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Assessment Of Treated Wastewater And Traditional Falaj Water On Watermelon Seed Germination And Seedling Vigor In Arid Agriculture

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Abstract
Salinity and water quality are critical factors affecting agricultural productivity, particularly in semi-arid regions with limited freshwater resources. This study investigates the effects of irrigation water quality including falaj water, treated wastewater, and control conditions on seed germination, crop performance, and soil salinity dynamics across four locations at varying distances from the sea. Field experiments using watermelon seeds revealed that falaj water consistently produced higher germination rates (up to 100%), whereas treated wastewater showed reduced and variable germination (10–80%), highlighting the negative impact of elevated salinity, total dissolved solids (TDS), and heavy metals. Farmer interviews corroborated field observations, indicating increasing salinity effects closer to the coast, with some lands abandoned due to severe salt accumulation. Water quality assessments showed high electrical conductivity (2117–3750 µS/cm), elevated chlorides (250–400 mg/L), and high TDS levels, which correlate with reduced germination and crop stress. GIS-based spatial mapping further highlighted heterogeneity in water quality and salinity across sites, emphasizing the need for targeted irrigation and salinity management strategies. The study underscores the importance of careful water source selection, pre-treatment of wastewater, salinity-tolerant crops, and improved irrigation practices to maintain crop productivity in salt-affected areas.
Keywords: *Salinity, Irrigation Water Quality, Germination, Treated Wastewater, Crop Performance*

1. INTRODUCTION

The cultivation of watermelon (Citrullus lanatus) is influenced by various environmental factors, among which water quality plays a pivotal role. In arid and semi-arid regions, where water scarcity is prevalent, the use of alternative water sources such as treated wastewater and traditional irrigation systems like falaj has become common practice. However, these water sources often contain elevated levels of salinity and other contaminants, which can adversely affect seed germination and early plant development.

Salinity is a significant abiotic stressor that hampers seed germination and seedling vigor in watermelon. High salinity levels create osmotic imbalances, reducing water uptake and delaying or preventing germination. Moreover, excessive salts can lead to ion toxicity and oxidative stress, impairing plant growth and productivity. The impact of salinity on watermelon varies depending on the developmental stage, with germination and early seedling growth being particularly sensitive.

In Oman, water quality varies significantly across different regions. For instance, Wadi Al Khoudh exhibits high electrical conductivity (EC) and total dissolved solids (TDS), indicating saline water, while Wadi Amarat presents slightly lower EC and TDS levels. These differences in water quality can influence soil salinity and, consequently, crop performance. Additionally, the method of irrigation be it flood irrigation, canal irrigation, or sprinklers can affect the rate of salt accumulation in the soil, further impacting plant health.

This study aims to assess the effects of different water qualities on watermelon seed germination and early crop performance. By comparing the outcomes across farms utilizing falaj water, treated wastewater, and a control water source, the research seeks to elucidate the relationship between water quality and crop establishment. The findings are expected to inform sustainable water management practices and irrigation strategies in watermelon cultivation.

The primary objective of this study is to evaluate the impact of different water qualities specifically falaj water, treated wastewater, and a control source on the seed germination and early growth of watermelon crops. The study aims to identify correlations between water quality parameters and crop performance, providing insights into the suitability of alternative water sources for sustainable agriculture in arid regions.

2. METHODOLOGY

2.1 Study Zone and Experimental Setup

The study was conducted in an agricultural region characterized by semi-arid to arid climatic conditions, with pronounced water scarcity and seasonal variability in precipitation, temperature, and solar radiation. These conditions directly affect soil moisture dynamics and nutrient cycling, making the use of treated wastewater for irrigation a relevant management strategy.

The experimental system comprises three comparable fields (Fields A, B, and C) with uniform soil texture, baseline soil properties, and cropping practices.

- **Field A**: Irrigated with freshwater (reference regime).
- **Field B**: Irrigated with treated wastewater.
- **Field C**: Control (non-irrigated, standard local practice).

Baseline soil data include texture (loam to silt-loam), pH, organic matter, cation exchange capacity (CEC), and major nutrients. The hydrological framework integrates field irrigation events with 22 years of remote sensing data to assess both long-term trends and seasonal cycles in soil moisture and nutrient availability.

2.2 Treatments

- **Freshwater irrigation (Field A):** Conventional reference.
- **Treated wastewater irrigation (Field B):** Assesses the role of nutrient inputs and possible contaminants.
- **Control (Field C):** No irrigation or minimal local practice for isolating irrigation effects.

