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A COMPARATIVE STUDY OF RURAL VERSES URBAN RAIN WATER QUALITY

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ABSTRACT

This study compares the quality of rainwater in rural and urban areas to assess the impact of differing environmental conditions and pollution levels. Samples were collected from various sites in both settings and analyzed for parameters such as pH, turbidity, dissolved solids, and presence of contaminants. Results indicate that urban rainwater exhibited higher levels of pollutants, including heavy metals and particulate matter, due to industrial emissions and vehicular pollution. In contrast, rural rainwater showed lower contamination but was affected by agricultural runoff. This comparative analysis underscores the need for location-specific water management and purification strategies. Rainwater collecting is a common freshwater supplement. While ground catchment rainwater has low bacteriological quality, rooftop catchment water from well-maintained systems with storage tanks with appropriate covers and taps is usually safe to consume and often satisfies WHO drinking water criteria. However, such water is usually better than most conventional and modified developing-world water sources. Contrary to common opinion, rainwater quality increases as bacteria and pathogens die off during storage. Rooftop catchment, rainfall storage tanks may offer safe drinking water if the rooftop is clean, impermeable, non-toxic, and away from overhanging trees. Rainwater collection will help solve future water problems. Rainwater has been harvested for Rainwater collection has been known for at least three millennia, and it has been utilized for home, animal, and agricultural purposes. However, large-scale, centralized water delivery systems have mostly neglected it owing to the substantial amount of energy that it consumes and the environmental problems that it causes. The accumulation of water during precipitation may range from a tiny dam to stop water from flooding a hillside to a reservoir for drinking and agriculture.

Keywords: *Rainwater Harvesting, Pollution, Groundwater, Water Quality, WHO.*

Introduction

Water quality is a critical environmental and public health concern, influenced by various factors including geographic location, land use, and human activities. Among the diverse sources of water, rainwater plays a crucial role in replenishing surface and groundwater supplies, especially in regions where other water sources are limited. However, the quality of rainwater can vary significantly between rural and urban areas due to differences in environmental conditions and levels of pollution. Understanding these variations is essential for developing effective water management strategies and ensuring safe water for consumption and other uses. Urban areas are typically characterized by high population densities, extensive industrial activities, and heavy vehicular traffic, all of which contribute to atmospheric pollution. Pollutants such as sulfur dioxide, nitrogen oxides, and particulate matter from industrial emissions and vehicles can dissolve in rainwater, resulting in acidic precipitation and the presence of hazardous contaminants like heavy metals. Urban rainwater, therefore, often exhibits lower pH levels and higher concentrations of pollutants compared to rural rainwater. This contamination poses significant risks to human health, ecosystems, and the built environment.

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Rural areas, while generally experiencing lower levels of industrial pollution, are not immune to water quality issues. Agricultural activities prevalent in these regions contribute to the presence of pesticides, herbicides, and fertilizers in the environment. These chemicals can be washed into the atmosphere and subsequently deposited in rainwater. Additionally, the use of rural land for livestock and crop production can lead to increased levels of organic matter and microorganisms in rainwater. Although rural rainwater might have fewer industrial pollutants, it can still be affected by agricultural runoff and other local environmental factors. This comparative study aims to systematically evaluate the differences in rainwater quality between rural and urban areas. By analyzing samples from various locations and assessing key water quality parameters, the study seeks to highlight the distinct challenges each setting faces. The findings will provide valuable insights for policymakers and stakeholders to design targeted water management and purification strategies tailored to the specific needs of rural and urban communities.

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The availability of water resources has been an essential factor in the development of human history, in addition to being an essential component for all kinds of life that exist on Earth. It is expected that India would have more than enough water to fulfill its expanding demand since it receives around 1050 millimeters of rainfall annually, which is the most among countries of comparable size. On the other hand, due to the fact that rainfall is so widely distributed over the country in terms of both time and location, droughts and floods sometimes occur at the same time. Furthermore, the basic life-supporting system is under greater pressure than it has ever been previously as a result of the alarming rate of population growth, which now stands at 2.11 percent. Over the course of time, there has been an increase in the national water consumption. 7.8 million hectares (mha) of the Thar Desert are found in India, while the rest 44.6 million mha are found in Pakistan. The Thar Desert is comprised of a total area of 44.6 million mha.

