Volume 01
Issue 01
November
2026

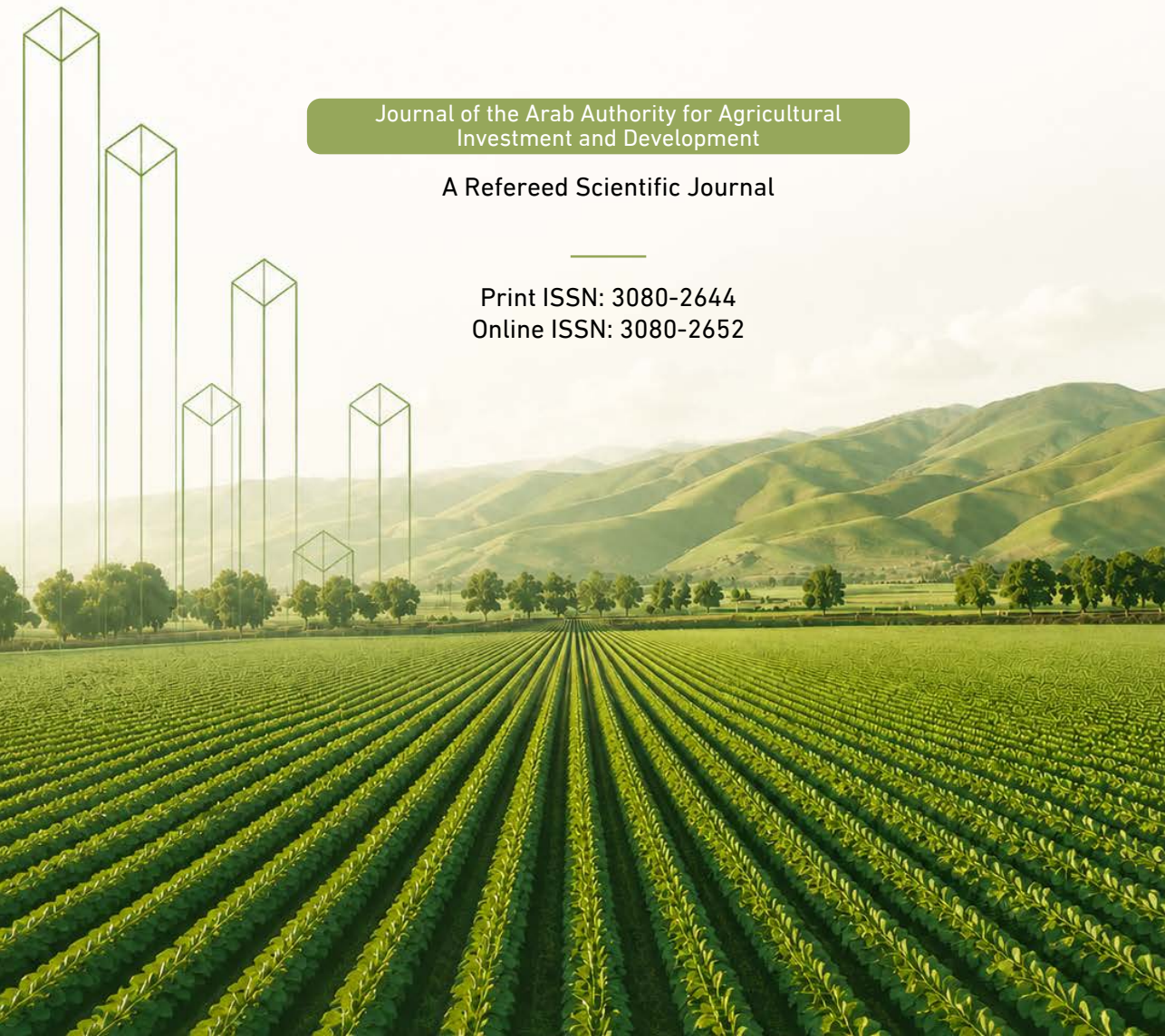
الهيئة العربية
للاستثمار والإنماء الزراعي
ARAB AUTHORITY FOR
AGRICULTURAL INVESTMENT & DEVELOPMENT

Journal of Investment & Sustainable Food Security

Journal of the Arab Authority for Agricultural Investment and Development

A Refereed Scientific Journal

Print ISSN: 3080-2644
Online ISSN: 3080-2652



Journal of Investment & Sustainable Food Security, Volume 1, No.1 November 2026
https://doi.org/10.68363/jifs.01.01.24

An Innovative System Study for Sustainable Agriculture in the Salinized Lands in Central and Southern Iraq without Reclamation or Drainage Processes

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Received Date: 14-10-2025 Accepted Date: 18-05-2026

Abstract:

Agricultural production in central and southern Iraq faces a serious challenge due to soil salinity, which arises from a combination of environmental and hydrological factors. A major cause is the rise of saline groundwater to shallow depths, restricting proper root development of crops. Conventional reclamation through large-scale drainage projects is constrained by diverse terrain, extremely high costs, and the shortage of fresh water required for extensive leaching operations.

To address these limitations, this study introduces an alternative farming system designed for long-term sustainability. The approach involves cultivating plants in sealed containers with a lifespan of no less than ten years, ensuring root growth beyond the direct influence of salinity. Shallow groundwater (0.5–1.5 m depth) is utilized after being desalinated through an evaporation–condensation cycle powered by flared gas from oil refineries, thereby converting a wasted by-product into a useful source of irrigation water.

The research included soil sampling from several locations, estimation of water volumes required for leaching, evaluation of salinity levels before and after treatment, and determination of field capacity across soil types. Findings indicate that this system effectively mitigates the primary obstacles of saline land management, namely the scarcity of fresh water, high reclamation costs, and the proximity of saline groundwater to the surface. Moreover, continuous withdrawal of groundwater throughout the system's operational period is expected to gradually lower its level, removing it from the active root zone and enhancing soil productivity on a sustainable basis.

Keywords: salinity, soil leaching, field capacity, Shura soils, Sabakh soils.

Introduction:

Global Water Scarcity and Soil Salinization: To meet the rising global food demand, agricultural production must increase by roughly 60% by 2050 [FAO. 2012]. The global population, currently near 7 billion, is projected to reach 10 billion within the next fifty years [Goswami et al. 2016]. This rapid population growth, combined with diminishing arable land, constitutes one of the most critical challenges limiting agricultural productivity and sustainability [Saghafi et al. 2019]. Within this framework, water availability emerges as a key determinant in meeting these challenges [FAO. 2017]. Therefore, improving agricultural output remains the most feasible strategy to ensure future food security [Vaishnav et al. 2016].

