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Hydrogeochemical characteristics of mineral and thermal waters

title: **Pesticides in mineral waters of the transcarpathian region**

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The Transcarpathian region is the richest province of Ukraine, its main recreation resources being mineral waters, climate and landscape. About 50 fields with mineral waters of different types are known, among those the most widespread and valuable are carbonic waters. In 1989 and 1997 the Institute of Geological Sciences National Academy of Science of Ukraine (IGS NASU), carried out examinations of mineral water fields for the content of strong organochloric pesticides (DDT and its metabolites, HCCH and its isomers, aldrin, heptachlor, dilor); organophosphoric pesticides (methaphos, carbophos); fluorine-containing pesticide (trephlane). In 1989 sexteen fields were examined, and three fields in 1997. Analytical experiments were performed using two a gas chromatographs "Tsvet-500M" (Models 550 and 570). It was established that in the same sample there could be present up to eight substances and their metabolites, derivatives of chemical compounds of different groups in concentrations lower than MPC (maximal permissible concentration) for potable water. However, the total effect of their influence on human health has not been studied yet.

The Transcarpathian region is the richest natural province of Ukraine, its main recreation resources being mineral waters, climate and landscape. On a relatively small territory, mineral water fields of different types are concentrated. All over the territory of Union of Independent States variability of mineral waters in this region could be compared only with Caucasian mineral waters. About 50 fields with mineral water are known, among those the most widespread and valuable are carbonic waters. In the region 15 sanatoria and pensions with medication function as well as, several rest homes, 13 tourist centres and complexes, departmental health-improving organizations. Six enterprises for mineral water spillage function here.

The Transcarpathian region comprises a complex system of hydrogeological districts that differ in the conditions of groundwater formation.

The most widespread are carbonic waters of «Narzan» type. Large reserves of these waters are located near Uzhgorod. There are also springs near the settlements Uzhok, Krasny Ples, Belin, Kobyletzkaya Poljana. Chemical composition of the majority of Ukrainian narzans is hydrocarbon magnesium-calcium and sodium-calcium and dissolved carbon dioxide content is 0.8–2.9 g/L [1]. Carbonic waters of «Borzhomi» type are distributed mainly in Mukachevo and Svaljava districts of the Transcarpathian region. They are exploited by «Poljana» resort as well as by factories for spillage of mineral waters «Poljana Kvasova», «Luzhanskaya», «Plaskovskaya». The yield of wells comprises in average 1-2 and up to 10 l/sec. Mineralization of transcarpathian hydrocarbon sodium waters is 4.3–11 g/L. Increased content of such biologically active ions as fluorine and boron could be detected in the mineral waters.

Carbonic waters of «Essentuki» type are concentrated in the region of villages Dragovo, Sojmy, V. Bystraya. At the base of two large springs there operates a factory for spillage of mineral water «Dragovskaya». This water is of hydrocarbon-chloride- sodium composition with total dissolved solids (TDS) content of 5.9–10.5 g/L. Mineral waters near v. Sojmy are exploited by a sanatorium «Verchovina». They are of chloride-hydrocarbon sodium-calcium composition, mineralization equals 6–7 g/L. Out of biologically active ions only boron presents in the water.

Large reserves of «Essentuki» mineral waters were detected in the neighbourhood of the Vyshkovo settlement in Chustkovo district near «Shajan» sanatorium. A carbon dioxide content in water reaches 2.6 g/L. Their chemical composition is hydrocarbon and hydrocarbon-chloride sodium, sodium-calcium and magnesium-calcium. TDS content is equal to 4 - 6 g/L. Carbonic

waters of «Arsni» type are often in the valleys of Uzh river and its tributaries near Kostrina and Sol villages. They consist of chloride sodium, 4.6–14.4 g/L. Besides carbon dioxide, mineral waters could also contain other medical components (iron — in the waters of the field Kelechenskoye, arsenic — in the field Gornotisenskoy).

