Natural mineral waters of the Chechen Republic: current usage and prospects for development

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Abstract. The article analyzes the natural mineral waters of the Chechen Republic which are a leading factor in the formation of a sanatorium and health resort base. The conditions of formation and distribution of natural mineral waters on the territory of the Chechen Republic are studied, their classification by chemical composition, general mineralization and balneological properties is presented. Five water-bearing zones within the region are identified and characterized. A brief historical analysis of the research and development of mineral springs is given. A detailed description of mineral springs from the point of their use for balneological purposes is given. On the territory of the Chechen Republic, there are mineral springs with various chemical composition and balneological properties, which are comparable by some properties to the best world analogues, and this creates significant prerequisites for expanding the existing sanatorium and health resort base. At this stage, the main focus should be concentrated on meeting domestic needs, solving the problem of recreation and treatment of residents of the Chechen Republic, and in the future, it should be focused on the development of domestic and international tourism and recreation.

1. Introduction

Mineral natural drinking waters include waters extracted from aqueous layers or aquifer systems protected from anthropogenic impact, preserving their natural chemical composition and related to food products, and with increased mineralization or content of certain biologically active components, have a therapeutic and preventive effect. They do not include mixtures of groundwaters from aqueous layers with different conditions of formation of hydrochemical types, groundwaters of different hydrochemical types, natural mineral water with drinking water or with artificially mineralized water. Mineral drinking water must be clear, colourless or yellow to greenish liquid with a taste and a smell characteristic of the contained substances. Mineral water may precipitate the contained mineral salts. The study of the composition, functional properties and mechanisms of action of natural mineral drinking water is of considerable theoretical and practical interest. Rational use and protection of underground water is a national task [13]. In the Chechen Republic, on the territory of which there are mineral waters with diverse chemical composition and balneological properties, the relevance of this problem increases significantly in the context of assessing the prospects of development of the tourist-recreational sector, in general, and the sanatorium and health resort complex, in particular [2, 11, 12].
In general, the role of mineral natural drinking waters in improving the health of the population can hardly be overestimated [4, 5, 14].

2. Materials and methods.
The article was prepared using stock and published materials on natural mineral waters. The main research methods were analysis, generalization and systematization of the materials.

2.1 The classification of drinking mineral waters.
Depending on the total mineralization, mineral waters are divided into fresh (mineralization up to 1 g/dm³ inclusively), weakly-mineralized (more than 1 to 2 g/dm³), low-mineralized (more than 2 to 5 g/dm³), medium-mineralized (more than 5 to 10 g/dm³) and high-mineralized (more than 10 to 15 g/dm³).

Depending on the application, there are table, therapeutic-table and curative-mineral drinking mineral waters. Table waters include mineral waters with mineralization of less than 1 g / dm³ and with a content of biologically active components of less than the accepted concentration. Table waters are suitable for daily use by healthy people without any restrictions. The therapeutic-table waters include mineral waters with mineralization of more than 1 g and up to 10 g/dm³ inclusively at a concentration of biologically active components less than the accepted norms, or mineral waters with mineralization of less than 1 g/dm³, but with exceeding of some biologically active components the established norms. The therapeutic-table waters are allowed for table consumption by healthy people without any restrictions for a short period or irregularly. They can be used for the prevention and treatment of certain diseases. The curative water category includes mineral waters with mineralization greater than 10 g/dm³ or with lower mineralization, but with exceeding of the concentration of some biologically active components the established norm. The curative-mineral waters are prescribed for therapeutic and prevention use in certain diseases and are not recommended for regular table drinking.

The classification of mineral waters by chemical composition allows distinguishing the following classes: hydrocarbonate, chloride, sulfate, mixed, biologically active and sparkled. There is another interpretation of this classification (by ionic composition): hydrocarbonate (alkaline), sulfate, chloride, magnesian, ferrous, etc. Hydrocarbonate (alkaline) waters are intended for those who are engaged in sports because they have a favourable effect on the increased work of muscles, help restore the reserve blood alkalinity, they are also recommended in cases of diabetes, infectious diseases, for the treatment of urolithiasis and gout. They are contraindicated for people suffering from gastritis since carbon dioxide released during the decomposition of hydrocarbonates stimulates the secretion of gastric juice. Sulphate waters are recommended in the treatment of liver and gallbladder diseases, due to their choleretic and laxative effects, as well as in the fight against obesity and diabetes [8]. For children and adolescents, this water is contraindicated because sulfates interfere with the growth of bones, binding the calcium of food into insoluble salts in the lumen of the gastrointestinal tract. The active role of chloride waters in improving the functioning of the intestines, bile ducts and liver has been proven, but they can not be used in cases of high blood pressure. Magnesian waters are recommended for stressful situations if there is no tendency to stomach disorders.

