Rebecca Colvin

Investigating the potential impacts on groundwater as a result of sludge, determined from the current levels of toxicity in the soil and potential leachate, released from the depository of the Ajka Aluminium plant in Hungury.

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Rebecca is studying a Masters in Environmental Science, Policy and Management (MESPOM) at Central European University, Budapest She also has a BSc in Geography.

Rebecca investigated and assessed the current levels of soil contamination at selected sites proximate to Akja Aluminium plant via ICP-MS. She planned to determine the potential for leachate/metals mobilization from the soils, and the resultant effects this could have on groundwater quality via sequential extraction.

By cooperating with fellow applicant Eva Kopataki, Rebecca hopes that by looking at the science behind groundwater contamination, as well as the policy and management associated with effective remediation, she can carry out independent field-work that will enable her to establish confident data and result. Therefore creating more conclusive outcomes that can go on to help support both local management strategies, protect local citizens and support wider research.

Below is Rebecca's summary on her project.

Abstract

The red mud accident of October 4, 2010, in Ajka Hungary contaminated a vast area with caustic, alkaline red mud that contains several trace elements above soil limits, representing an industrial accident involving the release of red mud on a scale that had never happened before.

Chemical analysis of red mud indicates that total metal concentrations of Pb, Cu, Cd and Cr exceeded maximum threshold levels for metals in sewage sludge in certain locations; with the majority of such occurrences situated proximate to the dam, close to the Torna Creek, with lower levels in the soil. Expansion of the affected area into the area south of creek occured in one location, highlighted by levels of Cu beyond Dutch intervention standards. Nevertheless exchangeable fractions of metals (used as a proxy for bioavailability), indicate that solubility of all elements measured is below critical levels, signifying minimal threat to the environment. Contamination in the remediated zones is lower than in the red mud, but still higher than the average concentration within the affected area; exemplifying the illogical nature of the remediation process and the potential influence of wind-blown particulates.

It is difficult to determine the long-term environmental hazards however since no similar accident has happened anywhere in the world (Javor et al., 2011). Further the temporal variability associated with soil, geology, climate and biota and the influence of remediation could result in an increase solubility of the contaminants over time, with potentially hazardous effects; especially when considering Pb, Cu, Cd and Cr. Thus although arsenic appears the most seemingly mobile of the elements, due to its appearance at depth, highlighting its ability to enter the aqueous phase more readily in an alkaline medium, multiple toxic metals may become mobilized in acidic media (Javor et al., 2011).

Consequently although current threats to plants, biota, microorganisms, groundwater and human health appear minimal it is necessary to continuously monitor the chemical composition of the soil, groundwater, wells and surface water and to ensure methods to protect the local community are emplaced.

Conclusion

Concentrations of trace elements in the red mud appear to be typical for this type of waste. Definition of the affected area remains difficult however due to the apparent spatial variability, and potential temporal variability a result of, for example, changing soil properties and/or airborne movement of particulates. The highest levels of total metal concentrations are generally located in the red mud surrounding Torna Creek, closest to the dam breach. Metal levels exceed standards for soil receiving sewage mud in some instances (Pb, Cd, Cr, Cu) – thereby indicating that some contamination had occurred. Generally the metal concentrations in the contaminated soil are lower than the red mud. Copper however exceeds threshold limits in the soil not directly contaminated by red mud. This either indicates that wind-blown dust plays a significant role, or that the land was already polluted. However as it appears no true control samples were obtained as no samples were taken sufficiently far from the pollution it is difficult to identify the cause.

The exchangeable metal fractions - as an indication of bioavailability - are currently lower than critical levels (Macnicol and Beckett, 1992), indicating that the contamination poses a minimal to non-existent threat to biota, including microorganisms. One possible threat to the environment however is the high availability of Na. Sodium inhibits the creation of aggregate structure of the soil and changes the hydraulic conductivity, thereby inhibiting plant growth (Grafe et al., 2011), whilst also inducing deficiencies in other elements. There is no clear pattern as to the relative importance of factors influencing the exchangeable metal fraction, presumably because a variety of variables are involved including pH, organic matter, the microbial community, and soil composition (e.g. percentage clay, amount of Fe oxides/ hydroxides). Moreover, these variables influence the behaviour of each element slightly differently. It is concluded that the pH was not high enough (6 to 9.5) to fully mobilise a significant proportion of the elements. Overall Zn, Al, Fe and Cd are more available in the soil as the lower pH induces formation of soluble complexes (which was negatively correlated with pH), whilst Cr, and Pb are more available under the alkaline conditions of the red mud (positively correlated with pH). Copper tended to respond most readily to changes in the concentrations of organic matter, increasing in concentration when organic content was low. Thus pH neutralization and the maintenance of organic content should be the focus of remediation.

The majority of the elements appear immobile due to the circum-neutral pH (6 to 8.3) and lower exchangeable fraction deeper in the soil horizon. Only arsenic appears more abundant at depth in multiple locations; even so the maximum exchangeable fraction remains below critical levels. The potential for an increase in mobility due to a reduction in organic content and pH however does not preclude future environmental and human health hazards associated with the contaminant trace elements – but only if preferential flow pathways outweigh the high CEC of the clayey subsoil.

Although remediation has reduced concentrations of the red mud, levels are still higher than average concentrations measured at the site, perhaps due to wind-blown red dust remobilizing some of the contaminants. Although according to Gelencsér et al., (2011) this dust is not a threat to human health due to the relatively large particle size it may enhance bioavailability through entering plant stomata.

Reliance on thresholds and critical levels enable us to determine the extent or potential hazard associated with trace elements. This has drawbacks however due to the large variability in the legislation in the national and international (NGO) standards, making it difficult to identify the extent of the risk with assurance. The Dutch list, for example is based on one single measurement of the total metal content and does not take into consideration mobility and bioavailability of metals (Gupta et al., 1996). Additionally some may consider comparison to sewage sludge inadequate as a point of reference, as normally the average citizen does not encounter sewage sludge, or even soil fertilized with this material. There is therefore an urgent need to include bioavailability in the setting of soil contaminant limits for regulatory purposes.

Overall, the ‘worst-case’ potential scenario is the possibility of an increase in exchangeable fraction (beyond critical levels) due changing soil properties, hydrology, geology, meteorological changes, or the addition of excess gypsum/lime, enhancing the concentration of soluble aqueous complexes over time. For Pb, Cr, Cu, Cd the exchangeable fractions have the capability to exceed standards for soils receiving sewage sludge, with the potential to become toxic; however the likelihood of this happening in unclear and requires further investigation. Thus to predict metal behavioral dynamics and changes in bioavailability, further information is required on the target organisms, behavior of the red mud over time, plus its interaction with the soil – which in turn will be influenced by spatial and temporal changes in soil composition.