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ORIGINAL ARTICLE

Hydrogeological conditions and quality of ground waters in northern Banat, Pannonian basin

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Abstract Geological relationships, hydrogeology and chemical composition of ground water in northern Banat were studied through the period 2000–2004 using the available background data from published and unpublished sources. Northern Banat is the extreme northeastern part of the Republic of Serbia and a geotectonic part of the vast Pannonian depression. The source of domestic and industrial water supply is only groundwater from artesian and subartesian aquifers of Lower Pleistocene (Q_1^1) and Upper Pleistocene (Pl_3^2) sand deposits. The ground water, "peculiar" in chemical composition, is the only source of drinking water in the arid area. A notable variation in the chemical composition of artesian waters within the same geotectonic unit (Pannonian basin), abstracted for municipal water supplies of Kikinda, Novi Knezevac and Djala, has attracted attention of these authors. Our paper attempts to interpret the variation in the chemical composition of ground water and the cause of the variation by the interaction of ground water and rocks forming the aquifers on the case example of the water supply sources for the three mentioned towns. With respect to the depth and lithology of the aquifers, we interpret the varied chemical compositions of waters in the mentioned sources as a consequence of natural factors (geological environment), geological relationships and hydrogeological conditions.

Keywords Ground water · Hydrogeology · Water supply · Northern Banat · Pannonian basin

Introduction

Northern Banat is the northeastern part of the province of Vojvodina in the southern belt of the Pannonian depression. The study area has a surface of about 1,125 km^2 in the extreme NE of the Republic of Serbia (Fig. 1). Northern Banat is drained by the Tisa to the Danube to the Black Sea. It is a very gently rolling land at altitudes between 75 and 94 m formed of deposits (on the Pannonian lacustrine floor) and subsequently shaped by the processes of erosion. The geomorphologic forms developed are the Tisa and the Zlatica alluvial plains, river terraces, oxbows, oxbow lakes and marshes (Menkovic et al. 2003).

Public water supply and distribution systems have been estimated in northern Banat from the sixties of the last century. Hydrogeological surveys for the purpose of water supply, first to major, and later to other communities, were sporadic. Only in the last few decades, Hydrogeological data of exploratory works for various purposes were classified and updated. Very useful hydrogeological data were obtained also from deep drilling for petroleum and gas, regional geophysical, geological and other prospectings.

Domestic and industrial consumers are supplied with water from aquifers, 140 to 230 m deep. Shallower aquifers, excluding the shallowest subsurface one, are

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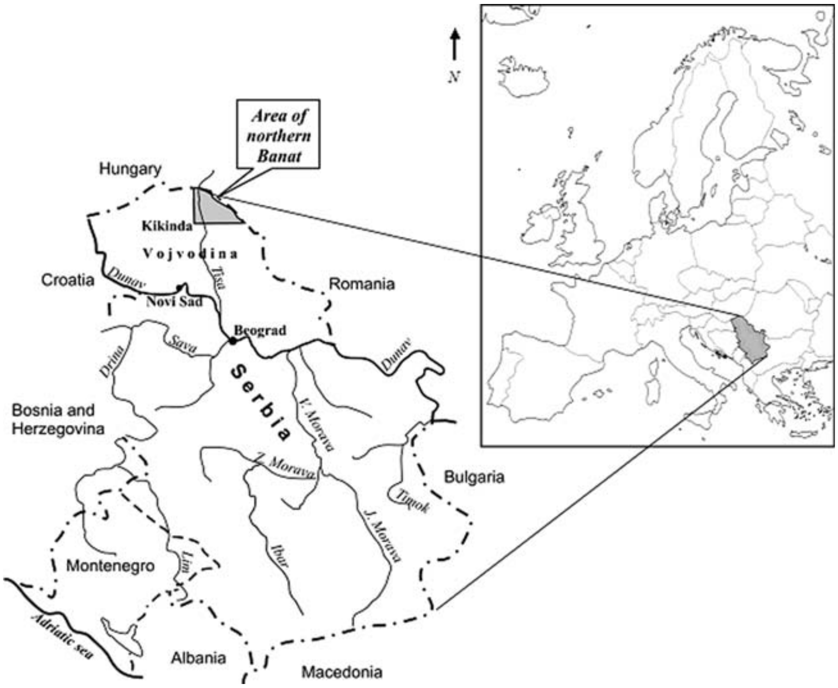


Fig. 1 Geographical location of northern Banat

thin and semipervious. Deep artesian aquifers consist of Upper Pliocene (Pl$_3^2$) and Lower Pleistocene (Q$_1^1$) sands that contain water of a particular chemical composition. At present and in the near future, these aquifers will be the only source of drinking water. The quality of water, however, is not uniform in the area, it differs from one source to another.

The departing hypothesis of the authors was that the uncommon chemical composition and variability of ground waters within the same geotectonic unit should be interpreted as consequences of a long interaction between ground waters and rocks of the aquifers (Brencic 2006). A characteristic example of the ‘‘peculiar’’ ground water composition influenced dominantly by the mentioned interaction is the source of water supply to Kikinda, Novi Knezevac and Djala in northern Banat.