2.3 Temporal Framework

- **Remote sensing (22 years):** Soil moisture proxies, vegetation indices (NDVI, SAVI), and land surface parameters from Landsat 5/7/8 and Sentinel-2.
- **In-situ measurements:** Periodic monitoring of soil moisture, nutrients, germination, and leaf chlorophyll for validation of remote-sensing data.
- **Water quality:** Irrigation water tested for pH, electrical conductivity (EC), turbidity, dissolved organic carbon (DOC), and major ions (Ca, Mg, Na, K, Cl, SO_4) using portable kits and laboratory analyses (Patel, 2019).

2.4 Key Variables

- **Soil moisture:** Derived from remote-sensing proxies and validated with volumetric soil moisture (θ) at depths of 0–10 cm and 10–30 cm.
- **Plant performance:** Germination rate, early growth parameters, and chlorophyll content (SPAD).
- **Water quality:** pH, EC, turbidity, DOC, and ionic composition.

2.5 Data Sources and Collection

Remote Sensing Data:

- Platforms: Landsat 5/7/8 (30 m), Sentinel-2 (10–20 m).
- Products: Soil moisture proxies, vegetation indices, albedo, and land surface temperature.
- Processing: Radiometric/atmospheric correction (LEDAPS, LaSRC, Sen2Cor), cloud masking, geometric correction, and reprojection to a common grid (UTM/WGS84).

Soil In-situ Measurements:

- Instruments: Hydrosense soil moisture meters (calibrated).
- Parameters: Soil moisture, pH, organic matter, CEC, macronutrients (N, P, K).
- Sampling: Stratified layout with subplots and grid points; quarterly/seasonal frequency; vertical cores at 0–10 cm and 10–30 cm depths.
- QA/QC: Calibration, replication, and removal of instrument drift.

Plant Growth Measurements:

- Metrics: Germination percentage, emergence timing, plant height, biomass, leaf area index (where applicable), and chlorophyll content.
- Frequency: At germination, early growth, and peak growth phases.

Irrigation Water Quality:

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- Sampling: Collected post-irrigation and monthly intervals from freshwater and treated wastewater sources.
- Measurements: Field-based pH, EC, turbidity, followed by laboratory analysis of DOC and ionic content.
- QA/QC: Instrument calibration, cross-validation with standard solutions, and replicate analyses.

Baseline Data:

- Soil: Texture, pH, organic matter, CEC, and nutrient content.
- Field Management: Uniform agronomic practices (crop type, planting date, density, weed/pest control, and fertilization) applied across all fields to isolate the effect of irrigation water.

2.6 Data Collection Workflow

The study integrates remote sensing, in-situ soil data, plant performance, and water quality within a unified workflow:

1. **Remote sensing retrieval:** Acquire data according to field campaigns; preprocess (calibration, correction, cloud masking); extract soil moisture proxies and vegetation indices.
2. **In-situ soil and plant data:** Collect field measurements aligned temporally with satellite overpasses.
3. **Water quality:** Monitor at each irrigation event and monthly intervals.
4. **Validation:** Ground-truth remote-sensing estimates against in-situ soil moisture; compute RMSE, bias, and R^2.
5. **Integration:** Link water quality, soil moisture, and plant growth metrics to identify direct and lagged effects of irrigation water sources.

3. COMPUTER SIMULATION

The analysis of the site, conducted with the ArcGIS software platform, is visually depicted in the figure below. This figure clearly marks out the three distinct zones within the study area, designated as Moist, Mid-Moist, and Dry zones. Moreover, it offers an approximate spatial relationship among these zones, depicting the relative distances that separate each from the others. It is essential for comprehending the environmental gradients and variations throughout the study site to understand this spatial distribution.

Figure 3.1 Study zones with distance (ArcGIS, 2024)

4. GERMINATION PERCENTAGE

After receiving the farm land and calculating its moisture content, the seed was selected by the farmers and based on the soil conditions , watermelon seed has been chosen.

500g seed have been taken for the cultivation and and in 1 grm 8 to 10 seeds have been there so total 5000 approx seeds have been spread in whole land to grow.

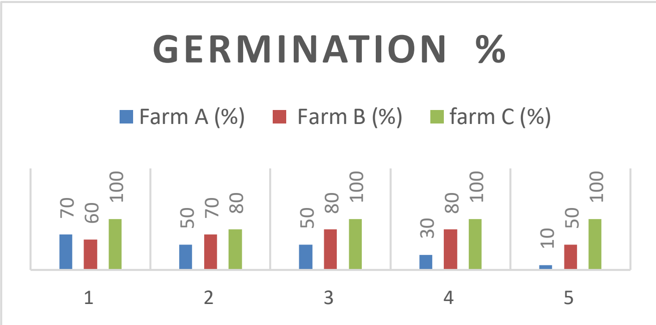
Seed Germination

The findings of the seed germination test are indicated in Table 1 after using the following formula to extract germination percentage (G%):

