



PHYSICO-CHEMICAL ANALYSIS OF UNDERGROUND IN OVIA-NORTH AREA OF BENIN-CITY



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Abstract : The quality of groundwater in Ovia North Local Government Area of Benin City, Edo State, was investigated using physicochemical parameters. Water samples were collected from boreholes and open wells across four locations: two (a well and a borehole) from Igwe Hana community and two (a well and a borehole) from Ekosodin community. The parameters analyzed included pH, turbidity, total dissolved solids (TDS), conductivity, chloride, alkalinity, sulphate, nitrate, phosphate, arsenic, and lead. Standard methods of analysis were employed for each parameter, with heavy metal concentrations determined using atomic absorption spectrophotometry (AAS). The results indicated pH values ranging from 4.20 to 6.87, turbidity from 0.00 NTU to 32.00 NTU, TDS from 20.10 mg/L to 117.50 mg/L, alkalinity from 36.00 mg/L to 156.00 mg/L, chloride from 0.35 mg/L to 1.00 mg/L, phosphate from 0.04 mg/L to 1.95 mg/L, and lead concentrations from <0.005 mg/L to 0.91 mg/L. When compared with WHO standards, the borehole water samples were generally more suitable for drinking, except for elevated lead levels observed in boreholes relative to the open wells.

Key words: Groundwater, physicochemical parameters, water quality, atomic absorption spectrophotometry, WHO standards

Introduction

The main resource of fresh water is the groundwater, which is commonly used for domestic, irrigation and industrial purposes. The domestic and agricultural activities in towns and villages entirely depend on the groundwater and hence, the importance of groundwater quality. Ayesha .D. (2012) and Bakare, O. M. (2005) The quality of water and its environment is subjective to the geologic formation of an area and mostly, the groundwater contains more mineral contents than the surface water. It is due to the fact that the groundwater movement is slow and hence, longer contacts time with the sediments. Chapolikar, A. D., and Ubale, M. B. (2010) Furthermore, the hydrologic conditions have a significant role in the change of groundwater quality over a period of time. Chapolikar, A. D., and Ubale, M. B. (2010)

The main cause for the outbreak of chronic diseases in human beings is the polluted groundwater. Ayesha .D. (2012) Chapolikar, A. D., and Ubale, M. B. (2010) and Deepshikha, G., et al., (2008) Hence, it becomes essential to ensure the quality of groundwater to utilize it for various purposes. Rapid growth of industrial activities, dumping of industrial waste and improper disposal of garbage are among the major factors that affects the groundwater quality. Chuita, J., and Sarma, S. (2009) . The various physico-chemical groundwater quality parameters were assessed and the values obtained are compared with the permissible/desirable values prescribed by the Bureau of Indian Standards (BIS) and World Health Organization (WHO) in order to ensure the quality of groundwater to make use of it for domestic purpose. Acquiring the relationship between various physico-chemical parameters helps in reducing the uncertainties associated with decision making and also, it helps in promoting the

advancement in research.. The present study was undertaken to investigate the groundwater quality at various sampling site in Ovia North LGA of Benin-city, Edo state.

Materials and Methods

Sample location and study

SAMPLE 1 (W₁) – Well water from Igwe-Hana Community, Ovia-North LGA, of Benin

SAMPLE 2 (B₁) – Borehole water from Igwe-Hana Community, Ovia-North LGA, of Benin

SAMPLE 3 (W₂) – Well water from Ekosodin Community, Ovia North East LGA, of Benin

SAMPLE 4 (B₂) – Borehole water from Ekosodin Community, Ovia North East LGA, of Benin

Determination of pH

pH is a measure of free hydrogen ions and hydroxyl ions concentration in water. Because it can be affected by chemicals in the water, pH is an important indicator that changes chemically. Deepshikha, G., et al., (2008)

The pH of the water samples collected was determined in the laboratory using the JENWAY 3020 pH meter instrument. The meter was first calibrated using a buffer of 7.0, and rinsed severally with distilled water. The electrode was inserted into each of the sample bottles containing underground water from different sites and was held in the container for a few minutes until the digital display reading stabilized. The values was read and recorded.

Determination of Turbidity (NTU)

Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter and plankton and other microscopic organisms.

