Integrated monitoring of the springs of the north-eastern part of the Carpathians

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SUMMARY

The purpose of the research was an inventory and monitoring of springs in the territory of the Carpathian National Natural Park (northeastern Carpathians, Ivano-Frankivsk Oblast, Ukraine) and the identification of the main hydrological and hydrochemical regularities of their functioning. For the period 2011-2019 about 40 expeditions were carried out. The main stages of monitoring of springs, which is carried out in the Carpathian National Natural Park: 1) collection of available information about the springs; 2) field surveys of the first level (description of springs and mapping); 3) field surveys of the second level (measurement of flow rates and water sampling); 4) field surveys of the third level (monitoring). Monitoring studies covered about 300 springs. The springs have insignificant flow rates, cold in the temperature regime of water. Most springs in the Carpathian National Natural Park (about 98 %) have water mineralization in the range of "very fresh" and "normally fresh" (30-250 $mg \cdot dm^{-3}$).

Introduction

A spring is a natural release of groundwater to the surface or under water. The springs are unique components of the geological environment that arise as a result of continuous dynamic processes of the global water cycle under the influence of gravity or hydrostatic pressure in various landscape and geomorphological conditions: at the bottom of ravines, gullies, on hillsides, steep river banks, and the like. In fact, all the rivers and streams of the Carpathians originate precisely from the springs.
The combination of geological, hydrogeological, climatic, and landscape-geomorphological features on the territory of the Carpathian National Natural Park (NNP) created the conditions for the widespread distribution of natural groundwater outcrops to the surface and the formation of springs. The outcrops of the springs to the surface are connected: 1) with coarse weathering fragments on the predeluvial hills, among relics of the Pliocene valleys and slopes not eroded by the glacier; 2) with the foot of the blow-out cone and discharges on the bottoms of the Carr and amphitheaters; 3) with sediments of stadial moraines; 4) with landslide areas.
Carpathian National Nature Park is located in the north-eastern part of the Carpathians (territory of the Yaremche city council and Verkhovyna district, Ivano-Frankivsk region, Ukraine) – Figure 1.
Since 2011, in the Carpathian NNP, detailed work has begun on a comprehensive survey (inventory and accounting) of the main springs located in the park and adjacent areas. In the process of research, descriptive reconnaissance works were carried out, quantitative and qualitative indicators were determined; appropriate generalized tabular materials and cartographic schemes were compiled, recommendations were provided on the improvement of the territory near the springs.

Methods of investigation

For the period 2011-2019 about 40 expeditions were conducted to study springs located in three main natural complexes on the territory of the Carpathian National Natural Park: the Skybovi Gorgany, the Yasynsko-Verkhovynska intermontane area, and the massif Chornogora. In hydrological terms, this is the Prut River Basin. Monitoring studies covered about 300 springs. In general, monitoring studies of springs were carried out according to the scheme: expeditionary work, chemical analysis of water samples in a stationary laboratory, desk data processing, generalization of the results (*Kravchynskyi et al., 2019, 2020*). The purpose of the research is an inventory and monitoring of springs in the territory of the Carpathian NNP and the identification of the main hydrological and hydrochemical regularities of their functioning.

Results of investigations

In different countries of the world, monitoring studies of springs have their own program with a clearly defined hierarchical structure. Methodological principles are reduced to the implementation of the main goal: to determine the state of the spring (resource potential, chemical composition and water quality); its relationship with environmental components; prospects for the existence of a spring - identification of the main risks that may affect its condition (*Stevens, 2011*).
The main stages of monitoring of springs, which is carried out in the Carpathian NNP: 1) collection of available information about the springs; 2) field surveys of the first level (description of springs and mapping); 3) field surveys of the second level (measurement of flow rates and water sampling); 4) field surveys of the third level (monitoring) – Figure 2.

1st stage of monitoring
Collection of available information - provides for the formation of a single database on the distribution of springs based on the analysis of available materials (cadastral, archival, space images). When studying springs in the Carpathian NNP, a regional approach was used. The data on the springs provided by the inspectors of the respective environmental research departments (ERD) were systematized. Created registration tables of springs.

