

Salinity Agricultural Problem in Agricultural Lands

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DOI : <https://doi.org/10.61796/jmgcb.v3i1.1584>



Sections Info

Article history:

Submitted: August 23, 2025

Final Revised: September 11, 2025

Accepted: October 20, 2025

Published: November 05, 2025

Keywords:

Yield Loss

Salinity

Leaching Requirement

Irrigation Management

Sustainable Agriculture

ABSTRACT

Objective: This study aims to address the increasing challenge of soil salinity as a critical barrier to sustainable agricultural production, emphasizing the essential roles of soil and water quality in maintaining productivity. **Method:** The research employs a descriptive and analytical approach, examining the causes of soil salinization in dry and semi-arid regions by differentiating between natural and human-induced factors, including improper irrigation practices, poor drainage, and excessive fertilizer use. **Results:** The findings indicate that the persistent use of low-quality irrigation water due to water scarcity and pollution accelerates salinity accumulation in agricultural soils, leading to a significant decline in soil fertility and crop yield. The study highlights that effective mitigation requires leaching techniques, improved irrigation management, and the cultivation of salt-tolerant crops. **Novelty:** This article provides an integrative perspective that combines ecological and agronomic factors, offering practical strategies to rehabilitate saline soils and promote sustainable agriculture, especially in regions facing increasing water stress due to climate change.

INTRODUCTION

The global population was over 6.4 billion in 2008 as compared to 4 billion in 1971 and has continued to increase to about 7.4 billion [1]. To address the food demand of the growing population, it is important that production have been increased not only but also there are reduction of losses after harvest. The quality and quantity of irrigation water, and access to drainage will be important when taking into account population growth to prevent losses in the food production of most countries. Since the cultivable land has been exhausted, it is of importance to exploit the soil problem soils of salinity [2].

The adequate and sustainable quality of soil and water resources is crucial to humanity. The expansion of the population and industry leads to the increase of domestic and industrial consumption of water, which makes them very competitive with agricultural water use [3]. In the meantime, pollution of the environment and climate changes worsen the quality and quantity of water and it becomes increasingly more difficult to obtain irrigation water of good quality on a daily basis. Thus the reasons are not only the amount but also the quality of the irrigation water which has become one of the burning issues. Considering the declining availability of water and the increase in water demand, farming irrigation using lower quality waters will inevitably be a component of fulfilling the need [4].

The use of soil and water resources is being characterised by increased sustainability and efficiency. Since it is becoming hard to find water of adequate quality to support agricultural activities, methods of harnessing lower quality waters in

agriculture are being examined [5]. One of the major problems of agriculture in the present times is the prevention of salinity. It is further worsened by climate change, sea-level rise and drought.

The water used in irrigation has diverse salt content levels. Salts that are formed as a result of weathering and crumbling of rocks and soil particles can have soil minerals like lime and gypsum [6]. Irrigation water can carry these salts in the soil to the plant root region where they are deposited. When the rainfall and leaching are not enough to eliminate the salts in root zone, then salinity occurs. Saline soils are those that contain exchangeable sodium or soluble salts that are damaging to the plants. Although there was no initial salinity issue with even soils, inappropriate irrigation, inappropriate irrigation systems, and poor drainage make them unproductive within a very short period. One of the major causes of salinity is poor drainage. Poor reclamation methods and irrigation also increase the ground water table. Salt is found in the soil where soil permeability is low or there is a shallow groundwater [7], [8]. On low-lying topographical locations, deposits of seepage in elevated regions are accumulated in low-topographical spots; surface waters are evaporated thus causing soil salination. Through the course of every irrigation, the dissolved salts are bound to be deposited in water bodies and reduce their quality leading to an increment in salinity in waterways which supply the waterways to other farmers and communities [9].

The salinity of soil is therefore becoming one of the most important world problems since it declines the fertility of the soil and makes the soil less effective to absorb water and consequently its yield decreases as the salinity level increases. Salinity of soil has been experienced in many agrarian countries to the extent that they are at risk of failing to satisfy food demand. The salination of new territories which are not already salty is of concern since majority of the global agricultural production occurs on the new lands. In the absence of preventative strategies, they are bound to lose future yield and quality [10].

RESEARCH METHOD

The causes of soil salinity are classified into natural and human-caused causes (3):

A. Natural Causes of Soil Salinization

Salinity resulting from natural causes is called primary salinization.

