Sultanate of Oman
Ministry of Education
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Hind bint Al-Muhallab Basic
Education School (Grades 5–10)

Comparative Analysis of the Impact of Climate Variability on the Chemical Properties of Agricultural Well Water in Sohar (2018–2025)

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Abstract

This study examines the relationship between climate variability and the chemical properties of agricultural well water in the Wilayat of Sohar during the period from 2018 to 2025, in light of the increasing challenges posed by climate change to water resources in arid and semi-arid regions. The study relied on official data obtained from relevant authorities and specialized platforms, including measurements of salinity (EC) and acidity/alkalinity (pH) for three agricultural wells, in addition to reliable climatic data comprising rainfall amounts and average annual temperatures for the same period.

The study focuses on addressing a set of key research questions, most notably:

(1)To what extent do changes in rainfall amounts affect the salinity and pH of agricultural well water?

(2)What is the nature of the relationship between average temperature and changes in the chemical properties of this water?

(3)Do salinity and pH differ in their degree of sensitivity to climatic factors during the study period?

To answer these questions, annual averages of salinity and pH values for the three agricultural wells were calculated and temporally linked to rainfall and temperature data through comparative analysis and graphical representation to examine general trends and relationships among the variables. The results revealed a clear inverse relationship between rainfall amounts and average well-water salinity, whereby salinity decreased during wetter years and increased during periods of relative drought. In contrast, pH values showed relative stability within a slightly alkaline range and were only marginally affected by climatic factors. The analysis also indicated that higher temperatures contribute to increased salt concentration as a result of higher evaporation rates, without a significant effect on pH values.

The study concludes that climate variability—particularly fluctuations in rainfall and rising temperatures—has a greater impact on the salinity of agricultural well water in the Wilayat of Sohar than on pH levels. This finding underscores the importance of strengthening sustainable groundwater management practices to mitigate the effects of climate change on the agricultural sector.

Key Terms

Climate Variability: Long-term changes in climate elements such as air temperature, rainfall amounts, and weather patterns resulting from natural or human-induced factors, which have direct impacts on ecosystems and water and agricultural resources (World Meteorological Organization, 2021).

Water Salinity (EC): A measure of the concentration of dissolved salts in water, expressed in deciSiemens per meter (dS/m), and used to assess water suitability for irrigation and its effects on soil and agricultural crops (FAO, 1985).

pH (Potential of Hydrogen): A chemical indicator used to measure the acidity or alkalinity of water, with values ranging from 0 to 14. pH influences chemical reactions and the availability of nutrients in soil and water (APHA, 2017).

Groundwater: Water stored in geological formations beneath the Earth's surface, which represents a primary source of freshwater in arid and semi-arid regions. Its quality depends on geological characteristics, climatic conditions, and rates of exploitation (Todd & Mays, 2005).

Agricultural Wells: Engineered structures constructed to extract groundwater for irrigation purposes, whose chemical properties are influenced by climatic factors, pumping rates, and the characteristics of the aquifer (Public Authority for Water Resources, 2019).

Introduction and Literature Review

Groundwater is considered one of the most important natural resources on which the agricultural sector in the Sultanate of Oman depends, particularly in coastal and arid areas such as the Wilayat of Sohar in the North Al Batinah Governorate. It represents the primary source of irrigation water due to the limited availability of surface water resources. With the increasing demand for water resulting from agricultural expansion and population growth, several environmental challenges have emerged, most notably the salinization of agricultural well water and the deterioration of its chemical quality.

