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Environmental impacts of ash deposition following the 2010 eruption of Eyjafjallajökull volcano, Iceland

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Ash deposition during a volcanic eruption can transfer large quantities of sulphur, chlorine, and possibly, fluorine degassed from magmas to the terrestrial and aquatic environments, thereby having the potential to create perturbations at various temporal and spatial scales. Such concerns were raised when Eyjafjallajökull volcano erupted as ash accumulated in deposits >10 cm in residential and farming areas ∼15 km south of the crater. In particular, the release of volcanic fluoride (F) into soils and surface waters was regarded as a likely possibility. Besides the latent chemical effects related to entry of ash in the environment, little is known regarding the physical impacts of ash on soils.

Exposure to near-neutral pH water of the ash erupted in April-May 2010 released various soluble major, minor and trace elements, similar to previous observations made for ash materials from other volcanoes. However, water-soluble F was distinctly enriched in the Eyjafjallajökull ash which had not been exposed to rain prior to analysis. This ash also generated low pH values (∼4) in the leachate, pointing towards the presence of acids such as H2SO4, HCl and/or HF adsorbed onto the surface of the ash particles. Based on the results from acid leaching and speciation modelling, we argue that F in the Eyjafjallajökull ash was present as fluorapatite, the solubility of which is known to be inversely correlated to pH. Thus, significant F release following ash deposition is inferred to be strongly dependent on environmental conditions. This statement is reinforced by detection of variably-timed and –sized peaks in F concentrations of affected rivers: Markarfljót river fed by Eyjafjallajökull glacier peaked in April (and returned to baseline by May), whereas Jökulsá river, draining the Mýrdalsjökull glacier, further east, peaked during the second eruptive phase in May with nearly double the peak concentration observed in the latter. Speciation modeling predicts the Markarfljót river is approaching saturation in fluorite and fluorapatite in April, suggesting that pH and secondary mineral precipitation is controlling the F release/concentration.

Laboratory studies were also carried out to assess the impact of ash on key soil chemical and physical properties. Ash was laid on reconstructed soil profiles and water was percolated through these to simulate ∼8 months of precipitation. Chemical analyses of the soil drainages did not reveal any significant differences between the ash-covered soils and the control soils. Similarly, the pH, total S and total F contents in the post-experiment soils did not differ from the values recorded in the pre-experiment soils. Collectively, the results imply that acidification and S/F contamination of the soils affected by Eyjafjallajökull ash deposition are unlikely to occur; a finding that is further supported by measurements of surface (0-6 cm) soil samples collected in April and July 2010. Another experiment was performed to evaluate the influence of ash on the flow of water in soil. According to the modelling outputs, the movement of water was not retarded in the soil topped with ash. However, when the ash was incorporated into the soil to mimic the effect of ploughing, the hydrodynamic dispersion coefficient decreased. This effect was interpreted as changes in soil pore-size distribution. Finally, the impact of an ash deposit on soil respiration was evaluated. A field experiment was conducted at a grassland site east of Eyjafjallajökull volcano. The data collected over a 5-day period showed a significant reduction in CO2 flux when the ash-laden soils were wetted; the magnitude of this effect seemed to be influenced by the grain size characteristics of the ash particles.