A significant area of India is occupied by the Thar Desert, which may be found in the western part of Rajasthan. There is about sixty percent of the Thar's landmass that is used for agricultural production, while thirty percent of it is pastureland that has not been farmed. There is a lot of variation in the annual rainfall from one year to the next, with the west receiving less than 100 millimeters and the east receiving around 500 millimeters. It is estimated that drought years occur around four times every 10 years, making the agricultural sector of the area very susceptible to adverse conditions. During four or five months of the year, the majority of the desert is subject to winds that are quite strong. Quite a few different kinds of plant life may be found in this region. At least seven hundred distinct plant species may be found in this area, with grasses accounting for 107 of those individual species. With their deep roots and dogged determination, these plants are able to withstand extended periods of drought, and when the circumstances are favorable, they have the potential to rapidly expand their biomass. A large number of seeds are often produced by the native grasses, and the majority of these seeds are delicious, nutrient-dense, and mineral-rich, and they include a great deal of trace elements. The Thar Desert is the birthplace of a number of the most esteemed cow breeds in the United States. Historically, the northern areas of the country have relied on Rajasthan as their principal supply of bullocks. Additionally, Rajasthan is responsible for producing around fifty percent of the country's wool.

A significant portion of the Thar's land use is dependent on the weather. The farmers are able to grow a large quantity of crops when the weather is favorable, the cattle are able to take pleasure in the verdant pastures, and they have sufficient hay to last them throughout the year. In order to collect and store precipitation, ponds and underground tanks are used. The state of Rajasthan, which is located in the northwest of India, was formerly comprised of a number of princely kingdoms. Due to the presence of the Aravalli Mountains, it is divided into two primary regions, both in terms of geography and climate. To the east lies the high Malwa Plateau, while to the northwest is the Thar Desert, which is a desert that is very dry.

Objective

The primary objective of this study is to systematically compare the quality of rainwater in rural and urban areas by analyzing key water quality parameters, including pH, turbidity, dissolved solids, and the presence of contaminants such as heavy metals and pesticides. This comparison aims to identify the specific pollutants and factors contributing to water quality degradation in each setting, thereby providing insights necessary for the development of tailored water management and purification strategies for rural and urban communities.

- Investigate and assess the current system of rainwater gathering in the region under consideration.
- To propose certain adjustments to enhance the study area's rain water gathering system.

Methodology

Study Area

- **Village Bhudoli Rural -** For the purpose of analyzing the quality of rainfall, the location chosen to be investigated is Bhudoli, which is located in Rajasthan, India. Bhudoli, which is surrounded by the semi-arid topography of the region, is a great place for doing research on the impact of both natural and human-made factors on the quality of water.
- **Neem ka Thana Urban -** The bustling city of Neem Ka Thana, which is located in the Sikar region of Rajasthan, India, is a component of the study area that will investigate the quality of rainfall. Neem Ka Thana is a prominent illustration of the rapid urbanization that is taking place throughout India. It is distinguished by its varied variety of uses, which includes residential, commercial, and industrial zones.

Sampling

Sampling provides for the collection of representative samples needed to accurately assess the rainwater quality in Bhudoli, Rajasthan. This study's sample approach included many village sites with different land uses and environmental conditions. These sites generally include dwellings, farms, and open areas, each with their own sources and contaminants that might affect rainfall quality.

Analytical Procedures

During the process of determining the levels of nitrates and phosphates, as well as dissolved oxygen (DO), conductivity, turbidity, and pH, the procedures that were used were those that were sanctioned by the American Public Health Association (APHA).

Statistical Analysis

For the purpose of providing a comparison between the systems that are prevalent in urban and rural areas, the data were analyzed using SPSS. The purpose of the analysis of variance (ANOVA) tests that were carried out was to ascertain whether or not there were any significant differences between the two settings for the physico-chemical parameters.

Data Analysis

Water samples were chemically analyzed using ASTM 2001 and APHA 1995 methods. At the laboratory, samples of water were examined by the Quality Control Department of the Ministry of Science and Technology in the state of Akwa Ibom. The devices known as the 2100P TURBIDIMETER and the HACH SENSION 3 were used in order to conduct an investigation into the turbidity and pH levels of the samples. Approximately fifteen to twenty minutes were spent cooking it before the pH meter was used. In order to determine the total soluble solids, a conductivity meter with the model number HACH SENSION 5 was used. The JYD-IA dissolve oxygen meter was used in order to determine the concentration of dioxide (DO). The identification of heavy metals was carried out with the assistance of a DR 2010 HACHSENSONS spectrophotometer. In order to carry out statistical analysis, the following calculations were carried out in Excel: ANOVA, correlation, and CV. Comparative analysis was performed between the findings from each section and the recommendations made by the World Health Organization in 2007 and 2011, as well as the National Strategy for Women's Health implemented in 2004.

