THE IMPACT OF COLLECTOR-DRAINAGE WATERS ON WATER QUALITY AND BIOTA OF LAKES IN THE SOUTHERN ARAL SEA REGION

R. Khojamuratova
Doctor of Geographical Sciences
Berdakh Karakalpak State University
K. Kalenderova
basic doctoral student of Berdakh Karakalpak State University
e-mail: qumarqalenderova@gmail.com

Abstract: *In the context of an arid climate and scarcity of freshwater resources, the issues of secondary use of collector-drainage waters (CDW) and their impact on aquatic ecosystems are of particular importance. This article analyzes the effects of CDW on the hydrochemical state and biota of lakes in the Southern Aral Sea region. Based on literature sources and field observations, characteristic changes in water quality, biodiversity, and the stability of lake ecosystems have been identified. Proposals for the rational management of CDW have been put forward to mitigate environmental consequences.*

Keywords: *collector-drainage waters, lakes, Southern Aral Sea region, water quality, hydroecology, biota, eutrophication*

Introduction The South Aral Sea region ranks among the most environmentally vulnerable territories in Central Asia. Profound transformations of the natural environment, caused by the dramatic shrinkage of the Aral Sea, coupled with the rapid development of irrigated agriculture in the 20th century, have led to significant changes in the region's hydrological and ecological balance. One of the key anthropogenic factors affecting the state of water bodies has been the intensive use of water for agricultural needs and the subsequent discharge of collector-drainage waters (CDW) into natural depressions and lakes.

Collector-drainage waters constitute a complex mixture containing residues of fertilizers, pesticides, salt ions (sodium, chlorine, sulfates, etc.), organic matter, and biogenic elements (nitrogen, phosphorus). When these waters accumulate in closed or poorly-flowing lakes, they significantly impact the hydrochemical composition of the water, biological diversity, and the structure of biocenoses. In some cases, they also affect the potential for using these lakes for economic or ecological purposes.

These processes are particularly pronounced in the Amu Darya delta, where numerous small lakes (Sudoche, Zhyltyrbas, Mashankol, etc.) have been exposed to direct or indirect influence of collector-drainage waters. Changes in the water-salt regime, intensification of eutrophication processes, development of

hypoxia, and pollution of biota with heavy metals and nutrients are becoming a serious threat to the region's ecological stability. In some cases, lakes become new centers of biodiversity (with controlled water exchange), while in others, they lose the ability to sustain even resilient species.

Modern hydroecology requires a comprehensive approach to studying such systems, taking into account not only physicochemical indicators but also the biological responses of aquatic organisms to pollution. In this context, monitoring biocenoses (zooplankton, macrophytes, benthos) plays a key role in assessing the ecological status of a water body.

The aim of this study is to evaluate the impact of collector-drainage waters on water quality and biological components of lakes in the Southern Aral Sea region. The article examines changes in hydrochemical parameters, biodiversity, and ecosystem stability at various levels of anthropogenic influence, proposing ways to minimize environmental damage.

Materials and Methods The object of the study is the lakes of the Southern Aral Sea region, including Sudochye, Zhyltyrbas, Mashankol, and a number of unnamed depressions filled with collector-drainage waters. The research involved a review of scientific publications and hydrometeorological service reports, as well as an analysis of archival and field data on hydrochemical and biological indicators.

The following parameters were studied; Physicochemical: temperature, pH, electrical conductivity, mineralization, ion concentrations (Na^+, Cl^-, SO_4^{2-}, HCO_3^-), nutrients (nitrates, phosphates), biochemical oxygen demand (BOD); Biological: species composition and abundance of phytoplankton, zooplankton, benthos, and aquatic vegetation.

The main findings of the conducted analysis demonstrate that collector-drainage waters (CDW) flowing into the lakes of the Southern Aral Sea region exert a significant influence on their hydrochemical conditions, as well as on the structure and abundance of aquatic biota. Several characteristic water bodies of the region were studied, including Lakes Sudochye, Zhyltyrbas, and Mashankol, which are subject to varying levels of anthropogenic pressure.

The influx of collector-drainage water (CDW) into lakes leads to a significant change in their water-salt balance. Increased mineralization (up to 8-12 g/l) contributes to changes in biota structure: the number of freshwater species decreases, while the proportion of eurythermal and salt-tolerant organisms increases. In zooplankton, the dominance of rotifers and salt-tolerant cladocerans is observed. Among macrophytes, algae and plants resistant to high concentrations of salts and nutrients predominate. Signs of eutrophication are manifested in water blooms, hypoxia, and the deterioration of lakes' self-purification capacity. The state of biocenoses indicates the stressful impact of CDW on lake ecosystems. Shallow lakes without outflow are especially vulnerable. However, with moderate CDW

inflow, cases of ecosystem adaptation and the formation of stable communities are possible.

