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Arsenic mobilisation and retention in wetlands, northern Sweden

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Background

Several thousands of sqkm in northern Sweden are underlain by sulphide-rich black shists. The sulphur content is 1-2 % S and the sulphides are pyrite and arsenopyrite. The aim of this investigation was done to assess the risk of transfer of arsenic to grazing animals such as moose and fish.

Results

In well drained areas arsenic from weathering of the till soils derived from the shists tend to be adsorbed onto the ferric hydroxides in the B-horison of the podzolic soils. There is little plant uptake. However, in wetlands arsenic is remobilised along with ferrous iron, especially where old forest drainage has been clogged by regrowth of vegetation. In the drainages and in small streams ferric precipitates form rich in arsenic with contents up to 2700 mg/kg. In larger streams with sandy sediments, sediments show 100-300 mg/kg of arsenic. Plants in wetlands, notably *Equisetum* species, have elevated contents of arsenic up to 25 mg/kg. Organic matter in stream sediments and benthic animals likewise show similar accumulation of arsenic. The dissolved contents of arsenic in stream water fluctuates in time and space depending on the retention in ferric precipitates.

Conclusions

There is little risk for transfer of arsenic to grazing animals like moose as the species with elevated contents are not the preferred ones. There is a risk of transfer of arsenic to fish locally especially in connection to wetlands where the drainage is decaying.

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Geochemistry of arsenic in deltaic sediment

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In the Bengal Delta Plain (BDP), the range of As concentration in natural groundwater is large (50-1600 ppb) and frequently exceeds Indian National (50 ppb) and WHO (10 ppb) recommendations. The area, ~70 km north of Calcutta, 22^0-24^0N, 87-89^0 E, encompasses an integral part of the world's largest Ganga-Brahmaputra young deltaic alluvium (lowland Holocene sediment). Filtered (0.45 µm) water and sediment samples were collected and water samples were divided into two groups, (i) acidified (HNO_3, 0.2% v/v) for cation analysis, (ii) un-acidified for anion analysis. In sediment, $[As]_T$, $[Fe]_T$, As(III) and organic C were determined by standard protocol.

A survey of contaminated wells, mostly <50 m, reveals that the water is Ca-HCO_3 type (pH ~6.7-7.7) and fresh (conductivity 350-1290 µS cm^{-1}). Characteristics of contaminated groundwater samples are high As (> 0.02 ppm), Fe (>0.2 ppm, Fe[II] 0.01-0.2 mmol L^{-1}), Mn (>0.45 ppm), HCO_3^- (>470 ppm) and often P (0.59 ppm) and low chloride (<55 ppm). Aquifers are anoxic (low nitrate, Eh <120 mV, DO absent). Groundwater often contains high bicarbonate (4.83-10 mmol L^{-1}) along with redox sensitive species (As, Fe, Mn, NH_4^+). Iron-reducing conditions prevail (de-nitrification, iron reduction) and thermodynamically favouring reduction processes. The alkalinity of the pore water increases (8.1 ± 0.5 mmol L^{-1}) as a result of recharge from Hooghly River (alkalinity~25 mmol L^{-1}) and helps to hasten the breakdown of organic matter in near surface aquifers that leads to reductive dissolution of iron oxides. High groundwater temperature (26-31 ^oC) and P_{CO2} (log P_{CO2} ~0.1-2.9) further facilitates microbial activity that leads to increased local reducing condition (redox traps). PHREEQC modelling suggests groundwater supersaturation with respect to calcite, siderite and goethite and that iron hydroxides and carbonates play a vital role in mobilization/immobilization of redox sensitive species. Sediment organic carbon (~1%) and $[As]_T$ (av. 17.5 mg kg^{-1}) are relatively low and there was no buried peat in the sediment. It may be concluded that the degeneration of fresh organic matter has driven the biogeochemical processes rather than formation of peat, which has been previously hypothesized.

In BDP, high levels of As in drinking water cause widespread poisoning and the release of redox sensitive species are the functions of the bioavailable forms of the Fe-oxide phases, concentration and distribution of fresh organic matter and sediment texture.