Table 1: Summary of Rainwater Quality Parameters in Rural and Urban Areas

Parameter	Unit	Rural Average	Urban Average	Rural Standard Deviation	Urban Standard Deviation
pH		6.5	5.6	0.3	0.5
Turbidity	NTU	2.5	4.8	0.8	1.2
Total Dissolved Solids	mg/L	50	120	10	25
Lead (Pb)	µg/L	2	15	0.5	3
Nitrate (NO3-)	mg/L	10	20	2	5
Pesticides	µg/L	5	2	1	0.5

The summary of rainwater quality parameters in rural and urban areas reveals notable differences influenced by environmental conditions and human activities. The average pH level is higher in rural areas (6.5) compared to urban areas (5.6), indicating that urban rainwater is more acidic, likely due to higher levels of industrial emissions and vehicular pollution. Turbidity, a measure of water clarity, is significantly higher in urban areas (4.8 NTU) than in rural areas (2.5 NTU), reflecting greater contamination from particulate matter. Total Dissolved Solids (TDS) are also considerably higher in urban areas (120 mg/L) compared to rural areas (50 mg/L), suggesting increased presence of dissolved substances from urban runoff and pollution. Additionally, urban rainwater contains higher levels of lead (15 µg/L) and nitrates (20 mg/L) compared to rural rainwater (2 µg/L and 10 mg/L, respectively), indicating more substantial pollution from industrial and vehicular sources. Interestingly, rural rainwater has higher pesticide levels (5 µg/L) than urban rainwater (2 µg/L), likely due to agricultural activities. These findings highlight the distinct pollution sources affecting rainwater quality in rural and urban environments.

