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 **BLUE RECHARGE**

# Recharge experience in Croatia: the case of karst aquifers

BLUE RECHARGE / IVS – Istarski vodozaštitni sustav

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WORKSHOP IN AQUA CENTER

Bologna, Italy, 14<sup>th</sup> of May 2026



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## Sinkhole Čiže – direct underground connection to Gradole spring

Gradole - capacity 1000 l/s, yield in the dry seasons of 1987-88 below 500 l/s.

Tracing tests (1969., 1976., 1979., 1987.) proved that the sinkhole of Čiže is directly connected by underground fissure systems to the Gradole spring.

Replenishing the Spring from Butoniga:

- installation of pumping stations (450 l/s)
- main pipeline - pressure line (about 12 km), to the tank at the hill, at about 400 m a.s.l.
- gravity pipeline to the sinkhole and outlet on the stream 50 m upstream before the entrance to the sinkhole.

The distance (on the map) is 14.5 km.



## MAR possibilities:

- Collecting rainfalls and precipitation water – needs significant capacities – reservoir at least the size and volume of Butoniga, puddles and pools are not sufficient size to provide required quality
- Southern Istria aquifer is already largely abandoned for bad water quality so it is used only for irrigation, in this case MAR with wastewater could be beneficial



Butoniga reservoir



Well  
Škatari

## CASE STUDY – CROATIA – IVS task

- Part 1: Implementation of exploration drilling, tracing test and monitoring of wastewater quality from Loborika WWTP and groundwater quality in the south Istria area; the preparation of a study of the obtained results and an assessment of the possibilities for managed aquifer recharge (MAR) of groundwater
- Part 2: Study of optimization of wastewater treatment processes and underground discharge techniques for achieving optimal results.



## CASE STUDY – CROATIA – selection of the pilot area

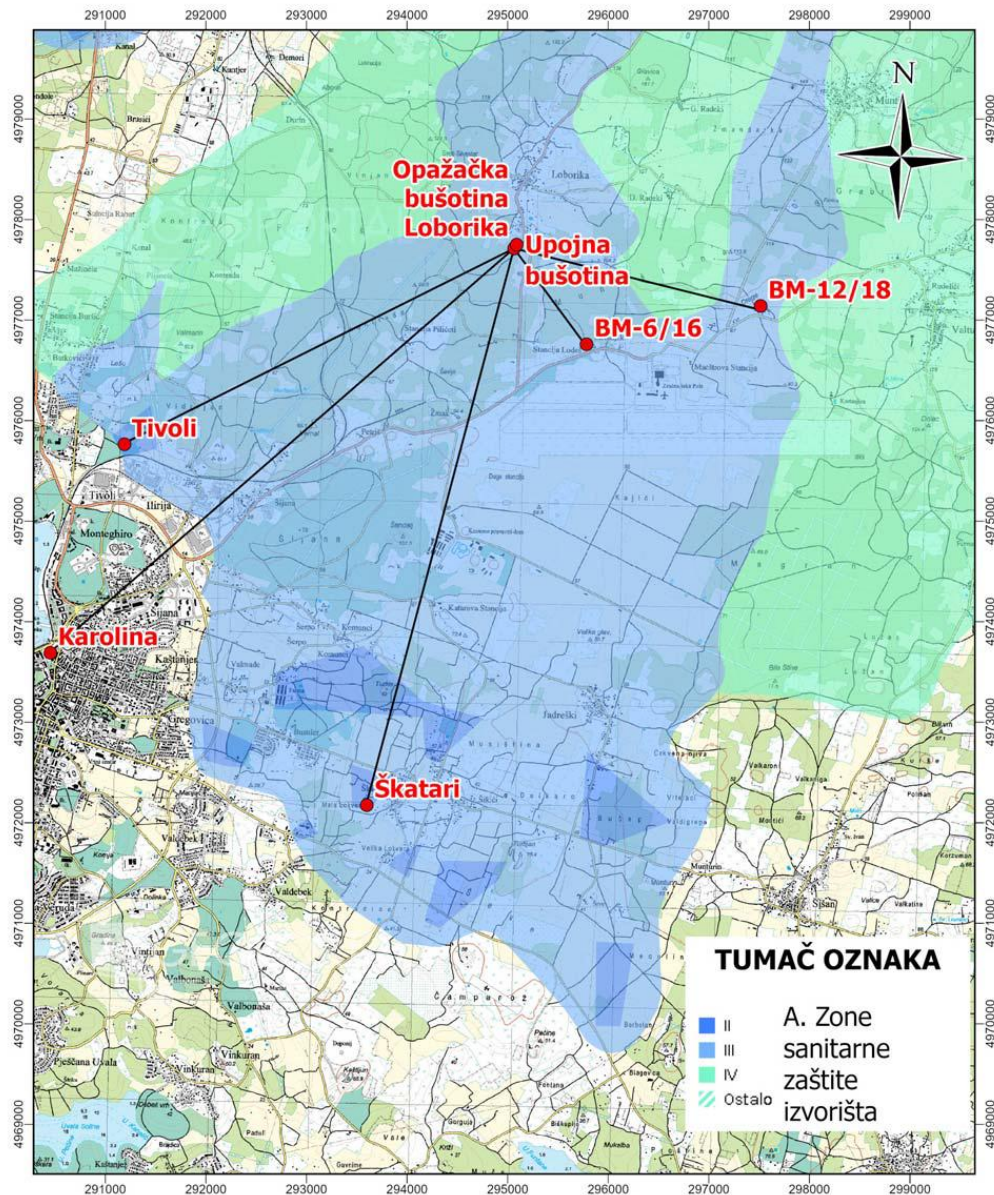
- The Groundwater aquifer Southern Istria has been assessed in document “River Basin Management Plan until 2027” (Official Gazette 84/23) as an environment characterized by "poor chemical status of waters". In this aquifer, which contains many wells dedicated to public water supply, exceedances of nitrate concentrations were recorded at many monitoring points, and a statistically significant upward trend for nitrates was found at several measuring points.
- Even if it can't be used for human consumption the aquifer is of interest for agricultural irrigation and technical purposes.



