Study of groundwater in rural settlements

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The chosen area for groundwater research is the territory of the village of Klishkivtsi (central part of the Khotyn Upland), where, as of 2022, there were 1344 wells. They became the points where research was conducted (Figure 1). Similar research was carried out in the village of Mlynky (northern slope of the Khotyn Upland), although with less detail.
The detailed study of wells has shown that they differ from each other in both qualitative and quantitative indicators, allowing for their classification into four categories as follows:
1. Landscape category – classified based on the landscape designation of the well. This category includes four classes: *watershed, sub-watershed, slope,* and *valley*. **2. Level category** – classified based on the average water level in the well. This category consists of three classes: *shallow* (up to 5 meters), *moderately deep* (from 5 to 20 meters), and *deep* (over 20 meters). **3. Category of use** – classified based on the well's usage for different purposes. It comprises three classes: *neutral, traditional,* and *donor*. **4. Water supply category** – classified based on the average water storage capacity in the well. It includes three classes: *weakly supplied* (up to 2 m^3), *adequately supplied* (from 2 to 4 m^3), and *well-supplied* (over 4 m^3).
The average dynamics of groundwater (GW) is directly proportional to the annual precipitation. The higher the amount of precipitation in a year, the higher the groundwater dynamics, and vice versa.
If the terrain is highly dissected, then GW levels usually tend to be deep. On the other hand, if the terrain is weakly dissected, GW levels will be at a shallow depth. However, these patterns are frequently disrupted. In the first case, when we have a highly dissected terrain, the GW levels can be relatively shallow due to local water tables. In the second case, in relatively homogeneous relief, GW levels can be at a significant depth due to the geological structure of the area, primarily influenced by the depth of the impermeable layer.
The GW level in river valleys, ravines, and gullies fluctuates between 2 to 10 meters. On the slopes of watersheds, the depth of the water table does not exceed 17 meters. At the actual watersheds, the depth can reach up to 25 meters. There are cases where, on certain sections of river valleys, the GW level is at a significant depth – around 10 to 15 meters, while on the watersheds, on the contrary, there are areas with relatively shallow water-bearing horizons (2–3 meters). The main reason for these variations is the lithological structure of the Khotyn Upland.
Thanks to drilling activities in the territory of the Khotyn Upland, the following types of aquifers have been identified: local aquifers, overlapped aquifers, and continuous (translandscape) aquifers. Local aquifers are small water-bearing horizons that are not connected to other aquifers. They are isolated, and there exists a so-called «dead zone» around them where GW is absent.
Local aquifers in the territory of the Khotyn Upland tend to dry up during dry periods since their recharge solely depends on precipitation. The thickness of these aquifers does not exceed 2 meters in wet periods and decreases to 20-40 centimeters in dry periods. Local aquifers are

associated with watershed landscape complexes, but there are cases where they can be found in isolated slope and even valley areas. Continuous (translandscape) aquifers cover vast areas and can extend over multiple populated areas with their surrounding territories. Local aquifers appear as isolated islands amidst the translandscape aquifers. The main groundwater regime and the regime of small rivers depend on continuous aquifers. They act as major reservoirs of atmospheric moisture and serve as the primary objects for the migration of groundwater masses and dissolved chemical elements. In wet periods, the thickness of continuous aquifers can reach up to 2.5 meters, while in dry periods, it decreases to 80 centimeters. These aquifers are widespread in all landscape complexes of the territory. Overlapping aquifers are rare and are mostly found in areas with old significant landslides or abrupt transitions from watershed areas to slopes (in such cases, the confinement of aquifers may occur at the intersection of two types of relief).

