COASTAL POLLUTION AND GROUNDWATER QUALITY IN THE YUGOSLAV PART OF THE DANUBE

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In order to assess the vulnerability and risk of the aquifer system in the Yugoslav part of the Danube, a great hydrogeophysical study was performed. This acquifer system is the primary source of drinking water for a numerically substantial community, and it is used for industrial purposes and agricultural activities. Hence, a potential source of pollution for the groundwater resources is land occupation and use, as well as the disposal of solid and liquid wastes. Within the lower part of the plain, the Salinac field exploratory test site, near Smederevo town, was particularly investigated. This is because the area is also part of the mouth of the Velika Morava into the Danube, where the Derdap reservoir is located.

The object of the study was to delineate the aquifer, obtain appropriate para-meters - groundwater level, groundwater chemistry, clay content, filtration characteristics and the physical parameters of geological functions - as well as to map aquifer vulnerability, in order to prevent and moderate a potentially harmful influence of the reservoir on the environment, such as increased groundwater infiltration from the reservoir into surrounding rocks, or permanent groundwater level rising. Based on the results, zoning of the study area, according to aquifer vulnerability, was performed. Land-use planning and the development of a stra-tegy for groundwater protection and management were subsequently possible.

This paper presents, not only the sources of contamination, the characteristics of pollutants and their influence on groundwater quality, but also the concentra-tion of organic matters, phosphates and nitrogen compounds. Measures for pro-tection and management are discussed, as well as appropriate legal regulations.

The territory between the Danube, the Velika Morava and the Jezava rivers, as well as the Jezava-Velika Morava channel - an area of approximately 5,700 ha - was studied several times. The most detailed investigation was carried out during the planning stage of the Derdap reservoir construction (Figure 1). A complex study was performed in order to prevent and moderate harmful influences of the reservoir on the environment, including increased groundwater infiltration from the reservoir into the surrounding rocks and permanent groundwater level raising.

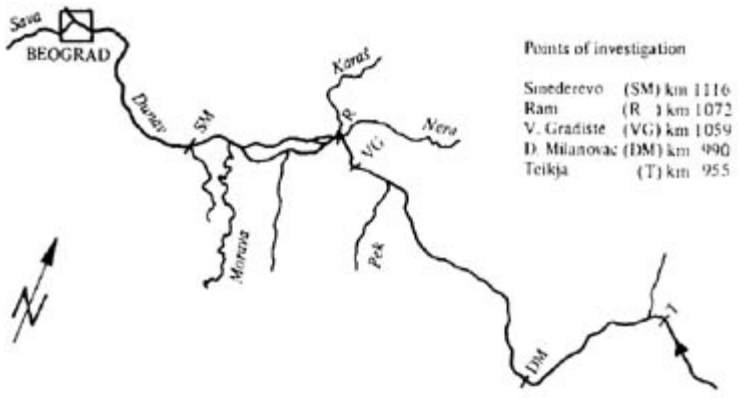

Figure 1. Investigated section of the Danube (signed as: SM-R)[1]

Tables 1-5 show the basic results - pollution sources, physicochemical characteristics of groundwaters and wastewaters, trace element values for the Danube river and its tributaries, and pesticide residue content - obtained from the investigated area.

Table 1. Pollution sources in the investigated area (discharge: 1,000m^3/d)[2]

Settlement Industry	Wastewater	Organic Loads	Sewage	Purified	Untreated
Smederevo sum	17.1	78.37	13.44	0.28	16.82
Smederevo population	11.1	61.05	11.1	-	11.1

Metal Works	2.04	0.34	-	0.28	1.76
Metal Works	2.62	2.18	1.25	-	2.62
Foundry	0.76	0.63	0.76	-	0.76
Fruit Industry	0.58	9.67	-	-	0.58

Table 2. Groundwater physicochemical characteristics at the Smederevo Power Stations[2]

1986	Water Temperature	Electrical Conductivity at 20 C	COD (KMNo4)mgO2/l	Phelons	pH	Mineral Oils mg/l
May	13.0	846	1.76	4.2	7.5	11.2
September	13.0	702	5.60	5.3	7.2	14.2

Table 3. Physicochemical characteristics of wastewaters in May/September 1986[2]

May 1986, Jezava pump. station

Pollution source	Visible wastes	Visible colour	pH	El. cond.	COD $KMnO_4$	COD K_2CrO_7	BOD_5	SS (mg/l)	Temp °C	Min. oils (mg/l)
Waste water	faecal	grey	7.7	1,126	153	318	184	165	25/19	28

May 1986, Channel metal works

Pollution source	Visible wastes	Visible colour	pH	El. cond.	COD $KMnO_4$	COD K_2CrO_7	BOD_5	SS (mg/l)	Temp °C	Min. oils (mg/l)
Ind.waste water	oil	brown	7.7	422	14.2	116	50	93	27/24	15

September 1986, Channel metal works

Pollution source	Visible wastes	Visible colour	pH	El. cond.	COD $KMnO_4$	COD K_2CrO_7	BOD_5	SS (mg/l)	Temp °C	Min. oils (mg/l)
Ind.waste water	wastes	brown	7.7	372	50.9	62.7	4.5	201	29/24	17

Table 3a. Wastewater characteristics in Jezava (pollution source: metal works)[2]

Date	air/w T °C	El. cond. 20 °C	$KMnO_4$ mg/l	BOD_5 (mg/l)	SS mg/l	DS mg/l	NH_4 mg/l	Phenols mg/l	Hg mg/lx10^3	Na mg/l
5/87	20/16	42.0	27.8	8.6	6	350	0.27	0.016	3.25	13.2
9/87	16/21	446	207	9.2	8.3	365	0.30	0.012	1.7	9.84

Table 3b. Wastewater characteristics in Jezava (pollution source: metal works)[2]

Date	pH	Min. oils mg/l	K mg/l	F mg/l	Mn mg/l	Zn mg/l	Cu mg/lx10^3	Cr mg/lx10^3	Cd mg/lx10^3	As mg/lx10^3
5/87	7.6	3	3.60	1.74	0.44	0.38	27	8	2.1	0.0
9/87	7.8	140	3.12	1.91	1.38	0.27	22	21	1.1	0.0

Table 4. Pesticide residue content in the investigated area in mg/l (Sept. 1986)[2]

DDT DDE	HCH	Lindan	Heprachlor Hepoxyde	Aldrine Dieldrine	Trifluraline	Atrazine Simazine	2.4-D 2.4.5-T
0.005	0.038	0.021	0.018	0.008	0.009	5.32	4.19

Table 5. Trace element values in the investigated area in mg/l x 10-3 (S: detection limit, *below detection limit, sought but not detected: Be, Sn, Ga, Nb, Zr, Y, La, Sc)[2]

Element	S	Salinac field
B	0.3	14.9
Cr	0.8	2.6
V	2.6	*
Mo	0.8	*

Ni	0.3	*
Cu	0.3	1.6
Mn	0.3	*
Sr	0.8	294.3
Ag	0.3	*
Pb	1.3	*
Ba	0.8	109.7
Al	8.4	116.4
Fe	2.6	137.0
Ti	1.3	*
dry residue (mg/l)	-	267.6

In hydrogeological studies, geophysical methods have a significant role in solving numerous problems: possibilities for safe analysis of aquifer geometry and structural properties; monitoring aquifer contamination by mineral and organic deposits; defining relevant indications on hanging-wall permeability characteristics and aquifer hydrodynamic parameters; indicating groundwater levels; analysing groundwater chemistry; determining clay faces in a complex of hanging-wall sediments; exploring transfer velocities for wet fronts and pollutants within. Regional hydrogeophysical studies are the basis for: regional measures for water resources utilisation, protection planning and production; space plan production; identifying safe zones for hazardous waste placement; distinguishing zones where groundwaters are not protected and for which protective measures have to be planned. Detailed geophysical investigations on overburdened sediments are significant in connection with drawing up plans for industrial, agricultural and other objectives.

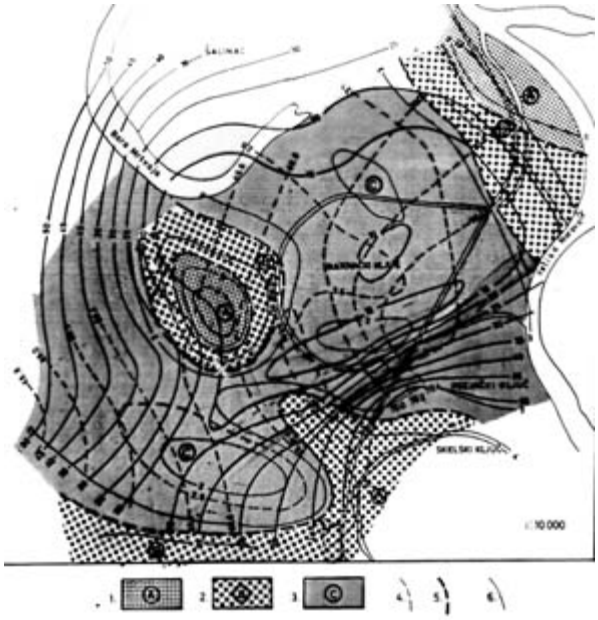

Figure 2. Aquifer vulnerability of the Salinac field area according to the results of the hydrogeophysical study (scale 1:10,000). 1) Category A. 2) Category B. 3) Category C. 4) Thickness contours of aquifer vulnerability. 5) Contours of the aquifer footwall. 6) Contours of the aquifer thickness for maximum groundwater level.[3]

To prevent and moderate a harmful influence of the artificial reservoir on the environment, a complex hydrogeophysical study was performed. It was useful in: delineating the aquifer; measuring groundwater level, chemistry, clay content, filtration characteristics and the physical parameters of geological formations; mapping the vulnerability of the aquifer system (Figure 2).

According to the results obtained from several geophysical methods - seismic, well-logging, electric and electromagnetic - vulnerability to pollution was evaluated through the following factors: (a) thickness of low-permeability hanging-wall; (b) groundwater level - thickness of aeration zone; (c) hanging-wall grain-size distribution; 4) hanging-wall rock filtration coefficients.

Based on the results, zoning of the study area, according to aquifer vulnerability, was carried out (Figure 2). Appropriate strict measures for groundwater source protection were determined for the area of the mouth of the Velika Morava river into the Danube - Derdap zone - where high concentrations of pesticides, detergents and phenols were distinguished. A potential risk from pollution by industrial wastewaters and agricultural chemicals is expected, especially near large towns in the area. According to the complex hydrogeo-physical analysis, land-use planning and the development of a strategy for groundwater protection and management were possible.

Conclusion

In this paper, not only sources of contamination, characteristics of pollutants and their influence on the groundwater quality of the Derdap reservoir are presented, but also the concentration of organic matters, phosphates and nitrogen compounds. Furthermore, measures of protection and management are discussed, as well as the appropriate legal regulations. Based on the results of complex hydrogeophysical studies, zoning of the study area, according to aquifer vulnerability, was performed. Land-use planning and the development of strategies for groundwater protection and management were subsequently possible.

References

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