

Anthropogenic Groundwater Contamination: a Case Study from the Nitra Region, Slovakia

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INTRODUCTION

The Water Research Institute (WRI) monitoring network is specialized in assessing the impact of agriculture on groundwater quality. We focused on locality with extreme NO₃⁻ concentration > 250 mg/L. This region is characterised by intense agricultural activity. The application rate of fertilizers has been steadily increasing and peaked at ~ N 140 kg/ha. However, wastewater from municipalities may also play a role, 60% of inhabitants are not connected to public sewage system. This situation is contributing to not achieving the aims of Nitrate Directive and Water Framework Directive. Despite compliance with measures the high concentration persists.

- Does NO₃⁻ concentration change throughout the year?
- What is the water quality in domestic wells near WRI monitoring wells?
- What is the origin of the extremely high NO₃⁻ concentration?

MONITORING

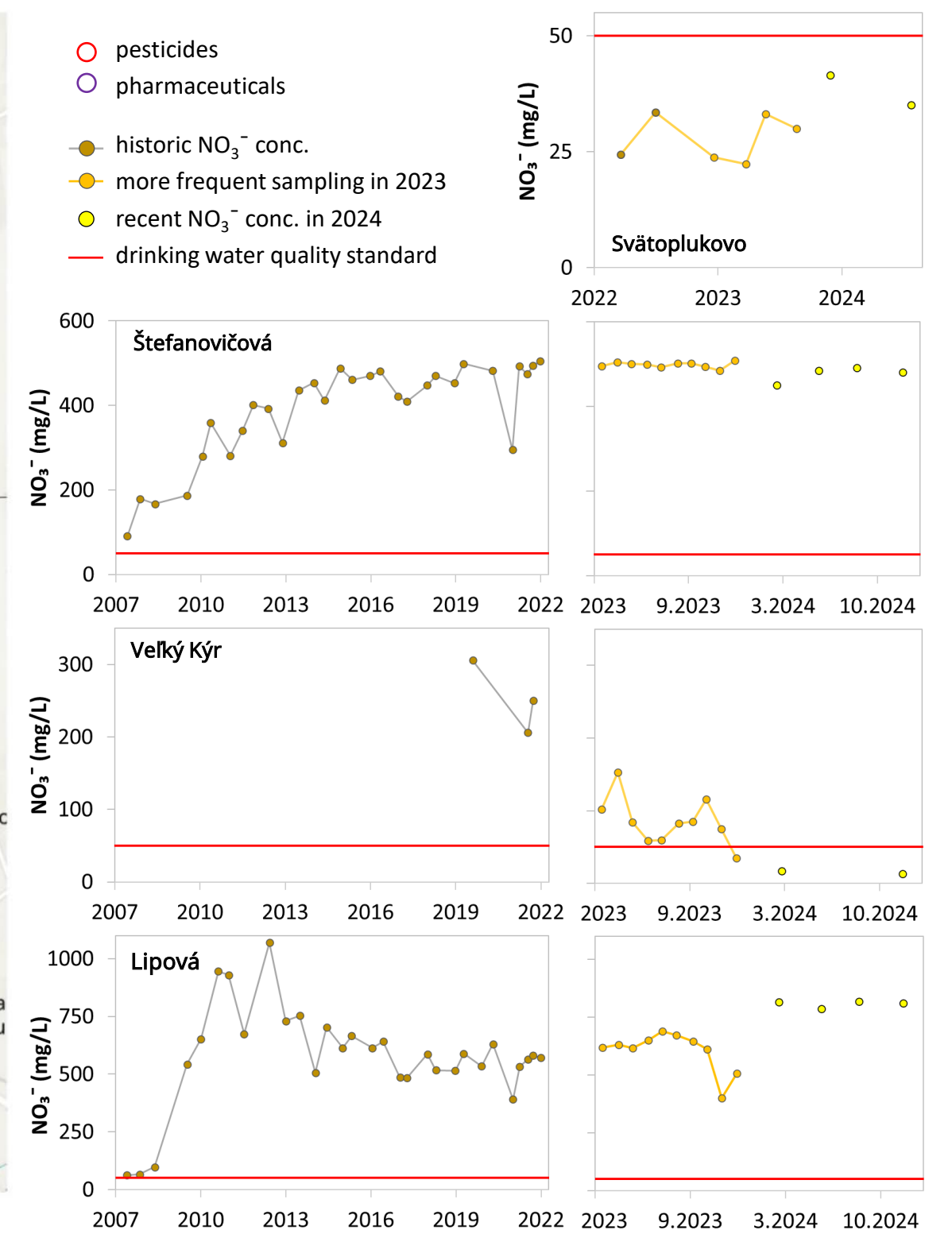
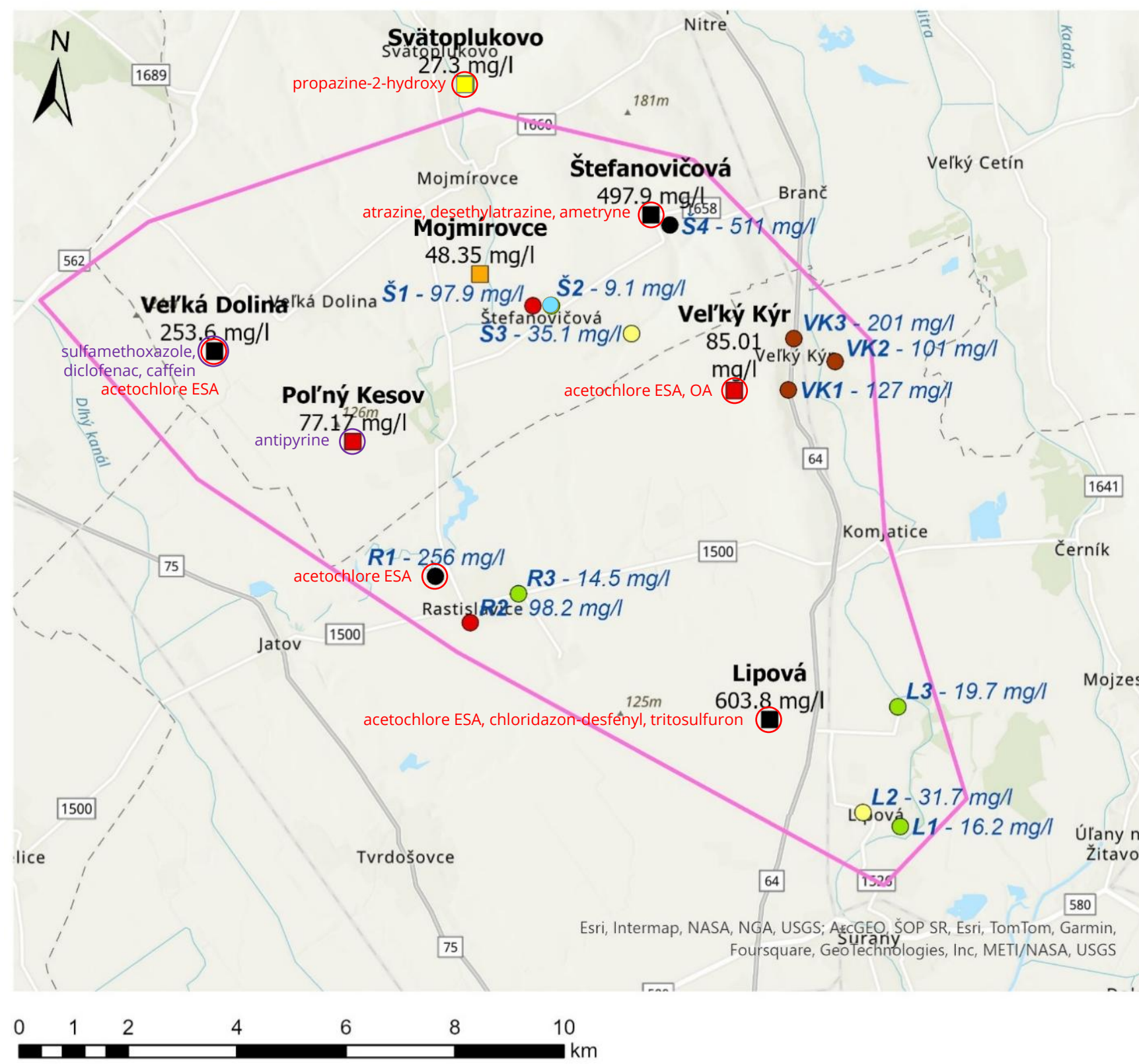
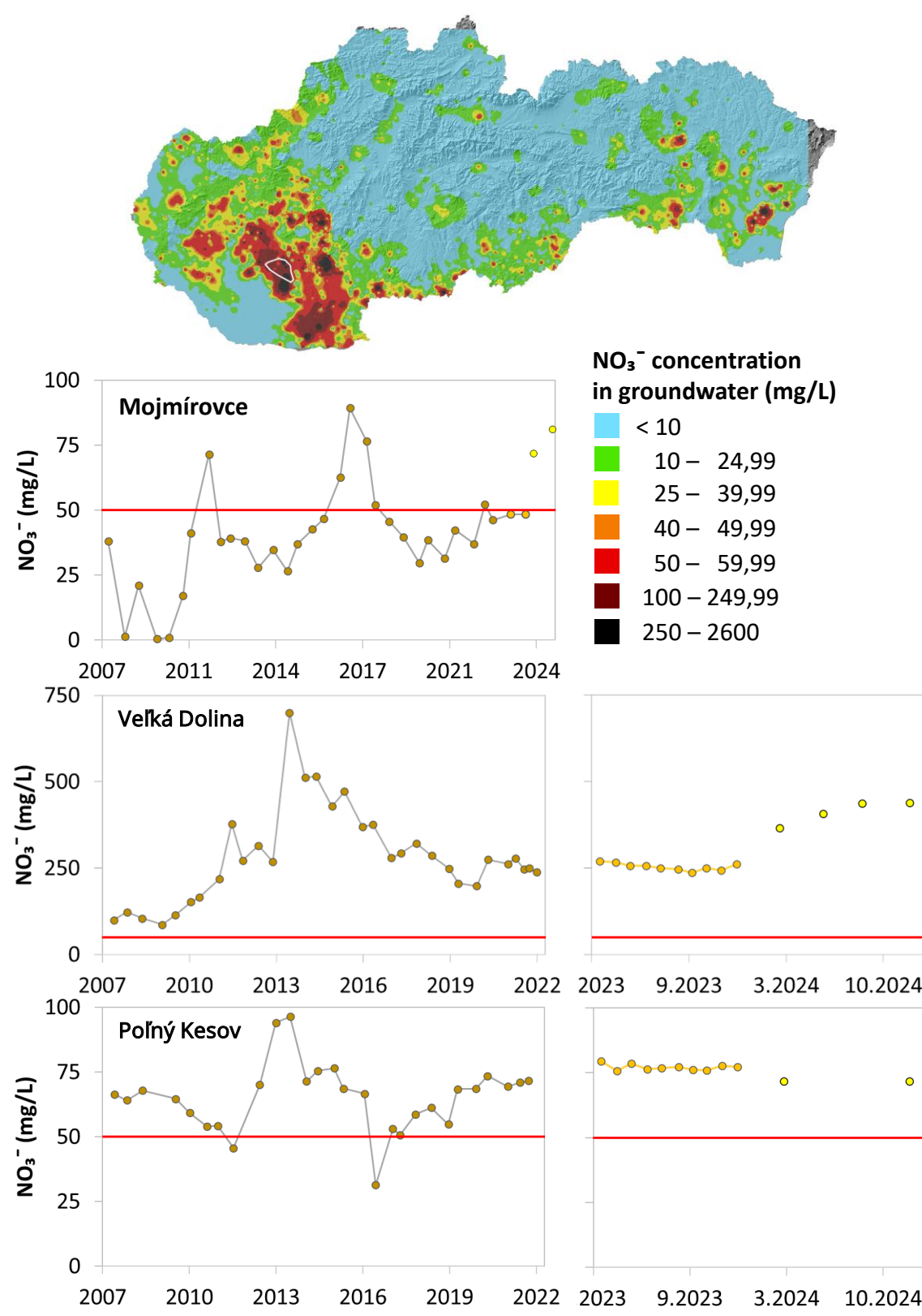
Area: 131 km²

