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How to investigate the fate of synthetic polymeric flocculants in a complex agricultural matrix – results of an experimental simulation study

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Polyacrylamides (PAMs) are a group of watersoluble polymers with a wide range of applications in industry e.g. for sludge dewatering in municipal waste water treatment plants (MWWTPs). Spreading of the sludge on agricultural land is currently one of the most important recycling routes and with the sludge significant amounts of PAM are added to the soil. Here it binds to the soil/sludge matrix and it is not possible to determine fate processes without the use of an isotope-labelled polymer, which is not commercially available. Furthermore guidelines for degradation of organic substances are not developed for testing slow degradable polymeric compounds.

The current study investigated the fate and effects of PAM applied to soils through land-spreading of flocculated sludge. Degradability, leaching, plant uptake of degradation products and effects on soil microorganisms were studied in both standard laboratory experiments and outdoor simulations at a realistic exposure scenario. This presentation focuses on the experimental methodology and in particular that of the analysis of a polymer in a complex environmental matrix.

Radiolabelled PAM was synthesized in the testing facility using ^{14}C-labelled acrylamide monomer in a downscaled procedure with the labelling positioned along the carbon-carbon backbone of the amide units. The ^{14}C-labelled polymer met the product specifications of commercially available polymer used for sludge dewatering. The ^{14}C-polymer was used to dewater digested sewage sludge obtained from a local MWWTP in a standard procedure. The dewatered sludge containing the ^{14}C-polymer was used for the tests in real-life matrix. A three year outdoor simulation study was accompanied by a modified OECD 307 test under standard lab conditions. The incubation period in that test was extended to one year and a second set of samples was exposed to simulated sunlight in a 12-hour day/night sequence.

The ^{14}C-label enabled the analysis of the polymer in the complex environmental matrix even after years. Due to the radiolabelling it was possible to develop an extraction procedure to recover most of the polymer from the matrix. Special care was taken to the extract clean up to avoid massive losses of the extracted polymer. Finally it was proven by hydrolysis experiments that the polymer backbone remains stable under the extraction conditions selected. In addition to the quantitative analysis by LSC the extracts were analysed by radio-GPC after clean-up to determine changes in the molecular weight of the polymer.

By this technique a significant reduction of the molecular weight of the polymer could be determined. Results of the chemical analysis in combination with the mass balance from the outdoor experiments indicate a significant degradation of the polymer within the observed period of time. No uptake of radioactive residues in agricultural crops was observed and terrestrial ecotoxicology tests did not show any effect over control at any time.