World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

Assessment of water quality from selected borehole locations in Ado Ekiti, Ekiti State, Southwest Nigeria.

Dolapo Funmi Odeyemi *, Ogunniran Adefunke Oluwaseun, Temitayo Sarah Omode, Ifeoluwa Eunice Ayeni and Anuoluwapo Florence Fagbure

Department of Science Laboratory Technology, Biotechnology Option, Faculty of Science, Ekiti State University, Ado Ekiti. Ekiti State, Nigeria.

World Journal of Advanced Research and Reviews, 2024, 21(02), 1161–1170

Publication history: Received on 29 December 2023; revised on 15 February 2024; accepted on 18 February 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.21.2.2601

Abstract

Borehole water is commonly believed to be pure and safe to drink. The present study assessed the quality of ten selected borehole locations within Ado -Ekiti. This was carried out by assessing the physicochemical parameters, microbial and heavy metal contamination using standard procedures. The physicochemical parameter results showed that Temperature range between 25.99 ^{o}C - 26.60 ^{o}C, Electrical conductivity range between 41.62 µs/cm - 202.54 µs/cm, pH range between 6.81-7.57, Total dissolved solids range between 28.15 mg/L - 116.22 mg/L, Total suspended solids range between 0.09 mgl -1.27 mgl, Turbidity range between 0.12 NTU-0.71 NTU, Total Hardness range between 29.64 mg/l -80.61 mg/l, Total Alkalinity range between 20.97 mg/l - 65.42 mg/l and all values were within World Health Organisation (WHO) permissible limits. The bacteria count of borehole water sample range from 10.66 ± 0.03 Cfu/ml to 12.56 ± 0.03 Cfu/ml. Highest fungi count of the borehole water sample was in the value range from 8.27 ± 0.00 Sfu/ml to 9.63 ± 0.02 Sfu/ml. The highest coliform detected in the borehole sample range from 5.33 ± 0.58 Cfu/ml to 8.67 ± 8.56 Cfu/ml. The bacteria, fungi and coliform count result observed in this study was higher than the WHO recommended limits. The metals occurred in the samples in this order Cr >Fe > Pb > As > Cd. The heavy metals were present in quantities higher than WHO recommended limit in some of the samples which is an indication of potential health hazards through the water consumption.

Keywords: Borehole; Health hazard; Water quality; Fungi; Bacteria; Coliform

1. Introduction

Water is an inorganic, odorless, tasteless, transparent, and colorless substance made up of hydrogen and oxygen existing in gaseous, liquid, and solid states [1]. Water covers 71% of the earth's surface and is vital for all known forms of life. Quite a number of people worldwide do not have access to clean, safe water, and most of these people are in developing countries. Clean drinking water is crucial in promoting good health. The water supply is not reliable in Nigeria, accounting for some of the people's ill health. Reports has shown that poor hygiene and consumption of unclean water are linked to transmission of disease. In Nigeria, borehole is a significant source of drinking water. However, this source is not entirely safe as most boreholes may have contaminants which may be detrimental to consumer's health. Borehole water is one of the major sources of drinking water all over the world, though mostly originates from rain or snowmelt infiltrates through soils into subsurface aquifers, and is apparently purer than surface water because of the natural purification process which it undergoes while percolating through piles of soils, Aturamu [2]. The water is a vital component of the global water cycle and the environment Adebo and Adetoyinbo, [3] and is also widely used as a source, for drinking water supply and irrigation in food production. Underground water may be subjected to pollution and may not be as safe as is generally assumed Odeyemi *et al.,* [4]. World Health Organization (WHO) defines safe water as water

* Corresponding author: Dolapo Funmi Odeyemi; Email: dolapo.odeyemi@eksu.edu.ng

having acceptable quality in terms of its physical, chemical, bacteriological parameters so that it can be safely used for drinking and cooking and with no significant health risk to end user (WHO, 2020). The pollution of water is increased due to human population, industrialization, the use of fertilizers in agriculture and other anthropogenic activities. Parameters such as temperature, turbidity, nutrients, hardness, alkalinity, dissolved oxygen, etc. are some of the important factors that determines the growth of living organisms in the water body. Hence, water quality assessment involves the analysis of physicochemical, heavy metals and microbiological parameters that reflect the biotic and abiotic status of the ecosystem [5]. Nowadays, water pollution is a major global problem which is increasing and becoming severe day-by-day and posing great risk to human health and other living organisms. Borehole water which is also referred to as ground water can become contaminated with a wide range of pollutants arising from human activities, including industrial activities, agriculture and changes in land use practices. It can also be contaminated with naturally occurring substances [6]. Some key threats that can detrimentally affect the quality of groundwater include: acidity, salinity, nutrient runoff (from fertilizers, farm animal manure and septic systems) and toxic contaminants (such as heavy metals, chemicals and pesticides). Naturally occurring substances such as arsenic, chlorides, fluoride, iron, manganese, radionuclides and sulfates can leach into groundwater from rocks and soils, while decaying organic particulate matter can be washed into groundwater. Some of these naturally occurring contaminants can potentially pose a health risk when present at high levels or when a person is exposed to them at low levels over a long period of time. Others are harmless, but may make water discolored and/or give it a foul taste or smell. Groundwater that contains high levels of undesirable pollutants can be treated to meet drinking quality standards [7].