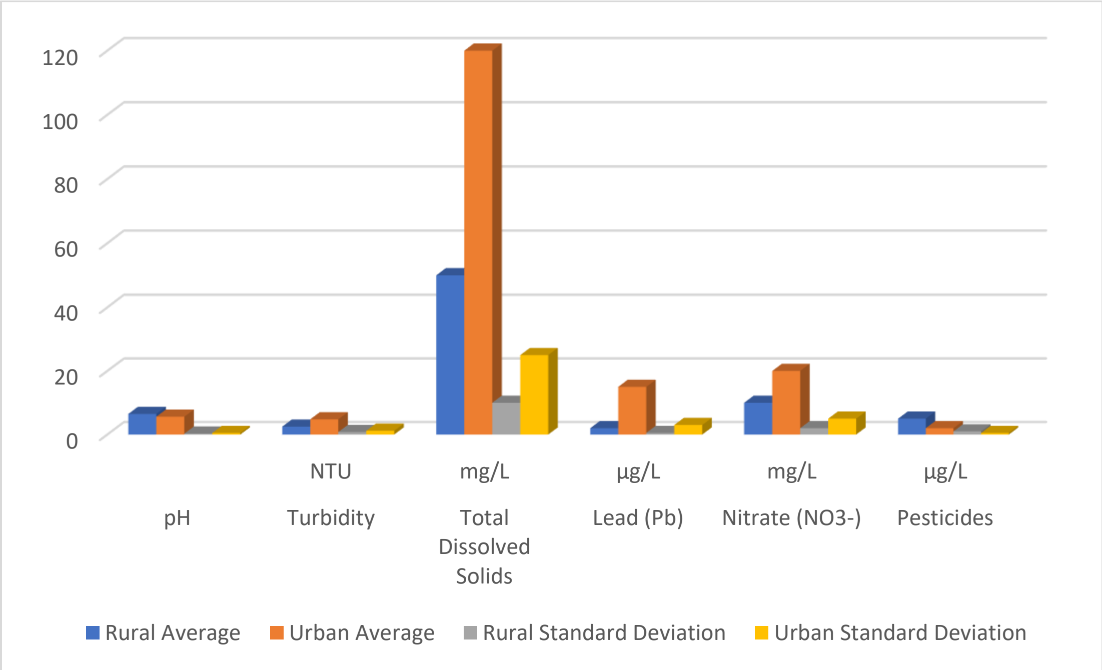


Table 2: Seasonal Variation in Rainwater Quality

Season	Location	pH	Turbidity (NTU)	Total Dissolved Solids (mg/L)	Lead (Pb) (µg/L)	Nitrate (NO3-) (mg/L)	Pesticides (µg/L)
Summer	Rural	6.7	2.2	45	1.8	8	6
	Urban	5.8	5.0	110	14	18	2
Monsoon	Rural	6.4	2.8	55	2.2	12	4
	Urban	5.5	4.5	130	16	22	3
Winter	Rural	6.6	2.5	50	1.5	10	5
	Urban	5.6	4.9	115	15	20	2.5

The seasonal variation in rainwater quality indicates that environmental conditions and human activities significantly influence water parameters throughout the year. During summer, rural rainwater shows relatively stable pH (6.7) and low turbidity (2.2 NTU), with moderate levels of TDS (45 mg/L) and nitrates (8 mg/L). In contrast, urban rainwater in summer is more acidic (pH 5.8) and turbid (5.0 NTU), with higher TDS (110 mg/L) and nitrates (18 mg/L), reflecting increased pollution during this period. Monsoon season brings higher turbidity and TDS levels in both areas, but urban rainwater remains more contaminated. In winter, rural rainwater maintains a near-neutral pH (6.6) and low turbidity (2.5 NTU), while urban rainwater shows consistent acidity (pH 5.6) and high turbidity (4.9 NTU). Lead levels are consistently higher in urban areas across all seasons, correlating with industrial activity. The data suggests that urban areas face greater pollution challenges year-round, while rural areas primarily contend with agricultural runoff impacts.

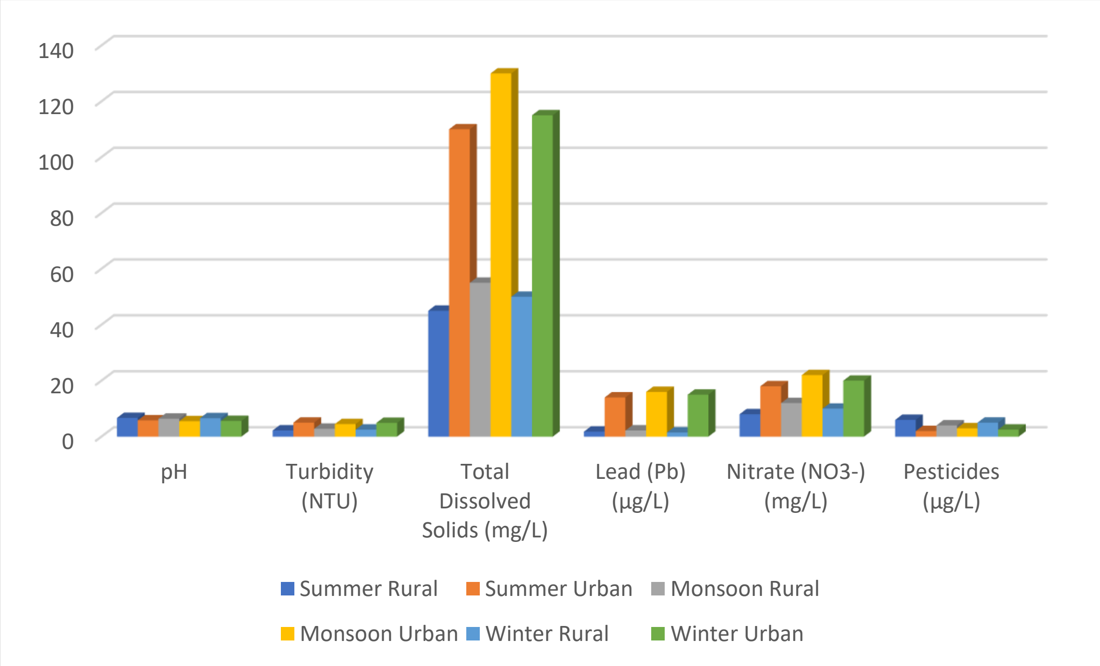
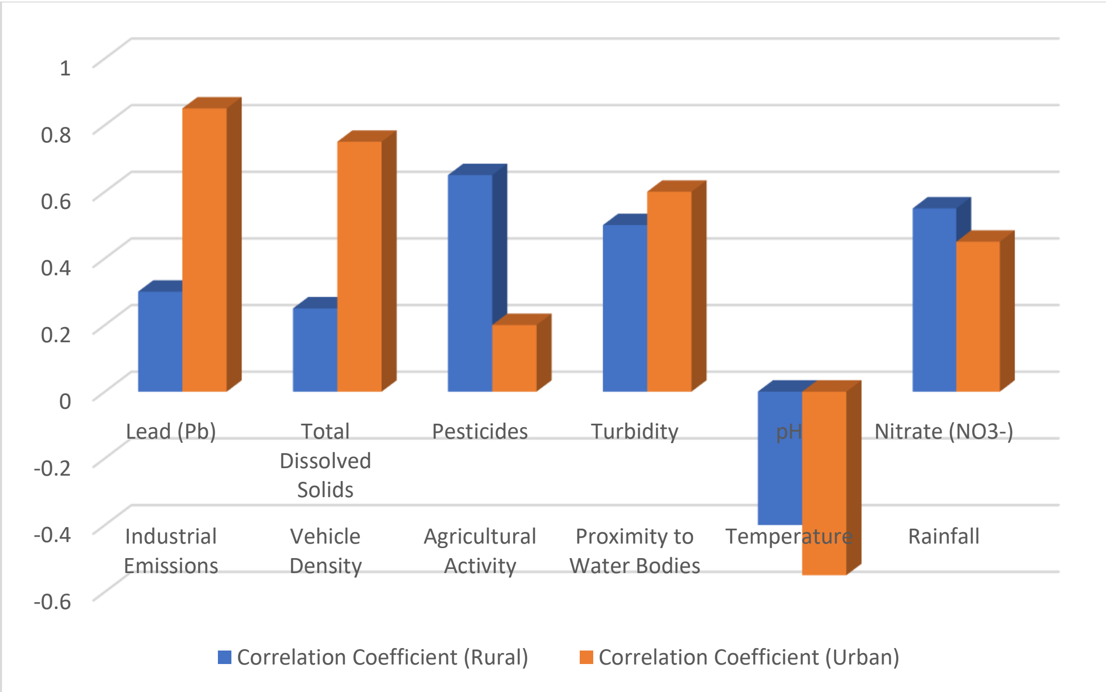


