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Biogeochemical processes driving the fate of arsenic in phytostabilised mine tailings based on a metric-scale experiment

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Securing mine tailings represents a major environmental challenge. Metal mines frequently produce solid wastes containing iron (Fe) and sulphur (S), often associated with the toxic metalloid arsenic (As). Phytostabilisation often appears as a suitable option to decrease contamination due to erosion, at a moderate cost. However, side effects linked to this remediation technique like the rise of As and metals mobility along the soil-groundwater continuum are not fully understand, preventing its deployment by site managers. A two-year pilot experiment at a metric scale was performed in order to reproduce the soil-groundwater continuum in a remediated tailing. A stainless-steel column was filled with 1200 kg of fine tailings from an old tin (Sn) mine. The column experiment was divided in two layers: unsaturated zone (UZN) in the upper part and below a saturated zone (SZ). Transient boundary conditions were applied to the top of the pilot implying periodic watering (close to site rainfall), controlled temperature and surface lighting (day/night cycles). Controlled outlet discharge was set at the bottom. Baseline monitoring of the bare tailing was performed during 6 months then assisted phytostabilisation was started by amending the half part of the UZN with limestone and compost and seeded with *Festuca rubra*. Porewater and solid samples were sampled monthly and every 6 months, respectively.

The As concentration in tailings porewater during baseline period was about 50 $\mu g.L^{-1}$. The following redox sequence has been monitored in SZ layer: denitrification, ferric iron reduction and reduction of AsV into AsIII. These two last microbially-mediated redox reactions played a key role in As mobility by inducing dissolution of As-bearing iron oxides and increasing As solubility, respectively. Immediately after starting of phytostabilisation, the porewater AsV concentration rose in the first centimetres of the UZN layer. The As plume then spread progressively in the deeper part. This light housing experimental dataset will be used to calibrate and validate a reactive transport model (RTM) explicitly integrating microbially-mediated reactions related to As, Fe and S metabolisms. This RTM outputs will be used to help the operational management of former mining sites to design efficient phytostabilisation framework for old tailings dump.