The surge in population, alongside expanding industrial and agricultural activities, has intensified the demand for irrigation, worsening water scarcity, particularly in arid and semi-arid regions [Ma et al. 2020]. Limited rainfall and elevated evaporation rates have further widened the gap between water supply and demand [Mohamed et al. 2020], [Gupta & Kumar. 2018]. Water resources in these regions are scarce, and competition with other sectors restricts the volume of freshwater available for agriculture. Consequently, water scarcity has become a major constraint on economic development and human well-being, affecting approximately 40% of the global population and numerous ecosystems [Oki & Kanae. 2006]. In semi-arid regions, agriculture accounts for around 80% of current freshwater usage [UN Environment. 2019]. Population growth, rising food demand, and climate change have collectively increased water demand by elevating temperatures and reducing availability [IPCC. 2013]. As a result, groundwater development and utilization have become common strategies to address the imbalance between supply and agricultural demand [Huang et al. 2012].

Soil salinity constitutes a major limitation to crop productivity worldwide. Salt accumulation in soils arises from primary causes, such as rock weathering, and secondary causes including excessive fertilizer use, irrigation with low-quality water, waterlogging, and discharge of industrial saline solutions [Sahab et al. 2021]. Climate change accelerates soil salinization through altered rainfall patterns, higher temperatures, and increased evaporation rates [Bannari & Al-Ali. 2020, Corwin. 2021].

Currently, over 50% of irrigated lands globally are affected by salinity, which impairs plant growth, development, and survival [Guo et al. 2022]. This situation threatens global food security, with climate change intensifying the problem [Mukhopadhyay et al. 2021]. The expansion of intensive orchard irrigation in recent decades, coupled with declining water quality, has worsened soil salinity. By 2050, more than half of arable lands may be affected by salinization [Jamil et al. 2011]. Anthropogenic activities have already impacted around 76 million hectares of productive land due to excessive salt accumulation [Nurbekova et al. 2024].

Soil salinity is closely linked to global issues such as climate change, food security, and the United Nations Sustainable Development Goals (SDGs). Addressing salinity is crucial for achieving the SDGs, particularly Goal 2 ("Zero Hunger"), Goal 3 ("Good Health and Well-being"), and Goal 15 ("Life on Land") [Lal et al. 2021]. Therefore, enhancing crop productivity on saline lands requires adopting effective management strategies [Du et al. 2023].

Local Salinization in Central and Southern Iraq: The President of Iraq emphasized that addressing land degradation and water scarcity requires $13 billion for land reclamation, $12 billion for dam construction, and $3 billion for water resource development [Abdul Latif 2022] (Climate Conference 2022). Nevertheless, financial limitations and water scarcity remain significant obstacles to implementing reclamation initiatives.

Iraq's Salinity Crisis: Irrigating large tracts of reclaimed land along the Tigris and Euphrates rivers presents serious challenges, particularly in preventing saline groundwater from contaminating the Shatt al-Arab waterway. Flood irrigation, poor soil management, and insufficient drainage have contributed to high salinity levels in Iraqi soils.

Classification of Saline Soils in Iraq: Iraqi saline soils are generally classified into two main types:

Al-Shura Soil: Exhibits a white, crystalline, non-soluble surface layer that swells upon wetting.

Sabkha Soils: Dark brown soils with high concentrations of calcium and magnesium chlorides.

Typical soil profiles include a dark brown surface layer, a middle layer at approximately 60 cm depth with sodium chloride accumulation, and a lower moist layer below the groundwater level [Khalaf & Alrijabo. 2006].

Geographic Distribution: The first Iraqi distribution map [Alrijabo. 1991] revealed concentrated salinization in central and southern Iraq, particularly within the Tigris and Euphrates river basins (Figure 1).

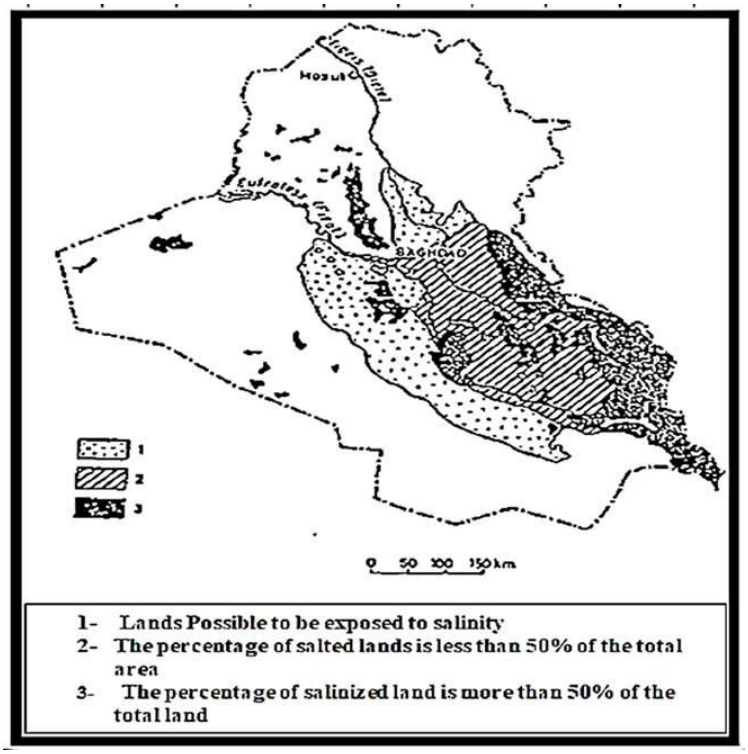


Figure 1: Salinized Land Distribution in Central and Southern Iraq

The Food and Agriculture Organization's map (Figure 2) Soil Salinity Map (FAO, [FAO. 2012]) illustrates Iraq's soil salinity levels:

Salinity Classification: **S1**: Moderate salinity (4-15 $ds.m^{-1}$), and **S2**: High salinity (>15 $ds.m^{-1}$).

Salinization Trends: **R1**: Moderate increase (2-3 $ds.m^{-1}.year^{-1}$), and **R2**: Rapid increase (3-5 $ds.m^{-1}.year^{-1}$).

