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Groundwater state from Bârzava hydrographical basin

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Abstract: The characteristics of groundwater from Bârzava hydrographical basin are a result of the climatic, morphological, hydrological, and in particular the lithological conditions, which explains the groundwater dynamics and the main values of hydrological parameters - higher for the mountain frame and lower for lowlands. Between Bocsa and the border with Serbia, along the Bârzava valley, overlap with depression district, unfolded or slightly folded, deep waters are sweet, carbonated, sulphurate, alkaline or salt.

Keywords: groundwater, hydrographical basin, a body of water, pollution

1. INTRODUCTION

Aquifers are formations with high permeability, able to store significant quantities of groundwater, representing the largest source of fresh water for people. The subfield of soil-water dynamics can be further subdivided into flow through a saturated or unsaturated medium, and steady-state or transient processes. Consideration of a saturated medium applies to groundwater flow problems. Flow through the vadose zone requires study of saturated and unsaturated flow through variably saturated media. Both saturated and unsaturated flow problems may be steady-state or transit. Soil-water dynamics is so central to topics involving the movement of water and solutes through the subsurface that it is fundamental to most, if not all, soil physicall processes and groundwater flow problems [3].While water in unsaturated soil is strongly affected by suction gradients and its movement is subject to very considerable variations in conductivity resulting from changes in soil wetness, groundwater is always under positive hydrostatic pressure and hence it saturates the soil. Thus, no suction gradients and no variations in wetness or conductivity normally occur below the water table and the hydraulic conductivity is maximal and fairly constant in time. Between the two types of aquifers (phreatic and captive), phreatic aquifer with free surface is most easily contaminated by pollutants entering from the vadose area, unsaturated of the soil.

Penetration of pollutants is done by the water from precipitation that infiltrates and supplies the phreatic layer or with water from other sources. [2]

There are many ways to groundwater contamination; the most common is through direct contact between surface water and groundwater. There are many such cases where rivers carrying pollutants who reach in the aquifer. In most cases, groundwater is contaminated by infiltration of pollutants through the unsaturated zone of the soil, which is above the aquifer. Transfer mechanisms in this area are extremely varied and connected to the water cycle in the environment. Involving transport of pollutants in different stages of the water cycle is crucial for maintaining human health and environmental balance.

It is appropriate to consider that any substance dissolved in water that has an upper concentration from the critical concentration can be considered as a pollutant whose presence is a risk to human health and the environment. Major interest area on the penetration of dissolved substance in phreatic aquifer is the capillary fringe area, containing water pressure lower than atmospheric pressure.

2. MATERIAL AND METHODS

In order to select the wells for the annual monitoring were considered:

- representative criterions in the subbasin for the global assessment of water quality in the aquifer from Bârzava drainage area;
- maintaining water quality monitoring network for hydrogeological wells I and II, which have significantly improved water quality evolution.

Sampling frequency from wells of first order was of 2 times a year, during period with high rainfall in spring and drought (summer - autumn). [6]

Analysis of samples collected in 2003, was done in laboratories in Timisoara and Resita from Department of Water Banat. For wells study order I, II and pollution were determined following physico-chemical characteristics to check ion balance and specific indicators of pollution in the area: temperature, pH, conductivity / fixed residue, CCO-MN, Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Mn^{2+}, Cl^-, SO_4^{2-}, PO_4^{3-}, HCO_3^-, NO_2^-,NO_3^-, NH_4^+, phenols.

3. RESULTS AND DISCUSSIONS

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Groundwater quality was monitored in I and II order wells and pollution in phreatic layer and deep wells. In drainage area Bârzava was established a network of points (wells) observation that to establish regime change in piezometric levels, temperature and chemistry of the phreatic groundwater.

