Features of spring waters of steppe regions (on the example of the city of Rostov-on-Don)

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Abstract. The springs of the city of Rostov-on-Don in the Rostov region have been investigated. It is an arid climatic zone characterized by limited natural resources of fresh groundwater. There are more than 60 springs in the city. In terms of chemical composition, water is characterized by increased hardness. An aesthetic assessment of the city’s springs was carried out. Three categories of springs are identified, their specialization and features of use and pollution are analyzed. Indicators have been obtained that can be used to regulate the ecological and aesthetic value of the landscape approach in the areas where the springs are located. This creates an opportunity to improve the springs and create new resting places on their basis. Work to increase the recreational value should be carried out for each source separately, after preliminary, thorough work on the study of the terrain, landscape approaches, so as not to cause irreparable harm to nature.

1. Introduction
Springs are natural objects of great interest to the population. The study of sources is a popular topic of research carried out by scientists from different countries of the world, including Russia [1–13]. In numerous works, it is noted that at present springs cannot be considered as objects of water supply in large settlements [6, 12], but they attract attention from an ecological and aesthetic point of view.

The identification of hydrogeological and landscape features of the distribution of springs is carried out in many countries of the world [1–5]. Active research on the territory of Russia springs are carried out in the city of Moscow and the region [6, 7], Orenburg [8] and Belgorod regions [9], Mordovia [10] and Altai [11].

The history of the study of springs in Rostov-on-Don counts more than 200 years. We find the first mention of them in the works of academician Gildenstedt of the St. Petersburg Academy of Sciences (1773–1774), later in the works of professor V. Bogachev (1898, 1919), M.B. Krasnyansky (1912). The most complete description of the sources is given in the work of P.I. Butov, who in 1913 conducted a study of them for the purpose of water supply to the city. In 1932, some of the springs were explored by N.I. Kononov. For several decades, little attention was paid to the sources, and only in the 1990s they began to be systematically studied again using new technologies [12, 13].

The fundamentals of the methodology for a detailed ecological-geographical study were developed [14]. A landscape assessment is essential for planning recreation sites, as aesthetic satisfaction is a popular form of recreation.
2. Studied territories

Rostov Region is located in an arid climatic zone and is characterized by limited natural resources of fresh groundwater. The city of Rostov-on-Don is located within the Severo-Azov plain on the high right bank of the Don. The subsided parts of the Russian and Scythian plates correspond to the morphostructure of stratal-accumulative plains. Within their limits, the North Azov low erosional-accumulative sloping plain is distinguished on the buried Rostov arch, the morphological features of which are determined by the position of the roof of pontic limestones. Its average height is 85 m, the largest is 115 m. The territory of the city is part of the Azov-Kuban hydrogeological basin. Underground waters of stratal forms of occurrence are widespread in the 500–700-meter strata of sedimentary deposits, and of those of fracture type are in the rocks of the basement. Within the city of Rostov-on-Don, the following aquifers and water-resistant strata are distinguished [12, 13]:

- The aquifer of Quaternary aeolian-deluvial deposits is widespread on watersheds and slopes. The aquifers are fed by infiltration of melt water, atmospheric precipitation and, to a large extent, is associated with man-made factors: leaks from water-carrying utilities, losses of industrial water, disruption of surface and underground runoff, and a decrease in evaporation under asphalt pavements. It is unloaded along ancient and modern river valleys and gully depressions in places where Scythian clays were eroded. The thickness Q of sediments varies from 30–40 m at watersheds to 2–3 m in the discharge zone. The mineralization and chemical composition of the waters of the described complex are quite diverse, but there is a certain pattern in the distribution over the area. Ground waters with a salinity of 1–3 g/l occupy the areas adjacent to the gullies and the Temernik river valley. These waters are mainly sulfate, less often chloride-sulfate or hydrocarbonate-sulfate: sodium-calcium or calcium-sodium. The watersheds are occupied by waters with a salinity of 3–5 g/l, according to their composition, they are mainly sulphate sodium-calcium or calcium-sodium. Groundwater with a salinity of more than 10 g/l is much less common, they are found mainly in watersheds or in areas where industrial waters are discharged. These are sulphate sodium waters.

- The water-permeable stratum of pontic sediments of the Lower Pliocene is developed on the right bank of the Don River. It is represented by shell limestones with interlayers of sands and less often by clays. The practical waterlessness of the pontic sediments of the river is due to their location above the local erosion network and the absence of a permanent aquicluded in the base. The underlying rocks are Sarmatian limestones and sands. Atmospheric precipitation is infiltrated into the underlying rocks of the Upper Miocene or drained by the river and gully network.

