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APPLICATION OF INDUSTRIAL WASTEWATER TREATED BY AQUATIC PLANTS FOR IRRIGATION

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Abstract: In the early twenty- first century, the rational and sustainable use of water resources has become a pressing issue for the rapidly developing economies of the sovereign republics of Central Asia, including Uzbekistan. Recent advances in hydrobiological research highlight the potential of aquatic plants and microalgae for wastewater treatment and resource recovery. Microscopic green algae are rich in proteins, carbohydrates, lipids, carotenoids, and vitamins, while higher aquatic plants such as *Pistia stratiotes* and duckweed species provide valuable biomass for agriculture and animal husbandry. Between 2010 and 2015, a series of laboratory and industrial experiments were conducted in Bukhara region to evaluate the cultivation of chlorococcal algae in collector–drainage waters. Results demonstrated enhanced algal productivity, increased dissolved oxygen, and significant reductions in biochemical oxygen demand, oxidizability, and concentrations of nitrogen and phosphorus compounds. Parallel studies on textile industry effluents showed that aquatic plants and algae effectively removed organic and mineral pollutants, eliminated odor, and improved water transparency. The treated water was successfully applied for seed soaking and irrigation of cotton and other crops, while the biomass proved suitable for multiple sectors. These findings confirm the ecological and economic benefits of integrating aquatic plants into wastewater treatment and resource management strategies in Uzbekistan.

Keywords: Wastewater treatment, Aquatic plants, Microalgae cultivation, Irrigation, Biomass utilization, Uzbekistan.

Introduction. At the beginning of the twenty- first century, the challenge of conserving and efficiently utilizing water resources has become increasingly urgent for the rapidly developing economies of the sovereign republics of Central Asia. Uzbekistan, in particular, faces growing demands for sustainable water management due to its expanding agricultural and industrial sectors. One promising solution lies in the repeated use of available water resources through effective purification technologies.

In recent years, hydrobiological research in Uzbekistan has advanced significantly, focusing on the application of both lower and higher aquatic plants in various branches of the national economy. Microscopic green algae are known to contain high levels of proteins, carbohydrates, lipids, carotenoids, and vitamins, while higher aquatic plants such as *Pistia stratiotes* and duckweed species provide valuable biomass with nutritional and economic potential. Numerous studies have demonstrated the feasibility of cultivating these organisms in collector–drainage waters and industrial effluents, resulting in improved water quality and the production of biologically rich biomass.

The integration of aquatic plants into wastewater treatment systems not only reduces organic and mineral pollutants but also generates resources that can be applied in agriculture, animal husbandry, aquaculture, and medicine. This dual benefit underscores the ecological and economic importance of developing biotechnological approaches to wastewater purification in Uzbekistan, offering sustainable solutions for both environmental protection and resource recovery.

Research Methodology. The study was conducted between 2010 and 2015 through a series of laboratory and industrial experiments in Bukhara region, Uzbekistan. The research design combined hydrobiological, ecological, and biotechnological approaches to evaluate the potential of aquatic plants and microalgae for wastewater purification and reuse.

- **Research Materials:** Collector–drainage waters and textile industry effluents served as the primary experimental media. These waters were characterized by high concentrations of organic matter, mineral salts, and nitrogen–phosphorus compounds.
- **Cultivation Techniques:** Chlorococcal microalgae (*Chlorella*, *Scenedesmus*) were cultivated under controlled conditions in aquaria and bioreactors. Higher aquatic plants, including *Pistia stratiotes* and duckweed species, were grown at varying densities on wastewater surfaces.
- **Experimental Procedures:** Growth dynamics, biomass productivity, and biochemical composition of algae and plants were monitored. Parameters such as dissolved oxygen, biochemical oxygen demand (BOD_5), oxidizability, and concentrations of nitrogen and phosphorus compounds were measured using standard hydrochemical methods.
- **Analytical Methods:** Comparative statistical analysis was applied to evaluate differences in productivity and water quality improvement across experimental conditions.
- **Ethical and Environmental Considerations:** All experiments adhered to ecological safety standards, ensuring minimal disturbance to natural ecosystems and compliance with national environmental regulations.

This methodological framework provided reliable data on the efficiency of aquatic plants and microalgae in reducing pollutants and generating biomass, thereby supporting their application in sustainable wastewater management and agricultural irrigation.

Results and Discussion. The experimental findings demonstrated that aquatic plants and microalgae significantly improved the quality of collector–drainage waters and textile industry effluents in Bukhara region. Cultivation of chlorococcal algae (*Chlorella*, *Scenedesmus*) in collector waters resulted in biomass productivity of 0.3–0.4 g/L dry matter, which increased to 0.6–0.7 g/L when supplemented with mineral or organic nutrients. Within 4–5 days, dissolved oxygen concentrations rose to 8.5–9.5 mg/L, while biochemical oxygen demand (BOD_5) and oxidizability decreased to 9.4–11.0 mg O_2/L. Nitrogen and phosphate compounds were efficiently assimilated by the algae, confirming their role in nutrient removal.

Parallel experiments with textile wastewater revealed similar improvements. Initially characterized by high organic loads, absence of dissolved oxygen, and unpleasant odor, the effluents showed remarkable transformation after algal and plant cultivation. Dissolved oxygen increased to 8.5–9.3 mg/L, BOD_5 decreased to 9.8–12.5 mg O_2/L, and nitrogen compounds were eliminated. The offensive odor disappeared, and water transparency improved. Cultivation of *Pistia stratiotes* further enhanced purification, achieving biomass yields of 420–435 g/m² within 6–7 days and reducing pollutant concentrations by 85–90%.

These results confirm that aquatic plants and microalgae can serve as effective biotechnological agents for wastewater treatment. Beyond purification, the resulting biomass offers economic value as a source of proteins, vitamins, and bioactive compounds for agriculture, aquaculture, and medicine. The dual benefits of water quality improvement and biomass production

highlight the ecological and socio-economic potential of integrating hydrobiological methods into sustainable resource management strategies in Uzbekistan.

Conclusion. The results of this study clearly demonstrate that aquatic plants and microalgae can serve as effective biotechnological agents for the purification of collector–drainage waters and industrial effluents in Uzbekistan. Their cultivation not only reduces concentrations of organic and mineral pollutants but also enriches water with dissolved oxygen, eliminates odor, and improves transparency. At the same time, the generated biomass represents a valuable resource rich in proteins, carbohydrates, vitamins, and bioactive compounds, suitable for applications in agriculture, aquaculture, animal husbandry, and medicine.

The dual benefits of water quality improvement and biomass production highlight the ecological and economic significance of integrating hydrobiological methods into wastewater management. By reusing treated water for irrigation and seed soaking, and by utilizing biomass across multiple sectors, this approach contributes to sustainable resource use and environmental protection. In the long term, the adoption of aquatic plant-based purification systems can enhance food security, support rural development, and strengthen the socio-economic resilience of Uzbekistan's national economy.

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