The Transcarpathian region is one of the most successful in Ukraine from an ecological point of view. This is favoured by mountain relief, extensive forests and the absence of large industrial enterprises. However, anthropogenic pressure on the territory, such as environment pollution by oil products, heavy metals, agricultural chemicals and social wastes are associated with hydromineral resources of the region. One of the most widespread and dangerous types of pollution in mineral waters is pesticides that are widely used in agriculture and forestry in the Transcarpathian. Factors that worsen the danger of pesticide pollution of mineral waters are the high permeability of the gravel deposits in the river valleys Latoritza, Uzh, Tisa, Piniya and others, where both the main mineral water fields and settlements with adjoining agricultural lands are present. Moreover, in the geological section of these districts, the bedrock is highly fractured resulting in increased permeability.

Two cycles of sampling were conducted in the Transcarpathian mineral waters in 1989 and 1997. Strong organochloric pesticides (DDT and its metabolites: n,n'-DDT; n,n'-DDE, HCCH and its isomers: α-HCCH, β-HCCH, γ-HCCH, aldrin, heptachlor, dilor); organophosphoric pesticides (methaphos, carbophos); and fluorine-containing pesticides (trephlane) were detected (Tables 1 and 2).

Along with mineral waters, pesticides were also measured in surface stream-flows and soils. In 1989 sixteen fields that exploit mineral waters of different types were examined: Polyanskoye, Ploskovskoye, Novo-Polenskoye, Svalyavskoye, Golubinskoye, Nelipenskoye, Medvezhye, Shayanskoye (Borzhomi type); Soimenskoye, Kelechenskoye, Uzhgorodskoye, Dragovskoye, Gorno-Tisenskoye (Synegorskoye type), Pasikskoye (Krinitza type) (Table1). Dr. E.Molozhanova took part in expedition 1989 and the authors express their thanks for her contribution to this work. In 1997 there were performed determinations in three fields of mineral waters: Luzhanskoye, Poljanskoye, Uzhgorodskoye (Table 2).

Examined fields are intensively exploited by different resorts and sanatoria («Solnechnoe Zakarpatye», «Kwitka Poloniny», «Shajan», «Karpaty», «Verchovina»), as well as by factories for spillage of mineral waters «Luzhanskaya», «Dragovskaya», «Polyana Kwasova».

RESULTS

Analysis of mineral waters for pesticides content was carried out in the laboratory at the Department of Hydrogeological Problems, Institute of Geological Sciences, NAS of Ukraine, using a gas chromatographs «Tsvet» (Models 550, 570).

Total concentrations of the examined pesticides in the mineral waters vary in the range of 10^{-6}–10^{-4} mg/L; the same range of concentrations was typical for surface waters.

In the soils and water-bearing rocks, pesticides concentrations were considerably higher and reached decimal fractions of mg/kg. In the mineral waters ΣDDT was detected in 100 % of samples in the concentration range 10^{-7}–10^{-4} mg/L. **Σ**HCCH is present in 100 % of samples in the range of concentrations 10^{-7}–10^{-5} mg/L.

Table 1. The content of pesticides in hydromineral resources of Transcarpathian region (July, 1989).