Millions of people in the world, especially in the developing countries are losing their lives every year from water borne-diseases. The inability of the Government to supply potable water to residents of some parts of Ado Ekiti is still a challenge [8]. The inadequate access to drinking water has activated the indiscriminate sinking of boreholes in homes within new settlements and some old settlements due to the unreliability of pipe-borne water sources. Individuals sink boreholes and pump the water for household use and also sell to water vendors who supply other homes. Borehole water is rarely tested for safety despite that some conditions capable of polluting ground water has been reported in the city. The assessment of water quality is therefore a vital tool to manage land and water resources within a particular catchment [9]. Water quality indicates the relation of all hydrological properties including physical, chemical and biological properties of the water body [10]. Hence, the present study intends to assess water quality of some bore holes points in Ado Ekiti, Ekiti State Nigeria.

2. Materials and methods

2.1. Study area

The study was carried out at different locations within Ado metropolis as shown in Fig. 1.

2.2. Sample Collection

Water sample were collected early in the morning at different locations as shown in Figure 1 using thoroughly washed plastic bottles. The bottles were also pre – rinsed with the water from the borehole samples from each borehole location and tightly covered with the bottle cap. Each location was tagged as alphabet. A-J as shown in Fig 1.0.

2.3. Physiochemical Analysis

The temperature of the sample was determined at the point of collection by dipping the stainless-steel penetration probe of the thermometer into the sample and the reading was taken in degree centigrade. pH was determined using pH meter. Turbidity was measured using a turbidimeter. Electrical conductivity was measured using electrical conductometer following the manufacturer's instructions. Total Hardness, Chlorides, Nitrates, Total alkalinity, Total dissolved solids, Total Suspended solids and Total solids were measured using standard volumetric procedures [11].

2.4. Heavy Metal Analysis

2.4.1. Digestion of water sample

Two millilitres of concentrated HNO_3 and 5mL of concentrated HCL were added to 100mL of water sample. The sample was covered and heated on a hot plate at 90^o C to 95^o C until the volume has been reduced to 15-20 mL. It was cooled and the walls of the beaker was washed down with distilled water and filtered to remove silicates and other soluble materials. The volume was adjusted to 100mL and presented for metal/mineral analysis [11]

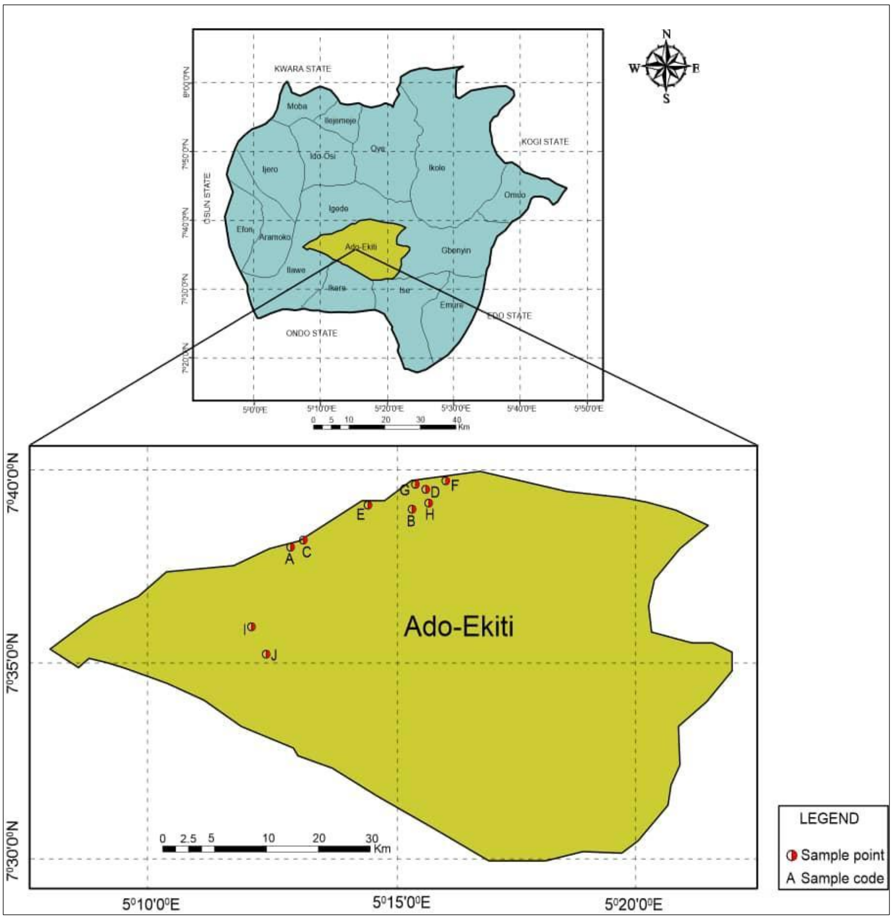

Figure 1 Map of Ekiti showing the different sampling points in Ado Ekiti

2.4.2. Metal/Mineral Analysis

The analytical method used for the analysis of heavy metal concentration was spectrometry and the equipment used was Atomic Absorption Spectrophotometer (AAS) Buck Scientific model 211 VGP using the calibration plot method. Three processes were involved; standard preparation, equipment calibration and sample analysis. For each element, the instrument was auto-zeroed using the blank (distilled water) after which the standards were aspirated into the flame from the highest to the lowest concentration. The corresponding absorbance was obtained by the instrument and the graph of absorbance against concentration was plotted. The samples were analyzed with the concentration of the metals present being displayed in parts per million (ppm) after extrapolation from the standard curve [11]

2.5. Statistical Analysis

All evaluations were done in triplicates and data obtained were presented as mean ± SEM using Microsoft Excel 2007.