Map: Chemical status of groundwater bodies in the Adriatic water area

# CASE STUDY – CROATIA – location

WWTP Lobarika (connected about 250 PE) started with operation end of 2023. Treated wastewater is discharged into the underground, through absorption field, which represents MAR. There are existing wells and springs in the vicinity that have been selected as checkpoints.

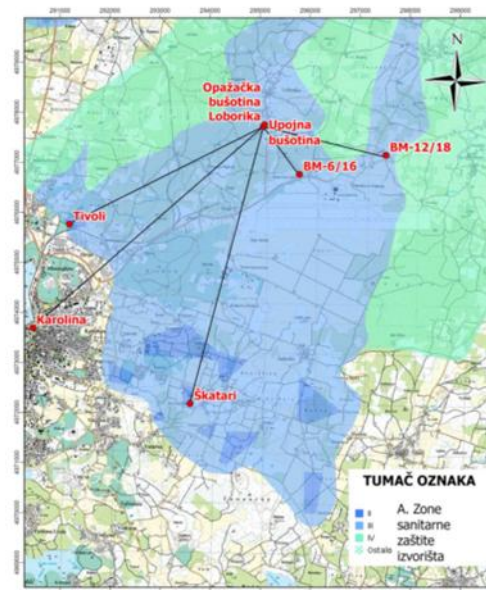
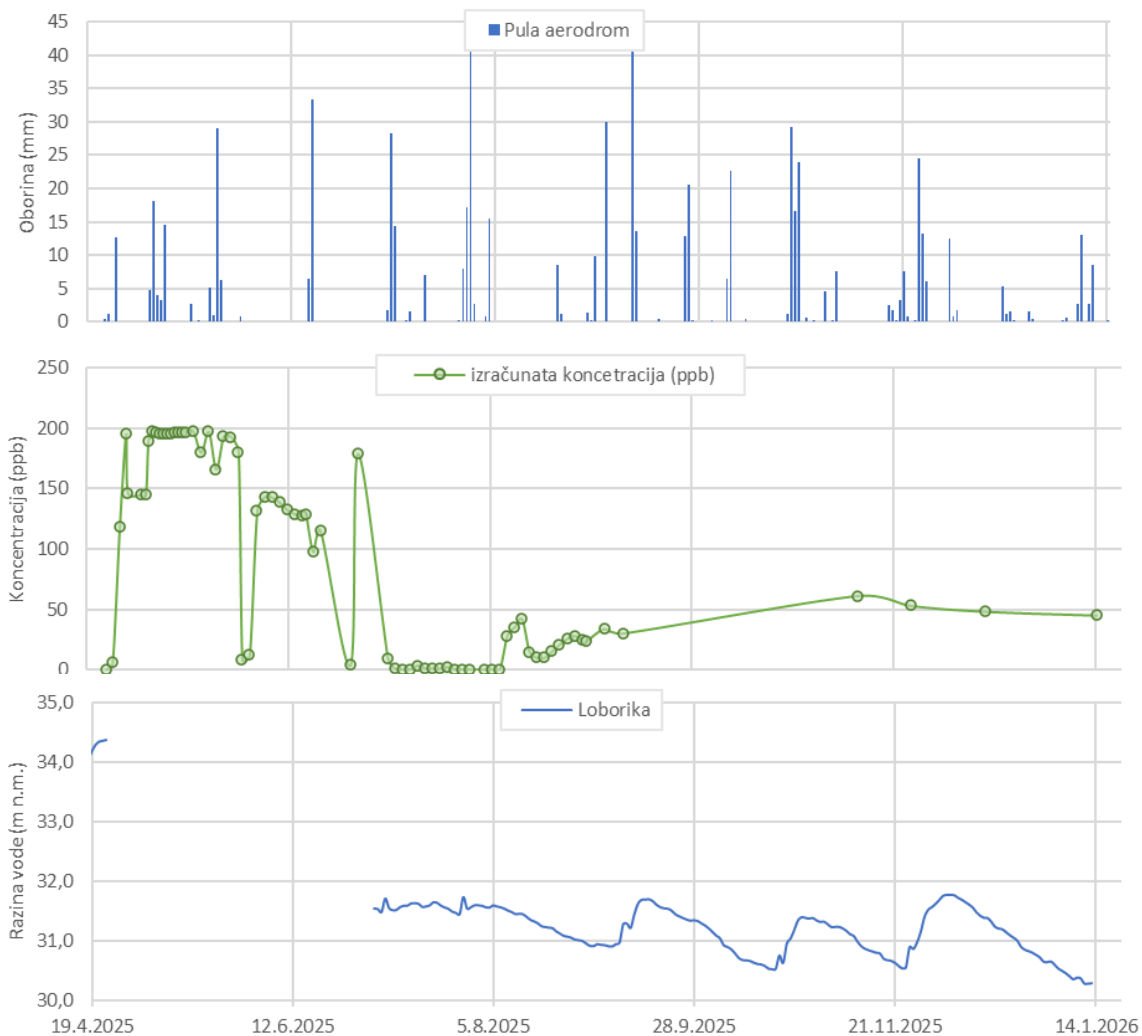


