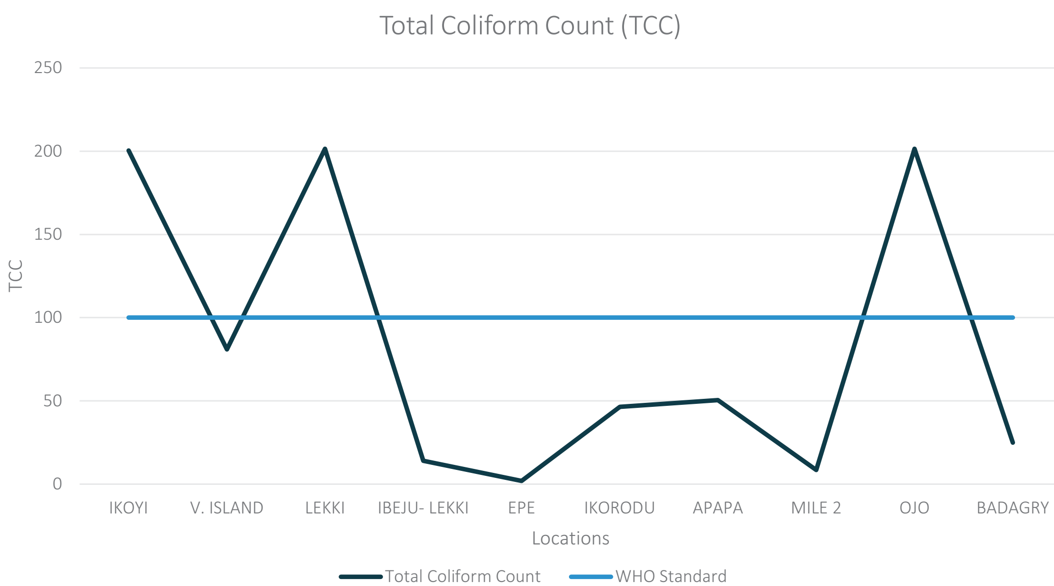

Fig. 7 Total coliform count in the boreholes

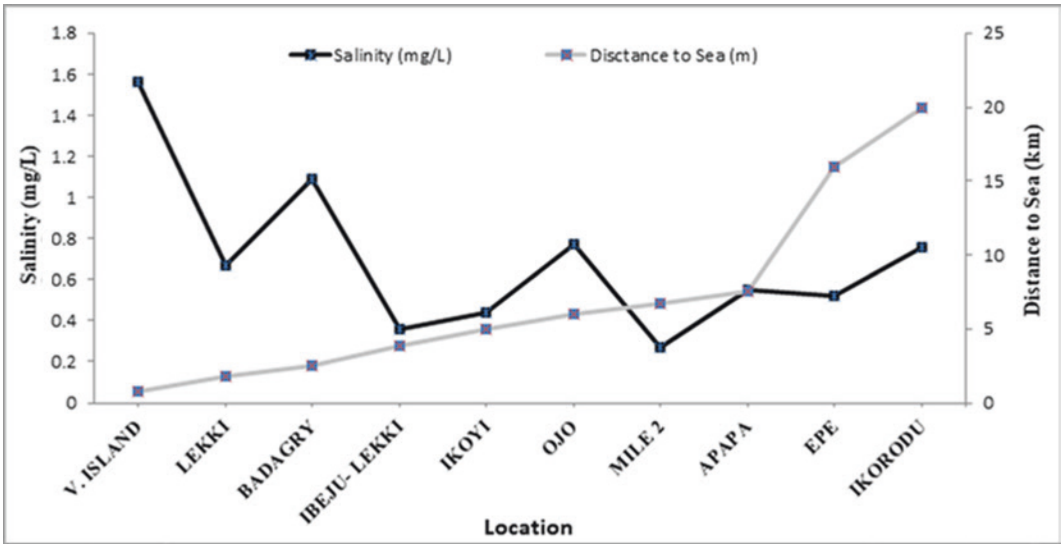

Fig. 8 Salinity variation and distance to the sea

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