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COMPARATATIVE ANALYSIS OF PIPE-BORNE AND GROUND WATER QUALITY IN DUTSIN-MA TOWN, KATSINA

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ABSTRACT
The study investigated the quality of pipe-borne and groundwater in Dutsin-ma town, Katsina state. Ten water samples, comprising five each of pipe-borne and groundwater, were collected from different locations using GPS coordinates for mapping. Physio-chemical analysis was conducted, comparing results with WHO standards. ANOVA-F tested research hypotheses. Results indicated pipe-borne water contamination sources, including cracked pipes and inadequate treatment, with some samples exceeding WHO recommendations for lead, iron, pH, and turbidity. Recommendations include more frequent laboratory analysis and broader research on pipe-borne water quality, particularly regarding lead.

Keywords:
Comparative, Analysis: Quality; Pipe; Ground; Water.

1.0 INTRODUCTION

Access to safe and clean drinking water is a fundamental human right and a cornerstone of public health(Mirumachi et al., 2021). In many developing regions, including Dutsin-ma Town in Katsina State, Nigeria, the availability and quality of water sources vary, impacting the health and well-being of the populace (AHMED et al., 2024). This study aims to conduct a comparative analysis of the quality of pipe borne water and groundwater in Dutsin-ma Town, shedding light on potential disparities and areas for improvement in water management and infrastructure. Dutsin-ma Town, situated in the semi-arid climate of northern Nigeria, faces challenges in ensuring access to safe drinking water due to factors such as rapid urbanization, population growth, and limited infrastructure development (SANI, 2022). While pipe borne water is supplied by the municipal water system, groundwater remains a primary source for many residents, accessed through boreholes and wells (BELLO et al., 2021). Understanding the quality of these two water sources is crucial for assessing potential health risks and guiding policy interventions aimed at improving water quality and public health outcomes (Organization, 2022). This comparative analysis encompass a comprehensive assessment of key water **quality parameters**, including physicochemical characteristics, **microbial contamination**, and pollutant levels, in both pipe borne and groundwater samples collected from various locations across Dutsin-ma Town. By analyzing and comparing these datasets, this study seeks to identify potential sources of contamination, assess the effectiveness of current water treatment processes, and provide evidence-based recommendations for enhancing water quality management practices in the region. Furthermore, this research endeavor aligns with broader sustainable development goals, including ensuring access to clean water and sanitation (SDG 6), promoting health and well-being (SDG 3), and fostering resilient infrastructure and sustainable communities (SDG 11) (Delanka-Pedige et al., 2021). By elucidating the quality disparities between pipe borne and groundwater sources, this study aims to contribute valuable insights to the ongoing efforts aimed at achieving these global targets and improving the livelihoods of communities in Dutsin-ma Town and similar settings.
The hypothesis postulation is as follows:

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Ho: There is no significant difference in the concentration of the analyzed parameters between the pipe-borne water and the groundwater samples.
Hi: There is a significant difference in the concentration of the analyzed parameters between the pipe-borne water and the groundwater samples.

2.0. METHODOLOGY

2.1. Study Area

Dutsin-ma Town is situated in the northwest geopolitical zone of Nigeria, specifically within Katsina State (Faruk & Abdullahi, 2022). Geographically, the town lies approximately 60.61 kilometers from the state capital, Katsina City, and occupies a strategic location within the state. Dutsin-ma Town, located in Nigeria's northwest, is a significant urban center with a semi-arid climate. Its population is diverse and primarily driven by agriculture, trade, and services (Faruk & Abdullahi, 2022). The town's infrastructure includes residential, commercial, and institutional buildings, but challenges persist in infrastructure maintenance, access to basic services, and environmental management (Mazele & Amoah, 2022). Access to safe drinking water remains a critical issue due to the town's semi-arid climate and growing population (Ahamad et al., 2023). Understanding water availability and quality is essential for sustainable development and public health (Lal et al., 2021). Addressing these challenges requires collaboration between government authorities, community stakeholders, and development partners to foster sustainable urbanization, enhance service delivery, and improve the quality of life for residents (Nop et al., 2023).