The water supply source for Kikinda was developed in 1960. Production wells were drilled to extract water from a depth interval of 170–220 m. Heavy pumping at the rate of 340 l^{-1} in 40 wells led to the drawdown of about 22 m (in 2001) below the initial piezometric level. The source for water supply to Novi Knezevac was developed in 1975. It is located about 37 km NW of Kikinda. Production wells were drilled into a system of aquifers at a depth of 170 to 197 m (Pavlovic 1975; Jovanovic 1988). Eleven wells of this source produce water at about 80 l^{-1}. The piezometric level in the source area in 2001 was 7 m lower than at the beginning. The source area of water supply to Djala is about 10 km north of Novi Knezevac, developed in 1986. Water is supplied from a well, 172 m deep, at an average rate of 1.5 l^{-1} (Rogulic 1986). The piezometric level in the source area was 1 m lower in 2001 than at the beginning.

Methods

Some data of the extensive 2000–2004 prospecting, tests and analyses are presented in this work for application of the knowledge of the common and contribution to the study of ‘‘uncommon’’ compositions of abstracted ground waters for public water supply in northern Banat. Results of the following investigations were used: geological and hydrogeological mapping, well pumping tests, chemical analyses of ground waters, inquiry among population, etc.

The hydrogeology of northern Banat is interpreted on the basis of the available documentary evidence and records, published works, and the investigation data.

Water for chemical analysis was sampled directly from the suction pipe of wells for municipal and industrial water supply. Annually, thirty samples were collected from each source and analyzed. The chemical composition data are interpreted for each water source.

The chemical parameters analyzed were (pH, colour, dry residue, $KMnO_4$ consumption, total hardness, ammonia, nitrate, nitrite, calcium, magnesium, sulphates, chlorides, total iron, sodium and potassium) and specific analyses were made (humic substances and trihalomethane formation potential-THMFP). The water quality parameters were determined using standard methods (Clesceri et al. 1995; EPA 1981, 1997). In each sampling place, nitro acid was added to water samples to pH < 2. A Perkin Elmer Model 5000, HGA 4000 in the atomic absorption spectrometry (AAS) was used to measure metal concentrations. The instrument producer's (Beauty 1988) instructions were followed for all measurements. A chromatograph of Varian type, model GC 3400, with electron absorption detector (63 Ni-ECD), was used in the capillary column chromatography for separation and concentration of trihalomethane in an automated, microprocessor controlled Purge-Trap system (Rook 1974, 1976; EPA 1984, 1988; Clesceri et al. 1995). The data were used to determine water quality and as an information for assessment of the water-bearing rock influence on the chemical composition of the abstracted ground waters.

Results and discussion

Geology of northern Banat

Northern Banat is a part of the extensive Pannonian depression in southeastern Europe. The Pannonian depression is a geotectonic entity of a particular structural pattern and lithology (Fig. 2). It was formed through gradual land subsidence along many large ruptures, which began in the Eocene, continued through the Neogene and ceased in the Lower Quaternary. The depression was filled with marine and lacustrine Tertiary and Quaternary deposits (Varsanyi et al. 1999).

