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ANALYSIS OF THE HYDROCHEMICAL COMPOSITION OF SALT BRINS OF LAKE INDER

Abstract. The article presents an analysis of the hydrochemical composition of the salt brines of the Inder Lake, which consists of three sources Tuzdybulak, Aschybulak and Telepbulak. The analysis shows that the chloride content on Tuzdybulak ranges from 19538 mg/l to 36868 mg/l during the research period from 1961 to 2017, which exceeds the maximum permissible concentration by 55,8-105.3 times; on Aschybulak from 12880 mg/l to 28080 mg/l, the excess is 36.8-80.2 times; on Telepbulak from 11900 mg/l to 26000 mg/l with an excess of 34-74.3 times. Analysis of sodium showed that on Tuzdybulak it is 10,877 mg/l -28,680 mg/l with an excess of the maximum permissible concentration of 54-143.4 times; on Aschybulak from 8430 mg/l to 21697 mg/l with an excess of 42.2-108.5 times; on Telepbulak from 8010 mg/l to 18280 mg/l with an excess of 40.05-91.4 times. This analysis shows that these brines are of the sodium chloride type, while the most saline in terms of sodium and chloride is the Tuzdybulak source. According to the content of calcium cations at the source, Tuzdybulak varies from 860 mg/l to 1499 mg/l, which is 573.3-999.3 times the maximum permissible concentration; at the source of Aschybulak from 930 mg/l to 1325 mg/l, which is 620-883.3 times higher than the MPC; at the source of Telepbulak from 1000 mg/l to 1980 mg/l, which is 666.7-1320 times higher than the MPC. According to sulfate anions at the Tuzdybulak source, from 4096 mg/l to 20077.85 mg/l, which is 8.2–40.2 times higher than the MPC; at the Aschybulak source, from 3370 mg/l to 10841.54 mg / l, which is 6.74-21.6 times higher than the MPC; at the source of Telepbulak from 3360 mg/l to 50816.14 mg/l, which is 6.72-101.6 times higher than the MPC. According to the sulphate-calcium type, the highest content is typical for the Telepbulak source. The analysis of mineralization and solids shows that in salt solutions of Lake Inder they exceed: at the source of Tuzdybulak from 22.3 to 50.9 times; at the source of Aschybulak from 17.8 to 38.5 times; at the source Telepbulak from 17.1 to 33.1 times, which shows that the brines of Lake Inder belong to brine mineral waters.

Key words: Tuzdybulak, Aschybulak, Telepbulak, sodium cations, calcium cations, chloride anions, sulfate anions, salt brine, mineralization, dry residue.

Introduction. As you know, Atyrau region is characterized by difficult climatic conditions. It is located in a semi-desert zone with a sharply continental climate.

In this regard, the organization of a new health resort in the Atyrau region is of great importance for the improvement of the population of the region.

In the region there are necessary mineral resources for the organization of a spa resort in the village of Inderborsk. Rapa Lake Inder has a long history of study [1].

The healing mud of salt lakes is formed in certain geological conditions. Brines that have accumulated in lower areas of the earth, feeding on atmospheric precipitation and other various water sources, mainly under arid conditions, evaporate and form various mineral salts in some parts, and therapeutic mud sludge accumulates under them for a long time.

Healing mud is available on the north coast of Inder Lake. These dirt accumulates at the places of exits of large sources Tuzdybulak, Telepbulak and Aschybulak. Mud yields associated with the source of Telepbulak are approximately 200-250 m long from west to east, 60 m wide from north to south with a visible thickness of 17 cm. The dimensions of the mud outlet associated with the Aschybulak spring are

200 m long, 10 m wide and 10 cm thick. The length of the mud outlet at the Tuzdybulak spring is 210 m, the width is from 54 to 74 m, the thickness is 10-20 cm. The therapeutic mud outlets associated with the Telepbulak spring are approximately 200-250 m long from west to east, north to north wide south up to 60m with a visible power of 17cm. The dimensions of the mud outlet associated with the Aschybulak spring are 200 m long, 10 m wide and 10 cm thick. The length of the mud outlet at the source of Tuzdybulak is 210 m, width is from 54 to 74 m, thickness is 10-20 cm [2].