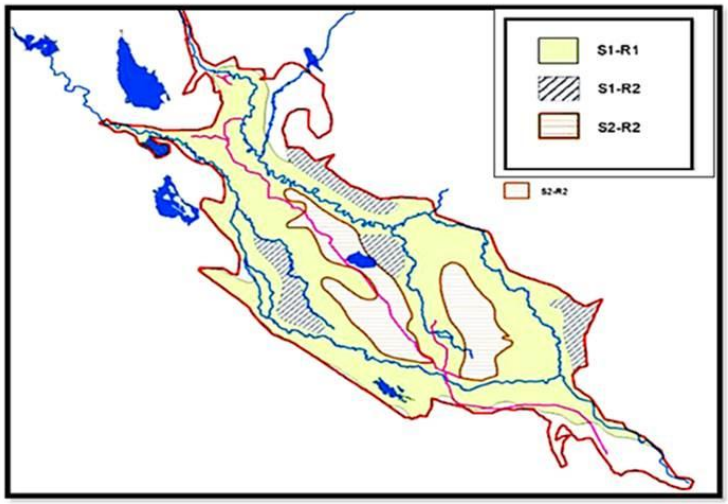


Figure 2: Soil Salinity and Degradation in the Mesopotamian Valley

Recent Soil Salinity Assessment (Ministry of Water Resources, [Al-Mashhadani. 2016]). The map illustrates soil salinity levels in central and southern Iraq: Salinity Zones: Red: Extremely saline (>25 $ds.m^{-1}$), and Orange: Moderately saline (16-25 $ds.m^{-1}$).

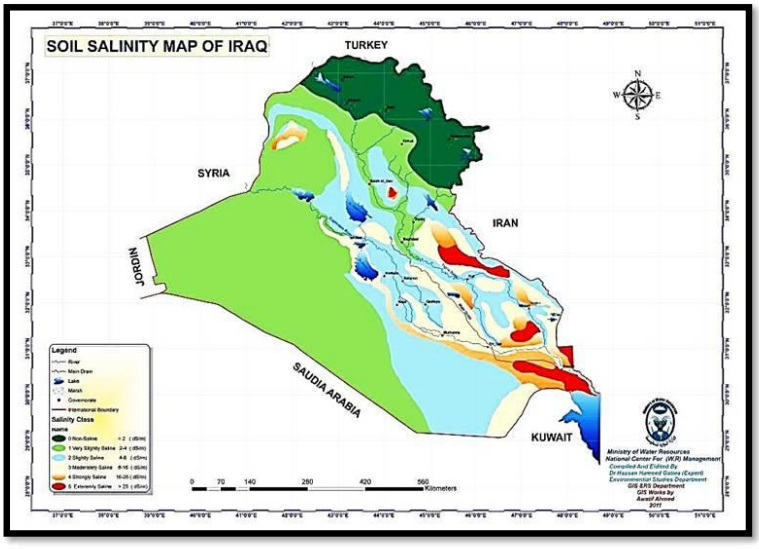


Figure 3: Salinity Levels in the Iraqi Plain

Factors Contributing to Iraqi Soil Salinity

- First, Low elevation (e.g., Baghdad: 33 m above sea level, 600 km from the sea)
- Second, Excessive irrigation water waste by farmers
- Third, Inadequate drainage systems
- Fourth, Seasonal groundwater level rise due to lack of natural drainage
- Fifth, High temperatures, evaporation, and low precipitation.

  These factors cause groundwater to rise to the soil surface, accumulating dissolved salts and leading to salinity issues [Asaad & Adnan. 2015].

Groundwater Depth and Quality:

Soil salinization in central and southern Iraq is directly related to the depth and quality of groundwater. In central Iraq, the depth of the groundwater level ranged from 100 to 200 cm during different months of the year, and in southern Iraq, the groundwater level ranged between 45 cm in February and 200 cm in August, and the salinity of groundwater in the unreclaimed soil was very high, ranging from 42 to 44 $ds.m^{-1}$, while the groundwater of the semi-reclaimed and reclaimed soils was medium saline, and ranged from 8.2 to 10 $ds.m^{-1}$.

The salinity of the groundwater in the low Mesopotamian plain ranged from 10,000 to 60,000 ppm [Qureshi et al. 2013].

Reclamation Challenges: Saline soil reclamation requires substantial water resources for leaching. Iraq's water resources have significantly declined:

Euphrates River: from 30 billion cubic meters (1933) to 9.5 billion cubic meters (2021).

Tigris River: from 20.5 billion cubic meters (1933) to 9.7 billion cubic meters (2021) [Al-Jubouri. 2022].

Project Goals and Features:

This innovative project transforms the curse of highly saline groundwater in central and southern Iraq into a blessing, leveraging vast groundwater resources for agricultural irrigation.

The key objectives are: Utilize purified groundwater for irrigation, to eliminate drainage and leaching needs.

Lower groundwater levels over 10+ years, facilitating negotiation with river source countries in this period.

Implement sustainable agriculture using natural Iraqi resources. Foster self-sufficiency, minimizing imports.

Project Highlights:

Water scarcity has emerged as a global maritime issue, with population growth, industrialization, and pollution all contributing to its challenges. Only 0.014% of the Earth's total water is available for human use, with 97.5% being saltwater and the remaining 2.5% consisting of freshwater. Unfortunately, access to this freshwater remains a challenge, as most of it is trapped in glacial ice and vast forests [Masoud et al. 2023].

For this reason, approximately one-third of the world's population suffers from freshwater scarcity, particularly in areas experiencing severe freshwater impacts [Masoud et al. 2019].

Access to clean water is a critical challenge in areas with limited energy resources. Solar distillation systems have emerged as a popular and sustainable option for obtaining clean water in these regions. This method utilizes solar energy for heating, which is then condensed into potable water. This study presents a distillation system that is cost-effective and energy-efficient, while also ensuring its sustainability.

The average daily production of the proposed distillation system was presented as 1.14 liters/m^2, resulting in an annual production rate of 416.54 liters/year. The estimated cost of producing one liter of distilled water was $0.023 [Jakub et al. 2024].

There are several methods for desalinating seawater, including thermal methods (such as multi-stage flash distillation and multi-effect distillation) and membrane methods (such as reverse osmosis and electrolysis) [Taghavian et al. 2022], [Taghavian et al. 2023].

However, most common desalination methods cannot remove all the purified water from a saline or polluted source and must discard up to 50% of the incoming water.

This can be harmful to the environment and is also costly [Kandeal. 2021].

Solar distillers are a simpler and more efficient method for small-scale projects due to their lower cost. Solar water treatment is a practical solution for purifying various water sources, including seawater, groundwater, surface water, and different types of wastewater, such as pharmaceutical, industrial, and municipal effluents. There are three main types of solar desalination and purification systems: solar distillers, solar water disinfection systems (SODIS), and humidification and dehumidification (HDH) systems.

Among these systems, solar water disinfection systems (SODIS) are considered one of the simplest and most cost-effective methods for treating contaminated water, particularly in developing countries where biological contamination is a significant problem [Masoud et al. 2020].

Desalination via water evaporation/condensation using refinery gas. Legalizing the burning of natural gas in oil refineries, which is currently being done without benefit, and using it to evaporate salty groundwater. In addition to the possibility of relying on solar energy to evaporate and condense groundwater. Locally manufactured plastic containers and drip irrigation systems. Conservation agriculture using containerized tree planting. Reduced water scarcity impacts.

Environmental benefits:

Desalinated saline groundwater will be utilized for irrigation, gradually lowering groundwater levels over 10+ years. This allows many key benefits such as negotiation opportunities with river source countries for restored Tigris and Euphrates River flows. Natural soil drainage through rainfall will eliminate the need for drainage projects for saline soil in the future. In 10 years mature, productive trees with optimized economic returns.

Iraq's sustainable agriculture project aims to utilize saline groundwater for irrigation, reducing reliance on river imports. This innovative approach leverages natural resources, specifically refinery gas, to desalinate water through evaporation and condensation. Approximately 17 billion cubic meters of refinery gas are available annually, with less than a third required for nationwide desalination efforts.

Key Project Components

Desalination Technology: Utilizes refinery gas for water evaporation and condensation. Conservation Agriculture: It employs locally manufactured containerized tree planting resistant to physical pressure and saline groundwater. It can be locally manufactured through the Ministry of Industry's production of polyethylene, which has been re-produced, according to the statements of the Minister of Industry on 11/15/2022 [Khaled. 2022].

Materials and Methods:

This research represents a design study of a pioneering system for coexisting with salinity in difficult-to-reclaim soils. These difficulties are due to the interaction of several factors, such as the scarcity of leaching and irrigation water, the high level of saline groundwater reaching the plant root zone, and the impact of high temperatures and low rainfall on the fluctuating groundwater level throughout the year.

Therefore, analytical laboratory studies for some soil traits were conducted on numerous samples of saline soils, both before and after leaching, including determining their field capacity. The complete system will be implemented with the plant parts in subsequent seasons on a continuous and ongoing basis.

The research plan comprised the following components:

- Soil Analysis
- Sampling: Collected soil samples (0-50 cm depth) from Baghdad to Nasiriya.
- Physical and Chemical Properties: Analysed texture, salinity, and chemical characteristics.
- Saline Soil Leaching Study
- Soil Selection: Used dry soil samples with low, medium, and high salinity. Study of the leaching of saline soils: one kilogram of selected dry soil (low, mid, and high soil salinity compared with control soil) was placed in pots perforated from the bottom to drain the water. The soil was leached with two levels of tap water: (A) half a liter of water. 1 kg of soil. (B) A liter of water. 1 kg of soil. Soil salinity was analysed after that, and the salinity of the drained water was tested for each sample.
- The water used for salty soil leaching was tap water, whose electrical conductivity EC ($ds.m^{-1}$) was (0.23) and its pH was (7.3). Tap water is better than the Tigris

River in Mosul, whose electrical conductivity EC ($ds.m^{-1}$) was (0.43) and its pH was (7.3), and better than the AlKhuser River in Mosul, whose electrical conductivity EC ($ds.m^{-1}$) was (1.61) and its pH was (7.1) [Al-Jubouri. 2009].

- Determining the field capacity: The field capacity of each sample was determined by immersing one kilogram of dried soil in a liter of water and leaving the sample for 48 hours until the gravity water exuded from it. Then measuring the weight of the wet soil to determine the maximum capacity of the soil to hold. Moisture retention 48 hours after immersion.
- Evaluating the results and presenting a cultivation plan within the data of the soil and water analysis results.
- As part of the methodology, the academic search engine Google Scholar was used to identify some relevant studies and peer-reviewed research that support the objectives of this research.

Results and Discussion:

Soil Physical and Chemical Traits Results

The majority of soil samples tended to be clayey in texture, according to the values shown in Table (1). Soil values varied in their content of cations and anions, with a general increase in the index as a result of the effect of the presence of salts in it (Tables 2, 3). The salinity values in the soil varied from the lowest value (10.90 $ds.m^{-1}$) to the highest value (16.10 $ds.m^{-1}$).

Table 1. Soil texture analysis.

Sample No.	Sand %	Silt %	Clay %	Soil Texture
1	17.05	45.75	37.2	Silt-Clay Loam
2	19.55	48.25	32.2	Silt-Clay Loam
3	26.3	29.0	44.7	Clay
4	12.05	38.25	49.7	Clay
5	17.05	35.75	47.2	Clay
6	52.05	15.75	32.2	Sandy Clay
7	51.3	11.5	37.2	Sandy Clay
8	27.05	33.25	39.7	Clay Loam
9	31.3	29.0	39.7	Clay Loam
10	29.55	38.25	32.2	Clay Loam

Table 2. Analysis of cations and anions in some soil samples.

Sample No.	Mg %	K %	Na %	N %	P %	Cl %	Hco3 %	So4 %
1	0.081	0.0019	0.0053	0.015	0.00026	0.81	0.23	0.061
2	0.068	0.0022	0.0072	0.047	0.00050	1.88	0.024	0.056
3	0.042	0.0019	0.0045	0.023	0.00050	0.71	0.041	0.078
4	0.067	0.0020	0.0049	0.015	0.00042	0.75	0.25	0.109
5	0.032	0.0024	0.0044	0.039	0.00026	0.80	0.036	0.104
6	0.016	0.0015	0.0051	0.008	0.00036	0.86	0.053	0.050
7	0.032	0.0014	0.0051	0.054	0.00042	0.90	1.03	0.069
8	0.024	0.0019	0.0048	0.031	0.00079	1.04	0.029	0.083
9	0.008	0.0020	0.0022	0.015	0.00079	0.34	0.014	0.021
10	0.015	0.0024	0.0051	0.023	0.00026	0.88	0.12	0.062

The pH values ranged from (7.1 to 8.0), and organic matter was between (2.62 and 4.03) as shown in Table (3).