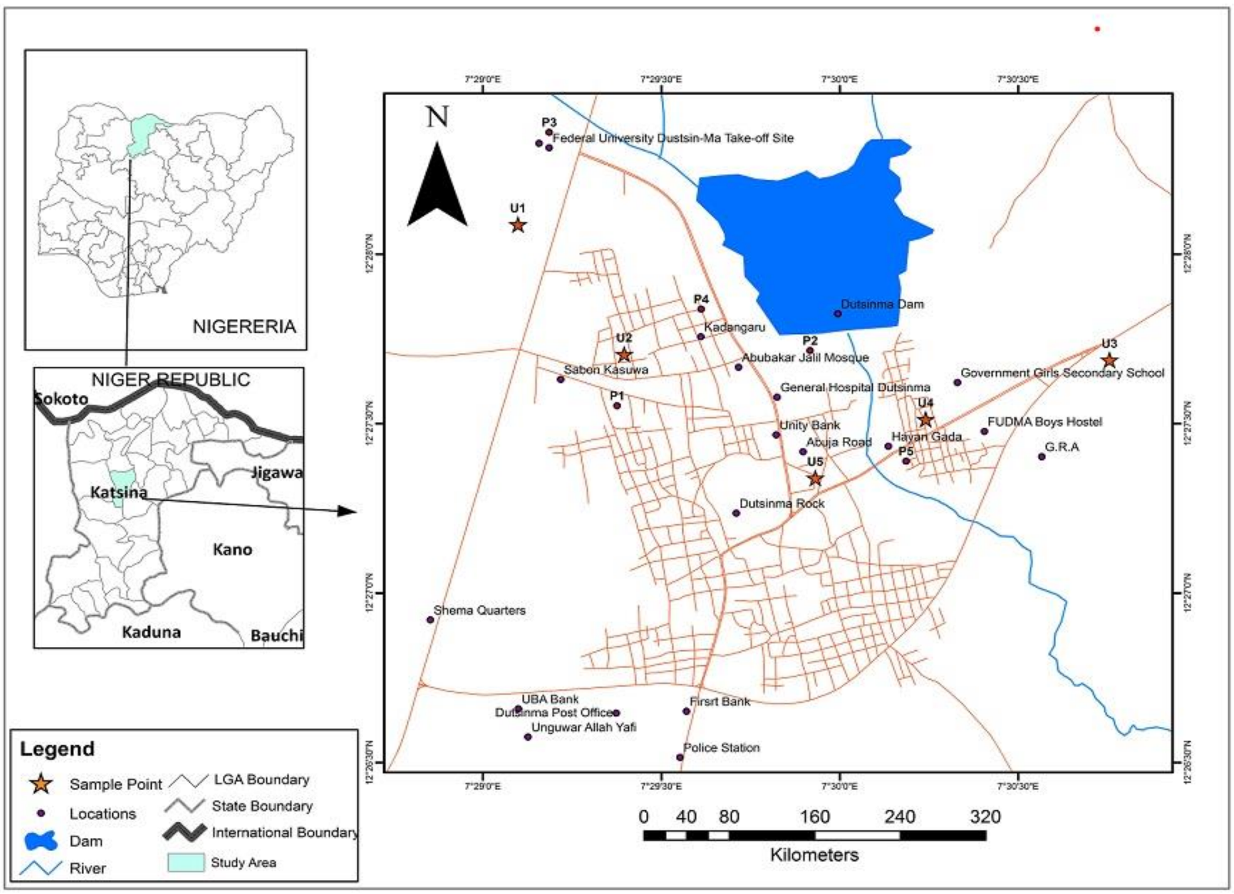

Fig.1 Map of Dutsin-ma showing water sample areas.

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2.2. Methods

Descriptive and inferential statistics were used for the analysis of the data generated. The descriptive statistical tool was used to summarize the laboratory results of the analyzed samples through the use of graphs, charts, and frequency tables.

Five (5) pipe borne water samples and five (5) underground water samples were collected from different locations within Dutsin ma town and analyzed at the Ahmadu Bello University (ABU) Zaria's Chemistry laboratory and the Biochemistry Laboratory of Federal University Dutsin ma, where the quality of pipe borne were compared with ground water samples collected using the World Health Organization (WHO) recommended standards as reference.

Biological analysis was also conducted on both pipe borne and ground water samples collected in the study area.

3.0 RESULTS AND DISCUSSION

This section compares and discusses the quality of pipe-borne water and ground water in Dutsin-