Turbidity is a measure of the clarity of water body and is an optical measurement that compares the intensity of light scattered by a water sample with the intensity of light scattered by a standard reference suspension. It is commonly recorded in nephelometric turbidity units (NTUs).

The turbidity of water was carried out using the HACH COLORIMETER [DR/890]. The program number (95) was typed and the equipment was blanked using 10ml of distilled water measured into a sample cell. The sample cell was wiped and put into the colorimeter, thereafter zero the equipment.

10ml of the water sample to be analyze was measured and put in another sample cell and wiped and put in the colorimeter, wiped with a white handkerchief, then the read button was pressed to read and record the value. Denise, E. M., and John, V. S. (2014)

Determination Of Electrical Conductivity (MS/CM)

A conductivity/TDS meter (model 470) was used to measure the conductivity of water samples. The meter was first calibrated with 0.01M potassium chloride solution (KCL). The conductivity was then determined by placing the meter probe into the sample containers containing water samples. The probe was held in the container for a few minutes until the digital display reading stabilized. The value was read and recorded. Emmanuel, B., and Aiyeni, N. (2012)

Determination of Total Dissolved Solid (mg/L)

A conductivity/TDS meter (model 470) was used to measure the total dissolved solid (TDS) of water samples. The meter was first calibrated with 0.01M potassium chloride solution (KCL). The TDS was then determined by placing the meter probe into the sample containers containing water samples. The probe was held in the container for a few minutes until the digital display reading stabilized. The value was read and recorded. Gichuki, J. G., and Gichumbi, J. M. (2012)

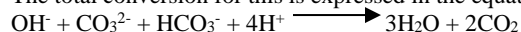
Determination Of Alkalinity (mg/L)

Alkalinity is a measure of the substance in water that have "acid-neutralizing" ability. The main sources of natural alkalinity are rocks, which contain carbonate, bicarbonate and hydroxide compounds, borates, silicates and phosphates may also contribute to alkalinity. Total alkalinity is the total concentration of bases in water expressed in milligram per liter (mg/L) of calcium carbonate. Water with high total alkalinity is not always hard, since the carbonate can be brought into the water in the form of sodium or potassium carbonate. Alkalinity itself is not harmful to health, but in large quantity, alkalinity impact bitter taste to water Deepshikha et al., (2008).

The alkalinity was determined using titrimetric method to a pH of 4.5 with methyl orange as indicator.

The reagents used are: 0.02M HCL, methyl orange indicator, water sample.

Procedure: 50ml of the sample was measured out, using a measuring cylinder, into a clean conical flask and 3 drops of methyl orange was added and shaken, thereafter the solution titrated against 0.02M HCL until a pH of about 4.5-4.6 (end point), the colour changes from yellow to orange. This was repeated and the average volume of the acid was calculated. The total conversion for this is expressed in the equation:



$$\text{Total alkalinity (mg/l)} = \frac{[V \times M \times 100000]}{\text{ml of sample}}$$

V = volume of titrant used.

M = molarity of titrant.

Determination of Chloride (mg/L)

Chloride anion (Cl^-) is generally present in natural water. Chlorides as chloride anions (Cl^-) are major anions in waste water. The chloride concentration is higher in organic waste and its higher level in natural water is a definite indication of pollution from domestic sewage (Shinde *et al.*, 2011).

The chloride ion was determined by Argentometric titration. The reagent used are; distilled water, water sample, potassium chromate indicator solution, 0.0141M AgNO_3 .

The potassium chromate indicator solution was prepared by dissolving 1g of K_2CrO_4 in a little distilled water and adding AgNO_3 solution until a definite red precipitate formed. Thereafter left to stand for 12hours, then filtered and diluted to 20ml with distilled water.

Procedure: 100ml of the sample was measured into a conical flask and 1ml of potassium chromate indicator (K_2CrO_4) added before titrating against 0.0141M silver nitrate (AgNO_3) to a pinkish yellow end point.

This was repeated and the average volume of the AgNO_3 was calculated.

The titration was repeated with distilled water for blank.