Methods. In this work, we used methods of comparative analysis of data on the hydrochemical composition of the salt brines of Inder Lake, according to the results of ongoing studies in different years from 1961 to 2017 [2-5]. All results were compared with regulatory documents GOST 26449.1-85, ST RK 1015-200, SanPin 2.1.4.1074-01 and RD 5224.365-2008.

Results. Inder Lake is located in the Atyrau region, 170 km north of Atyrau and 1.2 km from the left bank of the Ural River. Length 13.5 km, maximum width 11 km. Its area is 123 km^2. Inder Lake is fed by atmospheric precipitation and due to the waters of the main aquifer (thickness 14 meters) of the gypsum stratum of the Inder rise, which is unloaded on the northern shore of the lake in the form of numerous descending and ascending sources, the total flow rate of which ranges from 31.0 to 147.5 l/sec (average 60.5 l/sec) [3].

A total of 33 sources were recorded, arising mainly from karst gypsum or from Permian-Triassic sandstones. Three groups of sources have the greatest value in flow rate: 1) Tuzdybulak, Aschybulak on the northeastern outskirts and 2) Telepbulak - on the northwestern part of the lake.

The average annual water consumption is according to sources: Tuzdybulak - 12.3 l/s, Aschybulak - 7.84 l/s and Telepbulak - 9.18 l/s.

In spring and winter, the lake is sometimes covered with a thin layer of brine, and in summer and autumn brine remains only in the northern and northwestern parts, and even then in small areas.

From the north, the lake is surrounded by hills called the Inder Mountains. The southern part of the lake is shallow, imperceptibly passing into the steppe plateau.

The northern part of the lake lies on the southern wing of a large salt dome uplift and has a complex geological structure. The southern, sloping shores of the lake are composed exclusively of the latest Caspian sediments.

The productive stratum of the lake is composed of thick sediments of self-landing cooked high-quality salt. The maximum installed thickness of salt deposits in the lake is 56.2 m.

Indera's lake salt (Figure 1) is divided into five lithological differences: new salt, old salt, granular, pomegranate and black salt. There are no sharp boundaries between them, and their selection is somewhat arbitrary. The main distinguishing features of these salt differences are as follows [4]:

• The new salt is dazzlingly white, finely crystalline (the size of halite crystals is from fractions of mm to 2-5 mm), densely cemented. It is difficult to break with a shovel, easily breaks through with a crowbar. New salt covered almost the entire surface of the salt.

• The old salt tightly cemented 0.05-0.50; yellowish gray, medium crystalline, clay-carbonate with rare gypsum crystals.

• The bulk is transparent, light gray, crystalline, friable, in some places slightly cemented, slightly contaminated with clay-clay material. Easy to take with a shovel. When driving wells, it easily crumbles from the walls. In this regard, wells can only be cased.

• The grenade differs from the above differences in its well-formed halite crystals. The maximum dimensions of the latter are 15-26mm. The salt is clear, light gray, sometimes pinkish, coarse-grained. Small crystals of gypsum and an admixture of carbonate-clay material are observed, rarely in significant quantities. Pomegranate is more difficult to drill than granular, due to the cementation of the rock.

• The black salt gray, dark gray, dense, silted, gypsum, self-salt. The structure is medium and large crystalline. The sizes of halite crystals range from 5-20 mm. A distinctive feature from other differences is a rather significant contamination with clayey-salty carbonate material, gypsum and a sharply increased density, in contrast to grenades and granules. The black salt lays the salt stratum and salty, clay-sand saline and gypsum formations. The salt stratum of Lake Inder has a high porosity reaching 40%. Due to this, the lake has reserves (about 1 billion m^3) of highly mineralized brine, the chemical composition of which is characterized by more or less constancy.