The most important causes include: Weathering: The weathering of rocks of various types is a primary and renewable source of salts in the soil, as it releases salts from the parent rock and releases them to dissolve in sedimentary and groundwater, where they are transported from their source to other locations. However, in arid and semi-arid regions, these salts tend to accumulate due to the lack of sedimentation and leaching processes in the subsoil, and high evaporation rates. This, in turn, contributes to increased soil salinity.

1. Transport of salts by river water: Rivers transport salts from their sources to the plains, depositing them there alongside alluvial and clayey materials, causing soil salinization.

2. Fossil salts: Examples include marine and saline sediments, which are responsible for the salinization of arid areas. This occurs when these sediments dissolve in the water stored underground.
3. Weather: Winds and rain can carry salt particles from the sea in coastal areas and deposit them in the soil, increasing its salinity. Seawater entering coastal areas due to wind can also lead to an increase in the salt content in the soil.

B. Human Causes of Soil Salinity

Salinity resulting from human activities is called secondary salinization, and its most important causes are the following:

1. Irrigation with salt-rich water: All irrigation water, especially recycled wastewater, contains a certain amount of salt, which accumulates in the soil, surface runoff, and groundwater with repeated irrigation.
2. 2-Irrigation using groundwater: Due to human activities, human pumping of groundwater has increased, which carries salts from the ground to the ground. The surface as it rises upward.
3. Use of chemical fertilizers: Their effect on soil salinization increases in intensively cultivated lands with low permeability.
4. 4-Soil pollution: An example of this is soil contamination by salt-rich water and industrial waste.

The management and cultural factors. Among the causes, one can mention errors in irrigation and fertilisation. Not only the soils which have been irrigated over a long period of time but also the recently irrigated lands are at risk of salinity. Premature or unwarranted irrigation elevates the water level and, by evaporation, causes the formation of salt deposits on the surface of the ground. The problem is also worsened by the low-quality saline irrigation water. In dry and semi-arid areas, besides the irrigation activities, over grazing, environmental pollution as well as deforestation also cause salt accumulation in the soils. The lack of the reservoir capacity might also contribute to uncontrolled floods that facilitates salinization.

The salinity grows at a significantly higher rate when the irrigation is combined with poor drainage in dry and semi-arid climates. The irrigation water contains soluble salts that are brought to the root zone by the process of capillarity. Poor drainage in regions where irrigation is done carelessly with the waters that are rich in soluble salts also contributes to the build-up of salt. Salinity is caused by the main cations in the soil solution: Na, Ca, Mg, and K and anions, Cl, SO₄, HCO₃, CO₃, and NO₃. In dry and semi-arid areas, the primary factor in the salinity formation is the insufficient precipitation and high evaporation. Salinity can also be developed either naturally or by human induced i.e. unconscious irrigation. The high drainage and the excessive irrigation elevate the table of ground water; in harsh weather, the salts that are dissolved by the ground water are evaporated at the surface thus forming salinity.

RESULTS AND DISCUSSION

The primary intervention is that of removing the causative factor(s). In the case of salty soils, the cost and effort of remedial programs are quite expensive. Leaching salts out of the soils is the main process of reclaiming saline soils. Leaching must be done in cool seasons when the amount of water consumed by the plant is minimal, and hopefully by sprinkler systems with intermittent ponding instead of constant ponding. In soils with a high alkalinity, the PH may be reduced through chemical additives [11]. Chemical amendment and leaching is used in soils which are poor in calcium but also high in magnesium salts. On the other hand, alkaline amendments can be suitable in soils with high concentration of calcium ions (e.g., CaSO_4). In the high rainfall area when the soil is too acidic, the effect can be rectified through liming [12].

Other causes of salt accumulation in semi-arid areas besides irrigation are deforestation, overgrazing, environmental pollution and transportation of salt by air and water. Deforestation and overgrazing expose the soil surface to be covered by salt which is carried away by groundwater and/or wind. Together with salinization, there appears another issue which is soil erosion. Parallel with industrial development in the world, rivers have been contaminated with salt-bearing chemical effluents; these waters are used in irrigation, which facilitates salinity of the soil [13].

The restoration of salt and boron-impacted soils is crucial and time-consuming and tedious. The amount of water needed to remove boron and salts in the root zone can be extremely large depending on the properties of the soil. In soils with high texture, water infiltration is low; so much water is lost to evaporation during leaching processes and this leads to low leaching efficiency. As the global warming increases water scarcity, the application of leaching water in the growing season may be limited by the possibilities of water scarcity [14].