In recent decades, climate variability—manifested in fluctuations in rainfall amounts and rising temperatures—has contributed to increased pressure on groundwater resources. Periods of drought and higher evaporation rates lead to greater salt concentration in groundwater, which negatively affects agricultural productivity and its sustainability. (Abdullah, M, 2017))

Numerous studies indicate that irrigation water salinity is among the chemical properties most affected by climate change, whereas pH levels tend to show relative stability compared to salinity. However, the persistence of climate variability may result in gradual changes in the chemical balance of groundwater over the long term.(Al-Dhakhriya, R. bin S, 2022)

Accordingly, this study seeks to analyze the relationship between climate variability—represented by rainfall amounts and average temperatures—and the chemical properties of agricultural well water in the Wilayat of Sohar during the period from 2018 to 2025. This is achieved through a comparative analysis of salinity and pH values for a number of agricultural wells, thereby contributing to efforts aimed at supporting sustainable water resource management and agricultural planning in the region.

Research Methods

Data for this research were collected using the following methods:

A. Data Collection and Analysis:

Climatic data related to rainfall amounts and average annual temperatures for the period from 2018 to 2025 were obtained from accredited meteorological sources. Data on the chemical properties of agricultural well water—specifically salinity (EC) and pH values—were obtained from the Agricultural Research Center in the Wilayat of Sohar. These data were organized into chronological tables, followed by a comparative analytical process to link climatic variations with changes in the chemical properties of agricultural well water.

B. Interview:

A personal interview was conducted with farmer Yusuf bin Mohammed Al-Maqbali, the owner of one of the farms in the Wilayat of Sohar, with the aim of benefiting from his practical experience and documenting the changes he has observed in the quality of agricultural well

water over recent years. A set of questions was posed regarding the impact of climate variability on water salinity and the quality of irrigation water.

C. Field Study:

A field study was carried out to collect water samples from the wells included in the study. Specialized instruments were used to measure salinity and pH levels in order to support the official data, verify their accuracy, and link the results to on-site field conditions.

Research Procedures

The research was organized according to the following steps:

1. Collecting climatic data related to rainfall amounts and average annual temperatures for the Wilayat of Sohar during the period from 2018 to 2025 from accredited meteorological sources.
2. Collecting data on the chemical properties of agricultural well water—specifically salinity (EC) and pH values—for three agricultural wells from the Agricultural Research Center in the Wilayat of Sohar.
3. Developing a comprehensive research plan that included defining the research problem, objectives, and questions, as well as specifying the study timeframe and research methodology.
4. Conducting a personal interview with farmer Yusuf bin Mohammed Al-Maqbali, the owner of one of the farms in the Wilayat of Sohar, to benefit from his practical experience and to document observed changes in the quality of agricultural well water.
5. Carrying out a field study to collect water samples from the agricultural wells included in the study, using specialized instruments to measure salinity and pH levels in order to support and verify the official data.
6. Organizing and classifying the collected data chronologically by year and by agricultural well, with standardization of the measurement units used.
7. Calculating annual averages of salinity and pH values for the studied wells to represent general trends over the study period.
8. Conducting comparative analysis to link climatic variables (rainfall and temperature) with the chemical properties of agricultural well water.
9. Presenting the data using analytical tables and graphical representations to illustrate trends and relationships among the variables.
10. Analyzing the results of the relationship between climate variability and changes in salinity and pH values of agricultural well water, and deriving scientific conclusions regarding the impact of climate on agricultural groundwater quality in the Wilayat of Sohar.

Research Plan and Implementation Timeline

No.	Student Name	Task	Date of Implementation
1	Mira Omar Al-Yahyai	Selection of the research topic	October 2025
2	Mira Omar Al-Yahyai Sultanah Ibrahim Al-Balushi	Collecting climatic data (rainfall amounts and temperatures) and salinity and pH data from relevant official authorities	October 2025
3	Mira Omar Al-Yahyai Sultanah Ibrahim Al-Balushi	Conducting a personal interview with a farmer and collecting field information on the quality of well water	October 2025
4	Mira Omar Al-Yahyai Sultanah Ibrahim Al-Balushi	Carrying out a field study to collect water samples from agricultural wells and measuring salinity and pH levels using specialized instruments	November 2025 — December 2025 —
5	Mira Omar Al-Yahyai Sultanah Ibrahim Al-Balushi	Organizing and classifying data by years and agricultural wells, calculating annual averages, conducting comparative analysis, and presenting results graphically	November 2025 — December 2025
6	Mira Omar Al-Yahyai Sultanah Ibrahim Al-Balushi	Writing the research, interpreting the results, and drawing conclusions and recommendations	December 2025

