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INVESTIGATING ENVIRONMENTAL FACTORS AFFECTING PIPE-BORNE WATER COMPOSITION IN ELIOZU COMMUNITY, RIVERS STATE, NIGERIA

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Abstract: **Access to safe and potable water remains a major public health concern in developing communities, where environmental factors significantly influence water quality. This study examined the impact of environmental factors on the chemical composition of pipe-borne water used in Eliozu community, Rivers State, South-South Nigeria. Water samples were collected from two supply points and analyzed under standard laboratory conditions for key physicochemical parameters including pH, temperature, dissolved oxygen (DO), electrical conductivity, total dissolved solids (TDS), phosphate, chloride, alkalinity, turbidity, nitrate, and sulphate. Findings revealed that the pH values (5.80 and 5.50) were below the permissible WHO range (6.5–8.5), indicating acidic water with potential risks of pipeline corrosion and adverse health effects. DO levels (1.50 mg/l and 2.50 mg/l) were also far below recommended limits (4–6 mg/l), suggesting organic pollution and possible microbial contamination. Electrical conductivity (1.27 µS/cm and 9.00 µS/cm) and TDS (0.86 mg/l and 11.25 mg/l) were considerably lower than WHO limits, classifying the water as soft and deficient in essential minerals. Phosphate concentration (0.24 mg/l) exceeded the WHO threshold of 0.1 mg/l, pointing to anthropogenic pollution sources. Conversely, chloride, alkalinity, turbidity, nitrate, and sulphate levels were within safe limits, reflecting partial compliance with water quality standards. In conclusion, while the water samples met some physical standards, chemical imbalances pose potential health hazards. It is recommended that regular monitoring, treatment, and community sensitization be prioritized to ensure safe drinking water supply in Eliozu.**

Keywords: **pipe-borne, environmental, composition, water and chemical.**

1. INTRODUCTION

In several urban and peri-urban Nigerian areas, pipe-borne water is regarded as the most convenient supply of domestic water; yet, its chemical composition is inconsistent. This instability arises from the interaction of source water chemistry, treatment procedures, distribution infrastructure conditions, and diverse environmental stressors from adjacent land uses and human activities. Studies demonstrate that industrial effluents, landfill leachate, agricultural runoff, and insufficient wastewater management compromise water quality, frequently elevating dissolved solids and introducing heavy metals such as lead and cadmium, which may exceed regulatory thresholds (Nwinyi, 2020; Ganiyu et al., 2021; Ubuoh et al., 2023). The physical and chemical properties of piped water are intricately connected to source-to-tap operations and local environmental factors. In several Nigerian towns, "tap" water mostly originates from surface rivers, reservoirs, or groundwater, each exhibiting distinct baseline chemistry shaped by geological and seasonal influences. Deficiencies in treatment or contamination during storage and distribution might intensify chemical alterations, including interactions

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between acidic water and corroding pipes, resulting in metal breaches and modified dissolved oxygen levels (Ewuzie et al., 2021; Nwinyi, 2020). Local environmental conditions profoundly affect the chemical of piped water. Unregulated industrial clusters, uncontrolled landfills, and intensive agriculture lead to pollutant loads that impact rivers and aquifers via runoff and leachate. Research in South-South and South-East Nigeria demonstrates that human activities elevate heavy metal and nutrient concentrations in aquatic systems, posing ecological hazards and possible health risks for domestic water sources (Ubuoh et al., 2023; Ganiyu et al., 2021). Therefore, local environmental management measures are essential for maintaining the chemical quality of piped water. Water is vital for survival and absolutely necessary for most life driven processes (Saturday &Runyonyozi, 2019). Satisfactory supply of clean, safe, and hygienic drinking water is therefore imperative for good health amongst other benefits. Globally, 844 million people live without adequate access to improved water sources (WHO/UNICEF, 2017). Inadequate safe water supply has serious public health implications as water related diseases continue to be one of the major health problems particularly in developing countries. The aim of this study is to evaluatethe impact of environmental factors on the chemical composition of pipe borne water used in Eliozu community in Rivers State, South-South, Nigeria. Water is an important natural resource that is frequently called a "universal solvent" since it can dissolve many different kinds of compounds. The chemical formula for water is H_2O, which means it has two hydrogen atoms and one oxygen atom. It can be made when hydrogen and oxygen come into contact with each other, and it may be in three different physical forms: solid, liquid, and gas. Water, in its purest form, lacks color, smell, and taste, making it an essential inorganic molecule (Chowdhury & Al-Zahrani, 2020).