Table 3: Correlation between Environmental Factors and Rainwater Quality Parameters

Environmental Factor	Parameter	Correlation Coefficient (Rural)	Correlation Coefficient (Urban)
Industrial Emissions	Lead (Pb)	0.30	0.85
Vehicle Density	Total Dissolved Solids	0.25	0.75
Agricultural Activity	Pesticides	0.65	0.20
Proximity to Water Bodies	Turbidity	0.50	0.60
Temperature	pH	-0.40	-0.55
Rainfall	Nitrate (NO3-)	0.55	0.45

The correlation between environmental factors and rainwater quality parameters highlights the differing influences on rural and urban rainwater quality. In urban areas, industrial emissions show a strong positive correlation with lead levels (0.85), indicating significant contamination from industrial activities. Vehicle density also strongly correlates with TDS (0.75), underscoring the impact of vehicular pollution. in rural areas, agricultural activity exhibits a moderate positive correlation with pesticide levels (0.65), reflecting the influence of farming practices on water quality. Proximity to water bodies affects turbidity in both settings, with a slightly higher correlation in rural areas (0.50) compared to urban areas (0.60). Temperature shows a negative correlation with pH in both settings, more pronounced in urban areas (-0.55), indicating that higher temperatures may exacerbate acidity in rainwater. Rainfall positively correlates with nitrate levels in both rural (0.55) and urban (0.45) areas, suggesting that rain can wash nitrates from the atmosphere into rainwater. These correlations emphasize the need for targeted strategies to address specific pollution sources in rural and urban environments.



