

## Fingerprints of environmental stressors in three selected Slovenian gravel-bed rivers: geochemical and isotopic approach

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Rivers are severely impacted by a range of simultaneous processes including water pollution, flow and channel alteration, over-fishing, invasive species and climate change. Systematic studies of river water geochemistry provide important information on chemical weathering of bedrock/soil and natural anthropogenic processes that may control the dissolved chemical loads, while the isotopic studies of biological components of river systems (macrophytes, periphyton, heterotrophic biofilm, invertebrates, fish) contribute to the understanding how the system response to human impacts by means of functional response.

In this contribution, insights in the fingerprints of various environmental stressors in three gravel-bed rivers (River Kamniška Bistrica, River Idrijca and River Sava) in Slovenia, using geochemical and stable isotope approach are discussed. Gravel bed of all three rivers investigated is composed of carbonates and clastic rocks. The Sava and Kamniška Bistrica Rivers have alpine high mountain snow-rain regime. The Idrijca River is a boundary river between the Adriatic and Black Sea catchments and has rain-snow discharge regime with torrential character. Geochemical methods (ICP-OES, IC, total alkalinity after Gran) and isotope mass - spectrometric methods (isotopic composition of dissolved inorganic carbon, particulate organic carbon and isotopic composition of carbon in carbonates) were used to evaluate biogeochemical processes in rivers. Isotopic composition of carbon and nitrogen of the moss *Fontinalis antipyretica* (the whole vegetative shoot) and isotopic composition of carbon of heterotrophic biofilm was also analyzed in order to better understand the fluxes and fractionation of carbon and nitrogen across trophic levels. Geochemical composition of all investigated rivers is  $\text{HCO}_3^-$ - $\text{Ca}^{2+}$ - $\text{Mg}^{2+}$  with different  $\text{Mg}^{2+}/\text{Ca}^{2+}$  ratios as follows: around 0.33 for Kamniška Bistrica and River Sava in Slovenia and above 0.75 for River Idrijca. In the Kamniška Bistrica River pollution with nitrates was observed in lower reaches, while the other two rivers in our studies have good ecological status from chemical point of view. From isotopic composition of inorganic dissolved carbon (DIC) it can be observed that DIC originates from dissolution of carbonates in upper reaches in the Sava and Kamniška Bistrica Rivers. In the Idrijca River more degraded material is leached from the terrestrial environment.

Isotopic composition of carbon of *F. antipyretica* in the River Sava Basin in Slovenia seasonally ranged from -45‰ to -32.9‰ and isotopic composition of nitrogen from -0.2‰ to +6.5‰. The higher isotopic composition of nitrogen of +6.5‰ found in *F. antipyretica* was related to agricultural activity in the watershed. The isotopic composition of carbon in heterotrophic biofilm was from +22.7 to +27.4‰ indicating the flux from terrestrial (allochthonous) compartment.

The use of water geochemistry and stable C and N isotopes in our studies revealed as promising approach to better understand the processes and fluxes of carbon and nitrogen across abiotic and biotic components of undisturbed and impacted river systems.