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TRANSFER FACTORS OF NATURAL RADIONUCLIDES FROM SOILS TO CROPS CULTIVATED AT THE CERRADO REGION, BRAZIL

V.M. JACOMINO[1], *M.C. SIQUEIRA*[2], *M.H. TADDEI*[2], *K.A. OLIVEIRA*[1], *D.F. SILVA*[3], *J.W.V. MELLO*[3], *A.A.MOZETO*[4]

[1]*Developing Center of Nuclear Technology (CDTN), Environmental Sciences Division,Caixa Postal 941, CEP 30123-970, Belo Horizonte, Minas Gerais, BRAZIL.*
[2]*Laboratory of Poços de Caldas (LAPOC/CNEN), Radiochemistry Division, Caixa Postal 913, CEP 37701-970, Poços de Caldas, Minas Gerais, BRAZIL.*
[3]*Federal Univesity of Viçosa, Soil Department, Av. P. H. Rolfs, s/n. CEP: 36570-000,*
Viçosa, Minas Gerais, Brazil.
[4]*Federal University of São Carlos, Chemistry Department,*
Caixa-Postal: 676, CEP 13565-905, São
Carlos, São Paulo, BRAZIL.

In Brazil, phosphogypsum (PG), a NORM byproduct generated by the industry of phosphoric acid has been used for decades as a source of calcium and sulfur and as soil conditioner, mainly at the Cerrado region, which nowadays is the most important expansion area of agribusiness in the country. However, due to the presence of radionuclides in PG, it is important to understand the soil/plant transfer mechanisms in that ecosystem and to evaluate if its use for agricultural purposes can contribute to an increase in human exposure. The radiological impact of radionuclides released to the terrestrial environment is usually predicted with mathematical models in which the transfer of radionuclides from soil to the plant is described with the transfer factor (TF). As these factors vary significantly with changes in climate each country has to generate its own data base. The main objective of this study was to determine the soil-to-plant transfer factors for uranium, thorium, radium, lead, and polonium, as well as to evaluate if the use of PG as a conditioner of soils from the Cerrado region contributes to an increase to the natural radiation exposure. In order to attain these objectives, a series of experiments were carried out in a greenhouse using surface soils (sand and clayey) collected in two different areas of the Cerrado. Initially, a quantity of each surface soil sample (610 g dry weight) were mixed with chemical fertilizers (N:P:K=14:10:13) and different doses of phosphogypsum (0.0 PD, 0.5 PD, 1.0 PD and 2.0 PD, where PD is the recommended phosphogysum dose according to the Brazilian Agriculture Department, which is 0.5 $g.dm^{-3}$ for clayey soils and 0.2 $g.dm^{-3}$ for sandy soils). One week after mixing each soil, seeds of lettuce, corn and soy beans were sowed in each pot and cultivated until harvest. After the plants were harvested, the edible parts of each one, the soil mixtures and the percolated water from each pot were sent for radionuclides analysis. The concentrations of U-238 and Th-232 were determined by neutron activation analysis (soil mixtures and crops) or UV espectrofotometry with Arsenazo III (percolated water). Ra-226, Ra-228, Pb-

210 concentrations were measured by Gamma Spectrometry (soil mixtures) or by radiochemical separation followed by an alpha or beta radiometry with a gas proportional counter (crops and percolated water), and Po-210 concentration by radiochemical separation followed by an alpha spectrometry (all samples).

The average activity for Ra-226 in phosphogypsum samples (252±26 Bq kg^{-1}) was lower than the limit recommended by the EPA (370 Bq kg^{-1}) for use in agriculture. The estimated Transfer Factors ranged from 9.4E-04 to 3.4E-01, considering all radionuclides. In general, the results indicated that the mobility of radionuclides in the two soil types studied was low. The annual committed effective dose equivalent to for the public was 1.3E-02 mSv per year. This value is lower than the constraint limit established by ICRP, which is 0.3 mSv per year, indicating that the radiological impact associated with the use of phosphogysum in the Cerrado agriculture region is not significant.