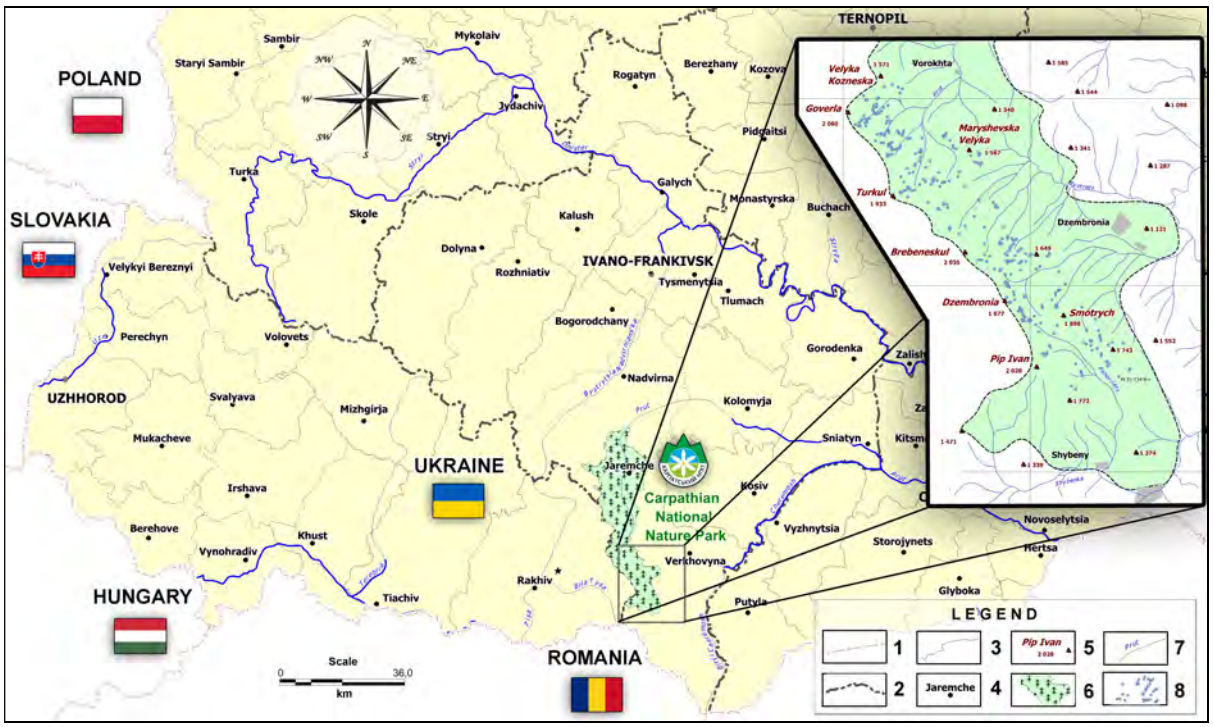

Figure 1 *Location of the Carpathian National Nature Park and layout of the springs within the massif of Chornogora: 1- state border; 2-3 – administrative boundary (oblasts and regions); 4 – settlement and its name; 5 – mountain peak, its name and absolute height; 6 – borders of the CNNP; 7 - hydrographic network 8 – springs.*