3. Results

3.1. Microbial count in borehole water samples

Total bacteria count (TBC) of borehole water sample as presented in Figure 2 showed that Sample H bore hole has the highest bacteria count of (12.56 ± 0.03) x 10^3 Cfu/mL followed by the Sample G with the value of (10.66 ± 0.03) x 10^3 Cfu/mL and the lowest bacteria count of borehole water sample was observed in Sample E with the value of (1.97 ± 0.01) x 10^3 Cfu/mL. The bacteria count observed in this study were higher than the WHO recommended limit for bacteria count in water sample which is $\leq$ 100 Cfu mL as shown in Figure 2. The highest fungi count (9.63 ± 0.02) x 10^3 Sfu/mL was observed in sample H followed by borehole water sample G with the value of (8.27 ±0.00) x 10^3 Sfu/mL while the lowest fungi observed was from sample E with the value of (1.23 ± 0.02) x 10^3 Sfu/mL as illustrated in Figure 2. The fungi count result observed in this study was higher than the WHO recommended fungi count value for water sample which is 0 – 0.1 Sfu mL. The highest coliform of 8.67 ± 0.58 MPN/mL was observed in sample H borehole followed by the borehole located at sample G with the value of 5.33 ± 0.57 MPN/mL. The coliform count result observed in this study is within the WHO recommended limit for water sample which is ≤ 10 MPN mL. whereas, no coliform was observed in sample A, sample C, and sample I borehole water sample.

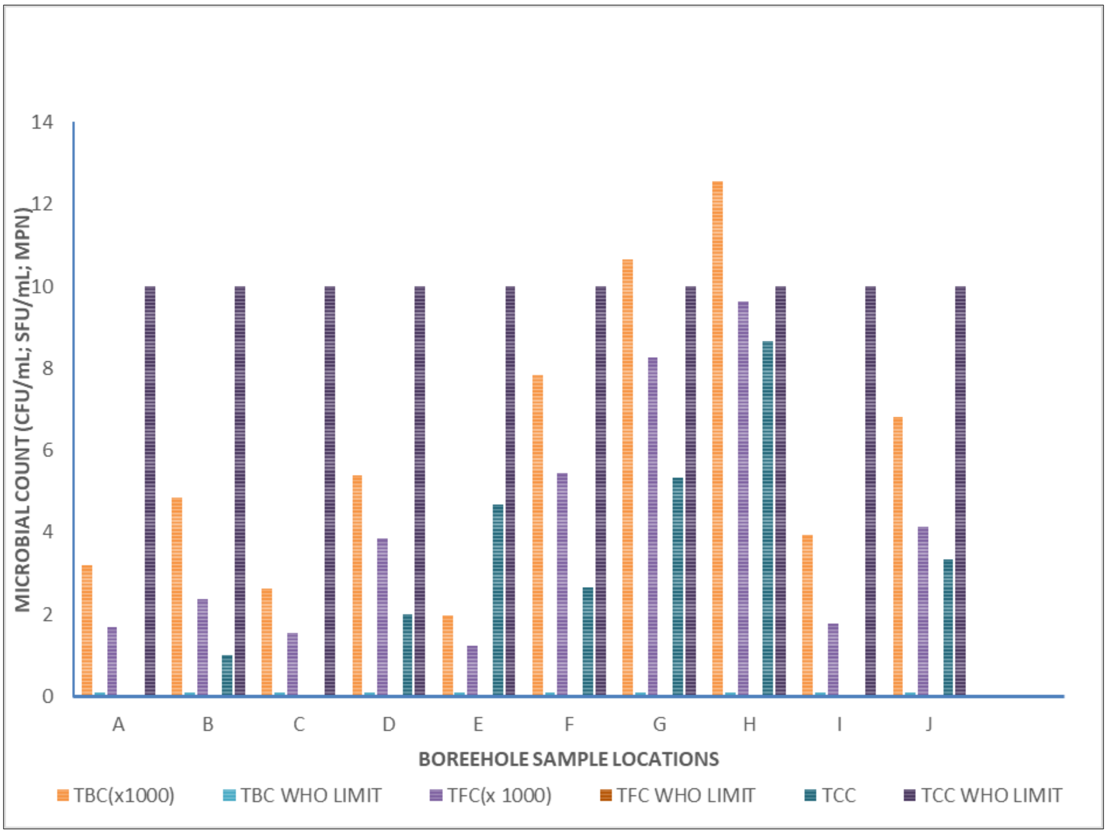

Figure 2 Microbial count of borehole water samples showing total bacteria count (TBC), total fungi count (TFC) and total coliform count (TCC).

3.2. Heavy metal assessment of borehole water samples

The heavy metal composition of borehole water samples is presented in Table 1. Chromium, iron, cadmium, lead, arsenic was assessed in the ten water samples and they were present in this order Cr >Fe > Pb > As > Cd. The highest Chromium value was observed in borehole water sample G with the value of (0.351 ± 0.02) ppm followed by borehole water sample H with the value of (0.142 ± 0.01) ppm while the lowest chromium value was observed in borehole water sample C with the value of (0.045 ± 0.01ppm) as shown in Table 1. The highest iron value was observed in borehole water sample B with the value of (0.298 ± 0.11) ppm followed by borehole water sample G with the value of (0.263 ± 0.02) ppm while the lowest iron value was observed in borehole water sample H with the value of (0.035 ± 0.01) ppm. The highest lead value was observed in borehole water sample H with the value of (0.105 ± 0.01) ppm followed by borehole water sample G with the value of (0.094 ± 0.00) ppm while the lowest lead value was observed in borehole water sample I with the value of (0.012 ± 0.00) ppm. The highest arsenic value was observed in bore hole water sample H with the value of (0.028 ± 0.02) ppm followed by borehole water sample G with the value (0.017 ± 0.01) ppm while the lowest arsenic value was observed in borehole water sample C with the value of (0.002 ± 0.01) ppm. The highest cadmium value was observed in borehole water sample B with the value of (0.026 ± 0.13) ppm followed by borehole water sample E (0.025 ± 0.01) ppm while the lowest cadmium value was observed in borehole water sample I with the value of (0.002 ± 0.01) ppm as shown in Table 1.

