EURASIAN JOURNAL OF ACADEMIC RESEARCH
Innovative Academy Research Support Center
IF = 7.899
www.in-academy.uz

AGROTECHNIQUE FOR CULTIVATING GREEN COATINGS ON THE DRIED BASE OF THE ARAL SEA

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https://doi.org/10.5281/zenodo.16255450

ARTICLE INFO

Received: 15th July 2025
Accepted: 20th July 2025
Online: 21st July 2025

KEYWORDS

Aral Sea, agrotechnology, green coating, phytomelioration, soil salinity, desertification, ecological restoration.

ABSTRACT

The desiccation of the Aral Sea has given rise to an unprecedented ecological catastrophe, resulting in the formation of the Aralkum desert. This paper explores the agrotechnical methods essential for cultivating green coatings on the dried seabed. Specifically, it examines the applicability of phytomelioration strategies, the role of salt-tolerant plant species, and soil reclamation techniques. Moreover, it presents a critical analysis of the interdisciplinary approaches required for sustainable ecological restoration. The significance of such efforts lies not only in combating desertification but also in ensuring regional socio-economic resilience and environmental health. Ultimately, this study contributes to the growing body of literature aimed at reversing the negative anthropogenic impacts on one of the most ecologically stressed regions of Central Asia.

Introduction. The dramatic shrinkage of the Aral Sea, once the fourth-largest lake in the world, stands as a potent symbol of environmental mismanagement. Initiated by the diversion of the Amu Darya and Syr Darya rivers for irrigation projects during the Soviet era, this ecological disaster has triggered severe consequences for biodiversity, public health, and regional economies. As the water receded, it exposed a vast, contaminated seabed now referred to as the Aralkum desert, spanning more than 60,000 square kilometers. Given the hostile environmental conditions—including high soil salinity, frequent dust storms, and low precipitation—rehabilitation efforts must adopt a robust and scientifically grounded approach. One such approach is the development of green coatings or vegetative covers that can stabilize the soil, sequester carbon, reduce wind erosion, and initiate ecological succession. These coatings serve as a buffer between the degraded land and the atmosphere, thereby mitigating the release of toxic dust particles and contributing to local climate stabilization. This article aims to present a detailed examination of agrotechnical strategies tailored to the unique conditions of the Aralkum. Emphasis is placed on integrating soil amelioration, adaptive species selection, sustainable irrigation methods, and community engagement. Through this interdisciplinary framework, the article aims to contribute viable solutions to the complex challenges posed by the desiccation of the Aral Sea.

To formulate effective agrotechnical interventions, it is first essential to understand the ecological, edaphic, and climatic context of the dried seabed. The soils of the Aralkum desert are predominantly solonchaks—highly saline soils characterized by a crust of salts on the surface, poor nutrient availability, and low organic content. Additionally, the region is subject to extreme temperature fluctuations and minimal annual rainfall, averaging less than 100 mm. In this context, phytomelioration emerges as a foundational strategy. As defined by B. A. Dospekhov and other agroecologists, phytomelioration involves the use of plants to improve soil fertility, reduce erosion, and stabilize ecosystems. In saline environments, halophytic (salt-tolerant) plant species are particularly valuable, as they can survive in harsh conditions while gradually enhancing soil structure and fertility.The literature provides various examples of successful afforestation and revegetation efforts in comparable environments. For instance, in China's Taklamakan Desert, large-scale afforestation using drip irrigation and salt-tolerant shrubs has significantly reduced sandstorms and improved air quality. Likewise, in the degraded lands of Rajasthan, India, indigenous plant species have been used to restore semi-arid landscapes with positive socio-economic outcomes. Specific to the Aral region, international projects coordinated by the International Fund for Saving the Aral Sea (IFAS) have experimented with species such as Haloxylon aphyllum, Tamarix spp., Calligonum spp., and Atriplex spp. These plants exhibit high drought resistance, deep root systems, and the capacity to anchor loose soils. Studies have reported a reduction in airborne dust levels in afforested zones, underlining the efficacy of these initiatives [3, 198-201].