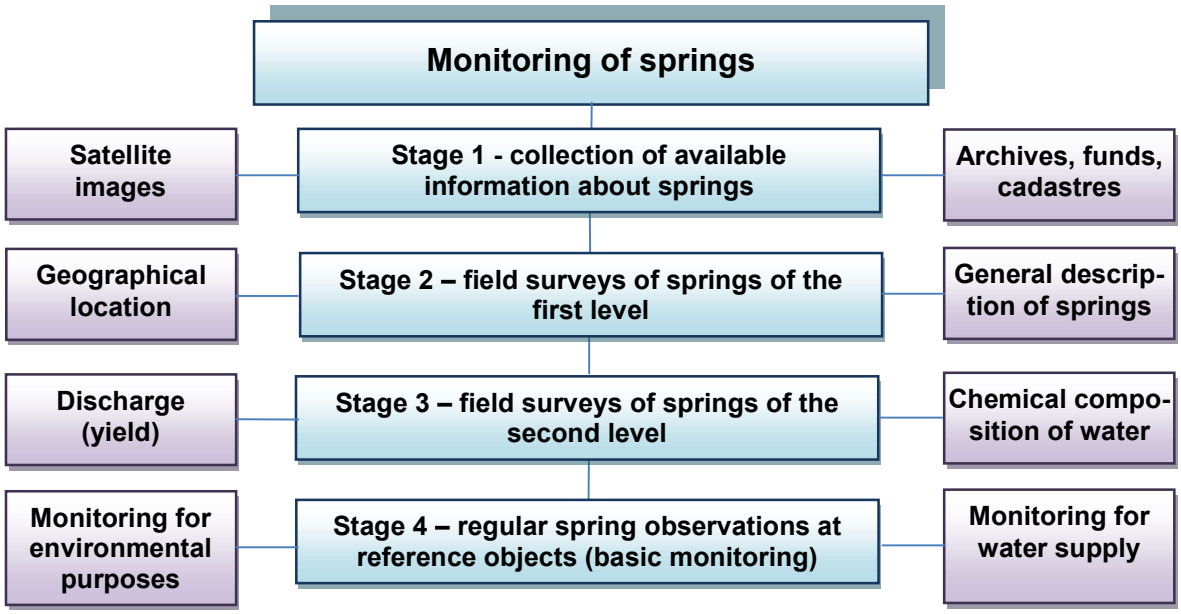

Figure 2 *Block diagram of the sequence of springs monitoring in the Carpathian National Nature Park*

2nd stage of monitoring

Field surveys of the first level - the purpose is to carry out the geographic location of the springs and to draw on cartographic media (tablets, maps, terrain plans, etc.) the exact location of the main springs and to carry out descriptive and reconnaissance work in local areas. To determine the physical and

geographical characteristics of the spring (position, coordinates, absolute elevations, etc.), both classical small-scale topographic maps, plans and modern global positioning systems - GPS are used. A number of GIS (Mapinfo Professional, ArcGis, ArcView, etc.) are used to create digital maps. In the description indicate the position of the spring in relation to the nearest village, stream, river, lake. A relief element is marked on which the spring output is fixed. When conducting a field survey of the second level, the primary database is often adjusted and supplemented. At the same time, studies of individual springs located both in the territory of the Carpathian NNP and in adjacent territories are carried out.

Descriptive and reconnaissance surveys are recommended to be accompanied by photofixation of the springs and the adjacent territory (Figure 3,A).

