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Time evaluation of available uranium and radium from a contaminated mine soil of Urgeiriça (Portugal) amended with ground bone and sheep manure

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Most of the uranium and radium mines in Portugal are located in the centre-north granitic regions and their exploitation began in 1907. Mines were exploited for radium until 1944 and after that, to around 2000 uranium was exploited in several mines, being the majority of the ore treatment centralized in the Urgeiriça mine. Past ore exploitation and processing in this mine caused noticeable contamination in soils and waters, which are, frequently, used for soil irrigation in the agricultural area. This contamination represents a potential risk of chemical and radiological toxicity to human health being a concern for Urgeiriça inhabitants. Contaminants in soils and plants may be ingested by farm animals or taken up into root/shoot system of edible plants and thus be transferred through the food chain to man.

The main objective of this work was to improve the physic and chemical characteristics of agricultural soils contaminated in uranium and radium. The capacity of organic amendments and hydroxiapatite to reduce the soil available fraction of Utotal and 226Ra, as well as in soil leachates was evaluated. Soil to plant transfer of these elements and the soil aggregation improvement was also studied.

A soil from Urgeiriça region containing large concentration in Utotal (635 mg/kg) and 226Ra (2310 Bq/kg) was used. The soil available fraction, extracted with ammonium acetate, corresponds to 100% and 20% of total concentration of Utotal and 226Ra, respectively.

Pot experiments, under controlled conditions, were undertaken for incubation periods of 1.5, two and four months. Fine ground bone (FB) and sheep manure (OM) single or mixtures were used as amendments. Four treatments, plus control were carried out in triplicate: (A) soil+40 Mg/ha of FB; (B) soil+70 Mg/ha of OM; (C) soil+70 Mg/ha of OM+40 Mg/ha of FB; (D) soil+70 Mg/ha of OM+20 Mg/ha of FB. After the incubation periods, soils were analysed for pH, electric conductivity (EC), available and leachate fractions of Utotal and 226Ra. After two and four months of incubation stable aggregates were also quantified and the soils used for ryegrass (Lolium multiflorum Lam.) and oat (Avena sativa L.) cultivation, respectively.

Urgeiriça soil had loam texture, pH(H2O)-5.15, EC-7.3 μS/cm; CEC-10.08 cmolc/kg; Corgnic-12.5 g/kg. After two months of incubation soil pH increased until 6.35 in amended samples and EC showed a dramatic increase when compared to the control (0.398 dS/m), from 1.5 dS/m (A treatment) to 4.7 dS/m (D treatment). After four months of incubation soil pH did not show significant differences, but EC increased dramatically in C and D treatments (5.2 and 7.5 mS/m, respectively). Soil aggregation was improved in treatments A and C where the increase of aggregate soil classes >0.5 mm was observed.

Uranium and radium concentrations in leachates from 1.5, two and four months samples were not significantly different and correspond to a small percentage of the total concentration of the elements in soil: 226Ra -1% (control) and 0.4% in all the other treatments; Utotal –7% (control) and between 1 and 2.5% for treatments. A 97-99% decrease of the available fraction in the four treatments, compared to the control samples was observed after the three periods of incubation. No statistic differences between treatments or incubation time were observed. Ryegrass yield was greatest in treatment B, and the other treatments and control showed similar yield values. Oat yield were similar for control and treatments C and D but smaller than treatments A and B. Determination of uranium and radium concentrations in plants is in progress. Addition of organic amendments and hydroxiapatite to soils seems to be an adequate technique for soil remediation as decrease dramatically the available fraction of Utotal and 226Ra in soil.