Medical and other radioisotopes as tracers in the wastewater-river-sediment chain

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Introduction

Medical isotopes in wastewater and river sediment

- City wastewater carries considerable amounts of medical isotopes (mainly ^{99m}Tc and ^{131}I). They originate from excretions of the patients after diagnosis or therapy.
- ^{131}I had been detected in river sediment over 20 km of length in a previous study.
- Found concentration data are compatible with simple equilibrium models and average patient application data. [1]

A more detailed study was conducted, covering a larger river length and focused also on other (artificial and natural) isotopes.

Methods

Sampling

28 bank sediment samples were collected from locations distributed over 71 km length of the (tidal) river Weser, located in NW Germany (Fig. 1). The uppermost sample was taken above the first permanent barrage which separates the fluvial and tidal sections of the river.

Laboratory methods

Wet samples were investigated by high resolution gamma spectroscopy. Dry mass was determined afterwards by oven drying

Results

Primordial ^{40}K, cosmogenic ^{7}Be and fission-generated ^{137}Cs were found in all samples. Medical ^{131}I was detected at sampling sites near the WWTP outlet. No influence of a local NPP at km 52 could be detected. Data are presented in form of concentration profiles vs. position along the river.

Results for individual isotopes

^{40}K: flat profile, scatter is attributed to sample variability. Absolute values are common for mineral sediments (Fig. 2).

^{137}Cs: profile shape similar to ^{40}K, with parallel small oscillations. Concentration step at barrage. Absolute values are common for German rivers in 2010. Assumed long-time erosion process (main ^{137}Cs deposition occurred on land surface) (Fig. 2).

^{7}Be: concentration decreasing in downstream direction. Values might be proportional to inverse total discharge, indicating a (tidal) dilution effect. No concentration step at barrage. This finding is compatible with the assumption that ^{7}Be input is related to rainfall, as the main catchment area of the river (85%) is situated above the barrage and no substantial contribution is added withing the investigated river section. Data can only reflect short and medium time scales ($T_{1/2}$ = 53.4 d) (Fig. 3).

^{131}I: characteristic profile with a peak centered about the WWTP outlet and a plateau which disappears downstream due to the instrumental detection limit. The concentration ratio peak/plateau reflects the discharge ratio of river (about 300 m^3/s and WWTP (about 2 m^3/s). It can be assumed that a two-step process in involved: fast (<1d) hydrodynamic dispersion (peak) and slower (maximum: weeks, as $T_{1/2}$ = 8d) tidal redistribution (plateau). A fit indicating these contributions has been added to the graph (Fig. 4).

Conclusions and outlook

In our view, the presented data show an immense potential for the usage of radioisotopes of different origin as tracers in fluvial systems. Modelling of the above mentioned processes is in progress.

[1]: H.W.Fischer, S.Ulbrich, D. Pittauerová, B.Hettwig: Medical radioisotopes in the environment – following the pathway from patient to river sediment. Journal of Environmental Radioactivity 100 (2009) 1079–1085

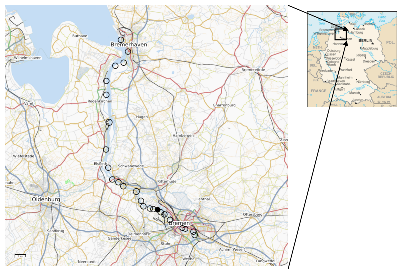

Fig. 1. Geographical map of the study area. Sediment sampling sites are marked by open symbols, the main WWTP is indicated by the filled circle

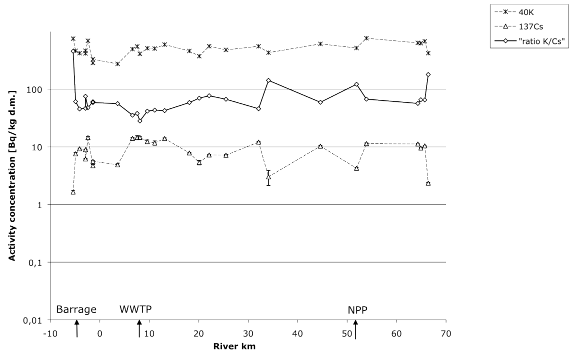

Fig. 2. Data plot for ^{40}K, ^{137}Cs and K/Cs ratio

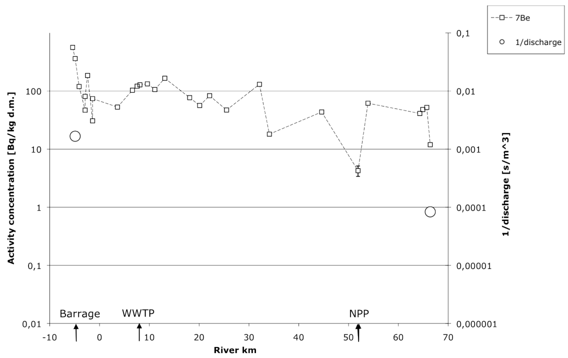

Fig. 3. Data plot for ^{7}Be and inverse discharge

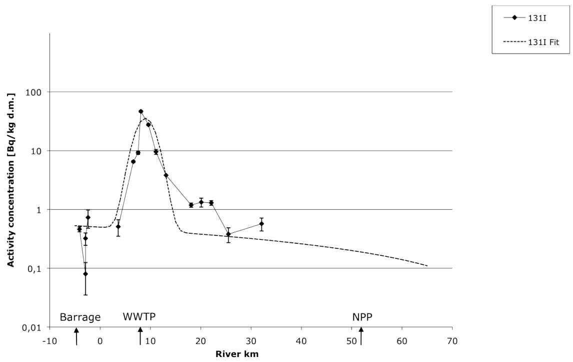

Fig. 4. Data plot for ^{131}I (fit is purely phenomenological)

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