Understanding the mobility of potential nutrients in rock mining by-products: An opportunity for more sustainable agriculture and mining

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Abstract

The increase in demand for highly soluble fertilizers brings a global sustainability concern. Alternative sources for traditional fertilization are therefore needed. Rock powder use has been proposed as an alternative approach to soil remineralization. However, research on the agricultural potential of minerals and rocks as alternative sources of nutrients is limited to changes in soil chemical attributes or effects on crop yield. In this work, we report an experimental study addressing the dissolution of two silicate rock-derived powders (andesite and dacite) that were produced during mining activities in Southern Brazil. The rock powders were exposed to Milli-Q water at pH (7.4–8.8) range, in solutions of 0.1 mol L^{-1} citric acid at pH range 2.1–3.3, and Milli-Q water acidified with 0.5 mol l^{-1} acetic acid (pH 5–5.8), in a continuous mechanical rotatory shaker at room temperature. Dissolution kinetics were determined as a function of reaction times at 24 to 5760 h, and solution pH. Based on this kinetics, dissolution rates were determined for the individual powders and compared to expected values for aluminosilicates. Based on this comparison, it was shown that the application of andesite and dacite rock-derived powder to replace high soluble fertilizers is feasible due to high dissolution rates of their minerals. The average andesite dissolution rates in Milli-Q water, in citric acid solution, and in Milli-Q water acidified with acetic acid were 2.1×10^{-5}, 1.92×10^{-1} and 6.3×10^{-4} mmol cm^{-2} s^{-1}, respectively for Ca, being 183%, 22.6%, and 69.2% higher than for the dacite rock. This make andesite rock a potential substitute for carbonate-based liming. In contrast, the average dacite dissolution rates in Milli-Q water, in citric acid solution, and in Milli-Q water acidified with acetic

acid were 1.05 × 10–5, 7.22 × 10^{-5}, and 3.72 × 10^{-5} mmol cm^{-2} s^{-1}, respectively for K, being 72.0%, 61.4%, and 73.6% higher than the andesite rock. This highlights its potential use as a K source for agriculture to replace highly soluble K-fertilizers.

Keywords

Mineral dissolution; Silicate rocks; Andesite; Dacite; Multi-nutrients source; Sustainable agricultura; Dissolution kinetics.