3.3. Physical and chemical parameters of borehole samples

The physical and chemical parameters of borehole water samples as presented in Table 2 showed that temperature range for all the samples assessed was between (25.99 ± 0.22) and (26.60 ± 0.31) ^{o}C which was above the standard limits by WHO. pH recorded a range of (6.81 ± 0.05) and (7.57 ± 0.51), Electrical conductivity was between (41.62 ± 1.40) and (202.54 ± 9.78) µs/cm, Total Dissolved solids ranged from (28.15 ± 0.78) mg/L and (116.22 ± 4.18) mg/L; Total suspended solids ranged from (0.09 ± 0.01) mg/L and (1.27 ± 0.02) mg/L; Turbidity measured was between (0.12

± 0.01)NTU and (0.71 ± 0.14) NTU; Total Hardness ranged from (29.64 ± 0.27)mg/L and (80.61 ± 0.89)mg/L; Total Alkalinity measured between (20.97 ± 0.05) mg/L and (65.42 ± 0.32) mg/L ; Chloride measured between (0.03 ± 0.01) mg/L to (0.15± 0.02) mg/L, although it was absent in some of the samples such as C, G, H. Nitrate was not detected in all of the samples except sample B which recorded (0.045± 0.01) mg/L. All parameters except temperature, total dissolved solids, hardness were within the standard limits of WHO.

Table 1 Heavy Metal Composition of Borehole Water Samples in Ado Ekiti.

SAMPLE CODES	As (ppm)	Cd (ppm)	Cr (ppm)	Fe (ppm)	Pb (ppm)
A	0.005 ± 0.01	0.006 ± 0.02	0.058 ± 0.1	0.133 ± 0.2	0.026 ± 0.00
B	0.009 ± 0.02	0.026 ± 0.13	0.081 ± 0.02	0.298 ± 0.11	0.051 ± 0.01
C	0.002 ± 0.01	0.013 ± 0.02	0.045 ± 0.01	0.095 ± 0.01	0.077 ± 0.01
D	0.005 ± 0.01	0.016 ± 0.02	0.066 ± 0.12	0.193 ± 0.02	0.037 ± 0.02
E	0.009 ± 0.03	0.025±0.01	0.093±0.01	0.215± 0.02	0.044±0.01
F	0.011 ± 0.01	0.008 ± 0.01	0.095 ± 0.01	0.213 ± 0.01	0.073 ± 0.00
G	0.017 ± 0.01	0.015 ± 0.00	0.351 ± 0.02	0.263 ± 0.02	0.094 ± 0.00
H	0.028 ± 0.02	0.022 ± 0.01	0.142 ± 0.01	0.035 ± 0.01	0.105 ± 0.01
I	0.002 ± 0.01	0.002 ± 0.01	0.072 ± 0.01	0.194 ±0.00	0.012 ± 0.00
J	0.003 ± 0.02	0.006 ± 0.02	0.056 ± 0.02	0.184 ± 0.00	0.026 ± 0.01

As: Arsenic; Cd: Cadmium; Cr: Chromium; Fe: iron; Pb: lead; ppm: parts per million.

4. Discussion

Total bacteria count of borehole water samples in this study ranges from (2.62 ± 0.02) x 10^3 Cfu/mL to 12.56 ± 0.03 Cfu/mL. This was higher than the WHO recommended bacteria count value for water sample which is ≤ 100 Cfu/mL. Microbiological pollution of borehole water is often determined by counting bacteria considered as bio-indicators such as coliforms and *E. coli* [12]. This result corresponds with the assertion of Okoro *et al*. [13] who reported higher total bacterial counts (15 Cfu/g) in borehole water sources in Nsukka Urban area, Enugu state, Nigeria. Borehole water samples from sample E recorded lowest bacteria count of bore hole with the value of 1.97 ± 0.01 Cfu/ml. This might be due to the difference in hygiene practices by people in the surrounding environment [13].

The coliform recorded in the present study ranges from 1.00 ± 0.00 MPN/mL to 8.67 ± 0.58 MPN/mL. The result is lower than the report of Adeiza *et al*. [14] who reported coliform count which ranged from 0 to 11 Cfu/mL. Sample B had the least with 1.00 ± 0.00 MPN/mL while sample H had the highest with 8.67 ± 0.58. It was also observed in our result that no coliform was observed in Sample A, Sample C, Sample I water sample. This was in agreement with the results of Adeola *et al*. [15], who reported no faecal coliforms in water samples of some boreholes and wells and boreholes in Ijebu-Ode, South western Nigeria. In general, the absence of faecal coliforms in borehole water means that it was accurately drilled to get clean water [16]. This borehole perhaps might not be located close to a toilet or soak away system, had consistent washing and disinfection of the water tank, and might also had a water purifier which increased water quality [15].

Fungal infections are becoming more and more important because of increasing numbers of immunosuppressed patients. Nonetheless, waterborne fungi are associated with taste and odour problems, contamination of food and beverage preparation, and in a variety of health-related effects [16]. It was also observed in this study that borehole water sample H had the highest fungi count of the value (9.63± 0.02) x 10^3 Sfu/mL. The fungi count in this study range from (1.23±0.02) x 10^3 to (9.63± 0.02) x 10^3 Sfu/mL which is lower than the report of Emmanuel and Francis [17] who reported heterotrophic fungi count in borehole water in a Lagos community as (6.00 to 1.6:16) x 10^3 Cfu/mL.