Quality monitoring wells are in the order I, II and wells pollution. Characterization of phreatic groundwater quality was considered the comparison of determined values with the permitted limits and exceptionally allowed in STAS 1342-91, comparison based by computer program. Compiled program prepared by ANAR: - Banat Basin Administration remarks exceeded values versus permissible limits and exceptional allowed. [5, 6]

Tabel 1 Distribution of wells monitored in 2003 - phreatic layer [6]

No.	Wells type	Number of wells	Number of distribution areas in the drainage area
1	- order I	8	4
2	- order II	-	-
3	- polluted	4	1
TOTAL in Bârzava drainage area		12 monitorized wells	

Table 2 Exceeded permissible concentrations of pollutants situation exceptionally [6]

Index	No of exceeding	Drilling name
nitrite	max. 1,3-1,7	Bârzava – Bocşa Română
nitrogen	max. 1,16-2,2	Bârzava – Gătaia, Gherteniş
iron	max. 1,9-36,3	Bârzava – Gherteniş-Bocşa Română
organic substances	max. 1,13-6,73	Bârzava – Gherteniş-Bocşa Română
manganese	max. 1,1-2,3	Bârzava – Gherteniş-Bocşa Română
ammonium	max. 1,1-1,7	Bârzava – Bocşa Română, Birda, Gherteniş

Transfer of pollutants from phreatic aquifer and vadose zone is strongly intensified by fluctuations in the phreatic layer, temporary, seasonal or annual fluctuations.

Pollutants entering the capillary fringe, the wetting front or due to fluctuations phreatic layer are exposed at least two differential equations of groundwater flow, respectively Darcy equation and diffusion-advection:

$$q = K \cdot J \qquad (1)$$

$$\frac{\partial C}{\partial t} + V \cdot \nabla C = \nabla \cdot (D_h \cdot \nabla C) - R \qquad (2)$$

where q is the vector of specific flux (Darcy velocity), K is the hydraulic conductivity tensor (which depends on the diffusion and kinematic viscosity of the fluid - water), J is the hydraulic gradient load, C is the pollutant concentration, V is the interstitial velocity (specific flow divided the effective porosity), D_h is the hydrodynamic dispersion tensor (incorporating the effects of diffusion and tortuozity power lines), which depends on V and permeability properties of the domain and R which expresses the possible chemical reactions (such as adsorption, disintegration) [1].

A special case is represented by pollution of the aquifer and the vadose zone with immiscible organic pollutants in aqueous liquid phase (or a very low miscibility of the order of a few ppm). This is the case of fossil fuel used in combustion engines or creosote to treat wood used in the forest industry, in medicine chlorinated hydrocarbons, trichlorethylene in the steel industry.

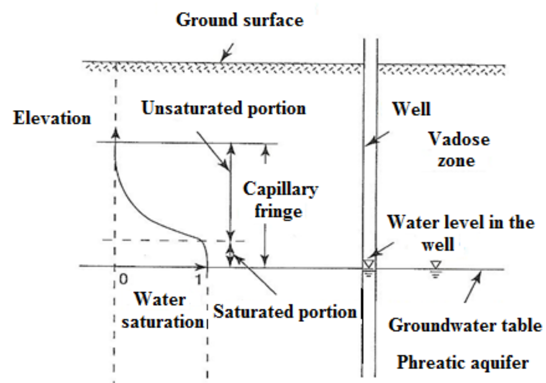

Figure 1 Water saturation distribution in the phreatic aquifer and the vadose zone

By density, immiscible fluids can be grouped in two categories:

(1) fluids density lower than water density;

(2) fluids whose density is higher than water density.

This grouping is extremely important to assess penetration of immiscible fluids contaminants in the aquifer and their migration with groundwater.