## CASE STUDY – CROATIA – Part 1 - Task 1 - tracer test

10 kg of uranine (Na-fluoresceine) was applied in the test well, instruments were installed to measure conductivity and color in test well.



# CASE STUDY – Part 1 – results

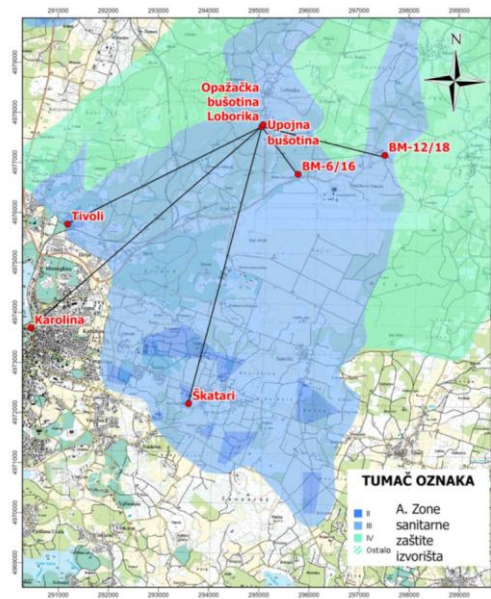
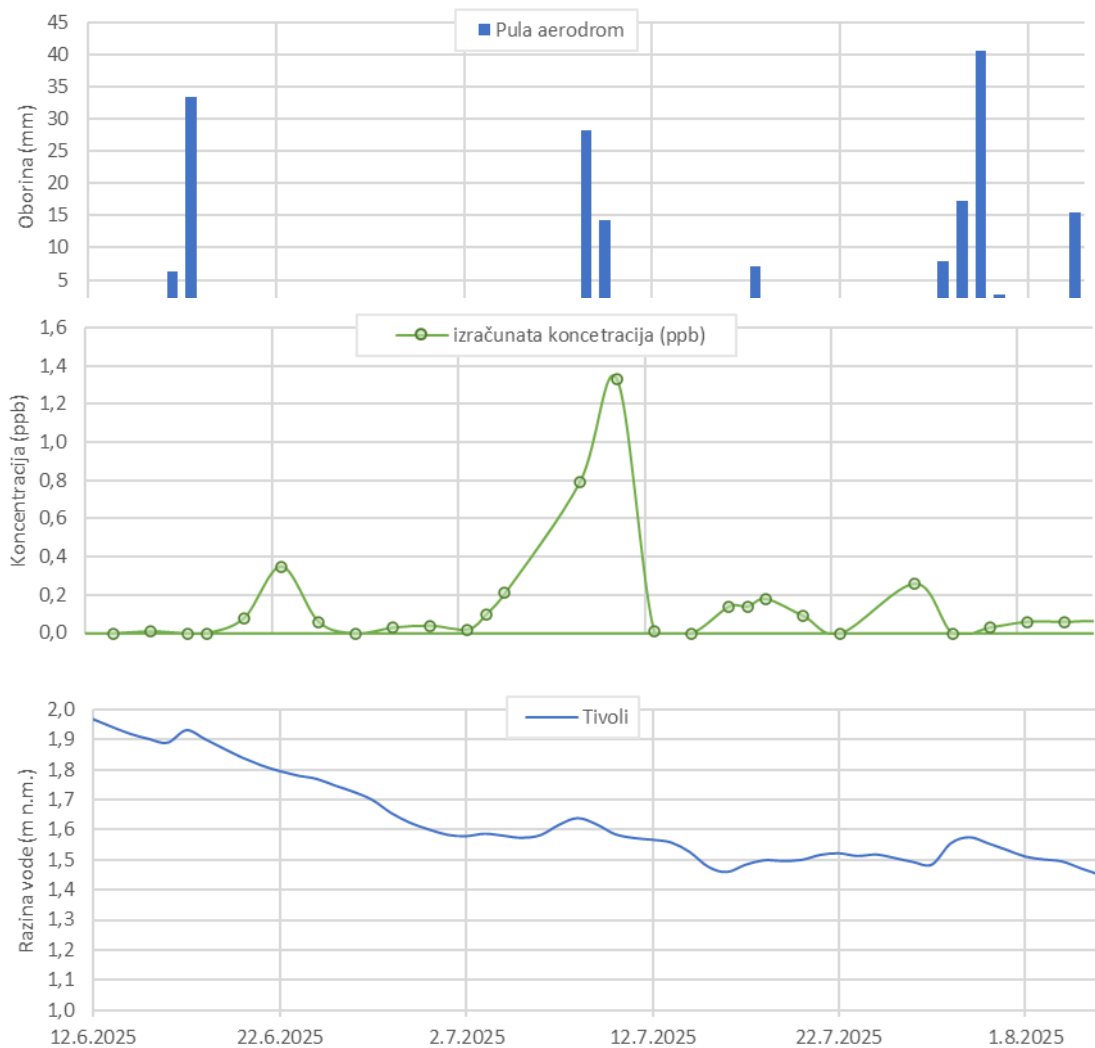


