BIO Web of Conferences **116**, 03013 (2024) https://doi.org/10.1051/bioconf/202411603013
EBWFF 2024

Increasing the ecological and recreational importance of the springs of the Chuvash Republic

Inna Nikonorova[1], *Vladimir* Ilyin[1], *Anastasia* Ilyina[1], and *Andrey* Nikitin[1*]

[1]Chuvash State University I.N. Ulyanova, 15, Moskovsky Prospect, Cheboksary, 428015, Russia

Abstract. The object of the study is the hydrological and ecological description 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. The visits include a description of the ecological state of the springs, water sampling for physico-chemical analysis. The recreational importance of springs 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 with average water hardness. There is an increase in hardness and mineralization indicators when moving from north to south. The flow rate is the highest for alluvial deposits. The springs of the region belong to the following types: household and drinking, cultural and recreational and protected. Springs belonging to protected objects – protected areas - have the greatest recreational significance (very high level). 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. The presence of such a database will allow you to identify the order and ways to solve the problems of using springs.

1 Introduction

The Chuvash Republic is located in the eastern part of the East European Plain and is characterized by numerous elevated areas and depressions, river valleys, deep ravines, a girder network and swampy lowlands (fig. 1). Active erosion activity led to the appearance of a significant number of springs [8]. The springs of the Chuvash Republic are unique natural and historical objects that are part of the natural complex of the Chuvash Republic. All rivers of Chuvashia, including the drinking water supply of Cheboksary, depend on their condition. However, due to the active urban planning and economic activities, the number of springs is decreasing, and the water quality in the springs is decreasing. At the

* Corresponding author: suvar2009@yandex.ru

same time, attention to springs is increasing due to their use as an alternative source of water supply, especially in the southeastern municipalities of Chuvashia. Interest in springs has also intensified in connection with the development of ecological and pilgrimage tourism.

The factors highlighted above lead to a deterioration in the ecological state of the water quality in the springs and the territory adjacent to the springs. In turn, a decrease in the quality of water in springs can lead to a deterioration in the quality of all surface waters. This will also affect the drinking water supply of Cheboksary, the economic use of surface waters in agriculture of the Chuvash Republic.

Fig. 1. Geographical location of the Republic of Chuvashia

2 Materials and methods

The purpose of the study is a comprehensive analysis of the ecological state of springs and the surrounding area to optimize their use in the national economy. To achieve this goal, the following tasks were identified: 1) collection of factual data on springs; 2) analysis of the current state of the springs of Chuvashia; 2) development of a comprehensive program for the restoration of springs.

The most important task of optimizing the condition of springs is their accounting. Sources with natural or anthropogenic (cultivated) "centralized" access to the daytime surface are subject to accounting [2]. Further improvement and economic use of springs involves the installation of pipes, drainage systems, landscaping and other landscaping. Depending on the type of economic use, springs can be divided into the following types according to their intended purpose:

1) springs for household and drinking water supply;
2) environmental,
3) scientific and educational,

4) historical and cultural,
5) recreational.

The complexity of the economy has led to the fact that all types of springs are represented in the Chuvash Republic. The difference of springs in physical, chemical and landscape features has led to the fact that they differ in different ecological, cultural, educational and recreational potential. Therefore, the process of optimizing springs should begin with their study and evaluation [1]. The following components of spring water should be studied: the physico-chemical properties of spring water [4,9], the landscape diversity of the territory adjacent to the springs [10], the degree of anthropogenic influence on the springs, the recreational potential of the springs [5,6].

The value of recreational potential was determined based on the methodology of E.G. Katkova. This technique involves an analysis of the aesthetic attractiveness of the territory adjacent to the springs. The score is based on 9 criteria: 1) the presence of a unified system of landscaping facilities, 2) the aesthetic attractiveness of the territory adjacent to the springs, 3) the presence of a font, 4) compliance with drinking water requirements, 5) aesthetic attractiveness, 6) flow rate, 7) the presence of access roads, 8) the presence of a recreation area, 9) lack of access to the garage, 10) the absence of garbage in the surrounding area. The result of the assessment is the allocation of spring areas with high, medium and low levels of recreational potential. The recreational significance of springs is determined by the sum of the points obtained when evaluating each of the indicators: 0-2 points – very low (unsatisfactory); 2.5-4 points – low; 4.5–6 points – average; 6.5-8 points – high; 8.5-10 points – very high [7]. The selected methodology is qualitative and allows us to assess the recreational potential in absolute terms.

