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ASSESSMENT OF LOKOJA BOREHOLE WATER QUALITY FOR DOMESTIC USE, LOKOJA, KOGI STATE.

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ABSTRACT

Water source pollution has grown dramatically in the study region due to factors such as an expanding population, decreasing sanitation standards, recurrent floods, and low enforcement of environmental sanitation rules. Water samples were gathered from the Niger River, manually dug wells, and a borehole at Felele, Lokoja, in north-central Nigeria, in order to conduct investigations on the quality of the water. The hydro-geochemical data indicates that the pH values range from 6.40 to 7.30, suggesting an alkaline water type. The water hardness readings of the hand-dug wells are mildly to moderately hard, ranging from 8.46 to 237.09 on average, with an average of 95.30. The hardness readings in the hand-dug wells varied from 62.91 to 215.11 mg/l, the river samples from 6.92 to 9.78 mg/l, and the borehole sample from 61.02 mg/l, in that order. The results show that every value is higher than the World Health Organisation's (WHO) permitted drinking water level as well as the Nigeria Standard for Drinking Water Quality standard. Magnesium concentrations in all of the samples range from 1.11 to 10.74 mg/l, which is higher than the recommended level for drinking water in Nigeria. In every other water sample, the levels of TDS, Ca, and K, together with the heavy metals Pb, Cd, Cu, Fe, Mn, Ni, and Zn, and the physico-chemical parameters ToC, Ec, BOD, COD, HCO3, CO3, SO4 Cl, NO3, Na, and Ca, were all within permissible limits. TDS is correlated with taste, hardness, corrosion resistance, and water incrustation tendency. Some of the unsightly effects of hard water include deposits on dishes, utensils, and laundry basins; difficulty getting soap and detergents to lather; insulating precipitate formation on clothing; sinks that stain a distinctive blue-green color; choking in household pipes; scaling; incrustations on kitchen utensils; and increased soap usage. Both an individual's and a society's financial burden may result from water hardness. It is recommended to treat the water for hardness, TDS, calcium, magnesium, and potassium before drinking or utilizing it for other home uses. Adequate oversight by the appropriate authorities is required to ensure compliance and safety.

Keywords: Hydrochemistry, Lokoja, heavy metals, pH, hardness, Kogi State

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INTRODUCTION

This study presents an assessment of the water quality at Felele, Lokoja, close to the confluence of the Niger and Benue Rivers (Fig. 1). 1). Apart from the exceptional flooding incidents that occurred in September 2012 and October 2015 as a result of the Niger and Benue Rivers overflowing, the research region also experiences random rubbish disposal by the residents. This explains why the flooding was so severe, why hundreds of people needed to be evacuated, why thousands of homes were damaged, and why the surface and surrounding environment in parts of Kogi State, and especially Lokoja City, were inundated.

During floods, the contents of septic tanks and rivers are discharged into the environment, contaminating the surrounding regions and deteriorating the water resources. A variety of processes, including soil leaching, rock weathering, atmospheric aerosol particle dissolving, and human activities including mining, processing, and utilising metal-based items, may result in the entry of metals into an aquatic system (Ipinmoroti and Oshodi, 1993; Adeyeye, 1994; Asaolu et al., 1997). The government's increasing use of metal-based fertilisers in the agricultural revolution may contribute to the accumulation of metal contaminants in freshwater reservoirs by increasing runoff. Metals that enter the water may be absorbed by plants and animals, leading to their eventual accumulation in marine species that people consume, according to Asaolu et al. (1997).

The study area exhibits a disturbing prevalence of indiscriminate waste and faeces, particularly along river and stream courses and their tributaries. Septic tanks that are overflowing and visible in the research area should be taken seriously since they have the potential to pollute water sources with human waste. Water-borne illnesses caused by faecal contamination of drinking water have killed millions of people in cities and villages (Asaolu et al., 1997). Uncontrolled rubbish dumping into a river's discharge may harm the aquatic life there and alter the waterway's chemical composition (Adewoye, 1998). Water quality characteristics in any given location result from numerous physical, chemical, and biological processes.

Drinking contaminated water may lead to many ailments, such as cholera, typhoid, dysentery, skin problems, and mental health problems, regardless of the toxins present (Okolo et al., 2009). The groundwater supply's quality is determined by the way human waste is handled and by the catchment regions' natural physicochemical characteristics (Efe et al., 2005).