We need water every day. It is necessary for cooking, cleaning, drinking, farming, and making things in factories. Chemists and environmental scientists are most concerned with the quality of water since it determines whether it is safe to drink and use for other purposes (Egbueri, 2020). Surface water (streams, rivers, ponds, and lakes) and groundwater (boreholes and wells) are the main sources of water. Both are necessary for human survival and economic growth (Yakubu et al., 2021). Water is important for biological systems as well as for homes and businesses. About 60% of the human body contains water, which is necessary for life. Basic biological processes, such as DNA replication, food digestion, and oxygen transport in the bloodstream, occur in aqueous solutions (Prüss-Ustün et al., 2019). This shows how important it is for health and well-being to have access to clean water. The historical availability of water has influenced the establishment of human settlements, shaping the development of villages, towns, and cities. The lack of access to clean drinking water and poor sanitation systems has been linked to the spread of deadly diseases such cholera, typhoid, and diarrhea, especially in developing countries (World Health Organization [WHO], 2022). The quality of water is determined by its physical, chemical, and biological characteristics, which must meet established standards for its intended use (Ajayi & Sridhar, 2021). About 70% of the Earth's surface contains water. The oceans hold 97% of it, polar ice and glaciers hold 2.1%, groundwater holds 0.3% to 0.8%, lakes hold about 0.009%, and rivers hold about 0.00009% (Eja, 2020). Water is made up of two hydrogen atoms and one oxygen atom that are covalently bound together. This is what makes up water. The different electronegativity values of hydrogen and oxygen cause polar covalent bonds to form. Because of this, the hydrogen atoms have a partial positive charge around them, while the oxygen atom has a partial negative charge around it (Campbell, 2019). Groundwater is responsible for the filling of the fractures, fissures, and openings in rocks and sediment that are present beneath the surface. The water is either directly derived from precipitation that flows into the ground or indirectly from bodies of water, such as rivers and lakes. Permeable minerals, including sand, gravel, sandstone, and limestone, are the primary sources of it. Granite is an example of a rock that is not highly permeable, yet it is still possible to detect groundwater in this type of rock. Water pollution is significantly influenced by human activities and naturally occurring elements. Adetunji et al. (2022) contend that the introduction of hazardous substances into aquatic ecosystems, as a result of the discharge of untreated wastewater, industrial effluents, agricultural runoff, and urban precipitation, results in a decline in water quality. Industries located near rivers and streams discharge untreated or poorly treated effluents containing toxic heavy metals such as lead, chromium, arsenic, and mercury, as well as hazardous organic and inorganic chemicals including acids, alkalis, and cyanides (Olalekan et al., 2022). Such pollutants are often non-biodegradable, accumulating in sediments and aquatic organisms, and posing long-term ecological and health risks. Chronic exposure to heavy metals in contaminated water may result in neurological damage, reproductive problems, kidney failure, and cancer in humans (Odipe et al., 2020). Additionally, industries such as textiles, tanneries, pulp and paper mills, and pesticide production contribute significantly to chemical oxygen demand (COD) and biological oxygen demand (BOD) in receiving waters, leading to oxygen depletion (Abioye & Oyewole, 2019). A pH value of less than 7 indicates acidity, a value greater than 7 indicates alkalinity, and a value of exactly 7 indicates neutrality (Sadiq, 2021).

2. MATERIALS AND METHODS

Eliozu (4.8619352N,7.0191502E), the study area is a fast growing suburban in Obio/Akpor Local Government Area, Port Harcourt, capital of Rivers state. Port Harcourt is located within the Niger Delta Basin of Southern Nigeria, within the eastern lower Niger Delta in the south eastern part of Rivers State of Nigeria. It is situated at the right bank of the Bonny River approximately 65km inland from the Bight of Bonny. The study adopted both field and laboratory based analytical procedures to generate the data required. Water samples were collected at thirty different borehole locations (residential houses) within the Eliozu community of Port Harcourt and where all geolocated.

