PREDICTION CAPACITY OF A SEQUENTIAL EXTRACTION SCHEME

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The predictions of a sequential extraction scheme with respect to the mobility of some radionuclides (\(^{85}\)Sr, \(^{134}\)Cs and \(^{110m}\)Ag) in two Mediterranean sandy and sandy-loam soils, are compared to short-term soil-to-plant transfer factors and soil migration. Total soil-to-plant transfer is higher in sandy soil than in sandy-loam soil, as expected and predicted by the scheme. The relative transfer to plants of \(^{134}\)Cs and \(^{85}\)Sr follows the scheme predictions about exchangeable radionuclide fraction, radiosilver being less mobile than expected. Migration in soil of radiocesium and radiostrontium is also higher in sandy soil, especially for the latter radionuclide, the relative behavior of these two radionuclides being nearer to the bioavailable radionuclide fraction defined by the scheme. However, the scheme fails in predicting radiosilver migration, which is lower than deduced by the scheme.

The soil-to-plant transfer of radionuclides, especially radiocesium and radiostrontium, is influenced by many soil parameters, as pH, organic matter and mineral content, calcium and potassium levels. Sequential extraction schemes applied to obtain radionuclide distribution in soils are a quite useful tool to predict plant uptake at long-term situations, considering the possibility of defining exchangeable or bioavailable fractions in soils but taking into account that these fractions are defined operationally, it seems necessary to compare these predictions by means of the calculation of the soil-to-plant transfer factors of cultures growing in contaminated soils. Furthermore, radionuclide migration in soils can be also related to mobile fractions and, subsequently, it can be predicted by speciation studies.

A four-step scheme was applied to two types of Mediterranean soil previously contaminated with a radioactive aerosol, containing \(^{85}\)Sr, \(^{134}\)Cs and \(^{110m}\)Ag, in order to obtain their distribution in both soils. This scheme uses \(\text{MgCl}_2\), \(\text{Na}_4\text{P}_2\text{O}_7\), \(\text{NaOH}\) and \(\text{H}_2\text{O}_2-\text{HNO}_3-\text{NH}_4\text{OAc}\) as extractant solutions. Prior to the contamination processes, both types of soil were sowed with seeds of lettuce (\textit{Lactuca sativa}), to be able to calculate transfer factors along the period of growing of plants. Radionuclide distributions in soils were obtained in samples taken a few months after contamination, in coincidence with the mature stage of plants. In these samples, radionuclide distribution in the soil profile was also obtained. These experiments were carried out in the frame of TARRAS CEC project, whose global aim is the study of the behavior of accidentally released radionuclides in agricultural systems, mainly from the soil-to-plant...
transfer and soil migration standpoints. In this work, therefore, radionuclide distributions in soils obtained after applying sequential extractions will be compared with soil-to-plant transfer factors and migration percentages.

**Experimental**

*Samples:* One square meter of each of two types of agricultural, Mediterranean soil was contaminated using a thermogenerated aerosol, containing $^{134}$Cs, $^{85}$Sr and $^{110m}$Ag, as described elsewhere. A contamination process was carried out per each type of soil, samples being previously divided in four lysimeters. One type of soil was a sandy-loam soil (soil 1), from the experimental fields of the University of Barcelona (Barcelona, Spain), the other being a sandy soil (soil 2), from Belleville (Aix-en-Provence, France). Both types of soil were air dried, sieved through 1 cm, located in lysimeters and seeded with lettuce (*Lactuca sativa*) just before contamination.

Three months after contamination, an area $10 \times 15$ cm$^2$ was taken to a depth of the complete soil profile, this being divided in different layers. Soil samples were air dried and stored in polyethylene bottles for analyses. With respect to plant sampling, mature plants were taken, dried at 80 $^\circ$C, ground and, as soil samples, stored in polyethylene bottles for analyses.

Main characteristics of both types of soil have been determined, as summarized elsewhere. It is important to point out that both types of soil have a low organic matter content (soil 1-2.4% and soil 2-0.2%) and a high relative illite proportion in clay fraction (soil 1-79.0% and soil 2-65.4%). The cation-exchange capacity is lower in sandy soil (soil 1-14.5 cmolq/kg and soil 2-3.8 cmolq/kg), due mainly to its high coarse sand fraction (soil 1-36.8% and soil 2-86.2%).

*Instrumentation and measurements:* Activity measurements of $^{134}$Cs, $^{85}$Sr and $^{110m}$Ag were carried out in plant, soil and liquid fractions by high-resolution $\gamma$-spectrometry, using an intrinsic Ge detector (Canberra GR2020), with 25.1% relative efficiency and 1.9 keV of resolution (FWHM) at 1.33 MeV, connected to a multichannel analyzer (Canberra Series 35 Plus) with 4096 channels. Calibration was carried out with an Amersham cocktail of isotopes for different geometries and densities (plant, liquid, sandy soil and sandy-loam soil). The time of measurement was between 10 000 and 80 000 seconds. Radionuclide activities were corrected taking into account the contamination day and expressed in Bq · kg$^{-1}$ of dry weight.

*Sequential extraction scheme:* A complete description of the experimental conditions has been given previously, but the speciation procedure applied can be summarized as follows: