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HYDROCHEMICAL STUDIES OF SALT LAKES IN THE NORTHERN PART OF THE CASPIAN LOWLAND

The article presents a hydrochemical analysis and heavy metal content of salt lakes of Atyrau region on the example of salt lakes Inder, Karabatan and lake near Kh.Dospanova International Airport. Analysis of heavy metals shows that the content of chromium, manganese, cobalt, nickel, copper, lead, zinc and cadmium does not exceed the maximum permissible concentrations. The analysis of cations in all salt lakes shows data that are identical in all three lakes and the lowest values are typical for potassium and sodium ions, whose contents are about 3 mg/l and 9 mg/l, respectively. The content of calcium and magnesium cations exceeds hundreds and thousands of mg/l. The content of calcium ions in the lake near the airport is almost twice as high as in other lakes and amounts to 1059 mg/l. The magnesium ion content is minimal for Lake Karabatan and amounts to 801 mg/l, whereas in the other two salt lakes it exceeds 1.5 times. For anions, the lowest values are typical for hydrocarbonates and are in the range of 200-300 mg/l. The indicators for sulfates and chlorides are very diverse, as for sulfates they vary from 500 mg/l in the lake near the airport to almost 8000 mg/l in Lake Karabatan. The maximum values are typical for chlorides, while their contents are also diverse in all lakes and range from more than 4,000 mg/l to more than 63,000 mg/l. At the same time, the following ratios of HCO_3:SO_4:Cl anions are noted – in Lake Inder 1:4:32; in Lake Karabatan 1:39:316; and in the lake near Kh.Dospanova International Airport 1:1.8:14.8. Thus, salts of magnesium and calcium chlorides, magnesium and calcium sulfates are formed in all lakes, and the salt contents of sodium and potassium bicarbonates are the most minimal.

Key words: salt lake, Atyrau region, hydrochemical analysis, heavy metals, cations, anions.

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Каспий маңы ойпатының солтүстік бөлігіндегі тұзды көлдерді гидрохимиялық зерттеу

Мақалада Индер, Қарабатан және Х.Доспанов атындағы Халықаралық әуежай маңындағы тұзды көлдердің мысалында Атырау облысының тұзды көлдерінің ауыр металдарына талдау және гидрохимиялық сараптау жүргізілді. Ауыр металдарды талдау хром, марганец, кобальт, никель, мыс, қорғасын, мырыш және кадмийдің мөлшері рұқсат етілген шекті мөлшерден аспайтынын көрсетеді. Барлық тұзды көлдердегі катиондарды талдау барлық үш көлде бірдей деректерді көрсетеді және ең төменгі мәндер калий мен натрий иондарына тән, олардың мөлшері сәйкесінше шамамен 3 мг/л және 9 мг/л құрайды. Кальций мен магний катиондарының мөлшері жүздеген және мыңдаған мг/л-ден асады. Әуежай маңындағы көлдегі кальций иондарының мөлшері басқа көлдердегі мөлшерден екі есе дерлік және 1059 мг/л құрайды. Қарабатан көлі үшін магний иондарының мөлшері минималды және 801 мг/л құрайды, ал қалған екі тұзды көлде 1,5 есе көп. Аниондар бойынша ең төменгі мәндер гидрокарбонаттарға тән және 200-300 мг/л аралығында болады. Сульфаттар мен хлоридтер бойынша көрсеткіштер өте алуан түрлі, сондықтан сульфаттар бойынша олар Әуежай маңындағы көлде 500 мг/л-ден Қарабатан көлінде 8000 мг/л-ге дейін өзгереді. Максималды мәндер хлоридтерге тән, олардың құрамы барлық көлдерде де әр түрлі және 4000 мг/л – ден 63000 мг/л – ге дейін өзгереді. Бұл жағдайда аниондарының келесі қатынасы атап өтіледі HCO_3:SO_4:Cl-Индер көлінде 1:4:32; Қарабатан көлінде 1:39:316; және Х.Доспанов атындағы Әуежайының жанындағы көлде 1:1,8:14,8. Осылайша, барлық көлдерде магний мен кальций хлоридтерінің тұздары, магний мен кальций сульфаттары түзіледі, ал натрий мен калий гидрокарбонаттарының тұздары ең аз болады.

Түйін сөздер: тұзды көл, Атырау облысы, гидрохимиялық талдау, ауыр металдар, катиондар, аниондар.

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Гидрохимические исследования соленых озер северной части Прикаспийской низменности

В статье проведен гидрохимический анализ и содержание тяжелых металлов соленых озер Атырауской области на примере соленых озера Индер, Карабатан и возле Международного аэропорта имени Х. Доспанова. Анализ по тяжелым металлам показывает, что содержание хрома, марганца, кобальта, никеля, меди, свинца, цинка и кадмия не превышает предельно-допустимые концентрации. Анализ катионов во всех соленых озерах показывает данные, которые идентичны во всех трех озерах и самые минимальные значения характерны для ионов калия и натрия, содержание которых находятся около 3 мг/л и 9мг/л соответственно. Содержания катионов кальция и магния превышают сотни и тысячи мг/л. Содержание ионов кальция в озере возле аэропорта почти в два раза превышает содержания в других озерах и составляет 1059 мг/л. Содержание ионов магния минимально для озера Карабатан и составляет 801 мг/л, тогда как в двух других соленых озерах превышают в 1,5 раза. По анионам самые минимальные значения характерны для гидрокарбонатов и находятся в пределах 200-300 мг/л. По сульфатам и хлоридам показатели очень разнообразны, так по сульфатам они меняются от 500 мг/л в озере возле аэропорта до почти 8000 мг/л в озере Карабатан. Максимальные значения характерны для хлоридов, при этом их содержания также разнообразны во всех озерах и варьируются от более 4000 мг/л до более 63000 мг/л. При этом отмечается следующие соотношения анионов HCO_3: SO_4: Cl – в озере Индер 1:4:32; в озере Карабатан 1:39:316; и в озере возле Х. Доспанова аэропорта 1:1,8:14,8. Таким образом, во всех озерах образуются соли хлоридов магния и кальция, сульфатов магния и кальция, а содержания солей гидрокарбонатов натрия и калия самые минимальные.

Ключевые слова: соленое озеро, Атырауская области, гидрохимический анализ, тяжелые металлы, катионы, анионы.

Introduction

Due to the fact that salt lakes are widespread in the World, they are important and valuable natural objects for the economy, culture, recreation and scientific research, but at the same time: in some regions of the World, salt lakes are intensively degraded and are not objects of active conservation to the extent that they deserve due to their unique resources.

Currently, there is no universal classification scheme of lakes that allows us to consider natural reservoirs based on any single limnological characteristics. This is due to the existence of such a wide variety of constantly changing (under the influence of natural and anthropogenic factors) natural limnic parameters.

The Caspian basin is a flat loamy plain with extensive development within its limits of sorov (shore) and estuarine basins occupied by mineral lakes and salt marshes. The chain of estuaries and sores of the Caspian lowland is a relic of the previously existing river hydrographic network [1], the topographic surface of the seabed, coastal ramparts and terraces of the retreating sea. The coastline of the Caspian Sea within the Caspian lowland is strongly indented by small bays (kultuks) and deltas of the Kura, Terek, Kuma, Volga, Ural, Emba and other smaller rivers. In the Caspian basin, there are sub-basins: Primorsky, Delta, Mangyshlak, Kara-Bogaz, Chagishlyar, etc. These landscape facies are stretched out in a narrow strip 10-12 km wide around the Caspian Sea, and the delta basins have a peculiar landscape of the primary surface of the accumulative marine plain, modified by the work of “blind” rivers that do not have runoff into the sea. These are the landscapes of the delta sub-basins of the Volga, Kura, and Ural rivers [2].

The Ural-Embinsky basin occupies the northern part of the Caspian lowland, which is a negative relief form made of sedimentary rocks, among which the thickness of marine brackish clays, loams and sands of Neogene and Quaternary age has the greatest thickness. In the southeastern part of the lowland, the sifted sands represent barkhanno-bumpy and ridge massifs. Salt domes are widespread in the central part of the basin.

The conditions of salt accumulation and the formation of the chemical composition of the salt lakes of this basin are influenced by the recent regression of the sea, salt domes and waste waters of oil fields. All the waters of the Ural-Emben basin, both surface and underground, are saline to one degree or another. Halite, mirabilite, tenardite, glauberite, astrakhanite, epsomite and others are common in the bottom sediments of lakes. Many lakes are characterized by an increased content of potassium, bromine, iodine, etc.

An integral part of the landscapes of the giant salt domes of the Caspian Lowland are dry (root) lakes [3]. Depending on the ratio of the water level and tectonic activity, lakes in salt dome structures can be divided into three groups. With sufficient water supply to the lake and a weak manifestation of the activity of salt dome structures, rapine and silt lakes with low bottom sediment capacity and unstable water-salt regime are formed. The low water content of the territory, accompanied by an active growth of salt dome uplifts, leads to the fact that the salt mirror is raised above the groundwater level, as a result of which drying lakes are formed. A sufficient amount of water entering the lake basin, together with the high activity of salt dome structures, is the reason for the formation of dry (root) salt lakes with powerful layers of lake salts filling deep compensatory mulches. The Caspian lowland is a vast area of salt lakes. These are unique aquatic ecosystems, characterized by alkaline conditions and high salt concentrations. It should be noted that, despite numerous studies, the salt lakes of the region have not been sufficiently studied, especially with the use of modern scientific methods and methodology.

The purpose of this work was to study the hydrochemical characteristics of some salt lakes of the Caspian lowland located in the Atyrau region. These lakes have different volumes and are located both in the city of Atyrau, in the immediate vicinity of the airport, 30 km from the city, next to the Bolashak plant on Karabatan and 180 km from the city of Atyrau near the village of Inder, called Inder Lake.

Methods

Sampling was carried out in June 2023 from the reservoirs of the Inderbor and Kabatan salt lakes. The cation content was carried out in accordance with GOST 26449.1-85 “Stationary distillation desalination plants. Methods of chemical analysis of salt water”, potassium – chapter 18.1, sodium – chapter 17.1, calcium – chapter 11, magnesium – chapter 12. The anion content was carried out on the basis of the following documents: chloride – ST RK ISO 9297-2008 “Water quality Determination of chloride content”, sulphates – ST RK 1015-2000 “Graphimetric method for determining sulfate content in natural wastewater”, bicarbonates – HDPE F 14.1:2:4.190-03 “Quantitative chemical analysis of waters. The method of measuring bichromate oxidizability (chemical oxygen consumption) in samples of natural, drinking and wastewater by photometric method using a liquid analyzer “Fluorat-02”. Sampling was carried out in accordance with ST RK GOST R 51592-2003 “Water. General requirements for sampling.” and ST RK GOST R 51593-2003 “Drinking water. Sampling.”

Salty continental reservoirs, in particular lakes, are very numerous. Their origin is quite clear. Any lake, unless it is flowing, closed, i.e. has no runoff, sooner or later must become salty due to evaporation of water, especially .if it is located in arid areas and on highly saline rocks. The degree of salinity of such reservoirs can be very significant, up to the precipitation of salts from a saturated solution. The waters of the lakes are very diverse in their chemical composition and mineralization. In contrast to seawater, lake waters do not have constant ratios between basic ions. According to the degree of salinity, lake waters are divided into the following types: fresh (up to 1‰), brackish (from 1 to 24.7%0), salty (from 24.7 to 47‰), mineral or salt (over 47%0).

The first person who tried to create a classification for salt lakes was M.G.Valyashko, 1952 [4], who identified the main classification features of salt (salt) lakes, considering the specifics of their development as an emerging mineral deposit. He classified the lakes by:

1. Concentrations of lake solution characterizing the general course of salt accumulation. At the same time, a group of fresh waters was distinguished – with a sum of dissolved substances less than or equal to 0.1% (by weight), a group of brackish wa-

ters – with a sum of dissolved substances from 0.1 to 3.5%, a group of salt waters – with a sum of dissolved substances higher than 3.5%.

2. According to the chemical composition of the lake solution, when, depending on the predominance of that Lakes are divided into carbonate ($Na_2CO_3^-$, $NaHCO_3^-$, $Ka_2CO_3^-$, $NaCO^-$, H_2O), sulfate ($2Na^+$, $2K^+$, $S0_4^{2-}$, Cl^-, H_2O) and chloride ($CaCl^-$, $FeCl^{3-}$, $NaC1^-$, H_2O).

3. According to the state of the lake solution (brine). At the same time, rapnye, dry and sub-sandy lakes differ. Rapnoe Lake is characterized by the year-round presence of water in the lake, in a dry lake brine occurs only during the wet season, and the sub-sandy lake is characterized by the complete absence of surface brine throughout the year, when the level of bottom brine lies below the surface of solid lake sediments. At the same time, the stratification of sediments is abnormal.

To determine the type of salt lakes, the Dobrovskiy and Todorov classifications were applied, the basis of which is aimed at the content of anions and cations in saline reservoirs. According to the Dobrovskiy classification, it is necessary to take into account the contents of the most maximally significant cations and anions, the content of which exceeds 25% of the total of all ions. For designation, the formulas are used first for the anion, then for the cation. According to the Todorov classification, cationic and anionic series are distinguished and determined in descending order of ion concentration. It is often used in engineering geology, hydrogeology and hydrology.

According to the total number of ions of chemical elements that determine the salinity of water, in 1958 the Venetian system was adopted, accord- ing to which natural waters are divided into fresh (up to 0.5%), mixogaline or brackish (0.5-30%), eugaline or marine (30-40%), and hypergaline or saline (>40%). Mixohaline are divided, in turn, into oligohaline (0.5-5%), mesohaline (5-18%) and polyhaline (18-30%). However, this classification has not been widely used in modern limnological research.

