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Experimental Study and Assessment of Underground Water Quality and Treatment

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Abstract - Groundwater is one of the most important fresh water resources and provides water for domestic and agriculture and industrial activities. Although groundwater is naturally protected by soil and geological formations, contamination may occur through agriculture runoff, sea waste infiltration, septic system, industrial activities, waste disposal and natural occurring mineral. The present study was conducted to assess selected physio – chemical characteristics of underground water and to investigate effectiveness of water – treatment processes in improving its quality. Underground – water samples were clearly analyzed for pH, temperature, color, turbidity and total dissolved solid TDS. The results were compared before and after treatment to identify changes in water quality. The investigation showed that Groundwater samples generally had better physical clarity and lower turbidity than sewage water however, defenses TDS and other chemical characteristics demonstrated that groundwater quality cannot be judged solely From Visual Appearance. A treatment resulted in improvement of selected parameters, particularly via suspended or particulate matter was present. The study emphasizes that groundwater treatment must be selected according to the contaminant of concern. Physical filtration may be effective for turbidity but is not necessarily sufficient for dissolve iron such as fluoride, nitrate, arsenic or excessive salinity. WHO's current drinking – water guidance promote risk – based management and comprehensive monitoring rather than reliance on a single water – quality parameter. The findings would continue groundwater monitoring and the application of contaminant- specific treatment process for safe and sustainable groundwater use.

Keywords: Groundwater, underground water, groundwater quality, pH, turbidity, TDS, contamination, water treatment, Physio–chemical analysis.

INTRODUCTION

Groundwater is water stored below the Earth's surface in soil pores, fractures and geological formations. It represents an important component of the hydrological cycle and act as an important source of fresh water in many regions.

Groundwater is found when precipitation and surface water infiltrate through soil and permeable geological formations. During infiltration and percolation, water interact with soil and mineral. These interactions may naturally modify its chemical composition. Groundwater is generally less exposed to direct contamination than surface water. However, once contaminants enter an aquifer, they may persist for long periods because groundwater generally moves slowly major anthropogenic sources of groundwater contamination include sewage leakage, septic systems, agriculture fertilizer and pesticides, industrial effluents, landfill leachate and improper disposal of solid waste.

Natural geological process may also contribute to groundwater contamination. Dissolution of mineral can increase concentration of fluoride, iron, manganese, arsenic and other constituents depending on local geology.

The quality of groundwater is therefore influenced by both natural and anthropogenic factors. The present research investigates selected physio – chemical characteristics of underground water and valid improvement obtained through treatment.

Formation of Groundwater

Groundwater formation can be represented as:

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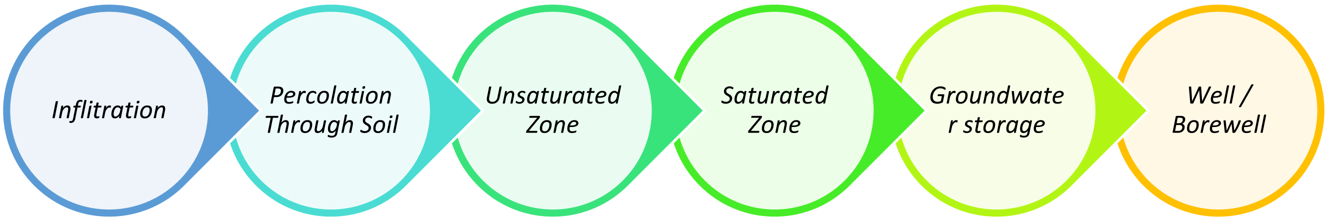

Are rainfall infiltrates the ground and moves downward through pores and fractures. When water reaches the saturated zone, the available space becomes filled with water. The upper surface of the saturated zone is commonly referred to as the water table. The amount and the quality of the water depend on rainfall, geological conditions, soil properties, re recharge rate, groundwater abstraction and contamination sources.

Sources of Groundwater Contamination

Domestic Sewage Improper disposal of domestic wastewater can result in infiltration of nutrients, pathogens and dissolve contaminants into groundwater.

Agricultural Activities Excessive use of fertilizers can increase nitrate concentrations. Pesticides and other agriculture chemical may also enter groundwater.

Industrial Activities Industrial wastewater can introduce heavy metals, chemicals, organic compounds and salt into groundwater.

Solid-Waste Disposal Leachate generated waste disposal area may migrate through soil and contaminate groundwater.

Natural Geological Sources Groundwater may naturally contain elevated concentration of mineral such as fluoride, iron, manganese and arsenic depending upon geological conditions

Aim of the Study

The aim was to experimentally assess selected physico-chemical properties of underground water and investigate the effectiveness of selective treatment processes in improving water quality.