Oluduro and Aderiye (2007) assert that enhancing quality of life and reducing illness rates rely on having access to clean water. In Ganaja, Lokoja, the Niger River, hand-dug wells, and boreholes were all assessed for water quality as part of the present research to determine whether the water was suitable for human consumption and household use. This is critical since water is the most essential resource for human existence, second only to air. Water is not only important for drinking but also for washing, cooking, and maintaining overall hygiene. Before man runs out of food more quickly than water, more time may pass.

THE HYDROGEOLOGY AND GEOLOGY OF THE STUDY AREA

The study area is situated in Felele, Lokoja, north-central Nigeria, between latitudes 6°57′N and 6°38̩N and longitudes 6°43′E and 6°45′E (Fig. 1). According to Omada et al. (2009), Lokoja is located at the confluence of the Niger and Benue Rivers, the Nigerian Precambrian Basement Complex, the Lower Benue sedimentary inland basin (Benue Trough), and the

Campanian-Maastrichian sedimentary Bida Basin. The geology is made up of rocks from the Precambrian basement complex, mostly gneiss and migmatite with older granite intrusions. Mineral layering in gneiss is often seen, with alternating zones rich in quartz-feldspar and biotite (Obaje, 2009). The principal foliation and fracture tendencies of the River Niger are evident in its flow direction, which is north-south and northnortheast (Obaje, 2009).

The research region is mostly composed of gneiss (augen, porphyroblastic, and biotite gneiss), migmatite, and earlier granite that have been intruded by pegmatite dykes that trend NE-SW. The Cretaceous to Recent coarse-medium-grained sands that make up the eastern portion of the region constitute the bank of the River Niger (Fig. 1).

The Niger River and precipitation recharge groundwater in the Lokoja area, which is located in worn and/or cracked foundation rocks (Omali, 2014). The two aquifer types found in the area are weathered layer aquifer and weathered/fractured aquifer (Musa et al., 2014). Normally, the Lokoja area is drained by the Niger, Benue, and Meme rivers. Ibrahim et al. (2014) state that the research field lacks sufficient data on aquifer properties. Aquifer test results show that the static water level ranges from 1.5 to 7.6 meters, the well depth is between 8.2 and 21.8 meters, and the yield is between 70 and 130 meters per day (Ibrahim et al., 2014).

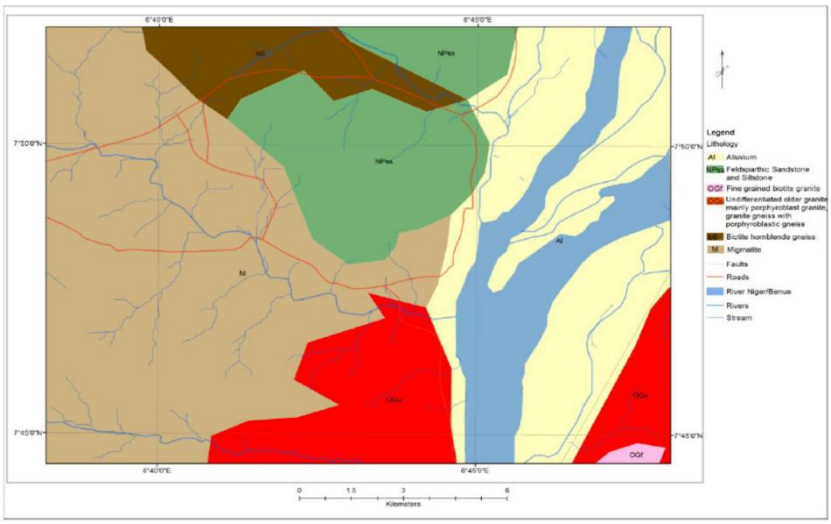


Figure. 1. Geological map of Lokoja & Environs (Source: Omali, 2014)

MATERIALS AND METHODS:

Water samples were gathered from various sources as shown in Table 1.0 (three from the River Niger, eleven from hand-dug wells, and one from a borehole) in multiple locations in Felele. The altitude and coordinates for Water Samples