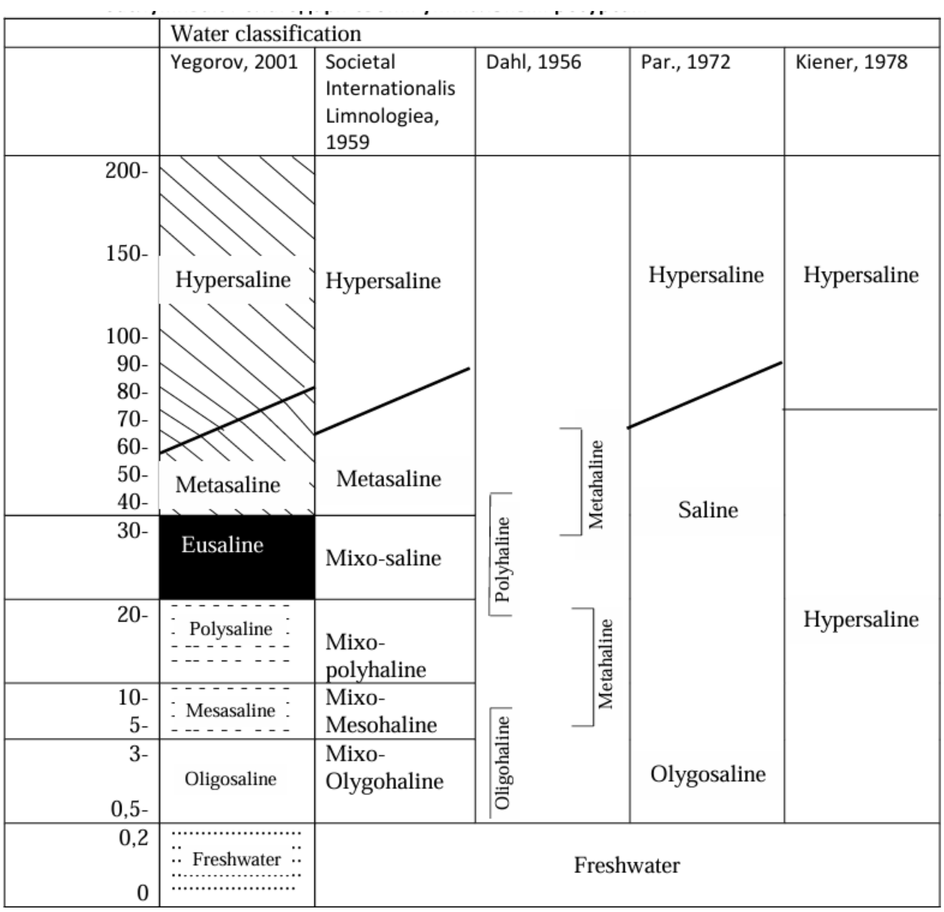

Figure 1 – Classifications of salt lakes by various authors in terms of mineralization

One of the latest classifications of natural waters by their mineralization and the corresponding classification of biological species for the pur- poses of paleogeographic analysis was proposed by Gasse et al. (1987) and presented in Figure 1 [5]. As can be seen from the data in Table b, the classification boundaries differ from those proposed by other authors, for example Ham- mer U.T. (1986), which divides salty waters into hyposalted (3-20 g/l), unsalted (20 – 50 g/l) and hypersalted (>50 g/l) and coincide with the data of Javor (1989), which refers lakes with a min- eralization above 70 g/l to hypersalted lakes, but many researchers consider lakes with a salinity exceeding 35 g/l to be hypersalted (i.e. , the min- eralization of seawater) .

When managing water resources (for agriculture, industry and drinking water supply), specific salinity gradations are used: "fresh water" – less than 0.3 g/l, "slightly salty" – 0.3-1.0 g/l, "salty" – 1.0-3.0 g/l and "strongly salty" – more than 3.0 g/l.

Thus, the total salinity of salt lakes is considered in the range from 3 to more than 500 g/l (Williams, 1998) and the author rightly believes that there are no universal criteria for determining on the basis of biological and physico-chemical characteristics of "fresh" and "salty" waters. However, given the fact that there are certain differences between the biological and physico-chemical properties of fresh and salty waters, W.D.Williams considers it possible to accept a threshold value of mineralization of 3 g/l, below which water is considered fresh, and above – salty. As it turned out, this threshold of mineralization corresponds to the loss of calcium from natural waters and the possibility of taste determination of salinity [6].

Results

Therapeutic mud of salt lakes is formed under certain geological conditions. Brines accumulated on low-lying areas of the earth, fed by precipita- tion and other various water sources, mainly in arid conditions, evaporate and form various mineral salts in some parts, and therapeutic silt mud accumulates under them for a long time.

To assess the prospects for increasing resources, the conditions of formation and patterns of their placement in the salt lakes of the Ural-Emba district of the Caspian region, such as Inder, in the Karabatan area and near the Atyrau airport, were analyzed.

Inder Lake (Fig. 2) is located in Atyrau region, 170 km north of Atyrau and 1.2km from the left bank of the Ural River. The length is 13.5 km, the maximum width is 11 km. Its area is 123 km^2 [7].

Figure 2 – Inder Lake

The Karabatan group of lakes (Fig. 3) is located 45 km from Atyrau, directly near the Atyrau-Kandahach railway line. The area of the Northern Karabatan is 1.08 million m^2, the southern one is 0.14 million m^2. The therapeutic mud on the lakes of Karabatan lies at a depth of 45 cm and has a capacity of 40 cm. Lake Karabatan is located on the left bank of the river. The Urals is located 150 km south of Inder Lake, near the paved Inder-Atyrau road [8].

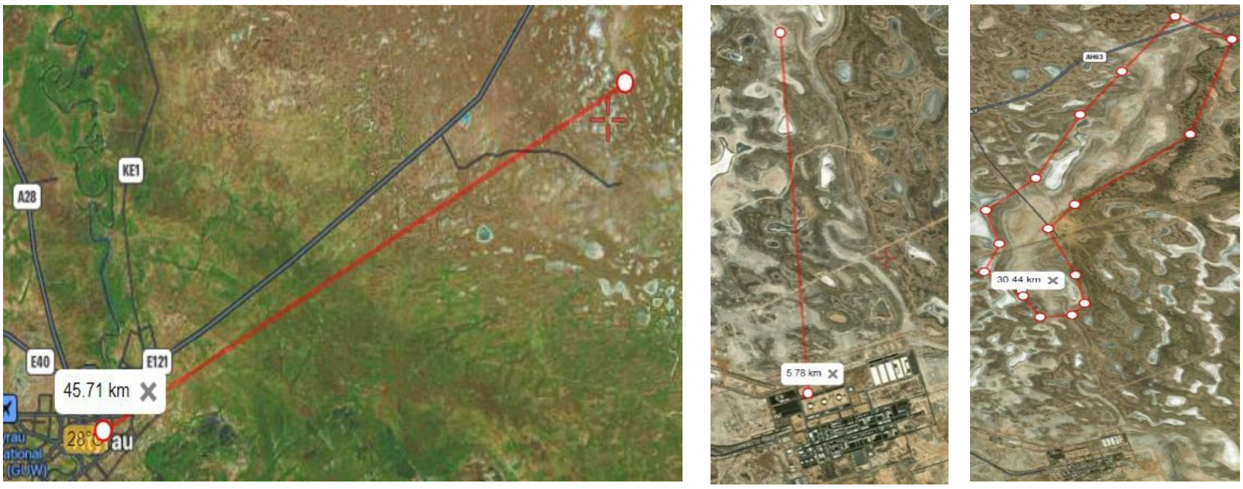

Figure 3 – The Karabatan group of lakes

Not far from the Kh.Dospanova International Airport in Atyrau (Fig. 4), at a distance of 1.33 km, there is a salt lake. The length is 1.72 km, the maximum width is 0.77 km. Its area is about 1.3 km^2 or 4.36 km in circumference.