Table 3. Soil salinity, pH, and percentage of OM. for some soil samples.

Sample No.	EC ($ds.m^{-1}$)	pH	$CaCo_3$ %	O. M. %
1	11.30	8.0	49	3.82
2	16.10	7.1	46.5	3.69
3	10.90	7.5	48	2.79
4	11.30	7.3	49	3.31
5	11.60	7.2	47	3.38
6	12.30	7.3	49.5	4.00
7	13.01	7.7	47	3.48
8	13.70	7.2	46.5	2.62
9	13.70	7.5	44.5	4.03
10	13.40	7.3	48.5	3.48

The Results of the Salty Soil Leaching Study

It is clear from Table (4) that leaching the soil samples with a volume of 500 ml of water led to a decrease in salinity in the three samples (10.9, 12.3, 16.1 $ds.m^{-1}$) to a very low degree (1.90, 2.60 and 2.70 $ds.m^{-1}$), respectively. The salinity decreased in the same samples when washed with a volume of 1000 ml of water to percentages (1.30, 0.90, and 1.00 $ds.m^{-1}$), respectively.

Reducing soil salinity to 2.7 ds.m^{-1}, which is the higher limit in soil salinity after leaching with a volume of 500 ml, means that this degree of soil salinity is suitable for growing all types of trees [Kumar et al. 2020], grain crops, and vegetable crops [Michael & Khalid. 2015].

Therefore, the leaching process was very efficient in reducing soil salinity. Repeating irrigation with tap water will make the soil salinity decrease until it is equal to the Ec. of irrigation water.

Table 4. Soil salinity (ds.m^{-1}) after leaching of (1000 gm.) soil weight.

Soil Samples	Soil salinity Before leaching	After leaching with 500 ml water	After leaching with 1000 ml water
control	1.20 fg	0.60 i	0.50 i
A	10.90 c	1.90 e	1.30 f
B	12.30 b	2.60 d	0.90 h
C	16.10 a	2.70 d	1.00 gh
Mean	**10.13 a**	**1.95 b**	**0.93 c**

Similar letters have no significant difference according to Duncan's significance test.

Determination of Field Capacity:

Determine the amount of water required to reach 80% of the field capacity of the soil container per tree: The average field capacity of 100% for four samples of saline soil with a weight of 1000 gm. for each sample is very close to = 27.6 + 24.4 + 23.5 + 22.6 = 98.1/4 = 24.5% = 245 ml is sufficient to achieve 100% field capacity for one kilogram of dry soil.

Volume weight of 1 kg of dry soil = approximately 700 ml (cm3).

Weight of a liter of soil = 1000 x 1000 / 700 = approximately 1430 grams of soil.

100% of the field capacity for the weight of 1000 grams of soil is equivalent to 245 grams of water; 80% of the field capacity for the weight of 1000 grams of soil is equivalent to 196 grams of water.

That is, 1000 grams of soil + 196 grams of water = 1196 grams, which represents 80% of the field capacity per kilogram of soil.

Mathematically, a liter of dry soil (1430 gm) would need (280 gm water) to reach (80% field capacity).

This means that the water required per one container of 200 liters of soil to reach 80% of its field capacity is about 56 liters from the multiplying of 200 liters by 280 grams of water.

It seems that the soil texture controls the field capacity values of the four soil samples; the results of [Datta et al. 2017] showed that field capacity values that are very close to the results of this study have a similar soil texture.

The volume of water required to reach 80% of the field capacity of the first irrigation for an area of one hectare (600 trees) = 56 liters x 600 trees per hectare = 33,600 liters, which means only 34 cubic meters for (the first irrigation).

The need for traditional irrigation (the irrigation canals 4 X 4 m. distances) for an area of a hectare is not less than ten times what is consumed per hectare by drip irrigation in plant containers.

That means: 33,600 * 10 = 330,000 liters of water per one hectare, or 330 cubic meters, for the first irrigation only.

The evapotranspiration rate of trees in general = 10% in winter and 30% in summer. Due to the sealing of the upper barrel nozzle, evaporation will be very limited, and only transpiration will remain, so the loss rate will decrease to 5% in winter and 15% in summer, approximately.

Irrigation is done until the field capacity reaches 80%. Then it is stopped.

When the field capacity falls below 50%, irrigation is repeated, and so on.

Table 5. Determination of the field capacity of the four sites.

Sample	Dry soil weight gm.	Soil weight (gm.) after 36 hours of immersion	Soil weight difference gm.	Field Capacity %
Control	1000	1276	276	%27.6
A	1000	1244	244	%24.4
B	1000	1235	235	%23.5
C	1000	1226	226	%22.6

Conclusions and Recommendations:

Through the foregoing, it is clear to us the seriousness of salinity on Iraqi soils and how most of the soils of central and southern Iraq were salinized as a result of irrigation and turned into salty soils and therefore need reclamation (Figure 4(.

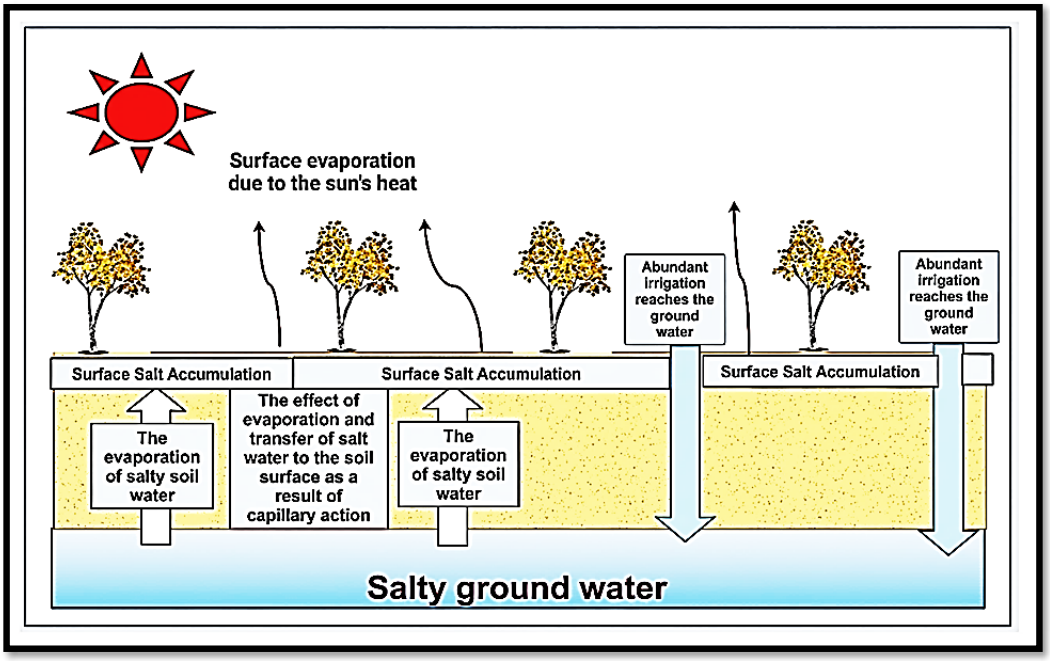


Figure 4. Shows how Iraqi soils are salinized and transformed into Shura salt.