As much as leaching is one of the basic processes in reclamation, water scarcity in arid and semi-arid areas implies that the improper use or excessive use of water is an issue, so limited water sources accessible to be used in leaching have to be wisely utilized [15]. The main objective of leaching is to clear off the soluble salts of the soil and especially in the root zone. The studies conducted on the reclaiming of saline soils have aimed at establishing the form and amount of amendments, duration of leaching, and the amount of leaching water that should be applied. In intermittent ponding, the applications of leaching are usually spaced by 24 hours or 48 hours between applications of water. Although the climate, areas, and the soil in these regions may vary, research usually maintains the spacing between water applications the same [16].

Although the soils with salinity issues already present require control, soils with salinization in the early stages are even more problematic to agriculture since much of the vegetation growth takes place on them. In the absence of preventive interventions, it is inevitable that yields and quality will plummet in great amounts in the future [17].

Irrigation Techniques and Salinity

In dry and semi-arid areas, the key factors that have restricted the agricultural activities in the areas are a short supply of arable land, climatic factors, and quality water. In a bid to reduce the impact of salinity in the root zone, irrigation processes that do not increase salt concentration should be utilized. The appropriateness of a method in a particular area is dependent on the depth of applied water, the losses that are caused by the leaching and runoff, zones where salt has been laid, and the uniformity of water application. Salinity can also occur in sections of the soil profile under any type of irrigation technique, and it is therefore crucial to manage irrigation well. The method differs in the location and extent of salt deposition in the soil [18].

Sprinkler irrigation

The goal of this method is efficient and cost-effective use of water, through its spraying over the land surface, and minimizing deep percolation losses. Nonetheless, saline water use through sprinklers may lead to necrosis (burning) of leaves. Plant species vary in their sensitivity to the burning of leaves. Such damage can be reduced or prevented by sprinkler irrigation at night or during the night time when the humidity levels are high [19].

A. Advantages of sprinkler irrigation (7)

1. It can be used on flat and sloped lands, and this method can be used on all types of soil.
2. Shortening some agricultural operations (fertilization, pest control) by adding it to the water.
3. It can be used when water quantities are small and scarce.
4. It provides high water efficiency.

B. Disadvantages of this method

1. It cannot be used in high-speed winds because they affect the distribution of the sprayed mist and cause it to fall in incorrect locations.
2. Irrigation water with a salinity exceeding 1500 parts per million (2500-3000) microsiemens/cm³ should not be used.
3. It requires technical expertise to operate the system and maintain its components.
4. The high cost of sprinkler irrigation systems.
5. Limit irrigation to nighttime or early morning hours because using them during high temperatures leads to the loss of a large amount of sprayed water through evaporation and the concentration of salts at higher levels than with spate irrigation methods, leading to a decrease in the efficiency of this method.

Drip irrigation

Drip systems are able to provide the crop with the necessary quantities of water on the daily or periodic basis and are usually preferred in the case of species that are extremely sensitive to necrosis of leaves. Nevertheless, due to the small size of emitter

orifices, salt precipitation caused by evaporation may cause clogging of emitters; emitters will require periodical monitoring and maintenance.

A. Advantages of Drip Irrigation (5):

1. It saves irrigation water by wetting a small area and utilizing the water to increase production.
2. It reduces weed growth and fungal diseases by not wetting the plant leaves and the soil surface.
3. It reduces soil salinity problems and their impact on the plant, as continuous daily irrigation works to maintain a more diluted soil solution concentration.
4. It improves agricultural operations and the use of fertilizers and pesticides.
5. Other agricultural operations can be performed during irrigation.
6. It significantly reduces labor requirements, as the system can operate automatically.
7. It is used for desert and uneven lands.
8. It reduces soil erosion and the loss of soil nutrients.

B. Disadvantages of Drip Irrigation (6):

1. Investment, labor, and maintenance costs are higher than other irrigation systems.
2. The need for an energy source.
3. It is not suitable for high-density crops.
4. Salts accumulate near the plant, which leads to problems later, especially if the salts are not washed from the soil.