Hydrochemical analysis of heavy metal ions was carried out in all three salt lakes [9].

Data on the content of heavy metals are presented in Table 1.

As can be seen from Table 1, the content of heavy metals in all salt lakes of the Atyrau region does not exceed the maximum permissible concentrations.

Figures 5 and 6 show analyses of the content of cations and anions in the waters of the Inder Salt Lake [10].

Figure 4 – Salt lake near Kh.Dospanova International Airport in Atyrau

Table 1 – The content of heavy metals in the salt lakes of the Atyrau region.

Name of the indicator to be determined	MPC, mg/l	Salt Lake Inder	Salt Lake Karabatan	Salt lake near Kh.Dospanova International Airport in Atyrau
Chrome	0,5	<0,005	<0,005	<0,005
Manganese	0,1	<0,002	<0,002	<0,002
Cobalt	0,01	<0,0005	<0,0005	<0,0005
Nickel	0,1	<0,005	<0,005	<0,005
Copper	0,1	<0,0005	<0,0005	<0,0005
Lead	0,03	<0,002	<0,002	<0,002
Zinc	1,0	<0,1	<0,1	<0,1
Cadmium	0,001	<0,0001	<0,0001	<0,0001

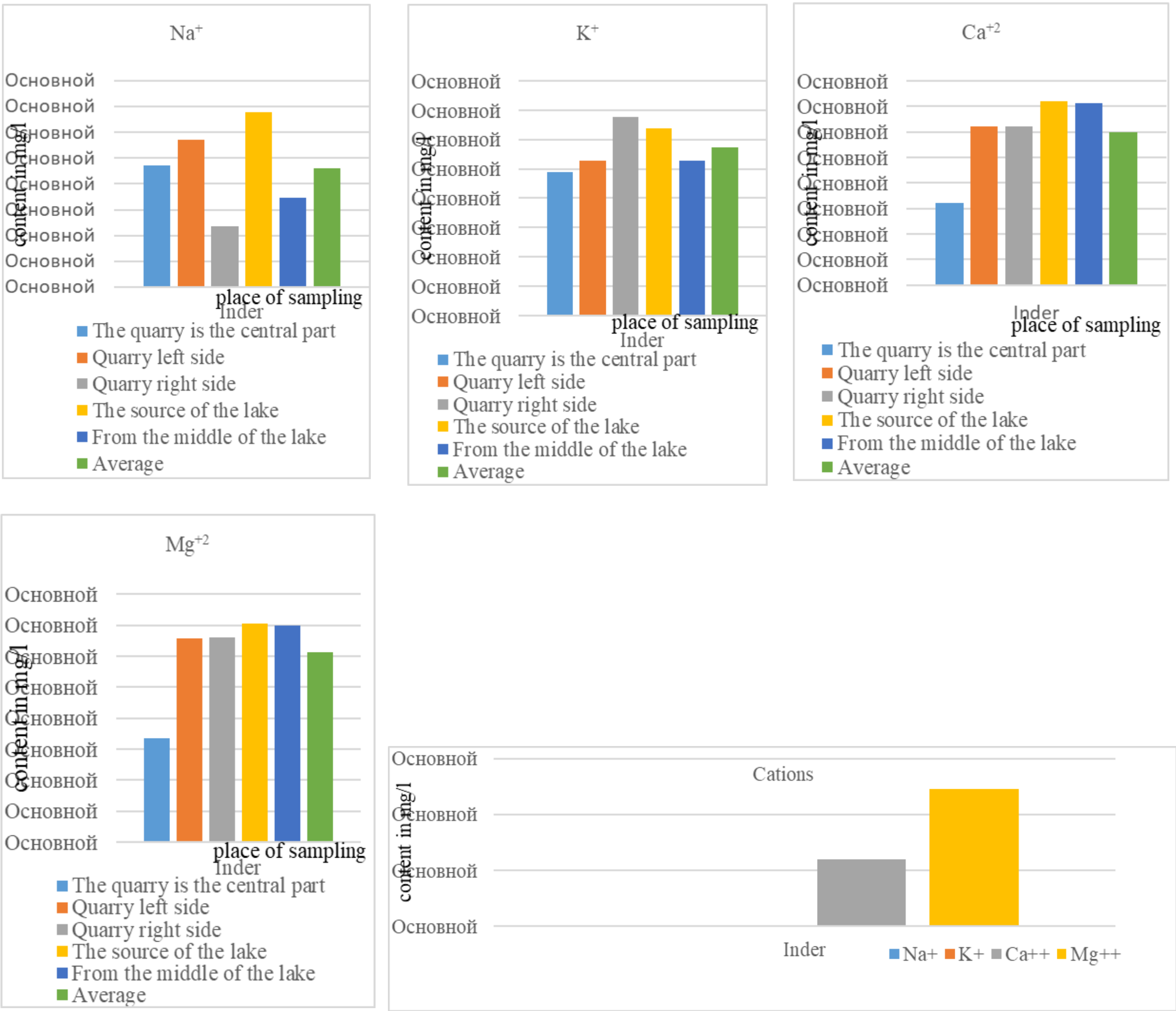

Figure 5 – The content of cations in the salty waters of Lake Inder, mg/l

In the Inder salt lake, the minimum values were noted for potassium ions, the content of which is about 3 mg/l (2.45-3.38 mg/l), sodium slightly more than 8-9 mg/l. The calcium content is much higher than the previous two cations and ranges from 320 to 720 mg/l. The maximum values were noted for magnesium cations, the content of which is in the range of 670-1412 mg/l. The average content of all cations shows that the magnesium content is more than 300 times higher than the content of potassium ions, sodium by 70-100 times and calcium by 2-3 times. Thus, the main predominant cations in the water of the Inder Salt Lake are magnesium and calcium cations.