Figure 1 - Inder Lake self-settling salt

Mineral mud or black silts with healing properties are classified as fine. Mud solution is less than 50%. In the mud, particles with a diameter of more than 0.25 mm (clogging) are absent. The colloidal absorption complex is very significant.

Inder mud in its component composition has balneological properties.

The mud of the lake is silt with a strong odor of hydrogen sulfide. The water content in the peloid is 30-35%, and sulphurous iron - about 42 grams per kg of mud, the salt concentration is very high - more than 200 grams per kg of raw mud. The crystalline skeleton consists of calcium carbonates and sulfates. Inder mud is homogeneous black, oily, sticky with the smell of hydrogen sulfide. There are sites littered with sand particles [5].

100 grams of the peloid contains hydrogen sulfide - 250 mg, organic substances - 1.54 g; carbonates in terms of calcium carbonate - 8.5, specific gravity - 1.56; heat capacity - 0.32 calories. Peloid reserves in the lake are significant.

According to the main physical and chemical indicators, the mud of the Inder Lake is: according to the content of water-soluble salts in the mud solution (in g/l) - to salt-saturated (more than 150), according to the content of sulfides (FeS as a percentage of natural mud) - highly sulfide (more than 0.50) , according to the reaction of the medium (pH) - slightly alkaline (7.0-9.0) [6].

The water extract of the mud of Lake Inder consists of (g/l): calcium 0.29; magnesium 0.40; sodium 0.47; potassium 0.05; no carbonates detected, bicarbonates 0.009; chlorides 2.70; sulfates 1.20 and a dense residue of 6.20, with a pH value of -7.27 [7].

Their balneological value is determined by their moisture capacity (natural humidity), texture (shear resistance), the degree of clogging by large fractions, heat capacity and heat holding ability, mineralization of the mud solution, the presence of hydrogen sulfide and iron sulfides, redox potential and the reaction of the medium.

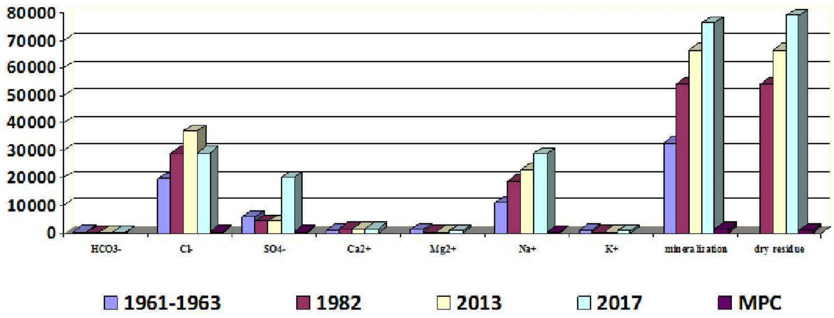
The requirements for the quality of therapeutic mud include such normative indicators, the mismatch of which excludes the possibility of therapeutic use of preloads [8]:

- humidity determines the consistency of the mud mass, which only at a certain water content can remain plastic, retain on the patient's body and have a high heat-holding ability;

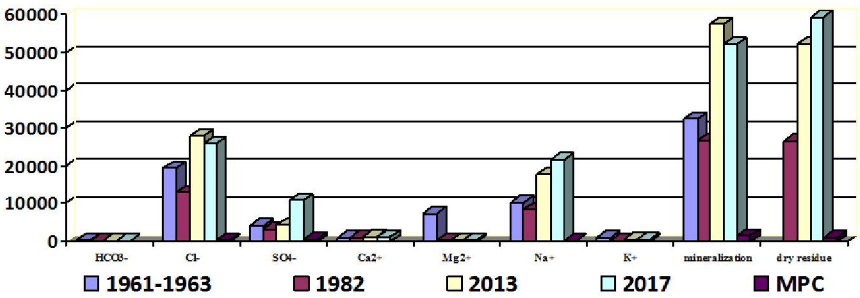
- contamination with mineral particles or plant debris worsens the plasticity of the mud, and in the presence of large inclusions (crystals, fragments of shells, etc.) causes burns;

- shear resistance characterizes the plasticity of the mud procedural mass and, therefore, its suitability for mud applications [9].