3.1 Turbidity

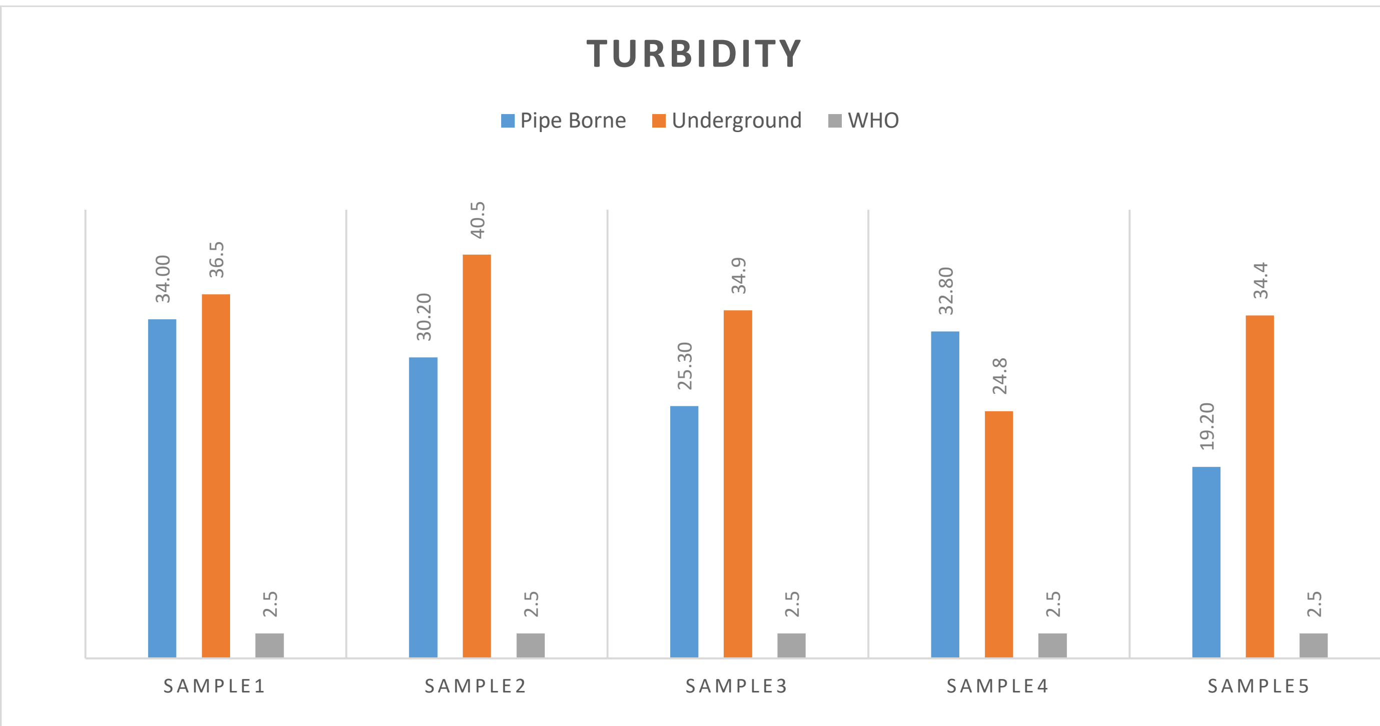

Fig 2 .Sample Analysis Result for Turbidity Concentration between Pipe Borne and Ground Water.

The result of the analyzed samples collected in the study areas shows that the concentrations of turbidity in pipe borne and ground water are 34.00, 30.20, 25.30, 32.80 & 19.20 NTU and 36.5, 40.5, 34.9, 24.8 & 34.9 NTU respectively. However, the WHO recommended standard for turbidity is 2.5 NTU, the study therefore shows that the concentration of turbidity both in ground and pipe borne, although to a lesser degree, water samples taken from in the study areas are above the recommended standard and thus, somewhat unsafe for domestic consumption (Antehun Mengstie, 2021).

3.1. p_H Level

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p_H level obtained for the samples of both pipe borne and ground water under investigation are as shown in figure 3 below;