– Quaternary sediments composed of loess to clays of eolian origin

- 7 WRI monitoring wells 8 – 11,7 m b.g.l.
- 13 domestic wells 7 – 53 m b.g.l.

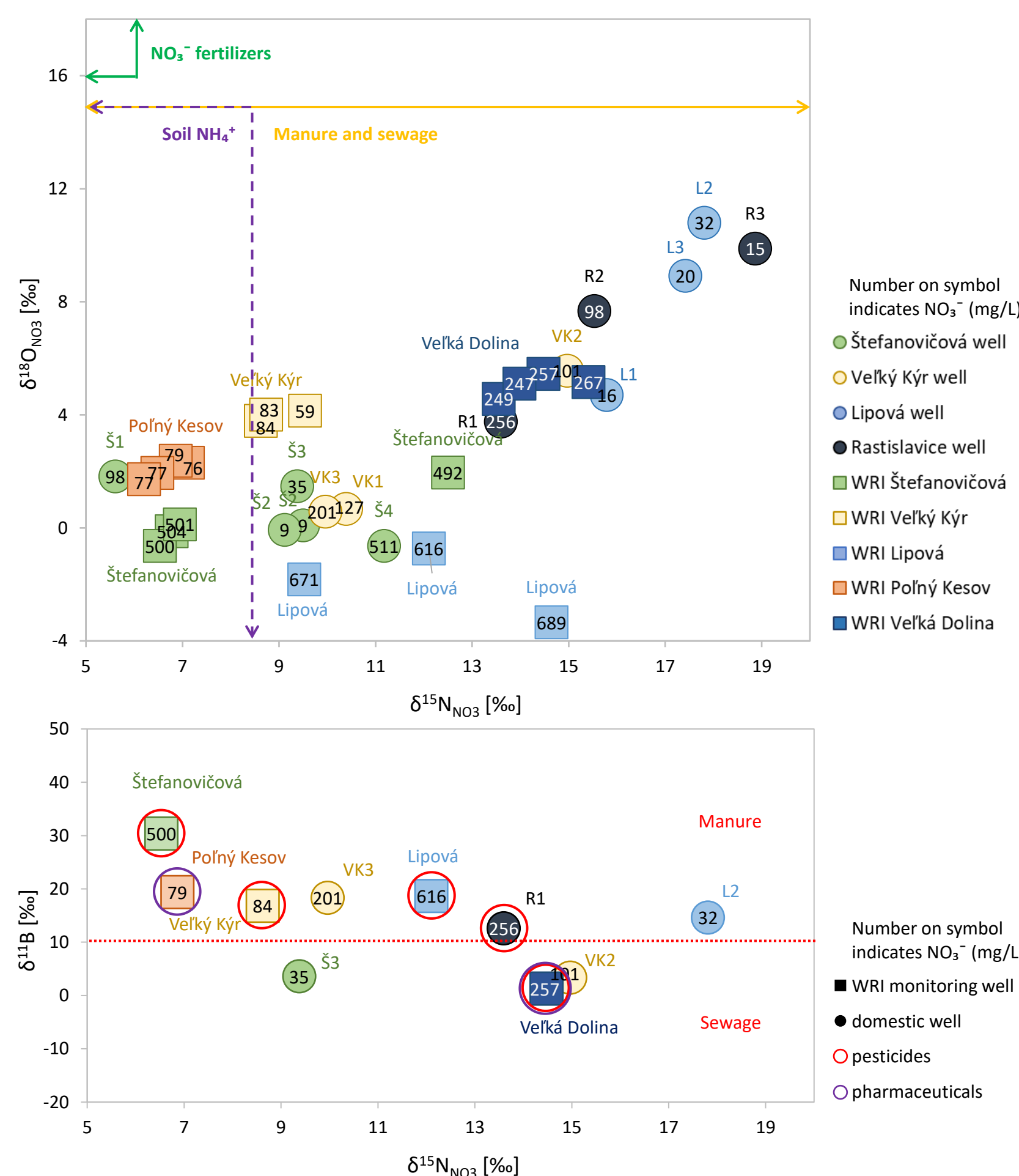
ANALYSIS

- field parameters: temperature, pH, conductivity, groundwater level
- nitrogenous substances: NO₃⁻, NO₂⁻, NH₄⁺
- other substances: PO₄³⁻, SO₄²⁻, Cl⁻
- pesticides: 69 compounds
- pharmaceuticals: 26 compounds
- isotopes: δ¹⁵N_{NO3}, δ¹⁸O_{NO3}, δ²H_{H2O}, δ¹⁸O_{H2O}, δ¹¹B, tritium ³H



RESULTS

- Seasonal variations in NO₃⁻ concentrations were observed in 3 monitoring wells; concentrations remained stable in 2 others.
- Monitoring wells with the highest NO₃⁻ concentrations had the lowest groundwater levels and showed the slowest recovery after withdraw, indicating limited dilution and greater accumulation.
- In 5 monitoring wells and 1 domestic well, pesticide concentrations exceeded the drinking water limit.
- When pesticides were detected in WRI monitoring wells, concentrations in nearby domestic wells remained below the drinking water limit.
- Nitrogen and oxygen isotopic analysis revealed that NO₃⁻ has an organic origin.
- Boron isotopic composition distinguished that nitrates originate from manure, indicating an agricultural source.
- In monitoring wells with extreme NO₃⁻ concentrations where boron isotopes indicated municipal wastewater influence, pharmaceutical residues and caffeine were also detected, supporting this interpretation.



CONCLUSIONS

This case study successfully identified pollution sources, supported by a novel isotopic application in the Slovak context. The extremely high nitrate concentrations observed are likely due to a combination of intensive agricultural activity and unfavourable geological and redox conditions, which hinder NO₃⁻ attenuation or dilution, leading to its accumulation. Fertilizer application regulations should be tightened in this area and in other regions with similar geological conditions to prevent further deterioration.

Acknowledgement

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References

- Kendall C., 1998 Tracing nitrogen sources and cycling in catchments. Isotope Tracers in Catchment Hydrology, Elsevier Amsterdam.
- Briand, et al., 2013 Combination of nitrate (N, O) and boron isotopic ratios with microbiological indicators for the determination of nitrate sources in karstic groundwater. Environmental Chemistry, 10(5).