



PARADOX OF BRACKISH WATERS ON THE EXAMPLE OF THE AIDAR-ARNASAY LAKE SYSTEM

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Abstract

This article examines the dynamics of the hydrochemical regime of the Aydar-Arnasay Lake System (AALS) from its formation in 1969 to the present. It describes changes in water level, mineralization, and salt balance in Lakes Aydar and Tuzkan under the influence of emergency discharges, collector-drainage water, and groundwater flows. Particular attention is paid to the phenomenon of "minimum species" in brackish-water ecosystems, as well as an analysis of the current state of fauna and flora. Based on field studies conducted in 2024, data on water salinity at various points in the AALS are presented. It is concluded that future biodiversity directly depends on further salinity dynamics: if the range of 5–8‰ is maintained, the composition of inhabitants will remain stable, but with increasing salinity, an increase in species diversity is possible.

Keywords: Aydar-Arnasai lake system, mineralization, salinity, hydrochemical regime, brackish water paradox, biodiversity, euryhaline forms, succession.

Introduction

The formation of the Aydar-Arnasay Lake System (AALS) was one of the unique natural and anthropogenic phenomena of Central Asia. In 1969, as a result of emergency water discharges from the Chardara Reservoir, the water level in Lakes Aydar and Tuzkan rose significantly, causing fundamental changes in the region's hydrological and hydrochemical regimes. Water salinity, initially



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ranging from 750–900 mg/L, reached 8–12 g/L by the late 1970s due to the influx of highly mineralized groundwater and the dissolution of salt marshes.

Researchers' predictions in the 1970s predicted a gradual aging and degradation of the lake system—shallowing, overgrowing vegetation, and swamping. However, actual processes followed a different scenario: in the 1990s, freshwater discharges again altered the balance, reducing mineralization by almost half. Subsequently, especially after the construction of the dam near the Golden Bridge, freshwater supply ceased, causing a resurgence of salinity.

The Arnasai Lakes are a dynamic ecosystem, where changes in salinity directly impact biodiversity. Of particular interest is the "brackish water paradox," where minimal species diversity is observed in the salinity range of 5–8‰. Analysis of this phenomenon and its impact on the modern ecosystem of the Arnasai Lakes is the focus of this study.

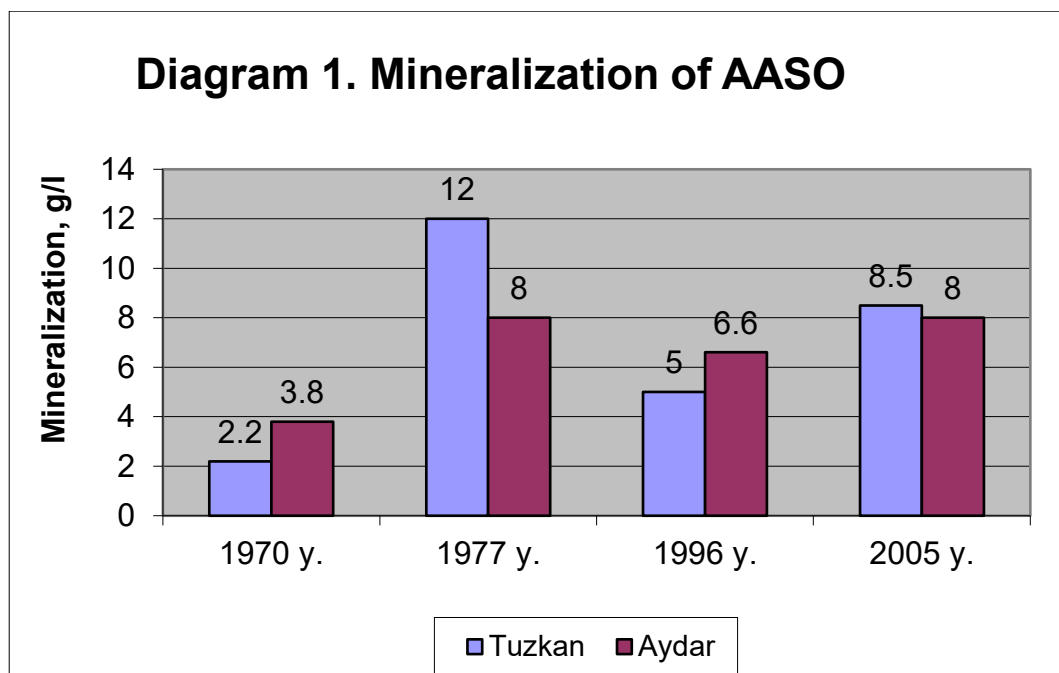
When the Arnasai Lake Complex formed as a single system in 1969 following emergency discharges from the Chardara River, the water level in Lake Aydar rose by 25 meters, and in Lake Tuzkan by 7 meters. Initially, discharges from the reservoir were the primary factor in shaping the lakes' water and hydrochemical regimes and their salt balance. Water mineralization in 1969 ranged from 750 to 900 mg/L. Salinity then began to increase, reaching 8 g/L in Aydar and 12 g/L in Tuzkan by 1977. This was due to the influx of salts from collector-drainage and highly mineralized groundwater (especially from the Nurata Range, where up to 10 g/L was added). About half of the salt reserves came from the dissolution of the salt marsh crust after the basin filled. Given that the lakes are endorheic, salt accumulation has begun. About 98% of the total salt reserves are concentrated in Aydar and Tuzkan.