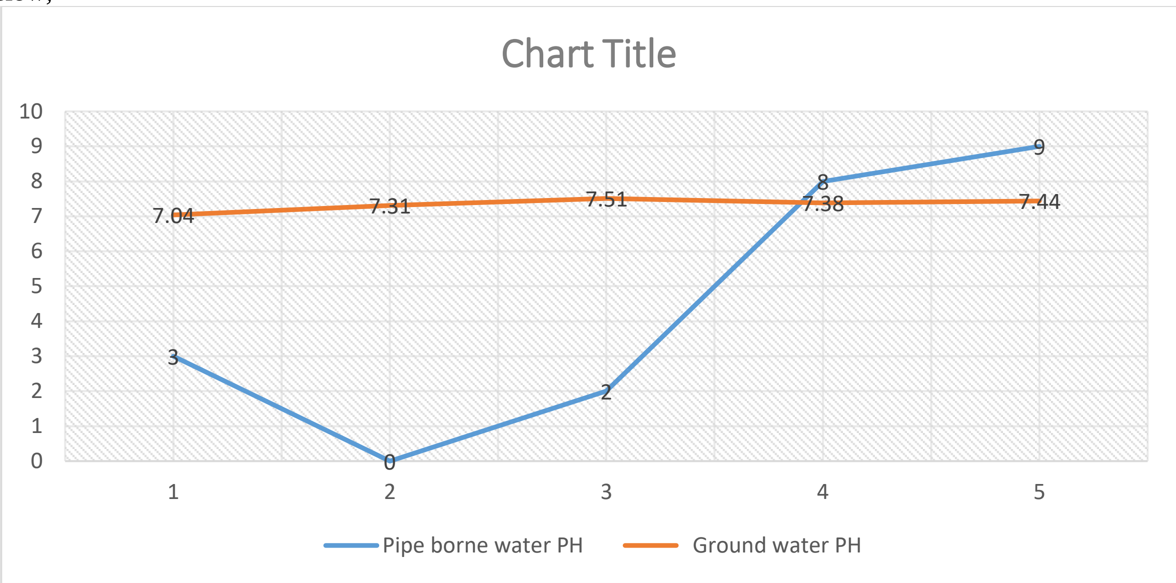

Figure 3 Pipe-borne and groundwater P_H level

The World Health Organization (WHO) pH recommended standard for domestic consumption ranges between 7NS and 8.5NS (Korfali & Jurdi, 2011). The result of the analyzed samples collected in the study area however shows that the ground water pH concentration ranges from 7.04NS to 7.44NS which is within the recommended standard. The readings obtained for pipe borne water however range from 6.59 to 6.93NS, which is below the recommended standard, thus unsafe for domestic consumption. Based on WHO standards, water that ranges from 7 to 8.5 are ranges considered good for domestic uses.

3.1.2 **The zinc concentration**

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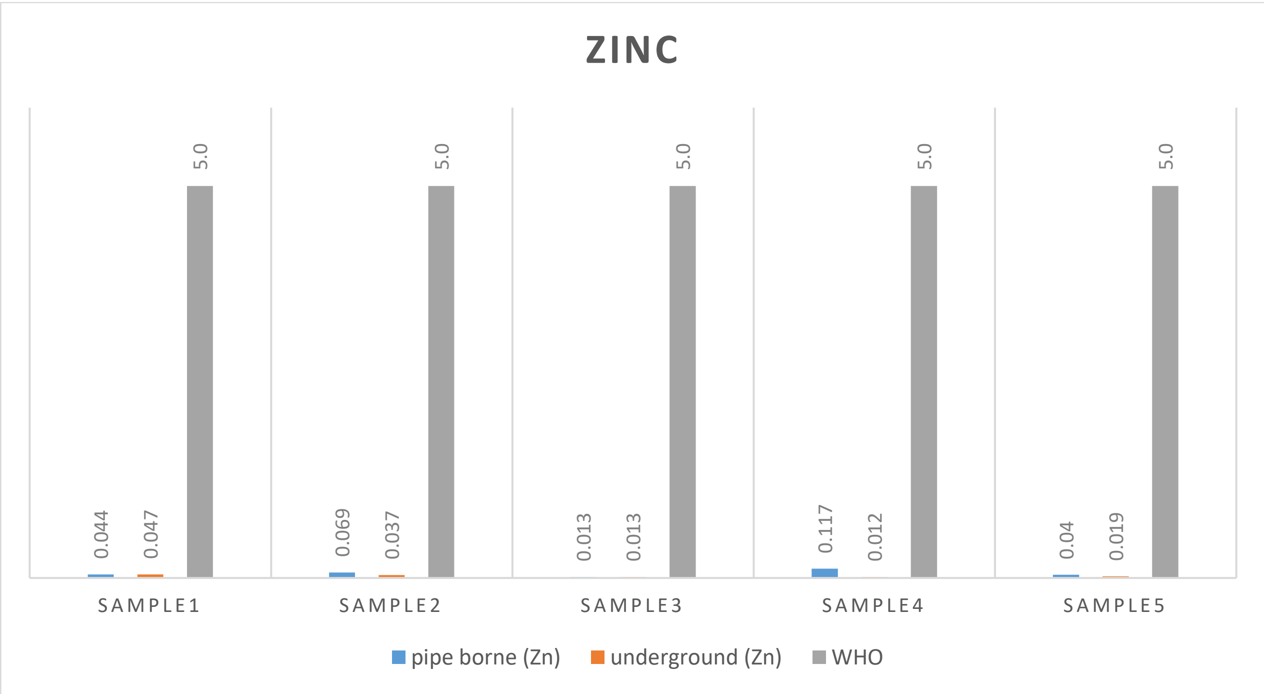

Fig 4. The zinc concentration between pipe borne water and ground water.

The result of analyzed samples collected in the study areas show that pipe borne water has the highest amount of zinc at a concentration of 0.117mg/l (Musa, 2022). In sample 1, zinc concentration in ground water is higher than in pipe borne water, in sample 2 the reverse is the case with pipe borne water indicating a higher concentration than in underground water. Sample 3 however show a parity in zinc concentration for both pipe borne and underground water while for samples 4 and 5 the concentration is higher in pipe borne water. Therefore, given the World Health Organization (WHO) zinc concentration recommended standard of 5.0mg/l, the highest zinc concentration reading of 0.117mg/l for tap water and 0.047mg/l for underground water qualifies all the sample from the different areas as safe for domestic consumption.