Depending on the gas composition and the presence of specific components, mineral waters are divided into carbonate, sulfidic (sulfurated), nitrogenous, silicic, bromic, iodic, ferrous, arsenic, radioactive, etc.

Carbonate waters of recent folded structures are common in the Caucasus, Pamir, Sayans, Kamchatka, Transcarpathia, Southern Tien Shan, Transbaikal, etc. These waters belong to the well-known types of mineral waters – North Caucasian Narzan (and Burkut -Carpathian Narzan), Borjomi (Georgia), Arzni (Armenia) and Yessentuki (the Caucasian Mineral Waters). Nitrogenous waters often delineate the distribution areas of carbonate mineral waters and are associated with zones of tectonic faults and fractures of igneous rocks. Nitrogenous mineral waters are known in the Tien Shan and Altai, and hot nitrogenous waters are known in Tbilisi, Krasnodar, and Pyatigorsk. Hot radioactive mineral waters are found in Kyrgyzstan, Georgia, the Caucasian Mineral Waters and the Altai territory, as well as in the Khmelnytsky group (Khmelnyk, Vinnystia region), the Mironovka group (Mironovka, Kiev region), the Polonsky group of resorts (Polonnoe, Khmelnytsky region), and others.
Sulfurated mineral waters are distributed on the Black Sea coast of the Caucasus (Sochi-Matsesta, as well as Kudepsta and Khost) and the Caucasian Mineral Waters (Pyatigorsk, Haazo-Ponomarevsky source of Essetntuki), in Dagestan (Talgi) and Tersko-Sunzhenskaya hills (Sernovodsk-Kavkazsky), in the Carpathian region (Truskavets, Nemirov, Velikiy Luben, Shklo) and the Urals, the Ferghana valley, etc. Sulfurated and iodine-bromic mineral waters accompany oil fields and natural gas, as well as gases from volcanic eruptions. Glauber, salt and salt-alkaline mineral springs are known in the foothills of the Carpathians and Crimea, in the region of the Dnieper-Donets basin (the most famous of them are in Truskavets Morshyn, Lviv region and Mirgorod, Poltava region).

Patterns of mineral water distribution (in general) are determined by geological and structural features, the geological history of the territory, as well as geomorphological, meteorological and hydrological factors. In the area of recent folded structures, carbonate and nitrogenous mineral waters are often found. The deep-lying parts of submountain basin are characterized by highly mineralized mineral waters and even brine enriched with hydrogen sulfide. In the deep layers of the platform depressions, calcium-chloride and sodium-chloride waters are common; above lies the zone of sulphate waters and, finally, in the highest zone – water of the hydrocarbonate type. Mineral waters of various chemical composition are found within the boundaries of crystal arrays and shields. Radioactive mineral waters are more often associated with acidic crystalline rock formations.

Mineral water can be ground (poured out to the surface by gravity flow) and pressure (artesian, gushing).

3. Discussion of results

3.1 The general characteristics of underground aqueous layers, mineral and fresh drinking waters of the region

In terms of freshwater reserves per person, the Chechen Republic occupies one of the leading places in Russia. According to hydrogeological research reports and some published studies, there are more than 600 springs of freshwater on the territory of the Chechen Republic. Many of them do not have a sanitary control and protection zone around them, as well as a water storage facility. The Chechen Republic generally does not lack water resources, both surface and underground. On the territory of the Chechen Republic, it was revealed the significant resources of underground water, diverse in their physical and chemical parameters - fresh, mineral and thermal. The operational reserves of these types of water are significant in volume and can provide almost unlimited possible demand.

The geological-hydrological and structural-tectonic features of the territory of the Chechen Republic are determined by its location in the southern part of the East Pre-Caucasian Artesian basin, at the junction of the mountain-folded region of the Greater Caucasus and the Pre-Caucasian forward deflection. Within the East Pre-Caucasian Artesian basin, two hydrological structures are separated on the territory of the Chechen Republic: the Sunzhensky and Tersko-Kumsky basins of underground waters. Fresh groundwater reserves in the region are distributed unevenly. Only the central part is assessed as sufficiently provided with underground water for domestic drinking water supply. The problem of the northern and southern parts of the territory with drinking-water supply can be solved increasing the available reserves by intensifying exploration activities. In general, there are five aquifer zones within the territory of the Chechen Republic:

1. The South-Eastern Tersko-Kumsy basin (the territory located to the north of the Tersk ridge). Water-bearing complexes are represented by the Old Caspian deposits ( sands, sandstones); the Apsheron deposits (sands, sandstones of various grains); the Caragana-Chockrack deposits (dense medium and fine-grained sandstones containing thermal and balneological waters). The depth of aquifers /Q, Q psh/ is 250-300 m, sometimes up to 600 m. Thermal waters are found at depths of up to 3,000 m.