The equation for calculating chloride ion content is shown below; Chuita, J., and Sarma, S. (2009)

$$\text{Cl}^- (\text{mg/l}) = \frac{(A-B) \times N \times 35450}{\text{ml of sample}}$$

Determination of Sulphate (mg/L)

The HACH colorimeter (DR/890) model was used in the analysis of sulphate. The instrument was first blanked with 10ml distilled water after entering the program number (91). The content of one sulfa ver 4 sulphate reagent powder pillow was added to 10ml of the sample in a sample cell, mixed by inverting several times and concentration read from the display screen in mg/l after allowing to stand for 5 minutes. Thus the values were recorded. Ikejimba, C. C., and Sakpa, S. (2014)

Determination of Nitrate (mg/L)

The HACH colorimeter (DR/890) model was used in the analysis of nitrate. 10ml of distilled water was measured into the blank cell. After entering the program number (54), the blank cell was used to zero the equipment by inserting it into the cell holder, replacing the cap and pressing the zero button. 10ml of the sample to be analyzed was measured into the sample cell and one Nitra Ver 5 nitrate reagent powder pillow was added and mixed. The sample was allowed to stand for five (5) minutes. The nitrate concentration of the sample was then measured by inserting the sample cell into the cell holder and covered. After pressing read, the concentration was displayed on the screen in mg/l. and the value recorded. Janardhana, R. D., Hari, B. B., Swami, A., and Sumithra, S. (2013).

Determination of Phosphate (mg/L)

The HACH colorimeter (DR/890) model was used in the analysis of phosphate. The instrument was first blanked with 10ml distilled water after entering the program number (79). The content of one PhosVer 3 phosphate powder pillow was added to 10ml of sample in the sample cell, mixed by inverting severally for 15 seconds, and allowed to stand for two (2) minutes.

The phosphate concentration of the sample was then measured by inserting the sample cell into the cell holder and covered. After pressing read, the concentration was displayed

on the screen in mg/l and the value recorded. Janardhana, R. D., et al., (2013)

Determination of Trace Metals (mg/l)

In determining trace metals, the water samples were pre-concentrated from 60 ml to about 20 ml by evaporation on a hot plate after addition of 3 ml concentrated nitric acid to digest the organic matter. Where waters are relatively clean with low total dissolved solids content, water can be introduced directly into the instrument. After concentration, the sample was filtered by Whatman filter paper and transferred to 50 ml volumetric flask. The volume was made up to the mark with distilled water.

Table 1.1: Results of physicochemical analysis

PARAMETERS	SAMPLE 1 (W1)	SAMPLE 2 (B1)	SAMPLE 3 (W2)	SAMPLE 4 (B2)	PARAMETERS
P _H	6.87	4.72	5.70	4.20	P _H
TDS (mg/l)	117.50	22.30	47.50	20.10	TDS (mg/l)
Turbidity (NTU)	4.00	0.00	32.00	1.00	Turbidity (NTU)
Conductivity (µS/cm)	13310.00	33.60	77.20	36.30	Conductivity (µS/cm)
Alkalinity (mg/l)	156.00	34.80	45.20	36.00	Alkalinity (mg/l)
Chloride (mg/l)	0.50	0.35	0.65	1.00	Chloride (mg/l)
Nitrate (mg/l)	1.03	0.84	0.53	0.66	Nitrate (mg/l)
Sulphate (mg/l)	20.00	3.00	13.00	19.00	Sulphate (mg/l)
Phosphate (mg/l)	1.61	1.95	0.40	0.04	Phosphate (mg/l)
Lead(Pb) (mg/l)	0.91	0.46	< 0.005	0.91	Lead(Pb) (mg/l)
Arsenic(As) (mg/l)	<0.005	<0.005	<0.005	<0.005	Arsenic(As) (mg/l)

Table 1.2: WHO permissible limit for drinking water

PH	6.5-8.5
ELECTRICAL CONDUCTIVITY (µS/cm)	1000
TURBIDITY (NTU)	5.0
TOTAL DISSOLVED SOLID (mg/L)	500
ALKALINITY (mg/L)	100
CHLORIDE (mg/L)	250
SULPHATE (mg/L)	500
NITRATE (mg/L)	50
PHOSPHATE (mg/L)	0.01
LEAD (mg/L)	0.01
ARSENIC (mg/L)	0.01

WHO Standard for drinking water 1993

Discussion

The results presented in Tables 1.1 and 1.2 outline the physicochemical parameters analysed in the water samples.

pH Levels:

The pH values recorded for the four sampling stations were 6.87, 4.72, 5.70, and 4.20 for W1, B1, W2, and B2,

The various metals in water samples after pre-concentration were determined using the atomic absorption spectrophotometer. WHO, (2017).