3 Results

There are at least 1,700 springs on the territory of the Chuvash Republic. Most of the springs of the Chuvash Republic are confined to the groundwater outlets of the Volga-Sursky artesian basin of reservoir pressure waters. The left bank of the Volga River is located in the eastern part of the Vetluzhsky artesian basin of reservoir and block-bed pressure waters. The main operational hydrogeological units are:

1) medium-Quaternary-modern alluvial aquifer (aQ_{III-IV});

The springs of this horizon are confined to the deposits of the third floodplain terrace of the Sura and Anish rivers. The water-bearing rocks are multi-grained sands of varying degrees of clay content in the sole with gravel and pebbles. The springs are pressure-free, in places pressure-free. The specific output rates are 0.01 - 1.6 l/s in the Anish River valley and 0.8 - 4.2 l/s in the Sura River valley. According to the chemical composition of the water, calcium-magnesium-sodium bicarbonate waters with a mineralization of 0.3 - 0.5 g/l, with a total hardness of 1.5 - 8.3 mmol/ l. The waters are characterized by an increased iron content up to 8-16 mg/l. They are operated in rural settlements of Poretsky, Sumerlinsky, Krasnochetaysky, Alatyrsky, Yadrinsky, Kozlovsky municipal districts.

2) aquiferous lower Quaternary-modern alluvial, alluvial-fluvioglacial horizon (aQQ_{I-IV});

Springs of this horizon are common in the left-bank part of the Volga River. Geographically located in the northern part of Cheboksary city district. It is confined to the deposits of the floodplain terrace of the Parat River, the remnants of the sub-floodplain terraces of the Volga River, alluvial - fluvioglacial accumulations of the valley zander, buried alluvial deposits. The water-bearing rocks are fine- to coarse-grained sands, clay to varying degrees, with a content of gravel and pebbles. The waters are unpressurized. Land-based and underwater springs are characteristic. The flow rate of springs is extremely uneven: from 0.2 l/s to 8.9 l/s (on average – 4.5 l/s).

The waters are very fresh with a mineralization of 0.1-0.3 g/l, a total hardness of 0.5-5.9 mmol/l. By chemical composition, bicarbonate sodium-magnesium-calcium. The waters are characterized by an increased content of iron up to 10.32 mg/l, manganese - up to 0.85 mg/l.

3) locally low-water resistant Albian terrigenous complex (K_1al);

Springs of the locally weakly water-bearing Albian terrigenous complex (K_1al) are widespread in the southwestern part of the republic's territory on high sections of watersheds. The outputs of springs with a discharge of 0.2-0.6 l/s are noted. Fresh water, with a mineralization of 0.3-0.77 mg/l. The total hardness is 0.6-13.35 mmol/l. The chemical composition is calcium bicarbonate.

4) water-resistant, locally weakly water-bearing Bath-Kellovey terrigenous complex (J_2bt-k);

The springs of the Batsky terrigenous horizon (J_2bt-k) stretch in a wide strip from northwest to southeast, occupying the Yadrinsky, Morgaushsky, Krasnochetaysky, Alikovsky, Krasnoarmeysky, Kanashsky, Komsomolsky, Yalchiksky, Batyrevsky municipal districts. The flow rate ranges from 0.09 l/s to 3.2 l/s (the average flow rate is 0.5 l/s). Water mineralization is 0.13-0.9 g/l, total hardness is 8.8 mmol/l. By chemical composition - from calcium-magnesium bicarbonate to sodium sulfate-bicarbonate. The springs of this horizon are characterized by local distribution, increased hardness and mineralization.

5) the Upper Tatar carbonate-terrigenous aquifer (P_2t_2);

Springs of the Verkhneurzhum terrigenous-carbonate formation (P_2t_2) are widespread in the north-east of the region (Cheboksary, Mariinsko-Posadsky, Tsivilsky, Kozlovsky, Urmarsky, Yantikovsky municipal districts). The flow rate of springs varies greatly by location: from 0.04 l/s to 14 l/s. Freshwater with a mineralization of 0.3-0.65 g/l, a total hardness of 5-8 mmol/dm, and a bicarbonate sodium-calcium composition prevail. When moving from north to south, there is a gradual increase in total mineralization.