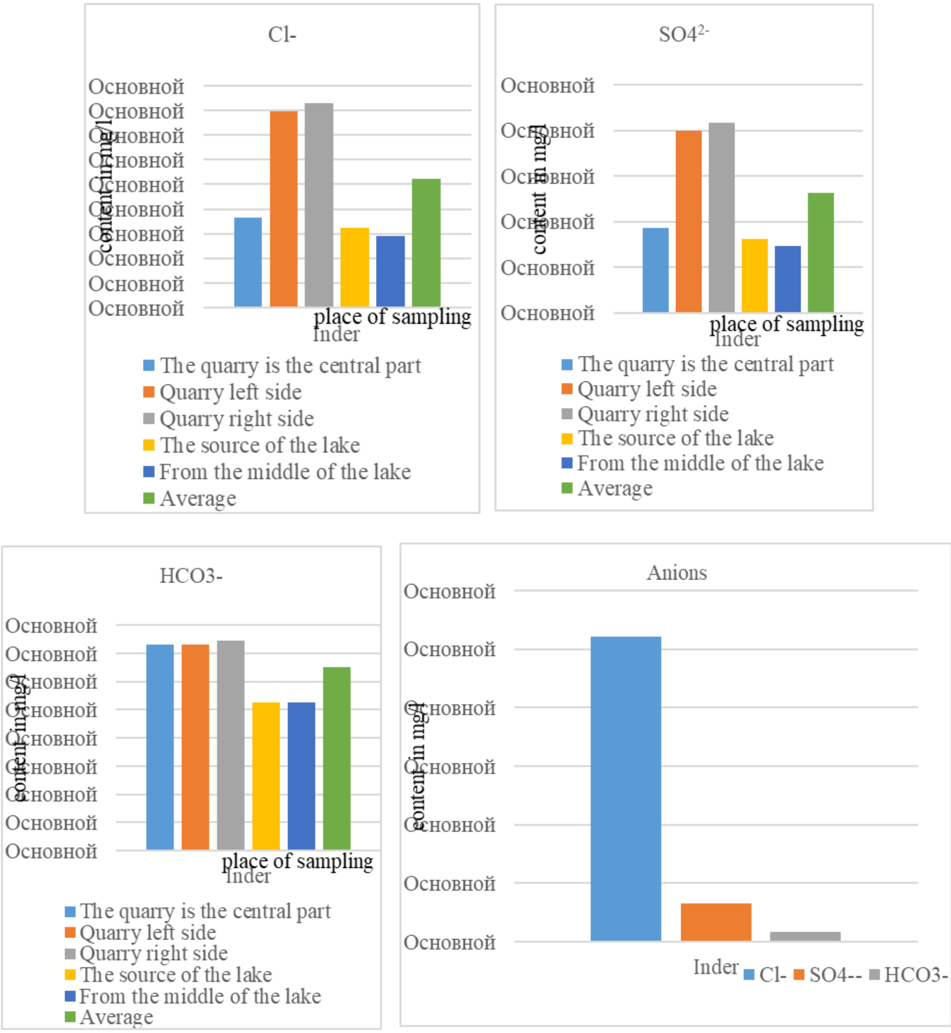

Figure 6 – The content of anions in the salty waters of Lake Inder, mg/l

Among the anions in Inder Lake, the minimum values are typical for bicarbonate ions ranging from 262.3 to 366 mg/l, the second place is occupied by sulfate ions with a content from 736.6 to 2086.2 mg/l, with an average content of 1310.5 mg/l. And the maximum concentrations are typical for chloride ions with a content from 5814 to 16592 mg/l. The content of chloride ions is more than 20-45 times higher than that of bicarbonate ions, and 7-8 times higher than that of sulfate ions [11].

Thus, calcium and magnesium cations, as well as sulfate and chloride anions, predominate in the Inder salt lake, which indicates that the main salts in the salty waters of Inder Lake are magnesium and calcium chlorides, as well as magnesium and calcium sulfates. Thus, according to the classification of Dobrovskoye Lake Inder, chlorides and sodium — Cl–Na predominate. The chloride content is more than 80% of the total volume of anions and sodium cations, the content of which is more than 65% of the total content of cations. According to Todorov's classification, the water of Lake Inder belongs to the sodium chloride series. Thus, the waters of Lake Inder are characterized by the highest mineralization due to the high concentration of chlorides and sodium. Figures 7 and 8 show analyses of the content of cations and anions in the waters of the salt lake of the Karabatan territory.

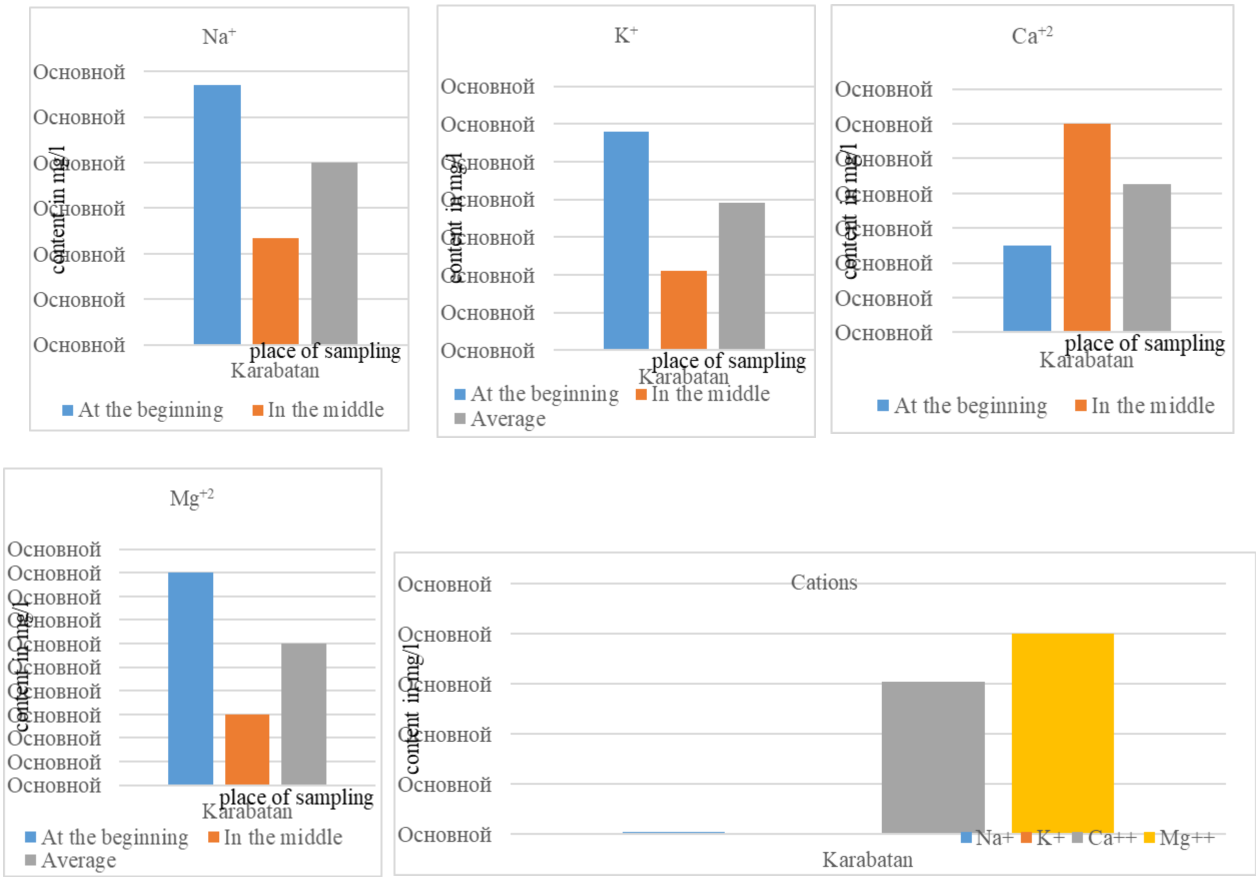

Figure 7 – The content of anions in the salty waters of the Karabatan area

In salt lake Karabatan, a low content of potassium and sodium cations was observed, and their content in Lake Inder ranges from 3.01-3.38 mg/l (K+) to 8.67-9.34 mg/l (Na+). The calcium con- tent is higher and ranges from 605 to 612 mg/l. The maximum value is the magnesium cation, whose content ranges from 798-804 mg/l. According to the average content of all cations, the content of magnesium is more than 237-266 times higher than the content of potassium ions, sodium 86-92 times and calcium 1.3 times. Thus, the main cations in the water of Salt Lake Karabatan are magnesium and calcium cations.