Table 2 Physical and Chemical Parameter Assessment of Borehole Water Samples in Ado Ekiti.

Parameters	A	B	C	D	E	F	G	H	I	J	WHO LIMIT
Temperature (^{0}C)	26.22 ± 0.18	26.33 ± 0.29	26.10 ± 0.29	26.60± 0.31	25.99 ± 0.22	26.43 ± 0.29	25.99 ± 0.89	26.21± 0.5	26.40 ± 0.43	26.38 ± 0.35	25 ^{o}C
PH	6.97 ± 0.03	7.24 ± 0.15	7.17 ± 0.32	6.83 ± 1.70	7.57 ± 0.51	7.35 ± 0.02	6.81 ± 0.05	6.92 ± 0.38	7.14 ± 0.32	7.47 ± 0.42	6.5 – 8.5
EC (µs/Cm)	96.17 ± 5.61	152.64 ± 7. 12	103.95 ± 6.82	202.54 ± 9.78	173.49 ± 7.32	41.62 ± 1.40	76.23 ± 0.98	100.27 ± 0.82	71.54 ± 1. 67	93.23 ± 0.43	300-400
TDS(Mg/L)	51.55 ± 2.16	84.16 ± 4.43	72.57± 3.19	116.22 ± 4.18	95.14 ± 2.75	28.15 ± 0.78	45.97 ± 2.34	61.82 ± 0.56	40.40 ± 0.54	55.63± 0.56	10 - 20
TSS(Mg/L)	0.14 ± 0.02	0.34 ± 0.03	0.22 ± 0.001	1.08 ± 0.16	1.27± 0.02	0.09 ± 0.01	0.17 ± 0.012	0.12 ± 0.01	0.17 ± 0.32	0.29 ± 0.32	4 - 5
Turbidity (NTU)	0.71 ± 0.14	0.46 ± 0.03	0.12 ± 0.01	0.55 ± 0.02	0.67 ± 0.01	0.322 ± 0.11	0.305 ± 0.02	0.116 ± 0.05	0.155 ± 0.12	0.286 ± 0.14	1.5 NTU
T. Hardness (Mg/L)	45.23 ± 2.78	50.81 ± 0.33	80.61 ± 0.89	56.26 ± 0.34	40.37 ± 0.04	37.16 ± 0.34	50.72 ± 0.15	33.23 ± 2.78	29.64 ± 0.27	30.64 ± 0.76	40-45
T.Alkalinity (Mg/L)	51.83± 1.05	60.43 ± 0.04	53.13 ± 0.03	20.97 ± 0.05	62.51 ± 0.15	65.42 ± 0.32	40.92 ± 0.43	46.15 ± 0.52	50.17 ± 0.46	58.80 ± 0.11	200-600
Chloride (Mg/L)	0.03 ± 0.012	0.11 ± 0.01	ND	0.15 ± 0.02	0.06 ± 0.01	0.07 ± 0.34	ND	ND	0.06 ± 0.24	0.03 ± 0.24	2.67
Nitrate (Mg/L)	ND	0.05 ± 0.01		ND	ND	ND	ND	ND	ND	ND	1-2.5

Legend: ND=Not Detected; (ºC)= Degree Celsius; EC= Electrical Conductivity; TDS= Total Dissolved Solids; TSS= Total Suspended Solids; Mg/L= Milligram per liter; NTU= Nephelometric Turbidity Units; WHO = World Health Organization

The presence of fungi in the borehole samples probably indicates poor treatment techniques which could be as a result of intrusion from compromised water pipes during distribution. Furthermore, since these boreholes are sited within residential areas, poorly designed septic tanks, poor drainage, human waste water disposal and poor sanitation can aid the contamination of water with fungi [18]. Also, differences in raw water sources, treatment protocols and system maintenance could certainly account for the unique fungal assemblage [19]. The influence of physical and chemical factors unique to a given distribution system should be recognized as an important determinant of fungal disposition and growth. Fungi in water can cause a wide range of diseases in humans, ranging from hypersensitivity reactions to invasive infections associated with angioinvasions [20] Although it is unlikely that concentrations as low as those reported in our study can cause fungal infection in healthy people, immunosuppressed persons are at risk of infection.

The Arsenic value observed in all borehole water sample in this study range from 0.002 ppm to 0.028 ppm while WHO permissible limit is 0.05 mg/L. The level of Arsenic (As) recorded in this work were far lower than those reported by Edori and Nwoke [21] in the boreholes of Ikono, Akwa Ibom which has the value range of 0.05 ± 0.10 ppm. The existence of arsenic in the groundwater (borehole) constitutes health challenges to humans and animals and that make use of the water and exposure to arsenic at even low levels might have significant poisonous effects. Arsenicosis manifests in 2 to 20 years and it is a human disease that has slow manifestation in its occurrence. Certain diseases like hypo and hyper pigmentation, Peripheral neuropathy and peripheral vascular disease, are notable signs that manifests due to arsenic toxicity that affects children and adults and also reduces the development the intellects of children. The effects due to arsenic toxicity may result in skin lesion and stigmatization which may ruin the life of an individual in his developmental stages and eventually affect the entire family.