Germination % = $Number\ of\ seeds\ germinated$*5000×100

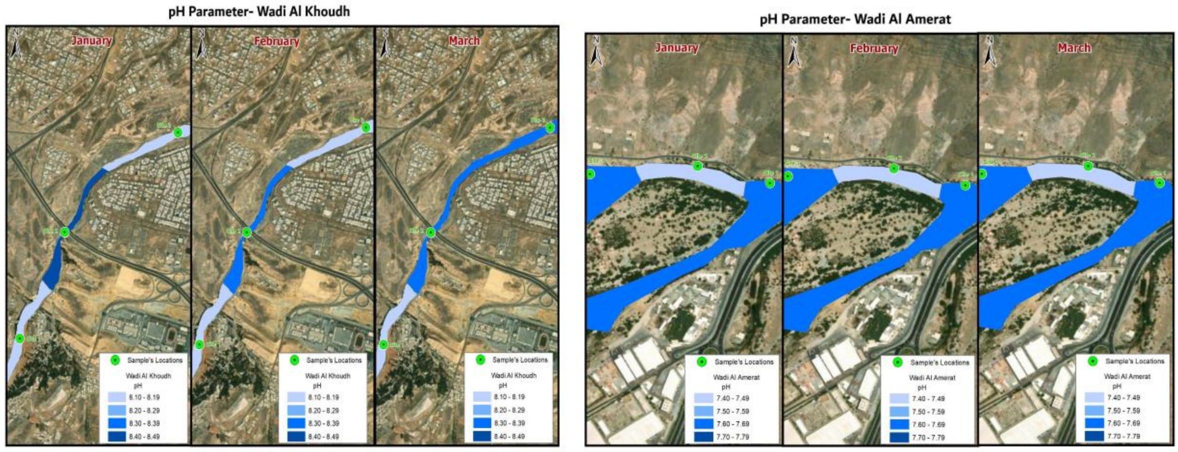
Table & Graph 3.1: Germination Percentage (G%)

Watermelon seed		
Farm A	Farm B	Farm C
70%	60%	100%
50%	70%	80%
50%	80%	100%
30%	80%	100%



5. SOIL DYNAMICS AND CROP DEVELOPMENT UNDER SALINITY

This section presents themes and patterns derived from interviews with farmers and field observations across four locations, using manual coding techniques to categorize key insights (Lungu, 2022).



Figur 5.1: PH Parameter map in wadi al khoud and Amarat in three-month in different sites

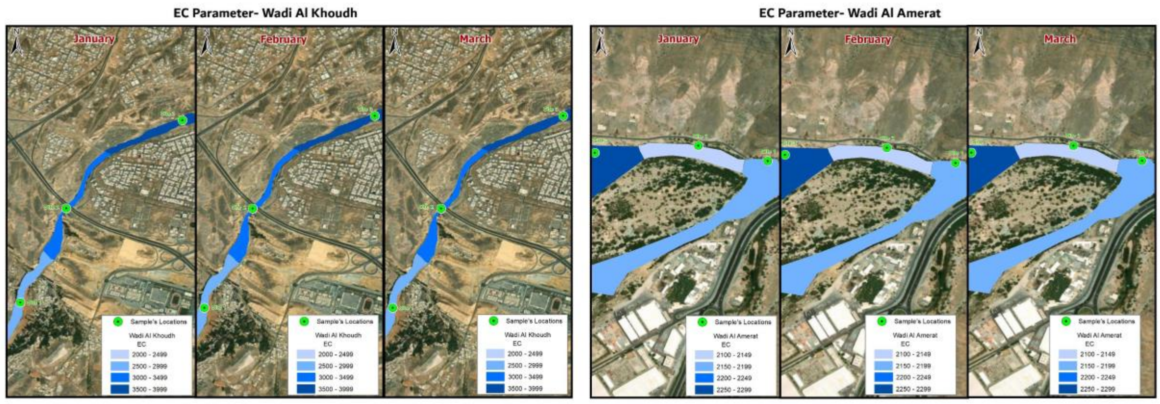


Figure 5.2: EC Parameter map in wadi al khoud and Amarat in three-month in different sites.

