Ecological condition and economic use of springs of the Chuvash Republic

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Abstract. The object of the study is the hydrological and ecological characteristics of the springs of the Chuvash Republic. The springs of the region are of great economic importance. They are used for household and drinking water supply, for recreation and protection of unique landscapes. Intensive development and lack of improvement measures have led to the fact that the water quality in the springs is decreasing. The landscapes of the surrounding territories are oppressed. The study of the state of the springs is carried out by expeditions. During the visits, the ecological state of the springs is described, water samples are taken for physico-chemical analysis. The recreational significance of the sources for the development of a set of measures to optimize economic development is also described. Most of the springs of the Chuvash Republic belong to low-flow freshwater sources with medium water hardness. When moving from north to south, an increase in hardness and mineralization is observed. The flow velocity is the highest for alluvial deposits. The sources of the region belong to the following types: household and drinking, cultural and recreational and protected. All the studied springs perform an economic and drinking role. Sources related to protected sites – specially protected areas - have the greatest recreational value (very high level). The cultural and recreational role is to create fonts, conduct excursions to the springs. 75% of the springs are used daily. There are seasonally used and abandoned springs. To develop a program for optimizing the economic use of springs, it is proposed to compile a Register of springs of the Chuvash Republic. It will include the physico-chemical and landscape characteristics of the springs. Having such a database will allow you to determine the order and ways to solve problems related to the use of springs.

1 Introduction

he Chuvash Republic belongs to the Volga-Kama Artesian basin, located on the East European Plain. The Volga-Kama basin is distinguished by the high water content of aquifers. In turn, the dense erosive dissection of the plain led to the formation of a large number of areas of discharge of aquifers – springs (Fig. 1). Intensive economic development of the territory of the Chuvash Republic led to the fact that the springs were actively used for economic and drinking purposes. A dense network of rural settlements was created near drinking water sources, which were primarily springs. That is why only the number of well-

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maintained, used springs in the Chuvash Republic reaches 1,500 units. Thus, the density of used springs is 0.1 units per 1 sq. km. Most springs were actively used before the introduction of central water supply systems. At the present stage, well-maintained springs serve as an alternative water supply. They are used in case of water supply failures, power outages, and in dry seasons. The ecological and cultural role of springs has also increased in recent decades. In the Chuvash Republic there are springs – holy springs, specially protected natural areas. Some of the springs are used for educational purposes as stations of ecological trails.

At the same time, some of the springs are in critical ecological condition. A complex of factors contributed to the appearance of substandard springs: the moral deterioration of captcha devices, intensive use of springs, misuse, economic development of nearby territories. Therefore, the issue of determining the ecological state of springs is very acute.

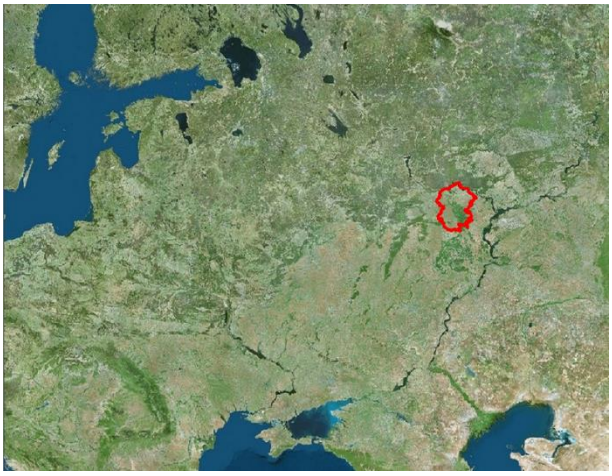

Fig. 1. Geographical location of the Republic of Chuvashia.

2 Materials and methods

The purpose of this study is a comprehensive study of the ecological status and intensity of economic use of springs in the Chuvash Republic. The following indicators describing the springs were studied: the type of economic development, the intensity of economic use, the ecological state of the springs, the degree of well-being of the springs, the physical parameters of the springs, the quality of water in the springs, recreational potential.

According to the type of economic use, springs are used for the following purposes:

1) household and drinking water supply;
2) holy springs;
3) natural monuments;
4) environmental education;
5) recreational;
6) historical and cultural [1].

The most common are springs of drinking and household water supply [2]. Rural festivals, religious rituals, and ablutions are held on the territory of the holy springs. The ecological and educational role of springs is to conduct excursions and open environmental lessons for schoolchildren and students on their territory [6]. Natural monuments are springs of special conservation status, distinguished by unique physico-chemical characteristics [3]. They are protected by the state. The recreational role is played by springs confined to large settlements and highways. These springs are equipped with gazebos, benches, tables, playgrounds,

barbecues. Springs associated with outstanding historical events and facts have historical and cultural significance. Excursions among tourists and the adult population are often conducted on their adjacent territory [7].