Tota

Result

The physicochemical parameters of the water samples analyzed are shown in the Table below WHO Standard for drinking water 1993 The physicochemical parameters of the water samples analyzed are shown in the Table below The physicochemical parameters of the water samples analyzed are shown in the Table below

respectively. According to WHO standards, a pH range of 6.50-8.50 is considered safe for drinking water. Sample W1, with a pH of 6.87, falls within this range. However, samples B1, W2, and B2, which are strongly acidic, could lead to corrosive water. Acidic water can erode pipes, leach harmful metals such as lead and copper into the water supply, and cause skin and eye irritation upon exposure WHO, (2017).

Total Dissolved Solids (TDS)

The TDS levels in mg/L were 117.50, 22.30, 47.50, and 20.10 for W1, B1, W2, and B2, respectively. The WHO standard for TDS is 500 mg/L. All the samples are within the safe limit. However, low TDS levels, as seen in B1 and B2, can result in water that is less palatable and may lack essential minerals. Conversely, high TDS levels, though within the standard, might lead to a bitter taste and potential scaling in pipes and appliances if consistently elevated WHO, (2017).

Turbidity

Turbidity levels, recorded in NTU, were 4.00, 0.00, 32.00, and 1.00 for W1, B1, W2, and B2, respectively. WHO recommends a maximum turbidity of 5 NTU. Samples B1 and B2 had lower turbidity values, while W1 was near the limit, and W2 significantly exceeded it. High turbidity can harbor microbial pathogens, reducing water disinfection efficiency,

leading to potential outbreaks of waterborne diseases such as diarrhea WHO, (2017)..

Alkalinity

Alkalinity in the samples, measured in mg/L, was 156.00, 34.80, 45.20, and 36.00 for W1, B1, W2, and B2, respectively. While B1, W2, and B2 were within WHO limits, W1 and W2 showed elevated alkalinity levels. High alkalinity can cause scaling in pipes and affect the taste of water, while low alkalinity reduces the buffering capacity of water, making it more susceptible to pH changes, which can lead to corrosive conditions WHO, (2017)..

Chloride Content

The chloride levels were 0.50, 0.35, 0.65, and 1.00 mg/L for W1, B1, W2, and B2, respectively, all well below the WHO limit. Excessive chloride in drinking water, though not observed here, can impart a salty taste and lead to high blood pressure when consumed over time (WHO, 2017).

Nitrate Levels

Nitrate levels in the samples were 1.03, 0.84, 0.66, and 0.53 mg/L for W1, B1, W2, and B2, respectively, all within WHO standards. High nitrate levels, particularly in infants, can cause methemoglobinemia or "blue baby syndrome," which impairs the blood's ability to carry oxygen (WHO, 2017).

Sulphates and Phosphates

While sulphate levels were within WHO standards, phosphate levels in samples W2 and B2 slightly exceeded the limit. High phosphate levels can lead to nutrient pollution in water bodies, promoting algal blooms that can produce toxins harmful to aquatic life and human health (WHO, 2017).

Heavy Metals - Arsenic and Lead

Arsenic levels in all samples were minimal and met WHO standards. However, lead levels in W1, B1, and B2 exceeded the permissible limits, with only W2 meeting the standard. Lead exposure is particularly dangerous, as it can cause neurological damage, especially in children, and increase the risk of hypertension and kidney damage in adults. The elevated lead levels might result from lead service pipes, domestic sewage, and effluents from chemical laboratories (WHO, 2017).

Conclusion

Among the physicochemical parameters analysed for the four water samples, the values for Sample 2 (borehole from Igue Hana) and Sample 4 (borehole from Ekosodin) were within the permissible limits of WHO standards, except for elevated lead levels. In Sample 3 (well water from Igue Hana), turbidity exceeded the WHO standard. In Sample 1 (well water from Ekosodin), conductivity, alkalinity, lead, and phosphate levels were above the WHO standards. Overall, the water samples from the two boreholes were found to be suitable for drinking, except for high lead concentrations,

whereas the water from the wells was deemed unsuitable for consumption.

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