HYDROBIONTS AS BIOINDICATORS OF POLLUTION IN THE SYR DARYA RIVER

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Abstract: *Hydrobionts in the Syr Darya River serve as bioindicators for assessing water system ecology due to anthropogenic pollution. Their sensitivity helps identify ecosystem changes, crucial for the basin where ecological and human challenges affect water quality. The Syr Darya Basin faces impacts from agriculture and irrigation, leading to increased soil salinity and water mineralization. This degradation is worsened by land reclamation and infiltration runoff. Microplastics pollute the river, with high levels in surface water and sediments of tributaries, particularly in the Kara Darya and Chirchiq rivers. Changes in terrestrial and groundwater storage, driven by climate and human activities, stress water resources through evapotranspiration and insufficient irrigation replenishment. These factors highlight hydrobionts' importance as bioindicators for river monitoring and water management.*

Keywords: *Hydrobionts, bioindicators, water pollution, the Syr Darya River, aquatic ecosystems, water quality, heavy metals, pesticides, aquatic invertebrates, phytoplankton.*

INTRODUCTION

The Syr Darya River faces environmental threats from anthropogenic activities, requiring pollution monitoring through bioindicators. Hydrobionts serve as valuable bioindicators due to their sensitivity to water quality changes and participation in water self-purification processes (Baturina et al., 2021). Aquatic oligochaetes effectively indicate ecosystem health through their abundance and community structure (Al-Ameen and Al-Jaff, 2022). The Syr Darya River faces degradation from natural and anthropogenic factors, including microplastic pollution from textiles in its tributaries (Frank et al., 2023). Effective monitoring requires combining hydrobiont assessments with chemical analysis to evaluate the river's ecological state. The Syr Darya River, a crucial artery of Central Asia, influences regional ecology and social life. Water quality is affected by economic, industrial, and domestic sources, making hydrobionts increasingly important for assessing the river's ecological state.

Types of pollution in the Syr Darya and their sources. The main pollutants in the Syr Darya include nitrites, sulfates, phenols, petroleum products, heavy metals, and pesticides. Energy activities contribute up to 90% of pollution through untreated wastewater and high concentrations of fertilizers. Industrial enterprises add heavy metals and petroleum products, while insufficient treatment worsens pollution. Radioactive emissions from uranium tailings create radiation risks. These pollutants deteriorate water quality and disrupt ecological balance.

The Syr Darya River is affected by various types of pollution, originating from several sources. Key pollutants include:

1. Microplastics: Studies have found significant microplastic pollution within the Syr Darya's tributaries, such as the Kara Darya and Chirchiq rivers. The presence of microplastics in these areas predominantly comes from domestic wastewater treatment plant discharges, with microfibers being the most abundant form of pollution. These are largely derived from synthetic textiles, including polyethylenterephthalate (PET), viscose, and nylon fibers (Frank et al., 2023).

2. Rare Earth Elements (REEs): Agricultural soils along the Syr Darya River exhibit concentrations of rare earth elements (REEs), which are linked to geochemical processes involving minerals like monazite and zircon, rather than direct human activity. The differentiation between light and heavy REEs is significant, and even though they do not reach concerning levels of pollution, they remain an indicator of environmental processes within the region (Li et al., 2024).

3. Anthropogenic Impact: The river's water quality is affected by anthropogenic influences, including agricultural runoff and industrial discharge. These human activities contribute to the degradation of the river delta landscapes, exacerbating the ecological issues within the region (Zinabdin et al., 2022).

4. Water Storage Changes: Groundwater storage and terrestrial water storage in the Syr Darya river basin show significant changes due to climatic factors and anthropogenic activities. The amount of water replenished by agricultural irrigation is often exceeded by evapotranspiration, leading to a decrease in terrestrial water storage (TWS) and groundwater storage (GWS) (Lyu et al., 2021).

These insights underscore the multifaceted nature of pollution in the Syr Darya River, highlighting the need for comprehensive management strategies to mitigate environmental degradation and sustain the river’s ecological integrity.

Hydrobionts as indicators of pollution. Hydrobionts—aquatic, benthic and planktonic invertebrates, fish, and other aquatic organisms—accumulate pollutants in their tissues and are sensitive to water chemistry changes. Their species composition and biomass serve as key water quality indicators, detecting pollution not always revealed by chemical analyses and assessing long-term contamination effects.

