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A multi-isotope approach (N-, S-, O, Sr and Pb) to estimate the impact of long distance air pollution on sensitive alpine karst groundwater

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Karst and other sensitive aquifers contribute up to 90 % to the total drinking water supply in some European regions. However, they are more vulnerable to contamination than other aquifers due to short transfer times from recharge to source. Therefore, the main objective of this study is to show possibilities to quantify the impact of even small long distance air pollution on sensitive water resources (e.g. karst).

In spite of strong efforts initiated by the European Union and other international organisations in the past 20 years, air pollution from industry, traffic and agriculture is still significant. Transboundary transport processes by atmospheric circulation are responsible for its long range distribution. There is evidence that even remote mountainous regions in the Pyrenees or Alps as well as the Mediterranean islands are contaminated by inorganic and organic airborne pollution. This is most evident on the surface, but also may penetrate straight into aquifers, particularly in carbonate areas with strong karstification.

In a pilot study precipitation, soil, rock and spring waters were collected in a small catchment at the front of the Northern Calcareous Alps to test the application of isotope analyses to estimate the amount of far transported contaminants and their impact on the spring water quality. The hydrochemistry and the isotopic composition of nitrate, sulphate, strontium, lead and the water molecule itself has been analysed in five laboratories, each of them specialised in a certain group of isotopes.

Comparison of strontium isotope measurements in precipitation, spring waters and

dolomite bedrock in a relatively pristine and remote area at the front-range of the Northern Calcareous Alps in Austria with literature data indicate that $^{87}Sr/^{86}Sr$-isotope ratios in preciptiation (0.7092) support at least a more radiogenic, far transported source in addition to a possible recycling of local dolomite and limestone dust (0.7080-0.7083). Spring waters show similar ratios (0.7083-0.7084) confirming Sr-isotopes are good indicators for groundwater contact with specific host rocks.

The monthly precipitation samples show ^{18}O-rich sulphate ions, whereas the soil sulphates change in a direction to lower ^{18}O- and higher ^{34}S-values with depth. The spring waters and the bedrock dolomites vary in the range of $\delta^{34}S$-values (4-9 ‰). Assuming the precipitation samples and the dolomite bedrocks are endmembers the straight contribution of atmospheric sulphate without biogenic cycling can estimated to be 20 % in the spring waters and 10-45 % in the soil samples.

The monthly precipitation and total deposition samples show ^{18}O-rich nitrate ions, whereas the spring waters show variable influence of soil nitrates. Assuming the field of soil nitrification and the precipitation as endmembers a direct atmospheric nitrate contribution of 10-30 % derived from fossil fuel burning and agricultural emissions can be calculated.

Radiogenic Australian gasoline-lead still dominates with 60-80 % the composition of the trace lead in the spring waters. In addition to the lead leached from the dolomite bedrock a third source contributes about 5-10 %. This second long distance Pb-contribution may originate from coal burning and/or Ag-Pb-ore smelting in Central Europe in the past.