3.1.3 Lead Concentration

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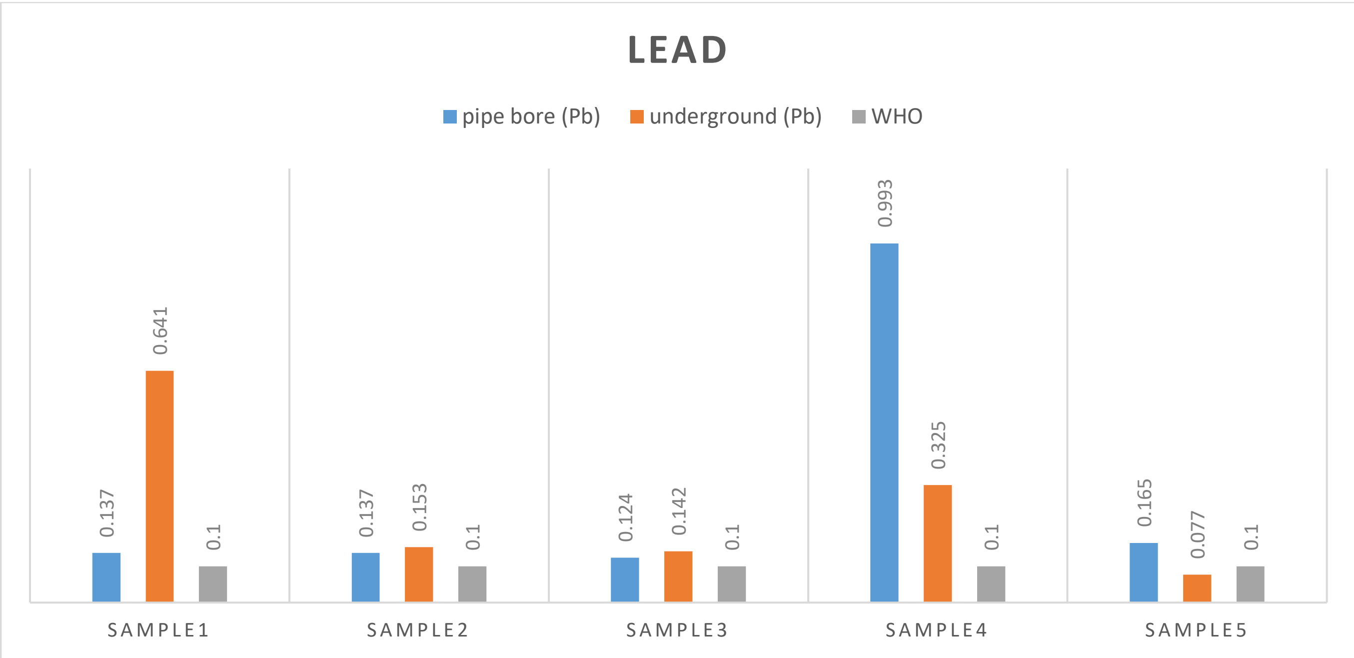

Fig 5. Sample Analysis result for Lead concentration between Pipe borne water and ground water.

Analyses result of samples obtained from the various show that lead concentrations in pipe borne water is generally higher than WHO recommended levels of 0.1mg/l (Khalid et al., 2018)with just sample 5 exception for underground water where the reading indicated is 0.077mg/l.

While sample 1, 2 and 3 showed that underground water has higher concentration than pipe borne, the reverse is the case in samples 4 and 5 where pipe borne water outpaced underground water in concentration.

Comparatively however, pipe borne water has the highest amount of lead at 0.993mg/l while underground water has the lowest reading at 0.077mg/l of lead concentration.

Lead laden geological configuration areas and rusting water distribution galvanized pipes may most likely account for situation. Since dissolving of natural formations and gradual flushes from aging pipes both combine to elevate contamination (Coates, 2012).

Medically, liver and kidney are associated ailments with consumption of above limit lead tainted water while the bones are its ultimate repository. It is therefore, generally speaking, unadvisable to consume the water without proper treatment (Afrin et al., 2021).