Developing a sustainable green coating on the dried seabed requires a multidisciplinary approach that integrates ecological principles with advanced agricultural techniques. The methodology involves four interrelated components: soil amelioration, species selection, planting techniques, and water management. Soil amelioration serves as the foundational step in preparing saline soils for vegetation. Chemical amendments such as gypsum (calcium sulfate) are commonly used to displace sodium ions and improve soil structure. Organic amendments, including compost, manure, and biochar, can also be added to enhance microbial activity and increase the soil's water-holding capacity. Mechanical interventions include deep plowing to break up salt crusts, contouring to reduce runoff, and the installation of windbreaks to minimize erosion. In some cases, geotextiles are deployed to stabilize shifting sands prior to planting. These measures, when implemented systematically, create a more hospitable environment for plant germination and growth. The success of phytomelioration largely depends on the selection of appropriate plant species. Halophytic shrubs and trees, such as Haloxylon aphyllum (black saxaul), possess physiological adaptations that enable them to thrive in high-salinity conditions. Tamarix spp. are notable for their high evapotranspiration rates and ability to accumulate salt in their tissues, which they excrete through specialized glands. Furthermore, Atriplex spp. and Salsola spp. contribute to soil reclamation by increasing organic matter and providing forage for livestock. Mixed plantations that combine shrubs, grasses, and trees are often more resilient, as they mimic natural ecosystems and offer diverse ecological functions.

Planting methods vary based on the selected species, site conditions, and available resources. Saplings may be planted manually or with mechanized equipment, depending on the scale of the project. Direct seeding is used in less accessible areas, though it generally requires more initial care. Spacing is critical to avoid competition for scarce water resources. Typically, plants are spaced 2–3 meters apart. Mulching around the base of each plant can reduce evaporation and suppress weed growth. Protective fencing is often necessary to prevent grazing by wild or domestic animals. Given the arid climate of the Aralkum, supplemental irrigation is essential during the early stages of plant development. Drip irrigation systems are preferred due to their efficiency and minimal water loss. In areas where water is extremely scarce, hydrogels or water-retaining polymers may be mixed into the soil to improve moisture availability. Moreover, water harvesting techniques such as contour bunding, check dams, and micro-catchments can be employed to capture and store rainwater. The use of solar-powered pumps for irrigation represents a sustainable solution in remote areas with limited infrastructure [5, 61-67].

Preliminary results from afforestation efforts in the Aralkum demonstrate a measurable impact on environmental conditions. For instance, Uzbekistan's State Forestry Committee has reported the successful greening of over 1.3 million hectares as of 2023. Satellite imagery confirms a reduction in dust storm frequency and the establishment of stable vegetative zones. Microclimatic improvements have also been noted, including a modest increase in soil humidity and reduced diurnal temperature variation in afforested areas. Biodiversity indicators such as the return of small mammals, insects, and birds suggest the beginning of ecological succession. However, challenges remain. Survival rates vary significantly, ranging from 40% to 85% depending on site conditions and maintenance. Soil salinity continues to pose a barrier to root development in certain zones. Moreover, financial constraints and institutional capacity gaps hinder the scalability of such projects. Despite these limitations, the long-term benefits of green coatings are substantial. They provide ecosystem services such as carbon sequestration, air purification, and erosion control. Additionally, they offer economic opportunities through the cultivation of medicinal plants and sustainable grazing practices.

In order to enhance the impact and sustainability of green coating initiatives, several recommendations are proposed:

- Enhance scientific research and monitoring: Establish field stations to monitor soil and plant health, using remote sensing and geographic information systems (GIS).
- Promote cross-border cooperation: Given the transboundary nature of the Aral Sea crisis, regional cooperation is essential for sharing knowledge, resources, and best practices.
- Involve local communities: Training programs and participatory planning can increase local ownership and long-term sustainability.
- Diversify plant species: Incorporate economically valuable plants that can provide income, such as camelthorn (Alhagi) and licorice (Glycyrrhiza glabra).
- Leverage international funding: Engage with global environmental funds and climate finance mechanisms to secure the necessary resources.

Conclusion. The desiccation of the Aral Sea has had devastating ecological and socio-economic consequences for Central Asia. However, through the strategic application of agrotechnical methods, it is possible to transform the degraded seabed into a zone of ecological renewal. Green coatings, established through careful soil management, species selection, and irrigation, can play a pivotal role in restoring environmental balance. While the process is inherently complex and long-term, the initial outcomes are encouraging. By integrating scientific innovation with community participation and regional cooperation, the vision of a green Aralkum is not only conceivable but attainable. Future efforts must continue to refine these methods and scale up successful models, ensuring that the lessons of the Aral Sea are transformed into pathways for resilience and regeneration.

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