Table 1: Research Implementation Steps

Table (1) illustrates the research plan and the timeline for implementing the study phases. The research tasks were systematically and sequentially distributed, beginning with the selection of the research topic and the collection of climatic and chemical data, followed by the personal interview and field study, and culminating in data analysis and the writing of the final research paper. This structured approach ensures that the study is completed within the specified timeframe and that its scientific objectives are achieved.

Study Location

The study area is located in Sohar, within the North Al Batinah Governorate of the Sultanate of Oman. Data on the chemical properties of agricultural well water were collected from three wells located on three different farms within the boundaries of the wilayat. These farms were selected to represent the actual conditions of agricultural groundwater quality in the region.

The geographical coordinates (latitude and longitude) of each farm were documented to accurately determine the locations of the wells and to link the chemical properties of the water with the spatial characteristics of the sites. This spatial identification enhances the accuracy of the analysis and allows for future comparison of the results with similar studies.

Sohar is characterized by an arid to semi-arid climate, marked by fluctuating rainfall amounts and high air temperatures. These climatic conditions make groundwater resources in the area particularly vulnerable to climate variability and salinization processes, which justifies the selection of Sohar as the study area..

m No.	Wilayat / Area	Latitude (N)	Longitude (E)
1	Sohar – Majis Al-Kubra	24.23058	56.81361
2	Sohar – Al-Fateq	24.24744	56.81135
3	Sohar – Al-Tareef	24.354	56.69326

Table2: Table (1): Geographic Coordinates of the Farms Included in the

This table presents the geographical coordinates of the three farms included in the study area in Sohar, which were used to accurately locate the agricultural wells and support spatial analysis of groundwater chemical properties.

Identification of the Protocols Used in the Study

This study relied on GLOBE Program protocols, including the Atmosphere protocols for monitoring rainfall and air temperature, the Water Quality protocol for measuring salinity (EC) and pH of agricultural well water, as well as the Site Definition protocol to document the geographical coordinates of the study locations.

Identification of the Instruments and Tools Required for Conducting the Study

Several instruments will be used to measure water properties. Table (2) presents the most important of these instruments and their respective uses.

No.	Device	Image	Use
1	pH Meter (Soil Acidity Meter)		Measuring soil acidity (pH)
2	Salinity and Conductivity Meter		Measuring soil salinity

Table 3: Instruments and Tools Required for Conducting the Study

Data Collection and Analysis

First: Collection and Analysis of Climatic Data and Their Comparison with Salinity and pH Levels

Data on the chemical properties of agricultural well water—namely salinity (EC) and pH values—were obtained from three wells located on three different farms in the Wilayat of Sohar through the Agricultural Research Center in Sohar. In addition, climatic data related to rainfall amounts and average annual temperatures for the period from 2018 to 2025 were collected from accredited climatic records available on the official website (www…..com).

The data were organized into chronological tables, after which annual averages of salinity and pH values for the studied wells were calculated. This was followed by a comparative analysis to link these values with climatic variables using analytical tables and graphical representations, with the aim of illustrating general trends and relationships among the variables.

Year	Rainfall (mm)	Climatic Description
2018	95	Moderately rainy year
2019	110	Relatively heavy rainfall
2020	85	Below average rainfall
2021	100	Scattered rainfall
2022	70	Relative drought
2023	90	Normal climatic conditions
2024	105	Moderate rainfall with local flooding
2025	95	Moderate rainfall

Table 3: Annual Rainfall Amounts in Sohar (2018–2025)

The table illustrates the variability in annual rainfall amounts in Sohar during the study period, showing years with relatively high rainfall such as 2019 and 2024, in contrast to relatively dry years such as 2022. This variability provides a suitable basis for analyzing the impact of climate variability on the chemical properties of agricultural well water.