Discussion. As can be seen from the diagrams in Figure 2, the chemical composition of aqueous salt solutions is dominated by the content of chloride anions and sodium cations at all three sources:



a)



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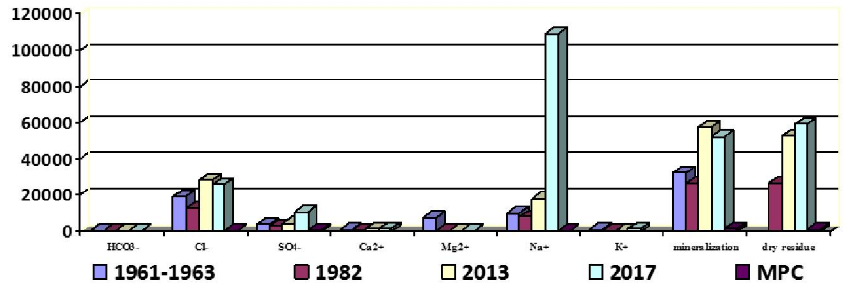

c)

Figure 2 - Analysis of the results of the hydro chemical composition of Inder Lake for the period from 1961 to 2017
a) the source of Tushybulak; b) the source of Aschybulak; c) the source of Telepbulak

• the chloride content on Tuzdybulak is from 19538 mg/l in 1961-1963 up to 36868 mg/l in 2013; on Aschybulak from 12880 mg/l in 1982 mg/l to 28080 in 2013; on Telepbulak from 11,900 mg/l in 2017 to 26,000 mg/l in 2013.

• the sodium content on Tuzdybulak is from 10877 mg/l in 1961-1963 up to 28680 mg/l in 2017; on Aschybulak from 8430 mg/l in 1961-1963 until 21697 mg/l in 2017; on Telepbulak from 8010 mg/l in 1982 to 18280 mg/l in 2013 [10].

These data indicate that the mud solution of Lake. Inder refers to the sodium chloride type.

In accordance with regulatory documents (GOST 26449.1-85), the concentration of chlorides in the MPC of chlorides is 350 mg/l, while at the sources of Lake Inder they exceed 55,8 to 105.3 times at the source of Tuzdybulak; from 36.8 to 80.2 times at Aschybulak and from 34 to 74.3 times at Telepbulak source [11].

The maximum permissible concentration of sodium according to RD 5224.365-2008 is 200 mg/l, while in salt solutions of Inder Lake they exceed: from 54 to 143.4 times at the source of Tuzdybulak; from 42.2 to 108.5 at Aschybulak and from 40.05 to 91.4 times at the source of Telepbulak [12].

The content of calcium cations is lower than the content of sodium cations, but despite this, they exceed the maximum permissible concentration, which is 1.5 mg / l for drinking water according to SanPin 2.1.4.1074-01. The content of calcium cations is: at the source of Tuzdybulak from 860 mg / l in 1961-1963. up to 1499 mg l in 2013, which is 573.3-999.3 times more than the MPC; at the Aschybulak source, from 930 mg/l in 1982 to 1325 mg/l, which is 620-883.3 times higher than the MPC; at the source Telepbulak from 1000 mg/l to 1980 mg/l, which is 666.7-1320 times higher than the MPC [13].