Agricultural lands require a great effort in planning and implementing reclamation projects that the government may not be able to implement; in addition, any reclamation process requires the establishment of a comprehensive drainage network for central and southern Iraq to reduce the level of saline groundwater, as well as filtering the soil with fresh water.

Through the foregoing, it is clear to us that it is impossible to cultivate in such soil due to the scarcity of water required in the filtration process, in addition to the establishing of the drainage network that may cost the government its total budget.

The question now: How can we restore life to these vast lands without opening a comprehensive network of drains, and without sufficient fresh water for leaching and reclamation and then for cultivation, and even how to plant the streets and orchards again without the presence of the most important components of agriculture, which are water for leaching and irrigation, in addition to drains to lower the level of groundwater below the level of crop roots or tree roots?

Through the foregoing, and after analysing many soil samples that were brought from the implementation site, it became clear through the results of testing the samples that these soils can be leached with small quantities of water according to the degree of their salinity, but in the end, they turn into suitable soil for planting all kinds of trees and shrubs, whether pastoral or horticultural plants and, most importantly, this cultivation will take place in the same salinized sites and will not be affected by soil salinity or groundwater level according to the idea presented in the following diagrams.

Accordingly, the curse of salty water and the rise in the groundwater level will turn into a blessing and a water treasure that will enrich Iraq for decades, until the water returns to the Tigris and Euphrates rivers, and then there will be no concern about return rising of groundwater level because much of it will have been used in irrigation after treatment.

The results of the study conducted on the many soil samples of the implementation site in central Iraq succeeded in reducing the level of salinity in it from 10-16 $ds.m^{-1}$ to about 1-1.3 $ds.m^{-1}$ only, and the planning and implementation of this project will be through sustainable agriculture that manages itself, preserves the environment from pollution, and restores life to Iraqi orchards and villages that were abandoned decades ago.

Summary of Action Steps

- Digging a small pond or well 6 meters deep, connecting an anti-salt water pump and electrical connection to the pump. The location of the well is chosen in the middle of the project so that it turns into an outlet for salty groundwater.
- Installing a water desalination plant on these ponds to convert this relatively salty water into fresh water through an evaporation and condensation system that

relies on Iraqi resources only by using refinery gas exhausted by burning, as well as using evaporation technology by heating with direct sunlight or generating electricity through solar energy when needed (Proposed Figure 5).

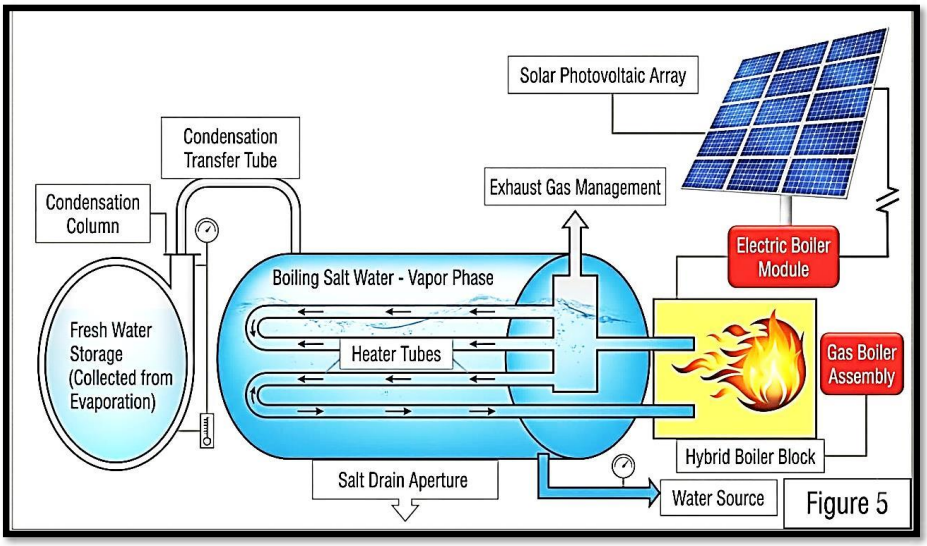


Fig. 5: Water desalination by gas or solar energy. Illustration chart

- After obtaining fresh water (relatively limited and sufficient for sure), sufficient salty soil blocks will be leached in limited and studied quantities of fresh water according to the results of the study and prior analysis of soil and water samples.
- Tree seedlings will be planted in resistant plastic containers (drums) with an expiration date of not less than 10 years and a volume of 220 liters. This period is sufficient to eliminate the risk of salinity from the Iraqi soil if the Iraqi plain turns to the adoption of the drip irrigation technique, and this volume will be sufficient for the roots of the trees and shrubs whose species will be carefully selected (Fig. 6).