3.1.4 Magnesium Concentration

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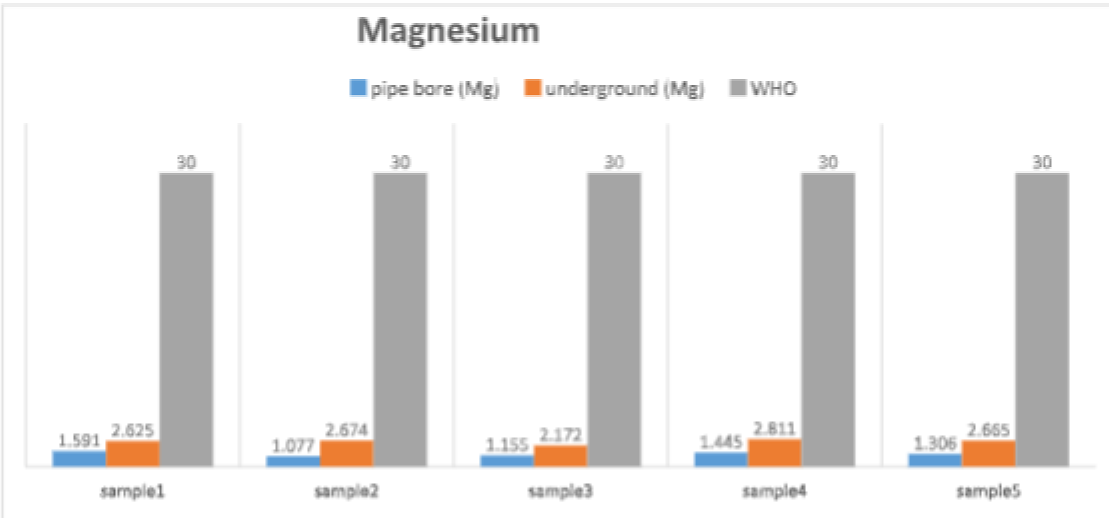

Fig 5. Sample Analysis result for Magnesium Concentration between Pipe Borne water and Ground Water.

The result of the analyzed samples collected in the study area shows that underground water has the highest concentration of magnesium, which is 2.811mg/l in sample 4. Pipe borne water has the lowest amount of magnesium, which is 1.077mg/l in sample 2. The amount of magnesium in the samples ranges from 1.077 to 2.811.

The WHO recommended standard is 30mg/l (Kumar & Puri, 2012). Consequently, the concentration of magnesium in all the samples are within the recommended standard, thus pipe borne water is safe for domestic consumption.

3.1.5 Iron Concentration

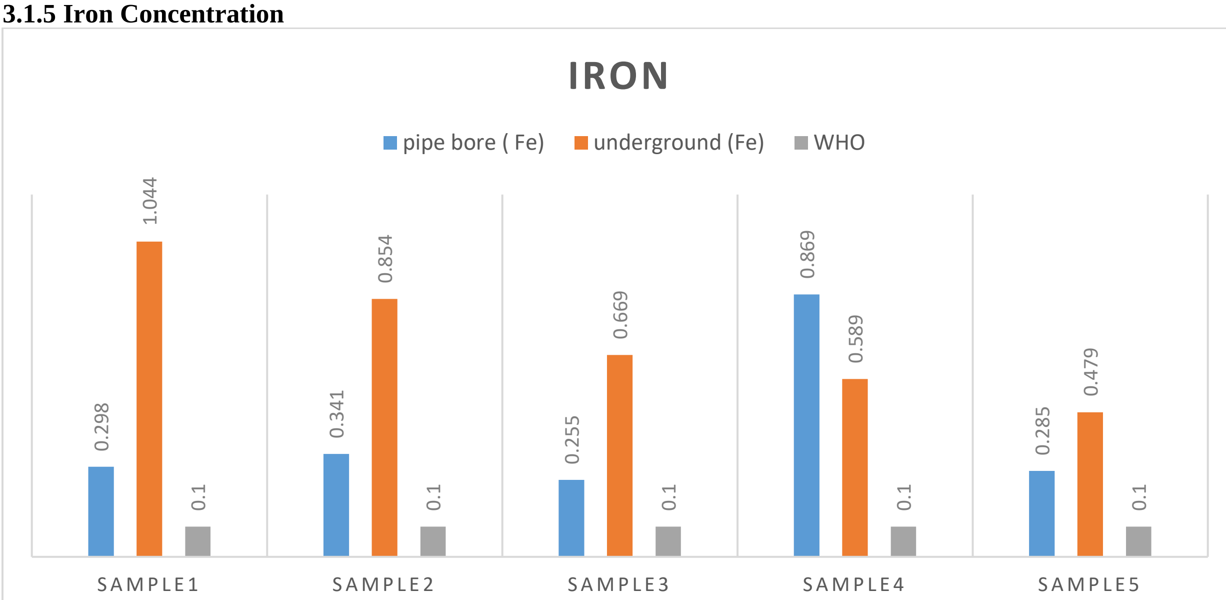

Fig 6. Sample Analysis Results for Iron Concentration between Pipe borne water and Ground Water.