Objective

The objective were:

1. To collect representative underground – water samples
2. To analyze selected Physico - chemical parameters
3. To assess the quality of underground water
4. To identify variation between sampling locations
5. To apply your selected treatment process
6. To compare water quality before and after treatment
7. To calculate treatment efficiency
8. To identify the limitation of conventional treatment
9. To Recommended appropriate future treatment and monitoring strategies

Material and Method

Sample Collection

Underground- Water samples were collected from selective sources such as borewell, wells or other underground sources forming parts of the study area.

Clean and labelled Containers were used. Samples were transported carefully to the laboratory for analysis.

Physico-Chemical Parameters

Parameter	Unit	Importance
pH	-----	Acidic/Alkaline Condition

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Temperature	°C	Thermal Condition
Colour	-----	Visible Quality
Turbidity	NTU	Suspended Matter
TDS	ppm	Dissolved Matter

pH Analysis

pH was measured using a calculated digital pH meter. Groundwater pH can be affected by geological interaction, dissolved mineral, Carbon dioxide and anthropogenic influences.

The measured PH value was recorded for each sample and compared before and after treatment.

Temperature Analysis

Temperature was measured using a thermometer or digital temperature meter. Ground water temperature is usually more stable than surface – water temperature because it is less directly exposed to atmospheric temperature changes.

Turbidity Analysis

Turbidity was measured using a turbidity meter. Groundwater generally has lower turbidity than untreated sewage because so and geological formation can naturally filter suspended particles. However, turbidity may increase because of well disturbance, soil particles, iron magnesium precipitation, surface – water infiltration or well construction. Who identifies stability as an important water – quality characteristics and note that elevated turbidity can interfere with treatment and disinfection.

TDS Analysis

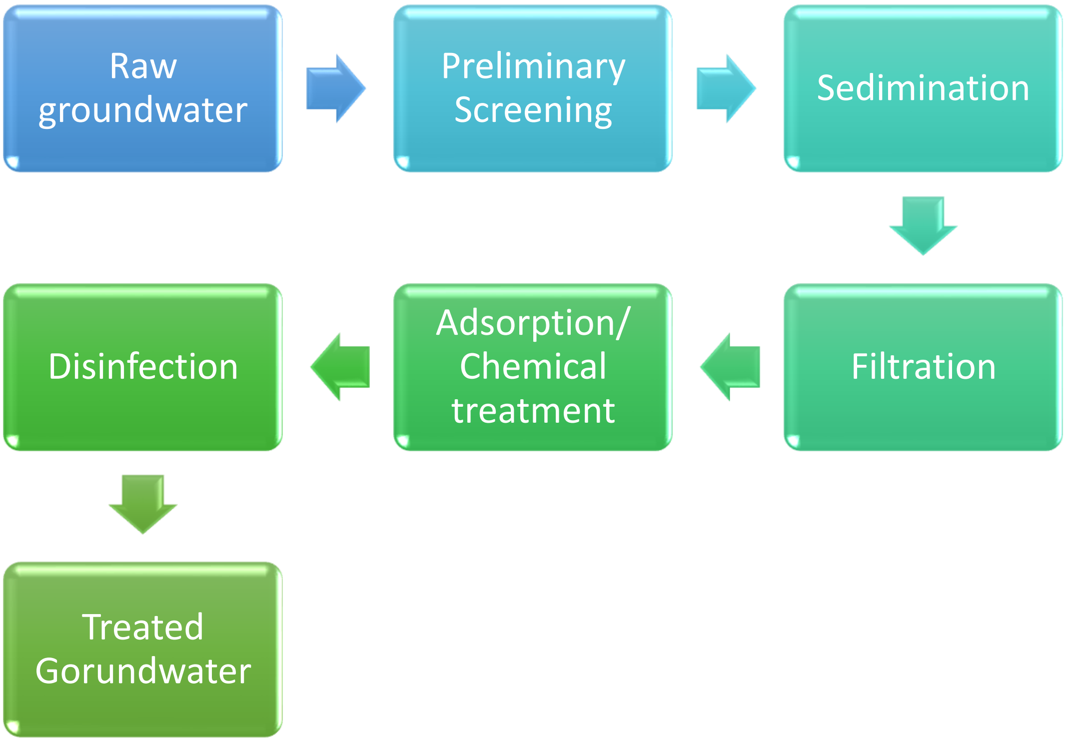
TDS was measured using a calibrated TDS meter.

TDS may be affected by mineral dissolution, geological formation, agriculture return flow, sewage waste contamination and saline intrusion. Higher TDS does not automatically indicate a specific contaminant.

Therefore, additional chemical analysis is necessary when elevated TDS is observed.

