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**The role of the chemical composition of atmospheric precipitation in mineralization of lake waters (on the example of monitoring lakes in Kazakhstan)**

**8D05203 - Hydrology**

**Annotation of the dissertation for obtaining the scientific degree of Doctor of Philosophy (PhD).**

Surface waters of the Republic of Kazakhstan include water resources in the lower forms of relief of inland water bodies. These include: seas, lakes, swamps, glaciers, reservoirs, rivers and adjacent canals. Renewable water resources include fresh water, which is renewed several times throughout the year through the hydrological cycle. An integral characteristic of renewable water resources is river flow with its underground component. The water problem should be considered from two points of view: from the point of view of the quantity of water resources and their quality, and these categories are equivalent.

In recent years, activities in the field of hydrochemistry have grown significantly throughout the world. The role of the chemical composition of lake waters in the territories under consideration has a negative impact on agriculture, biophysical systems and various structures associated with human activities. The volume of natural pollutants is not equal to the volume of man-made substances. The current state of lakes is an integral result of the influence of natural and man-made factors.

**Relevance of the dissertation:** All surface waters, i.e. waters located in various reservoirs on the surface of the earth (rivers, lakes, reservoirs, etc.), form their initial chemical composition while in the atmosphere. In addition, dissolved salts in atmospheric waters may be very important for the surface waters of some geographic areas, while for others their effect is negligible due to their relatively low levels. The greatest influence of the chemical composition of atmospheric waters is observed in the northern regions, where the composition of some substances in surface waters can be determined by their amount in atmospheric waters. This effect loses its significance as one moves south, since the salinity of surface waters increases significantly in this direction. This provision determines the great importance of studying the chemical composition of atmospheric waters for hydrochemistry. Atmospheric water may contain various pollutants such as heavy metals, organic compounds, pesticides and other chemical compounds that are released into the atmosphere from various sources including industry, transport and agriculture. In this regard, studying the chemical composition of atmospheric precipitation makes it possible to assess the level of environmental pollution, in particular surface waters, and assess its impact on human health and the ecosystem. This will enable future action to restore and protect vulnerable water resources.

**The practical value of a dissertation** is determined by the ability to use research results to develop recommendations on a given topic.

**Purpose of the work:** to determine the role of the chemical composition of atmospheric precipitation in the mineralization of lake waters.

**Object of study:** monitoring lakes in Kazakhstan.

**The subject of the study** is the state of the lake's water quality to assess the efficiency of water resource use.

**Research methods:** methods of foreign and Kazakh scientists studying the problems of assessing the quality of natural waters to solve problems, including fundamental work in the field of water hydrochemistry O. A. Alekin, A. M. Nikanorov, B. A. Beremzhanov, S. P Kitaev, N. A. Amirgaliev, M. J. Burlibaev, S. M. Romanova, etc. was used.

**Theoretical and practical significance of the study:** in the modern period of development of Kazakhstan, there is a trend of growth in industry and energy, production of non-ferrous and ferrous metals, especially coal consumption. At the same time, there was also an increase in emissions of pollutants into the atmosphere, and the volume of emissions increased several times compared to the level of the 1950s. This leads to severe pollution of the atmosphere and surface waters.

Currently, the quality of natural waters in most watersheds is influenced by natural and anthropogenic factors. Industrial, domestic, agricultural and other wastewater discharged into water bodies worsens the quality of water and makes serious changes in its regime. In recent years, another source of pollution of river and lake waters has appeared - atmospheric precipitation. This source of pollutants entering rivers and lakes is not controlled and is very difficult to account for. However, assessment of its impact is necessary in the analysis, forecasting and regulation of surface water quality. In this regard, assessing the influence of atmospheric precipitation on the chemical composition of lake waters is relevant and important from the point of view of the national economy.

**Scientific novelty of the work:**

A forecast was made in connection with changes in the amount of precipitation;

The contribution of sediment mineralization to the mineralization of lake waters was assessed;

It has been established that the amount of mineralization decreases due to evaporation.

**First protected position:**

Modeling of changes in atmospheric precipitation and its extreme indicators in the area of monitoring lakes was carried out on the basis of the Canadian climate model CanESM5 using scenarios ssp1-2.6 and ssp2-4.5 for the period 2050-2074. compared to the period 2025-2049. .

The purpose of this modeling is to assess possible changes in precipitation and its extreme indicators in the monitoring lakes of Kazakhstan in a new time period. The model provides new data that can be used to assess the impact of changes in precipitation on the health of lakes and their ecosystems, and to identify potential risks associated with climate change and water use in lakes.

### **Second protected position:**

The contribution of the chemical composition of atmospheric precipitation to the mineralization of lake waters was assessed. The share of atmospheric mineralization in the mineralization of the studied lakes is 0.3...23.6%. The contribution of sediment mineralization to lake waters depends on the concentration of industrial enterprises in the lake. The contribution of precipitation mineralization is higher in areas of lakes where there are industrial enterprises.

