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## RADIOCARBON AND TRITIUM MEASUREMENTS OF GROUNDWATERS IN EASTERN SLAVONIA

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**Key words :** groundwater, isotopes, activity

**Ključne riječi:** podzemna voda, izotopi, aktivnost

The aim of this work was to determine the mean residence time of groundwater in Vinkovci and Đakovo at different water-bearing layers. The results of radiocarbon and tritium measurements in groundwater samples gave some information about recent infiltration and potential antropogenic influence on groundwater quality.

Cilj ovog rada bio je utvrditi srednje vrijeme zadržavanja podzemnih voda u različitim vodonosnim slojevima Vinkovaca i Đakova. Rezultati mjerenja radioaktivnog ugljika i tricija u uzorcima podzemnih voda dali su informacije o recentnoj infiltraciji i mogućem antropogenom utjecaju na kvalitetu podzemne vode.

### 1. INTRODUCTION

Radiosotopes tritium (<sup>3</sup>H) and radiocarbon (<sup>14</sup>C) are included in natural hydrologic cycle. Measurements of the isotopes in natural waters (precipitation, surface water and groundwater) were used to obtain information about recharge time, mean residence time of groundwater from different water-bearing layers and recent infiltration to groundwater (IAEA, 1983; HORVATINČIĆ & GRGIĆ, 1989)

Radiocarbon and tritium measurements in Đakovo and Vinkovci groundwaters were used as a part of comprehensive hydrogeologic study of the Eastern Slavonia groundwater system. All water samples were prepared and measured in the Radiocarbon and Tritium Laboratory of the Ruđer Bošković Institute, Zagreb.

### 2. HYDROGEOLOGICAL SETTING

In tectonic sense the investigated area of water supply stations Kanovci-Vinkovci and Trslana-Đakovo, is the part of the Slavonia-Srijem Depression and the Sava river basin, respectively. The depression was separated from the Đakovo-Vinkovci horst with the main active fault zone (HERNITZ, 1983; PRELOGOVIĆ & CVIJANOVIĆ, 1983). In accordance with regional hydrogeological zoning the explored area belongs to hydrogeologic unit of the plain and to the first hydrogeologic zone, built from Quaternary deposits: terrigenous clastic river sediments, terrestrial marsh sediments, lake sediments and Pleistocene loess deposits. Within the first hydrogeologic zone four permeable gravely and sandy water-bearing horizons, interesting for water supply, were selected:

1. water-bearing layer "Velika Kopanica"
2. water-bearing layer "Vinkovci"
3. water-bearing layer "Nijemci"
4. water-bearing layer "Strizivojna"

Overlying and underlying sediments consist mostly of silty-clayey, clayey-silty and sandy materials (MILETIĆ et al., 1975; MILETIĆ et al., 1986). In the area south of Vinkovci and Đakovo, regional first water-bearing layer "Velika Kopanica" lenses out and disappears. Therefore, first and second water-bearing layers of investigated water supply stations represent Vinkovci layer and Nijemci layer, respectively.

### 3. RESULTS AND DISCUSSION

The groundwater samples were taken from piezometers with filter sections situated in the first and second water bearing layers, semipermeable overlying and underlying sediments in the area of water supply stations Kanovci-Vinkovci and Trslana-Đakovo (Fig. 1).

Tritium and <sup>14</sup>C activity of water samples were measured by the proportional counter filled with methane. The methane for tritium measurements was obtained by the reaction of water sample with aluminium carbide. For radiocarbon analyses, carbonates precipitated from water samples, were treated with H<sub>3</sub>PO<sub>4</sub>, and the evolved CO<sub>2</sub> was converted to methane by the reaction with hydrogen (HORVATINČIĆ, 1980). <sup>14</sup>C results were expressed in radiocarbon age (year BP) and in percent age with respect to the "modern carbon" standard (% modern) (OBELIĆ, 1980). The initial activity of 85% was used for the calculation of radiocarbon age of groundwaters at Vinkovci and Đakovo locations. The results of the tritium and radiocarbon analyses are presented in Table 1.