Sampling sites	Object	Pesticides, mg/dm³, mg/kg					ΣD*
		Σ DDT	ΣHCCH	Dilor	Metaphos	Carbophos	
Svalyava district, village Golubinnoye, depression Lug, right bank of the river Piniya, well 4RE	Mineral water	$2.5\cdot10^{-4}$	$4.7\cdot10^{-7}$	$2.9\cdot10^{-5}$	$3.1\cdot10^{-6}$	$1.0\cdot10^{-6}$	$2.8\cdot10^{-4}$
River Piniya	Fresh water	$1.3\cdot10^{-4}$	$5.2\cdot10^{-7}$	$1.3\cdot10^{-5}$	$5.2\cdot10^{-6}$	Not detected	$1.5\cdot10^{-4}$
Depression Lug, 300 m to the west from well 4RE	Rock loam	$3.1\cdot10^{-1}$	$1.8\cdot10^{-3}$	$2.8\cdot10^{-1}$	Not detected	$1.0\cdot10^{-6}$	—
Depression Lug, 300 m to the west from well 4RE	Rock sandy loam	$8.9\cdot10^{-2}$	$7.0\cdot10^{-3}$	$2.5\cdot10^{-1}$	$2.4\cdot10^{-2}$	$5.0\cdot10^{-5}$	—
Depression Lug, 300 m to the west from well 4RE	Fresh water	$7.3\cdot10^{-5}$	$2.3\cdot10^{-7}$	$2.4\cdot10^{-5}$	$5.2\cdot10^{-6}$	Not detected	$1.0\cdot10^{-4}$
Village Polyana, well 3R	Mineral water	$1.1\cdot10^{-5}$	$3.0\cdot10^{-7}$	$3.0\cdot10^{-5}$	$4.1\cdot10^{-7}$	$1.0\cdot10^{-7}$	$4.1\cdot10^{-5}$
Sanatorium «Solnechnoye Zakarpatye», depression Nova Polyana, well 10-K	" "	$1.5\cdot10^{-5}$	$3.1\cdot10^{-7}$	$2.5\cdot10^{-5}$	$3.1\cdot10^{-6}$	$1.0\cdot10^{-7}$	$4.4\cdot10^{-5}$
Village Polyana, water intake Lug, spring 7 km from Polyana	Fresh water	$6.0\cdot10^{-6}$	$7.8\cdot10^{-8}$	$5.1\cdot10^{-6}$	Not detected	$1.0\cdot10^{-7}$	$1.1\cdot10^{-5}$
Sanatorium «Karpaty», stream Labij Potok	" "	$4.8\cdot10^{-5}$	$1.9\cdot10^{-7}$	$8.0\cdot10^{-6}$	$2.0\cdot10^{-7}$	Not detected	$5.6\cdot10^{-5}$
Mukachevo district, sanatorium «Karpaty» 4 km along the road Chinadievo-Svalyava, well 5.	Mineral water	$1.2\cdot10^{-4}$	$1.8\cdot10^{-7}$	$1.4\cdot10^{-6}$	$3.2\cdot10^{-7}$	$1.0\cdot10^{-7}$	$1.3\cdot10^{-4}$
Chust district, village Shayan, sanatorium «Shayan», well 242	" "	$2.2\cdot10^{-4}$	$2.0\cdot10^{-7}$	$3.5\cdot10^{-6}$	$1.0\cdot10^{-7}$	Not detected	$2.2\cdot10^{-4}$
Chust district, village Vyshkovo, well 713	Fresh water	$1.4\cdot10^{-6}$	$1.7\cdot10^{-7}$	$3.5\cdot10^{-6}$	$1.2\cdot10^{-6}$	$1.0\cdot10^{-7}$	$6.3\cdot10^{-6}$
Chust district, village Shayan, sanatorium «Shayan», well 9T	Mineral water	$2.2\cdot10^{-6}$	$5.8\cdot10^{-7}$	$1.8\cdot10^{-5}$	$2.4\cdot10^{-6}$	Not detected	$2.3\cdot10^{-5}$
Mezhgorskij district, village Soimy, sanatorium «Verchovina», well 4R	" "	$5.0\cdot10^{-7}$	$5.6\cdot10^{-5}$	$1.2\cdot10^{-6}$	$1.2\cdot10^{-6}$	$1.0\cdot10^{-7}$	$5.9\cdot10^{-5}$
Mezhgorskij district, village Soimy, stream Kwasovets (the place of falling into r. Rika)	Fresh water	$4.6\cdot10^{-6}$	$7.1\cdot10^{-8}$	$4.3\cdot10^{-6}$	$2.4\cdot10^{-7}$	$1.4\cdot10^{-7}$	$9.4\cdot10^{-6}$
Mezhgorskij district, village Soimy	Soil	$2.2\cdot10^{-2}$	$1.8\cdot10^{-2}$	$9.3\cdot10^{-1}$	$2.4\cdot10^{-2}$	Not detected.	—
Mezhgorskij distrikt, village Kelechin, well 359	Mineral Water	$1.5\cdot10^{-4}$	$6.5\cdot10^{-7}$	$8.6\cdot10^{-6}$	$4.8\cdot10^{-7}$	$1.0\cdot10^{-7}$	$1.6\cdot10^{-4}$
Factory "Polyana Kwasova", village Polyana Kwasova, well 7R3	" "	$2.0\cdot10^{-4}$	$5.1\cdot10^{-7}$	$5.2\cdot10^{-6}$	$1.2\cdot10^{-6}$	$1.0\cdot10^{-7}$	$2.1\cdot10^{-4}$
Village Polyana, Medvezhye, well 4P	Mineral Water	$1.5\cdot10^{-4}$	$6.5\cdot10^{-7}$	$8.6\cdot10^{-6}$	$4.8\cdot10^{-7}$	$1.0\cdot10^{-7}$	$1.6\cdot10^{-4}$
Factory «Lugy» (near Golubinnoe), well 3R3	" "	$2.0\cdot10^{-4}$	$5.1\cdot10^{-7}$	$5.2\cdot10^{-6}$	$1.2\cdot10^{-6}$	$1.0\cdot10^{-7}$	$2.1\cdot10^{-4}$
The city of Svalyava, factory «Svalyava», well 26K	" "	$8.0\cdot10^{-5}$	$2.6\cdot10^{-7}$	$6.3\cdot10^{-5}$	$2.1\cdot10^{-6}$	Not detected	$1.5\cdot10^{-4}$
Svalyava district, Nelipenskoe field, village Nelipeno, Svalyava food products factory, well 21	" "	$5.0\cdot10^{-7}$	$4.0\cdot10^{-7}$	$5.0\cdot10^{-6}$	$2.1\cdot10^{-6}$	$1.0\cdot10^{-7}$	$8.1\cdot10^{-6}$
The city of Uzhgorod, Gorkogo park, well 8	" "	$3.0\cdot10^{-7}$	$7.0\cdot10^{-7}$	$1.3\cdot10^{-5}$	Not detected	$2.0\cdot10^{-7}$	$1.4\cdot10^{-5}$
Mukachevo district, village Pasika, Pasikskoe field, well 1P	" "	$4.0\cdot10^{-7}$	$5.1\cdot10^{-7}$	$3.5\cdot10^{-6}$	" "	$2.0\cdot10^{-7}$	$4.6\cdot10^{-6}$
Dragovo field, well .51	" "	$5.0\cdot10^{-7}$	$2.2\cdot10^{-6}$	$1.8\cdot10^{-6}$	" "	Not detected	$4.5\cdot10^{-6}$
Gornaya Tisa, well 353R	" "	$6.3\cdot10^{-6}$	$5.8\cdot10^{-7}$	$5.2\cdot10^{-6}$	$2.4\cdot10^{-6}$	$2.0\cdot10^{-7}$	$1.5\cdot10^{-5}$
Gorno-Tisenskoe field, stream Trostinets	" "	$1.8\cdot10^{-6}$	$3.0\cdot10^{-6}$	$2.4\cdot10^{-5}$	$1.3\cdot10^{-5}$	$2.1\cdot10^{-6}$	$4.4\cdot10^{-5}$