### **Third protected position:**

The values of the coefficient of change in the concentration of substances in sediments associated with the chemical composition of sediments and their influence on the composition of lake waters were calculated using the ERA5-Land model. It has been established that chemical elements entering the waters of the lake with precipitation are subject to evaporation in different quantities, as a result, the amount of mineralization falling with precipitation in all lakes has decreased by 3...44 times.

**As a result of the dissertation work, the following conclusions were obtained:**

- During the period 1941-2020, there was an increase in the average annual air temperature on the territory of water bodies of Kazakhstan from 0.21 °C/10 years (Nura-Sarysu basin) to 0.42 °C/10 years (Zhaiyk-Caspian basin);
- In winter, a statistically significant increase was observed only in the Zhaiyk-Caspian basin 0.48 °C/10 years;
- In spring, the most intense warming is observed in all water bodies of Kazakhstan from 0.60 °C/10 years to 0.66 °C/10 years. All spring trends are statistically significant. The contribution of the trend to the total dispersion is 20-33%;
- Statistically significant positive trends from 0.16 °C/10 to 0.45 °C/10 were observed in the summer in the Shu-Talas, Balkhash-Alakol, Zhaiyk-Caspian basins;
- Positive dynamics of air temperature in autumn is observed in all water bodies, a statistically significant growth rate from 0.11 °C/10 years to 0.41 °C/10 years (Esil, Zhaiyk-Caspian basins);
- Annual precipitation in the Yesil and Nura-Sarysu basins increased by 3.6 and 3%/10 years and was statistically significant;
- In the Balkhash-Alakol and Yesil basins there is a tendency to increase in winter by 5.5...6.9%/10 years;
- In the spring, in the inter-basin area: in the Zhaiyk-Caspian and Yesil basins there is a statistically significant increase in precipitation - 7.9...8.9%/10 years;
- A statistically significant positive trend in summer precipitation was 7.3%/10 years in the Nura-Sarysu basin;
- A statistically significant trend of decreasing atmospheric precipitation was observed in autumn only in the Zhaiyk-Caspian basin - 4.9%/10 years (share of the trend in the total variance - 6%);
- Statistically significant increase in precipitation by 40-50% in 2050-2074, compared to the period 2025-2049 with a radiation effect of 2.6 W/m<sup>2</sup> in the area of Lake Shalkar (Aktobe region) precipitation in April and May. In winter, only in January, a significant decrease in precipitation by 10-20% is observed in lakes

Balkhash, Alakol and Sasykkol. Summer rainfall is expected to be within normal limits across much of the area. In autumn, a statistically significant decrease in the amount of precipitation by 30-50% is observed in Lake Shalkar (Aktobe region);

- 2050-2074 According to the radiation load scenario of 4.5 W/m<sup>2</sup>, an increase in precipitation is expected in April in the areas of lakes in the Yesil and Balkhash-Alakol basins. In August, the amount of precipitation in the area of lakes located in the Balkhash-Alakol basin is likely to decrease by 40-50%. Precipitation is expected to be normal in most of the republic during the winter months;

- During the research, it was established that the concentration of ions in precipitation was transferred from Balkhash to Aul 4. Also in the annual bulletin issued by the RSE Kazhydromet, the highest level of precipitation pollution was noted in MS Aul 4 for several years in a row;

- According to the state standard of the Republic of Kazakhstan, only the waters of the following lakes are suitable for centralized water supply: Burabay, Koshkarkol, Markakol, Sasykkol, Shalkar (Aktobe region);

- Lakes Markakol, Burabay, Koshkarkol, Shalkar (Aktobe) can be used as drinking water depending on the degree of mineralization;

- Copper in all lakes exceeded the MPC for fishery purposes;

- According to H. Stebler's criteria, the waters of lakes Markakol, Burabay, Bilikol, and Elken Shabakty are suitable for irrigation;

- The level of probability of soil salinization (ie sodium absorption coefficient) is estimated to be very high in Alakol, eastern and western parts of Balkhash, Kishi Shabakti, Kokai and Lake. Shalkar (WKO);

- The probability of salinization or salinization in Lakes Markakol and Burabay is low, and in Bilikol is average;

- The work established that the chemical composition of sediments has a contribution to the state of lake waters.

- Taking into account the evaporation coefficient according to the results of the GLEAM v3.6b model, it was determined that the concentration of substances falling with precipitation decreased by 5 times in Balkhash, by 1.7 times in Alakol. Taking into account the coefficient of precipitation and evaporation according to the ERA5-Land model, the chemical components falling with precipitation in all lakes decreased by 3.6...11.1 times. This is explained by the fact that part of the concentrations entering the lakes along with precipitation decreased due to evaporation.