Among Salt Lake Calabatan anions, the minimum value of bicarbonate ions is 109.8 to 292.8 mg/L, followed by sulfate ions with a content of 7700.3 to 8254.5 mg/l, with an average content of 7977.4 mg/l, and the maximum concentration is chloride ions with a content of 61888 to 65234 mg/l. the content of chloride ions is more than 223-568 times higher than that of bicarbonate ions and sulfate ions.

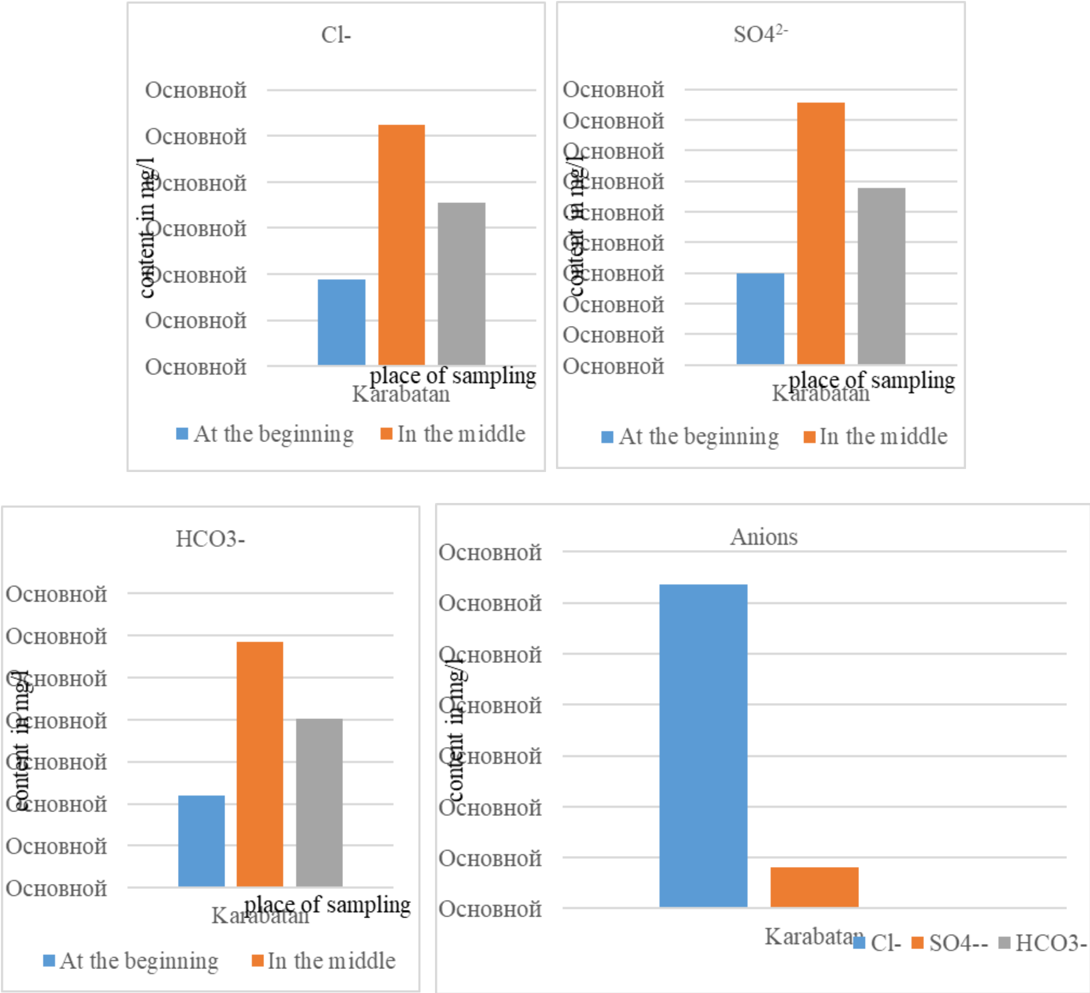

Figure 8 – The content of anions in the salty waters of the Karabatan area

Therefore, calcium and magnesium cations, as well as sulfate and chloride ions, dominate the salty lake Kalabatan, which indicates that the main salts in the salt water of Lake Kalabatan are magnesium and calcium chlorides, as well as magnesium and calcium sulfates. Therefore, according to Dombrovsky's classification, chloride and magnesium Cl–Mg dominate the water of Lake Karabatan, and according to Todorov's classification, it will belong to the chloride-magnesium series. Therefore, due to the high concentration of chloride and magnesium, the waters of Lake Karabatan have the highest degree of mineralization.

Figures 9 and 10 show analyses of the content of cations and anions in the waters of the salt lake near the airport.

