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Analysis of time series of Cs-137 concentration in sewage sludge at Fukushima City

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Daily routine radioisotope measurements of sewage sludge at the sewage plant of Fukushima City starting in 2011 have provided a detailed data set for the isotopes Cs-137, Cs-134 and I-131. The long-term trend for the Cs isotopes is comparable to data sets from Central Europe caused by the Chernobyl emissions in 1986 – the average Cs-137 concentration decreases faster in the first year ($T1/2 < 1$ yr) and slower in later years ($T1/2 > 1$ yr). Absolute values at Fukushima City are comparably low (mostly below 1 kBq/kg dry mass), due to the existence of separate wastewater and rainwater sewer systems, with only a small portion of rainwater and erosion products reaching the purification plant. Cs-134 data decay faster due to the shorter radioactive half-life. I-131 appears even years after the NPP releases and is assumed to originate from the common medical usage of the isotope for thyroid treatment.

Short-term Cs data show a clear dependence on rainfall: each significant rainfall event causes a concentration increase in sludge of up to a factor of ten. Therefore the time series exhibits high short-term variability. Here we attempt to numerically analyse the detailed Cs-137 data set, using two separate approaches:

The first method tries to connect parameters like the local surface deposition density, surface types (sealed/unsealed), rainfall statistics, rainfall-induced erosion rate, leakage rate from rainwater to wastewater sewer, transport time in the sewer and residence time in the purification plant for a basically physical approach. As not all parameters are known, values have to be assumed or can be extracted in the course of the fitting process.

The second approach is purely heuristic, based on a water surface runoff and transport model. Whilst there is no ad-hoc physical meaning in the extracted parameters, they can possibly be interpreted as such when compared with physical modeling results.

The combination of both methods is expected to give a deeper insight into the transport dynamics of radioisotopes in contaminated areas, helping to identify important sources and sinks and to predict long-term behaviour.