Year	Average Air Temperature (°C)	Climatic Description
2018	27.5	Relatively moderate
2019	27.2	Below average
2020	28	Above normal
2021	27.8	Relatively high
2022	28.5	High
2023	27.6	Normal
2024	27.4	Moderate
2025	27.9	High during summer

Table 4: Annual Average Air Temperatures in Sohar during the Period (2018–2025)

The table shows fluctuations in the annual average air temperatures in Sohar during the study period, with relatively higher temperatures observed in some years, such as 2020 and 2022. These conditions may contribute to increased evaporation rates and higher salt concentrations in groundwater, thereby supporting the analysis of the relationship between air temperature and the chemical properties of agricultural well water.

Year	Farm No. 1	Farm No. 2	Farm No. 3	Average pH
2018	8.4	8.5	8.3	8.4
2019	8.2	8.5	8.4	8.37
2020	8.2	8.4	8.4	8.33
2021	8.4	8.3	8.2	8.3
2022	8.4	8.5	8.3	8.4
2023	8.3	8.4	8.3	8.33
2024	8.3	8.4	8.2	8.3
2025	8.2	8.4	8.3	8.3

Table 5: Salinity (EC) Values of Agricultural Wells in the Three Farms and Their Annual Average in Sohar (2018–2025)

The table illustrates the temporal variation in salinity values of agricultural well water across the three farms, including the calculated annual average salinity. The results show clear fluctuations in salinity levels between years, with noticeably higher salinity during relatively dry years and lower salinity during years with higher rainfall amounts, supporting the hypothesis that groundwater salinity in Sohar is influenced by climate variability.

Year	Farm No. 1	Farm No. 2	Farm No. 3	Average pH
2018	8.4	8.5	8.3	8.4
2019	8.2	8.5	8.4	8.37
2020	8.2	8.4	8.4	8.33
2021	8.4	8.3	8.2	8.3
2022	8.4	8.5	8.3	8.4
2023	8.3	8.4	8.3	8.33
2024	8.3	8.4	8.2	8.3
2025	8.2	8.4	8.3	8.3

Table 5: pH Values of Agricultural Wells in the Three Farms and Their Annual Average in Sohar (2018–2025)

Second: Personal Interview

During the personal interview, farmer Yusuf bin Mohammed Al-Maqbali reported that he observes an improvement in well-water quality during years with good rainfall, as water salinity decreases and irrigation becomes relatively easier. This improvement is positively reflected in the condition of the farm and crop productivity. In contrast, he indicated that during years characterized by low rainfall, an increase in well-water salinity is observed, leading to weaker growth of some crops and a greater need for care during irrigation. He also explained that in years with moderate rainfall, no noticeable changes occur, and both farm conditions and well-water quality remain relatively stable.

Third: Field Study

Field measurements of water salinity and pH were conducted during the months of October, November, and December 2025 by collecting samples from Farm No. (2). Accordingly, the average of these measurements does not represent the full annual average for the year 2025; rather, it reflects the chemical properties of well water during a specific period of the year. Minor differences were observed between the average of the three-month measurements and the official annual average issued by the relevant authority, which is considered normal due to differences in the measurement period and the distribution of readings throughout the year.

Month	Salinity EC (dS/m)	pH
Oct-25	1.28	8.36
Nov-25	1.33	8.39
Dec-25	1.38	8.42
Average of the Three Months	1.33	8.39
Official Annual Average for 2025	1.35	8.4

Table (8): Monthly Salinity and pH Readings for Farm No. (2) – 2025 (within the study period 2018–2025)

Table (8) presents the results of the field measurements conducted during October, November, and December 2025 at Farm No. (2). The table shows a slight difference between the average of the monthly readings and the official annual average for 2025. This difference is considered logical, as the annual average is based on data distributed throughout the entire year, whereas the field measurements represent a specific time period at the end of the year.