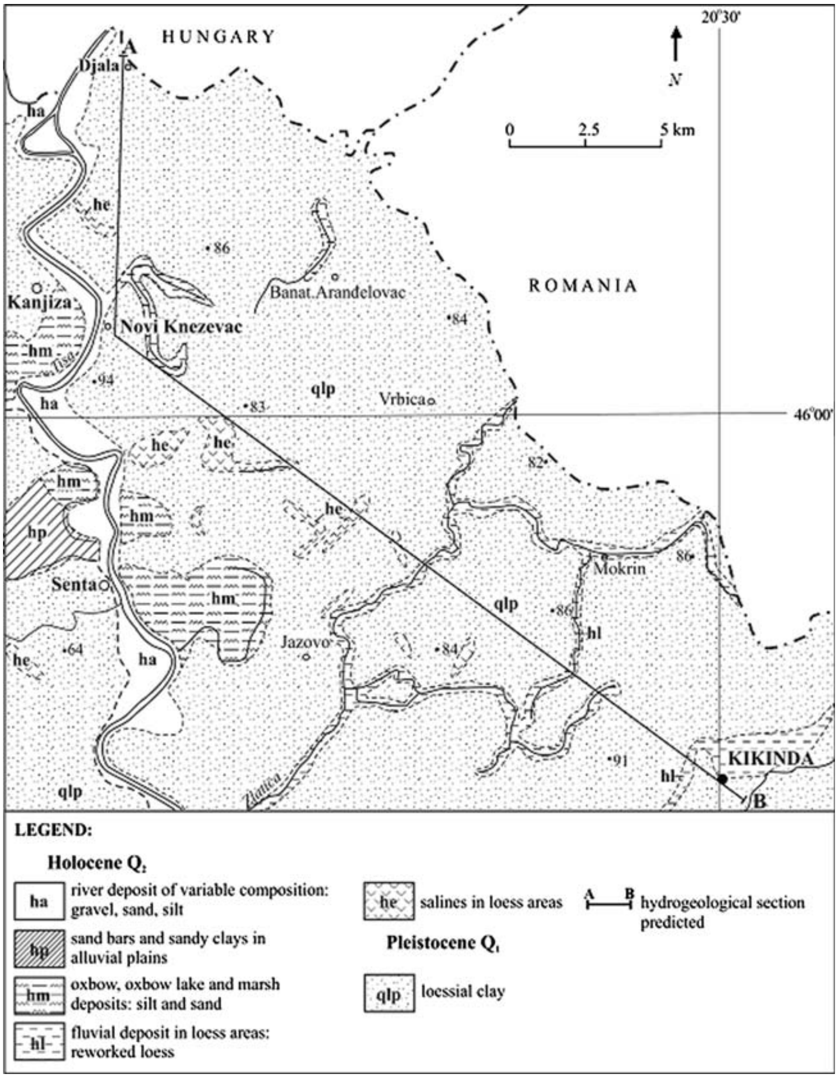


Fig. 2 Geological map of northern Banat (Milovanovic and Ciric 1968)

The geological section of northern Banat shows three structural stages:

- Pre-Tertiary,
- Tertiary deposits, and
- Quaternary sediments.

Pre-Tertiary rocks that form the paleotopography of the Pannonian basin are Precambrian crystalline schists and Paleozoic and Mesozoic rocks.

Geophysical survey and deep drilling in the Kikinda-Nakovo-Mokrin area of northern Banat identified a trough in Precambrian schists filled with Tertiary sedimentary rocks (Sikosek 1971). Pre-Tertiary rocks form the lowest impermeable floor under all younger geological formations of northern Banat.

Tertiary deposits lie transgressively and unconformably over the paleotopography. The thickness of the deposits is 3,000 m at the most (Rajcevic et al. 1989; Koprivica and Strain 1995). Conglomerates, sandstones, limestones, gravels, sands, silts, coal, and clay represent the deposits. The Miocene, Lower, Middle and Upper Pliocene ages of rocks are proved on paleontological evidence. Tertiary deposits include several water-bearing bodies (Jovicic 1996). Thermomineral water occurs at depth, commonly with the petroleum and gas deposits. Its chemical and physical properties reflect the environmental conditions.

The Pliocene is represented by paludal strata—lacustrine and lacustrine-fluvial sediments deposited in depressions that became lakes after the retreat of the Paratethys from the Pannonian province (Rabrenovic et al. 2003). Lithological constituents are sands and clays with local lignite occurrences. Pliocene deposits vary in thickness from 350 to 1,200 m (Rajcevic et al. 1989). The highest Pliocene deposits include more water-bearing sands. Layers or complexes bearing mineral-low water are less than 300 m deep, rarely deeper (Petkovic 1976). Mineral-low water in Upper Pliocene is an important potential resource of water supply.

Quaternary deposits in northern Banat are about 240 m deep from the surface (Rajcevic et al. 1989; Koprivica and Strain 1995) over all the preexisting rocks. They are freshwater and terrestrial deposits composed of gravels, fine to coarse sands, sandy clay, coal, clay, loessial loam, and loess (Rajcevic et al. 1989). Deposits of the Pleistocene (Q_1) are fluvial-lacustrine, fluvial-palustrine and fluvial, and of the Holocene (Q_2) fluvial, palustrine and eolian sediments (Fig. 3).

Fluvial-lacustrine deposits of the Lower Pleistocene age (Q_1^1) are represented by polycyclic fluvial and fluvial-lacustrine sands and gravels. These deposits are known in paleontology as layers bearing *Viviparus böckhi* (Petkovic 1977a, b).

Their thickness in northern Banat is from 70 to 130 m (Koprivica and Strain 1995) and the extent beyond the limits of the study area to the margin of the Pannonian basin in Romania, Hungary and Croatia (Jovicic 1996). The deposits were laid through a transitional stage in the Pannonian depression and the peri-Pannonian regions. The fluvial-lacustrine deposits form the main aquifer for water supply in northern Banat.

Fluvial-paludal sediments of the Middle Pleistocene (Q_1^2) were deposited over the preexisting fluvial-lacustrine deposits in a total thickness of 50–70 m (Koprivica and Strain 1995). The deposits consist of silt, silty and paludal clays, and carbonaceous material of fluvial and oxbow facies, less commonly lenses of dominantly fine sand of riverbed facies. Generally, these deposits are less permeable than the fluvial-lacustrine sediments. The deposits were found in the whole northern Banat (Petkovic 1976). The formation of Upper Pleistocene (Q_1^3) fluvial deposits and stream terraces is associated with the Tisa flooding. These deposits of low permeability consist of sands, silts and clays in a total thickness of about 30 m (Koprivica and Strain 1995). Holocene (Q_2) deposits are relatively thin, from 10 to 14 m, composed of clastic materials of various derivations (Petkovic 1977a, b). Fluvial deposits form the shallowest aquifer in direct hydraulic communication with surface waters.