Underground-Water Treatment

The treatment process was based on the measured characteristics of the collected groundwater.



Experimental Observation

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Underground – water observation table

Samples	pH	Temperature (°C)	Turbidity	TDS	Colour	Chloride	Total alkanity
S1	7.51	21(°C)	1.0	120	5	18	114
S2	7.38	22(°C)	1.0	125	3	12	108
S3	7.44	21.5(°C)	1.0	200	4	19	116
S4	7.83	23(°C)	1.1	185	4	22	108
S5	7.79	24.1(°C)	2.3	176	5	20	126
S6	7.49	27(°C)	2.4	164	2	15	124
S7	7.24	25.6(°C)	1.6	215	3	13	108
S8	7.1	23.4(°C)	2.6	139	3	25	115
S9	6.98	22(°C)	2.1	186	5	23	116
S10	7.12	23.3(°C)	1.0	225	5	18	114
S11	6.94	25.7(°C)	0.18	196	4	29	60
S12	7.82	24(°C)	0.85	115	3	19	54
S13	7.41	25.8(°C)	1.77	136	2	22	187
S14	7.70	24(°C)	1.58	182	5	27	58
S15	7.80	21.7(°C)	3.2	177	5	12	40

Treatment Efficiency

The treatment efficiency for a parameter was calculated using

$$Removal\ Efficiency\% = \frac{Ci - Cf}{Ci} \times 100$$

where:

C_i = initial concentration

C_f= final concentration

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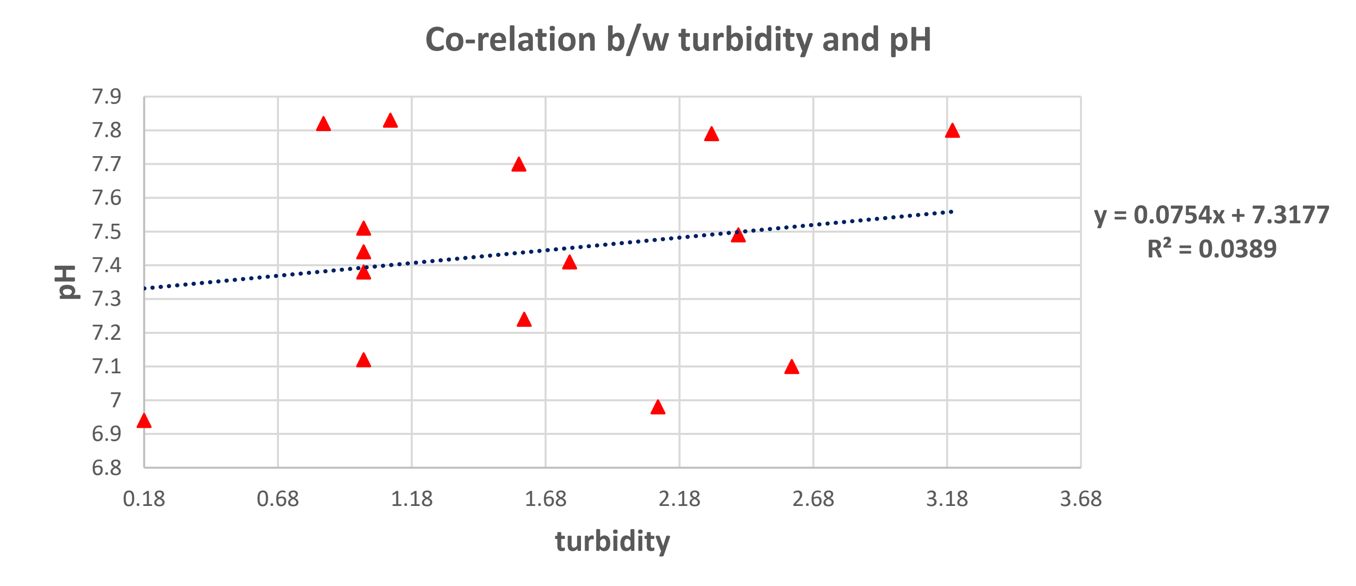
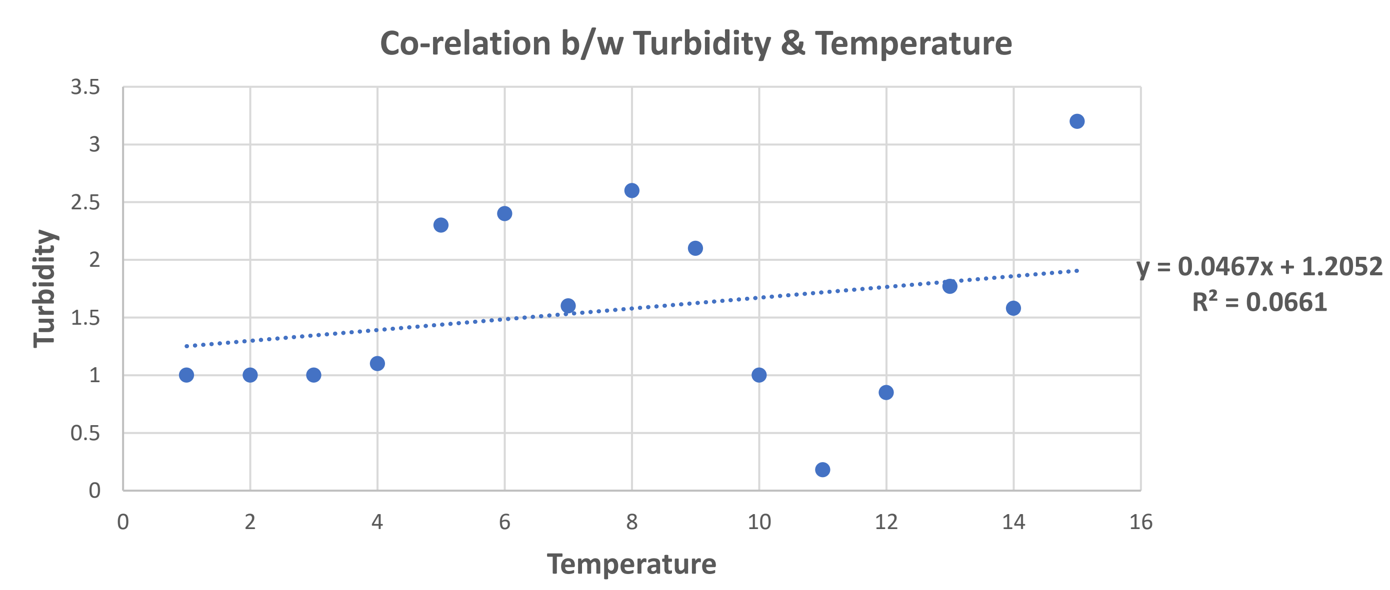
r value	Interpretation
0.00 to ±0.19	Very weak
±0.20 to ±0.39	Weak
±0.40 to ±0.59	Moderate
±0.60 to ±0.79	Strong
±0.80 to ±1.00	Very strong