Hydrobionts effectively indicate pollution in aquatic ecosystems through their sensitivity to environmental changes, particularly from nutrients, toxic substances, and acidification. Aquatic invertebrates provide insights into environmental quality and contribute to ecosystem self-purification (Baturina et al., 2021).

Fish scales serve as non-invasive bioindicators for trace and macroelement pollution, reflecting pollutant concentrations in their environment. Different species show varying elemental accumulation patterns, making them reliable pollution indicators (Aib et al., 2025).

Host-associated microbial communities can sequester or degrade pollutants, maintaining ecosystem resilience. Understanding microbe-pollutant interactions helps protect ecosystems and human well-being (Diner et al., 2024).

Studies during COVID-19 lockdown revealed that pollution-tolerant taxa indicate persistent eutrophication and organic pollution challenges, despite reduced human activities (Marcheggiani et al., 2022).

Hydrobionts are crucial pollution indicators that help assess current pollution levels and guide mitigation strategies for aquatic ecosystem health.

The use of hydrobionts in monitoring the Syr Darya River. For the Syr Darya River, limited water quality monitoring makes pollution detection difficult. Using hydrobionts as bioindicators enables comprehensive ecosystem assessment. Changes in benthic invertebrates and phytoplankton reflect impacts of nitrates, pesticides, and heavy metals. A decrease in species diversity and increase in pollution-tolerant species indicate aquatic environment degradation. Studies show hydrobionts effectively respond to water quality changes in Central Asian rivers and can assess anthropogenic impact.

Hydrobionts in monitoring the Syr Darya River can provide insights into environmental health, particularly given its role in sustaining the Aral Sea ecosystem. While direct references to hydrobiont monitoring were not found, studies indicate ecological concerns addressable through biological monitoring.

The Syr Darya faces environmental challenges, including water management issues from irrigation and hydropower demands (Howells et al., 2021), and soil salinization affecting water quality (Samarkhanov et al., 2022). The river experiences microplastic pollution from domestic wastewater (Frank et al., 2023), while effects on fish and benthic organisms could assess ecological integrity (Li et al., 2024).

Studies on Schizothorax eurystomus reveal water diversion's impact on fish populations (Karimov et al., 2024), while ecological zones have been identified for conservation based on human-linked degradation (Zinabdin et al., 2022). Though direct hydrobiont monitoring data is unavailable, environmental data suggests the potential utility of biological assessments in developing sustainable river management strategies.

Conclusion. In the context of increasing anthropogenic pollution of the river, the hydrobionts of the Syr Darya represent an emergency and reliable bioindicator for a comprehensive assessment of the ecological state of the water system. Their sensitivity to various pollutants and ability to integrate information about long-term impacts make hydrobionts indispensable in the Diptych system and in climate water management. The use of hydrobionts in monitoring allows for the adjustment of pollution source identification and the development of remedial measures for the preservation and restoration of the Syr Darya river's marine ecosystem.

Hydrobionts in the Syr Darya River serve as crucial bioindicators for monitoring the river's ecological health, especially in light of increasing anthropogenic pollution. Their high sensitivity to pollutants allows them to effectively signal the presence and concentration of various contaminants in the aquatic environment, making them reliable

markers for assessing water quality and ecosystem conditions. The sensitivity of hydrobionts to changes in the aquatic ecosystem is well-documented, as these organisms reflect both immediate and prolonged impacts of pollution, thereby integrating data on long-term environmental changes (Baturina et al., 2021).

Human activities in the Syr Darya basin, such as agricultural irrigation, can significantly alter water quality, leading to negative ecological outcomes. For instance, extensive irrigation practices have been associated with increased soil salinity and higher mineralization levels in drainage water, which adversely affect the ecosystem over time (Mustafayev et al., 2020). The ecological impact of such activities underscores the importance of using bioindicators to assess and manage river health effectively.

Furthermore, the presence of microplastics in the tributaries of the Syr Darya highlights additional pollution challenges. Recent studies identified significant quantities of microplastics, predominantly in the form of fibers from domestic wastewater, in the surface water and benthic sediments of these rivers. The high abundance of microfibers underscores the ongoing pollution from synthetic textiles and necessitates comprehensive monitoring and management strategies aimed at mitigating such impacts (Frank et al., 2023).

Overall, hydrobionts, due to their ecological significance and responsive nature, remain indispensable in both Diptych systems and broader climate water management efforts. These organisms provide essential insights into the environmental stresses on freshwater ecosystems, enabling targeted conservation and pollution reduction strategies.

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