Release kinetics of multi-nutrients from volcanic rock mining by-products: Evidences for their use as a soil remineralizer

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Abstract

Great quantities of stone by-products are stored alongside different exploiting mines in south Brazil, which are becoming an unsustainable environmental issue. Powder materials of andesite and dacite rocks were obtained from two mining companies of Southern Brazil. The particle size classification of the materials was determined by sieving. The X-ray diffraction (XRD) technique was used to identify the mineral phases of the by-products and X-ray fluorescence (XRF) was applied to determine their chemical compositions. The concentrations of calcium (Ca), potassium (K), magnesium (Mg), phosphorus (P) and silicon (Si) released by the by-products were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES). Dissolution rates of andesite and dacite rocks were measured in Milli-Q water, and in solutions of 0.1 mol L^{-1} citric acid, and Milli-Q water acidified with 0.5 mol L^{-1} acetic acid, as a function of reaction times at 24–96 h (short-term), and at 96–5760 h (long-term). The solutions were agitated continuously on a mechanical rotatory shaker at room temperature. The parabolic diffusion, simplified Elovich, and power function models were applied at both time slots of solid-solution reaction. The results indicated that the relationships of quantity of released multi-nutrients were well described by power equation: $\ln qt = \ln a + b \ln t$. Dissolution rates were obtained based on the release of Ca, K, Mg, P and Si at a steady state under far from equilibrium conditions. Dissolution rates of both by-products were not affected, within the experimental uncertainty, by Milli-Q water. Although the by-products dissolution rates were unaffected by Milli-Q water, its rates are increased along the time. The dissolution of the by-products minerals was significantly affected by the pH of the solutions. The multi-

elements release by both by-products in 0.1 mol L^{-1} citric acid solution was significantly larger than another solutions, indicating that exchangeable cations were readily available in citric acid solution. The results obtained from power function model in two reaction time intervals can contribute to estimate the multi-nutrients-supplying power of by-products to soil. The present study provides both to solving an environmental issue associated with Brazilian rock exploitation and to create an alternative for soil fertilization and a more sustainable agriculture.

Keywords
Rock by-products. Multi-nutrients source, Sustainable agricultura, New procedure