Physical and Chemical Parameters

	SU 1	SU2	SU3	SU4	SU5	SU6	SU7	SU8	SU9	SU10
	Concentration in mg/l									
Si	0.10	0.02	0.02	0.01	0.01	BDL	0.02	BDL	BDL	0.01
Mn	0.02	0.04	0.03	0.03	0.02	BDL	0.01	BDL	BDL	0.03
Ti	0.02	0.01	0.01	0.01	0.01	0.01	0.01	BDL	BDL	0.01
Cl^-	18.32	5.22	5.80	5.56	4.95	4.80	1.84	0.89	0.68	7.43
CO_3^{2-}	2.01	0.15	0.93	0.14	0.17	0.18	0.12	0.15	0.14	0.16
HCO_3^-	19.42	8.62	8.00	3.57	4.01	4.98	15.89	18.60	3.11	5.94

Note: BDL……..Below Detection Limit

This study presents a water quality assessment of Felele, Lokoja, which is close to the confluence of the Niger and Benue rivers (Fig. 1). 1). The Niger and Benue Rivers overflowing caused the study region to undergo unparalleled flooding occurrences in September 2012 and October 2015, in addition to the random disposal of rubbish by the residents. This explains the extreme flooding, the destruction of thousands of houses, the forced relocation of hundreds of people, and the inundation of the surrounding environment and surface in parts of Kogi State, especially the capital of Lokoja.

Floods degrade water supplies and pollute neighbouring regions by releasing septic tank guts and rivers full of different forms of filth into the environment. Many processes, such as soil leaching, rock weathering, air aerosol particle dissolution, and human activities like mining, processing, and using metal-containing products, can introduce metals into an aquatic system (Ipinmoroti and Oshodi, 1993; Adeyeye, 1994; Asaolu et al., 1997).

The concentration of metal contaminants in freshwater reservoirs may continue to rise as a result of water runoff and the government's expanding use of fertilisers based on metals in the agricultural revolution. Asaolu et al. (1997) state that metals that enter the water may be taken up by plants and animals, which might lead to an accumulation of the metals in marine species that people consume.

The extent of indiscriminate faeces and waste across the survey zone is alarming, particularly in the areas near river and stream courses and their tributaries. Visible in the research region, overflowing septic tanks are a source of worry as well since they have the potential to pollute water systems with human waste. Consuming water contaminated by human waste has killed millions of people in cities and towns due to waterborne diseases (Asaolu et al., 1997). Trash that is dumped into rivers without supervision may negatively affect the aquatic life there and alter the waterway's chemical composition (Adewoye, 1998). Numerous physical, chemical, and biological interactions result in the features of every ecosystem that are connected to water quality.

Whatever the pollutants, drinking contaminated water may lead to cholera, typhoid, dysentery, skin problems, and mental health problems, among other disorders (Okolo, et al., 2009). The natural physicochemical traits of the catchment areas and how human waste is managed affect the quality of the groundwater supply (Efe et al., 2005).

Having access to clean water is crucial for lowering disease and improving quality of life, claim Oluduro and Aderiye (2007). The purpose of the present research was to assess the suitability of the water for home use and human consumption in Ganaja, Lokoja, by testing the water quality in hand-dug wells, boreholes, and the Niger River. This is important because water is the second most essential resource for human life after air. Apart from being required for drinking, water is also needed for cooking, cleaning, and overall hygiene. It will take more time for man to run out of food than water.

GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

The research area is in the north-central Nigerian state of Felele, Lokoja, between the latitudes 6°57′N and 6°38′N and longitudes 6°43′E and 6°45′E (Fig. 1). The Lower Benue sedimentary inland basin (Benue Trough), the Nigerian Precambrian Basement Complex, the Campanian-Maastrichian sedimentary Bida Basin, and the Niger and Benue Rivers all converge in Lokoja (Omada et al., 2009). The rocks that make up with earlier granite intrusions, the precambrian basement complex is mostly composed of gneiss and migmatite.

Biotite and quartz-feldspar-rich alternating zones are typical characteristics of gneiss mineral layering (Obaje, 2009). The primary tendency for foliation and fracture in the N-S and NNE directions are seen in the flow direction of the River Niger (Obaje, 2009).

Intruded by NE-SW trending pegmatite dykes, the study region is predominantly composed of migmatite, earlier granite, and gneiss (augen, porphyroblastic, and biotite gneiss). The coarse-medium grained sands from the cretaceous to recent eras dominate the eastern portion of the region and form the bank of the River Niger (Fig. 1).