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The result obtained from analyzing the samples collected in the study areas show that the concentration of iron from both sources, both pipe borne and ground water samples, exceeded WHO recommendation of 0.1mg/l (Zhang et al., 2020).
Samples 1, 2, 3 & 5 analyses returned a result of high concentration with ground water source clearly and significantly in the lid except in the case of sample 4 where pipe borne exceeded both WHO standard and ground water readings.
According to WHO, high iron concentration in drinking water can lead to iron overload in humans and this can cause diabetes, hemochromatosis, stomach problems, nausea and vomiting and can out rightly damage the liver, pancreas and heart (Bivens, 2017).
The levels of iron in groundwater can be due to large amounts of iron deposits within the rocks, it can also be increased by the dissolving of ferrous borehole and hand pump components (Bissonram, 2023).
Considering that concentration exceeds WHO recommended standards, it is advisable for concerned authorities to pay focus attention on treatment before domestic consumption
3.1.6 **Copper Concentration**

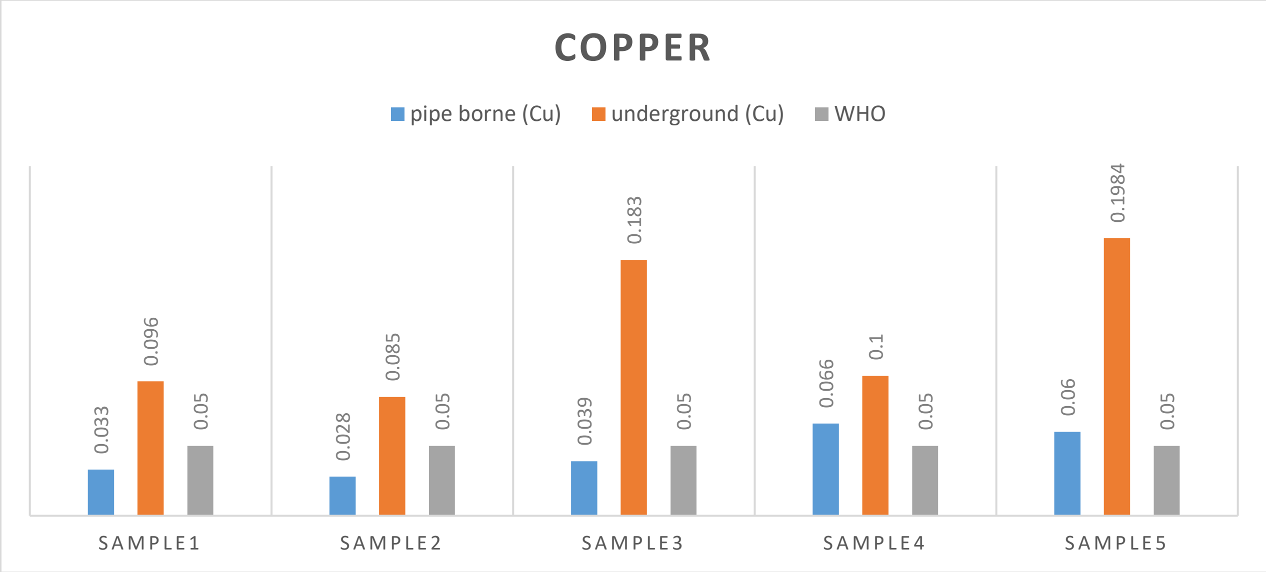

Figure 7. Copper concentration between pipe-borne and ground water samples

The result of the analyzed samples obtained from the study area show that ground water has the highest amount of copper concentration which measures 0.198 while the pipe borne water has the lowest at 0.028.
The measured ground water concentration range of between 0.085 and 0.198 is evidently above WHO recommended standard of 0.05.
The pipe borne water samples 4 and 5 with concentrations their ranging between 0.66 and 0.06 also exceeds the recommended standards while samples 1,2 and 3 of between 0.033 to 0.039 are within the recommended standard and therefore safe for domestic consumption.
The corrosion action in copper pipes are largely responsible the volume of copper concentration in pipe borne water which is further a function of the length of contact time either as storage or during distribution or redistribution (Imran, 2018).
Using ANOVA (Single factor: Appendix 1), the results highlighted that the calculated F = 0.03, whereas, the Critical F = 4.74 at α0.05 level of significance. Thus, we accept the null hypothesis states that no significant difference in the concentration of the analyzed parameters between the pipe-borne water and the groundwater samples in Dutsinma town. .
Especially within and between the selected samples and across the different selected elements used for the research, there is no significant variation.

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4.0 Biological Analysis of Pipe borne Water and Typhoid occurrence in the study Area

ISOLATES	SHAPE AND ARRANGEMENT	GRAM REACTION	INFERENCE
1	Cocci in cluster	+	Staphylococcus aureus
2	Rod	-	Salmonella typhi
3	Short rod	-	E.Coli

In this experiment different types of pathogens such as staphylococcus aureus, salmonella typhi and E. coli were collected from the pipe borne water samples.

The isolates were identified on the basis of morphological characteristics, cultural and biochemical tests. *Staphylococcus aureus* is both a commensal bacterium and a human pathogen.

