

## LIXIVIATION OF NATURAL RADIONUCLIDES IN COLUMNS OF TROPICAL SOIL AMENDED WITH PHOSPHOGYPSUM

M. B. Nisti, C. R. Saueia, L. H. Malheiro, G. Groppo and B. P. Mazzilli

*Instituto de Pesquisas Energéticas e Nucleares, CEP 05508000, São Paulo, Brazil  
mazzilli@ipen.br*

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The main phosphate industries in Brazil are responsible for the annual production of  $5.5 \times 10^6$  metric tons of a TENORM residue, phosphogypsum (PG), which is stored in stacks. The presence of radionuclides puts restrictions on the use of PG in building materials and in soil amendments. The Brazilian regulatory body (CNEN) ruled that PG would only be permitted for use in agriculture or in the cement industry if the concentration of Ra-226 and Ra-228 does not exceed  $1 \text{ Bq g}^{-1}$ . In Brazil, PG has been widely used as soil amendment, to improve the soil fertility. To assure a safe utilization in agriculture, it is important to estimate the lixiviation of the radionuclides in PG. For this purpose, an experiment was carried out, in which columns filled with sandy and clayish Brazilian typical soils and PG were percolated with water, to achieve a mild extraction of these elements. The results obtained for the activity concentrations of U-238, Th-232, Ra-226, Ra-228, Pb-210 and Po-210 in the clayish soil are approximately four times higher than the sandy soil. The results obtained for the radionuclides concentration in the PG varied from  $144 \pm 11$  to  $294 \pm 5 \text{ Bq kg}^{-1}$  for Ra-226, from  $149 \pm 4$  to  $352 \pm 23 \text{ Bq kg}^{-1}$  for Pb-210, from  $155 \pm 11$  to  $346 \pm 7 \text{ Bq kg}^{-1}$  for Po-210, from  $86 \pm 8$  to  $210 \pm 6 \text{ Bq kg}^{-1}$  for Th-232 and from  $116 \pm 1$  to  $228 \pm 6 \text{ Bq kg}^{-1}$  for Ra-228. The addition of PG to the soils studied did not represent any increase in the final activity concentrations, which were of the same order of magnitude of the values reported by UNSCEAR for the world soil average values. The maximum Ra-226 and Ra-228 activity concentration observed in the PG samples,  $294 \pm 5 \text{ Bq kg}^{-1}$  and  $228 \pm 6 \text{ Bq kg}^{-1}$ , are below the limits adopted by CNEN, therefore its use is allowed for agricultural purposes. The results obtained for the activity concentration of all the radionuclides in the leachate were close to the detection limits of the methodologies adopted, giving evidence that, although the radionuclides are present in the PG, they are not available for the intake by plants.