#### 3.1. KANOVCI - VINKOVCI

<sup>3</sup>H concentration of groundwater from the first water-bearing layer is quite close to the detection limit; and because of that this low <sup>3</sup>H activity is not reliable evidence for recent water infiltration, the radiocarbon age being

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KANOVCI-VINKOVCI			
	<sup>14</sup> C activity (% modern) <sup>14</sup> C aktivnost (% postotak ugljika)	<sup>14</sup> C age (year BP) <sup>14</sup> C starost (godine)	<sup>3</sup> H activity ( Bq/l)* <sup>3</sup> H aktivnost ( Bq/l)*
overlying sediment of 1. water-bearing layer (V-24/3) krovina 1. vodonosnog sloja (V-24/3)	94.0±1,5	modern	4.9±0.4
overlying sediments of 1. water-bearing layer (P-16) krovina 1. vodonosnog sloja (P-16)	-	-	4.2±0.4
1. water-bearing layer (P) 1. vodonosni sloj (P)	32.0±1.0	8070±250	0.4±0.2
2. water-bearing layer (V-26) 2. vodonosni sloj (V-26)	< 0.5	> 37000	< 0.2
Table 1. Results of radiocarbon and tritium measurements of Vinkovci and Đakovo groundwaters. Tablica 1. Rezultati mjerenja radioaktivnog ugljika i tricija u podzemnim vodama Vinkovaca i Đakova.			

8070 years. The second water-bearing layer contains water free of tritium and is of much older radiocarbon age. The mean residence time of that water exceeds 37000 years. The influence of recent infiltration was established only in the shallow seepage sandy layer placed within the semipermeable cover deposits. No recent water contribution in deeper horizons may result in limited groundwater resources.

### 3.2. TRSLANA - ĐAKOVO

Groundwater sample of the shallow seepage semipermeable sediments has higher <sup>3</sup>H concentration (Table 1) and closely reflects the tritium activity of precipitation. It indicates the recent infiltration of meteoric and surface water in these horizons. Water from deeper horizons is free of tritium and has not shown any influence of direct surface water contribution in last 40 years. Groundwater sample from the first water-bearing layer contains 85% of modern carbon which reflects recent water, but in respect of tritium activity, older than 40 year. The mean residence time of groundwater from the second water-bearing layer is shorter than the same water-bearing layer in the area of Vinkovci.

Both investigated groundwater systems, in spite of quite similar lithological and hydrogeological characteristic of semipermeable overlying deposits, have different mean residence time distribution. The mean residence time of groundwater in Đakovo is significantly shorter than in Vinkovci. The possible reasons for that might be the consequence of better permeability properties of cover sediments and/or the cropping out of water-

TRSLANA-ĐAKOVO			
	<sup>14</sup> C activity (% modern) <sup>14</sup> C aktivnost (% postotak ugljika)	<sup>14</sup> C age (year BP) <sup>14</sup> C starost (godine)	<sup>3</sup> H activity ( Bq/l)* <sup>3</sup> H aktivnost ( Bq/l)*
shallow overlying sediments of 1. water-bearing layer (V-27/3) plitka krovina 1. vodonosnog sloja (V-27/3)	-	-	3.4±0.3
deep overlying sediments of 1. water-bearing layer (V-27/2) duboka krovina 1. vodonosnog sloja (V-27/2)	-	-	<0.2
1. water-bearing layer (V-27) 1. vodonosni sloj (V-27)	85.0±1.2	modern	<0.2
underlying sediments of 1. water-bearing layer (V-27/1) podina 1. vodonosnog sloja (V-27/1)	-	-	<0.2
2. water-bearing layer (V-5/1) 2. vodonosni sloj (V-5/1)	57.5±1.0	3200±150	<0.2
* Detection limit of tritium system is 0.2 Bq/l			

bearing layers on the Đakovo horst surface. Further, hydrogeologic and isotopic investigations are necessary for definitive conclusions.

### 4. CONCLUSIONS

Radiocarbon and tritium analyses of groundwaters at Vinkovci and Đakovo water supply stations suggest the following:

1. Although the investigated area of Vinkovci and Đakovo water supply stations belongs to the same hydrogeologic zone, as well as same hydrogeologic unit of plain region with analogous lithological and hydrogeologic properties, they represent two separate hydrodynamic system with different infiltration rate and different recharge area.
2. There are no significant hydraulic communications between recent meteoric water and water bearing horizons. The first and the second water-bearing layers of both locations are isolated from the direct surface water pollution.

