Environmental risk assessment of red mud contaminated soil in Hungary

Katalin Gruiz[1], Emese Vaszita[1], Viktória Feigl[1] Orsolya Klebercz[1], Éva Ujaczki[1], Attila Anton[2]

[1]Applied Biotechnology and Food Science, Budapest University of Technology and Economics, 1111 Budapest, Gellért sq 4. Phone and fax: +361 463 2347 Gruiz@mail.bme.hu
[2]Reseach Institute of Soil Science and Agricultural Chemistry, Hungarian Academy of Science

The red mud catastrophe of 2010 in Hungary has caused a hardly manageable environmental problem, due to the lack of published information on such a seemingly simple situation: agricultural soil flooded by alkalic liquor and suspended solids.

This paper introduces the results of a prospective risk assessment in aid of managing priority risks and decision making on the most efficient risk reduction measures in the impacted area.

The accidental spill downstream the broken red mud storage dam in the Torna Creek area has raised several questions, such as: mobility of the Na^+ and OH^- ions at the site; the acceptable Na^+ and alkalinity levels in soil and groundwater; loss in habitat function and other ecological services in NaOH flooded soils; changes in the water and air household of the soil; the influence on soil characteristics of the incorporated red mud; maximum percentage of red mud to be mixed into the soil; plant growth and production on red mud contaminated soil; risk posed on residents and farmers on the long term; the most risky exposure pathways; short and long term deteriorations; which site specific quality targets should be used; how much effort, labor and money may be spent for the remediation, what will be people's response to products (vegetables, grains etc) grown on red mud contaminated soils.

This study covers only some points of the above list.

In addition to the risk assessment, risk mitigation and long term monitoring of the impacted area the bauxite processing plant has implemented changes in its red mud disposal technology e.g., switching from wet lagooning to dry stacking.

The conceptual risk model illustrates the primary and secondary sources, the transport pathways, the impacted environmental compartments and the users of the atmosphere, waters and soils, namely the ecosystem members and human receptors.

We developed a problem-specific risk characterization methodology to quantify the risk posed on human health and on the ecosystem, to estimate the maximum permissible red-mud proportion to be mixed into local agricultural soil and to enable the comparison of the candidate risk mitigation measures.

The sampling campaign and the results of the integrated analyses and testing including microcosms tests confirmed the prognosis of the risk assessment, providing additional information on the risk reduction measures and on the maximum incorporable red mud and its effect on soil ecosystem, sodification and plant production.

The most important findings focusing on agricultural land are the following: air pollution by particulate matter and its human health risk became acceptable by the end of clean-up activities, the dry red mud disposal increased dusting again; risk of alkaline soil

inhalation, ingestion and dermal contact became negligible by the end of the clean-up activities; the alkaline infiltrate poses high risk to soil structure and vegetation, but the attenuation of alkalinity is significant; fine particles of the red mud slurry plugged soil pores resulting anaerobic soil conditions and killing of soil dwelling animals. Tilling reinstalls aerobicity; the microcosm tests forecasted a higher acceptable red mud mixing dose (8–10%) into the soil, than the calculated 5%; Na-ion-concentration increased significantly, exceeding the site specific screening level. Significant Na-attenuation (half-life: three months) may reduce the risk on the long term; directly measured toxicities were not significant, and were mainly associated with alkalinity (pH); the risk of toxic metals is not significant, some metals have been mobilized from the soil due to alkalic conditions (phosphate, arsenate, nickelate, chromate, molibdenate and selenate), but without causing ecotoxicity, plant growth inhibition or food chain effects.

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