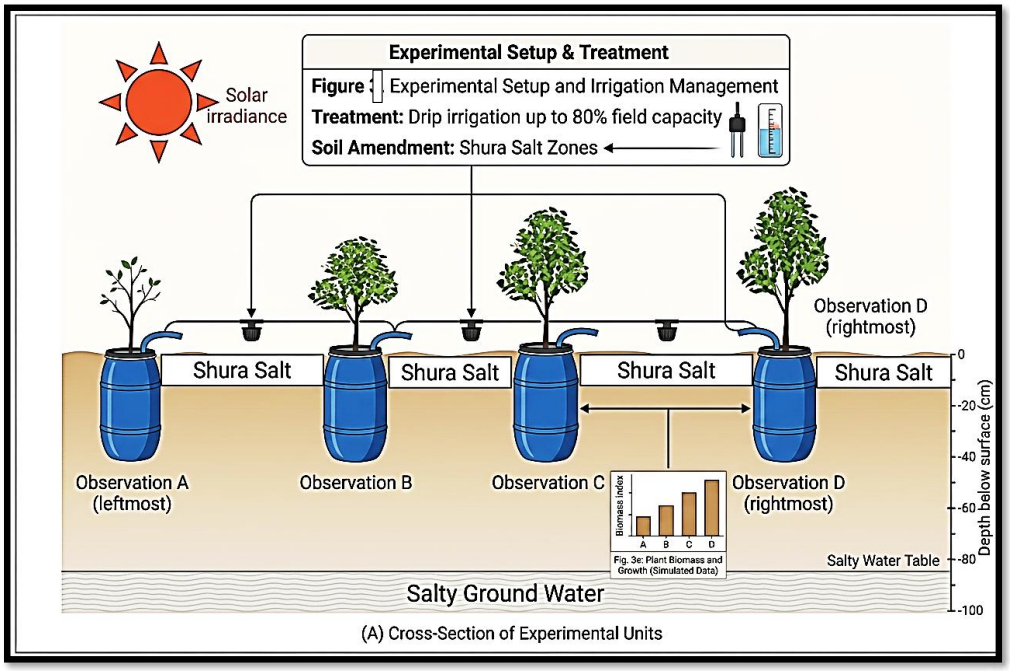


Figure 6. Container cultivation technique with drip irrigation.

- All planting containers will be connected to a drip irrigation network, and irrigation will be done with extreme precision after determining the field capacity of all the soil samples that have been studied.
- Irrigating will be done at a constant rate that does not exceed 80% of the field capacity of the soil. Then the pumping is resumed for irrigation when the soil loses 30% of its moisture when it reaches 50% field capacity, and the pumping continues until the moisture returns to 80% field capacity; this irrigation management is controlled in a standard and weighing manner by preparing a field container (or two containers) to determine the field capacity by a field capacity sensor.

A field capacity sensor was placed in it, and the pointer delivered an electrical signal to the water pump to operate when the soil moisture reached 50% and to turn off when it reached 80% (Fig. 7).

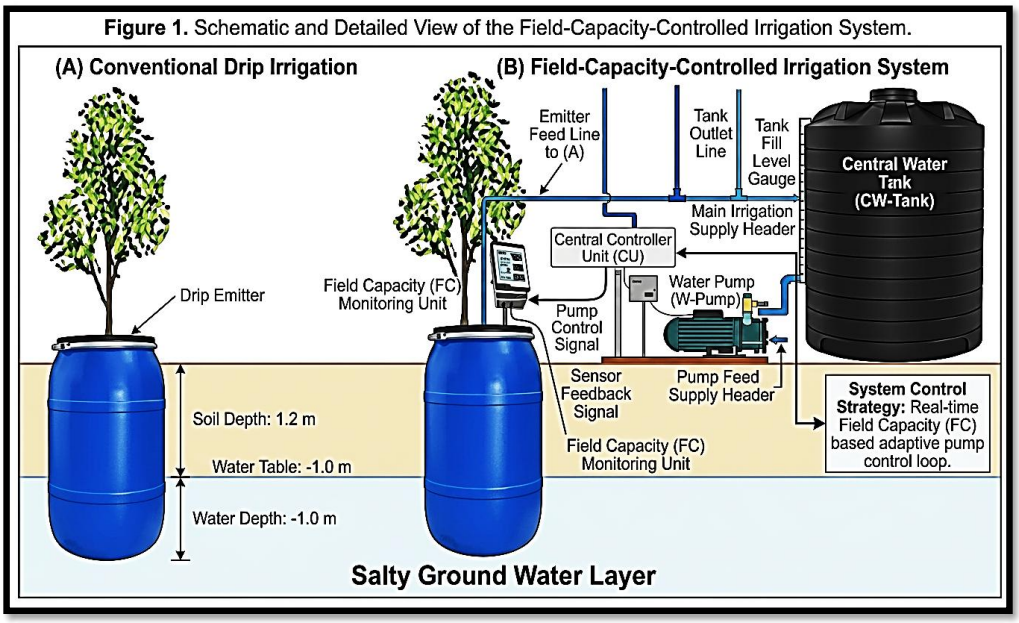


Figure 7. The field capacity sensor for irrigation determines the field capacity.

The method of determining the amount of irrigation is based on measuring the field capacity by a specific field capacity sensor or using a wireless moisture meter (Figure 7) to determine soil moisture, and according to its data, the amount of water is determined for each container to reach the required field capacity.

The device can transmit moisture meter data wirelessly and display it using an application on the farmer's mobile phone. The watering can be operated remotely using the same app based on hygrometer readings.

- After burying these containers in the fields at a depth of more than 1.25 meters, there will be no concern about the problem of the salt water level rising in the winter to about half a meter from the soil surface, because the containers of trees are completely impermeable to water. No matter how high the salt column rises to the surface of the soil to turn into Shura, it will not reach the soil of the seedlings, since the mouth of the container is slightly higher than the surface of the soil, as shown in the attached figure (Fig. 7).

- When we deal with a project to grow trees in agricultural containers, we must understand the mechanisms by which environmental factors control root traits within the root zone is crucial for improving fruit tree productivity by regulating root structure with irrigation [Li et al. 2024].
- Fine roots, the primary organs for water and nutrient absorption in fruit trees, are densest in the 0–100 cm soil layer (Li et al., 2024). Therefore, choosing a container depth of more than 120 cm is ideal for planting trees [Li et al. 2024].
- The irrigation water will be controlled so that it does not cause soil waterlogging through the control system shown in the previous figure. However, if a defect occurs and the soil of one of the containers becomes waterlogged, the excess water can be withdrawn through the excess water intake pipe shown in Figure (8) below.
- This innovation can be used in the implementation of the afforestation of the roadsides, as this method will be beneficial for all farmers to implement it in their fields and with the help of the government, as all farmers' requests for containers can be met by operating the production line for these containers in the petrochemical plant in Basra.
- This application will provide great job opportunities for unemployed youth and will restore life to the Iraqi villages again, with decent and easy means of living.
- Several pastoral shrubs will be planted, the most important of which is the saltbush to cover plant and animal production.
- The period of ten years, which is the period of container life, is sufficient to leach salinity by seasonal rainwater from the soil surface to deeper than the root zone; ten years of rainwater is sufficient for natural leaching of soil salinity, accompanied by a sharp drop in the groundwater level due to withdrawing groundwater in high quantities by farmers to purify it and use it to irrigate all cultivated lands in central and southern Iraq.

