Study of Groundwaters Using the Environmental Tritium and Hydrochemical Data in the Belgrade Region

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ABSTRACT / A study of tritium content and some physicochemical parameters has been performed in order to investigate interconnection between surface and atmospheric waters and underground waters in Belgrade area. Samples of the precipitation at Zeleno Brdo-Belgrade meteorological station, the Danube and the Sava river water, and underground water (Ranney wells and piezometers) have been analyzed. The 3H content, the content of dissolved ions, total hardness, and electrical conductivity have been measured. The tritium data show existence of two water strata in the aquifer. The upper stratum (about 16 m thick) contains older water (mean monthly 3H concentration of 17 TU) and has weak interaction with the river and the precipitation. Below this stratum lies the principal water bearing stratum, strongly connected with the river with the 3H concentration similar to that of surface water (mean monthly 3H concentration of 50 TU) and spreading out through the entire aquifer. The contribution of the Sava river water and the two water layers at the Ranney well are calculated starting with the hydrological aquifer model, which supposes that three water components are mixed in the pumped Ranney well water. According to calculation results using the 3H concentration and physicochemical characteristics as parameters, more than 70 percent of the water pumped by the Ranney well (in 1983) comes from the Sava with a time delay of less that 15 days.

Properties of tritium distribution in precipitation, river waters, and underground water in the Belgrade region are established from the results of measurements of 3H concentrations in the period 1976–1983.

Introduction

The Sava and the Danube rivers' valley at Belgrade presents an alluvial region in underground water exploited by the Ranney wells located along the banks of the Sava river. Due to an urgent need to increase water supply and because of possible pollution of wells through contamination of the rivers, it was important to investigate interconnection between these waters. The nuclear power plant at Krško on the Sava river is another reason for these investigations. However, complicated hydrogeological conditions make it difficult to comprehend the water regime in the Belgrade region. For this reason after the first experience with the results on velocity of filtration of the river waters underground obtained with stable and 3H isotope and water temperature (Boreli and others 1978) during 1976–1977, the investigations have been concentrated on the locality of Makig (one part of the Sava alluvium, Fig. 1) and are still being carried out. The measurements of 3H content and chemical composition of water, the water temperatures, water levels, and electric conductivity of water should contribute to a better understanding of complex connections of waters in the aquifer and underground water regime. Further, the investigations at different points of the alluvium should help to define the natural background of 3H and to clarify the connections between different strata of underground and surface waters. Some principal results of these investigation and critical discussion of the data obtained during the period 1976–1983 are presented in this article.

Measurements

Analyses of 3H in the period 1976–1983 were performed on the collected monthly samples of precipitation and of the Danube and the Sava river waters. From 1978 3H content in underground waters has been measured in a wide region around the confluence of the Sava into the Danube. The samples were taken from the Sava river and underground at the depths up to 28 meters and from Ranney wells (eight times per month, during October 1978 to December 1979 and three times per month later). Be-
sides these, basic chemical analyses were also carried out (in 1977, 1983–1984) along with the electrical conductivity.

Water temperatures and water levels were measured during sample taking. The data of precipitation quantities, water levels in the rivers, and flow velocities at the sampling spots in the Sava and the Danube were used for interpretation of the results.

The $^3$H activity in the samples was measured applying a liquid scintillation counter and electrolytic enrichment of $^3$H in the samples. The statistic error of the measurements is ±10 percent.

Hydrologic Conditions in the Investigated Region

In the experimental region of Makiš (area about 25 km$^2$, Figure 1), one of the most important parts of the Belgrade alluvial aquifer lies on the right bank of the Sava, several kilometers upstream from the Sava’s confluence into the Danube.

Large accumulation of underground waters has been found in the alluvial strata of Makiš (Fig. 2). The aquifer is fed with water from three main different sources: (1) By filtration of the river water along the bank, (2) by infiltration of the precipitation, and (3) by infiltration of the water along the edges of the aquifer. The filtration of the river water is enhanced by the work of a Ranney wells chain located at the bank of the Sava.

Characteristics of the Tritium Distribution in the Natural Waters of the Belgrade Region

Belgrade is situated in the zone between 30°–50° north latitude, where the highest $^3$H concentrations of thermonuclear origin in the precipitation should be expected due to global atmospheric circulation (Brown...