According to the intensity of use, springs are divided into:

1) regularly used;
2) used periodically;
3) seasonally used;
4) rarely used;
5) abandoned [5].

Regularly used springs are confined to rural areas without running water. Periodically used are springs, the value of which increases when the water supply is broken, there is no electricity supply, in dry years and seasons. Some of the springs are used only seasonally – during baptism, tempering, or by shepherds in the warm season. Springs that are rarely used include springs where the water quality has temporarily deteriorated due to anthropogenic influence. Basically, these are springs located next to active buildings, livestock complexes, which have broken drainage devices. Abandoned springs are those with completely outdated landscaping elements, or located far from residential buildings [9, 10].

The ecological condition of the springs includes an assessment of water quality and the preservation of the landscapes of the territory adjacent to the springs. Springs are distinguished by their ecological safety:

1) undisturbed;
2) violated [8].

Undisturbed springs are characterized by high water quality and preservation of the natural state of the surrounding landscapes. Disturbed springs are distinguished by exceeding one or more indicators of chemical composition from the values allowed by standards, deterioration of the ecological condition of the territory adjacent to the springs [4].

The following were selected and studied as the main physical indicators of spring water: water temperature, flow rate of the spring, location, type of spring (ascending or descending).

Among the chemical indicators were described: the content of chlorides, nitrites, nitrates, sodium, ammonium, iron, sulfates, hydrogen index, total hardness.

3 Results

During field expeditionary research in the summer of 2024 and the collection of personal data among the local population, factual material was collected on 520 springs of the Chuvash Republic, from which 55 springs were selected - key sites, information on which is the most complete and reliable. Certification of 55 springs as key sites included the collection of physical parameters, chemical analysis, and the environmental condition of the surrounding area. The analysis showed that 51 springs (94%) are descending. The rest of the springs belong to the ascending springs. Other physical indicators depend on the level of improvement of the springs.

The temperature of spring water ranges from 4 to 12 ° C. The average water temperature in the springs left 7-8 °C. The presence of drainage devices, long gutters and pipes leads to a slight increase in water temperature.

According to the amount of flow, springs are divided into high-flow, medium-flow and low-flow. 51 springs out of 55 belong to the low-income (92%). Only 4 of the studied springs belong to the medium-sized ones. No high-flow springs were found. The average flow rate of the springs of Chuvashia is 0.2-0.4 l/s.

The region is dominated by springs used for drinking water supply. All the studied springs were landscaped and developed primarily for subsequent use for drinking purposes. Some of the studied springs have a special environmental or cultural status (Fig. 2).

About 100 springs in the Chuvash Republic are consecrated and belong to holy springs (for example, No. 3,4,6, etc.). Such springs are approximately evenly distributed throughout the region and have the best indicators of well-being and ecological condition. They are used by local residents for religious rituals and ablutions.

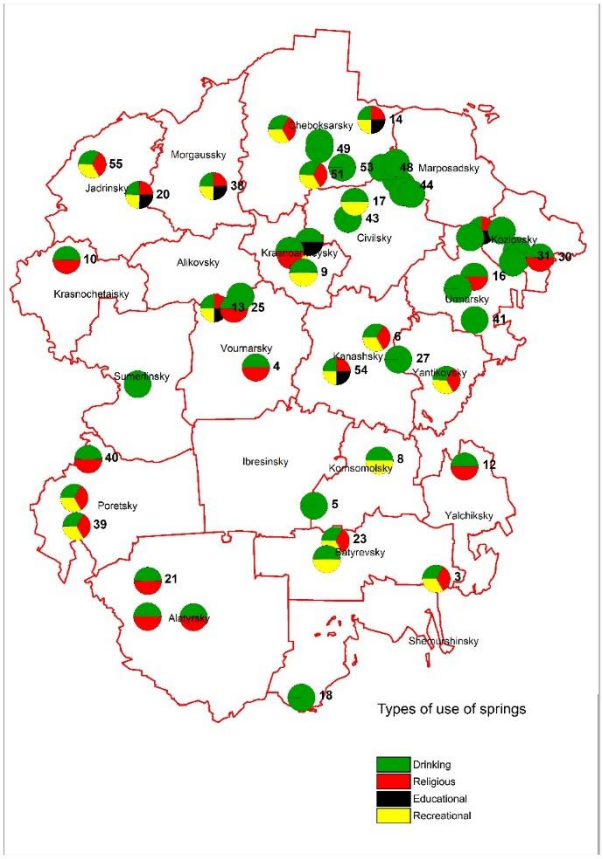

Fig. 2. Using the springs of the Chuvash Republic.