Gorno-Tisenskoe field	" "	$1.3 \cdot 10^{-5}$	$5.2 \cdot 10^{-7}$	$2.8 \cdot 10^{-5}$	$8.4 \cdot 10^{-6}$	Not detected	$4.9 \cdot 10^{-5}$
Svalyava district, village Golubinnoye, depression Lug, right bank of the river Piniya, well 4RE	Mineral water	$2.5 \cdot 10^{-4}$	$4.7 \cdot 10^{-7}$	$2.9 \cdot 10^{-5}$	$3.1 \cdot 10^{-6}$	$1.0 \cdot 10^{-6}$	$2.8 \cdot 10^{-4}$
River Piniya	Fresh water	$1.3 \cdot 10^{-4}$	$5.2 \cdot 10^{-7}$	$1.3 \cdot 10^{-5}$	$5.2 \cdot 10^{-6}$	Not detected	$1.5 \cdot 10^{-4}$
Depression Lug, 300 m to the west from well 4RE	Rock loam	$3.1 \cdot 10^{-1}$	$1.8 \cdot 10^{-3}$	$2.8 \cdot 10^{-1}$	Not detected	$1.0 \cdot 10^{-6}$	—
Depression Lug, 300 m to the west from well 4RE	Rock sandy loam	$8.9 \cdot 10^{-2}$	$7.0 \cdot 10^{-3}$	$2.5 \cdot 10^{-1}$	$2.4 \cdot 10^{-2}$	$5.0 \cdot 10^{-5}$	—
Depression Lug, 300 m to the west from well 4RE	Fresh water	$7.3 \cdot 10^{-5}$	$2.3 \cdot 10^{-7}$	$2.4 \cdot 10^{-5}$	$5.2 \cdot 10^{-6}$	Not detected	$1.0 \cdot 10^{-4}$
Village Polyana, well 3R	Mineral water	$1.1 \cdot 10^{-5}$	$3.0 \cdot 10^{-7}$	$3.0 \cdot 10^{-5}$	$4.1 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$4.1 \cdot 10^{-5}$
Sanatorium «Solnechnoye Zakarpatye», depression Nova Polyana, well 10-K	" "	$1.5 \cdot 10^{-5}$	$3.1 \cdot 10^{-7}$	$2.5 \cdot 10^{-5}$	$3.1 \cdot 10^{-6}$	$1.0 \cdot 10^{-7}$	$4.4 \cdot 10^{-5}$
Village Polyana, water intake Lug, spring 7 km from Polyana	Fresh water	$6.0 \cdot 10^{-6}$	$7.8 \cdot 10^{-8}$	$5.1 \cdot 10^{-6}$	Not detected	$1.0 \cdot 10^{-7}$	$1.1 \cdot 10^{-5}$
Sanatorium «Karpaty», stream Labij Potok	" "	$4.8 \cdot 10^{-5}$	$1.9 \cdot 10^{-7}$	$8.0 \cdot 10^{-6}$	$2.0 \cdot 10^{-7}$	Not detected	$5.6 \cdot 10^{-5}$
Mukachevo district, sanatorium «Karpaty» 4 km along the road Chinadievo-Svalyava, well 5.	Mineral water	$1.2 \cdot 10^{-4}$	$1.8 \cdot 10^{-7}$	$1.4 \cdot 10^{-6}$	$3.2 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$1.3 \cdot 10^{-4}$
Chust district, village Shayan, sanatorium «Shayan», well 242	" "	$2.2 \cdot 10^{-4}$	$2.0 \cdot 10^{-7}$	$3.5 \cdot 10^{-6}$	$1.0 \cdot 10^{-7}$	Not detected	$2.2 \cdot 10^{-4}$
Chust district, village Vyshkovo, well 713	Fresh water	$1.4 \cdot 10^{-6}$	$1.7 \cdot 10^{-7}$	$3.5 \cdot 10^{-6}$	$1.2 \cdot 10^{-6}$	$1.0 \cdot 10^{-7}$	$6.3 \cdot 10^{-6}$
Chust district, village Shayan, sanatorium «Shayan», well 9T	Mineral water	$2.2 \cdot 10^{-6}$	$5.8 \cdot 10^{-7}$	$1.8 \cdot 10^{-5}$	$2.4 \cdot 10^{-6}$	Not detected	$2.3 \cdot 10^{-5}$