2. The zone of Front Range. Thermal mineral (balneological) waters are here related to the Caragana-Chockrack sandstones. The depth ranges from 0 to 1,500 m, and sometimes up to 2,000 m.

3. The Alkhanchurt valley. Deposit complexes from the Quaternary to the Akchagyl Formation (exclusively) with a depth of 200-400 m, sometimes up to 500 m.
4. The Sunzhskaya valley. The aquifers are related to deposits from the Quaternary to the Akchagyl Formation exclusively, represented by pebbles (the Apsheron deposits), sands and sandstones;

5. The Chernogorskaya monocline. The stratigraphic range of aquifers is very extensive, including the Mesozoic deposits. The main aquifers are concentrated in the Quaternary and Caragan-Choerack deposits. Their depth ranges from 0 to 1,000 m, and sometimes up to 3,000 m (the Benoyskaya area). The layers are related to sandstones of varied grain sizes. Water availability is from 5-10 l/s to 50-60 l/s.

Mineral waters are mainly widespread in zones of deep circulation of aquifers of the Miocene, Cretaceous and Lower Jurassic periods. Mineral underground waters on the territory of the Republic are known and studied in the valley of the Chanta-Argun river, on the slopes of the Gudermes and Bragun ranges. Mineral waters come out as springs and are opened by wells, they are diverse in their composition. The famous mineral springs are Sernovodsky, Vedensky, Bragunsky, Gudermessky, Argunsky, etc. The healing power of these springs has been known since ages ago. Long before it became known in Russia about the Sernovodsky hot springs, they were already used by residents.

3.2 The brief description of mineral springs.

The Goryachevodsky springs were divided into the western and eastern ones. The western springs are related to the sand layer of the Lower Chokrak, and the eastern ones – to the XIII layer of the Caragan horizon [7]. In 1849, based on these springs, a sanitary treatment station was built, which later became a large sanatorium-resort complex that received up to 1,000 people in the summer [9]. Due to the exhaustion of springs in 1929, the medical treatment facility was closed. Currently, the Goryachevodsky mineral springs have been restored.

The Mikhailovsky (Sernovodsky) springs are represented by infiltration, sulfate-hydrocarbonate-sodium and thermal hydrogen sulfide chloride-hydrocarbonate-sodium waters. They are associated with the sandstones of the Chokrak period. Water mineralization reaches 15 g/l, the content of silicon dioxide is more than 50 mg/l. The water flow rate is 305 m³/day, and the temperature is – 62/63°C. In 1848, a Cossack military hospital and a Department based on mineral springs were opened. In all literary sources, the Sernovodsky mineral waters are described as curative, with a therapeutic effect in diseases of the cardiovascular and musculoskeletal system, gastrointestinal tract, rheumatism and traumatism [3, 10, etc.]. Since 1950, the Sernovodsk-Kavkazsky resort was included in the catalogue of the best resorts and sanatoriums of the former USSR. In 1978, the sanatorium had 505 beds [7]. At present, the flow rate of the springs is 30-32 m³/day, the temperature is 24-29°C. The thermal (up to 73°C) sulfide chloride-hydrocarbonate sodium waters with mineralization of 3.4 g/l, containing 60 mg/l of hydrogen sulfide, as well as magnesium, bromine, iodine, silicic acid of the water spring “Serniy” is used for taking baths. Sulphate-hydrocarbonate sodium water of the source “Sodovy” with mineralization of 4.6 g/l, contains 0.6 g/l of free carbon dioxide, is used for drinking treatment and bottling at the Sernovodsk plant of mineral waters. In the past, the resort had more than 20 mineral springs with a flow rate of about 1,000 cubic meters of water per day. There are only 6 springs currently operating at the resort. Among them, 2 springs are operated (No. 1 and No. 4) with a total flow rate of 700-750 cubic meters per day. The Mikhailovsky (hydrogen sulfide) springs are a priceless gift of nature. Springs of hydrogen sulfide are the main natural therapeutic factors of the “Sernovodsk Caucasian” resort. The water of the Mikhailovsky (hydrogen sulfide) springs belongs to the waters of thermal sulfide, siliceous and low-mineralized sodium hydrocarbonate-chloride composition.