The scatter plot shows a very weak positive correlation between turbidity and pH, with r ≈ 0.197. The positive value indicates that pH tends to increase slightly with an increase in turbidity. The low R^2 value (0.0389) indicates that the relationship is weak and turbidity explains only a small proportion of the variation in pH.



The scatter plot shows a **very weak positive correlation** between turbidity and temperature, with **r ≈ +0.257**. The positive correlation indicates that temperature tends to increase slightly with an increase in turbidity.

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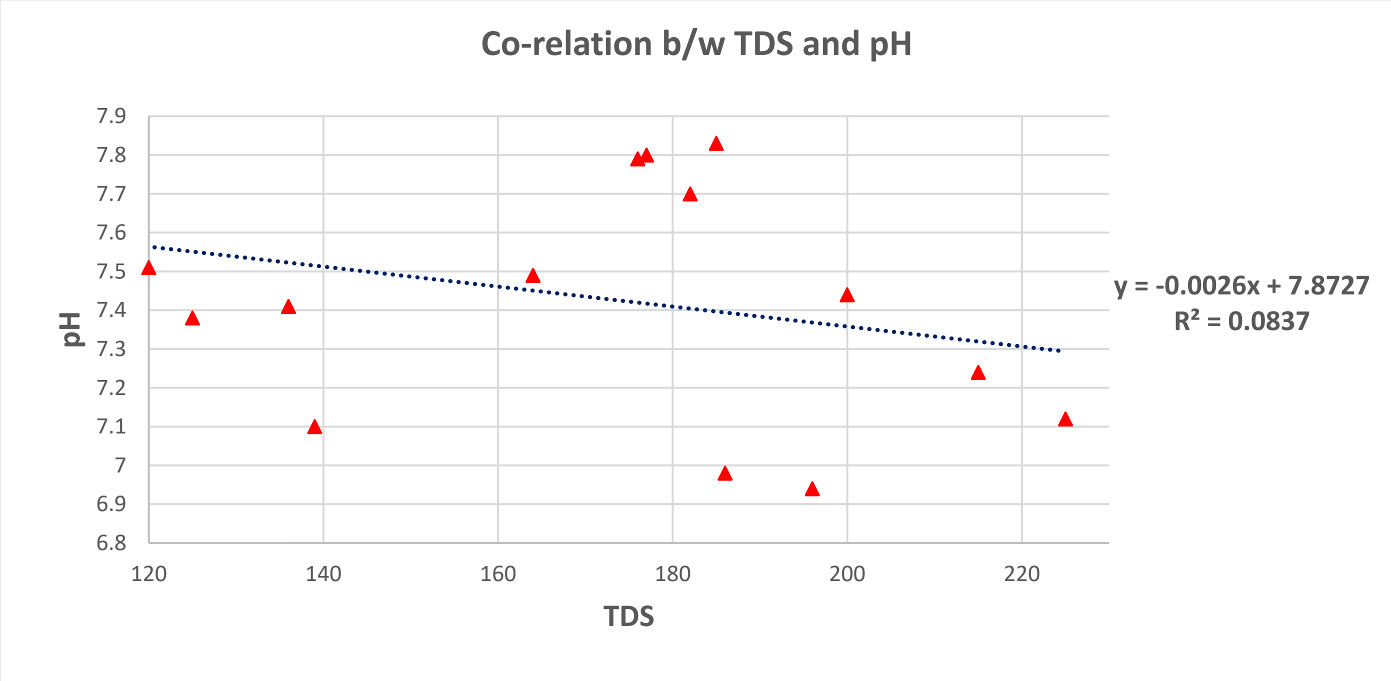
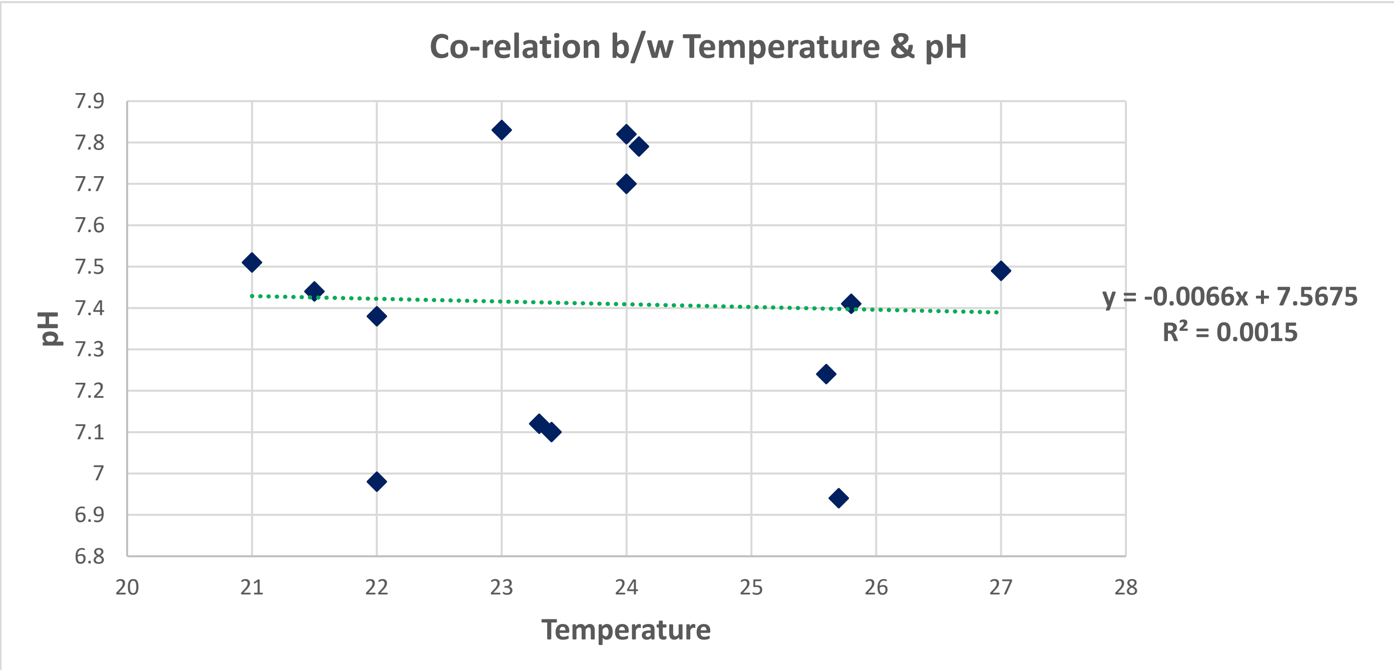
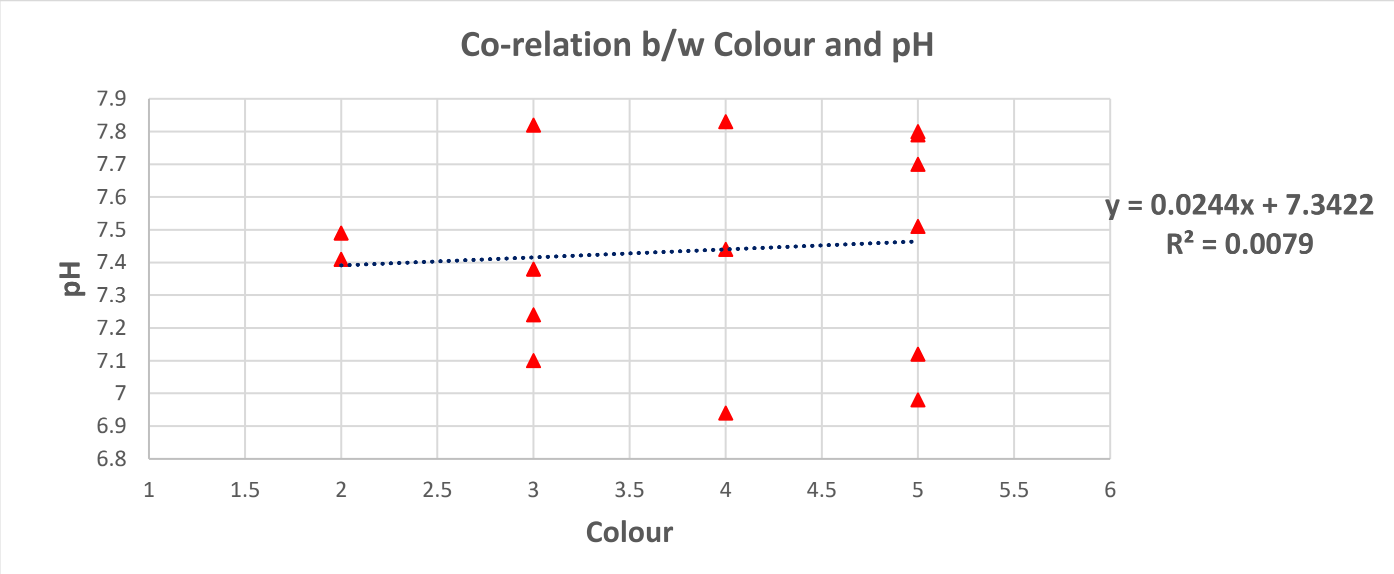
The low **R^2 value (0.0661)** indicates that the relationship is weak, with only about **6.61% of the variation** explained by the linear relationship.