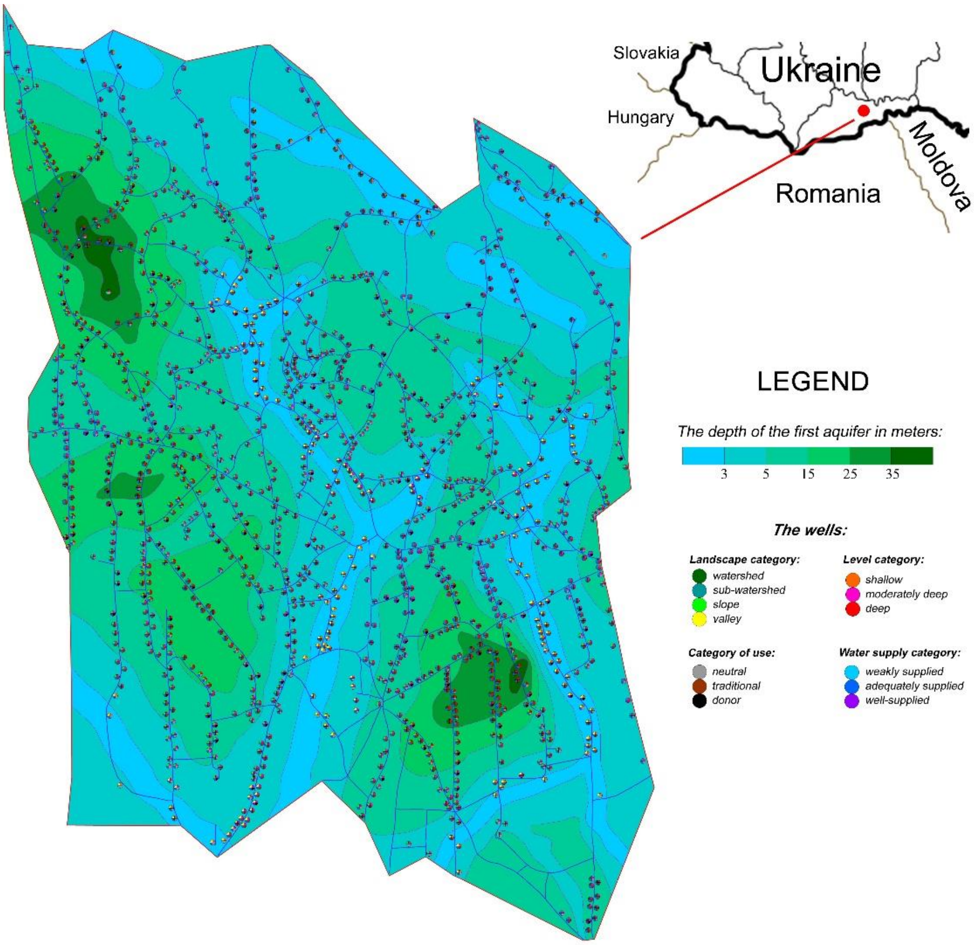

Figure 1 Groundwater of Klishkivtsi village.

Groundwater horizons are predominantly located within the thickness of anthropogenic deposits, mostly eluvial deposits (on watersheds and sub-watersheds), as well as alluvial deposits (in river valleys, floodplains, and lower terraces). However, in some cases, water-bearing horizons can be situated at the contact zone between bedrock and anthropogenic deposits.

Water-bearing and formative rocks include (within the thickness of anthropogenic deposits) loess-like loams, heavy brown loams, brown sandy loams, and pebble-gravel-sandy deposits.

Within the thickness of bedrock, they include clayey, silty, sandy, and stony loams of the Neogene and Sarmatian formations, among others.

The «dead zones», mentioned earlier, occur where water-bearing horizons lie on bedrock formations. The absence of aquifers in certain sections of the bedrock layers is due to their oblique monocline deposition, which causes water to flow towards interlayer waters.

Throughout the year 2022, the most stable groundwater level was observed during the winter period. This can be explained by the fact that water input from precipitation was almost negligible. Additionally, the water consumption by the population also decreased due to the inactivity of pumping stations.

The sharp increase in the groundwater level in spring was caused by snow melting and the beginning of rainwater recharge. During the summer period, the groundwater level reached its lowest point, with several short-term peaks associated with intense rainfall events.

Chemical monitoring provides valuable and sufficient information about the qualitative state of groundwater, enabling the assessment and prediction of geochemical processes occurring in groundwater. It helps identify the degree of contamination and the quality of groundwater, find sources of pollution, methods of their elimination, and rational water use in various activities. Certain components of the ionic set exceed the maximum permissible concentrations (MPC) by one or more orders of magnitude. The pH ranges from 7.1 to 7.8, indicating neutral to slightly alkaline water. The overall water hardness varies from 10.2 mg-eq/l (hard water) to 22.2 mg-eq/l (very hard water), and the degree of mineralization ranges from 0.54 g/l to 1.76 g/l. NH_4 and NO_2 are present in relatively small amounts. The prevailing water types in the northwestern parts of the territory are hydrocarbonate-magnesium-calcium, while in the southeastern parts, they are hydrocarbonate-calcium. In some cases, Cl^- and SO_4^{2-} slightly exceed MPC levels.