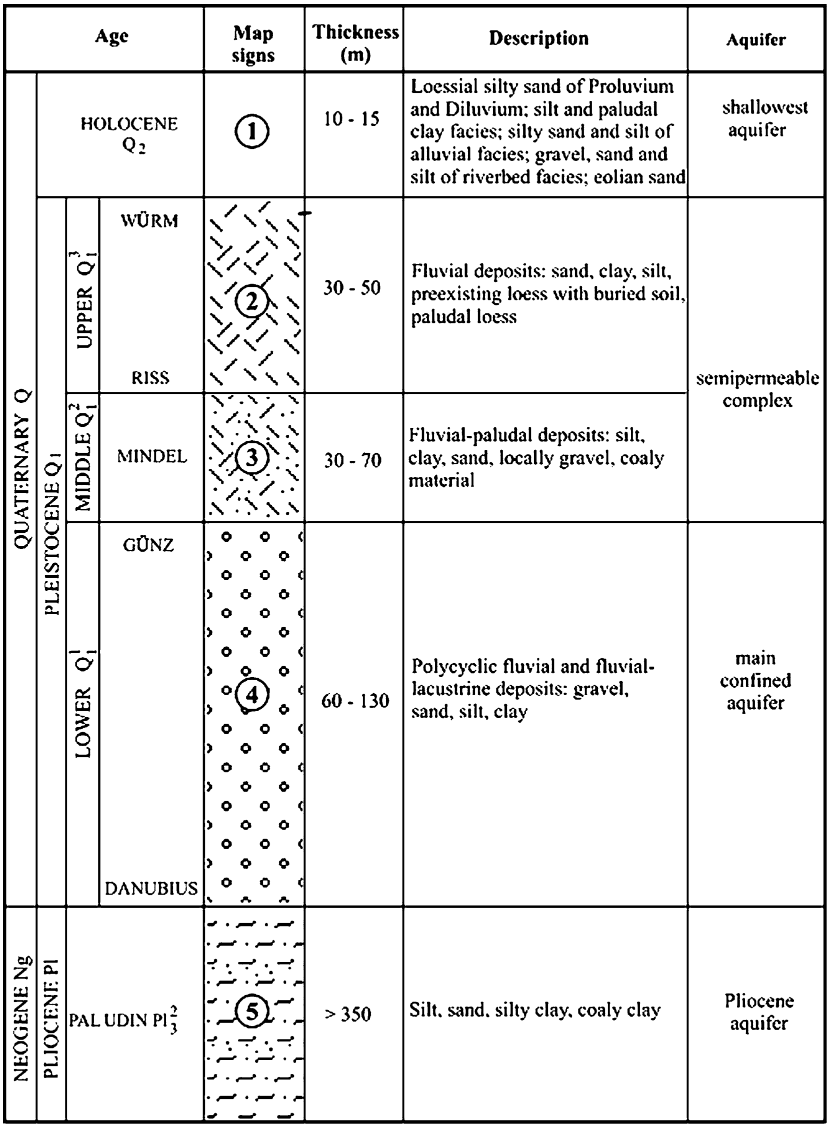
Hydrogeology of utilized groundwater reservoirs

The hydrogeological section of northern Banat to the ground water abstraction depth can be divided (Fig. 4) into:

- the shallowest, Holocene (Q_2) aquifer,
- semipermeable aquifer system of Upper Pleistocene (Q_1^3) fluvial and Middle Pleistocene (Q_1^2) fluvial-palustrine deposits,
- main confined aquifer of Lower Pleistocene (Q_1^1) polycyclic fluvial and fluvial-lacustrine deposits,
- Upper Pliocene sand aquifers—Upper Paludine beds (Pl_3^2).

For a cost-effective water supply in northern Banat, only Upper Pliocene (Upper Paludine Beds, Pl_3^2) and Lower Pleistocene (Q_1^1) water-bearing sands are important.

The Upper Paludine beds (Pl_3^2) are represented by sands (locally tens of metres thick), in places by gravelly sand alternating with silt, silty clay and sporadic lignite, as in Kikinda source area (Jankovic 1970).



Age				Map signs	Thickness (m)	Description	Aquifer
QUATERNARY Q	HOLOCENE Q_2			①	10 - 15	Loessial silty sand of Proluvium and Diluvium; silt and paludal clay facies; silty sand and silt of alluvial facies; gravel, sand and silt of riverbed facies; eolian sand	shallowest aquifer
	PLEISTOCENE Q_1	UPPER Q_1^3	WÜRM RISS	②	30 - 50	Fluvial deposits: sand, clay, silt, preexisting loess with buried soil, paludal loess	semipermeable complex
		MIDDLE Q_1^2	MINDEL	③	30 - 70	Fluvial-paludal deposits: silt, clay, sand, locally gravel, coaly material	
		LOWER Q_1^1	GÜNZ DANUBIUS	④	60 - 130	Polycyclic fluvial and fluvial-lacustrine deposits: gravel, sand, silt, clay	main confined aquifer
NEOGENE Ng	PLIOCENE Pl	PAL UDIN Pl_3^2		⑤	> 350	Silt, sand, silty clay, coaly clay	Pliocene aquifer