Mezhgorskij district, village Soimy, sanatorium «Verchovina», well 4R	" "	$5.0 \cdot 10^{-7}$	$5.6 \cdot 10^{-5}$	$1.2 \cdot 10^{-6}$	$1.2 \cdot 10^{-6}$	$1.0 \cdot 10^{-7}$	$5.9 \cdot 10^{-5}$
Mezhgorskij district, village Soimy, stream Kwasovets (the place of falling into r. Rika)	Fresh water	$4.6 \cdot 10^{-6}$	$7.1 \cdot 10^{-8}$	$4.3 \cdot 10^{-6}$	$2.4 \cdot 10^{-7}$	$1.4 \cdot 10^{-7}$	$9.4 \cdot 10^{-6}$
Mezhgorskij district, village Soimy	Soil	$2.2 \cdot 10^{-2}$	$1.8 \cdot 10^{-2}$	$9.3 \cdot 10^{-1}$	$2.4 \cdot 10^{-2}$	Not detected.	—
Mezhgorskij distrikt, village Kelechin, well 359	Mineral Water	$1.5 \cdot 10^{-4}$	$6.5 \cdot 10^{-7}$	$8.6 \cdot 10^{-6}$	$4.8 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$1.6 \cdot 10^{-4}$
Factory "Polyana Kwasova", village Polyana Kwasova, well 7R3	" "	$2.0 \cdot 10^{-4}$	$5.1 \cdot 10^{-7}$	$5.2 \cdot 10^{-6}$	$1.2 \cdot 10^{-6}$	$1.0 \cdot 10^{-7}$	$2.1 \cdot 10^{-4}$
Village Polyana, Medvezhye, well 4P	Mineral Water	$1.5 \cdot 10^{-4}$	$6.5 \cdot 10^{-7}$	$8.6 \cdot 10^{-6}$	$4.8 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$1.6 \cdot 10^{-4}$
Factory «Lugy» (near Golubinnoe), well 3R3	" "	$2.0 \cdot 10^{-4}$	$5.1 \cdot 10^{-7}$	$5.2 \cdot 10^{-6}$	$1.2 \cdot 10^{-6}$	$1.0 \cdot 10^{-7}$	$2.1 \cdot 10^{-4}$
The city of Svalyava, factory «Svalyava», well 26K	" "	$8.0 \cdot 10^{-5}$	$2.6 \cdot 10^{-7}$	$6.3 \cdot 10^{-5}$	$2.1 \cdot 10^{-6}$	Not detected	$1.5 \cdot 10^{-4}$
Svalyava district, Nelipenskoe field, village Nelipeno, Svalyava food products factory, well 21	" "	$5.0 \cdot 10^{-7}$	$4.0 \cdot 10^{-7}$	$5.0 \cdot 10^{-6}$	$2.1 \cdot 10^{-6}$	$1.0 \cdot 10^{-7}$	$8.1 \cdot 10^{-6}$
The city of Uzhgorod, Gorkogo park, well 8	" "	$3.0 \cdot 10^{-7}$	$7.0 \cdot 10^{-7}$	$1.3 \cdot 10^{-5}$	Not detected	$2.0 \cdot 10^{-7}$	$1.4 \cdot 10^{-5}$
Mukachevo district, village Pasika, Pasikskoe field, well 1P	" "	$4.0 \cdot 10^{-7}$	$5.1 \cdot 10^{-7}$	$3.5 \cdot 10^{-6}$	" "	$2.0 \cdot 10^{-7}$	$4.6 \cdot 10^{-6}$
Dragovo field, well .51	" "	$5.0 \cdot 10^{-7}$	$2.2 \cdot 10^{-6}$	$1.8 \cdot 10^{-6}$	" "	Not detected	$4.5 \cdot 10^{-6}$
Gornaya Tisa, well 353R	" "	$6.3 \cdot 10^{-6}$	$5.8 \cdot 10^{-7}$	$5.2 \cdot 10^{-6}$	$2.4 \cdot 10^{-6}$	$2.0 \cdot 10^{-7}$	$1.5 \cdot 10^{-5}$
Gorno-Tisenskoe field, stream Trostinets	" "	$1.8 \cdot 10^{-6}$	$3.0 \cdot 10^{-6}$	$2.4 \cdot 10^{-5}$	$1.3 \cdot 10^{-5}$	$2.1 \cdot 10^{-6}$	$4.4 \cdot 10^{-5}$
Gorno-Tisenskoe field	" "	$1.3 \cdot 10^{-5}$	$5.2 \cdot 10^{-7}$	$2.8 \cdot 10^{-5}$	$8.4 \cdot 10^{-6}$	Not detected	$4.9 \cdot 10^{-5}$