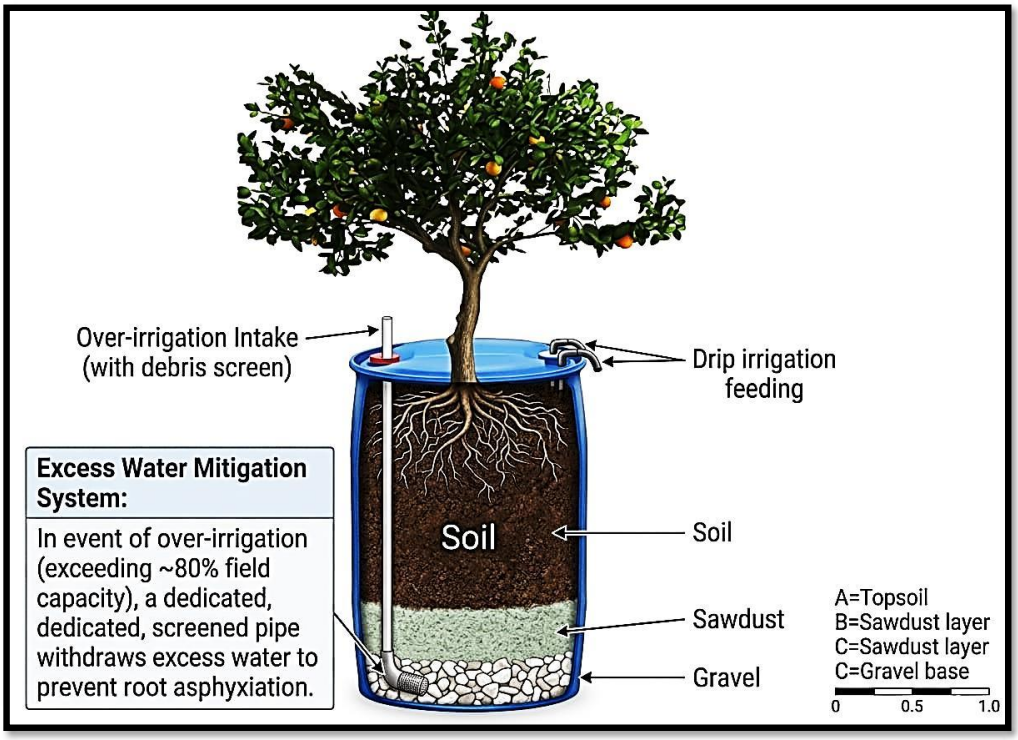


Figure 8. Controlled Container Agriculture System for Citrus Trees

The estimated cost of intensive tree cultivation per Iraqi donum (2500 m^2) is (150 trees / donum): its cost is between 9,000 and 10,000 $ in the event that the government provides desalinated water through a central groundwater desalination project.

Costs include the cost of purchasing 150 tree containers with a capacity of 220 liters through import now (and the ambition is to locally manufacture containers with a size of 300 liters), the cost of leaching the soil of the container and preparing it for cultivation, the cost of digging the positions of the containers and filling them with leached soil, the cost of purchasing tree seedlings and planting them, the cost of the drip irrigation system for an area of Iraqi donums with installation and operation, the cost of the technique of determining the field capacity by the electronic sensor to control the irrigation system, in addition to the cost of establishing small stations for desalination of groundwater to cover their irrigation water needs.

Acknowledgment and Approval:

The study was approved by the Iraqi Prime Minister, and His Excellency instructed it to be implemented in an experimental field. It is currently under implementation, and the study will continue for several years (Appendix).

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دراسة نظام مبتكر لتحقيق الزراعة المستدامة في الأراضي المتملحة بوسط وجنوب العراق دون الحاجة لعمليات الاستصلاح أو البزل. (مشروع استثماري في مجال الأمن الغذائي).

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تاريخ الاستلام: 14-10-2025 تاريخ القبول: 18-05-2026

الملخص:

تواجه الزراعة في مناطق وسط وجنوب العراق تحديات كبيرة بسبب ملوحة التربة، والتي تنشأ نتيجة تفاعل عوامل بيئية وهيدرولوجية متعددة. ومن أبرز هذه التحديات ارتفاع مستوى المياه الجوفية المالحة إلى قرب منطقة الجذور للأشجار والنباتات، مما يحد من نمو جذور النباتات. كما أن الاستصلاح التقليدي عبر مشاريع بزل واسعة النطاق يواجه صعوبات نتيجة للتنوع التضاريسي، وارتفاع التكاليف، ونقص المياه العذبة اللازمة لعمليات الغسل الشامل.

تسعى هذه الدراسة إلى تقديم نظام زراعي بديل يدعم الاستدامة طويلة المدى، ويعتمد على زراعة النباتات في حاويات مغلقة ومقاومة بعمر افتراضي لا يقل عن عشر سنوات، ما يتيح للجذور النمو داخلها خارج نطاق تأثير الملوحة المباشر. ويتم استخدام المياه الجوفية الضحلة (بعمق 0.5–1.5 متر) بعد تحليتها بواسطة دورة تبخير–تكثيف تعمل بطاقة الغاز المحترق الناتج عن مصافي النفط، فضلًا عن إمكانية دعم منظومة طاقة شمسية.

شملت منهجية البحث جمع عينات من التربة من مواقع مختلفة، وتقدير حجم المياه المطلوبة للغسل، وقياس مستويات الملوحة قبل وبعد المعالجة، بالإضافة إلى تحديد السعة الحقلية للتربة عبر أنواعها المختلفة. وأظهرت النتائج قدرة هذا النظام على معالجة أبرز التحديات المرتبطة بالأراضي المالحة، بما فيها محدودية المياه العذبة، وارتفاع تكاليف الاستصلاح، وارتفاع مستوى المياه الجوفية بالقرب من سطح التربة. كما يُتوقع أن يؤدي السحب المستمر للمياه الجوفية خلال فترة تشغيل النظام إلى خفض مستوى المياه الأرضية تدريجيًا، وإبعادها عن منطقة الجذور الفعّالة، مما يعزز إنتاجية التربة بشكل مستدام.

الكلمات المفتاحية: الملوحة، غسل التربة، السعة الحقلية، ترب الشورة، ترب السبخ.