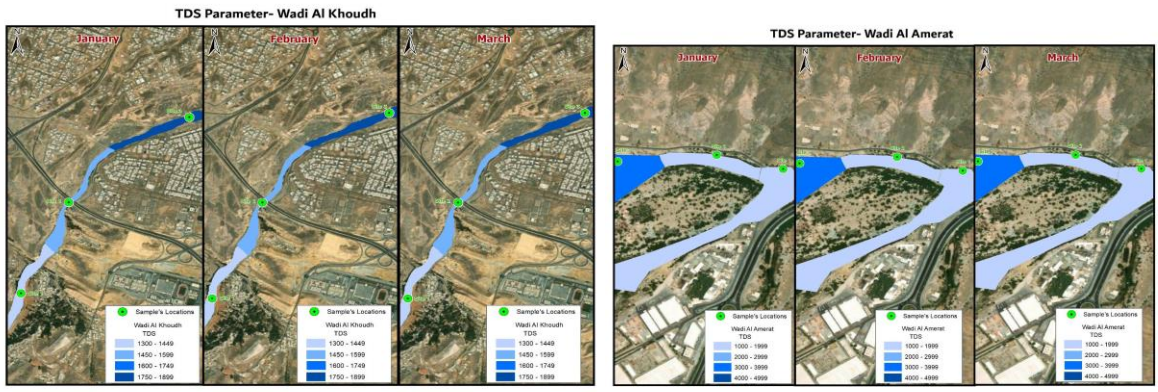


Figure 5.3: TDS Parameter map in wadi al khoud and Amarat in three-month in different sites.

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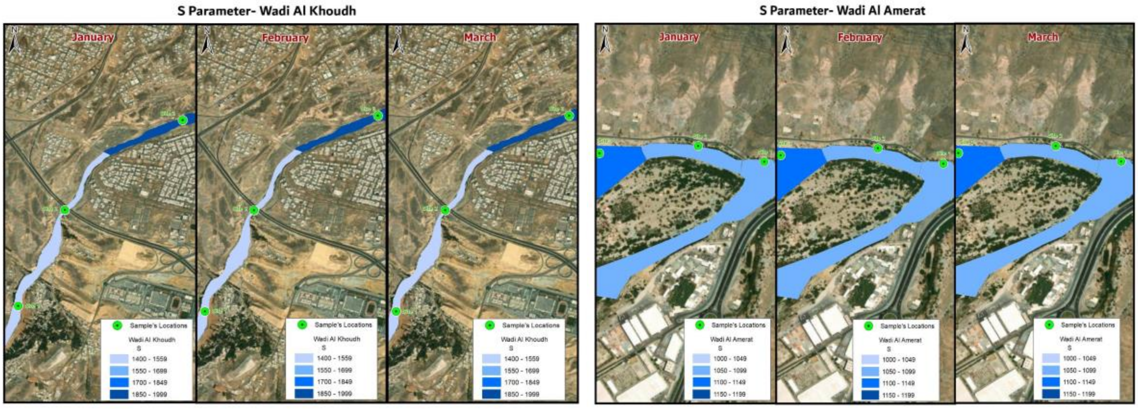
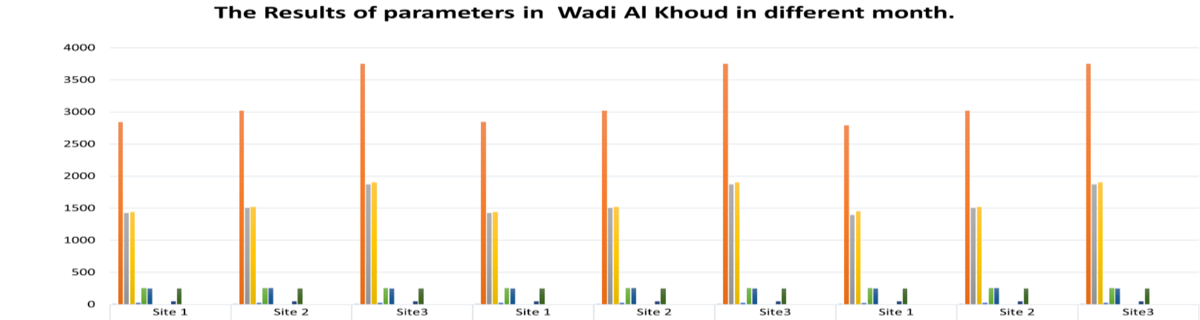


Figure 5.4: Salinity Parameter map in wadi al khoud and Amarat in three-month in different sites.



	January			February			March		
	Site 1	Site 2	Site3	Site 1	Site 2	Site3	Site 1	Site 2	Site3
PH	8.16	8.47	8.16	8.17	8.37	8.16	8.31	8.37	8.16
EC	2843	3020	3750	2845	3020	3750	2790	3020	3750
TDS	1423	1503	1870	1423	1503	1870	1394	1503	1870
S	1440	1520	1903	1440	1520	1903	1450	1520	1903
T	26.6	27	27	26.6	27	27	24.2	27	27
Sulfite Test	255	255	255	255	255	255	255	255	255
Chloride	250	255	250	250	255	250	250	255	250
Iron	1	1	1	1	1	1	1	1	1
Copper	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Lead	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
Nitrate	50	50	50	50	50	50	50	50	50
Hardness	250	250	250	250	250	250	250	250	250
Fluoride	0	0	0	0	0	0	0	0	0
Alkalinity	0	0	0	0	0	0	0	0	0
Mercury	0	0	0	0	0	0	0	0	0
Chromium	0	0	0	0	0	0	0	0	0
Nitrite	0	0	0	0	0	0	0	0	0
Bromine	0	0	0	0	0	0	0	0	0
Cyanuric acid	0	0	0	0	0	0	0	0	0
Carbonate	0	0	0	0	0	0	0	0	0

PH EC TDS S T Sulfite Test Chloride Iron Copper Lead
Nitrate Hardness Fluoride Alkalinity Mercury Chromium Nitrite Bromine Cyanuric acid Carbonate

Figure 5.5: Parameter results of wadi al khoud in different month.