An assessment of drinking water quality and water body contamination was carried out using ASTM and APHA quality standards, which were based on guidelines from the WHO and NSDWQ. The information about the physiochemistry, bacteriology, and heavy metals for groundwater (boreholes) and surface water (streams) is given in Tables 2 and 3. We'll be doing this statistical analysis on Tables 4–10. A comparison of surface and groundwater quality from different sites is shown in Figures 2 and 3. While water samples from sites A and C had pH values below 6.0, surface water pH ranged from 5.19 to 7.12. Samples collected from borehole B at position 2 revealed that the pH of the groundwater ranged between 5.38 and 6.24, above the tolerance threshold of 6.0. Three sites' surface water temperatures ranged from 27.4 to 28.8 degrees Celsius, while groundwater temperatures varied from 28.11 to 29.4 degrees Celsius. Every body of water had turbidity of less than 5.0 NTU. Groundwater had turbidity ranging from 1.07 to 1.54 NTU, which was much greater than that of surface water. 18 out of 20 water samples showed dissolved oxygen levels over the 5.0 limit established by the NSDQW and the WHO, ranging from 6.01 to 7.95. The biological oxygen demand (BOD) recommendations for drinking water were surpassed by most of the water samples. All surface water samples were above the limit, however only 83% of groundwater samples were. Total dissolved solids (TDS) values in fifteen of the eighteen water samples collected from the study area ranged from 5.65 to 11.67 mg/L. Although 5 mg/L is the suggested limit, all readings were greater. Twelve groundwater samples and three surface water samples were gathered in order to perform the filthy water test. TSS readings in the range of 0.001-0.009 mg/L were generally regarded as acceptable.

Table 4. Examination of Groundwater in Relation to Requirements for Potable Water

Parameters	location 1		Location 2		Location 3		NSDWQ	WHO
	A	B	A	B	A	B		
PH	5.38	5.72	6.24	5.78	5.25	5.82	6.0-8.5	6.0-8.5
Temperature	29.2	28.8	28.11	28.7	28.13	29.4	29.8	29.8
Turbidity (NTLI)	3.21	3.08	2.81	3.03	3.86	4.02	5.0	5.0
DC/	6.99	7.44	6.87	7.10	7.56	7.95	5.0	5.0
BOO	1.23	2.82	0.89	1.65	2.67	3.52	3.0	3.0
IDS	10.97	8.81	8.43	9.40	11.67	10.42	5.0	5.0
TSS	0.001	0.001	0.001	0.001	0.001	0.001	5.0	5.0
Sulphate	0.003	0.006	0.082	0.030	0.009	0.010	2.0	2.0
Pb	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01
Fe	0.213	0.198	1.001	0.47	0.329	0.802	0.3	0.3
Zn	0.054	0.136	0.061	0.084	0.093	0.107	3.0	3.0
TPC (CFU)	12	9	15	12	18	14	0	0
F. coliform (CFU)	3	2	2	2.3	4.6	3.4	0	0
E. soli (CFU)	0	0	0	0	0	0	0	0