The cadmium value observed in all borehole water sample in this study range from 0.002 ppm to 0.0026 ppm and this is below WHO permissible limit which is 0.005 ppm. The level of cadmium obtained in this work was at the same range or a bit higher than that which was reported by Musa *et al*. [22] which was in the range of 0.001 to 0.28 ppm in boreholes water in Zaria, Nigeria and was also at the same range or lower than that recorded by Edori and Nwoke [21] in the boreholes of Ikono which ranged from 0.47 to 0.22mg/L. Contact or intake of inorganic chemicals such as cadmium in the water can results in poisoning and health risk, due to the toxicity of cadmium and its effect due to accumulation. The high occurrence of cadmium (a toxic chemical) in potable water might result in acute or chronic health challenges like vomiting, nausea, dizziness and under extreme cases results in immediate death due to large doses of cadmium and other toxic chemicals. Cadmium in water is a public health issue for its chronic effects can produce renal dysfunction, testicular necrosis, cancer, damage of the central nervous systems, arteriosclerosis, the inhibition of growth in animals and even humans and immune system damage [23], and its effect also causes impairment of male fertility. High level of cadmium in the water samples in the study area may be connected with the farming activities and weathering of rocks naturally in the area. Therefore; care must be taken in the usage of borehole water especially for drinking purposes in all the areas due to the high level of cadmium which render it unfit for drinking.

The chromium value observed in all borehole water sample in this study range from 0.045 to 0.351 ppm. Sample C is same as the WHO limit, sample A, B, D, E, F, G, H, J were above WHO limit which is 0.05 ppm. The presence of chromium detected in the borehole sample in the present study could probably be attributed to the nature of the industrial waste found in the environment [24]. There might be activities of interest around these sampling sites includes tanning of hides, leather manufacturing among others; largely of which makes uses of chemicals containing some of these metals in their manufacturing processes. High level of chromium in drinking water is found to cause cancer and lethal to healthy well-being of human especially at the concentration above 1.0mg/L [21]. Iron is found widely in soils and is a constituent of many surface and underground waters [25]. The iron value observed in all borehole water samples in this study range from 0.035ppm to 0.299 ppm and were below WHO permissible limit which is 0.3 ppm. Iron values measured from the boreholes in this study was similar to that of Saheed and Amira [26] who reported iron level of the bore hole water samples to be 0.04mg/L, 0.04mg/L and 0.11mg/L for Doro, Tama and Agalawa in Kano State, Nigeria. Iron being one of the essential metals helps in the synthesis of heme proteins and the red colouration in blood. The human system also need iron to fight disease causing bacteria [27]. The concentration of iron above allowable level can result in cell damage of the gastrointestinal tract, heart and liver. Iron in excess may result in metabolic and genetic diseases which bring about blood transfusion repeatedly in patients [28, 29]. The lead value observed in all borehole water sample in this study range from 0.012 ppm to 0.105 ppm and is above WHO permissible limit which is 0.05 ppm while Nwoke and Edori [30] reported lead range of 0.012 - 0.015mg/L in bore sample at Kabuga Housing Estate, Kano State. Pb is linked to several ailing conditions such as neurobehavioral disorder, blood poisoning and reduction in judgement, lower intelligent quotient, growth retardation, hearing and speech deformations, and unbalanced behavior in children [31]. In adults, its effects are low sperm count, and influences abortion in women [32]. The occurrence of lead in boreholes (groundwater) might have originated from the corrosion of materials used for household and industrial plumbing works, mining activities and soil leaching and might also be from human activities like using lead laded fuels and the exploration, production and exploitation of oil [33]. Lead when contacted and ingested is detrimental to the health of adults, for exposure to it can result in increased pressure in the blood, cardiovascular effects, decrease in kidney functions, hypertension and reproductive challenges in both men and women.

pH is a significant factor that impacts many biological and chemical processes. It is a water quality assessment parameter which is very important in evaluating water supply and treatment. Our results show that pH of all the water samples from the boreholes range from 6.81-7.57. The values were within the recommended limit by WHO which is 6.5-8.5. In a related study, Ebong *et al.* [34] reported that the pH of borehole water sampled from different points in Mgboushimini is within the range of 4.31-4.73. Alex *et al*. [35] reported that pH of borehole water in Eliozu community, Port Harcourt is within the range of 5.5-8.0. The report of Ebong *et al.* [34] on pH range was below the range reported in the present study but the report of Alex *et al*. [34] was in accordance with the findings from this study. High pH of water sources could be as a result of bicarbonates that forms part of the raw materials essential for production which eventually reach the soil, later percolates into groundwater which is aided by rainfall. The pH of natural water range between 5.5 and 9.0. It has been established that high alkalinity of water is responsible for swelling of hair fibres as well as gastrointestinal irritation [35]. Since most of the minerals present in rocks underlying any area are soluble in water under appropriate geochemical condition, the pH of available water body in that area is affected based on the mineralogical and geochemical characteristics of the rocks [36]. Quite few of the unseen dissolved minerals as well as organic constituents found in ground water are highly toxic. Drinking water with an elevated pH above 11 can cause skin, eye and mucous membrane irritation. On the opposite end of the scale, pH values below 6.5 cause ulcer and irritation due to the corrosive effect of the low pH level [18]. Electrical conductivity (EC) is the ability of a solution to conduct an electrical current that is directed by the migration of solutions which is dependent on the nature and number of the ionic species in the same solution. It is an appropriate tool used in assessing the purity of water. Our result shows that the electrical conductivity of ranges from 41.616 - 173.485 µs/cm and was within WHO permissible limit which is 300-400 (µs/cm). Going by the result of EC of the water samples, they are suitable for domestic use, irrigation and other purposes. Low conductivity result reported in this study is an indication that small quantity of dissolved inorganic substances in ionized form could reach the water source from their surface catchment [35]. The EC of the water samples is in agreement with the findings of Olubanjo and Alade [38] from a related study involving water samples from boreholes. However, the values reported by the researchers is above the results reported in this study. Research findings by Ebong *et al*. [34] shows that the electrical conductivity of borehole water sampled from different points in Mgboushimini community is within the range of 331-533 µs/cm. Turbidity is the unclear condition of water caused by particles of organic matter, sand, clay and silt being held in suspension [37]. Turbidity value in the present study range 0.122 – 0.712 NTU. The concentrations of turbidity were within the WHO standard limit of 0 – 5 NTU. Low turbidity recorded in this study is due to little or no presence of colloidal solids presents in the water that causes water to have cloudy appearance and reduction in transparency. Turbidity in waters results from colloidal clay particles and colloidal organic matter originating from decay vegetation. The higher the turbidity level, the higher the risk that people may develop gastrointestinal diseases [39]. This is especially problematic for immune-compromised people, because contaminants like viruses or bacteria can become attached to the suspended solids [39].

