CHARACTERIZATION OF STOCKPILED PHOSPHOGYPSUM IN BRAZIL AND EVALUATION OF ITS ENVIRONMENTAL IMPACT

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Phosphogypsum, a waste by-product derived from the wet process production of phosphoric acid, represents a serious problem facing the phosphate industry in Brazil. This by-product (mainly calcium sulphate dihydrate) precipitates during the reaction of sulphuric acid with phosphate rock and is stored at a rate of about 4,000 ton per day on several stacks in Cubatão, Brazil (FIG.1). Contents of natural radionuclides from thorium and uranium series were measured in Brazilian phosphogypsum samples from stacks, using high-resolution gamma spectrometry. As a complementary study, trace and microelements (Ba, Fe, Cr, Sc, Ta, Hf, Co, Sb, Th, U, and rare earths (La, Ce, Nd, Sm, Eu, Tb, Yb and Lu) were also determined by instrumental neutron activation analysis (INAA). These phosphogypsum stacks present a potential threat to the surrounding environment and to the individual occupationally exposed. The most critical pathway between phosphogypsum and the public is through water contamination. The aquatic environment near the disposal area was assessed by measuring natural radionuclides activity in groundwater, river water and sediment samples. As for the individual occupationally exposed, the pathways considered were internal exposure due to inhalation of radon emanated from phosphogypsum stacks and external gamma and beta exposures due to immersion in the radioactive plume and due to direct irradiation from phosphogypsum. The results obtained in this study show that radionuclides, although present in relatively high concentrations in phosphogypsum, do not imply in significant doses for individuals occupationally exposed. As for the environmental impact, the results obtained for the water activity in the monitor wells showed that water is a critical pathway, giving indication of a possible groundwater contamination. Sediments from rivers, in the area of influence of the stacks, presented higher concentrations of U, Th, all rare earth elements (except Tb, Yb and Lu), Hf, As and Zr, when compared with reference values.

FIGURE 1 - Environmental radiological impact of the disposed phosphogypsum in Brazil.

DISTRIBUTION OF NATURAL RADIONUCLIDES, RARE EARTH AND TRACE ELEMENTS IN THE PRODUCTION AND USE OF PHOSPHATE FERTILIZERS IN BRAZIL

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The Brazilian phosphate fertilizer is obtained by wet reaction of igneous phosphate rock with concentrated sulphuric acid, giving as final product phosphoric acid and dihidrate calcium sulphate or phosphogypsum as by-product. Phosphoric acid is the starting material for triple superphosphate (TSP), single superphosphate (SSP), monoammonium phosphate (MAP) and diammonium phosphate (DAP). The phosphate rock used as raw material is enriched in radionuclides of the U and Th natural series. Taking this into account, the main aim of this paper is: to evaluate the fluxes of natural radionuclides and radioactive disequilibria involved in the industrial process of phosphoric acid production; to determine the content of radioactivity in several commercial fertilizers produced by this industry; to estimate their radiological impact in crop soils and the radioactivity released annually to the environment (FIG.1). Radiological and elemental characterization of phosphate rock, phosphogypsum and phosphate fertilizers was performed by instrumental neutron activation analysis and by gamma spectrometry. The fertilizers samples, which are derived directly from phosphoric acid, MAP and DAP, presented in its composition low activity concentrations for Ra-226, Ra-228 and Pb-210. As for U and Th, the concentrations found in MAP and DAP are more significant, up to 506 and 564 Bq/kg respectively. SSP and TSP, which are obtained by mixing phosphoric acid with different amounts of phosphate rock, presented higher concentrations of radionuclides, up to 693 Bq/kg for U-238, 704 Bq/kg for Ra-226, 1067 Bq/kg for Pb-210, 521 Bq/kg for Th-232 and 204 Bq/kg for Ra-228. From the results obtained for the radiological characterization of Brazilian phosphate fertilizers and the application of a single model, it was concluded that the dilution factor is high and, therefore, no environmental radiological impact can be predicted from this practice.

FIGURE 1 - Environmental radiological impact of the phosphate fertilizer industry in Brazil.