Sources: Weather forecasting Centre, 2021

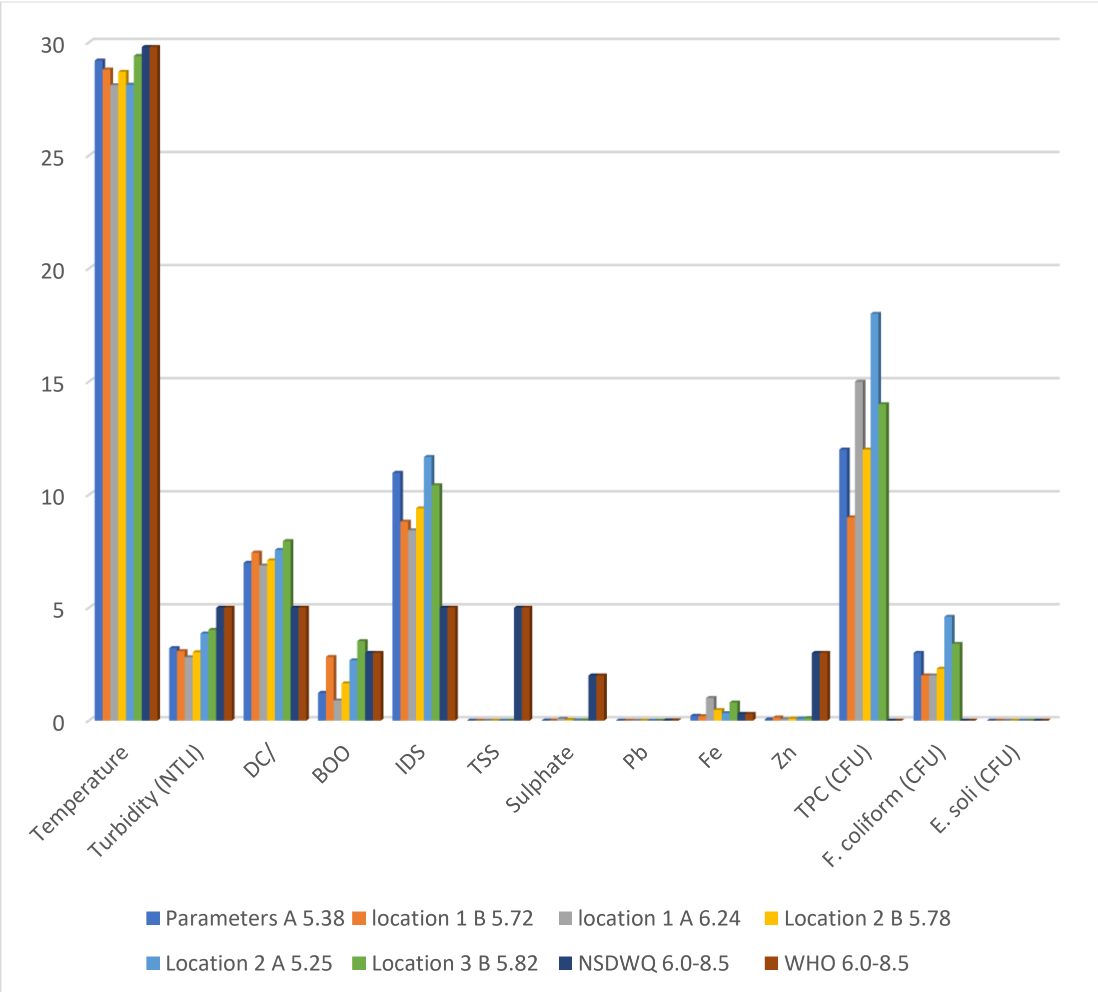


Figure 2: Surface water comparisons within the research region

Sources: Weather forecasting Centre, 2021

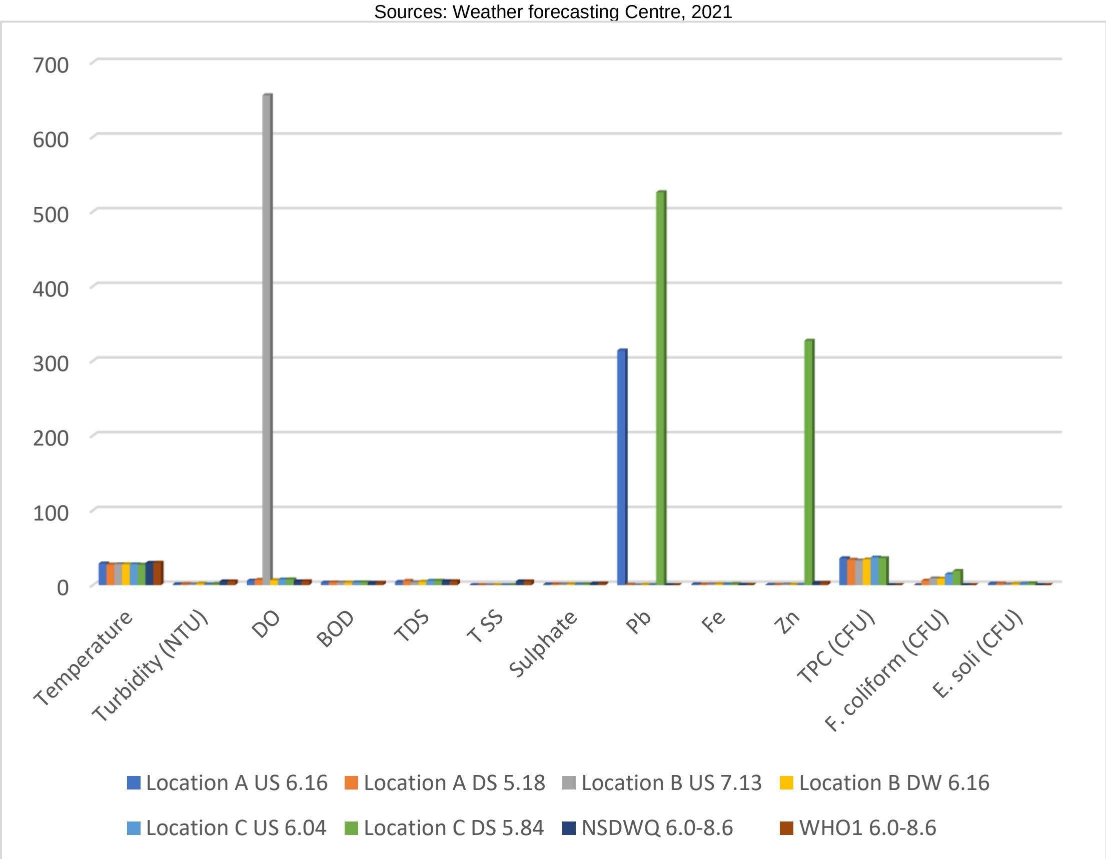


Figure 3: Groundwater comparison within the research region

Sources: Weather forecasting Centre, 2021

The maximum sulfate level was found in surface water, with all samples being below 2.0 mg/L. Six of the surface water samples had lead levels above the World Health Organization's and the NSDWQ's 0.01 mg/L drinking water threshold. The samples had lead contents ranging from 0.001 to 0.528 mg/L. Four samples showed iron levels between 0.198.1 and 1.482 mg/L, whereas thirteen samples had values less than 0.3 mg/L. The zinc levels in each sample ranged from 0.054 to 0.811 mg/L, which is less than the 3.0 mg/L advised by the NSDQW and the WHO. All of the samples had total plate counts (TPC) values over the safe drinking water limit, indicating a high degree of contamination. The surface water had 33–37 CUF, whereas the groundwater contained 9–18 CUF. The pattern was also seen in faecal coliform bacteria. There were violations of the WHO and NSDWQ zero-tolerance drinking water standards at amounts between 2 and 19 CUF. Samples of groundwater showed no signs of E. coli. The parameter's level in surface water was higher than the 1.0–2.3CUF drinking water standard.

Result and Discussion

It is possible to get the conclusion that all of the investigated water sources do not surpass the restrictions imposed by both domestic and international regulatory bodies by examining the pH measurements. There is a pH range of 6.5-8.2 that is good for long-term storage. Acidic deposition is likely to have occurred in the region immediately around the natural gas processing facility, as shown by the results, which reveal relatively low sample pH values. Data from an oil-impacted area indicates that very high or low pH water is dangerous for human health and may cause dietary issues. There is a consensus among most people that acid rain presents a risk to a broad variety of important natural resources, such as fisheries, crops, and animals. When hazardous metals from water distribution networks and watersheds accumulate in potable water, they may offer substantial health hazards to people. Acidified streams are a possible entrance site for these metals, which can be found in watersheds and water distribution networks.