Hydrochemical state of the lakes: Analysis of water samples revealed high mineralization in all studied lakes, which is attributed to the constant inflow of weakly diluted collector-drainage waters (CDW), rich in salts and agrochemical residues. Average mineralization values range from 6.3 to 11.2 g/l, exceeding the maximum permissible concentrations (MPC) for fishery waters by 6-10 times. Particularly high values are observed in Mashankol, located in the lowest-lying part of the region, where wastewater accumulates without natural water exchange.

Indicators of ionic composition (Na+, Cl−, SO42−) also point to significant salinization. Elevated concentrations of nitrates (up to 15.3 mg/L) and phosphates (up to 0.62 mg/L) serve as evidence of the influx of nutrients causing secondary eutrophication. Increased values of biochemical oxygen demand (BOD5) indicate a rise in organic pollution and intensification of organic matter decomposition processes (Table 1).

Table 1

Physicochemical parameters of water in the lakes of the Southern Aral Sea region (seasonal average values)

Indicator	Sudochye	Zhyltyrbas	Mashankol	MPC (fishery)
Temperature (°C)	24.3	22.7	25.1	-
Mineralization (g/l)	9.5	6.3	11.2	up to 1.0
Na+ (mg/l)	1300	980	1450	200
Cl− (mg/l)	2200	1800	2650	300
NO3− (mg/l)	12.5	8.9	15.3	9.0
PO43− (mg/l)	0.45	0.38	0.62	0.3
BOD5 (mg/l)	7.1	6.5	8.4	up to 3.0

The state of zooplankton and macrophyte biota- Against the background of changes in chemical composition, shifts are observed in the structure of aquatic biota. Zooplankton is represented mainly by salt-tolerant species: rotifers (Brachionus spp.), copepods and cladocerans (Arctodiaptomus spp., Moina salina) predominate. The total species diversity is low (6-12 species per

water body), with density ranging from 230 to 650 specimens/l. The poorest fauna is observed in Mashankol, where mineralization is highest.

Macrophytic vegetation is also undergoing transformation: salt-tolerant species predominate, such as fennel-leaved pondweed (Potamogeton pectinatus) and hornwort (Ceratophyllum demersum), while in some lakes, algal mats and filamentous algae characteristic of hypertrophic water bodies develop (Table 2).

Eutrophication processes and ecological stability - Observation results indicate signs of pronounced eutrophication in Lakes Sudochye and Mashankol: algal blooms are observed, along with a sharp decrease in water transparency (down to 0.4-0.6 m), morning fluctuations in oxygen content (below 5 mg/l), as well as sharp changes in pH (up to 8.5-9.0). This confirms the stressed state of the ecosystems and the reduced self-purification capacity of these water bodies.

Table 2

Species diversity of zooplankton

(number of species and density, specimens/L)

Lake	Number of species	Dominant groups	Density (individuals/L)
Sudochye	12	Rotifers, copepods	650
Zhyltyrbas	8	Crustaceans, cladocerans	410
Mashankol	6	Rotifers, halotolerant species	230

In contrast, lakes with moderate CDW inflow (such as Zhyltyrbas) exhibit more stable parameters: higher transparency, slightly greater zooplankton diversity, and weakly expressed eutrophication. This may indicate the potential for lake ecosystems to adapt to controlled CDW inflow when partial water exchange or dilution is present.

Table 3

Assessment of the degree of lake eutrophication

Lake	Algal bloom	Transparency (m)	Oxygen in the morning (mg/l)	Eutrophication
Sudochye	yes	0.6	5.2	high
Zhyltyrbas	moderate	1.2	6.8	medium

Mashankol	intensive	0.4	4.5	high

Seasonal changes also play a role in the concentration of pollutants and biota activity. In summer, peak temperatures and accelerated organic decomposition processes are observed, contributing to increased eutrophication. Lakes situated in depressions without natural outflow are more susceptible to the accumulation of pollutants and, as a result, to a sharp deterioration of their ecological condition.

Thus, the following trends can be identified:

• the higher the mineralization and concentration of nutrients, the poorer and more uniform the biota;

• water bodies with partial water exchange (natural or artificial) better maintain ecological balance;

• Collector-drainage waters (CDW) can be utilized provided they undergo preliminary filtration or biological treatment, for example, using aquatic plants. The obtained results align with the conclusions of previous studies conducted in the Aral Sea region and comparable territories (Sarykamysh, Tuyamuyun, Aralkum), and underscore the necessity of implementing comprehensive systems for monitoring and regulating the quality of discharged drainage waters.

Conclusions: Collector-drainage waters are a crucial factor influencing the water quality and the condition of biota in the lakes of the Southern Aral Sea region.

The impact of collector-drainage waters leads to increased mineralization and eutrophication, disrupting the ecological balance of these water bodies.

For sustainable management of lake ecosystems, constant monitoring, implementation of biofiltration technologies, and restricting the discharge of highly polluted waters are necessary.

In the long term, systems for the reuse of CDW in agriculture should be developed, with minimal impact on natural water bodies.

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