Groundwater in the Lokoja area is supplied by precipitation and the Niger River and is found in worn and/or cracked basement rocks (Omali, 2014). According to Musa et al. (2014), there are two kinds of aquifers in the area: weathered layer aquifer and weathered/fractured aquifer. The Lokoja area is normally drained by the Niger, Benue, and Meme rivers. As per Ibrahim et al. (2014), the research field has little data about aquifer properties. Data from aquifer testing indicate that the static water level is between 1.5 and 7.6 metres, the well depth is between 8.2 and 21.8 metres, and the yield is between 70 and 130 metres per day (Ibrahim, et al., 2014).

TABLE 2: MODAL COMPOSITION

Sample: SU 4					
Minerals present	1st count	2nd count	3rd count	Average	Percentage
Quartz	16	17	18	17.00	89.47
Felspar	0	0	1	0.33	1.75
Opaque	1	0	1	0.67	3.51
Others	1	1	1	1.00	5.26
Total	18	18	21	19.00	100.00

The methodology used is:

DETERMINATION OF CHLORINE (MOHR'S METHOD)

Apparatus

- ✓ Titration apparatus.
- ✓ Analytical balance.

REAGENTS

- ✓ 0.025M Silver nitrate solution.
- ✓ 5% Potassium chromate indicator.

PROCEDURE

50 ml of water sample was pipetted into 250 ml conical flask. 1 ml of the indicator was added and titrated with silver nitrate solution until a permanent brick red precipitate persisted. The titre value was recorded as V_T. The titration is repeated and the average is determined for each sample.

Then, $$Cl\ (ppm) = \frac{V_T \times 0.025}{1000} \times 35.5 \times \frac{1000}{50}$$

Determination of Carbonate (CO_3^{2-}) and Bicarbonate ($HCO3^-$)

Apparatus

- ✓ Standard volumetric flasks and beakers.
- ✓ Pipette, burette stand and holder.
- ✓ Burette with 0.05 graduations.
- ✓ pH meter.
- ✓ Thermometer.

REAGENTS

- ✓ Distilled water.
- ✓ pH meter buffers 4,7 and 10.
- ✓ H_2SO_4 standard solution.

Procedure

For determining carbonate and bicarbonate, the preliminary technique from Barnes et al., 1981 was utilized. The instruments used included standard volumetric flasks, beakers, pipettes, burette stands and holders, semi-micro burettes with graduations of 0.02 ml, pH meters, and thermometers. Distilled water, pH meter buffers (4, 7, and 10), and H2SO4 standard solution were the reagents employed. Every sample was filtered and then calibrated using buffers and pH meters. The pH levels of the samples were tested and recorded. The prepared H2SO4 standard solution was added in 0.5 ml increments if the pH was greater than 8.3. After each addition, the pH readings were recorded against the volume of titrant until the pH fell below 8.0. Equilibration was permitted to occur for 15–20 minutes. The endpoint, or the point at which the pH changes the most for a given quantity of titrant, is the inflection point of the curve.

Accordingly, HCO32- (mg/l) = 1000 x [(mla at endpoint near pH 4.5) - mls – 2 (mla at endpoint near pH 8.3)] x 1.0

Where mla is the titrant volume and mls is the sample volume utilised.

RESULTS AND DISCUSSION

Table 1: Water Hardness shows Classificationused for Water Hardness

Table 2: Classification used for Water Hardness (Source: Gray,1994)

Classification used for Water Hardness. **Degree of Hardness**	**Conc. (Mg/l)**
Soft	0-50
Moderately Soft	50-100
Slightly Hard	100-150
Moderately Hard	150-250
Hard	250-350
Excessively Hard	350+

Parameters	WHO(2011)	NSDWQ(2007)	Parameters	WHO(2011)	NSDWQ(2007)
pH	6.50-9.00	6.50-8.50	Cd	0.003-0.03	0.03
Ec(µs/cm)	250	1000	Mn	0.5	0.2
TDS(mg/l)	500.00-1000.00	500	Ni	0.01-0.02	N/A
Temp(°C)	29	Ambient	Cl	250	250
Mg	150	0.2	SO_4	50	50
Ca	75	N/A	NO_3	50.7	50.7
K	12	N/A	HCO_3	600	N/A
Na	200	200	CO_3		
Fe	0.3	0.3	BOD	NA	NA
Cu	2	1	Hardness	150	150
Zn	3	3	COD	NA	NA
Pb 0.4 0.01					