Materials

Apparatus

The apparatus to be use for the experiment includes; hot plate**,** weighing balance**,** 125ml erlenmeyer flask**,** volumetric flask, acid gloves**,** laboratory coat**,** hand gloves**,** nose mask**,** glass funnel**,** pipettes (1ml, 5ml)**,** pH meter, conductivity meter, thermometer, conical flask, turbidity meter, spectrophotometer, curette, stirring rod,plastic container**,** wash bottle**,** beakersand fume hood

Reagents

All reagents used were of analytical grades, and included silver nitrate ($AgNO_3$), potassium chloride (KCl), hydrochloric acid (HCl), phenolphthalein indicator, barium chloride, potassium nitrate (KNO_3), aluminium hydroxide, phenoldisulphoric acid, sodium hydroxide and sulphonic acid.

Sample Collection and Preparation

Ten groundwater samples were collected from two locations (Christine Hospital and Fish Food Company) within Eliozu community. These samples were collected in triplicate using new and clean polyethene plastic containers. Groundwater samples were obtained directly from the water pump after allowing the water to run for at least five minutes and each sample bottle and its cap rinsed three times with the water sample. Temperature, EC, pH, turbidity and salinity were determined on site with the various test meters.

Determination of Physicochemical Parameters

Determination of pH

The electrometric method which is essentially a measurement of the potential between an indicator electrode and a reference electrode was used to determine pH (Njosi, 2010). The pH was measured using a mobile digital pH meter (JENWAY 3520). The meter was switched on and allowed to warm for 5 minutes. It was then standardized with buffer 4, 7 and 10 solutions. Immediately it was introduced into the water sample and measurements were taken after a stable reading was obtained. The electrode was then rinsed with deionized water before another measurement was taken

Determination of Electrical Conductivity (EC)

Conductivities of the water samples were measured using a mobile digital conductivity meter (JENWAY multi-parameter test meter model 4520). The meter was switched on and standardized using 0.1M KCl at 25 °C. The electrode was then immersed into the water sample and conductivity reading of each sample was recorded (Sachchida et al., 2011).

Determination of temperature

Measurement of temperature was carried out in-situ of the sample collection. A bulb mercury filled Celsius thermometer (0°-360 °C) was used. The thermometer was dipped into the sample for few min, temperature in degree Celsius was then read from the scale (Njosi, 2010)

Determination of chloride

Chloride is determined using the argentometric method. About 20 ml of water sample was transferred into a conical flask and 2 drops of potassium chromate was added. A yellow colouration was obtained and was titrated with 0.1M silver nitrate solutions until a pink colour end point was reached. The volume of titrant used was noted (Njosi, 2010).

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Calculations:

Chloride (mg/1) = volume of $AgNO_3$ x M x 35.5 x 1000 volume of sample.

Where M = Molarity or Normality of $AgNO_3$

Determination of turbidity

The turbidity of the water samples was measured using a digital turbidity meter (2100AN model). Samples were shaken and a portion poured into the sample tube making sure no airbubbles were trapped. The sample tube was shaken vigorously and then thoroughly wiped dry, inserted into the instrument and the readings were noted (Njosi, 2010).

Determination of alkalinity

Ten (10) ml of the sample was introduced into a conical flask and 2 drops of phenolphthalein indicator was added. A pink colour was obtained indicating presence of carbonate. The mixture was then titrated with 0.1M HCl until a colour change was observed. The procedure was repeated twice to obtain the average titre

Determination of sulphate

Suitable portion of 100 ml of the sample was measured into a conical flask and 20 ml buffer solution is added. A spoonful of $BaCl_2$ crystal is added and stirred simultaneously for a continued time of at least 60 s at a constant speed. After stirring, the solution is poured into a clean glass cell (curette) of a spectrophotometer (Unicam SP 500 UV - Visible Spectrophotometer) and absorbance measured at 420 nm. Sulphate concentration was estimated by simply comparing absorbance (or concentration) reading with the calibration curve obtained from the spectrophotometer (Njosi, 2010).