- The aquifer of the Sarmatian sediments of the Upper Miocene is ubiquitous in the city. It is associated with the Khaprovsky sands, Sarmatian and Meotic limestones and the underlying Sarmatian sands. The thickness of the water-bearing rocks reaches 10–30 m. The aquifer is free-flow and low-pressure. The springs of Rostov-on-Don are confined to this aquifer. The most highly productive springs are in the Botanical Garden (flow rate up to 120 l/s), Bogatyanovsky (flow rate 50 l/s). Unloading takes place in the valleys of the Temernik and Don rivers in the form of springs. In areas where the Sarmatian strata adjoins the aquifer of alluvial deposits, underground water is discharged into the valley. The waters of the complex have variegated mineralization and chemical composition. According to the chemical composition, the waters of the complex are hydrocarbonate and chloride-sulfate, as well as sulfate-chloride. Scythian clays are the aquifer for this aquifer as a whole. The practical significance of the Sarmatian groundwater for the city is great. It is with them that most of the springs in the city are connected: “Bogaty”, “Gremuchy”, “Nizhnegnilovskiy”, “Vodopadny”, “Surb-Khach”, “Botanichesky sad”, “Aleksandrovskiiy Kluchi” are used for water supply to the city of Aksai. Now the waters of the Sarmatian complex provide technical and household water supply to most of the city's enterprises, watering vegetable gardens. The reserves of water supply for emergency situations are also fed from it.

- The water-resistant clayey stratum of the Sarmatian deposits of the Upper Miocene forms a regional aquicluded within Rostov. Its top lies at a depth of 0.2–80.4 m. In the valley of the Temernik River, in some places the upper stratum of clays is eroded and alluvial deposits of the floodplain and above-floodplain terraces are embedded in it.
3. Research methods

Aesthetic perception includes the characteristics and assessment of an object, the objective basis of which is optimal diversity and harmony [14]. There are many clearly defined and distinguishable units in the landscape. The landscape features are subdivided into quantitative and qualitative ones. The latter include the scale of objects, the distinctness of individual phenomena. This becomes an indicator of the aesthetics of the landscape. They can have both positive and negative meanings.

The graded features of the landscape are divided into 3 groups and are graded on three separate scales. The first group includes objects of the landscape that can be counted (lakes, groves), the second group includes the indicators of aesthetics of general features of the landscape, while the third group holds indicators of aesthetics, the presence of which can either increase or decrease the aesthetics of the landscape.

A landscape approach means the organization of a place of observation of any shape and size, which can be special or original, manmade or natural, compact and stretched in its form. The landscape approach is divided into two parts: the approach itself and the surrounding environment with a radius of about 100 m.

With the recreational significance of the springs, the most important are the springs located on the sites registered as “natural monuments” of the urban scale. It is advisable to use the following indicators:

- **Required.** The presence of one of the signs of this category of factors allows us to refer to the first category without additional research: significant scientific value; historical, valuable or natural value; important ecological significance.
- **Necessary.** The presence of at least one of the signs makes it possible to classify a natural object as a natural monument, given the uniqueness of a natural object and cultural and cognitive value.
- **Additional.** Aesthetic appeal, picturesqueness of the object; recreational and health-improving value of the object; educational value.

In the presence of environmental and recreational indicators, the sources can be classified as natural monuments (geological). According to the first group of indicators on the territory of Rostov, there are sources for which the landscape value is combined with a satisfactory water quality. The springs are characterized not only by their uniqueness, but also by a certain cultural and educational value. This factor is most valuable in those areas where the presence of a spring is combined with a historical and architectural monument, a protected area. Additional factors are inherent in almost all sources.