Springs related to natural monuments are singled out separately (for example, No. 7 – Baigulovsky spring). They have a conservation status due to their unique hydrological or chemical characteristics. The nature conservation status prohibits any economic activity that may lead to a deterioration of the environmental situation in the territory adjacent to the springs. There are 19 similar springs in the Chuvash Republic.

Some of the springs are used by teachers, educators and environmentalists for ecological and educational purposes (for example, No. 35 – D. Rear Karyki of the Red Army District). They are stations of ecological trails. Here you can add photos of children exploring the spring.

The presence of such landscaping elements as paths, benches, canopies and barbecues attract the local population and tourists to the springs. Some of the springs (for example, No. 8 – village of Malye Koshelei Komsomolsky MO) were purposefully landscaped for recreational purposes. It is precisely such springs that experience the maximum anthropogenic load.

Only about 75% of the springs are used in the region on a regular basis. About 20% of the springs are used periodically – in case of shortage of tap water, lack of electricity, in

religious ceremonies. During field trips, springs were identified that are used seasonally – in the summer by shepherds or for watering livestock. These are springs No.45-46 d. Also the reservoirs of the Civil MO, the springs of the Shemurshinsky MO. Several springs are completely abandoned. The spring of the village of Togaevo of the Mariinsko-Posadsky MO has a destroyed drainage system. The spring of D. Karabashi of the Mariinsko-Posadsky MO is used for watering livestock. The proportion of completely abandoned springs is about 1% of the total.

The chemical analysis of spring water was carried out using the knapsack laboratory of the Knapsack Field Laboratory for the study of reservoirs "NKV-Rm". A total of 10 chemical parameters were analyzed. The hydrogen pH in all the obtained samples does not exceed the permissible values (from 6.9 to 7.5). The total mineralization of spring water in the Chuvash Republic varies from 0.07 g/l to 0.6 g/l with an acceptable threshold of 1.0 g/l. The water is ultra-fresh and fresh. When moving from north to south-east, there is a gradual increase in the total hardness of the water. The average water hardness in the region is 5-7 mg-eq/l. In the extreme southeast, the hardness value increases to 10 mg-eq/l (with an acceptable 7 mg-eq/l). In the studied samples, there was no excess of sodium ions, nitrates and nitrites. The excess of ammonium, iron, sulfates and chlorides is observed point-by-point. Of the substandard springs, those in which there is an excess of ammonium indicators prevail. These are springs located close to livestock complexes and outbuildings. Their share does not exceed 1% of the total number of springs. There are also separate springs in which there is an excess of sulfates and chlorides (spring D. Ivankovo, Yadrinsky MO), iron ions (spring of the village of Akshiki, Mariinsko-Posadsky MO), general hardness (spring of the village of Bichurg-Baishevo, Shemurshinsky MO). Studies have confirmed that the water quality in the vast majority of springs meets the necessary requirements.

78% of the studied springs are in satisfactory condition. They belong to the undisturbed. About 13 springs can be attributed to partially or completely disturbed ones. In most cases, these are abandoned springs. The lack of supervision leads to the fact that the installation devices are not protected by a fence. A common problem is the wear of drainage tanks and pipes.

4 Discussion

The study of the physico-chemical parameters of spring water made it possible to draw up a map of the zoning of springs (see Fig. 3). Springs differ in flow rate, mineral composition, hardness and water capacity.

It can also be noted that the number of springs (landscaped and not landscaped) decreases when moving from north to south. The decrease in the total number of springs to the south is explained by a decrease in the erosion division of the territory. The decrease in the number of well-maintained springs is associated with a decrease in the density of rural settlements in the direction from north to south.

The proportion of disturbed springs is higher in urban settlements. Intensive urban construction leads to the degradation of springs. For example, pile construction in Cheboksary led to a decrease in the flow rate of the spring on the "Rivermen Square" by 7 times and to the complete disappearance of the spring during the construction of the Cascade shopping mall behind the Central House of Creativity and Youth of Cheboksary. Clogging of the nature reserve area reduces the water quality (Hopeless ravine spring, Novoselsky springs in Cheboksary).