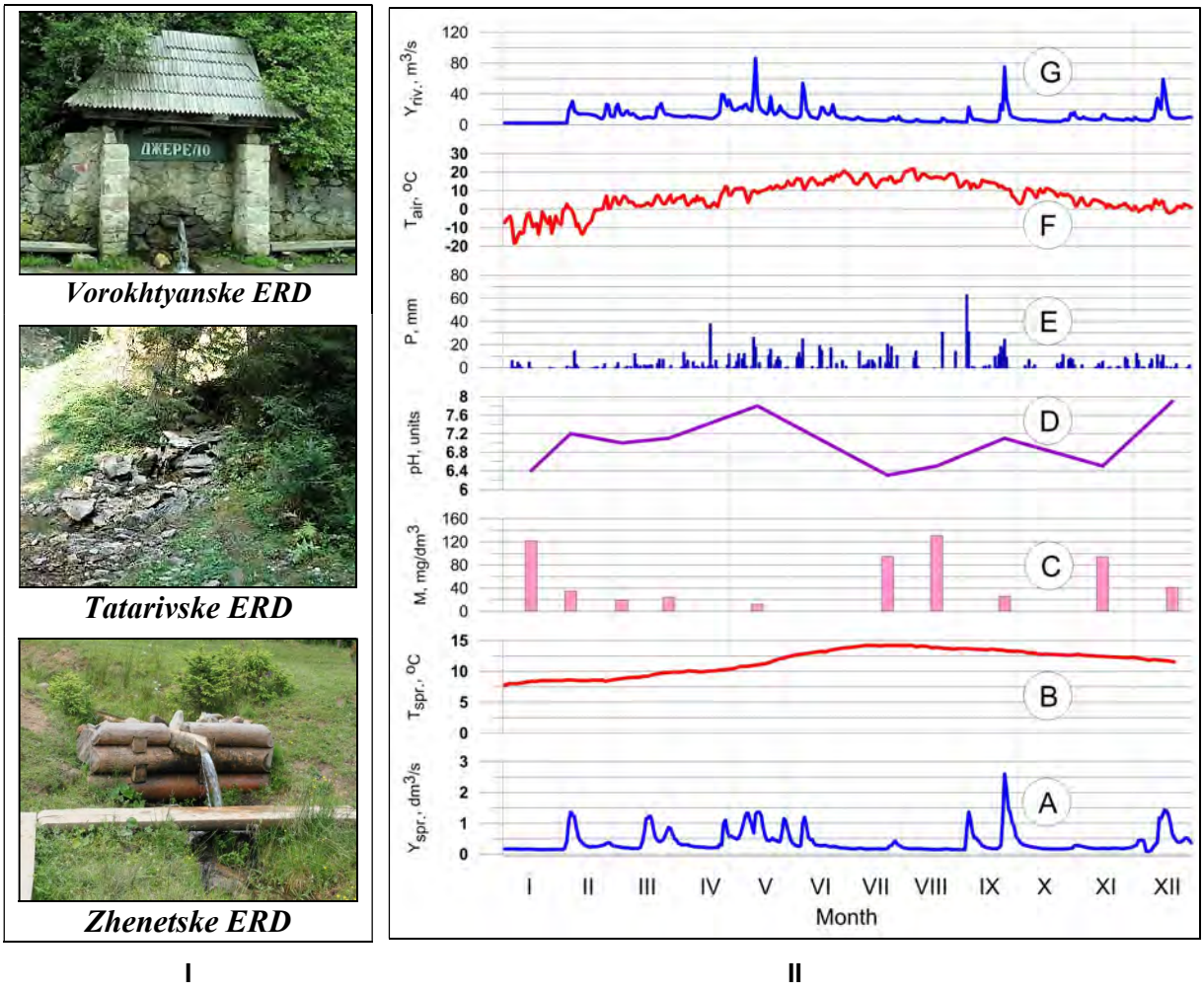

Figure 3 *Photofixation of some springs of the Carpathian National Natural Park (I) and a comprehensive schedule of the hydrometeorological regime of the spring in the village of Mykulychyn (II)(2017): A - spring yield ($Y_{spr.}$, dm^3/s); B - water temperature ($T_{spr.}$, °C); C - mineralization of water (M, mg/dm^3); D – power of hydrogen (pH, units); E - rainfall (P, мм); F - air temperature (T_{air}, ° C); G - water discharge of the Prut-Yaremche river ($Y_{riv.}$, m^3/s)*

3rd stage of monitoring

Field surveys of the second level - are aimed at determining the flow rate of springs and the chemical composition of water, which will become the basis for future research. Often the second stage of field surveys is combined with the third.

4th stage of monitoring

Field surveys of the third level – provide for the organization and conduct on an ongoing basis of observations on the reference springs. An occasional examination of the spring during field studies is not enough to identify its performance for practical purposes, for example, for water supply. The water flow rate, temperature and water quality in the spring can vary throughout the year, and sometimes over the course of a number of years (dry or wet). In this case, it is necessary to perform regular monitoring of the spring 1-2 times a month or after 2-3 months. In each case, it is necessary to study the parameters of the spring: flow rate, temperature, chemical composition of water (Figure 3, B).
Regular observations should be compared with meteorological data, as well as with hydrological data on the flow of the river, which is fed by the springs of the area. Comparison of all these data with the geological structure of the area and with the feeding area of a given aquifer can clarify the stability or variability of the flow rate and chemical composition of the water of the studied spring.

According to our calculations, the optimal frequency of measuring the flow of water from a natural source is once a week, similar to that conducted by Polish colleagues. At the same time, the average monthly and average annual indicators vary within ± 0.5% relative to the measurements carried out daily.

Conclusions

1) Monitoring of the springs is an important aspect in studying the operating conditions of many ecosystems at the regional, local, local levels.

2) It has been established that almost all the investigated springs in the Carpathian National Natural Park are fresh, with insignificant and sufficiently variable flow rates under the influence of hydrometeorological conditions (from 0.1-0.3 dm^3/min to 5.0-15.0 dm^3/min), "cold" – beyond the temperature regime of water (4.6-19.5 °C).

3) Mineralization of water of springs in the Carpathian NNP (about 98%) is in the range of "very fresh" and "normally fresh" (30-250 mg/dm^3).

References

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