Models to Simulate Boron, Vanadum and Selenium from Coal Fly Ash in Soil

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Abstract

Many micro-elements dissolved from fly ash when immersed in water. The most soluble elements (Dissolved fraction > 10% of their content in fly ash) are Boron (B), Vanadium (V), Selenium (Se) and Molibdenum (Mo). The dissolution of these elements from fly ash to water in the presence of soil is affected by the soil constituents content in soil.

Two representative soils of Israel (vertisol and sandy loam soil (Hamra)) were studied. In order to estimate soil and groundwater pollution with micro-elements dissolved from fly ash, the adsorption capability of soil constituents for B, V and Se was studied at various fly ash – soil ratios at pH 7.5. The suspensions were left open to the atmosphere.

The dissolution rate of these micro-elements at pH 7.5 was studied in a batch experiment. It was found that the time to reach equilibrium is 72 hours. It was also found that the most active component of the soil in the adsorption process is the clay minerals (mainly montmorillonite).

Based on the results, adsorption models for these three elements were developed to simulate the amount of the elements adsorbed by the soil (Qi, mg kg-1).
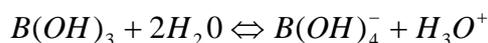
For B

$$Q_B = T\{1 + \frac{PR}{F(Q_T - Q_B)}[1 + K_{OH}(OH)]\}^{-1}$$

Where

$$P = 1 + K_h * 10^{14} * (OH)$$

K_h Is the hydrolysis constant for the reaction:

$$B(OH)_3 + 2H_2O \Leftrightarrow B(OH)_4^- + H_3O^+$$

$$F = K_{HB} + K_B(P-1)$$

R is the water content (L/g of soil)

T is the maximum adsorption of B per unit mass of soil (mol/g soil)

K$_B$, K$_{HB}$ and K$_{OH}$ are the affinity constants of the soil to B(OH)$_4^-$, B(OH)$_3$ and OH$^-$ species, respectively.

For Se

$$Qse = 13.898 * X^{-0.794}$$

For V

$$Q_v = 79.875 * X^{-0.74}$$

Where X is the clay concentration in suspension (%).

These models can be used to estimate the amount of B, V and Se released from fly ash to soil solution, available to cross the ash-soil mixture – soil interface.