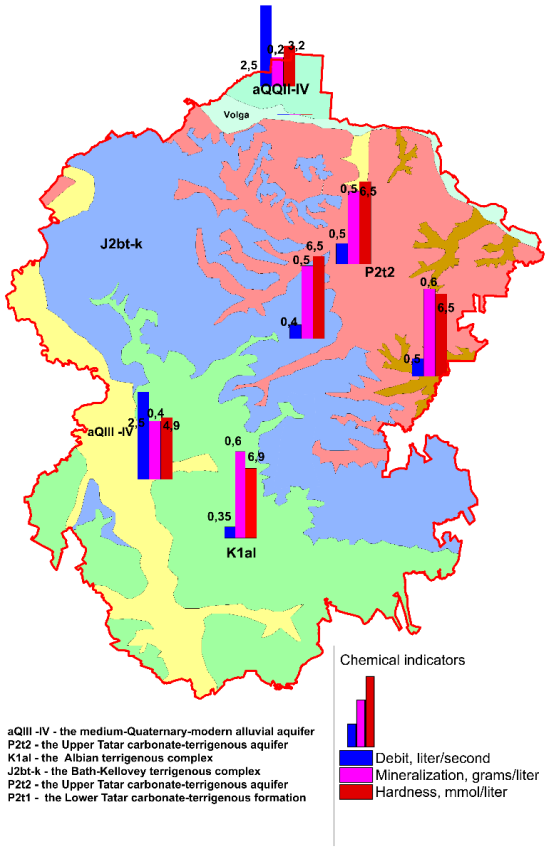

Fig. 3. Chemical parameters of spring water in the Chuvash Republic.

Degradation of springs in rural areas occurs due to pastoral livestock farming, erosion flushing, and the flushing of fertilizers from fields. This leads to an increase in the level of ammonium and nitrates.

5 Conclusion

The proximity to the Volga-Kama Artesian basin and the high erosive fragmentation of the Chuvash Republic led to the formation of numerous springs. A dense network of rural settlements contributed to the active improvement and use of springs for drinking and other purposes. The springs of the Chuvash Republic differ in different flow rates (from 0.01 l/s to 8.8 l/s), dry residue (0.2-0.6 g/l) and total hardness (from 3.2 to 11 mg-eq/l). Initially, the springs were used only for household and drinking water supply. Recently, the religious, ecological, educational, and recreational role of springs has been increasing. This leads to an increase in substandard, disturbed springs. In order to optimize the economic use of springs and improve the ecological condition, a unified Register of springs is being created. The register of springs includes summary information on the physical parameters, chemical composition and environmental condition of the territories adjacent to the springs. It will facilitate decision-making on the improvement of springs and improve the supervision of their environmental condition.

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References

1. M. Filippini, S. Segadelli, E. Dinelli, M. Failoni, C. Stumpp, G. Vignaroli, T. Casati, B. Tiboni, A. Gargini, Science of The Total Environment **913**, 169770 (2024)
2. J. Jalali, M. Shademani, M. Paripour, M. Jalali, Groundwater for Sustainable Development **24**, 101082 (2024)
3. A. L. Hakim, D. D. Saputra, L. Tanika, I.A. Kusumawati, R. R. Sari, F. Andreotti, M. Bagbohouna, A. Y. Abdurrahim, C. Wamucii, E. G. Lagneaux, M. Githinji, D. Suprayogo, E. N. Speelman, M. van Noordwijk, Current Opinion in Environmental Sustainability **62**, 101292 (2023)
4. M. Kiwanuka, H.E. Mutanda, J.B. Niyomukiza, E. Nakasagga, Environmental Challenges **10**, 100667 (2023)
5. A. J. Lewis, S. Kunze, J. M. Mueller, R. A. Fitch, A. E. Springer, Groundwater for Sustainable Development **22**, 100966 (2023)
6. F. Lingua, N.C. Coops, V.C. Griess, Ecological Indicators **149**, 110165 (2023)
7. G. A. Orekhova, Regional Geosystems **48**, 118-130 (2024)
8. A. Pandit, O. Batelaan, V.P. Pandey, S. Adhikari, Journal of Hydrology: Regional Studies **53**, 101752 (2024)
9. S. Pantha, S. Timilsina, S. Pantha, S.K. Manjan, M. Maharjan, Environmental Challenges **9**, 100658 (2022)
10. A. K. Taloor, R. A. Pir, N. Adimalla, S. Ali, D. S. Manhas, S. Roy, A. K. Singh, Groundwater for Sustainable Development **10**, 100364 (2020)
11. V. Nikonorova, V. N. Ilyin, A. A. Ilyina, A. A. Nikitin, BIO Web of Conferences **116**, 03013 (2024)