The content of sulfate anions is lower than the content of chlorine anions, but exceed the MPC, which is 500 mg/l according to the standard ST RK 1015-2000. The content of sulfate anions is: at the Tuzdybulak source from 4096 mg/l in 2013 to 20077.85 mg/l in 2017, which is 8.2–40.2 times higher than the MPC; at the Aschybulak source, from 3370 mg/l in 1982 to 10,841.54 mg/l in 2017, which is 6.74-21.6 times higher than the MPC; at the source Telepbulak from 3360 mg/l in 1982 to 50816.14 mg/l in 2017, which is 6.72-101.6 times higher than the MPC [14].

Thus, the saline solutions of Lake Inder can also be attributed to the sulfate-calcium type.

The increased content of salts of sodium chloride and calcium sulfate lead to an increase in the salinity of the saline solution, which is: for the source of Tuzdybulak from 33481 mg/l in 1961-1963 up to 76,400 mg/l in 2017, for the Aschybulak source from 26,710 mg/l in 1982 to 57,700 mg/l in 2017, for the Telepbulak source from 2,650 mg/l in 1982 to 49580 mg/l in 2013. According to GOST 26449.1-85, the MPC of mineralization is 1500 mg/l, in salt solutions of Inder Lake they exceed: at the source of Tuzdybulak from 22.3 to 50.9 times; at the source of Aschybulak from 17.8 to 38.5 times; at the source of Telepbulak from 17.1 to 33.1 times [15].

According to the classification, depending on the total salinity, the waters of Lake Indera belong to brine mineral waters.

According to the dry residue, the same pattern is observed as with saline salinity with a slight deviation of up to 10%: at the Tuzdybulak source from 54150 mg/l in 1982 to 78808 mg/l in 2017, which exceeds the MPC equal to 1000 mg/l according to GOST 26449.1-85 in 54.15-78.8 times; at the source of Aschybulak from 26570 mg/l in 1982 to 59406 mg/l in 2017, which exceeds the MPC by 26.57-59.41 times; at the source of Telepbulak from 25650 mg/l in 1982 to 49654 mg/l in 2013, which exceeds the MPC by 25.65-49.65 times. Dry solids data for 1961-1963 not available [16].

Conclusion A comparative analysis of the hydrochemical composition showed that the saline solution of Lake Inder belongs to the sodium chloride and calcium sulfate type. According to the MPC, the composition of brines exceeds the content of sodium cations from 40 to 143 times, calcium from 17 to 50 times; chloride anions from 34 to 105 times; sulfate anions from 6 to 101 times. It should be noted that the content of chlorine anions and sodium cations is higher at the source of Tuzdybulak, the content of sulfate anions and calcium cations is higher at the source of Telepbulak. Thus, the rosol of the source Tuzdybulak belongs to the sodium chloride, and the source of Telepbulak to the sulfate-calcium type [17].

Depending on the total mineralization and solids, it can be concluded that the brine of the Tuzdybulak spring is the most mineralized.

Thus, the physico-chemical study of the therapeutic mud of Inder Lake in the Atyrau region allows us to conclude that they meet the requirements for mud for therapeutic use. Unfortunately, the studied resources of high-quality therapeutic mud of Inder Lake are insignificant and cannot be used on an industrial scale [18].

The unique chemical composition of therapeutic mud in combination with brine baths makes Lake Inder attractive for recreation of citizens of Kazakhstan and vacationers from neighboring regions of Russia [19].

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ИНДЕР КӨЛІНІҢ ТҰЗДЫ ТҰЗДЫҚТЫҢ ГИДРОХИМИЯЛЫҚ ҚҰРАМЫН ТАЛДАУ

Аннотация. Мақалада Тұздыбұлақ, Ащыбұлақ және Телепбұлақ үш көзден тұратын Индер көлінің тұзды тұздарының гидрохимиялық құрамына талдау берілген. Судың орташа жылдық шығыны көздерге сәйкес: Тұзбұлақ - 12,3 л/с, Ащыбұлақ - 7,84 л/с және Телепбұлақ - 9,18 л/с. Көлдің балшықтары күкіртсутектің күшті иісі бар тұнбаға айналады. Пелоидтағы су мөлшері 30-35% құрайды, ал темір сульфиді әр балшық үшін шамамен 42 грамм, тұз концентрациясы өте жоғары - шикі балшықтың әр килограмына 200 грамнан астам. Кристалл қаңқасы кальций карбонаттары мен сульфаттардан тұрады. Ішіндегі балшық біртекті қара, майлы, күкіртсутегі иісімен жабысқақ. Құм бөлшектері бар жерлер бар [5].