Measurement of Water Salinity and pH

The results of the study were presented using graphical representations to illustrate the relationship between climatic variables and the chemical properties of agricultural well water. This approach aimed to clarify general trends and visually analyze the effects of rainfall amounts and temperature on salinity and pH values in a manner that facilitates interpretation.

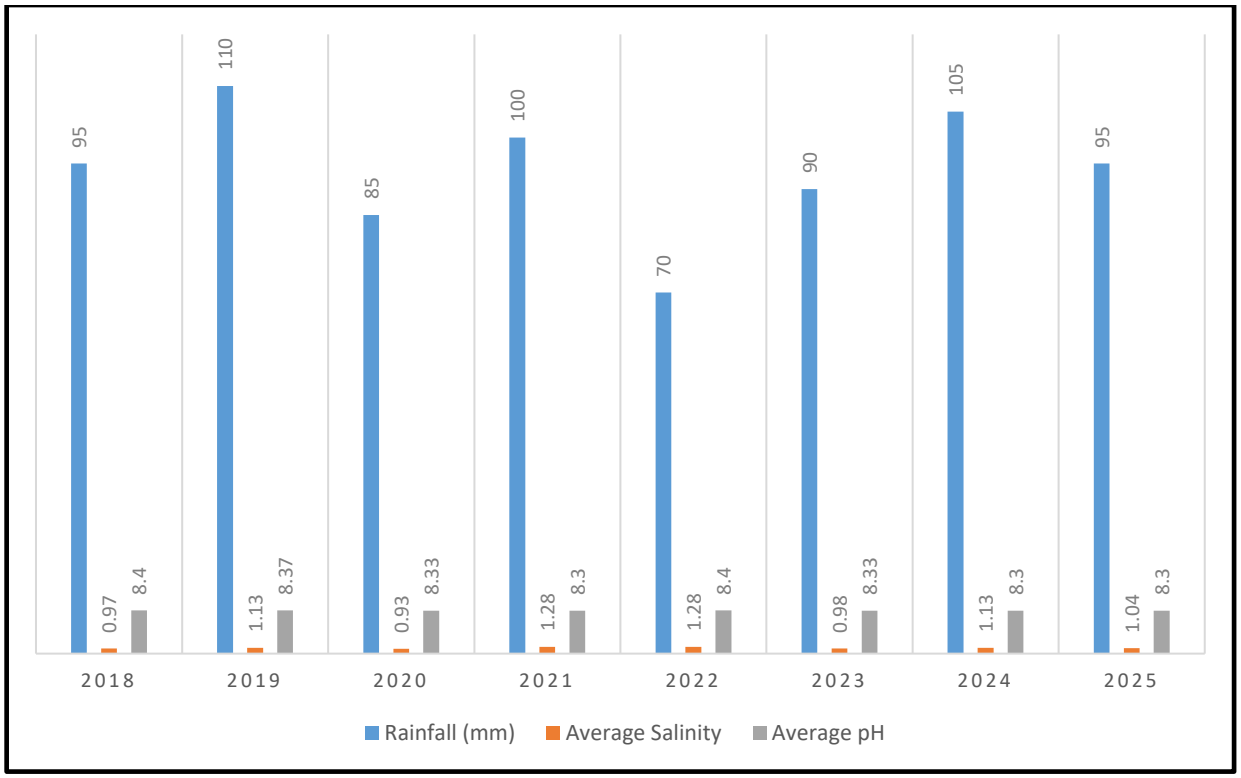

Figure (1): Relationship between Rainfall Amounts and Average pH Values

Figure (1) shows a clear inverse relationship between rainfall amounts and the average salinity of agricultural well water, while pH values exhibit relative stability despite variations in rainfall. This indicates that salinity is more strongly affected by climatic changes than pH