Calculation:

$$\text{Mg/1 } S0_4^{2'} = \frac{\text{mass (gf) of } SO4^{2'} \text{ x } 1000}{\text{Vol. of sample (1)}}$$

Determination of Nitrate

The water sample was collected and 100 ml was pipetted into an evaporating dish. 0.01 M H_2SO_4 required to neutralize alkalinity, a little amount of $AgNO_3$ required to precipitate chloride as well as a small amount of aluminium hydroxide were added into the evaporating dish containing the measured water sample. The mixture was stirred thoroughly and filtered into a second dish before evaporating to dryness. 3 ml of phenoldisulphoric acid was added to the residue with a stirring rod. It was then diluted with 20 ml of distilled water before adding slowly (with stirring) the sodium hydroxide solution until the maximum yellow colour was obtained. The solution was then filtered and made up to 50 ml mark with distilled water. Nitrate standards were prepared by adding 0.4, 0.5, 2.5, 5.0, 7.5 and 10 ml of standardKNO_3 to the mark and 2 ml of the sodium hydroxide added as well. Both samples and standards were read at 420 nm in the UV - Visible spectrophotometer. From the calibration curve, the values for the samples were obtained.

Calculation:

$$\text{Mg/1 NO3'} = \frac{\text{(sample solution - blank solution')mg/l x vol. of digestate x 4.427}}{\text{Vol. of sample (1)}}$$

Determination of Phosphate

A well filtered 50 ml of the water sample was pippeted into a clean, dry 125ml Erlenmeyer flask. 2 ml molybdate reagent was added and mixed by swirling. Another 2ml of sulphonic acid reagent was added and mixed again. After exactly 5min the colour was measured spectrophotometrically at 690 nm. The concentration of the sample was estimated from the calibration curve (Njosi, 2010).

Quality control and assurance

Standard Operating Procedures (SOPs) was developed for each step of the experimental process. SOPs included protocols for sample preparation, equipment calibration, data collection, and analysis. Equipment calibrations were done following manufacturer guidelines or established protocols. Samples were prepared and handled with care to avoid contamination or degradation. Protocols were implemented for proper storage, labeling, and tracking of samples.

3. RESULTS AND DISCUSSION

Table 1: Physical and Chemical parameters of Pipe Borne Water used in Eliozu Community

Parameters	Christine Hospital	Fish Food Company	WHO Standard
pH	5.80 ± 1.15	5.50 ± 0.12	6.5-8.5
Temperature(^{O}C)	24.00 ± 1.15	24.00 ± 1.15	25
Electrical Conductivity(µS/cm)	1.27 ± 0.02	9.00 ± 1.15	400
Total Dissolve Solid(mg/l)	0.86 ± 0.09	11.25 ± 0.01	500
Chloride(mg/l)	95.47 ± 1.15	35.49 ± 0.01	200 - 300
Dissolve Oxygen(mg/l)	1.50 ± 112	2.50 ± 112	4 - 6
Alkalinity(mg/l)	105.00 ± 1.15	85.00 ± 1.15	200
Turbidity(NTU)	0.10 ± 0.01	0.20 ± 0.06	5
Nitrate(mg/l)	0.02 ± 0.00	0.01 ± 0.00	50
Sulphate(mg/l)	150.00 ± 1.15	105.00 ± 1.15	200
Phosphate(mg/l)	0.01 ± 0.00	0.24 ± 0.00	0.1

Values are presented in mean ± Standard Error of Mean (SEM)

Discussion

The findings of this study revealed significant variations in the physical and chemical composition of pipe-borne water from Christine Hospital and Fish Food Company in Eliozu community, when compared to the World Health Organization (WHO) standards for safe drinking water. Deviations in chemical properties of water quality is most time attributed to environmental and anthropogenic factors such as industrial discharge, improper waste disposal, and pipe corrosion, which are known to influence water quality in urban communities (Ayoade et al., 2020; Ugbaja& Oti, 2021).

The study revealed low pH values of 5.80 at Christine Hospital and 5.50 at Fish Food Company. Both were below the WHO permissible range of 6.5–8.5, suggesting acidity. Acidic water has been linked to corrosion of distribution pipelines, which can lead to leaching of heavy metals such as lead and copper into water supplies, thereby increasing health risks (Nnaji et al., 2020). Chronic consumption of acidic water may also result in gastrointestinal irritation and dental erosion (WHO, 2022). Similar findings were reported by Odukoya and Bamgbose (2019), who observed that acidic pH in public water supplies in Nigeria was largely associated with poor treatment processes and environmental contamination.The temperature of the samples (24 °C) was slightly below the WHO recommended value of 25 °C but still within acceptable limits. Temperature influences water palatability and microbial growth. Lower water temperatures generally enhance taste and reduce microbial activity (Ojekunle et al., 2018).