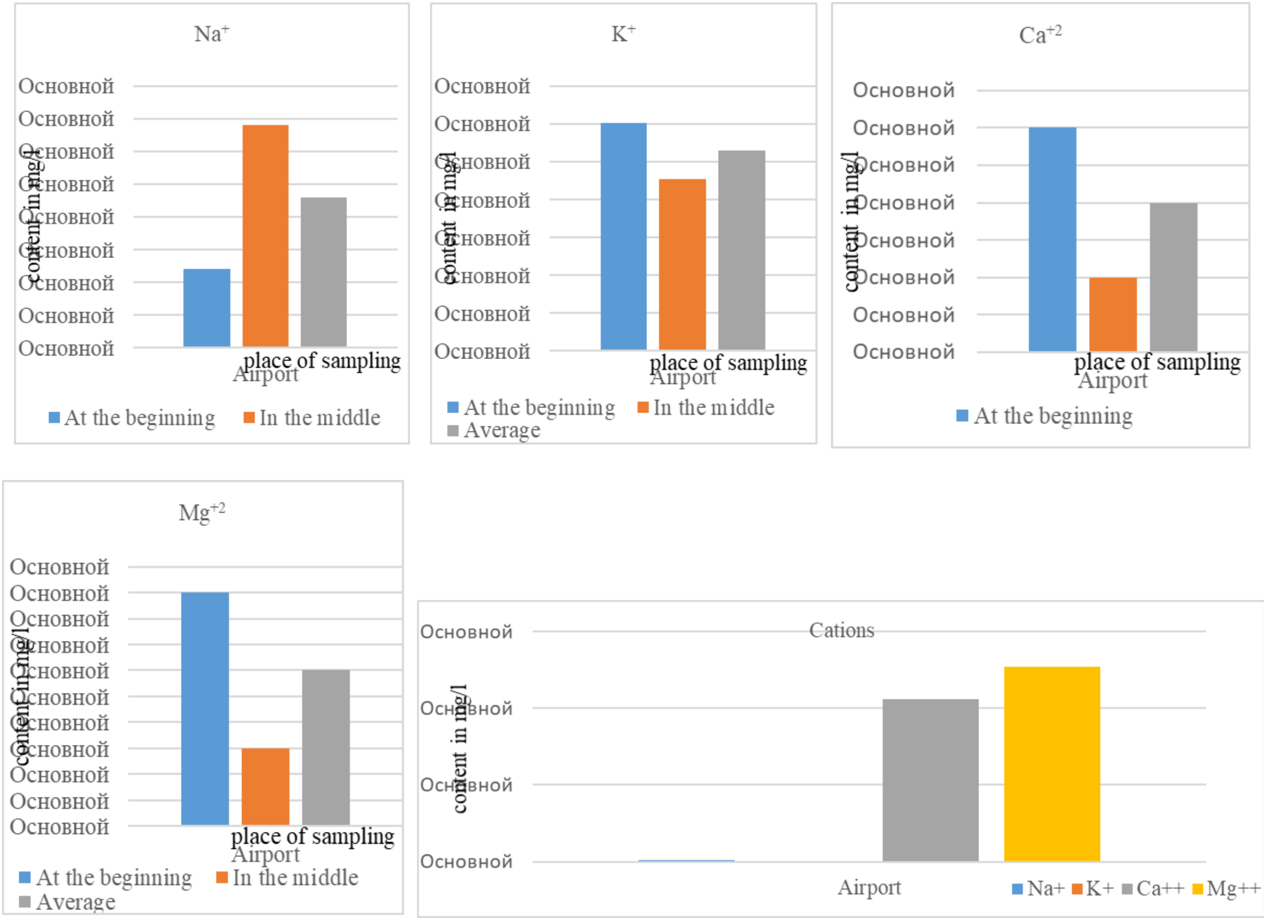

Figure 9 – The content of anions in the salty waters near the Atyrau airport

In the Salt Lake near the airport, the lowest values of potassium and sodium cations are characteristic, ranging from 2.27-3.01 mg/L (K+) to 8.67-8.89 mg/L (Na+). The calcium content is high, from 1058 to 1060 mg/l.the maximum value of the magnesium cation is from 1266 to 1272 mg/liter.The average content of all cations indicates that magnesium is 422 to 557 times more than potassium ion, 143 to 146 times more than sodium, and 1.2 times more than calcium. Therefore, the main cations in Salt Lake water near the airport are magnesium and calcium cations.

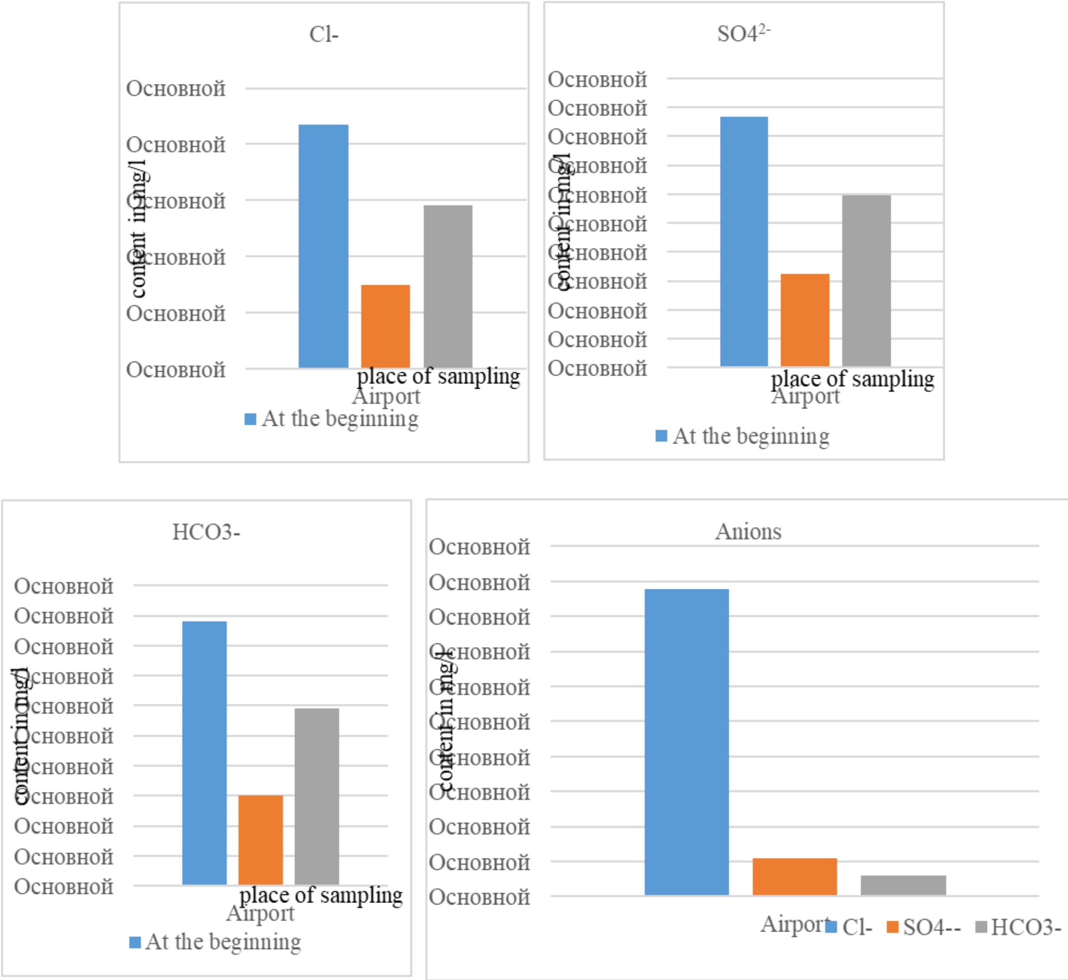

Figure 10 – The content of anions in the salty waters near the Atyrau airport

Among the anions in the salt lake near the airport, the minimum values are typical for bicarbonate ions ranging from 296 to 298.9 mg/l, the second place is occupied by sulfate ions with a content from 531.2 to 558.4 mg/l. And the maximum concentrations are typical for chloride ions with a content from 4325 to 4467 mg/l. The content of chloride ions is more than 14 times higher than bicarbonate ions and 8 times higher than sulfate ions.

Thus, the salt lake near the airport is dominated by calcium and magnesium cations, as well as sulfate and chloride anions, which indicates that the main salts in the salty waters of the lake near the airport are magnesium and calcium chlorides, as well as magnesium and calcium sulfates. Thus, according to Dombrowski's classification, water in the salt lakes near the airport belongs to Cl-Mg- Ca and according to Todorov's classification, it belongs to the chloride-magnesium-calcium series. Thus, the waters of the lake near the airport are characterized by the highest mineralization due to the high concentration of chlorides, magnesium and calcium.

Figures 11 and 12 show analyses of the content of cations and anions in the waters of the salt lakes of Atyrau region.

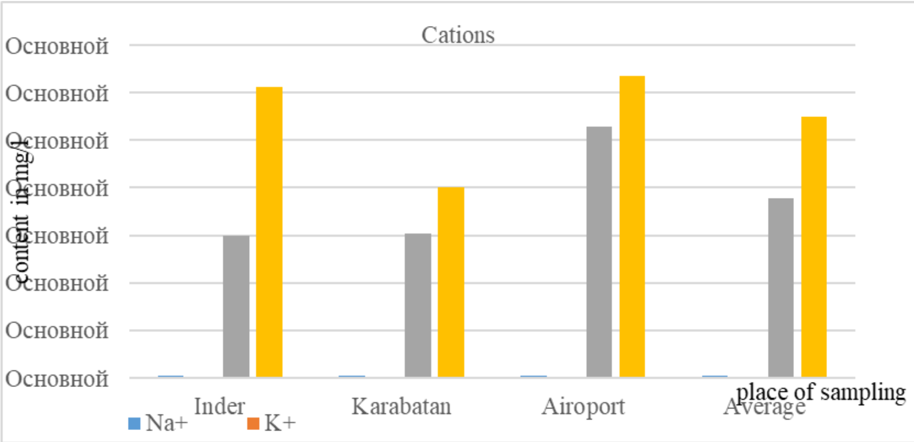

Figure 11 – The content of anions in the salt lakes of Atyrau region

In terms of the content of cations in all salt lakes, the minimum values are typical for potas- sium and sodium cations, the contents of which are identical for all salt lakes and range from 2.64 to 3.19 mg/l for potassium ions and from 8.78 to 9.12 mg/l for sodium ions. The content of calcium and magnesium ions is maximum in the salt lake near the Kh.Dospanova Aeroport, amounting to 1059 calcium and 1269 mg/l magnesium ions, are minimal in salt lake Karabatan, respectively 608.5 mg/l calcium ions and 801 mg/l magnesium ions, and in salt Lake Inder low content of cal- cium ions, i.e. 599.4 mg/l, whereas the content of magnesium ions is close to the content in the salt lake near the Kh.Dospanova Aeroport and is equal to 1223 mg/l.