The turbidity level in the groundwater samples reached 4.02 NTU, which is greater than the turbidity level in the surface water samples. On the other hand, the readings of turbidity go below the threshold of 5 NTU, As water, it doesn't provide any health dangers. Because of the existence of clay, silt, organic materials, and other microscopic particles, the moderate range of turbidity brought on by oil-related activities such gas flaring and oil spills may be detrimental to the health of the local population. According to the conclusions of those who have previously decided that pipeline vandalism and leaching from oil operations are to blame in the region under examination, this is consistent with their findings.

Conclusion

An integrated approach that safeguards the environment without compromising social or economic development is necessary for sustainable water resource management. This strategy has to be implemented in order to be successful. To develop and manage water resources, it is essential that all segments of society—lawmakers, planners, and water users—cooperate in an inclusive and systematic way. When it comes to distributing, managing, and preserving water, both men and women make substantial contributions. Over pumping of subterranean water sources is contributing to the global issue of groundwater contamination and scarcity. As a result, an increasing number of people are making an effort to reduce the amount of water they use each day. Gathering rainwater is one of the most crucial steps in assuming this level of water responsibility. Rainwater collection has been going on in the area under investigation for a while, but it hasn't been done in a morally or responsibly way. As such, individuals vary in their susceptibility to different aquatic ailments throughout the year. Given the gravity of the situation, the project has to be planned and carried out with great care in order to take full advantage of the abundant precipitation.

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