Source: NSDWQ (2007)

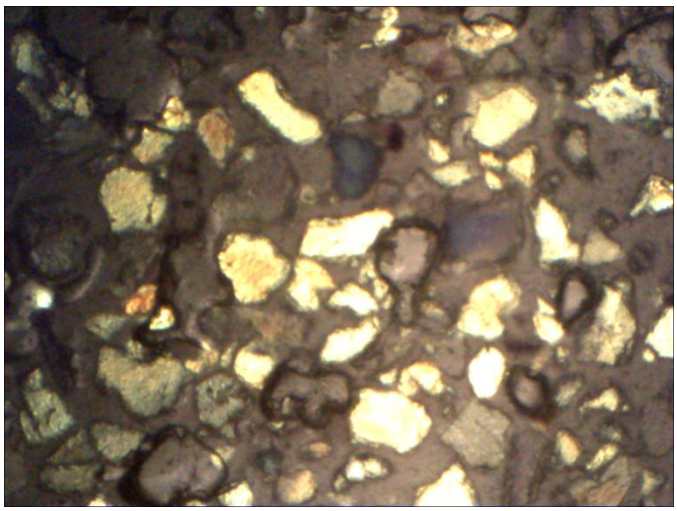


Plate I: SEM of soil sample

The water hardness measured in the borehole and the samples taken from the river both fall within acceptable ranges. Studies have shown an inverse relationship between water hardness and cardiovascular disease (Kahlown et al., 2006). Hard water could cause aesthetic

problems. Among these problems are deposits on dishes, utensils, laundry basins, an alkali taste (which makes coffee bitter in the morning), choking of household pipes, scaling, incrustations on kitchen utensils, trouble getting soup and detergents to lather, formation of insulating precipitate on clothing, and a unique blue-green staining of sinks. According to Kahlown et al. (2006), water hardness may be both an annoyance and a financial burden on the neighbourhood.

The pH readings of all the water samples range from 6.70 to 7.70, with an average of 7.14, suggesting that the water is alkaline. The Ec values vary from 0.21 to 0.73 µs/cm, with an average value of 0.36 µs/cm. The temperature (°C) values range from 28.50 to 29.40 °C with an average value of 29.07°C, while the TDS values range from 4 to 525 mg/l with an average value of 262.53 mg/l. WHO (2011) and NSDWQ (2007) drinking water permitted levels are all within range, with the exception of the borehole water sample (BH-S1) TDS of 525 mg/l, which is higher than the NSDWQ (2007) recommendation of 500 mg/l. TDS is correlated with taste, hardness, corrosion resistance, and water incrustation tendency. TDS and EC are important in assessing the quality of water because they affect the corrosiveness of a water sample and the solubility of compounds that are marginally soluble, such as CaCO3. (Nas, 2010). According to Langenegger (1990), electrical conductivity is often used as a proxy for salinity, which affects flavour and, in turn, the user's assessment of the water's suitability for drinking.

The BOD and COD values range from 0.12 to 5.97 mg/l and 0.97 to 20.54 mg/l, respectively, with an average concentration of 4.85 mg/l. The average concentration of COD is 0.75 mg/l.

The K concentrations in the water samples vary from 1.3 to 13.0 mg/l, and the average AF value is 5.93 mg/l, with a range of 0.11 to 1.08 mg/l. The sample (HW-S10) contains more potassium than what is considered safe for drinking water by the WHO, and the pollution's cause is human activity, as shown by the sample's anthropic footprint value of 1.08 mg/l. Potassium is a soft, silvery alkaline metal that is naturally linked to other elements in saltwater and minerals. It has a strong reactivity, oxidises fast in water, and has chemical similarities with sodium. The mineral potassium is necessary for the body's electrical and cellular functions. The range of total potassium in the body and blood serum is 4-5 mg/100 ml. A potassium deficiency results in irregular heartbeats, hypertension, muscle weakness, bladder weakness, and asthma; an overdose may induce cystitis, bladder infections, ovarian cysts, and weakened immune system (ACU-Cell, 2003). Excess potassium in the blood, or hyperkalemia, may cause serious infections, abnormal protein oxidation, and impaired kidney function (Aparna, 2001).