Graphical representation of the results of fluorometric analysis on the observation well B1 at the Loborika WWTP (19.4.2025 – 14.1.2026).



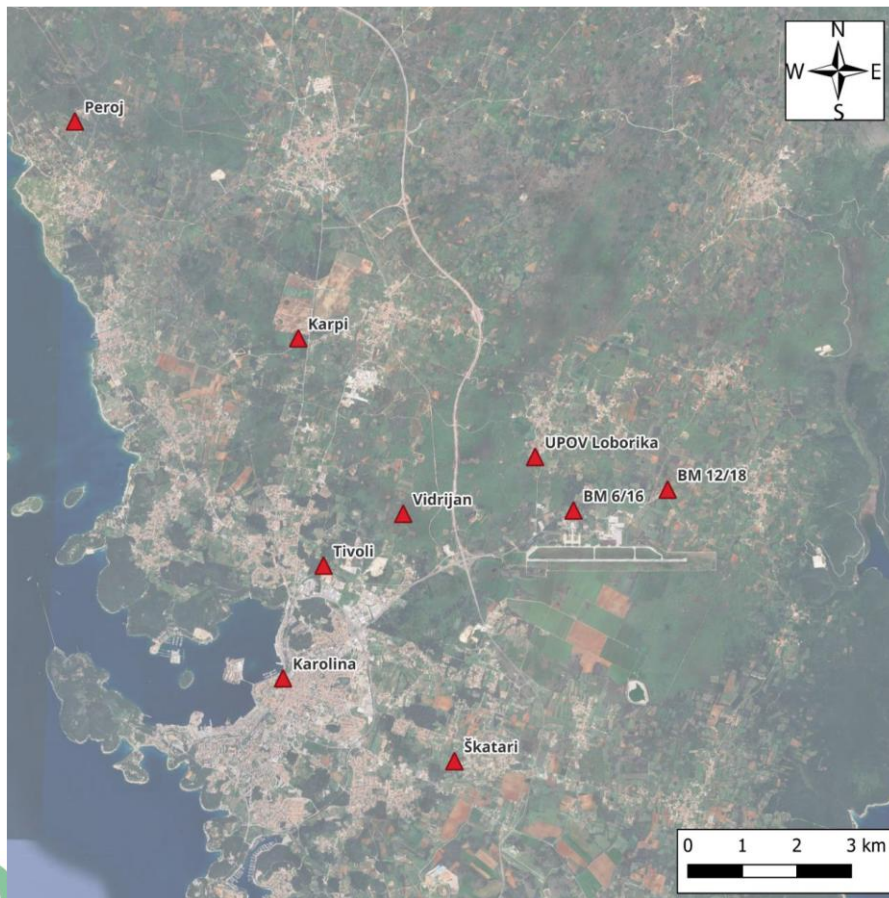
Photography of samples taken 11.11., the green bottle is sample from control well at WWTP Loborika.  
The color persisted until the last sampling in January 2026.