5. Conclusion and Recommendation

Most of the physicochemical parameters determined were within the WHO permissible limit for drinking water. The result of the study showed that the borehole water samples are contaminated with the heavy metals assessed although some were within permissible limit while others were not. Bacterial and fungi contamination in the water samples were above the WHO standard limits which suggests that water from some of the borehole locations in the study area are not safe for drinking without treatment. Since most bacteria and fungi species survive disinfection and water treatment, it is therefore suggested that good treatment techniques that would eliminate not only bacteria, fungi but all forms of microorganisms that could cause water related diseases should be used to treat borehole water before allowing community pump from it. Also, proper sanitation practices should be implemented within the vicinity of borehole water, reservoirs and during production of sachet water. Furthermore, improved monitoring of water and frequent application of chlorine and other water treatment agent should be adopted. Finally, siting of boreholes close to latrines/toilets or dumpsite should be avoided.

Compliance with ethical standards

Disclosure of conflict of interest

There was no conflict of interest

Acknowledgement

We acknowledge the contribution of the laboratory technologist, Mr Mabayoje Samson in the Department of Biological Science, Afe Babalola University Ado Ekiti, Ekiti State during the bench work.

References

[1] Zumdahl, S. S. Water. University of Illinois Encyclopedia Brittannica. ©2020 Retrieved from https://www.britannica.com/science/water

[2] Aturamu A. Physical, Chemical and Bacterial Analyses of Groundwater in Ikere Township, Southwest, Nigeria. Int. J. Sci. Technol. Res. 2012; 2(5): 301-308

[3] Adebo, K and Adetoyinbo, R. Domestic water quality service level and health. W.H. O. Geneva, Switzerland. 2019;435: 67-89

[4] Odeyemi P, J., Denbesten, P, K., Schunior, A., Kernan, W, J. Neurotoxicity of sodium fluoride in rats, Neurotoxicol. Teratol., 2011; 17(2):169-177.

[5] Umerfaruq, K and Solanki, E. Groundwater Pollution and Evaluation of Physicochemical properties of Groundwater. Environmental Ecology 2015; 22(2): 319-324

[6] Bodija, O. B., Ede, P. N., Obinna, V. C. and Akarolo, C. I. Land market distortions in Nigerian Cities and Urban sprawl: The case study of Abuja and Port Harcourt. 44th Congress, Dalin, China, **2022;**78: 19-23

[7] Bernard, J. N., Agunwamba, J. and Amah, V. E. Determination of re-aeration Coefficient K2 for polluted stream as a function of depth, hydraulic radius, temperature and velocity" Nigerian Journal of Technology. 2017; 312; 174-180

[8] Olusola, G., Adebo, B. A. and Adetoyinbo, A. Assessment of Groundwater in unconsolidated Sedimentary Coastal Aquifer in Lagos State, Nigeria. Scientific Research and Essay. 2019; 4(4), 314-532

[9] Karlsen, H., Onojake, M. C. and Frank, O. Assessment of heavy metals in a soil contaminated by oil spill: a case study in Nigeria. Chemical Ecology 2019; 29(3): 246-254.

[10] Benson, L., Onojake, M. C. and Frank, O. Assessment of heavy metals in a soil contaminated by oil spill: a case study in Nigeria. Chemical Ecology, 2019; 29(3): 246-254.

[11] American Public Health Association, American Water Works Association, Water Environment Federation. Lipps WC, Braun-Howland EB, Baxter TE, eds. *Standard Methods for the Examination of Water and Wastewater*. 24th ed. Washington DC: APHA Press; 2023.

[12] Ashbolt, N. J., Grabow, W.O.K., Snozzi, M., Indicators of microbial water quality. In: Fewtrell, L., Bartram, J. (Eds.), Water Quality: Guidelines, Standards and Health. Risk assessment and management for water-related infectious disease. IWA Publishing, London 2001; pp. 289–315.

[13] Okoro, M., Vincent, J Benjamin, G. A. The Rhizosphere as a reservoir for opportunistic human pathogenic bacteria. Environment Microbiology. 2017; 67, 1672–1685.

[14] Adeiza, Z. O., Zakari, H. H., and Jere, S. A. Assessment of Bacterial Quality of some selected Boreholes water in Kurnar Asabe Quarters Kano metropolis. Annals of microbiological and infectious diseases 2018; 1 (2), pp 11 – 17.

[15] Adeola, W., Olalekan, M and Moshood, B. G. Microbiology of Drinking Water Production and Distribution. International Journal of Environment and Public Health. 2016;1416: 11-12.

[16] Joseph, F and Michelle, W. Reported waterborne outbreaks of gastrointestinal disease in Africa are predominantly associated with contaminated water. Austrial Public Health, 2021; 34, 527–530.