The AF result indicates that the amount of Ca in (HW-S11) is greater than the WHO acceptable level for drinking water, which ranges from 0.01 to 1.06 mg/l. Ca has a value between 1.09 and 79.89 mg/l, with an average of 32.97 mg/l. The contamination is caused by human activities, as shown by the anthropic footprint value of 1.06 mg/l. When calcium and water mix, the hydrogen is displaced and calcium hydroxide is created.

The samples had an average magnesium content of 6.05 mg/l, ranging from 1.11 to 10.74 mg/l. Although this is over the drinking water standard set by the NSDWQ (2007), it is still within the permissible limits set by the WHO (2011). Anthropogenic causes of pollution are indicated by the AF value, which varies from 5.55 to 53.7 mg/l.

Sodium concentrations vary from 14.28 to 107 mg/l, with an average of 50.29 mg/l. Na is a soft, silvery, waxy reactive metal that is often present in organic substances. It belongs to the class of alkali metals. Because it oxidizes in the air and reacts negatively with water, it has to be kept in an inert atmosphere. Heart function, blood and body fluid regulation, nerve impulse transmission, and other metabolic activities all depend on sodium. ACU-Cell (2003) states that symptoms such as low blood pressure, tiredness, depression, convulsions, and mental apathy may indicate a salt deficiency in the body. Similarly, oversupply, as reported, can cause high blood pressure, stroke, nausea, migraines, kidney damage, and swelling.

The average content of HCO3 and CO3 is 75.38 mg/l, with a range of 12 to 183 mg/l, 0.13 to 1.66 mg/l, with an average of 0.51 mg/l in between. While the average findings of the heavy metal tests for lead, cadmium, copper, iron, manganese, nickel, and zinc are below the allowable limits for drinking water, the concentrations of chloride, nitrate, and sulfate are 1.12, 0.57, and 4.30 mg/l respectively. When the AF value of any trace element is less than 1, a geogenic source is indicated.

CONCLUSION

The water is alkaline due to the high calcium content in HW-S11, the high potassium content in HW-S10, and the high TDS value in BH-S1. The average hardness ratings of all the water samples indicate that the water is mildly to moderately hard. The amounts of magnesium in each sample exceed the permissible level established by the National Drinking Water Quality Standards (2007). The acceptable limits set by the NSDWQ (2007) and WHO (2011) apply to ToC, Ec, BOD, COD, HCO3, CO3, SO4 Cl, NO3 Na, Ca, and the heavy metals Pb, Cd, Cu, Fe, Mn, Ni, and Zn. Potassium is a soft, silvery alkaline metal that is naturally linked to other elements in saltwater and minerals. It has a strong reactivity, oxidizes fast in water, and has chemical similarities with sodium. The mineral potassium is necessary for the body's electrical and cellular functions. The range of total potassium in the body and blood serum is 4-5 mg/100 ml. A potassium deficiency results in irregular heartbeats, hypertension, muscle weakness, bladder weakness, and asthma; an overdose may induce cystitis, bladder infections, ovarian cysts, and weakened immune system (ACU-Cell, 2003). Excess potassium in the blood, or hyperkalemia, may cause serious infections, abnormal protein oxidation, and impaired kidney function (Aparna, 2001). TDS is correlated with taste, hardness, corrosion resistance, and water incrustation tendency. Studies have shown an inverse relationship between water hardness and cardiovascular disease (Kahlown et al., 2006). Hard water could cause aesthetic problems. Some of these issues include deposits on dishes, utensils, laundry basins, an alkaline taste (which makes coffee taste bitter in the morning), clogging of household pipes, scaling, incrustations on kitchen utensils, trouble getting soups and detergents to lather, formation of an insulating precipitate on clothing, and a unique blue-green staining of sinks. Both individuals and society as a whole experience the challenges and economic costs associated with contaminated water. The availability of clean water is essential for reducing sickness and improving living standards. Since consuming contaminated water can potentially cause long-term harm to one's well-being, water must be entirely purified before using it for other needs.

RECOMMENDATION

Bacteriological analysis should be used to ascertain the amount of contamination in both surface and groundwater, since their physical and chemical tests are not capable of doing so.

Regular water quality testing and validation, along with hygienic inspections to uphold environmental health laws, are crucial to guaranteeing a safe environment and healthy living.

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