Fig. 3 Geologic column of northern Banat Quaternary deposits (after BGM, Sheets Szeged and Kikinda 1:100,000, amended) and legend to the hydrogeological section predicted A-B

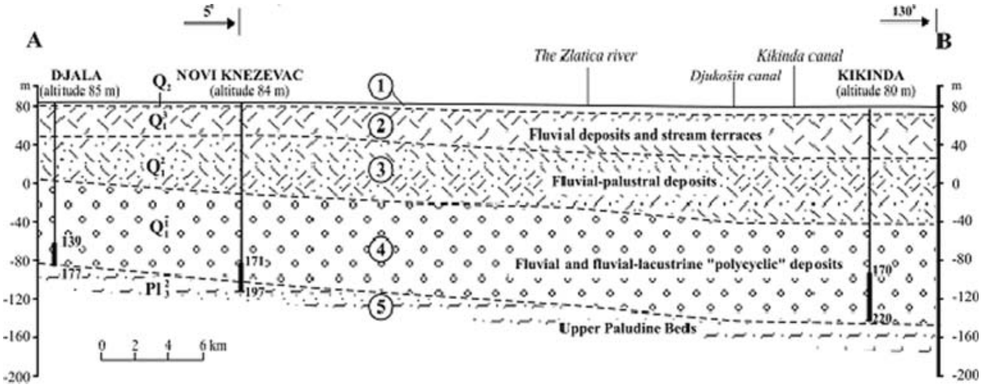


Fig. 4 Hydrogeological section Djala-Novi Knezevac-Kikinda (after BGM, Sheets Szeged and Kikinda 1:100,000, amended)

Sands containing artesian water vary in grain size. Clays are sandy, marly, gravelly, and locally coaly. Sand proportion increases upward in the geologic section (Babac 1990). Paludine beds have a thickness within the range from 250 to 1,000 m or more (Koprivica and Strain 1995).

Polycyclic fluvial and fluvial-lacustrine deposits of the Lower Pleistocene age (Q_1^1) lie unconformably over the

Upper Paludine Beds. The geological boundary between the Lower Pleistocene (Q_1^1) and the Upper Pliocene (Pl_3^2) in northern Banat has not been identified (Jovicic 1996). The Lower Pleistocene is a thick complex of both horizontal and vertical alternation of water-bearing sands and sandy clay and clay. Sand and gravel are in oblique and cross beddings, in places cemented into sandstone or conglomerate (Stevanovic et al. 1992). Oblique bedding and the grain-size composition of sediments suggest deposition in turbulent, now agitated and again calm water, classified as fluvial-lacustrine deposits. The rivers most likely had very wide valleys and a variable deposition regime due to the climate and the tectonic pulsations that caused the floor subsidence in parts of the Pannonian depression (Rabrenovic et al. 2003). A principal characteristic of the polycyclic fluvial deposits is the alternating succession of riverbed facies (sands, seldom gravels) and alluvial facies (silt and clay), through many sedimentation cycles. A vertical section shows the multiple alternation of full (gravel-sand-silt-clay) or reduced sedimentation cycles. Semipermeable or impermeable silts and silty clays, as a result of their derivation, separate water-bearing deposits. The complex of water-bearing deposits forms a unified main aquifer system despite the interbeds and lenses of semipermeable or impermeable silts and silty clays (Jovicic 1996). Pumping tests gave transmissibility coefficients that varied from 2.3×10^{-3} m^2 s^{-1} to 24×10^{-3} m^2 s^{-1} (Dokmanovic and Pusic 1995). Artesian aquifers are at present the principal resource of water for domestic use in northern Banat.

The source of the main confined aquifer recharge is ground water outside northern Banat, from marginal parts of the Pannonian basin. The inflow is very slow, because the hydraulic gradient is about 2×10^{-4} and coefficients of permeability from 10^{-2} ms^{-1} to 10^{-3} ms^{-1} (Babac 1990). The age of ground water from the source in Mokrin, some ten kilometres north of Kikinda, was determined as of the order of 27,000 years (Babac 1990). The very low movement of ground water from the recharge area is indicated also by the water age determined by ^{14}C method. Water is younger in the north (6,980 ± 500 years in Conoplje area) of Vojvodina (Soro 1999).

The main aquifer system is drained by abstraction for water supply and by outflow into the overlying, less permeable deposits. A large number of wells (with the increasing trend) and the growing amounts of abstracted water are leading to the piezometric level lowering. The water abstraction is greater than groundwater fluxes towards the pumping wells, and the consequence is continuous piezometric level lowering, particularly in areas of the water supply sources (Babac 1990).