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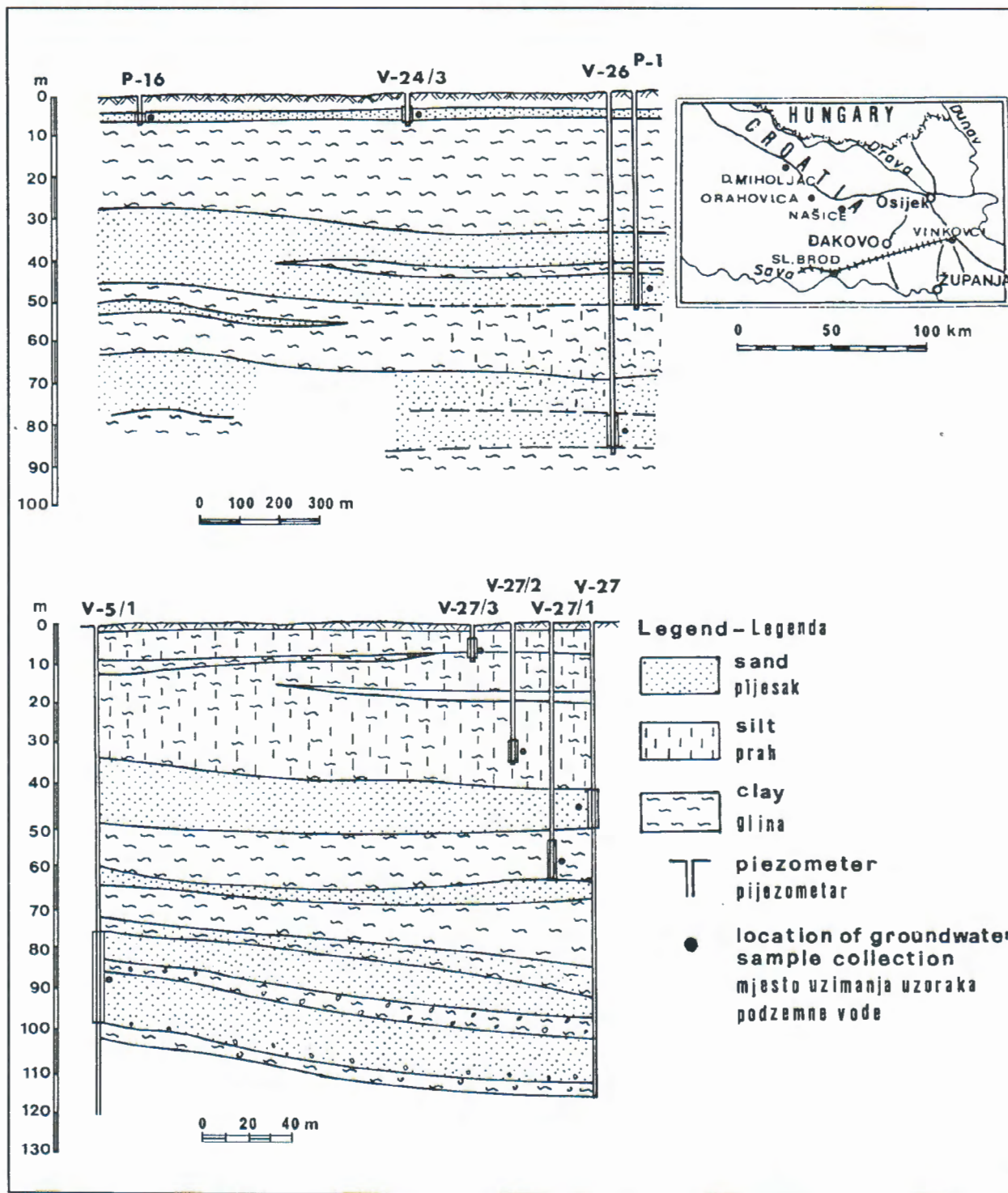


Fig.1. Hydrogeologic profiles of the KANOVCI-VINKOVCI and the TRSLANA-AKOVO areas with locations of groundwater sample collection.  
 Slika 1. Hidrogeološki profili područja KANOVCI-VINKOVCI i TRSLANA-AKOVO s mjestima uzimanja uzoraka podzemne vode.

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### MJERENJA RADIOAKTIVNOG UGLJIKA I TRICIJA U PODZEMNIM VODAMA ISTOČNE SLAVONIJE

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U okviru opsežne hidrogeološke studije istočne Slavonije, na području vodocrpilišta Kanovci u Vinkovcima i Trslana u Đakovu, pristupilo se određivanju starosti podzemnih voda, odnosno srednjeg vremena zadržavanja vode u vodonosnim slojevima, identifikaciji recentne infiltracije i mogućeg utjecaja zagađenja s površine. Na temelju rezultata mjerenja aktivnosti prirodnih radioaktivnih izotopa  $^{14}\text{C}$  and  $^3\text{H}$  utvrđeno je da prema lokaliteti vodocrpilišta u Vinkovcima i Đakovu pripadaju istoj hidrogeološkoj zoni i

hidrogeološkoj jedinici ravničarskih područja s analognim litološkim i hidrogeološkim karakteristikama, predstavljaju dva potpuno odvojena hidrodinamička sustava s različitim brzinom infiltracije i različitim područjem prihranjivanja.

Izraženiji doprinos suvremenih meteorskih voda i brža izmjena voda u plitkom pojednom proslojku u Vinkovcima i u vodonosnim slojevima Đakova povećava vjerojatnost antropogenog utjecaja na kvalitetu podzemne vode.