# CASE STUDY – Part 1 – results



Graphical representation of the results of fluorometric analysis at the Tivoli well (13.6. – 5.8.2025)

## CASE STUDY – CROATIA Part 1– Task 2 - monitoring



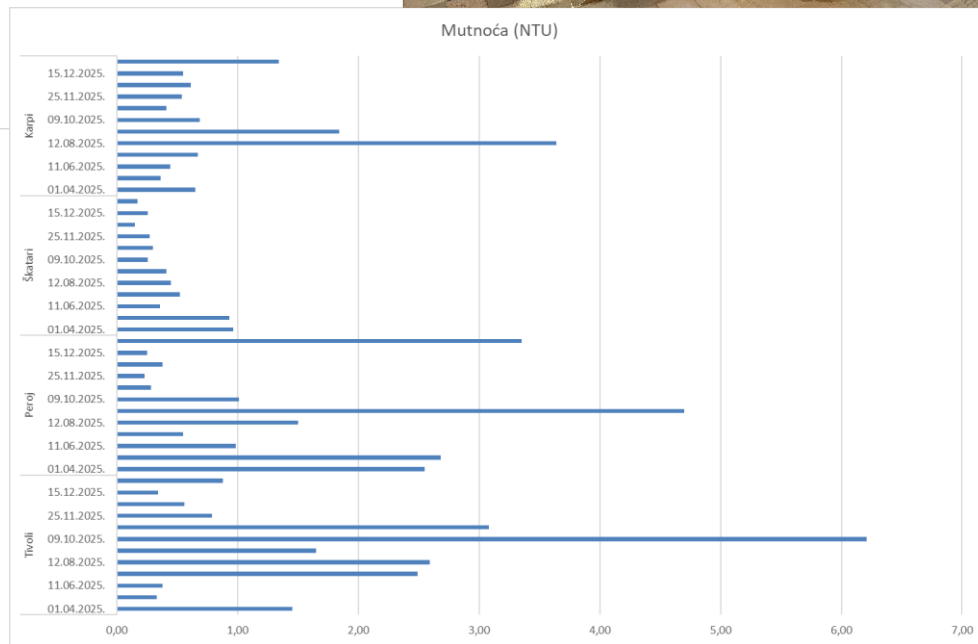
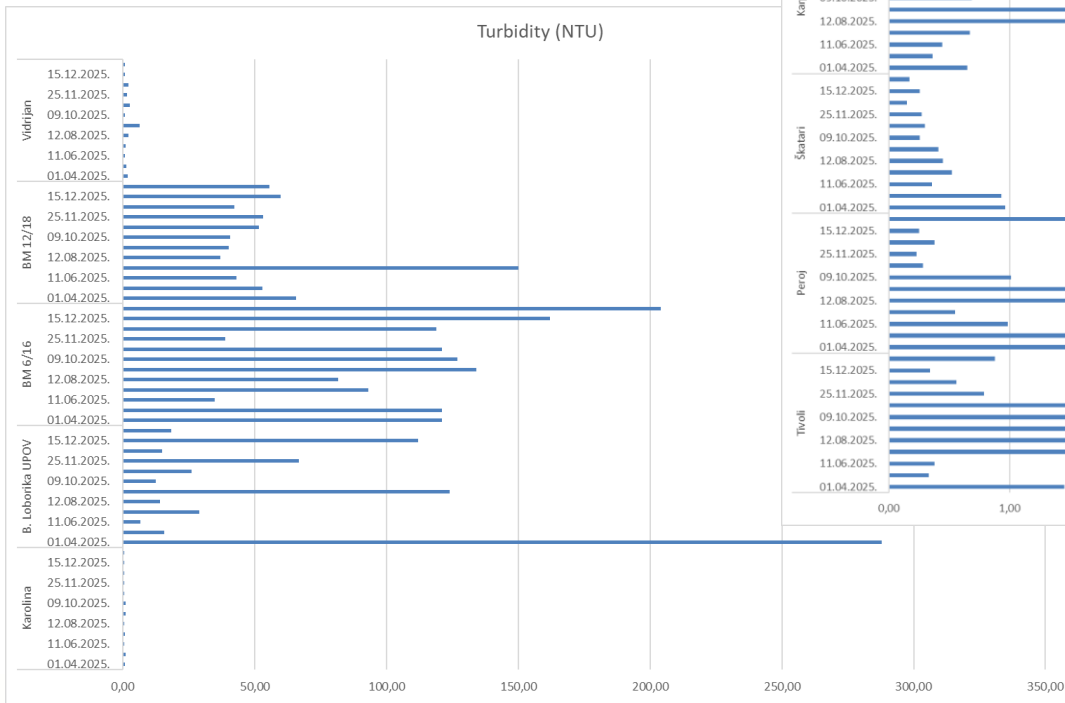
Monitoring was performed at 8 existing wells and springs, and at newly drilled well at the Lobarika WWTP site, for 3 groups of parameters, by 3 institutions:

1. physical-chemical, and microbiological „standard” parameters – Laboratory of Vodovod Pula –Labin
2. Some specific parameters – NZJZ Rijeka
3. Stable isotopes – Faculty of physics – Rijeka



# CASE STUDY – CROATIA

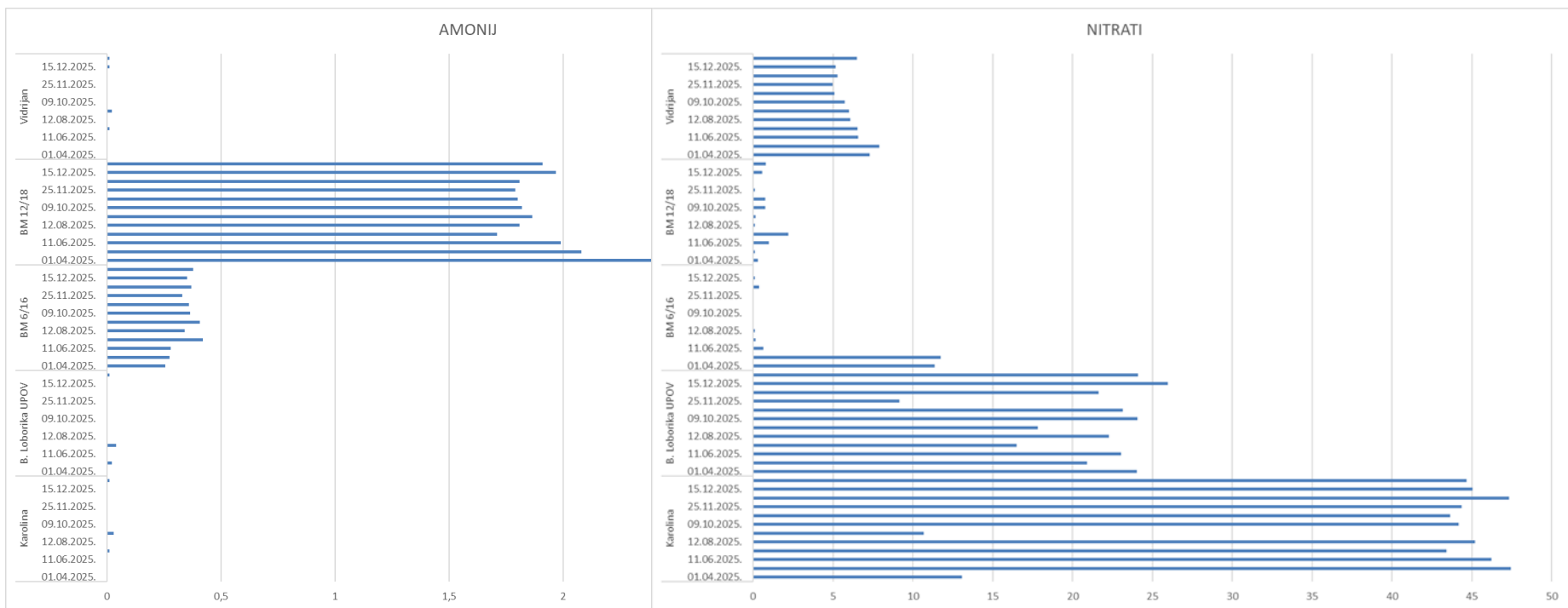
## Part 1– results



Turbidity

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Amonium

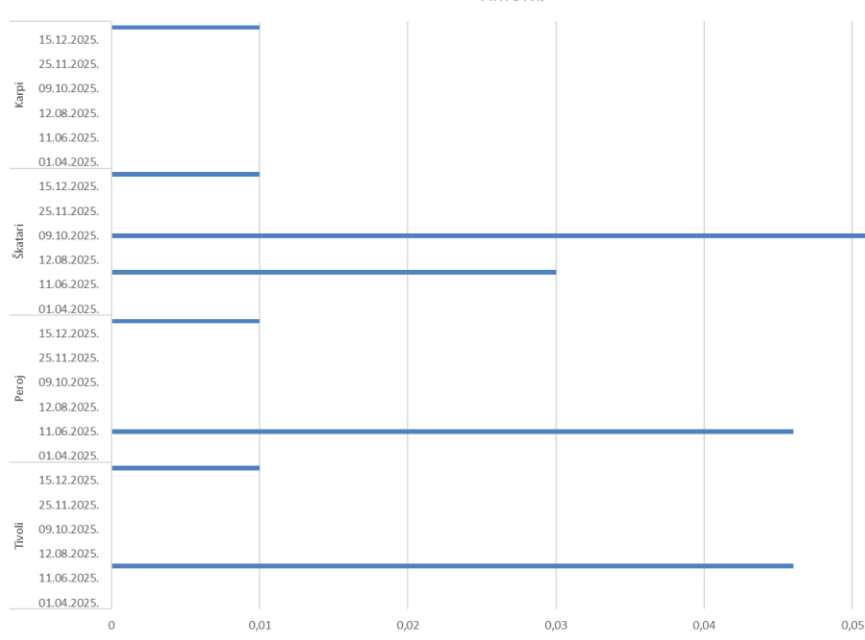
