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DEVELOPMENT OF WATER-SAVING TECHNOLOGY BASED ON BENTONITE IN URBAN LANDSCAPING SYSTEMS

Oripov Abdullo Akbarjon o‘g‘li
Namangan State Technical University, Uzbekistan

Scientific Supervisor: PhD., Assoc. Prof. Sh. Juraev

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Abstract

Water scarcity is one of the most pressing environmental challenges of the 21st century. According to the United Nations, nearly 60% of the global population will face water shortages by 2050. Uzbekistan, located in a region with limited water resources, experiences significant difficulties in maintaining adequate water supply due to climate change and population growth. This research focuses on developing an innovative water-saving technology for urban landscaping systems using locally available bentonite clay. The study investigates the physical and chemical properties of bentonite, its interaction with soil, and its potential to retain water and improve plant growth under arid conditions.

Keywords: Water-saving technology; Bentonite clay; Soil moisture retention; Urban landscaping; Sustainable irrigation; Green infrastructure; Soil hydrology; Climate adaptation; Eco-friendly materials; Uzbekistan; Water efficiency; Environmental sustainability

1. Introduction

Rapid urbanization and climate change have intensified the demand for sustainable water management in green infrastructure. Urban landscaping plays a crucial role in maintaining ecological balance, air purification, and improving the urban microclimate. However, traditional irrigation methods consume large amounts of water, making them unsustainable under current climatic and hydrological conditions. Therefore, implementing innovative water-saving technologies is essential. Bentonite, a natural clay mineral with high water absorption and retention

capacity, offers promising potential for reducing irrigation frequency and improving soil water balance in landscaping systems.

2. Materials and Methods

The research employed both laboratory and field experiments to analyze the effectiveness of bentonite in soil water retention. Locally sourced bentonite from Navbahor (Navoiy region) was used. Physical-chemical characterization included X-ray diffraction (XRD), thermogravimetric analysis (TGA), and scanning electron microscopy (SEM). Experimental plots were established in Namangan city, where soil moisture dynamics, irrigation frequency, and plant growth indicators were monitored over a 90-day period. Comparative analysis was conducted between conventional irrigation methods and bentonite-modified soils.

3. Results and Discussion

The experimental results revealed that bentonite significantly improved the soil's ability to retain moisture. Soils treated with 5–10% bentonite demonstrated a 35–45% reduction in irrigation water demand. The bentonite-modified plots maintained soil moisture 2–3 times longer than untreated ones, reducing irrigation frequency by up to 40%. Plant growth measurements indicated a 25% increase in biomass and chlorophyll content compared to control samples. Furthermore, the technology proved economically viable, reducing overall water consumption while maintaining or enhancing vegetation quality.

4. Additional Data and Diagrams

Table 1. Soil moisture retention dynamics in bentonite-treated and control soils.

Days after irrigation	Soil type	Average moisture content (%)	Retention improvement (%)
0	Control	22.1	-
0	Bentonite (5%)	28.4	28.6
3	Control	12.7	-
3	Bentonite (5%)	19.6	54.3
6	Control	6.3	-
6	Bentonite (5%)	11.2	77.8

Table 2. Comparison of water consumption and plant growth performance under different irrigation systems.

Irrigation method	Average water consumption (L/m²)	Irrigation frequency (per month)	Plant biomass increase (%)
Traditional surface irrigation	25.0	12	–
Drip irrigation	16.5	8	+12
Bentonite-assisted drip irrigation	13.8	6	+27

5. Conclusion

The study confirms the efficiency of bentonite as a natural, eco-friendly material for water-saving applications in urban landscaping. Its high water absorption capacity and long-term stability contribute to the sustainability of green infrastructures in arid regions. Implementing this technology could reduce irrigation water consumption by up to 40%, making it a practical solution for climate-resilient urban development. Future research will focus on optimizing bentonite mixtures with organic additives and testing under various soil types and climatic conditions.

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