According to forecasts made in the early 1970s, the lakes' water balance was expected to stabilize by 1985. Subsequently, the Arnasai Lakes would undergo a process of aging: as a result of the continuous accumulation of biogenic sediments, intensified by the sedimentation of suspended matter carried by rivers and collectors, the lakes would become richer, gradually



becoming shallower, overgrown with vegetation, becoming swampy, and disappearing.

The actual picture of lake succession differs greatly from the diagram presented. In the case of the AASO, this occurred due to changing hydrological factors—large volumes of freshwater were once again discharged into it in the 1990s. Salinity dropped almost 50%, then began to gradually increase again due to the dissolution of newly flooded salt marshes. Initially, it remained within the range of 6 to 8.5 g/L, or from 5 to 70/00 (see Diagram 1). However, after the 2000s, when another dam was built near the Golden Bridge, the influx of freshwater into the lakes virtually ceased. More precisely, Eastern Arnasai still remains freshwater, the salinity of the water in Tuzkan increased to 8.5 g/L, and the salinity of the water in Aidar Lake, the last lake in this system, is even higher. No actual data is available due to a lack of research.



(Fig. 1) Several recent trips to these lakes were conducted in 2024, but this time too it was not possible to organize research on Aidar Island



Figure 1. Sampling points on Arnasai and Tuzkan islands, August 2024.

The results of the analyses to determine water salinity are presented in the table.

Table 1. Data on water mineralization in lakes

No.	Sampling point	Salinity, g/l	Dry residue, mg/l
1	Tuzkan, 3rd post, channel near environmental inspections 40.0884 – 67.11 10	3.92	4.78
2	Tuzkana Center 40.04701 – 64.4035	6.43	7.85
3	Conjunction of Arnasai, Tuzkan, Aidar 40.0860 – 67.39093	6.60	8.05
4	Arnasai, shore, depth 0.5-0.7 m	0.7	0.85
5.	Golden Bridge 40.0379 – 67.6061	3.41	4.1
6	Tuzkan 40. 591925 – 67. 01420	6.86	8.3711



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The narrow salinity range of 5–8°C is considered the interface between two main types of aquatic fauna—marine and freshwater. Because the number of typically marine species declines sharply at salinities below this range, while freshwater species decline at salinities above this range, and because the brackish-water flora and fauna that thrive in these optimal salinities are numerically small, the overall number of species in this range is minimal. This phenomenon, noted by Remane, is known as the "species minimum" (Artenminimum) or the "brackish water paradox." There are no endemic families or orders among brackish water inhabitants, while typically marine and freshwater bodies even have endemic classes and phyla. V. L. Pauli (1954) believes that the cause of the "brackish water paradox" lies in the geological ephemeral nature of brackish water basins, which have a shorter lifespan than freshwater and marine basins. This results in insufficient time for the formation of mesohalobiotic species.

The aquatic population of the Aydar-Arnasai lake system consists of euryhaline forms (e.g., *Chaetoceros wighamii* from the Bacillariophyta), some freshwater forms (*Lagerheimia genevensis* from the Chlorophyta), and a small number of specifically brackish-water forms (*Chaetoceros muelleri*). If the Arnasai lakes remain within this salinity range during their development, the species composition of their inhabitants will remain virtually unchanged. However, a significant shift in one direction or another—and in our case, an increase in salinity is more likely—will lead to a qualitative leap in species composition. The idea that increased mineralization typically leads to a decrease in species diversity is not entirely correct. An increase in salinity from 5–80/00 in the AASO to marine levels will stimulate an increase in species abundance.

Conclusion

Observations and analyses have shown that the aquatic population of the Aydar-Arnasai lake system is formed by a combination of euryhaline forms, individual freshwater species, and specific brackish-water flora and fauna. Data from recent



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expeditions indicate that, with a salinity range of 5–8‰, biodiversity will remain relatively stable. However, further increases in mineralization could lead to an expansion of species composition, which contradicts the traditional view of a direct correlation between salinity and biodiversity decline.

Thus, the AASO represents a living laboratory for studying the succession of aquatic ecosystems, where changes in salinity are a key factor determining the structure of biocenoses. Future research should focus on monitoring hydrochemical processes and identifying long-term trends that will determine the ecological sustainability of the lake complex.

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