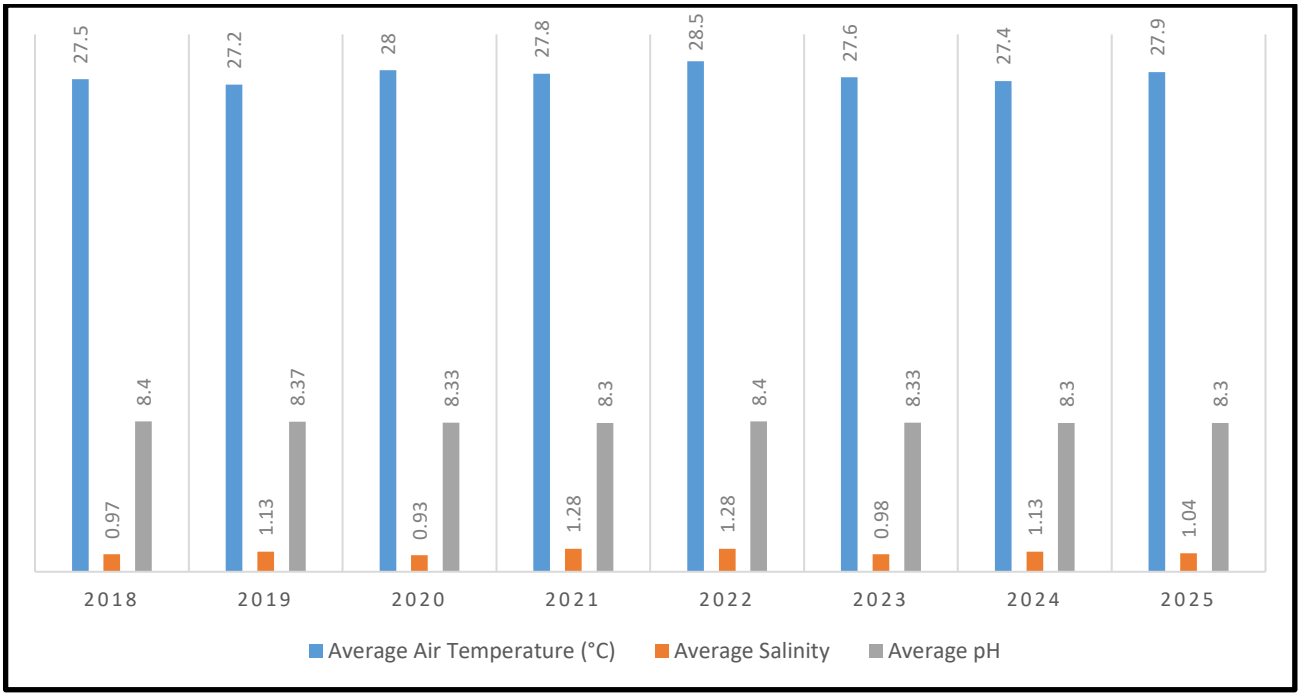

Figure (2): Relationship between Rainfall Amounts and Average pH Values

The figure illustrates the relationship between average temperatures and the average salinity and pH of agricultural well water. A relative effect of rising temperatures on increased salinity is observed, whereas pH values show general stability despite thermal variations.

Fourth :Data Entry Documentation

Documentation of Data Entry on the GLOBE Website (www.globe.gov)

Results Analysis and Discussion

The results of the comparative analysis of the study data revealed a clear impact of climate variability on the chemical properties of agricultural well water in the Wilayat of Sohar during the period from 2018 to 2025. The findings demonstrated a clear inverse relationship between rainfall amounts and the average salinity of well water, as salinity values decreased during years with higher rainfall and increased during years of relative drought. This reflects the role of rainfall in improving groundwater quality by enhancing natural recharge and reducing salt concentrations.