Nitrates



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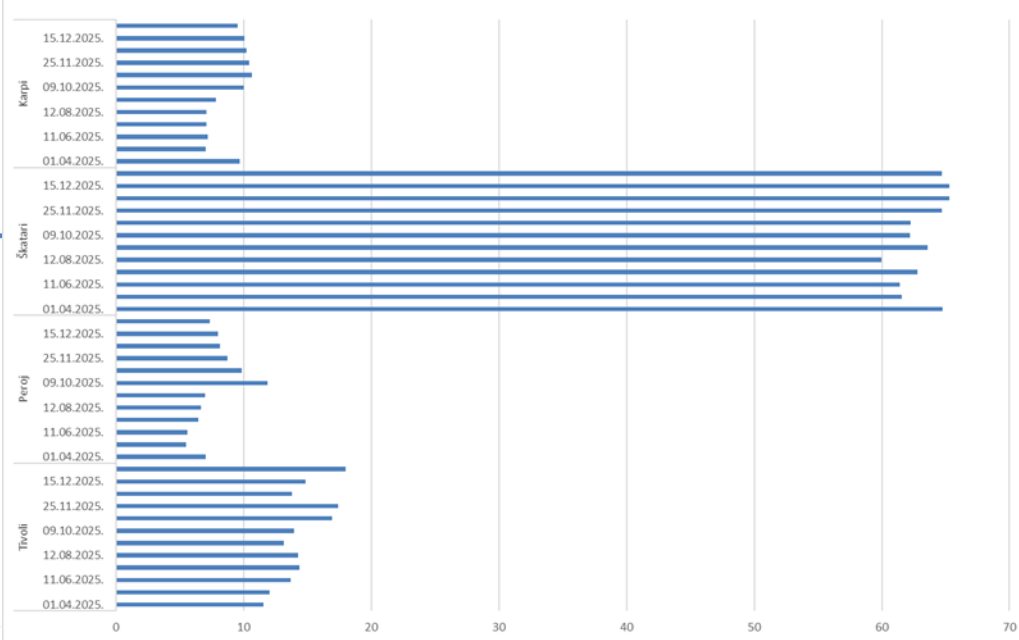
**BLUE RECHARGE CASE STUDY – CROATIA – Part 1 - results**

AMONIJ



Amonium

NITRATI



Nitrates



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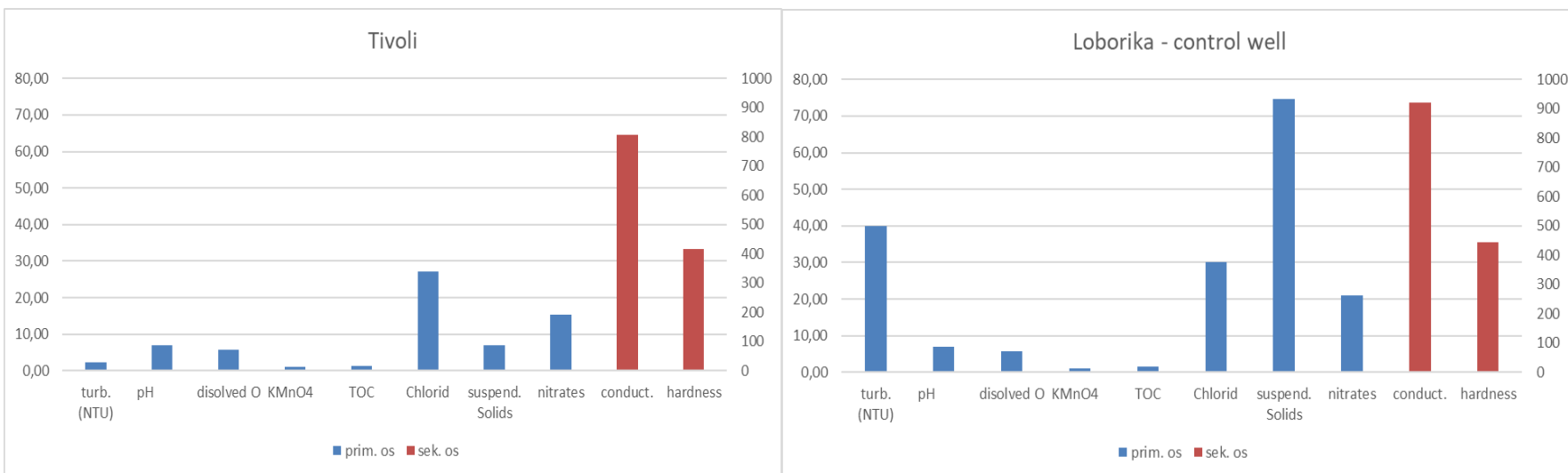
**BLUE RECHARGE CASE STUDY – CROATIA – Part 1 - results**