The Isti-Sui springs demand special attention. There are 4 groups of springs located on the northern slope of the Gudermes range, at 12 km south-east of the city of Gudermes. The highest rate group is the eastern one with a flow rate of approximately 1,470 m³/day and a temperature of 72-75°C. The formation was explored in 1987. The water type is chloride-hydrocarbonate-sodium and chloride-hydrocarbonate-sulfate, with mineralization of 1-7 g/l, sodium-hydrocarbonate with mineralization of 3-5 g/l, iodine-bromine, sodium-chloride with mineralization from 15-16 g/l to 40-60 g/l. Low-alkaline, high-thermal waters can be used for the treatment of diseases of the musculoskeletal system, nervous, skin, and gastrointestinal diseases. The approved reserves of category A+B+C are 766
The area of the Isti-Sui springs is promising for the placement of a sanatorium and resort complex.

The Bragunsky springs located on the northern slope of the Bragun ridge near the village of Darbankhi, to the south-western direction from the village of Braguny. These springs have been known for a long time. As noted above, in 1717 G.Schober examined these springs. Until 1938, there was a small sanatorium with 100 beds [1, 9]. The Bragunsky springs include 11 natural mineral water springs with different physical and chemical composition. It is known that the "Star" spring is the most effective. The water type is sulphate-chloride-hydrocarbonate-sodium, with mineralization of 1.3 g/l, the temperature is 96°C. At present, a new hydrotherapy centre is being built here [9].

For a long time, the Kuroysky and Baskhaisky carbonate, salt-alkali springs (like Narzan) located in the upper part of the river Chanti-Argun are popular among the locals. The Shandulinsky carbonate, salt-alkali spring (like Narzan) is located on the right slope of the gorge of the river Khakhichu, on the right-bank tributary of the river Chanty-Argun, with the flow rate is 4,000-6,000 l/day. The Chishkinsky hydrogen sulfide-chloride-sodium springs are related to the valley of the Chanta-Argun river in the Yarysh-Mardy region. There are two groups of springs on the right and left banks of the river Chanta-Argun. By chemical composition, they are analogues of the world-famous Matsestinsky springs, and their total flow rate is more than 2,000 m³/day. The highest value in balneological terms is the upper group (on the left bank of the river) with a total flow rate of about 1,000 m³/day [7].

The Chanta-Argun springs were discovered in 1985 based on long-known springs in the valley of the Chanta-Argun river and they are associated with the Miocene sandstones. The type of mineral waters is sodium chloride with mineralization of 9.3 g/l. The flow rate of the springs is 1,350 thousand m³/day. The area of springs is promising for sanatorium and resort construction. The waters have a balneological significance. The waters are recommended for the treatment of certain diseases of the cardiovascular system, central nervous system, gynaecological and other diseases. Today the formation is not being exploited.

The Shatoysky (Uschkaloysky) spring of sulfate and calcium sulfide waters is related to gypsum and limestone of the Upper Jurassic period. The salty spring is located on the right bank of the Martan river, in the distance of 4 km south of the village of Grushovoe. From the location of the spring, a stream flows into the Martan river [6]. Mineral springs similar to many well-known types of waters are predicted in the Benoyskaya, Vedenskaya, Elistanzhinskaya and other areas of the Chechen Republic.

4. Conclusion.

The Chechen Republic has a significant potential for drinking mineral and freshwaters in the form of spring rivers and springs, waters of artesian horizons, mineral water springs, etc. The patterns of mineral water distribution are determined by the specifics of geological and structural areas, the geological history of the region, geomorphological, meteorological and hydrological conditions. Mineral waters in the Chechen Republic are mainly defined to the zones of deep circulation of aquifers of the Miocene, Cretaceous and Lower Jurassic periods. Natural mineral drinking waters of the Chechen Republic are similar to hydromineral resources of other regions of the Caucasus. There are mineral waters with a wide range of balneological properties (Grozny, Shatoysky, Gudermessky and other areas), which several centuries ago were recommended as the base formations for providing health resorts. The region has prerequisites not only for the sanatorium and resort construction but also for the development of various types of tourism, including medical and health tourism. Nowadays, in the region, there are cases of spontaneous (unorganized) usage of mineral resources by the local population. Also, the special regime of water protection zones is not always observed, which is associated with serious environmental risks. Meanwhile, the rational use and protection of natural mineral drinking water are of great practical importance for both living and future generations, which meets the principles of the concept of sustainable development recognized by the world community.
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