[17] Emmanuel A. H., and Francis, P. Microbiological Assessment of Boreholes, Sachet and Bottle Water in Ayobo, Lagos. Bacterial Empire, 2021; 4 (3), e287.

[18] W. H. O. Physicochemical Analysis of Borewell Water samples. Journal of Chemistry. 2020; 54; 924-929.

[19] Doggett. Disease outbreaks associated with untreated water use. Epidemiology and Infection. 2020; 139 (57):1114-1125

[20] Morgan, K., Drudy, D., Mullane, N.R., Quinn, T., Wall, P.G., and Fanning, S. Entero bacter sakazakii: An emerging pathogen in powdered infant formula. Clinical Infection.Diseases. 2015; 42, 996–1002.

[21] Edori E. S and Nwoke J, B. concentration of Heavy metals in Borehole water from Ikono urban,Ikono Local Government Area,, Akwa Ibom state, Nigeria. International Journal of Advanced Research in chemical science. 2020; 7(1): 27-33

[22] Musa, H., Yakasai, I. A., Musa, H. H. Musa K. Y and Gwarzo, M. S. . The Concentration of Cadmium in Borehole and Well Waters in Zaria, Nigeria. Journal of Applied Sciences*, 2007; 7: 3572-3575.*

[23] Klaassen, F. H., Held, L., Figner, B., O'Reilly, J. X., Klumpers, K., de Voogd, L. D., et al. Defensive freezing and its relation to approach-avoidance decision-making under threat. BioRXiv*.* 2021; doi: 10.1101/2021.01.29.428809

[24] Rahman, P and Murthy, R.. Distribution and Risk Assessment of Some Heavy Metals in Surface Water Sediments and Grey Millet (*Mugil cephalus*) from Contaminated Creek Marine Pollution Bulletin*.* 2022; 154: 111042

[25] Johnson, N and Gared, S. Comparative Analysis of Borehole Water in Funtua Local Government Area of Katsina State. Records of Chemical Science, 2017;961; 21–56.

[26] Saheed, M. D. and Amira, A. H.: Physico-Chemical Analysis of Ground Water Samples from Nassarawa L.G.A. Kano State Nigeria. Journal of Chemical and Pharmaceutical Research 2013; 5(8):162-173.

[27] Adriano D. C. Trace metals in terrestrial environment. Bioavailability and Risk Metals 3: 133.

[28] Anake , W. U., Benson, N. U., Akinsiku, A. A., Ehi-Eromosele, C. O and Adeniyi, O. I. Assessment of trace metals in drinking water and groundwater sources in Ota, Nigeria. International Journal of Scientific and Research Publications. 2014; 4:5

[29] Iyama, W. A., Edori, O.S. and Ikpe, S Study of pollution levels in Ahoada-Ihuaba axis of Sombreiro River, Ahoada, Rivers State, Nigeria. International Research Journal of Pure and Applied Chemistry, 2014; 4(4): 378- 387

[30] Nwoke, I. B and Edori, E. S. Levels of some chemical species in water of boreholes situated near dumpsites Rumu Olume ni, Port Harcourt, Rivers State, Nigeria. World Journal of Advanced Research and Reviews 2021; 12(02): 202-211.

[31] Hertz-Picciotto I. The evidence that lead increases the risk for spontaneous abortion. American Journal of Industrial Medicine. 2020; 38: 300-309.

[32] Flora S. J, Saxena G, Gautam P, Kaur P, Gill K. D. Lead induced oxidative stress and alterations in biogenic amines in different rat brain regions and their response to combined administration of DMSA and MADMSA. Chemical and Biological Interactions. 2007;170: 209-220.

[33] Kpee F, Edori O. S. Trace metals content in shore crabs (Cardisoma guanhumi) from coastal area of Port Harcourt City, Rivers State, Nigeria. Archives of Applied Science Research. 2014;6(6):16-21.

[34] Ebong, S. S; Etim, D. U; Otugo, V. N; Uko, O. E (2018). Evaluation of physicochemical and microbiological characteristics of borehole water in Mgboushimini community of River State, Nigeria. J. Adv. Med. Medical Res. 27 (8): 1-9.

[35] Alex, A. A; Chinedu, N. V; Olatunde, A. M; Longinus, N. K; Omosileloa, J. A (2015). Groundwater Assessment in Eliozu community, Port Harcourt, Niger Delta, Nigeria. Inter. J. Sci. Technol. Res. 4 (12): 149-156.

[36] Adesakin T. A, Oyewale A.T, Bayero U, Mohammed A.N, Aduwo I. A, Ahmed P.Z, Abubakar N.D, Barje I.B. Assessment of bacteriological quality and physico-chemical parameters of domestic water sources in Samaru community, Zaria, Northwest Nigeria. Heliyon. 2020 Aug 25;6(8):e04773.

[37] Oladipo, I & Onyenike, I. & Adebiyi, Ayobamitale. (2009). Microbiological analysis of some vended sachet water in Ogbomoso, Nigeria.

[38] Olubanjo, Obafemi & Alade, Adebolu. (2018). Evaluation of Irrigation Water Quality from Major Water Sources in Ondo and Osun States, Nigeria. Journal of Experimental Agriculture International. 24. 1-12. 10.9734/JEAI/2018/41558.

[39] Gidado M. J., Okafor G. C. O., Ochigbo S. S., Jibrin N.A. (2017) Determination of some quality parameters and risk factors of groundwater in different parts of Municipal area council, Abuja, Nigeria, British journal of innovation in science and technology, Volume 2(4)