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Tracing anthropogenic effects on the urban water system using stable isotopes

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Urban water systems are polluted by diffuse and direct contributions from anthropogenic activities. Besides industrial contaminants like aromatic and chlorinated hydrocarbons and other persistent organic compounds, the urban aquatic environment is increasingly polluted by low concentrated but high eco-toxic compounds as pharmaceuticals, fragrances, and plasticizers, most of which are under suspicion of having disrupt endocrine functions. Therefore, these contaminants will have a long-time impact on the urban ecosystem and on human health when released by surface waste water outflows and seeping subsurface waste waters. For assessing the impact of human activities on the urban water system, isotope analyses seem to be a useful tool to estimate the origin of these contaminants, possible transformation processes ongoing within the aquatic environment, and their distribution within the urban water system. Among other indicators we investigated the isotopic signatures of water (H, O) and dissolved substances (sulfate, DIC, nitrate).

In 2001 we started investigations of the anthropogenic effect of the city of Halle on the urban water system. Halle is located at the river Saale which acts as the major draining system collecting different inputs along its city traverse from south to north. At the northern fringe of the city the treated waste water of the whole city flows into the river.

The river water reflects the meteoric water signature of the area with mean δ^2H and δ^{18}O values of about -60 ‰ and -8.6 ‰ and a typical seasonal variation. The isotopic signature of dissolved sulphate from the Saale river and its tributary Weisse Elster differs clearly due to the different origin of sulphate in their respective sub-catchments. Palaeozoic evaporates occurring upstream of Halle influence the dissolved sulphate of the Saale giving enriched δ^{34}S values > 9 ‰ whereas sulphate of the Weisse Elster is characterized by the Quaternary sediments more depleted in ^{34}S. Both rivers join just before entering the city region.

Treated waste water with $\delta^{34}S$ < 2 ‰ constitutes a third source of sulphate, which mixes into the Saale river at the northern border of the city.

Dissolved inorganic carbon varies in $\delta^{13}C$ between -10 to -16 ‰ which indicates degradation of organic matter and gas exchange with atmosphere.

Nitrate dissolved in the river water can be attributed to at least two distinct sources. Treated waste water with enriched $\delta^{15}N$ values of > 12 ‰ is typical for septic waste waters. In contrast to the waste water signature, the nitrate of both rivers is influenced by seasonal nitrogen input from the rural catchments showing a range of 5 to 12 ‰ as can be expected for nitrogen from agriculturally used soils. Denitrification processes presumably contribute to the enrichment in $\delta^{15}N$ occurring during the summer season, although not confirmed yet (e.g. by $\delta^{18}O$ of nitrate). According to the geochemical conditions, denitrification also can be expected in the urban groundwater which is the focus of the current investigations towards assessment of the sources and the fate of pollutants within the urban water system.