Farmers' Perception of Salinity

Interviews with farmers across different locations revealed varying degrees of awareness and concern regarding the effects of salinity on their agricultural land. The farmer at Location 1 (2.8 km from the sea) perceived salinity as negligible, noting only a slight salt taste in well water. In contrast, the farmer at Location 2 (1.5 km from the sea) recognized salinity as a constraint, stating, *"I used to harvest more crops than I do now due to salinity,"* reflecting declining productivity. The farmer at Location 3 (1.3 km from the sea) acknowledged salinity as a pressing issue, expressing a proactive stance: *"I would be happy if I found suitable solutions for my land, and I am willing to treat it as soon as possible."* The most severe impact was observed at Location 4 (1.1 km from the sea), where complete farm abandonment was reported: *"The land got so salted I had to abandon it."* This illustrates the progression of land degradation with increasing proximity to the sea.

Visible Effects on Crop Performance

Field observations demonstrated a gradient of crop performance across the study sites. No visible salinity-related damage was recorded at Location 1. However, **Locations 2, 3, and 4** exhibited marked crop stress, particularly in bananas and mango trees, which were reported by farmers as highly sensitive to salt stress. At **Location 4**, salinity-induced damage was so severe that complete crop failure occurred, culminating in the abandonment of farming activities.

Changes in Land Condition

The proximity of farmland to the sea strongly influenced soil deterioration. Salt accumulation was observed around wells, irrigation taps, and across larger patches of soil in Locations 2, 3, and 4, with the most severe accumulation occurring in Location 4. Variability in irrigation practices was also noted: flood irrigation dominated in Locations 2 and 4, while canal irrigation was practiced in Locations 1 and 3. Additionally, sprinklers were occasionally used at Location 1, likely contributing to the lower impact of salinity observed there.

Farmers' Responses to Salinity

Farmers' adaptive responses varied according to the severity of salinity and perceived economic feasibility. The farmer at Location 1 took no action, believing that distance from the sea safeguarded the farm. At Location 2, the farmer expressed conditional willingness: *"I am willing to fix the land as long as it's not very costly."* The farmer at Location 3 demonstrated more active engagement by applying fertilizers, albeit without adequate technical knowledge of effective salinity management practices. At Location 4, the farmer abandoned the land entirely, stating, *"Reclaiming the land is harder than abandoning it."* This highlights a spectrum of coping strategies, from inaction to complete withdrawal.

Water Quality Parameters of Wadi/Falaj Water

Monitoring and Spatial Interpolation

Physicochemical properties of water were analyzed to assess salinity risks and related pollutants. Parameters included temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), alkalinity (AK), total hardness (TH), nitrates, sulfate, fluoride, chloride, copper, and iron. Spatial interpolation using GIS and Inverse Distance Weighting (IDW) produced spatial maps (Figures 5.1–5.5) that visualized pollutant distribution across sites. The maps revealed significant variability in water quality between collection points, with human activities influencing pollutant load. Color coding indicated risk levels, where dark blue denoted high-risk zones and light blue represented safer areas, with intermediate shades capturing gradual transitions.

