IITB-Monash Research Academy

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Development and assessment of mineral lining systems with enhanced attenuating capacity for waste containment facilities

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The problem

Although most low-permeability clay soil barriers have some intrinsic attenuation capacity, the concept of designing liners or barriers with an enhanced attenuation capacity, referred to as reactive liners or barriers, recently has gained momentum. For example, the use of additive barrier materials, such as zeolites, organically modified clays, and tire chips, has been proposed to enhance the attenuation capacity of waste containment liners.

The design of reactive barriers requires knowledge of not only the physical properties of the barrier materials (e.g., hydraulic conductivity) but also the chemical properties of the barrier materials that will affect the migration rate of the contaminants in the pore water. Thus, an understanding of the potential attenuation mechanisms for the principal chemical species of interest is required. The principal attenuation mechanisms for many of the inorganic chemical solutions of concern are ion exchange (sorption), precipitation, dilution, and neutralization. However, the two primary attenuation mechanisms with respect to heavy metal migration are ion exchange, or adsorption, and precipitation.

Ion exchange or adsorption can be enhanced in a barrier by using additive materials that will increase the overall cation exchange capacity (CEC) or adsorption capacity of the liner. On the other hand, the precipitation potential of a passive barrier can be enhanced by adding materials that will increase the pH of the permeant liquid. For example, the addition of quicklime [CaO], hydrated high calcium lime [Ca(OH)2], dolomitic quicklime [CaO. MgO], or monohydrated dolomitic lime [Ca(OH)2.MgO] may aid in increasing the pH of an acid solution during migration through the liner to (a) neutralize the pore solution pH, (b) precipitate metals from solution, (c) clog the pores, and (d) decrease the hydraulic conductivity thereby enhancing the overall performance of the liner.

In many waste containment facilities, volatile organic chemicals (VOCs) are the primary contaminants of concern because of their mobility and the low concentrations at which they are toxic. Thus, reactive materials that adsorb VOCs and retard their movement can make liners more effective. One potential material for constructing reactive liners is fly ash from coal-fired power plants that contains a modest amount of residual organic carbon, which is a sorbent of VOCs. Such residual organic carbon could result in significant sorptive capacity for VOCs when compared to inorganic clays typically used in liner construction.

The project

The primary objective of this study is to conduct an in-depth geoenvironmental assessment of the potential for fly ash enhanced soil liners to contain contaminants and protect groundwater resources. To achieve this objective, five different tasks will be conducted:

1. water leach testing (WLT) and batch adsorption tests;
2. laboratory column testing;
3. Hydraulic conductivity testing;
4. centrifuge testing; and
5. numerical modelling.

The completed testing program will include different fly ashes and soils representing a wide range of conditions that might be encountered in India and Australia (Victoria).

Significance and expected outcomes

Large quantities of coal fly ash are generated each year by the electric power industry in India and Australia. Consequently, there is a need to dispose of this material in an environmentally safe manner to prevent contamination of the surrounding environment. For example, Loy Yang Power Station one of the major power stations in the Latrobe Valley Region in Victoria treats raw ash in a leaching pond for six to twelve months to remove a large fraction of soluble salts. After this period, the ash is considered a low level contaminated fill and is commonly referred to as 'leached ash' (La Motta et al., 2003). Reusing this type of material (or similar) in earthen lining systems for waste containment facilities can enhance their ability to capture organic compounds.

The major outcome will be the development of an innovative material capable of retarding the mobility of VOCs in lining systems.