Theme: Using functions of soil-water systems – Eco-engineering

Capillary barrier systems from construction wastes to cover red mud reservoirs

Viktória Feigl, Katalin Gruiz, Edina Mogyorós, Orsolya Klebercz, Éva Ujaczki

Budapest University of Technology and Economics, Department of Applied Biotechnology and Food Science, e-mail: vfeigl@mail.bme.hu

The existing red mud disposal technologies are wet lagooning, dry stacking, dry cake disposal and marine discharge. Wet lagooning is the simplest way of disposal, but its high risk was tragically demonstrated by the Ajka, Hungary dam failure in October 2010.
Wet lagooning is the main disposal method in North America, in Australia and in part of Europe, for example in Hungary, but nowadays most refineries switch from wet to paste or dry disposal technologies. The only advantage of wet disposal, namely the reduced dusting, is highly overcompensated by the large surface area demand, the high risk due to static uncertainties and the difficulties of the rehabilitation of the disposal sites due to high alkalinity, the liquor on its top, the long duration of desiccation and the thixotropy of the red mud.
A simple soil cover cannot serve as habitat for soil organisms and plants, because the large proportion of alkalic liquor in the disposed material is absorbed by soil capillaries and Na-ions move upwards until the soil surface gets sodified, OH^- ions make the whole soil layer alkalic and the humus degraded. The soil cover should be isolated from the red mud by a non-permeable isolating layer or by the application of a capillary barrier system, which is able to block the upward transport of the mobile components.
The system introduced in this paper consists of two layers made from waste: a capillary block layer from coarse material that prevents upward capillary transport of the highly alkaline and Na^+ containing liquor from the red mud and a capillary layer from fine material that withholds the infiltrating water from precipitation. Usually capillary barrier systems are constructed from fine to coarse sand or fine gravel. However, a more sustainable solution is the use of waste material, such as recycled building material or waste rock as constituents. This way the rehabilitation of waste disposals is solved in a socio-economically sustainable way.
Microcosm and field lysimeter studies were carried out to assess the suitability of crushed concrete and brick in the capillary barrier system. The top layer for plant cultivation was amended waste soil or cultivation medium from wastes. The function and capacity of the capillary barrier system was tested and monitored in scaled-up experimental series: 1. testing and measuring the different waste materials in simple plastic vessels (1−1.5 kg); 2. microcosms (20 kg) containing the capillary block layers on the top of the site-specific red mud; 3. lysimeters (1.5 tonnes) for measuring the technological parameters under field conditions.
The results of the microcosm studies showed that crushed concrete of 30−50 mm particle size can be used as capillary block layer while both crushed concrete (0−20 mm) and crushed brick (0−6 mm) can be used as capillary layers. We characterized the materials by the integrated application of physico-chemical analyses and environmental toxicity testing. Chemical analysis showed that the applied materials do not contain mobile metals that might pose additional risk. The environmental toxicity tests with soil organisms from three trophic levels (*Vibrio fischeri* luminescent bacterium), *Sinapis alba* (white mustard) and *Folsomia candida* (springtail) proved that the applied materials are non-toxic.

The appropriate layer sequence and thickness, as well as the mode of separation between the layers are assessed in field lysimeters, where the infiltration of water and ions are monitored by built-in sensors constructed specifically for this purpose. The following technology alternatives were compared by environmental and socio-economic evaluation: covering the red mud reservoirs with soil, with impermeable layer and soil, with capillary systems made from primary raw materials and capillary systems made from waste materials.

The work was funded by the National Innovation Office (SOILUTIL project, TECH_09-A4-2009-0129).