Key Water Quality Parameters

- **Temperature:** Ranged between 24.2–27°C in Wadi Al Khoud and 23.7–24°C in Wadi Amarat. These values are within safe limits and unlikely to adversely affect aquatic life (Jurgelenaite et al., 2012; Ashkanani et al., 2019).
- **pH:** Slightly alkaline across both wadis, ranging from 8.2–8.5 (Al Khoud) and 7.5–7.7 (Amarat), all within the acceptable range of 6.5–8.5 (Patel & Parikh, 2013; Gandaseca et al., 2011).
- **Electrical Conductivity (EC):** Elevated values far above permissible limits were recorded: 2710–3750 µS/cm in Al Khoud and 2117–2250 µS/cm in Amarat, directly reflecting high salinity (Atta, 2020; Matta et al., 2022).
- **Total Dissolved Solids (TDS):** Ranged between 1324–1870 mg/L (Al Khoud) and 1060–2250 mg/L (Amarat), exceeding WHO and Omani standards (Boyd, 2000; WHO, 2017).
- **Alkalinity (AK):** Both wadis recorded zero alkalinity, below the recommended maximum of 200 mg/L.
- **Total Hardness (TH):** 250 mg/L in Al Khoud and zero in Amarat, both within permissible limits (≤600 mg/L).
- **Nitrates:** Within the safe limit of 50 mg/L, posing no immediate risk of nitrate-related health issues (Majumdar & Gupta, 2000; Kumar et al., 2012).
- **Sulfates:** Measured at 255 mg/L (Al Khoud) and 200 mg/L (Amarat), within the 400 mg/L permissible limit.
- **Fluoride:** Absent in both wadis.
- **Chloride:** Elevated values of 255 mg/L (Al Khoud) and 400 mg/L (Amarat), with the latter exceeding safe levels of 250 mg/L (Pius et al., 2012).
- **Copper:** Elevated levels of 2.5 mg/L (Al Khoud) and 2 mg/L (Amarat), indicating potential anthropogenic influence.
- **Iron:** Detected at 1 mg/L in both wadis, within acceptable limits.

6. TREATED WATER PARAMETER

The chart presents a comparative analysis of water quality parameters across three locations, focusing on pH, conductivity, salt level, and ORP (Oxidation-Reduction Potential) ORP measures a solution's ability to gain or lose electrons, indicating its oxidation or reduction power..

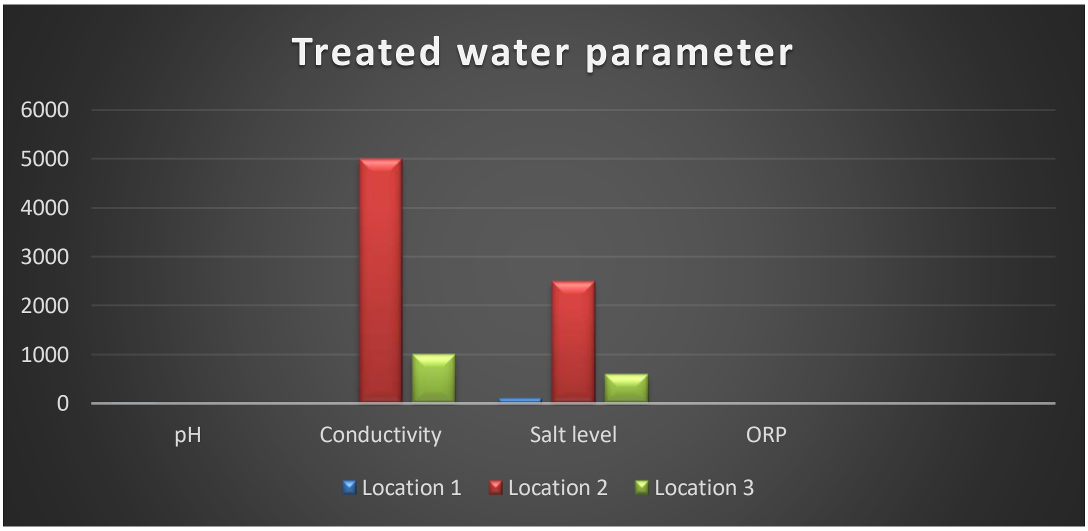
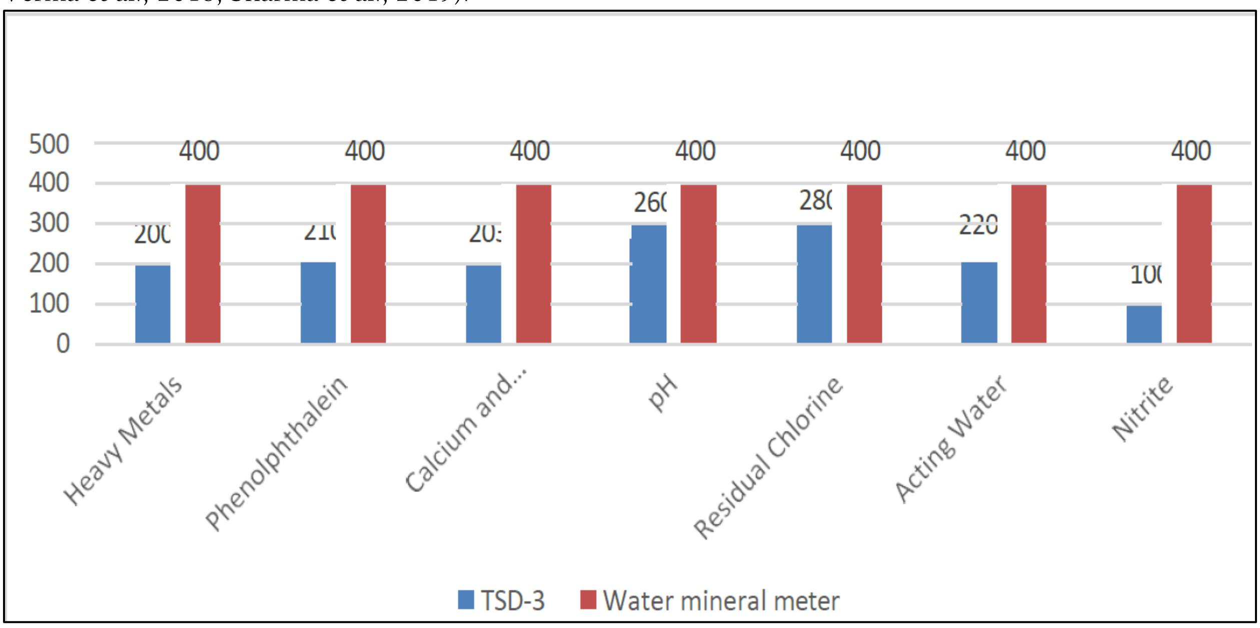