The electrical conductivity (EC) values were 1.27 µS/cm at Christine Hospital and 9.00 µS/cm at Fish Food Company, both significantly below the WHO threshold of 400 µS/cm. Low conductivity indicates minimal dissolved salts, suggesting the water is soft. While soft water is desirable in reducing scaling in pipes, extremely low EC and total dissolved solids (TDS) may indicate the absence of essential minerals like calcium and magnesium required for human health (Nwankwoala&Ememu, 2019). In this study, TDS levels were 0.86 mg/l and 11.25 mg/l, respectively, which though safe, point to very low mineralization that may affect the nutritional value of the water.

The chloride concentrations (95.47 mg/l and 35.49 mg/l) were within WHO limits (200–300 mg/l), implying no salinity concerns. However, the dissolved oxygen (DO) levels were very low (1.50 mg/l and 2.50 mg/l) compared to the WHO standard of 4–6 mg/l. Low DO is often associated with organic pollution from domestic or industrial effluents (Olalekan et al., 2021). Reduced oxygen content in drinking water is not only a concern for aquatic life but may also indicate microbial contamination, thereby posing indirect risks to human health through potential waterborne diseases such as cholera and dysentery (WHO, 2022).

The alkalinity values (105.00 mg/l and 85.00 mg/l) were within the permissible limit of 200 mg/l, suggesting adequate buffering capacity to neutralize acidity without posing risks. Similarly, the turbidity values (0.10 and 0.20 NTU) were far below the WHO maximum of 5 NTU, indicating high visual clarity and low suspended particles. Clear water is aesthetically acceptable and usually less contaminated microbiologically (Eze & Nwachukwu, 2019).Nitrate and sulphate concentrations were also well within WHO limits. Nitrate levels (0.02 mg/l and 0.01 mg/l) were particularly low, eliminating concerns of methemoglobinemia (blue-baby syndrome), which is commonly associated with nitrate pollution in infants (Adams et al., 2020). Sulphate values (150 mg/l and 105 mg/l) were also safe, confirming the absence of risks of diarrhea or laxative effects associated with high sulphate intake.

However, a major concern was phosphate concentration at the Fish Food Company site (0.24 mg/l), which exceeded the WHO limit of 0.1 mg/l. Elevated phosphate levels are often linked to domestic sewage or industrial effluents, which can encourage eutrophication in surface waters (Afolabi et al., 2020). Though not directly toxic to humans at low concentrations, phosphate enrichment is a strong indicator of anthropogenic pollution and may serve as a precursor to microbial proliferation in drinking water systems.

Overall, the results suggest that while most parameters in pipe-borne water in Eliozucommunity were within WHO limits, deviations such as low pH, low dissolved oxygen, and elevated phosphate concentrations present potential public health concerns. These findings are consistent with earlier studies in other parts of Nigeria, which reported that water supplies often met most physical standards but failed in chemical and biological safety due to environmental influences (Etim et al., 2018; Nnaji et al., 2020).

4. CONCLUSION

In conclusion, the assessment of pipe-borne water in Eliozu community, Rivers State, revealed that while most chemical parameters including chloride, alkalinity, turbidity, nitrate, and sulphate concentrations were within the permissible limits of the World Health Organization (WHO), the pH levels of 5.80 and 5.50 fell below the recommended range, suggesting acidic conditions capable of corroding pipelines and posing health challenges. Similarly, dissolved oxygen concentrations were considerably lower than standard values, indicating potential organic pollution and microbial risk. Although electrical conductivity and total dissolved solids were far below WHO limits, this indicated water softness with insufficient mineral content necessary for human health. Elevated phosphate levels suggested contamination from anthropogenic activities, especially industrial or domestic effluents. To sup it up, the water supply in Eliozu community is of low mineral content and showed potential chemical hazards. Hence, there is urgent need for corrective and monitoring measures to safeguard public health.

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