Upward in the hydrogeological section of northern Banat, fluvial-palustral sediments of Middle Pleistocene (Q_1^2) lie conformably over the polycyclic fluvial and fluvial-lacustrine sediments. These deposits consist dominantly of silt and silty and paludal clays (alluvial facies) and oxbow deposits interbedded or intercalated with fine sand (riverbed facies). A characteristic of fluvial-paludal deposits important for interpretation of water quality is the local occurrence of silt interbeds with marsh plant remains (hydromorphic fossil soil) as much as 5 m thick (Soro 1999). Because of the lack of thick water-bearing strata and a generally lower permeability, the entire fluvial-paludal complex is classified into the semipermeable deposits.

The subsurface sandy deposits of the Upper Pleistocene (Q_1^3) and Holocene (Q_2) form many unconfined and subartesian, shallow aquifers. The shallowest aquifer, about 30 m deep, is easily and extensively polluted from the surface (agriculture, industry, sanitary waste), therefore chiefly utilized in irrigation and for some industrial purposes, and only locally for supply to single rural households.

Quality of abstracted ground water

Chemically analyzed, ground water from the Kikinda source proved to be singular, or better say peculiar. It is stable in quality and its temperature is increased (about 20.5°C), the hardness very low (1.7°dH), and organic matter of natural derivation high (27 mg l^{-1} determined from $KMnO_4$ consumption) that gives the water a characteristic opalescent pale-yellow colour. The colouring matters are humic and fulminic acids contained by about 18 mg l^{-1} on average. Generally, the low hardness and high organic content are uncommon in ground water. These properties distinguish water from the Kikinda source from that of Novi Knezevac and Djala. It differs also in colour from 10°PtCo on the scale for water in Djala to 43°PtCo in Kikinda source. Water from the source at Novi Knezevac has a total hardness of 7.8°dH and organic content of 8.4 mg l^{-1} determined by the $KMnO_4$ consumption. Water quality parameters for Djala source indicate much harder water than in Kikinda and Novi Knezevac, 11.8°dH on average. Organic content, expressed by $KMnO_4$ consumption, is about 5.3 mg l^{-1}, or five times lower than in the water of Kikinda source (Fig. 5).

The pH value of water in the Kikinda source fluctuates within the range from 8 to 8.2, and in Novi Knezevac and Djala source within the narrow limits between 7.8 and 7.9. Mean mineral contents vary from 308 mg l^{-1} in Djala source to 548 mg l^{-1} in the water from Kikinda source.

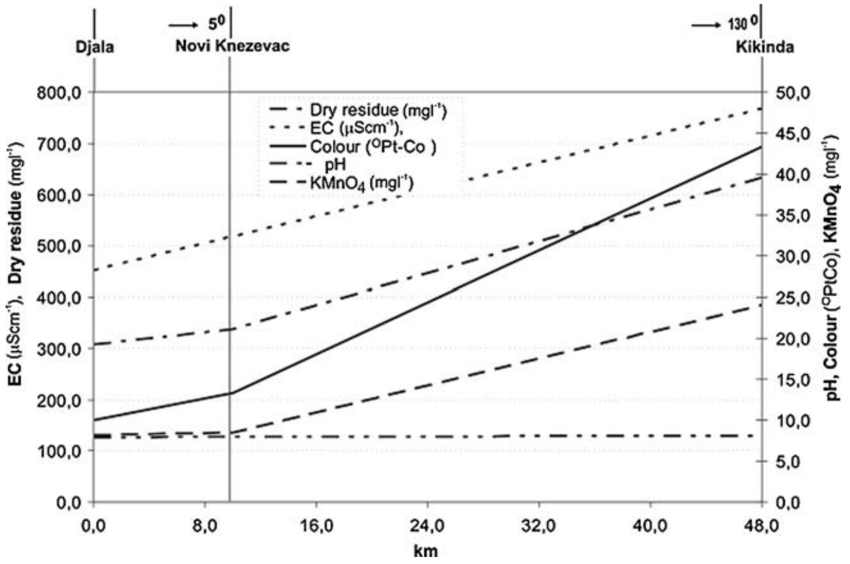


Fig. 5 Comparative diagram of mean values of some water quality parameters for three sources

Mean values of cations chemically determined in waters of the three sources are given in Fig. 6. Sodium-ions in water source at Kikinda are quite high (220 mg l^{-1}), compared to those in Djala (25.9 mg l^{-1}) or Novi Knezevac (85.16 mg l^{-1}). The likely source of sodium ions is the ion exchange, when calcium ions from ground water are replaced by sodium ions absorbed by clay rock particles (Ettazarini 2005). Sodium ions in the water from Novi Knezevac and Djala sources probably derive from sedimentogenic water (marine origin) (Huan-Xin Weng et al. 2005). Calcium-ion is dominant, 50.83 mg l^{-1}, in water from Djala source, but almost nine times lower, 5.65 mg l^{-1}, in Kikinda source. It seems reasonable to assume that calcium-ion content in waters of Djala and Novi Knezevac derives from the carbonate dissolution process. The vicinity of an aquifer of carbonate rocks and good hydraulic communication with the pumped aquifer is the likely explanation of the alimentation from karst aquifers. It also may explain the origin of calcium-ion content in the water of Djala source. The mean magnesium contents in Djala, Novi Knezevac and Kikinda waters are 27.90 , 16.80 and 3.42 mg l^{-1}, respectively. Magnesium ions in ground water at Novi Knezevac and Djala are probably also a consequence of the hydraulic communication between the pumped aquifer and the aquifer of carbonate rocks. Calcium and magnesium ion concentrations in water of the Kikinda source are extremely low, which is very uncommon and suggests a dominant genetic association with the aquifer of Lower Pleistocene (Q_1) fluvial-lacustrine deposits. The mean potassium content is 0.74 mg l^{-1} in water of the Kikinda source, 3.04 mg l^{-1} in Djala, and 1.21 mg l^{-1} in Novi Knezevac, much