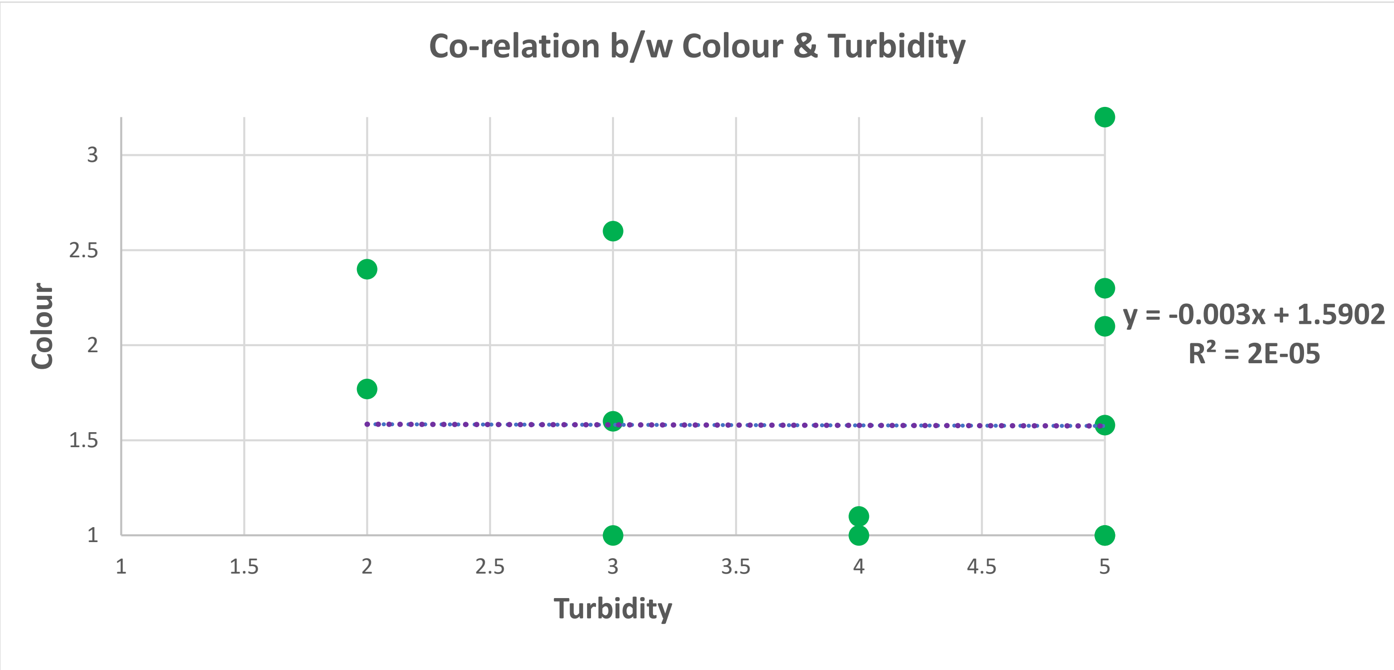
The scatter plot shows a **very weak negative correlation** between TDS and pH, with **r ≈ −0.289**. The negative correlation indicates that pH tends to decrease slightly as TDS increases. The low **R^2 value (0.0837)** indicates that the linear relationship is weak, with only about **8.37% of the variation** explained by the relationship.