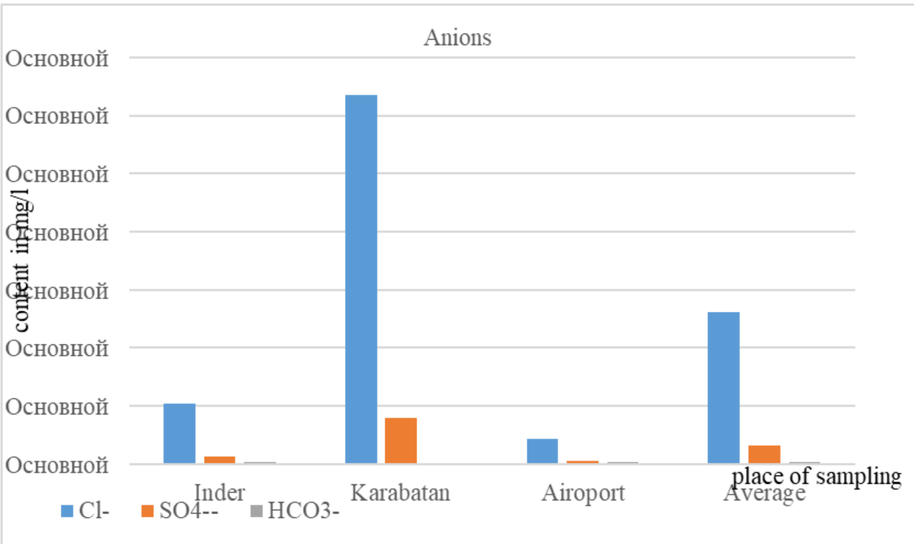

Figure 12 – The content of anions in the salt lakes of Atyrau region

Analysis of the cation content in salt lakes by three anions shows that the minimum values for all three lakes are characteristic of the bicarbonate ion and range from 201.3 to 325.74 mg/l, in sec- ond place are sulfate ions, the content of which is very diverse, so the lowest values in a salt lake are about Kh.Dospanova Airport and is 544.8 mg/l, then in the salt lake Inder 1310.5 mg/l, which is 2.5

times higher than previous data and is increased by Lake Karabatan and is 7977.4 mg/l, which is more than 14 times higher than in the salt lake about Kh.Dospanova Airport and 6 times salt lake Karabatan. The highest values are typical for chloride ions, while among the three lakes the content of chloride ions is the minimum value typical for the salt lake near the airport 4396 mg/l, in second place in the salt lake Inder 10410.8 mg /l, which is 2.3 times higher than the previous lake, and the maximum values are typical for the salt lake Karabatan, the content of which It is 63561 mg/l, which is 14.4 times higher than the data for the salt lake near the airport and 6.1 times higher than the salt lake Inder.

Thus, in all three salt lakes, according to the maximum contents, it can be concluded that they contain the following salts in descending order: magnesium chloride→calcium chloride→magnesium sulfates →calcium sulfate, and the remaining salts in smaller quantities.

Discussion

The analysis results show that salt lakes in the Atyrau region are mostly transparent due to chemical analysis of water and are characterized by an increase in the content of cations and anions of the same composition [12].

In general, there are high values of such cations as magnesium and calcium and chloride and sulfate anions. If we look at each lake, the magnesium cation content is the same in Lake Inder and the lake near Kh.Dospanov Airport and 1.5 times higher than the magnesium content in Lake Karabatan. The content of calcium ions is higher in the lake near Kh.Dospanov Airport and is almost twice as high as the calcium content in the other two salt lakes. The contents of potassium and sodium ions are in close values in all three salt lakes.

At the same time, different indicators were observed for anions, especially chloride ions, the highest of which is typical for salt Lake Karabatan, which is 6-14 times higher than in the other two lakes. There is also a sulfate-ion structure in Lake Karabatan, the content of which is 6-14 times higher than the content of sulfate ions in the other two lakes. However, compared with chlorides, their content is almost 8 times lower than that of chloride ions. In all three lakes, the hydrocarbon content is close, and compared to other chloride anions, it is 14 times less than in lakes near the airport, 32 times less than in Lake Inder, and 316 times less than in Lake Karabatan, compared to sulfates.

These studies have shown that the main salts formed in these three salt lakes are magnesium chloride and calcium chloride, followed by magnesium sulfate and calcium sulfate, as well as the least amount of sodium bicarbonate and potassium.

Conclusion

In conclusion, it can be concluded that in three salt lakes of the Atyrau region of different volume and nature of origin, as well as located in different territories of the Atyrau region, there is a similar hydrochemical composition, the predominant cations in which are magnesium and calcium ions and chloride and sulfate ions from anions. At the same time, cations show almost the same indicators for all cations, especially for potassium and sodium, the content of which is close to 3 mg/l for potas- sium and about 9 mg/l for sodium. The values for calcium are diverse, while in the Inder and Kara- batan lakes they amount to about 600 mg/l, and in the salt lake near the Atyrau airport they exceed 1000 mg/l. In terms of magnesium, the indicators differ from those of calcium ions and similar indi- cators are typical for Lake Inder and the lake near the airport and above 1200 mg/l, whereas in Lake Karabatan it is slightly above 800 mg/l. Ratio of contents Ca:Mg in Lake Inder is 1:2, in Lake Kara- batan 1:1.3 and Salt lake near Kh.Dospanova In- ternational Airport in Atyrau 1:1,2. For anions, the lowest values are typical for bicarbonate ions and are in the range of 200-300 mg/l. The indicators for sulfates and chlorides are very diverse, as for sulfates they vary from 500 mg/l in the lake near the airport to almost 8000 mg/l in Lake Karabatan. The maximum values are typical for chlorides, while their contents are also diverse in all lakes and range from more than 4,000 mg/l to more than 63,000 mg/l. At the same time, the following ratios of HCO_3: SO_4:Cl anions are noted – in Lake Inder 1:4:32; in Lake Karabatan 1:39:316; and in the Salt lake near Kh.Dospanova International Airport in Atyrau 1:1.8:14.8. Thus, salts of magnesium and calcium chlorides, magnesium and calcium sul- fates are formed in all lakes, and the salt contents of sodium and potassium bicarbonates are the most minimal.

Conflict of interest

All authors have read and are familiar with the content of the article and have no conflict of interests.

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