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IVANO-FRANKIVSK CITY GROUNDWATER LANDSCAPES ECOLOGICAL STATE

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Abstract. Ecological state of groundwater used as a source of potable water in urban areas of the city of Ivano-Frankivsk and its satellites is dealt with. Groundwater is assessed as a ratio between the content of pollutants and the relevant hygiene standards. Environmental assessment grounded on the materials of chemical analysis (74 samples) compared to maximum allowable concentrations and background values. Calculations of the value of hazard and the intensity of pollutions were the methods of ecological and geochemical evaluation of groundwater contamination. Based on calculation results, geochemical maps were compiled depicting satisfactory, hazardous and critical degrees of hydro-ecological situation. Developed maps can serve for the purposes of further geochemical monitoring of ecological situation.

Introduction

Ground water is among those nature resources whose use would significantly improve situation with population's provision with pure potable water fitting every sanitary - hygiene standard. Water chemistry is a result of multiple factors such as effects of aqueous rocks, hydrodynamic characteristics of water-bearing formations and conditions of their feeding and unload, ground water depth level, geo-morphological and climatic conditions of the territory, and anthropogenic loads.

Previous publications in the area of study

Methods of geochemical mapping to help assess ecological situation and establish sources of contamination were widely used as far back as 1970s [1 - 4]. Geochemical mapping deeply focused on various anomalies in the content of

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chemical elements and their compounds formed due to natural and anthropogenic factors. Transportation of polluting substances is to a great extent connected with atmospheric processes, wastewaters, traffic arteries, product pipelines, and chemicals input in agriculture. Mapping of groundwater pollution allows for specification of the zones of man-induced loads, as well as for the establishment of the impacts' spatial regularities and degrees.

Problem statement

Ecological state of urban ecosystems may change in high gear. Such changes necessitate complex and continuous geochemical monitoring of ground waters. Huge massifs of multifaceted information urge the development of data automated processing, while the purposes of ecological state's efficient control within the territories require visualization of study results in the form of pollution maps.

Discussion

Ground waters within urban territory of the city of Ivano-Frankivsk lie in the alluvial deposits of the floodplain, and the first and the second terraces rising above the floodplain. These are the channel sand- gravel-shingle formations, sometimes with heads, break stone lenses and untried fragments. The terraces are common for both rivers of Bystrytsia. The channel alluvium lies within hypsometrically close gauge marks giving in the process of sinking an impression of its single horizon and the same of ground waters. From the surface, the channel alluvium is plugged off by the flood plain facies – silts, sand clays and clay loams. Its capacity varies from 2-5 to 10-15 m, while the floodplain's alluvium – from 0-1 to 3-5 m. Ground water is free-flowing, its debit amounting to 0.2-1 l/sec. The water is widely used by urban population living in the private sector. People cut holes to have village pumps and wells. The level of ground water varies from 2-3 to 5-7 m.

The channel alluvium's undersurface is essentially uneven due to numerous migrations of pre - channels of both Bystrytsia Nadvirnianska and Bystrytsia Solotvynska. In fact, these rivers have formed the interior delta within the urban territory. A number of explorers pointed to subsurface ground water flow channels from the Bystrytsia Nadvirnianska to the Bystrytsia Solotvynska, that is, from southern east to northern west, due to different-elevation positions of the rivers.

Landscapes. The city from the point of view of landscapes is regarded as natural-anthropogenic territorial complex essentially transformed by town planning, communications and other elements of civilization. It is an integral geo-system composed of two sub-systems: natural and anthropogenic (technogenic

cover). The sub-systems and their elements participate not only in the formation of the landscape structure of the territory but also in the same of eco-geochemical properties of ground waters.

Complex interaction of natural and anthropogenic components and elements forms specific landscape complexes of different rank: 1st (parcel), 2nd (technogenic land type), 3rd (anthropogenic locality), and 4th (functional zone). Examples of the aforesaid landscape units are presented hereunder.

Specificity of landscape approach in groundwater studies lies in the fact that natural components and elements (objects) of anthropogenic cover are regarded in the processing system as the analogue of natural landscapes, which presupposes fixation of their chemical and physical properties.

Maximal consideration of natural and anthropogenic situation on the basis of singling out the structural-morphological landscape units (of the 1st – 4th order) is essential not only for the purpose of ecological (hydro-chemical) studies, but for the same of town territorial planning, etc. The landscape map serves as the basis for the analysis of the polluting substances areal distribution over the territory of the city.

Ivano-Frankivsk is located in the valley of the Bystrytsia Nadvirnianska and the Bystrytsia Solotvynska which explains predominance of valley-terrace landscape complexes which rise over the river channels as moderate steps and have a rather wide areal distribution.