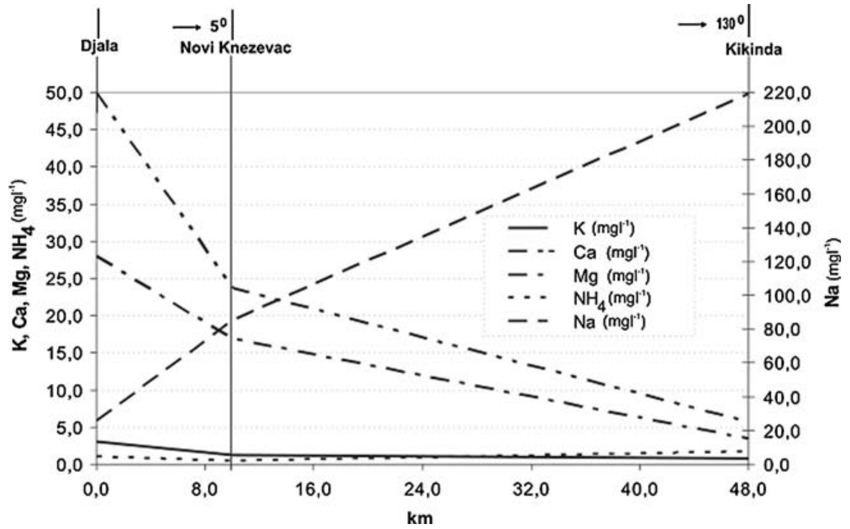


Fig. 6 Comparative diagram of mean principal cations for ground waters of the considered sources

below the maximum allowed concentration (12 mg l^{-1}) in drinking water (Yugoslav Regulations 1998). It is peculiar that ion concentration in ground water is less than 0.1 mg l^{-1} (maximum allowed concentration, MAC, in drinking water) and manganese less than 0.05 mg l^{-1} (MAC in drinking water), which is the case with the water in all the three sources. As to the cations in water of Kikinda source, it should be mentioned that ammonia nitrogen is1.66 mg l^{-1}, far above 0.1 mg l^{-1} (MAC in drinking water). Notable is also the high organic nitrogen in this water, 0.46 mg l^{-1}, which is probably incorporated in the structure of humic substances.

Mean anion concentrations, determined by chemical analysis of water from the three sources, are shown in Fig. 7. Dominant anions in each source are those of hydrocarbonate within the range from 369 mg l^{-1} in Djala to 545.76 mg l^{-1} in Kikinda. Sulphates are contained at 6.18 mg l^{-1} in Novi Knezevac, 15.06 mg l^{-1} in Kikinda, and 10.41 mg l^{-1} in Djala.

The sulphate-ion concentration, which was almost twice higher in Kikinda than in the source of Novi Knezevac, also indicates the presence of appreciable organic matter (sulphur is contained in many organic compounds of plant and animal species). Moreover, water from the Kikinda source has the sulphide odour from the products of anaerobic processes.

Nitrite and nitrate ion contents are low in the water of each source as a consequence of underground reduction processes, as corroborated also by the redox potential of –40 mV in water of the Kikinda source, –25 mV in Novi Knezevac, and 20 mV in the source of Djala. Mean chloride contents in the three sources vary within the range from 5.05 to 6.50 mg l^{-1} , which are lower than the MAC for drinking water. By inorganic contents, the waters in Kikinda and Djala sources are of $HCO^{-}{}_{3}Na^{+}$ and $HCO^{-}{}_{3}Ca^{+}$ types, respectively, as shown by Kurlov formula below:

- Kikinda:

$$CO^{2}_{0,0022}M_{0,548}\frac{HCO^{3}_{95}}{(Na+K)_{94}}t_{20.1}Eh_{-40mv}$$

- Novi Knezevac:

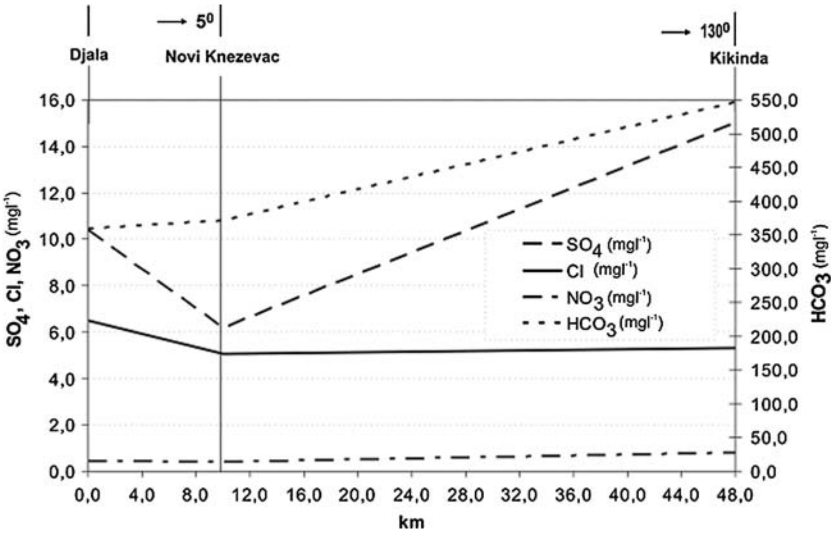
$$CO^{2}_{0,0079}M_{0,337}\frac{HCO^{3}_{96}}{(Na+K)_{59}Mg_{22}Ca_{19}}t_{18}Eh_{-25mv}$$

- Djala:

$$CO^{2}_{0,0102}M_{0,308}\frac{HCO^{3}_{96}}{Ca_{43}Mg_{38}(Na+K)_{19}}t_{18}Eh_{-20mv}$$

Owing to the presence of organic carbon, a suitable substrate for growth of microorganisms, saprophyte and other biological species in water supply systems, waters from the source in Kikinda relatively easily generate the so-called secondary pollution, and in the processes of disinfections render difficult the maintenance of residual chlorine level in the water distribution system from cancerous compounds. The chlorine demand by water at the source of Kikinda is 5.8 mg l^{-1}, and the trihalomethane (THM) formation potential is 388.7 $\mu g l^{-1}$, 77% of which is chloroform. In Novi Knezevac and Djala, the THM formation potential is below the MAC (100 $\mu g l^{-1}$) in drinking water (Vidovic 1998). A comparative analysis of the water quality parameters clearly shows that the bad organoleptic properties—increased organic

Fig. 7 Comparative diagram of mean principal anions for ground water of the three sources



matter and ammonia—are the key parameters characterizing water from the source in Kikinda by which it is distinguished from the waters of Novi Knezevac and Djala sources. A reasonable assumption, based on the defined hydrogeological situation and the chemical composition of ground water, is that organic matter in the water of Kikinda source derives from the geological layers that contain organic, plant remains. Evidence in support of the assumption is found in the lithologic section of an exploratory/production well (Sm 1/H) at Kikinda source. In the depth interval from 223 to 261 m the well penetrates ''grey-greenish sandy clay with coal interbeds'' (Babac 1990). Water from the source in Novi Knezevac contains less ammonia and sulphates than waters in Djala and Kikinda. Unlike the source in Kikinda, wells in Novi Knezevac abstract water from Lower Pleistocene (Q_1^1) and from Upper Paludine (Pl_3^2) aquifers. The Paludine Beds are directly overlain by polycyclic fluvial and fluvial-lacustrine deposits of the Lower Pleistocene age (Q_1^1). Hydraulic communication between the Upper Paludine and the Lower Pleistocene polycyclic fluvial deposits is most likely. The lack of coal interbeds in the rocks forming the aquifer that supplies water to Novi Knezevac has a favourable effect on the quality of ground water. High concentrations of calcium and magnesium and low content of organic matter characterize the water from Djala source. The well filter in Djala penetrates the lower part of the main confined aquifer and about ten metres of the Upper Paludine, which form an aquifer system with water exchange through thin silt layers. The lack of coal interbeds in the Djala aquifer has a favourable effect on the quality of abstracted water and the low organic matter. It should be added to the above information that fresh groundwater from the three sources is bacteriologically acceptable and healthy, which has been and remains an important argument for its use, despite the quality defects.

Conclusion

Ground water from some sources in northern Banat, used for water supply, is ''peculiar'' in chemical composition. The uncommon quality of the ground water from one and the same geotectonic unit (Pannonian basin) is a direct result of the many physical and chemical processes of mass-exchange and mass-transport between water and rock mass that builds the aquifer over a very long period of time. The long contact of groundwater and the aquifer is a consequence of both the low rock permeability and the low fluxes from the recharge areas on the Pannonian basin. The varied chemical composition of abstracted ground water in northern Banat is a manifestation of the genetic association between the ground water and the body of rocks that contain it. In the source of Kikinda water supply, production wells abstract water from the main confined aquifer of the Lower Pleistocene age, which lies over a coal interbed. Coal is most likely the source of organic matter contained in high concentrations in ground water of this source. Drilling data have shown that water-bearing sands are pure, without coal interbeds, and the contained water chemically much more suitable. With respect to the depth and lithology of the aquifers, we interpret the varied chemical compositions of waters in the Kikinda, Novi Knezevac and Djala sources as the consequence of natural factors (geological environment), geological relationships, hydrogeological conditions and lithology of the aquifers that contain the abstracted ground water.

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