100 грамм пелоид құрамында күкіртсутегі бар - 250 мг, органикалық заттар - 1,54 г; кальций карбонаты бойынша карбонаттар - 8,5, ерекше ауырлық күші - 1,56; жылу сыйымдылығы - 0,32 калория. Көлдегі пелоид қоры айтарлықтай.

Негізгі физикалық және химиялық көрсеткіштерге сәйкес Индер көлінің балшықтары: балшық ерітіндісіндегі суда еритін тұздардың құрамына сәйкес (г/л) - тұзға қаныққан (150-ден астам), сульфидтердің құрамына сәйкес (табиғи балшықтың пайыздық құрамындағы FeS) - жоғары сульфидті (0,50-ден жоғары), ортаның реакциясына сәйкес (pH) - сәл сілтілі (7.0-9.0).

Индер көлінің балшық суының сығындысы құрамы (г/л): кальций 0,29; магний 0,40; натрий 0,47; калий 0,05; карбонаттар анықталмады, бикарбонаттар 0,009; хлоридтер 2.70; сульфаттар 1,20 және қатты қалдық 6,20, pH -7,27.

Талдау көрсеткендей, Тұздыбұлақтағы хлоридтің мөлшері зерттеу кезеңінде 1961 жылдан 2017 жылға дейін 19538 мг/л-ден 36868 мг/л аралығында болады, бұл шекті рауалды мөлшерден 55,8-105,3 есе асады; Ащыбұлақ бойынша 12880 мг/л-ден 28080 мг/л дейін, асып кетуі 36,8-80,2 есе; Телебұлақта 11900 мг л-ден 26000 мг/л-ге дейін, 34-74,3 есе артық. Натрий талдауы бойыншаТұздыбұлақта 10,877 мг/л -28,680 мг/л құрайды, бұл шекті рауалды мөлшерден 54-143,4 есе асады; Ащыбұлақ бойынша 8430 мг/л-ден 21697 мг/л-ге дейін, 42,2-108,5 есе; Телепбұлақ бойынша 8010 мг/л-ден 18280 мг/л-ге дейін, 40,05-91,4 есе артық. Бұл талдау көрсеткендей, бұл тұздықтар натрий хлориді түріне жатады, ал тұзды тұздың ең көп мөлшері Тұздыбұлақ көзі болып табылады. Көздердегі кальций катиондарының құрамы бойынша Тұздыбұлақ 860 мг/л-ден 1499 мг/л-ге дейін өзгереді, бұл шекті рауалды мөлшерден 573,3-999,3 есе; Ащыбұлақ көзінде 930 мг/л-ден 1325 мг/л дейін, бұл ШРМК-ден 620-883,3 есе жоғары; Телепбұлақ көзінде 1000 мг л бастап 1980 мг/л дейін, бұл ШРМ-ден 666,7-1320 есе жоғары. Тұздыбұлақ көзіндегі сульфат аниондары бойынша 4096 мг/л-ден 2007,75 мг/л-ге дейін, бұл ШРМ-ден 8,2-40,2 есе жоғары; Ащыбұлақ көзінде 3370 мг/л-ден 10841,54 мг/л дейін, бұл ШРМ-ден 6,74-21,6 есе жоғары; Телепбұлақ көзінде 3360 мг/л-ден 50816,14 мг/л-ге дейін, бұл ШРМ-ден 6,72-101,6 есе жоғары. Сульфат-кальций түріне сәйкес Телепбұлақ көзі үшін ең жоғары мазмұны тән. Минералдану мен қатты заттарды талдау Индер көлінің тұзды ерітінділерінде, олар: Тұздыбұлақ көзінде 22,3-тен 50,9 есеге дейін; Ащыбұлақ көзінде 17,8-ден 38,5 есеге дейін; Телепбұлақ көзінде 17,1-ден 33,1 есеге дейін, бұл Индер көлінің тұздары тұзды минералды суларға жататындығын көрсетеді.