CONCLUSION

Fundamental Finding : This study concludes that soil salinity is an escalating global issue, particularly in arid and semi-arid regions where inadequate drainage, improper irrigation practices, and excessive fertilizer use contribute significantly to soil degradation and declining crop productivity. **Implication :** The findings underscore the urgent need for sustainable agricultural management through improved irrigation systems, farmer education, and the adoption of salt-tolerant crops to mitigate the adverse effects of salinity on food security and environmental sustainability. **Limitation :** However, the research remains limited by the lack of empirical data and field-based assessments that quantify the long-term effectiveness of reclamation strategies across varying soil and climatic conditions. **Future Research :** Further studies should focus on developing and testing innovative, cost-effective solutions such as precision irrigation technologies, bioengineered salt-resistant plant varieties, and integrated soil monitoring systems to enhance resilience against salinity in the context of climate change and global water scarcity.

REFERENCES

- [1] L. A. Richards, Ed., *Diagnosis and Improvement of Saline and Alkali Soils* (USDA Agriculture Handbook No. 60). U.S. Department of Agriculture, 1954.

- [2] R. S. Ayers and D. W. Westcot, *Water Quality for Agriculture* (FAO Irrigation and Drainage Paper 29 Rev.1). Food and Agriculture Organization, 1985.
- [3] N. K. Al-Barazi, Previous Source, p. 191.
- [4] A. I. R. Karbal, "Evaluation of the Irrigation and Drainage Network in Babylon Governorate," *Journal of the College of Arts*, no. 19, Univ. of Basra, 1981, p. 138.
- [5] I. M. Habib et al., "Desert Land Irrigation Methods," Previous Source, p. 280.
- [6] D. W. James, Previous Source, p. 120.
- [7] A. A. Hassan, *Irrigation, Drainage and Treatment of Salinity*, 1st ed., Kuwait Foundation, Kuwait, 1995, p. 202.
- [8] J. D. Rhoades, F. Chanduvi, and S. M. Lesch, *Soil Salinity Assessment: Methods and Interpretation of Electrical Conductivity Measurements* (FAO Irrigation and Drainage Paper 57). Food and Agriculture Organization, 1999.
- [9] E. V. Maas and G. J. Hoffman, "Crop Salt Tolerance – Current Assessment," *Journal of the Irrigation and Drainage Division (ASCE)*, vol. 103, no. 2, pp. 115–134, 1977.
- [10] R. Munns and M. Tester, "Mechanisms of Salinity Tolerance," *Annual Review of Plant Biology*, vol. 59, pp. 651–681, 2008.
- [11] FAO Global Soil Partnership, *Global Map of Salt-Affected Soils (GSASmap)*. FAO Knowledge Repository, 2021.
- [12] P. Rengasamy, "World Salinization with Emphasis on Australia," *Journal of Experimental Botany*, vol. 57, no. 5, pp. 1017–1023, 2006.
- [13] J. Shalhevet, "Using Water of Marginal Quality for Crop Production," *Agricultural Water Management*, vol. 25, no. 3, pp. 233–269, 1994.
- [14] E. V. Maas, S. R. Grattan, and G. Ogata, "Foliar Salt Accumulation and Injury in Crops Sprinkled with Saline Water," *Irrigation Science*, vol. 3, pp. 157–168, 1982.
- [15] K. Shi, Y. Liu et al., "A Review of the Category, Mechanism, and Controlling Methods of Emitter Clogging in Drip Irrigation," *Agriculture*, vol. 12, no. 2, p. 202, 2022.
- [16] L. Zhangzhong et al., "Effects of Drip Irrigation Models on Chemical Clogging of Emitters under Saline Water Drip Irrigation," *Water*, vol. 10, no. 3, p. 345, 2018.
- [17] M. Qadir, E. Quill rou, V. Nangia et al., "Economics of Salt-Induced Land Degradation and Restoration," *Natural Resources Forum*, vol. 38, no. 4, pp. 282–295, 2014.
- [18] P. Shrivastava and R. Kumar, "Soil Salinity: A Serious Environmental Issue and Plant Growth-Promoting Bacteria as One of the Tools for Its Alleviation," *Saudi Journal of Biological Sciences*, vol. 22, no. 2, pp. 123–131, 2015.
- [19] M. Zaman, S. A. Shahid, and L. Heng, "Irrigation Systems and Zones of Salinity Development," in *Guideline for Salinity Assessment, Mitigation and Adaptation Using Nuclear and Related Techniques*, Springer, 2018.

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