In the unsaturated zone, the calculations refer to the fluid found in three phases (gas, water and immiscible contaminant). The aquifer reference is made to two liquid phases (water and immiscible contaminant). Mathematical model for multiphase flow in porous medium is generally formulated as [4]:

$$\epsilon_\alpha \rho^\alpha \frac{\partial \omega_i^\alpha}{\partial t} + \rho^\alpha q^\alpha \nabla \omega_i^\alpha - \nabla \cdot \left(\epsilon_\alpha \rho^\alpha D_{h_i}^\alpha \cdot \nabla \omega_i^\alpha\right) = \sum_{\beta \neq \alpha} E_i^{\alpha\beta} - \omega_i^\alpha E^\alpha \qquad (3)$$

and subject to the following two conditions:

$$\sum_i \omega_i^\alpha = 1; \quad \sum_\alpha \epsilon_\alpha = 1 \qquad (4)$$

where ϵ_α is the volume of fraction from phase; α, ω_i^α is the mass fraction of component i in phase; α, $D_{h_i}^\alpha$ is the phase hydrodynamic dispersion tensor; α, q^α is specific phase debit, α, ρ^α the density of phase; α and $E_i^{\alpha\beta}$ variation of mass component i between α and β phases. In addition to 3 and 4 equations can be applied to a series of interrelations to calculate the propagation of each phase fluid and industry specific categories. For limited times, the immiscible contaminant is trapped in the unsaturated porous soil, groundwater movement with reduced vapor saturation is expressed by modified Darcy's law as:

$$q = \nabla \cdot \left[g \left(k \frac{k_{rw}}{\nu} \right) \cdot J \right] \qquad (5)$$

where g is the gravitational acceleration, K is the permeability tensor; k_{rw} is water relative permeability and ν is viscosity.

Diffusion-advection modified equation is given by:

$$\emptyset S_w \frac{\partial c}{\partial t} + q \cdot \nabla C = \nabla \cdot (\emptyset S_w D_h \cdot \nabla C) + R + E^{wn} \qquad (6)$$

where:

$\emptyset$ is porosity;

S_w - water saturation;

E^{wn} - interphase mass transfer, respectively contaminant mass trapped in pores by dissolving fluid immiscible pollutant,

R-term of a chemical reaction by adsorption or desorption.

Tabel 3 Water quality of deep aquiferous layer [6]

Well	NH_4	NO_3	CCO-Mn	PO_4
Berzovia F1 AD	*	-	*	-
Berzovia pigs complex	adm	-	-	-
Bocşa Română	adm	-	-	adm
Note : adm. – exceeding permisive limits * – exceeding permisive limits in exceptional circumstances				

Groundwater bodies which develop in the border area and continue on the territory of neighbouring countries are defined as transboundary waters.

In Banat catchment area were identified, defined and described a total of 20 groundwater bodies, five of them are transboundary ground water bodies (figure 2) [5].

Figure 2 Demarcation of groundwater bodies [5]

Groundwater bodies code (eg ROBA01) has the following structure:

RO = country code;

BA = Banat River Area/ catchment;

01 = water body indicator in the Banat River Area/ catchment.

All significant characteristics of groundwater bodies within the Bârzava catchment, as geological and hydrogeological characteristics, degree of protection, risk and water usage as polluters, eventually transboundary character and country have been summarized in table 4:

Table 4 Characteristics of groundwater bodies in the catchment area Bârzava [5]

Code/name		ROBA03/ Timişoara	ROBA05/ Gătaia
Geological /hydrogeological characterization	type	porous	porous
	pressure	no	no
	covered layers	3,0-5,0m	3,0-10,0m
Water use		public water supply; industry; zootechnics	public water supply; zootechnics
Polluters		industrial agricultural domestic	farmers
Global protection		medium, well	well, very well
State	qualitative	low	well
	quantitative	well	well

Groundwater bodies characterization of that have been identified and demarcated in catchment area Bârzava, is shown below:

- ROBA03 – Timisoara

Groundwater confined in porous and permeable alluvial deposits of quaternary age.

Coating sand-silt-clay and loess with an effective infiltration of 15-30 mm water column, the global protection from surface is average and good. Class of global protection at the level of this body is average and on his surface are numerous potential sources of pollution from the surface. Water chemistry varies from calcium magnesium bicarbonate to clorocalcic magnesium, chlorine or sodium bicarbonate. The body has transboundary character.