4. Results and Discussion

There are more than 60 springs in the city. Basically, the springs are confined to the floodplains of the Don and Temernik rivers, which is explained by the discharge of gravity waters. The chemical composition of the waters of some sources is shown in Table 1.

| No. | Name         | Kurlov's formula | Class         | Subclass          |
|-----|--------------|------------------|---------------|-------------------|
| 1   | Surb-Khach   | S0<sub>4</sub> 66HCO<sub>3</sub> 24Cl<sub>10</sub> | Hydrocarbonate- | Magnesium-        |
|     |              | M2.7 ---------------pH7.8°C10 | sulfate       | calcium-         |
|     |              | Na40 Ca32 Mg28 | Magnesium-     | sodium           |
| 2   | Monastery    | SO<sub>4</sub> 66 HCO<sub>3</sub> 20 Cl<sub>10</sub> | Hydrocarbonate- | Sodium-          |
|     |              | M2.8------------pH7.2°C12 | sulfate       | magnesium-       |
|     |              | Ca 42 Mg31 Na 27 | Calcium-       | magnesium-       |
| 3   | Botanical    | SO<sub>4</sub> 76 Cl<sub>20</sub> HCO<sub>3</sub> 4 | Chloride-sulfate | Calcium-        |
| Garden |            | M3.2---------------pH8.1 t°C11 |                | magnesium-       |
|     |              | Na46 Mg30 Ca24 | Calcium-       | sodium           |
| 4   | Rattlesnake  | SO<sub>4</sub> 67 Cl<sub>20</sub> HCO<sub>3</sub> 13 | Chloride-sulfate | Calcium-        |
|     |              | M3.7---------------pH7.6 t°C11 |                | magnesium-       |
|     |              | Na 49 Ca 28 Mg 23 | Calcium-       | magnesium-       |

Table 1. Results of chemical analysis of water from the springs of Rostov-on-Don
The ranking of the springs made it possible to distinguish the following groups:

- **Springs of the highest category of landscape value** are distinguished due to the quality of water, the presence of historical and cultural attractions (a nunnery, an Armenian temple), well equipped, conditions for observation, recreation, access are created. All the springs listed above are loved by the population, visited and used for health improvement.

- **Medium landscape value category.** The water quality is worse, the access conditions are not good enough, and there are no cultural and historical attractions. Used by the population for household needs.

- **Low category of recreational importance.** Not equipped, characterized by a high level of water pollution, poor access conditions. Used by the population for water supply.

A certain specialization of springs on the territory of the city has been noticed:

- "Surb-Khach" is located near the memorial complex, water meets the requirements of GOST. The spring is actively used by the population for medicinal purposes, in particular, methods of alternative medicine are practiced here. The spring is characterized by an increased total water hardness (23) and aluminum (0.53). Cadmium, iron, arsenic, lead were not found.

- The spring in the Botanical Garden has been consecrated; it has long been known to the population and is used for medicinal purposes. This is a place of pilgrimage for residents of the city and the surrounding area. It has high water quality and is well equipped. Increased hardness, other elements comply with the Sanitary Rules and Regulations “Requirements for the quality of water in decentralized water supply. Sanitary protection of sources”.

- The spring "Gremuchy" is used as a resting place, the water from it is not used for drinking purposes due to the increased concentration of nitrates in it. Increased hardness, exceeding SanPiN 2.1.4.559-96 for nitrates by 3.2 times. Iron, lead, cadmium were not found.
The spring near the monastery of the Iverskaya Icon of the Mother of God has more cult significance. Unsuccessful captation complicates the approach to the source, creates conditions for its pollution. Increased hardness, and content of other elements meet the requirements. Iron, cadmium, lead were not found.

5. Conclusion
On the territory of the city of Rostov-on-Don, there are a number of sources distinguished by high recreational and ecological significance. These are such springs as “Surb-Khach”, “Gremuchy”, on the territory of the Botanical Garden, near the monastery of the Iverskaya Icon of the Mother of God, in the village of Pervomayskoye, near the bridge over the Temernik River, in Aleksandrovka, St. Paul, in the area of the sanatorium. Springs on Krzhizhanovskogo street 334, in the area of the Zoo, on Kulikovskaya street, in the area of Molodogvardeisky descent are distinguished by an increased level of pollution and a lower recreational value. Most of the investigated springs were captated, but often the captation is of low quality and was carried out at the initiative of the local population. Most often it is a metal pipe and a poorly equipped approach. The springs in Karataev, Nizhnegnilovskaya stanitsa belong to this type. The state of the water catchment area in these areas is unsatisfactory, which reduces the drinking water quality and the recreational value of the springs, and creates preconditions for pollution.

As a result of this work, indicators were obtained, using which it is possible to regulate the ecological and aesthetic value of the landscape approach in the areas where the springs are located. This creates an opportunity to improve the springs and create new resting places on their basis. Work to increase the recreational value should be carried out for each source separately after preliminary thorough work on the study of the terrain, landscape approaches, so as not to cause irreparable harm to nature.

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