Well Tivoli: capacity 27-53 l/s; In operation since: 1897.g

Last time used for the water supply: 12/2016

Chlorides conc.: 30- 1740 mg/l

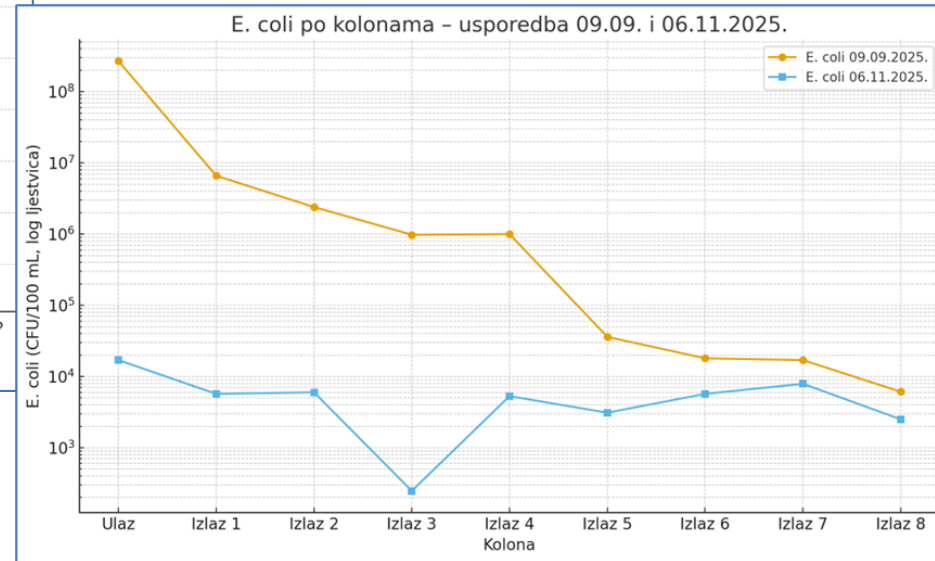
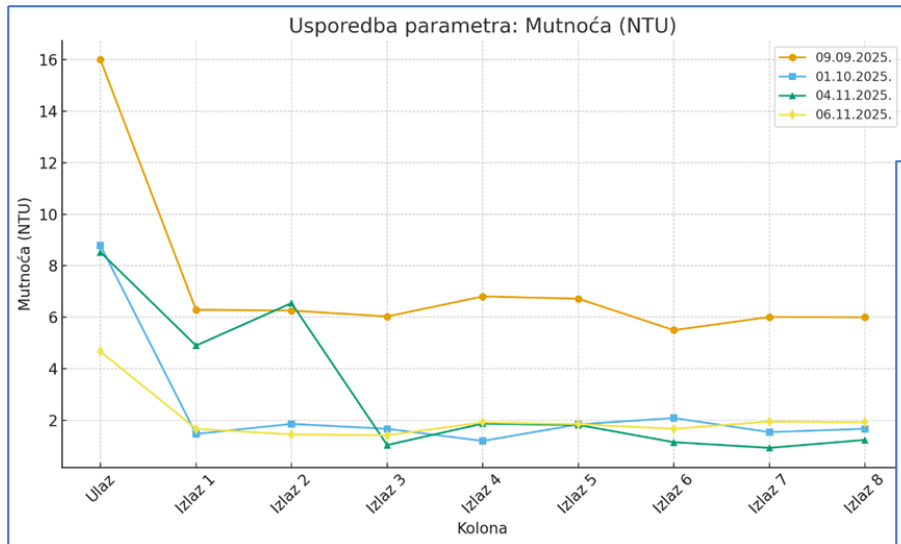
Nitrates average 1997-2001.: 19,9 mg/l ; 2002 -2012.:20,1 mg/l ; 2013.-2022.: 14,9 mg/l





- Study of optimization of wastewater treatment processes and underground discharge techniques for achieving optimal results: pilot-test on site.

# CASE STUDY – CROATIA – Part 2 - results



- Study of optimization of wastewater treatment processes and underground discharge techniques for achieving optimal results: pilot-test on site.





## CONCLUSIONS

- WWTP discharge can be applied as MAR in karst area, when water is not used for human consumption
- Results are showing that there was no significant movement of water; no influences on underground water quality were noticed (only about 15.000 m<sup>3</sup> were discharged in the field)
- WWTP process can be improved with implementing better filtration conditions in the absorption field
- For each location, previous comprehensive testing is required (tracer, monitoring...)



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Thank you for your attention.