- ROBA05 - Gătaia

Body consisting of accumulated groundwater, in porous and permeable alluvial and fluviolacustrine deposits of quaternary age; coating consisting of loess, clay and clay powders with effective infiltration of 30-60 mm of water column, which gives them a degree of global protection from surface good and very good.

There aren't significant sources of punctate pollution from the surface.

Piper and Schoeller diagrams performed on the tracking water wells of National Hydrogeologicaly Network (Bocşa Română, Măureni, Gătaia, Gherteniş and Vermeş) shows that they have a low mineralization.

Poorly mineralized waters are calcium bicarbonate and as is mineralized and become bicarbonatecalcic-sodium-magnesium.

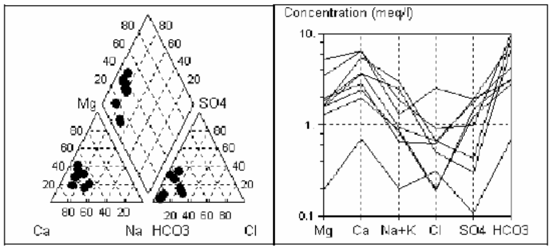

Figure 3 Piper and Schoeller diagrams made on the basis of chemical analysis of body water wells associated hydrogeological ROBA05 – Bocsa Română, Măureni, Gătaia, Gherteniş and Vermes [5]

All information about the interdependence of groundwater bodies existing in catchment area Bârzava with existing surface water bodies or with associated ecosystems is included in table 3:

Table 5 Interdependence of groundwater bodies with surface water bodies

Groundwater body code	**Body designation**	**Interdependence**
ROBA03	Timişoara	Bega Veche, Bega,Timiş, Bârzava,Moraviţa rivers
ROBA05	Gătaia	Pogăniş, Bârzava, Moraviţa rivers

At the Bocsa city level, deep wells have been made, owned by communal households and CNAR Heritage - Banat Water Directorate, aimed at assessing the quality of the water in deep layer.

The measurements indicate that all indicators have concentration values lower than permissible limits, according to STAS 1342/91, except ammonia indicator. Thus, a well of the Bocsa city, belonging to the communal household, had a value of 0.9 mg/l. Given this situation it is necessary to monitor ground water quality and implementation of measures for pollution reduction and cessation.

Phreatic water in the first layer (of wells) is used for drinking and household needs of about 80% of the population, water supply system is not developed enough to meet rural consumption.

Indirect supply area of phreatic layer through the discharge of ground water flow from higher parts of the plain, it can delineate in the areas of contact between the piedmont plain and low plain, on the following alignment: Liebling - Voiteg - Deta.

For this alignment are maintained areas with excess moisture. In areas of subsidence phreatic waters are closer to the surface land (0.5 - 3 m) and have a very slow or stagnant flow. Their regime is strongly influenced by embankment and drainage work. Under these conditions occur Salsodisols and water quality is deteriorating.

4. CONCLUSIONS

As regards hydrogeological network, from hydrogeological sections analysis obtained based on drilling carried, can trace lithological variation of the phreatic at different depths and horizontal and vertical expansion of the aquifer layers. They are favored by the vast limestone area that generated drainage with consequences of surface hydrographical network disruption and led to the emergence of important karst systems.

Deep waters, with ascending or artesian character, are common in sedimentary regions of the Bârzava valley. Area with fresh water, carbonated, between the Bârzava sources and Bocsa city coincides with the supply area of deep waters. This hydrochemical area stretching at surface, too, but has a special role in sweeting horizons of deep waters.

The mountain area with specific aquifer layer of watershed with folded layer, presents local accumulations of captive waters with a general direction of tilt of aquifer horizons east - west. These deep waters are used mainly to supply drinking water to the Bocsa city, being true underground lakes.

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