The scatter plot shows a **very weak negative correlation** between temperature and pH, with **r ≈ −0.039**. The negative correlation indicates that pH tends to decrease very slightly as temperature increases. The very low **R^2 value (0.0015)** indicates that there is **almost no linear relationship** between temperature and pH in the analysed water samples.



The scatter plot shows a **very weak positive correlation** between colour and pH, with **r ≈ +0.089**. The positive correlation indicates that pH tends to increase slightly with an increase in colour. The very low **R^2 value (0.0079)** indicates that there is **almost no linear relationship** between colour and pH in the analysed water samples.



The scatter plot shows a **very weak negative correlation** between colour and turbidity, with **r ≈ −0.0045**.
The negative correlation indicates that turbidity tends to decrease very slightly as colour increases.
The extremely low **R^2 value (0.00002)** indicates that there is **practically no linear relationship** between colour and turbidity in the analysed water samples.

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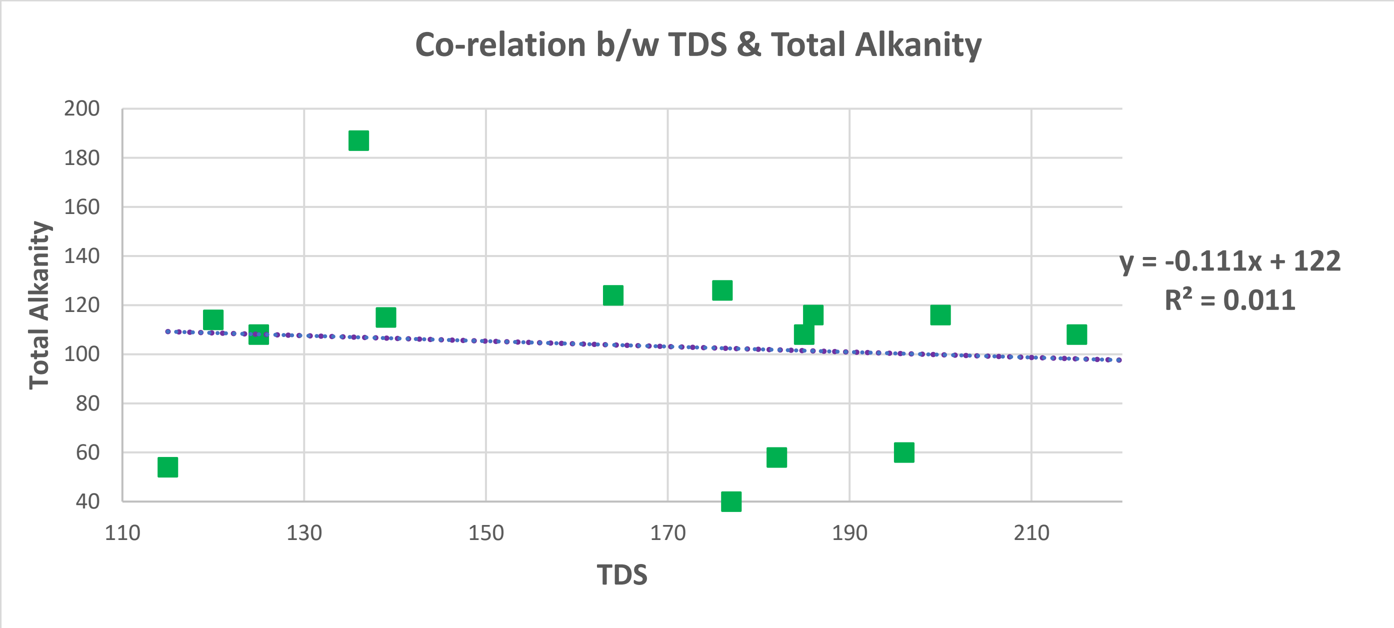

The scatter plot shows a **very weak negative correlation** between TDS and total alkalinity, with **r ≈ −0.105**. The negative correlation indicates that total alkalinity tends to decrease slightly as TDS increases. The very low **R^2 value (0.011)** indicates that there is **almost no linear relationship** between TDS and total alkalinity in the analysed water samples.