6) the aquifer of the Lower Tatar carbonate-terrigenous formation (P_2t_1);

The springs of the Nizhneurzhum carbonate-terrigenous formation (P_2t_1) are confined to the lower parts of river valleys, ravines and gullies in the northern and northeastern parts of the region. The flow rate of springs ranges from tenths of a liter /s to 1.4-2 liters / s, rarely more. The chemical composition of the waters varies from calcium-magnesium bicarbonate with a mineralization of 0.2-0.9 g/l, with a total liquid of 0.2 - 13.5 mmol/l in the northeastern, eastern regions to sodium sulfate with a mineralization of up to 4.1 - 4.9 g/l, with a total hardness of up to 8.7 mmol/l to the west.

Thus, most springs of the Chuvash Republic are low-flow, with an average flow rate of 0.1-0.3 liters per second. Territorial differences in the flow rate across the region are poorly traced. An increase in flow rate is observed at springs originating in modern alluvial deposits. The territorial differentiation of total mineralization is influenced by 2 parameters: the host rocks and the moisture coefficient. When moving from north to south, there is a general tendency to increase mineralization from 0.2 g/l to 0.6 g/l. The hardness of spring water is minimal at springs of alluvial deposits (3.2 mmol/l) and is of the greatest importance at springs of the Bath terrigenous horizon (up to 8.8 mmol/l) (Figure 2).

The springs of the Chuvash Republic are used by the population for various purposes. Most of the springs are landscaped for domestic drinking water supply. In large settlements, they serve as a source of alternative water supply, in rural areas they can be the main source of drinking water. The introduction of centralized water supply technology has a twofold role: on the one hand, the anthropogenic load on springs and the surrounding area is reduced; on the other hand, unused springs are abandoned, landscaping elements (floor systems, pipes, fencing) wear out. In most localities with centralized water supply, the springs are abandoned, the elements of landscaping have "morally" and physically aged.

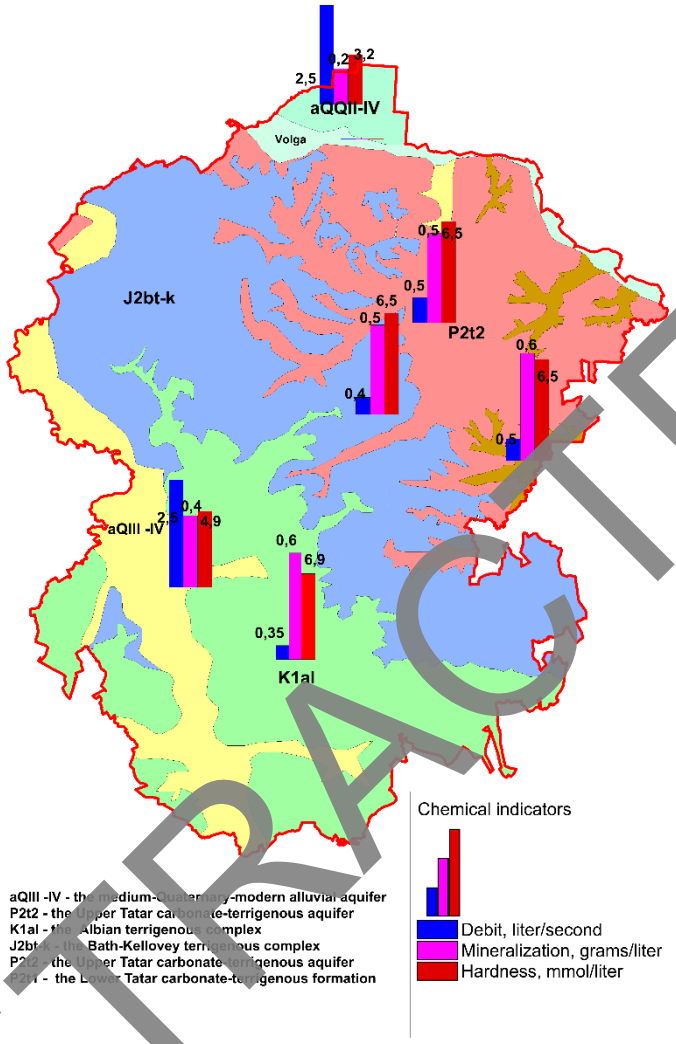

Fig. 2. Chemical parameters of spring water in the Chuvash Republic

The situation is better with a group of springs of the Chuvash Republic belonging to the "holy springs". According to various sources, there are about 100 units, evenly distributed among the municipalities of the region. The presence of a special historical, cultural and spiritual status contributes to the timely reconstruction of the capital systems and landscaping of the surrounding area. The negative side is the excessive, uncontrolled anthropogenic load due to religious rituals and visits to springs by tourist groups. Excessive anthropogenic load leads to pollution of springs with household waste and degradation of the landscapes of the territory adjacent to the springs. Health measures should be aimed at controlling the attendance of these territories (see Fig. 3).

