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HYDROECOLOGICAL EFFICIENCY OF IRRIGATION SYSTEMS IN AGRICULTURE

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Annotation: This article analyzes the hydroecological efficiency of irrigation systems used in agriculture. A comparative analysis was conducted between irrigation technologies' impact on water resources, water-saving methods (drip irrigation, sprinkler irrigation), and traditional open-channel irrigation systems. Additionally, the effects of irrigation systems on hydrological stability, soil salinization, and biodiversity were studied.

Keywords: irrigation system, hydroecology, water saving, drip irrigation, salinization, hydrological stability, agriculture, water resources

Introduction:

The agricultural sector is considered the largest consumer of water globally. Efficient use of water during irrigation, water saving, and reducing the negative impacts on soil and the environment are pressing issues. In the context of Uzbekistan, problems such as water scarcity, salinization, and soil degradation make the hydroecological efficiency of irrigation systems particularly important.

Modern irrigation technologies, especially drip and sprinkler systems, serve to ensure water savings and ecological sustainability. Therefore, this article examines the ecological and hydrological efficiency of various irrigation systems.

Methodology:
The study was conducted using the following methods:

1. **Literature review** – Materials provided by FAO, ICARDA, and the Ministry of Water Resources of the Republic of Uzbekistan were analyzed.
2. **Field observations** – Irrigation methods were monitored on farms in Chust, To‘raqo‘rg‘on, and Pop districts of Namangan region.
3. **Comparative analysis** – The following irrigation methods were compared based on hydroecological efficiency:
   - Traditional open-channel irrigation
   - Sprinkler irrigation
   - Drip irrigation
4. **Ecological indicators** – Measurements included salinity level, water consumption, plant biomass growth, and soil moisture.

Results:

1. **Water consumption analysis:**
   - Drip irrigation reduced water use by 40–60%;
   - In traditional methods, water loss exceeded 50% due to evaporation and seepage.
2. **Impact on soil and environment:**
   - In traditional irrigation, high levels of soil salinization and compaction were observed.
   - In drip irrigation, soil fertility and air circulation improved.
   - Areas with high biodiversity were noted in farms using modern irrigation methods.
3. **Crop yield indicators:**
   - In cotton and vegetable cultivation, yields increased by 20–25% in drip-irrigated fields.
4. **Hydroecological stability:**
   - New technologies reduced hydrological pressure and helped maintain the natural water cycle.

Discussion

In the context of Uzbekistan, factors such as water scarcity, climate change, and land degradation have made improving the efficiency of irrigation systems in agriculture a vital necessity. Observations and analyses indicate that modern water-saving irrigation methods not only increase crop yields but also help maintain hydroecological balance.

Drip irrigation technology reduces water usage by 40–60%, thereby ensuring the economical and efficient use of water resources. In such systems, water is delivered directly to the plant roots, significantly reducing evaporation and seepage losses. As a result, soil salinity decreases, biological activity is restored, and land productivity increases.

Sprinkler irrigation systems are considered effective for leguminous crops, vegetables, and forage crops. In this method, water is evenly distributed across the soil, reducing the risk of erosion. However, the likelihood of water evaporating under strong wind or intense sunlight necessitates its application under optimal conditions.

Traditional open-channel irrigation systems are still widely used in many farming areas. Although these systems are simple and inexpensive, they consume a lot of water, have low efficiency, and pose high environmental risks. In the long term, such systems lead to soil salinization, compaction, and erosion.

The discussion clearly shows that the advantages of drip and sprinkler irrigation systems lie in their ecological sustainability and resource efficiency. These methods make it possible to irrigate crops effectively even under water-scarce conditions. However, the implementation of these systems requires initial investments, technical maintenance, agronomic knowledge, and skilled personnel. Furthermore, irrigation systems directly affect ecosystems. Improperly designed irrigation can alter groundwater levels, increase salinity, and disrupt hydrological balance. Therefore, the selection and sustainable management of irrigation systems should be based on the natural and climatic conditions of each region.

Conclusion

The proper selection of an irrigation system not only increases water use efficiency but also plays an important role in ensuring ecological sustainability. Drip irrigation technology has proven to be the most optimal solution, being environmentally safe, water-efficient, and yield-enhancing. The widespread adoption of this technology in agriculture serves as a key guarantee

for sustainable development.
Based on the above analysis and discussion, the following key conclusions can be drawn:

1. The efficiency of irrigation systems directly affects not only agricultural productivity but also the conservation of water resources and ecological balance. Therefore, traditional irrigation methods should be gradually replaced with modern, resource-efficient technologies.
2. Drip and sprinkler irrigation systems are considered the most environmentally suitable, reducing water consumption, improving soil fertility, and mitigating environmental problems such as salinization and erosion.
3. To increase the hydroecological efficiency of irrigation systems, scientifically based approaches, agro-technical measures, and engineering solutions must be applied in combination. The quality, quantity, and timely distribution of irrigation water remain crucial factors.
4. It is important to select appropriate irrigation systems based on regional climate and geological conditions. A method effective in one area may be ineffective or even harmful in another.
5. In improving irrigation systems, the use of information technologies, remote control systems, and agro-monitoring has become a modern trend, significantly enhancing resource efficiency and overall effectiveness.
6. Given the limited water resources in Uzbekistan, planning and managing irrigation in a way that preserves hydroecological stability is a critical component of national security and food independence.

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