Зерттеулер Индер көлінің тұзды ерітіндісі натрий хлориді мен кальций сульфатының түріне жататынын көрсетті. Тұздықтардың құрамында ШРМ сәйкес натрий катиондарының мөлшері 40-тан 143-ке, кальций 17-ден 50 есеге дейін; хлоридті аниондар 34-тен 105 есеге дейін; сульфат аниондары 6-дан 101 есеге дейін. Тұздыбұлақ көзінде хлорлы аниондар мен натрий катиондарының мөлшері жоғары, сульфат аниондары мен кальций катиондарының мөлшері Телепбұлақтың қайнар көздерінде жоғары екенін атап өткен жөн. Сонымен, Тұздыбұлақ бұлағының тұздылығы натрий хлоридті, ал Телепбұлақ бұлағы кальций сульфатты түріне жатады. Жалпы минералдану мен қатты заттарға байланысты Тұздыбұлақ бұлағының тұздылығы ең минералданған деген қорытынды жасауға болады.

Сонымен, Атырау облысындағы Индер көлінің емдік балшықтарын физикалық-химиялық зерттеу олардың терапевтік пайдалануға арналған балшыққа қойылатын талаптарға сәйкес келеді деген қорытынды жасауға мүмкіндік береді. Өкінішке орай, Индер көлінің жоғары сапалы емдік балшықтарының зерттелген қорлары аз, сондықтан оларды өнеркәсіптік масштабта пайдалану мүмкін емес.

Түйін сөздер: Тұздыбұлақ, Ащыбұлақ, Телепбұлақ, натрий катиондары, кальций катиондары, хлорид аниондары, сульфат аниондары, тұзды тұз, минералдану, құрғақ қалдық.

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АНАЛИЗ ГИДРОХИМИЧЕСКОГО СОСТАВА СОЛЕВЫХ РАССОЛОВ ОЗЕРА ИНДЕР

Аннотация. В статье дан анализ гидрохимического состава солевых рассолов озера Индер, который состоит из трех источников Туздыбулак, Ащыбулак и Телепбулак. Средний годовой расход воды составляет по источникам: Тузбулак – 12,3 л/сек, Ащыбулак – 7,84 л/сек и Телепбулак – 9,18 л/сек. Грязь озера иловая с сильным запахом сероводорода. Содержание воды в пелоиде 30-35%, а сернистого железа – около 42 граммов на кг грязи, концентрация солей очень высокая – более 200 грамм на кг сырой грязи. Кристаллический скелет состоит из карбонатов и сульфатов кальция. Индерская грязь однородная черная, маслянистая, липкая с запахом сероводорода. Встречаются участки, засоренные песчаными частицами [5].

В 100 граммах пелоида содержится сероводорода – 250 мг, органических веществ – 1,54 гр; карбонатов в пересчете на карбонат кальция – 8,5, удельный вес – 1,56; теплоемкость – 0,32 калорий. Запасы пелоидов в озере значительные.

По основным физико-химическим показателям грязь озера Индер относится: по содержанию водорастворимых солей в грязевом растворе (в г/л) – соленасыщенным (более 150), по содержанию сульфидов (FeS в процентах к естественной грязи) – сильносульфидным (более 0,50), по реакции среды (pH) – слабощелочным (7,0-9,0) [6].