Table 2. The content of organochloric pesticides in mineral waters of Transcarpathian region (October, 1997).

Sampling sites	n,n-DDT	N,n-DDE	n,n-DDD	Σ DDT	α-HCCH	β-HCCH	γ-HCCH	Σ HCCH	Aldrin	Heptachlor	Trephlane	Σ D *
Kwitka Poloniny (Luzhanskaya type)	$8.4 \cdot 10^{-5}$	$1.2 \cdot 10^{-6}$	$2.7 \cdot 10^{-6}$	$8.7 \cdot 10^{-5}$	$1.2 \cdot 10^{-6}$	Not detected	$6.0 \cdot 10^{-7}$	$1.8 \cdot 10^{-6}$	Not Detected	$6.0 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	$8.9 \cdot 10^{-5}$
Polyana Kwasova (carbonic Carbonate-chloride sodium)	$2.8 \cdot 10^{-5}$	$3.0 \cdot 10^{-6}$	$3.6 \cdot 10^{-6}$	$3.5 \cdot 10^{-5}$	$8.0 \cdot 10^{-7}$	" "	Not detected	$8.0 \cdot 10^{-7}$	$4.0 \cdot 10^{-7}$	Not detected	$4.0 \cdot 10^{-8}$	$3.6 \cdot 10^{-5}$
The city Uzhgorod Bozozhdokski park (Darasun type)	$5.4 \cdot 10^{-5}$	$4.6 \cdot 10^{-6}$	Not detected	$5.9 \cdot 10^{-5}$	$3.2 \cdot 10^{-6}$	" "	$8.0 \cdot 10^{-7}$	$4.0 \cdot 10^{-6}$	$1.0 \cdot 10^{-7}$	" "	Not detected	$6.3 \cdot 10^{-5}$