The results also showed that higher average temperatures are associated with a relative increase in well-water salinity. This is attributed to increased evaporation rates, which lead to higher concentrations of dissolved salts in groundwater, particularly during hotter years.

With regard to pH, the analysis indicated relative stability in pH values throughout the study period when compared with both rainfall amounts and temperature variations. The values remained within a slightly alkaline range, with only minor differences recorded between years. This suggests that pH is less sensitive to climatic changes than water salinity.

Based on the findings of this study, it is evident that climate variability has a direct effect on the salinity of agricultural well water in the Wilayat of Sohar, while its impact on pH remains limited. This underscores the importance of focusing on salinity management within strategies for agricultural groundwater management in the region.

This leads to answering the research questions as follows:

Answer to the First Research Question:

The analysis results showed that variations in rainfall amounts have a clear effect on the salinity of agricultural well water, as a decrease in average salinity was observed during years with higher rainfall, compared to an increase during years of relative drought. This reflects the direct role of rainfall in recharging groundwater and contributing to the dilution of dissolved salt concentrations. In contrast, water pH values did not exhibit noticeable changes with fluctuations in rainfall amounts, remaining within a relatively stable range throughout the study period. This indicates that the impact of rainfall is more pronounced on salinity than on pH.

Answer to the Second Research Question:

The study results demonstrated a relative positive relationship between increasing average temperatures and higher salinity levels in agricultural well water. Elevated temperatures contribute to increased evaporation rates, which in turn lead to the concentration of salts in groundwater. With regard to pH, the results showed overall stability in pH values despite temperature variations, indicating that the impact of temperature on the chemical properties of groundwater is primarily reflected in salinity rather than in pH changes.

Answer to the Third Research Question:

The analysis results revealed a clear difference in the degree to which salinity and pH are affected by climatic factors, with agricultural well-water salinity being more sensitive to variations in rainfall amounts. The study also demonstrated a relative positive relationship between increasing average temperatures and higher salinity levels in agricultural well water, as elevated temperatures contribute to increased evaporation rates, leading to the concentration of salts in groundwater. In contrast, pH values exhibited overall stability despite thermal variations, indicating that the effect of temperature on the chemical properties of groundwater is primarily concentrated on salinity, with no significant changes observed in pH.

Conclusion

This study concluded that climate variability had a clear impact on the chemical properties of agricultural well water in the Wilayat of Sohar during the period from 2018 to 2025, particularly with regard to water salinity. The analysis results revealed an inverse relationship between rainfall amounts and the average salinity of well water, as years with higher rainfall contributed to reducing salt concentrations, while years of relative drought led to increased salinity. The findings also demonstrated a relative positive relationship between rising average temperatures and increased well-water salinity as a result of higher evaporation rates.

In contrast, pH values showed relative stability throughout the study period when compared with both rainfall amounts and temperature variations, indicating that pH is less affected by climatic changes than salinity. Accordingly, the study confirms that well-water salinity is the chemical indicator most sensitive to climate variability, highlighting the need for regular monitoring and its integration into sustainable groundwater management strategies for agricultural use in the Wilayat of Sohar.

Acknowledgment

The research team extends its sincere thanks and appreciation to the staff of the Agricultural Research Center in the Wilayat of Sohar for their cooperation and for providing the necessary data to conduct this study. The team also expresses its deep gratitude to all those who contributed to supporting this research and facilitating the procedures for data collection and analysis. Special thanks are extended to Ms. Asmaa Al-Alawiyah for her continuous supervision of the project implementation and for providing some of the equipment required for the study.

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This badge is earned because the study addresses a real environmental challenge related to water scarcity and soil salinity in arid environments by proposing and experimentally validating a soil model that improves water retention and reduces irrigation demand

I AM A COLLABORATOR

This badge is earned because the study was conducted through collaboration with a STEM professional and under academic supervision, integrating expert input, guidance, and cooperative effort throughout the research process.

I WORK WITH A STEM PROFESSIONAL

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