Водная вытяжка грязи озера Индер состоит (г/л): кальций 0,29; магний 0,40; натрий 0,47; калий 0,05; карбонаты не обнаружены, гидрокарбонаты 0,009; хлориды 2,70; сульфаты 1,20 и плотный остаток 6,20, при значении pH -7,27

Проведенный анализ показывает, что содержание хлоридов составляет на Туздыбулаке от 19538 мг/л до 36868 мг/л в периоды исследований с 1961 до 2017 г., что превышают предельно-допустимую концентрацию в 55, 8-105,3 раз.; на Ащыбулаке от 12880 мг/л до 28080 мг/л, превышение составляет 36,8-80,2 раз; на Телепбулаке от 11900 мг/л до 26000 мг/л с превышением 34-74,3 раз. Анализ по натрию показал, что на Туздыбулаке составляет 10877 мг/л -28680 мг/л с превышением предельно-допустимой концентрацией 54-143,4 раз; на Ащыбулаке от 8430 мг/л до 21697 мг/л при превышении в 42,2-108,5 раз; на Телепбулаке от 8010 мг/л до 18280 мг/л при превышении 40,05-91,4 раз. Данный анализ показывает, что данные рассолы относятся к хлоридно-натриевому типу, при этом наиболее соленым по натрию и хлоридам является источник Туздыбулак. По содержанию катионов кальция на источнике Туздыбулак варьирует от 860 мг/л до 1499 мг/л, что в 573,3-999,3 раза больше предельно-допустимой концентрации; на источнике Ащыбулак от 930 мг/л до 1325 мг/л, что в 620-883,3 раз выше ПДК; на источнике Телепбулак от 1000 мг/л до 1980 мг/л, что в 666,7-1320 раз превышает ПДК. По сульфат-анионам на источнике Туздыбулак от 4096 мг/л до 20077,85 мг/л, что в 8,2-40,2 раза выше ПДК; на источнике Ащыбулак от 3370 мг/л до 10841,54 мг/л, что в 6,74- 21,6 раз превышает ПДК; на источнике Телепбулак от 3360 мг/л до 50816,14 мг/л, что в 6,72-101,6 раз превышает ПДК. По сульфатно-кальциевому типу наиболее высокое содержание характерно для источника Телепбулак. Анализ по минерализации и сухому остатку показывает, что в солевых растворах озера Индер они превышают: на источнике Туздыбулак от 22,3 до 50,9 раз; на источнике Ащыбулак от 17,8 до 38,5 раз; на источнике Телепбулак от 17,1 до 33,1 раз, что показывает, что рассолы озера Индер относятся к рассольным минеральным водам.

Исследования показали, что солевой раствор озера Индер относится к хлоридно-натриевому и сульфатно-кальциевому типу. В составе рассолов, согласно ПДК, превышает содержание катионов натрия от 40 до 143 раз, кальция от 17 до 50 раз; анионов хлорида от 34 до 105 раз; анионов сульфата от 6 до 101 раза. Необходимо отметить, что содержание анионов хлора и катионов натрия выше на источнике Туздыбулак, содержание сульфат анионов и катионов кальция выше на источнике Телепбулак. Таким образом, рассол источника Туздыбулак относится к хлоридно-натриевому, а источника Телепбулак – к сульфатно-кальциевому типу. В зависимости от общей минерализации и сухого остатка можно сделать вывод, что к наиболее минерализованным относится рассол источника Туздыбулак.

Таким образом, физико-химическое изучение лечебной грязи озера Индер Атырауской области позволяет сделать вывод об их соответствии требованиям, предъявляемым к грязям для лечебного использования. К сожалению, изученные ресурсы высококачественной лечебной грязи Индерского озера незначительные и использовать их в промышленном масштабе не представляется возможным

Ключевые слова: Туздыбулак, Ащыбулак, Телепбулак, катионы натрия, катионы кальция, хлорид-анионы, сульфат-анионы, солевой рассол, минерализация, сухой остаток.

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