The territory of the city is distinctive for the two types of landscape complexes as follows:

I – terrace plains composed of sand clay and shingle alluvium with sod and soddy podzolic soils, residential. Landscape predominant localities within this landscape complex are as follows: 1) low terraces (I – II) composed of low and medium capacity (1-6 m) clay loams and clay-sand alluvium (1-6 m) with sod deep podzolized gleyic soils; 2) medium terraces (III) composed of powerful (5-11 m) clay loams and sand alluvium (4-7 m) with podzolic-sod gleyic soils (inter-stream area); 3) small valley bottoms composed of alluvial-deluvial clay loams and present-day alluvium with meadow-boggy soils;

II – terrace plains composed of clay loam alluvium on chalk-stone marls and lime-stones with sod soils, residential. Landscape localities: 4) low terraces (I – II) composed of low (1-3 m) and medium capacity (1-6 m) clay loams and clay-sand alluvium with sod podzolized gleyic soils; 5) medium terraces (III) composed of clay loams and clay-sand alluvium with sod deep podzolized gleyic soils.

Complete and thorough analysis of Ivano - Frankivsk ground waters' ecological state required availability of information on the region's general contamination. For the purposes of this study we have made use of the data of regional ecological monitoring of the Ivano-Frankivsk Oblast. The data were the

basis for the development of geochemical maps of contamination, as well as for compilation of the excerption related to technogenic background of the content of chemical elements in ground waters. The analysis showed regularities in pollution concentrations increasing from the oblast's south to its north (save for cobalt whose concentrations increased from the west to the east). Ground waters showed insignificant pollution in the vicinity of the towns of Rozhniativ, Kosiv, Verkhovyna, and the city of Ivano-Frankivsk. Generally, the pollutants' emission to the strata of ground waters can be explained by their infiltration from the stratum of soil. Processing of agricultural lands, in particular, introduction of pesticides, migration of air pollutants and other factors to this or that extent added to ground waters' ecological state.

It should be noted that contamination of ground waters within the territory of Ivano - Frankivsk can not only be explained by the local (urban) emission of chemical elements (activity of industrial enterprises, migration of chemical elements, etc), but also by general regional pollutions within the territory of the oblast which partly cross-cover the territory under this study. Hence, the wider analysis of the territories bordering the city would give the basis for explanation of certain regularities in distribution of chemical elements, as well as make possible still deeper analysis of the pollutants' emission.

To learn ecological situation with ground waters on the territory of Ivano-Frankivsk, we have selected and analyzed 74 water samples to establish the content of 12 most widespread polluting substances.

The obtained data themselves represent availability of the content of these or those compounds in environmental elements but can show neither the degree of the territory contamination nor they can disclose the zones of this or that element's over-concentration. The maximum allowable concentrations of the elements in the environment are indicators of its quality and are helpful in the development of ecological databases.

Analysis of geochemical coefficients and indices is a widely used methodical approach in determination of geochemical loads on urbo-ecosystems. For example, the consolidated index of contamination hazard (Z_h) in observation points shows total hazard of contamination of the territory by all elements (irrespective of hazard classes) in the point of monitoring [3].

$$Z_h = \sum_{1}^{n} C_h^{12}$$

where C_h represents the coefficient of the element's hazard, that is, the proportion of the element's actual concentration and its corresponding maximum allowable concentration.

The degree of groundwater pollution and its ecological state are presented in Table 1 and Fig. 1.

Table 1. Groundwater pollution degree and ecological state

Consolidated index's (Z_h) change intervals	Ground waters ecological state
5 – 10	Satisfactory
10 – 15	Hazardous
over 15	Critical

Fig. 1. Ivano-Frankivsk groundwater ecological state
1. critical state; 2. hazardous state; 3. satisfactory state

Conclusions

The hazardous ecological state with ground waters within certain landscape complexes can be explained by partial contamination of subsurface and ground waters by way of infiltration from the basin of surface-stream flow due to disposal of polluted and insufficiently filtrated wastewater. Another reason may lie in removal of considerable volumes of gravel and shingle materials for the purpose of (intense) building within the territory. Availability of tectonic shifts

(Pidluzhzhia, Stanislav-Korshiv, Mykytyntsi) is the reason for groundwater cross-flow that causes the shift of contamination area towards downtown. The areas of the Nezalezhnosti Street and the crossroad of the Obyizna Street and the Khotkevych Street can be the territory of subsurface cross-flow unloads. A huge contamination plume is a negative factor in the city's ecological situation, since there is a territory of summer cottages leftwards from the Obyizna Street nearby the Kaskad Micro-District where people use ground waters as potable water, as well as irrigate their small kitchen gardens and orchards, etc. Proceeding from general ecological situation of the city subsurface hydrosphere, we would recommend a continuous monitoring within the territories as follows:

— near No 50 Vovchynetska Street where the private sector still exists and uses ground water for consumption – the Spilna Street and the Selianska Street;

— the crossroad of the Halytska Street and the Vasylianok Street – with the zone of spreading of satisfactory-state ground waters on the territory of the Lermontov Street, Kobylianska Street and Bezkrovnyy Street;

— within the territory that conjoins the Stefanyk Naberezhna (Quay), the Puyul Street, and eastwards;

— the crossroad of the Konovalets Street, Stepan Bandera Street, Pobutova Street and Dudaiev Street, and to the northern west;

— near the municipal cemetery (village of Chukalivka).

Significant content of three toxic elements – mercury, beryllium and selenium – can be explained only by poor functioning of industrial wastewater clarification system.

The developed ecological map allows for complex analysis of the city groundwater's ecological state, and serves to be the basis for the next studies as an integral source of information to help solve problems of town planning and water supply.

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