



Fontinalis antipyretica as a bioindicator of environmental conditions in freshwater ecosystem from Sava River watershed and Cerkniško Lake, Slovenia

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Polluted waters recharging from agriculture water systems into watersheds have influence on water quality and living habitat. Stable isotopes of carbon and nitrogen in combination with other minor and trace elements are often used to trace biogeochemical processes and contamination of water systems. The aim of the study was to assess state of environment with minor and trace elements and stable isotopes of C and N in selected Slovenian streams. Ten locations in Notranjska region, Slovenia, with different land use in the catchment (town, village, agricultural areas, farms, dairy farms), including reference point considered as non-polluted site, were sampled. Samples of water and aquatic moss *F. antipyretica* in Slovenian fresh waters were taken in all four seasons during years 2010 and 2012, but for stable isotope analyses of C and N only in three seasons during years 2010 and 2011.

The water chemistry of investigated locations is dominated by hydrogen carbonate - calcium - magnesium, concentrations of nitrate seasonally range from 2.07 mg/l to 6.4 mg/l and at reference site does not exceed 1.3 mg/l. Total alkalinity of water at investigated locations ranges from 2.9 to 6.02 mM. The pH of investigated water range from 7.2 to 8.5, waters are saturated with oxygen (up to 134%) and conductivity ranges from 295 to 525 mikroS/cm, while at reference site conductivity is up to 180 mikroS/cm.

The content of minor and trace elements in *F. antipyretica* ranged for Ni 4-38 mikrog/g, Zn 17-105 mikrog/g, Pb 2-28 mikrog/g, Cd 220-1953 ng/g, Cu 4-27 mikrog/g, Cr 4-49 mikrog/g, As 1-6 mikrog/g and Se 0.33-3.24 mikrog/g. The most polluted watershed was Pšata stream (agricultural areas, cattle farm) with highest values for Ni, Cr, Pb, Zn and As. The highest content of Se, was found in village (dairy farms) in Žerovniščica stream. The highest values were measured in February and October.

Isotopic composition of dissolved inorganic carbon seasonally range from -13.3 to -8.1‰ and indicate waters dominated by degradation of organic matter and dissolution of carbonates. At the reference point average measured isotopic composition of dissolved inorganic carbon value is -2.7‰ which confirmed that this is a non-polluted site. Isotopic composition of carbon of *F. antipyretica* seasonally ranges from -45 to -32.9‰ and isotopic composition of nitrogen from -0.2‰ to 6.5‰ respectively. In comparison to C3 terrestrial plants *F. antipyretica* has more negative isotopic composition of carbon value, which is probably related with the difference in CO₂ plant fixation and depends on isotopic composition of dissolved inorganic carbon in water, which is primarily controlled by geological composition and soil thickness in the watershed. Higher isotopic composition of nitrogen value found in *F. antipyretica* is related to agricultural activity in watershed, while at the reference site measured isotopic composition of nitrogen value is -4.1 ‰. From our study it is evident that isotopic composition of carbon and nitrogen is useful tracer of natural and anthropogenic inputs from terrestrial (fertilizing, sewage sludge) to water system.