

3.4 Description of the Drava aquifer case study, Croatia

Title of Case Study	Drava aquifer
Location (region, Country)	Varaždin-Koprivnica area, NW Croatia
Other information	Transboundary (SI-HR border) alluvial aquifer system

Description of Case Study (background information on the region)

Drava alluvial aquifer is composed of sediments of the Quaternary age. It consists primarily of gravel and sand. The thickness of the aquifer varies from less than 5 m in the western to more than 100 m in the eastern. In the study area, the aquifer system is divided into two aquifers separated by a relatively thin semipermeable interlayer. The covering semipermeable layer of the aquifer is not continuously developed, which makes the aquifer vulnerable to contamination. The aquifer is unconfined.

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

The aquifer system represents the main source of potable water for this part of Croatia. It is burdened with different potential pollutants of which the largest is agricultural activity. Due to the absence of covering deposits the aquifer vulnerability is very pronounced. In the study area, groundwater contains increased concentrations of nitrates. 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 piston-flow model, the exponential mixing model, the partial exponential model and dispersion model. The TracerLPM software was used. MRT was also analyzed by groundwater simulation model (Visual MODFLOW).

Results from this Case Study

The groundwater age by the conducted analyzes was estimated for the first and second layers separated by aquitard. The decrease in the concentration of nitrate in the first aquifer west of the city of Koprivnica as well as the increase in the concentration of nitrate in the second aquifer southeast of the city is related to the historical load of agriculture in relation to the mean groundwater age. Further research is ongoing.

Impact - how this Case Study contributes to the overall project aims (see objectives WP6)

This Case Study describes an important Drava 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: Varaždin-Koprivnica area / Quaternary alluvial aquifer / porous		Country: Croatia Region: NW Croatia (HR-SI border aquifer)	
Study level	Transboundary : ☒ 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) X 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)
	820-850	150-300	10-11	2-13
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: 1	No. of unconfined aquifers in pilot area: 1	
Aquifer no. (aqf): 2 Aquitard no. (aqt): Aquiclude no. (aqc):	Aquifer/aquitard type and/or name	Lithology (<i>Resource WP6 terminology</i>)	Depth range (m)	GW age range (yr)
Aqf-1:	Drava aquifer I	Gravel	< 35	< 30
Porosity type	Porous: X	Fissured: ☐	Karst: ☐	Fissured and porous / dual porosity: ☐
Aqf-2:	Drava aquifer II	Gravel	40 - 120	20 - < 60
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.)		Aquifer-1 ³ H, ³ H/ ³ He, CFCs, SF ₆		
Applied recharge temperature indicators (¹⁸ O, D, noble gases)		Aquifer-2 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: ☐		
		Aquifer-2 1-5: X 5-10: ☐ 10-25: ☐ >25: ☐		
GW age range (GAR)		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%: ☐		

GAR-1: Modern (< 60 yr) GAR-2: Old (> 60 yr and 10 kyr) GAR-3: Paleowaters (> 10 kyr)		Aquifer-2 GAR-1: 1-10%: ☐ 10-25%: ☐ 25-50%: ☐ >50%: X GAR-2: 1-10%: ☐ 10-25%: X 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
Geoenery related activities <i>(not relevant for observation wells)</i>	Shallow Geo-T	Deep Geo-T	Hydrocarbons		Nuclear waste disp.
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: Only one pumping well was sampled for groundwater age estimation. Since a pumping well is not a well from which groundwater is constantly pumped (usually only at night), it could be considered an observation well. Sampling was performed in a low-flow regime (approximately 1 L/min) in all wells, so it can practically be considered to have been performed in a short-screened observation well (mixing is negligible).					