Results and Discussion

The groundwater samples generally demonstrated better visual quality than sewage samples. This difference is expected because groundwater passes through soil and geological formations, which can remove proportion of suspended particles. However good visual appearance does not guarantee chemical or microbiological safety. Groundwater may contain dissolve contaminants that cannot be detected through visual observation. This treatment process resulted in improvement in the parameter that was affected by the selected treatment mechanism. Dictation was particularly useful where tablet was associated with suspended material.

This reduction in TDS was dependent on the treatment mechanism. Conventional filtration generally removes suspended matters more effectively than dissolved iron therefore if groundwater contains excessive fluoride, nitrate, arsenic or salinity, contaminant – specific statement technologies may be necessary.

This distinction is important in groundwater treatment The treatment process should be selected according to the contaminants rather than simply according to the appearance of the water.

Groundwater and Public Health

Groundwater intended for drinking required comprehensive assessment. WHO's current drinking – water guidance promotes health -based targets, preventive risk management and water - safety plans covering the water supply chain from catchment to consumers.

Therefore, pH, turbidity and TDS alone cannot establish drinking water safety.

Additional analysis should include:

- Microbiological quality
- Nitrate
- Fluoride
- iron
- magnesium
- arsenic
- chloride
- sulfate
- hardness
- alkalinity
- selected heavy metals
- other contaminants relevant to local geology and land use

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Comparison Between Sewage and Underground Water

Characteristic	Sewage Water	Underground Water
Main Source	Domestic wastewater	Infiltration/recharge
Suspended Matter	Generally high	Usually lower
Colour	Often visible	Usually clear
Turbidity	Generally high	Usually low to moderate
TDS	Variable	Highly dependent on geology
Microbial Contamination	Potentially high	Usually lower but possible
Organic Matter	Generally high	Usually lower
Treatment Requirement	Usually extensive	Contaminant-specific
Main Treatment Objective	Removal of solid, organics and pathogens	Removal of site-specific contamination
Reuse Potential	Possible after appropriate treatment	Depends on quality

SIGNIFICANCE OF TDS

TDS is an important parameter for groundwater because dissolved mineral content mat increase as groundwater interacts with geological formations.

WHO states that TDS below approximately 600ppmis generally considered acceptable in terms of palatability, while water above approximately 1000ppm may become increasingly unpalatable. WHO does not specify a heath-based guideline value for TDS itself.

Therefore, TDS should be regarded as an indicator rather than a direct measure of overall water safety.

Significance of Turbidity

Attribute is particularly important because it provide information about particulate material in water. A reduction in ability following treatment indicates removal of suspended or collateral particles. However, very low turbidity does not necessarily mean that dissolve contaminants or microorganism have been removed. Consequently, turbidity should be evaluated together with chemical and microbiological parameters.

Limitations

The study has the following limitation:

1. Only selected physico – chemical parameters were considered.
2. The number of sampling locations was limited.
3. Seasonal variation was not comprehensively investigated.
4. Detailed hydrogeological characterization was outside the scope of the study.
5. Microbiological analysis was limited not included in the selected experimental parameters.
6. Specific contaminants such as fluoride, nitrate and arsenic were not included in the basic analysis.
7. Treatment efficiency depends on the characteristics of individual groundwater sources.

CONCLUSION

The present study evaluated selected physico – chemical characteristics of underground water and investigate the effectiveness of A selected treatment process. The investigation demonstrated that groundwater generally had better visual quality than sewage water,

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particularly with respect to color and turbidity. However, groundwater quality cannot be assessed solely through visual appearance because dissolve contaminants may remain undetected.

The treatment process improves lactic parameters, particularly where the contaminants were amenable to physical separation or filtration. The effectiveness of the treatment for TDS was comparatively dependent on the nature of dissolves substances and the treatment technology employed.

This study demonstrates an important principle of groundwater management our treatment must be contaminant – specific and supported by comprehensive water – quality monitoring. Groundwater intended for drinking should undergo a much broader assessment, including microbiological and relevant chemical parameters before being declared safe.

Overall, these study sports integrated groundwater – quality monitoring, source protection and appropriate treatment as essential component of sustainable water – resource management.

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