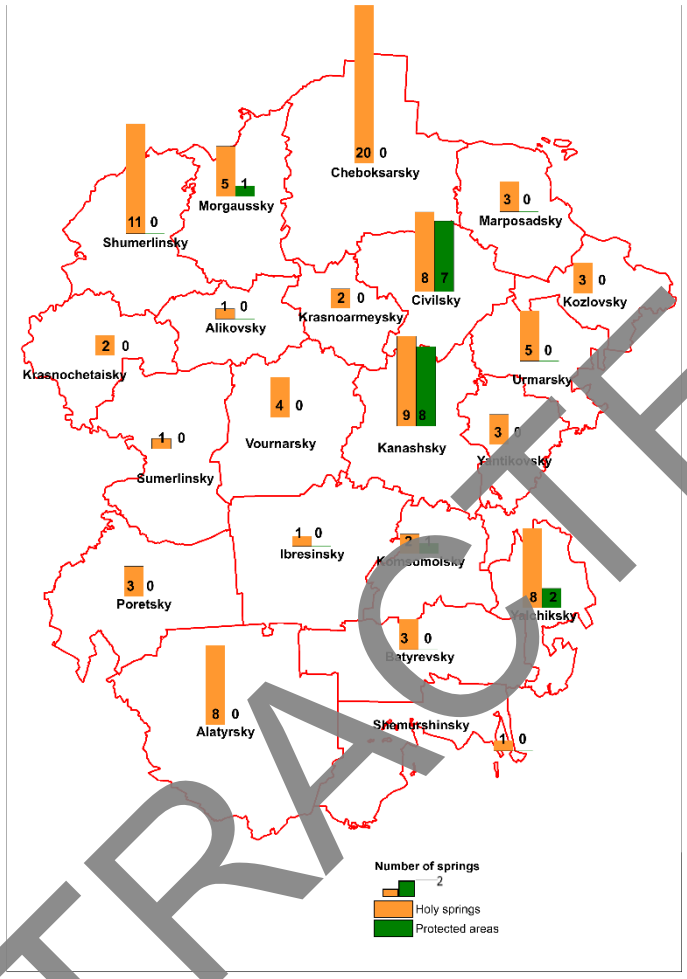

Fig. 3. Distribution of unique springs in the Chuvash Republic

The springs included in the system of protected areas of the region are characterized by the best condition [3]. These are springs belonging to specially protected natural territories – memorable natural places. There are 19 springs in the Chuvash Republic, which are protected areas of local importance. Geographically, they are confined to the Civil, Yalchik, Komsomolsky, Kanash and Morgaus municipal districts. The special nature protection status prohibits any kind of activity on the territory that entails a violation of the safety and pollution of the spring. In the protected area of such springs, the necessary sanitary measures, landscaping, and scientific research are carried out. That is why they can be considered "reference" in describing the ecological state, the degree of economic development and recreational significance. For springs that are protected areas of local importance, indicators of recreational significance were calculated using the methodology of Novykh L.L. et al.[1].

Thus, among the presented springs there are no watercourses with unsatisfactory and low levels of recreational significance. 7 springs (36%) belong to the group with average recreational significance, 3 springs (16%) – with high significance, 9 springs (48%) – with very high significance (see table 1). The above indicators indicate the high value of springs both in economic and drinking use and in recreational terms.