Approximately 30% of the human population is colonized with *S. aureus* (Tong et al., 2012). Simultaneously, it is a leading cause of bacteremia and infective endocarditis (IE) as well as osteoarticular, skin and soft tissue, pleuropulmonary, and device-related infections (Tong et al., 2015). *Escherichia coli* (*E. coli*) is a Gram-negative, rod-shaped, facultative anaerobic bacterium. This microorganism was first described by Theodor Escherich in 1885. Most *E. coli* strains harmlessly colonize the gastrointestinal tract of humans and animals as a normal flora (Omar, 2015). However, there are some strains that have evolved into pathogenic *E. coli* by acquiring virulence factors through plasmids, transposons, bacteriophages, and/or pathogenicity islands (Desvaux et al., 2020). These pathogenic *E. coli* can be categorized based on serogroups, pathogenicity mechanisms, clinical symptoms, or virulence factors (Sarowska et al., 2019)

However, salmonella typhi is found to cause most of the water borne infections in the study area e.g typhoid fever (Mogasale et al., 2018).

Salmonella infection remains a public health concern worldwide, contributing to the economic burden of both industrialized and underdeveloped countries through the cost associated with surveillance prevention and treatment of diseases (Eng et al., 2015).

4.1 Biological Analysis of Ground Water in the study Area

Parameters	Significance
Total Coliforms	++ Presence
Fecal Coliforms	+ Presence
Escherichia (E.coli)	Scanty
Total Bacterial count	Low count
Algae	Scanty
Protozoa	Not Present

In almost all the groundwater sample collected there were presence of total coliform.

The presence of total coliform in groundwater during water analysis could indicate contamination from fecal matter or other sources (Aram et al., 2021). It's essential to further investigate to determine the exact source and take appropriate actions to ensure the safety of the water supply. Water collected from all the evidently shows the presence of fecal coliforms in sample 3, 4 and 5 collected from the study area. The presence of fecal coliform in groundwater suggests contamination from human or animal feces (Schriewer et al., 2015). This contamination could pose health risks if the water is used for drinking or other purposes (Shakoor et al., 2017). Immediate action, such as implementing water treatment measures or finding an alternative water source, may be necessary to ensure public health and safety(Bartram, 2009). Virtually, in all the samples collected there were scanty Escherichia coli (E. coli) in all the samples. The presence of scanty Escherichia coli (E. coli) in a groundwater sample is concerning as it indicates fecal contamination(Thani et al., 2016). Even in small amounts, E. coli can pose serious health risks if ingested, leading to gastrointestinal illnesses (Ramos et al., 2020). In all the collected samples the total Bacterial count is low. A low total bacterial count in a groundwater sample suggests that the water may be relatively clean and free from significant

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bacterial contamination (Sasakova et al., 2018). There were scanty algae in all the samples. The presence of scanty algae in a groundwater sample is not uncommon, as algae can enter groundwater sources through surface water infiltration or other pathways (Servin, 2019). While low levels of algae might not necessarily pose a direct health risk, they could indicate potential water quality issues, such as nutrient pollution or organic matter input (Caracciolo et al., 2023).

5.0 SUMMARY AND RECOMMENDATIONS

The turbidity of both pipe borne water and ground water samples in the study area are above the WHO recommended standard. The P_H of both pipe and ground water in the study area are within the contaminant limit. The concentration of zinc both in tap and ground water is within the recommended standard, consequently, the tap water is safe for domestic consumption. The concentration of lead in all the water samples are higher than the recommended standard, therefore pipe borne and ground water in the study areas can be said to be unsafe for domestic consumption. Contra wise, the concentration of magnesium in all the samples are within the recommended standard, thus pipe borne water is safe for domestic consumption. The result of the analyzed samples collected in the study area shows that the concentration of iron in both pipe borne water samples and ground water samples are higher than the recommendation of 0.1mg/l.

It is also alarming that the result of the analyzed samples collected in the study area indicated that, as oppose to pipe borne water, ground water has a comparatively higher copper concentration at 0.198.

RECOMMENDATIONS

1. Domestic water use, particularly for drinking and other direct consumption, in the areas where sample were obtained in Dutsin-ma must be done with caution in view of the indications of some of the parameters investigated. Direct consumption of water with elements above WHO recommended standard are issues of significant concern particularly as triggers to specific ill health and general wellbeing. It is especially important to note that some of the health dangers they portend have medium to long term manifestation, as some have said, even generational!
2. The Government must demonstrate very high sense of responsibility through proactive prevention and mitigation measure such upscale in frequency of laboratory analysis, improved and additional establishment of water treatment facilities to prevent all observed excesses from reaching public consumers in those different parts of Dutsin ma town.
3. Locals should be adequately enlightened on prevention and mitigation methods to complement Government effort.
4. Further, broader and more detailed research on pipe borne and ground water quality should be commissioned for more comprehensive findings.
5. More modern or even latest approaches, techniques and facilities for water purification and treatment should be adopted for Dutsin ma Water Board Authority to guarantee higher quality of output for public consumption

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