Note: Σ D* - total concentration of the pesticides, mg/dm^3 (all pesticides in one liter mineral water).

Dilor was detected in100% of samples in the concentration range 10^{-6} –10^{-5}mg/L. Metaphos is present in 82% of samples in the concentration range 10^{-7}– 10^{-6} mg/L. Carbophos is present in 71% of samples in the concentration range 10^{-7}– 10^{-6} mg/L. There were a total of nine pesticides and their derivatives detected in the mineral waters. In some samples, up to eight different substances were measured.

There is no clear correlation between pesticide content in the mineral waters and type, composition or location of mineral water. Both maximum and minimum total concentrations of the pesticides were detected in the hydrocarbon sodium waters of Polyana-Svalyava group (maximum equals $2.8 \cdot 10^{-4}$ mg/L in the well 4RE, v. Golubinnoye; minimum — $4.6 \cdot 10^{-6}$ mg/L, in the well 21 on the territory of food products factory, v. Nelipino).

In Ukraine, as well as in other countries of UIS, maximal permissible concentrations (MPC) standards were not established for the estimation of total influence of pesticides on a human body especialy (organochloric, organophosphoric, fluorine-containing pesticides), either for mineral waters nor for potable waters. Thus, it is not possible to estimate the danger of the detected quantities of pesticides in the examined mineral waters. Comparing the results obtained with the standards for industrial and potable water, we assume that none of the detected pesticides exceeds MPC.

However, the pesticide products listed above are among the most dangerous environmental pollutants, according to classification by the World Health Organization (WHO) and other international organizations. Particularly dangerous is the simultaneous presence of several substances and their metabolites in the same sample or water because their combined effect on the human body has not yet been studied.

CONCLUSIONS

Analysis of the situation at mineral water fields in the Transcarpathian region revealed the primary stages of contamination by pesticides, most likely due to agriculture and industry activities. If the situation is not controlled, this could cause irreversible negative consequences in the near future. Despite the variability of hydrogeological conditions in the Transcarpathian region there were no apparent regional correlations between pesticides concentrations in the mineral waters and either geological structure of the territory, type, or chemical content of the waters.

Pesticide content in the mineral waters was characterized by a mosaic character of distribution which relates to the quantity and assortment of pesticides that are utilized at agricultural lands and forests, permeability of aeration zone and filtration properties of the water-saturated zone, the technical state of wells and regime of their exploitation, permeability of the near-well surface and the confined and unconfined character of the aquifer.

During the last ten years (1987–1997), DDT content in water significantly decreased while HCCH concentrations remained practically the same. This suggests that HCCH was periodically used at the agricultural lands and forests. As far as DDT is concerned, there were no new input into the ecosystem, and pollution of DDT gradually decreased.

It's necessary to conduct systematic observations of pesticide content in hydromineral resources and to perform ecological studies of the territories in order to eliminate or diminish

negative influence of the pesticides by changing the assortment of products used, decrease in concentration, and in some cases, prohibition of certain pesticides. Fundamental investigations are needed to reveal the transport mechanisms of these substances in the subsurface, to elaborate the criteria for the estimation of danger for the simultaneous presence of pesticides of different groups in the same mineral water.

To improve the ecological situation, modelling of DDT decomposition in mineral waters of the Transcarpathian region was established. As soon as DDT is concerned, there were no new income to natural ecosystems, and retrospective pollution gradually decreases ten years (for one order).

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