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Application of ground bone and sheep manure on soils from two contaminated sites and influence on oat growth, uranium and radium uptake and translocation

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Past radium and uranium exploitation and processing in Urgeiriça mine and radium processing in Barracão (centre-north of Portugal) led to soils and waters contamination. Most of the soils, located in rural areas, are cultivated for vegetables, fruit trees, and/or pasturage, and the waters used for soils irrigation.

The objective of this work was to evaluate the capacity of organic amendments and hydroxiapatite to reduce the soil available fraction of Utotal and 226Ra in soils of two areas after four months of incubation. Influence on oat growth, uranium and radium uptake and translocation was also studied.

Pot experiments, under controlled conditions, were undertaken during four months of incubation at 70% of the soil water-holding capacity. Urgeiriça (Urg) and Barracão (Brc) soils containing large concentrations of Utotal (635 and 189 mg/kg, respectively), and 226Ra (2310 and 1770 Bq/kg, respectively) were used. The available fraction of these elements, extracted with ammonium acetate, corresponds to: 90 and 20% of total concentration of uranium and radium, respectively, for Urgeiriça soil, and 19 and 43% of total concentration of uranium and radium, respectively, for Barracão soil.

Fine ground bone (FB), sheep manure (OM), and vermicompost (V) single or mixtures were used as amendments. Control (soil) and treatments were made in triplicate: (T1) soil+96 g FB/kg of soil; (T2) soil+168 g OM/kg of soil; (T3) soil+168 g OM/kg of soil+96 g FB/kg of soil; (T4) soil+168 g V/kg of soil.

After incubation, soil subsamples were analysed for pH, electric conductivity (EC), and available fractions of Utotal and 226Ra. The remaining soils were used for oat (Avena sativa L.) cultivation. Soils had pH 5.15 (Urg) and 6.04 (Brc), and EC 57.3 μS/cm (Urg) and 36.3 μS/cm (Brc). After incubation soil pH increased to a maximum of 6.82 (Urg) and 7.10 (Brc) in amended samples, and EC showed a large increase (15-19 times) when compared to the control. A decrease of the available fraction of uranium (80–99% for Urgeiriça soil, and 81–90% for Barracão soil) and radium (70–79% for Urgeiriça soil, and 72-87% for Barracão soil) in the four treatments, compared to the control samples, was observed after incubation.

Oat yield was greater in T2 and T4 treatments for both soils. Uranium concentration in the aerial part of plants growing in both soils was small (maximum 0.297 mg/kg DW) and similar among control and treatments. However, in treatment T4 plants from Barracão soils contain lower uranium concentrations (eighteen times less) than those from Urgeiriça soils. In opposition, radium concentration in the aboveground part of oat plants growing on amended soils is quite lower than those obtained for plants from control. The soil–plant transfer coefficients calculated for both elements and plants growing in the different soils and treatments are small (U: <0.001 (Urg and Brc); Ra: <0.01 (Urg), <0.001(Brc)) and below the upper limit considered for plants in general.