

3.3 Description of the Zagreb aquifer case study, Croatia

Title of Case Study	Zagreb aquifer
Location (region, Country)	Zagreb area, Croatia
Other information	Transboundary (SI-HR border) alluvial aquifer

Description of Case Study (background information on the region)

The Zagreb alluvial aquifer system is located in the southwestern part of the Pannonian Basin, in the Sava Valley in Croatia. It is composed of Quaternary unconsolidated deposits. In the western part of the investigated area the aquifer thickness reaches only 10-15 m. At the East, the aquifer thickness is much higher and reaches up to 100 m. Permeable and semi permeable layers alternate in the vertical profile of the aquifer system. However, semi permeable layers pinchout in many places, and, consequently, the aquifer acts as a single hydrogeologic unit. The covering aquitard is composed of silt, sand and clay. Its thickness reaches only 2-3 m. The aquifer is unconfined. The hydraulic conductivity values of the aquifer reach up to 0.02 m/s.

Description of problem (why is this location chosen for a Cases Study)

The Zagreb aquifer is highly utilised, mainly as a water supply for more than the one million inhabitants of the wider area of the capital city of Croatia. It is burdened with a number of potential pollutants. Due to the absence of covering deposits, the vulnerability of high permeable aquifer is very pronounced. In the study area (the catchment area of the Mala Mlaka pumping site), groundwater contains increased concentrations of nitrates and the nitrate origin is associated with the impact of agricultural activity.

Methods to be used in the Case Study (analytical and isotope techniques, modelling)

A mean residence time (MRT) of groundwater was calculated using tracer based estimates as well as lumped parameter approach by applying the exponential mixing model and dispersion model. The TracerLPM software was used.

Results from this Case Study

According to the conducted analyses, the groundwater age up to a depth of 30 m was generally estimated at less than 10 years. An association of the reduction of nitrate concentrations in groundwater with regard to the load from agriculture and the mean age of groundwater was found. Further research is ongoing.

Impact - how this Case Study contributes to the overall project aims

This Case Study describes an important Zagreb alluvial aquifer in Croatia. It demonstrates the use of groundwater age for assessment an impact agricultural activity on groundwater.

Name of pilot area / aquifers / type: Zagreb area / Quaternary alluvial aquifer / porous		Country: Croatia Region: Zagreb area (HR-SI border aquifer)	
Study level	Transboundary : ☒ X Regional: ☐ Local: ☐ Single well(s): ☐		
Type of observations <i>(choose one of the options, create separate template if needed for each type if each type need specific information)</i>	X Short screened observation wells (not pumped) X Long screened observation wells (not pumped) ☐ Pumped wells, long screens in one aquifer ☐ Pumped wells, long screens over multiple aquifers ☐ Springs ☐ Other (eg. research wells; indicate type and information on pumping):		
Approximate location of pilot:			
Geological cross section / conceptual model of the pilot area:			

Name of Shape- / Geopackage file defining the area: HoverHRPilotSub.shp		Projection to be used: HTRS96/TM		
Hydrological parameters:	Mean annual precipitation (mm or range in mm)	Mean annual groundwater recharge (mm or range in mm)	Mean annual groundwater recharge temperature (°C)	Thickness of unsaturated zone (range in m)
	850	260-300	10-11	4-10
Pumped wells only		Typical pump discharge of sampled individual well (m ³ /day):	Typical pump discharge of complete well field (m ³ /day): <i>If relevant</i>	
List of aquifers and aquitards in pilot area		No. of confined or semiconfined aquifers in pilot area:	No. of unconfined aquifers in pilot area:1	
Aquifer no. (aqf): 1 Aquitard no. (aqt): Aquiclude no. (aqc):	Aquifer/aquitard type and/or name	Lithology (Resource WP6 terminology)	Depth range (m)	GW age range (yr)
Aqf-1:	Zagreb aquifer	Gravel	< 30	< 20
Porosity type	Porous: X	Fissured: ☐	Karst: ☐	Fissured and porous / dual porosity: ☐
Applied tracer age indicators (³ H, ³ H/ ³ He, ⁸⁵ Kr, ³⁹ Ar, ¹⁴ C, ³⁶ Cl, ⁸¹ Kr, ⁴ He, CFCs, SF ₆ , etc.) Applied recharge temperature indicators (¹⁸ O, D, noble gases)		Aquifer-1 ³ H, ³ H/ ³ He, CFCs, SF ₆		
Number of sites (wells/springs) with age indicators		Aquifer-1 1-5: ☐ 5-10: X 10-25: ☐ >25: ☐		
GW age range (GAR) GAR-1: Modern (< 60 yr) GAR-2: Old (> 60 yr and 10 kyr) GAR-3: Paleowaters (> 10 kyr)		Aquifer-1 GAR-1: 1-10%: ☐ 10-25%: ☐ 25-50%: ☐ >50%: X GAR-2: 1-10%: ☐ 10-25%: ☐ 25-50%: ☐ >50%: ☐ GAR-3: 1-10%: ☐ 10-25%: ☐ 25-50%: ☐ >50%: ☐		
Groundwater age ranges (GAR) estimated by:		Tracer based estimates X Flow and age model simulations ☐ Combination of model and tracer estimates X Expert judgement: ☐		
Objective of age dating studies:				

Basic research or General groundwater management	Assessment of pollutant history		Assessment of the efficiency of remediation and mitigation measures		Indication of vulnerability of aquifers and water supply wells	
	X					
Water Usage <i>(not relevant for observation wells)</i>	Water supply		Irrigation	Industry	Other	
Geoenergy related activities <i>(not relevant for observation wells)</i>	Shallow Geo-T	Deep Geo-T	Hydrocarbons		Nuclear waste disp.	CO₂ storage
Mining activities <i>(not relevant for observation wells)</i>	Construction materials		Minerals / metals	Coal	Other	
REFERENCES						
OPEN Access reports and papers (PDF versions made available in EGDI repository making them downloadable via maps and keyword / free text searches):			Reports and papers with restricted access: Brkić, Ž., Kuhta, M., Larva, O. & Marković, T. (2019): Groundwater age dating as a tool for nitrogen pollution risk assessment in Croatia. Abstract book, 6th Croatian Geological Congress, 41-42. Brkić, Ž., Kuhta, M. (2020): Monitoring the groundwater age for the purpose of defining the effectiveness of protection measures. Technical report for Hrvatske vode (a legal entity for water management in Croatia) (in Croatian). Croatian Geological Survey, Zagreb.			
Remarks / other relevant information: 						