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Cesium and strontium sorption behavior in amended agricultural soils

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Biogas digestates and biochar are emerging soil amendments. Biochar is a byproduct of pyrolysis process which is thermal decomposition of biomass to produce syngas and bio-oil. The use of biochar for soil amendment is being promoted for higher crop yields and carbon sequestration. Currently, the numbers of biogas plants in Germany are increasing to meet the new energy scenarios. The sustainability of biogas industry requires proper disposal options for digestate. Biogas digestates being rich in nutrients are beneficial to enhance agricultural productions. Contrary to the agronomical benefits of these organic amendments, their use can influence the mobility and bioavailability of soil contaminants due to nutrients competition and high organic matter content. So far, the impact of such amendments on highly problematic contaminants like radionuclides is not truly accounted for.

In the present study, sorption-desorption behavior of cesium and strontium was investigated in three soils of different origin and texture. Two agricultural soils, a loamy sand and a silty soil, were amended with biochar and digestate in separate experiments, with field application rates of 25 Mg/ha and 34 Mg/ha, respectively. For comparison a third soil, a forest soil, was incubated without any amendment. The amendments were mixed into the top 20 cm of the field soils, resulting in final concentrations of 8-9 g biochar/Kg soil and 11-12 g digestate/Kg soil. The soils were incubated for about six months at room temperature. Sorption-desorption experiments were performed with CsCl and SrCl2 after pre-equilibrating the soils with CaCl2 solutions.

The amendments with field application rates did not have a significant effect on the relevant soil parameters responsible for the sorption behavior of the two radionuclides. Comparatively, the soil type lead to distinctive differences in sorption-desorption dynamics of the two radionuclides. Cesium showed a higher affinity for silty soil followed by forest soil and lowest for sandy soil. Comparatively, strontium displayed a lower adsorption for all three soils, with a slightly higher adsorption in silty soil and almost similar sorption for both forest and sandy soils.

We conclude that the applied organic amendments with field application rates will not deplete the FES (Frayed Edge Sites) responsible for cesium sorption in mineral soils. Furthermore, with the present application rates the increase in amount of organic matter is not high enough to significantly affect the strontium sorption in mineral soils. The desorption experiments showed that about 1/3 of the adsorbed cesium was extractable in silty soil and almost half was extractable in forest and sandy soils. In case of strontium, about half was extractable in the three soils. Similar to sorption, the effect of amendments was negligible compared to the soil type.