Table 1. Recreational significance of springs – protected areas of Chuvashia

The name of the springs	Architecture, composition	Aesthetics	Bathhouse	Water quality	The landscape value of the landscape	Power of spring water	Access to the spring	Equipped recreation areas	Ensuring sanitary requirements	Presence of household garbage	Total
The spring of the village of Anish-Akhperdino	1	0,5	1	1	0,5	1	1	0,5	1	0,5	8
The spring of the village of Atnashevo	0,5	0,5	0	1	0,5	1	0,5	0,5	1	0,5	6
The spring of the village of Vysokovka	0,5	0,5	1	1	0,5	1	0,5	0	1	1	7
The spring of the village of Kulikovo	1	1	1	1	1	1	0,5	1	1	1	9,5
The spring of the village of Sespel	0,5	0,5	0	1	0,5	0,5	0,5	0,5	0,5	0,5	5
A spring near the village of Starye Shaltyamy	0,5	0,5	0	1	0,5	0,5	0,5	0,5	1	0,5	5,5
The spring of the village of Huchel	1	0,5	1	1	0,5	1	0,5	0	1	1	7,5
The spring of the village of Shikhazany	1	1	1	1	1	1	1	1	1	1	10
Asanovo Spring	1	1	1	1	1	1	1	0,5	0,5	1	9
The spring of the village of Syatrakasy	1	1	1	1	1	1	1	1	1	1	10
Churashka Spring	1	1	1	1	1	1	0,5	1	1	1	9,5
The spring Anatry sai	0	0,5	0	1	0,5	0,5	0,5	0	0,5	1	4,5
The spring of the village of Buldeevo	1	1	1	1	1	1	0,5	0,5	1	1	9
The spring of the village of Shorkaush	0,5	0,5	0	0	0,5	1	0,5	0	1	1	5
The spring of the village of Kildyushevo	0,5	0,5	0	1	0,5	1	1	0	0,5	1	6
The spring of the village of Bolshaya Tayaba	0,5	0,5	0	1	0,5	0,5	0,5	0	0,5	1	5
The spring of the village of Tyunzyry	1	1	1	1	1	1	0,5	0,5	1	1	9
The Pavar Spring	1	1	1	1	1	1	0,5	0,5	1	0,5	8,5

The Chashlama Spring	1	1	1	1	1	1	0,5	1	1	1	9,5

4 Discussion

In order to improve the ecological condition, the authors of the article carry out an inventory of the springs of the Chuvash Republic. The need for an inventory is caused by the lack of reliable information about the number of well-maintained springs, the location and the current state of the drainage systems. The combination of expedition studies of springs and survey data of the local population will allow to obtain a comprehensive description of the physical and hydrodynamic properties of spring water (temperature, flow rate, color, transparency, smell, taste) and the ecological condition of the territory adjacent to the springs, the well-being of springs (relief, geology, type of landscape, absolute marks, economic development, ecological condition, level of landscaping). The analysis of the collected material will provide an opportunity to classify springs according to the following indicators: geographical location, hydrogeological conditions, water chemistry, the availability of landscaping facilities, the degree of suitability for drinking water supply according to the sanitary code, the presence of sources of environmental threat, and economic use opportunities (Figure 4). The result of the work carried out should be an electronic "Register of springs of the Chuvash Republic".

Fig. 4. Examples of unsettled and well-maintained springs

Creating a consolidated registry will allow: 1) to develop applied programs for the restoration of springs and the inclusion of their natural potential in the economy of Chuvashia;

2) to identify the degree of influence of groundwater of various ecological conditions on the water quality of other water bodies of the Chuvash Republic.

5 Conclusion

The peculiarities of the geological and geomorphological structure of the Chuvash Republic and the high erosion fragmentation have led to the fact that a dense network of springs is represented in the region. The springs of the region differ in flow rate (from 0.01 l/s to 8.8 l/s), total mineralization (0.2-0.6 g/l) and hardness (from 3.2 to 8.8 mmol/l). The vast majority of springs are used in the domestic drinking water supply of rural settlements. The

introduction of centralized water supply has led to the fact that a significant part of the sources are not used. The floor systems are not being reconstructed.

An inventory is needed to implement a set of measures to restore springs. The inventory of springs should include: a description of the physical and chemical properties of water, an analysis of the landscapes of the territory adjacent to the springs, the degree and type of economic development of the springs, and recreational attractiveness. In the course of the conducted research, it was revealed that the springs of the Chuvash Republic are characterized by high and very high economic significance.

The collected material on the ecological state of springs should be displayed in the unified "Register of springs of the Chuvash Republic".

Acknowledgments

The research was carried out at the expense of a grant from the Russian Science Foundation (project No. 24-27-20133) and the Chuvash Republic, https://rscf.ru/project/24-27-20133/

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, et.al., 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. Kumze, 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, Russia, **48** (2024) p.118-130. DOI: 10.52575/2712-7443-2024-48-1-118-130
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)