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Ecotoxicity evaluation of an amended soil contaminated with uranium and radium using sensitive plants

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In the centre-north granitic regions of Portugal, during the twenty century radium and uranium were exploited from approximately 60 mines. The closure of all uranium mines, in 2001, raised concerns regarding the possible chemical and radiological effects on the inhabitants health around the mine areas.
The main objective of this work was to evaluate the effect of organic amendments and organic hydroxiapatite in the ecotoxicity reduction of agricultural soils contaminated with uranium and radium, by germination and growth tests of two sensitive plants (Lactuca sativa L. and Zea mays L.).
Pot experiments, under controlled conditions, were undertaken during two months of incubation at 70% of the soil water-holding capacity. Fluvisol from Urgeiriça region containing large concentration of Utotal (635 mg/kg) and 226Ra (2310 Bq/kg) was used. The soil available fraction, extracted with ammonium acetate, corresponds to 90% and 25% of total concentration of Utotal and 226Ra, respectively. 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 moist soils were kept at 4–5 ºC and subsamples were used for leachates extraction following DIN 38414-S4 method. Maize and lettuce seeds were sown in filter paper moistened with the leachates aqueous solutions and in the moist soil for germination and growth tests. Seedlings after three days of germination were used for growth tests in hydroponic, during seven days, using the leachates. Five seeds per replicate were used.
Soil presented: pH(H_2O)=5.15, EC=7.3 μS/cm; and Corgnic=12.5 g/kg. After two months of incubation soil pH increased to a maximum of 6.53 in amended samples, and EC showed a dramatic increase when compared to the control (0.398 dS/m), from 1.5 dS/m (treatment-A) to 4.7 dS/m (treatment-D). A decrease of the available fraction of uranium (90–99%) and radium (70–78%) in the four treatments, compared to the control samples, was observed after incubation. Leachates presented the following characteristics: pH (5.7–6.9); EC (74–1490 μS/cm); Ra (0.43–1.38 Bq/L); U (0.55–2.71 mg/L); Na (1.3–20.8 mg/L); K (1.3–82.9 mg/L); and P (0.02–2.31 g/L).
Germination of both species was influenced by substrata being, in general, higher on filter paper than in soil, where it is smaller for lettuce than for maize, especially for treatments. Whatever the substrata, biomass (both species) differences among control and treatments were not observed, except for lettuce growing on soil, where control is greater than treatment-B. In hydroponics some differences concerning shoots and roots elongation was observed among species and treatments: aerial part – similar for maize, greater values for lettuce in treatments B, C and D; roots – similar for lettuce, greater values for maize in treatment-C. Lettuce and maize in control and in the three substrata did not show any ecotoxic symptoms due to high uranium and radium concentrations.