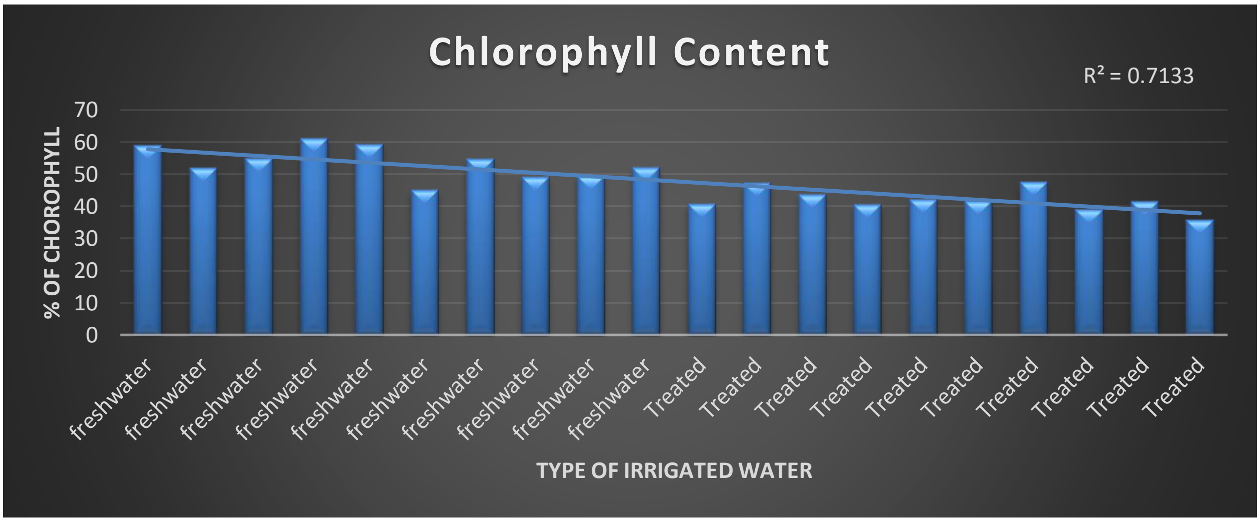
Figure 6.1 chart Examine PH and counductivity , salt level ,ORP, in Al Batinah for 3 locations for groundwater.

Location 2 exhibits the lowest pH (7.30) indicating it is slightly more acidic compared to location 1 (7.86) and location 3 (8.01) which are more alkaline. Location 2 shows a considerably higher conductivity (5068 µs/cm) and salt level (2500 ppm) relative to location 1 (216 µs/cm and 100ppm) and location 3 (1125 µs/cm and 561 ppm), suggesting a higher concentration of dissolved ions and salts. ORP values vary, with location 3 having the highest ORP (211), suggesting a greater oxidizing potential compared to location 2 (159) and location 1 (148).

7. CHLOROPHYLL ANALYSIS

Heavy metals such as lead (Pb) and cadmium (Cd) in treated irrigation water can impede chlorophyll synthesis and destabilize chloroplasts, leading to reduced chlorophyll content, impaired photosynthesis, and stunted plant growth; Pb and Cd disrupt chlorophyll biosynthesis enzymes, damage thylakoid membranes, induce oxidative stress that degrades chlorophyll, and cause nutrient antagonism by interfering with uptake of Mg, Fe, and Zn essential for chlorophyll maintenance, with the severity influenced by metal bioavailability, soil properties (pH, organic matter, CEC), crop species, and irrigation regime; these effects collectively result in lower photosynthetic capacity and yield, alongside potential accumulation of metals in edible parts and associated food safety concerns, necessitating mitigation via water treatment, soil amendments, crop selection, and regular monitoring (Pb and Cd concentrations in water and plant tissues) to meet regulatory limits (WHO/FAO, national standards) (Ali et al., 2020; Verma et al., 2018; Sharma et al., 2019).





8. DISCUSSION

- **Impact of Water Quality on Germination and Early Growth**: Experimental results clearly demonstrate that water quality strongly influences seed germination and early crop establishment. Falaj water (Farm A) consistently supported higher germination rates (up to 100%), while treated wastewater (Farm B) showed variable and generally lower germination (10–80%). The control (Farm C) exhibited mixed results. These findings align with previous studies indicating that high salinity, elevated TDS, and heavy metals in irrigation water adversely affect seed viability and seedling vigor (Munns & Tester, 2008; Atta, 2020).
- **Salinity Gradients and Farmer Perceptions**: Salinity impacts were more pronounced closer to the sea. Farmers at Locations 2–4 reported yield declines, crop stress, and even farm abandonment, which corresponded with observed salt accumulation in soils, especially under flood irrigation. Proximity to the sea and water source quality were thus key determinants of land degradation and crop performance.
- **Water-Quality Parameters and Crop Response**: High EC (2117–3750 µS/cm) and elevated TDS (1060–2250 mg/L) in treated wastewater and Wadi Al Khoudh water exceed safe thresholds for many crops, explaining reduced germination and early growth in affected plots. While pH levels (7.5–8.5) were suitable for irrigation, high chlorides and dissolved salts contribute to osmotic stress and reduced nutrient uptake. Heavy metals (Cu, Fe) were detected at moderate levels; their cumulative effect may further impair sensitive crops.
- **Spatial and Temporal Variability**: GIS-based mapping showed heterogeneity in water quality across sites and seasonal fluctuations. This spatial information is critical for targeted irrigation, crop placement, and salinity mitigation strategies. Farmers' responses reflected awareness of salinity dynamics, with adaptive behavior ranging from passive management to active intervention or land abandonment.
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9. CONCLUSIONS

- Water quality is the primary factor influencing germination and early crop performance. Falaj water with lower salinity and contaminants supports optimal germination, while treated wastewater with higher TDS, EC, and salts reduces germination rates and seedling vigor.
- Salinity increases with proximity to the sea, with severe impacts near 1.1–1.5 km zones, affecting crop yield and land usability.
- Flood irrigation exacerbates salt accumulation, whereas canal and sprinkler systems mitigate salt stress to some extent.

10. MANAGEMENT IMPLICATIONS:

- Prioritize irrigation with low-salinity water where feasible.
- Employ treated wastewater cautiously, with pre-treatment or dilution to reduce salts and contaminants.
- Adopt salt-tolerant crop varieties, improved drainage, and soil amendments to manage salinity.
- Regular monitoring of water quality (EC, TDS, major ions, heavy metals) is essential to safeguard crop establishment and productivity.

REFERENCES

1. Pandya, J. B., Mehta, K. J., & Patale, V. V. (2018). Germination treatments for watermelon seeds. *ResearchGate*. Retrieved from https://www.researchgate.net/publication/289108059_GERMINATION_TREATMENTS_FOR_WATERMELON_SEEDS
2. Simpson, C. R., et al. (2016). Salinity evaluation for watermelon (Citrullus lanatus) grafted with different rootstocks. *Subtropical Plant Science*, 66, 1-6.
3. Understanding salt stress in watermelon: Impacts on plant performance and adaptive solutions. (2025). *Preprints*. Retrieved from https://www.preprints.org/frontend/manuscript/fa2abafa17d83bab3da6436fa05b4f45/download_pub
4. Understanding salt stress in watermelon: Impacts on plant performance and adaptive solutions. (2025). *DigitalCommons@USU*. Retrieved from https://digitalcommons.usu.edu/psc_stures/16/
5. Understanding salt stress in watermelon: Impacts on plant performance and adaptive solutions. (2025). *ResearchGate*. Retrieved from https://www.researchgate.net/publication/392368702_Understanding_Salt_Stress_in_Watermelon_Impacts_on_Plant_Performance_and_Adaptive_Solutions
6. Understanding salt stress in watermelon: Impacts on plant performance and adaptive solutions. (2025). *DigitalCommons@USU*. Retrieved from https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1015&context=psc_stures
7. Understanding salt stress in watermelon: Impacts on plant performance and adaptive solutions. (2025). *ResearchGate*. Retrieved from https://www.researchgate.net/publication/392368702_Understanding_Salt_Stress_in_Watermelon_Impacts_on_Plant_Performance_and_Adaptive_Solutions
8. Understanding salt stress in watermelon: Impacts on plant performance and adaptive solutions. (2025). *DigitalCommons@USU*. Retrieved from https://digitalcommons.usu.edu/psc_stures/16/