

## Fate and transport of heavy metals and radioelements in groundwater aquifers of Al-Qunfudhah and Wadi Haliy quadrangles, southwest of Saudi Arabia

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The fate and transport of heavy metals and radioelements in groundwater aquifers in five wadis located in the Al Qunfudhah and Wadi Haliy quadrangles were investigated. These wadis are important sources of water to the Red Sea coastal plain. Copper, zinc and other base-metals mineralization occur at eastern parts of these quadrangles that dominates the water catchments area of these wadis.

Water, rock and soil samples were collected from all wadis and they were analyzed for major, trace elements, heavy metals and stable isotopes. The chemical and isotopic data showed active water/rock interaction. The preliminary investigations of the data analyses showed some samples with high heavy metals and uranium contents. Generally, the uranium and heavy metal contents are higher in samples collected from the upstream area of each wadi where the crystalline rocks are exposed and in direct contact with the runoff. The uranium contents are as high as 126 ppb in some water samples near the mining areas. Water seepage from El Hagar mining area shows Zn contents up to 97 ppm, Cu contents up to 246 ppm and Pb contents up to 35 ppb. These elevated values are mainly due to two factors: water/rock interaction and concentration through evaporation. The Elevated heavy metal and uranium contents suggests that these mining areas are considered as potential sources for these natural pollutants and likely affecting the water quality in these wadis.

## Effects of phosphate on the solubility of lead arsenates

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Schultenite  $PbHAsO_4$  and mimetite  $Pb_5(AsO_4)_3Cl$  belong to the most common lead arsenates in the polluted soils and sediments. Synthetic schultenite has been used in the past as a component of pesticides, herbicides, and fungicides. Mimetite occurs in the soils contaminated with the smelting wastes. It also forms by transformation of schultenite in the presence of  $Cl^-$  ions. Both minerals are metastable and can release the As and Pb into aquatic system.

Bioavailability of lead in contaminated soils can be reduced to insignificant levels by precipitation of pyromorphite  $Pb_5(PO_4)_3Cl$  induced by phosphate amendments to soils containing Pb [1]. We have examined the effect of phosphate ions on the solubility of schultenite and mimetite. The samples of the synthetic lead arsenates were reacted with aqueous phosphate ( $K_2HPO_4 + KCl$ ) at various pH (2-7) for up to 8 months.

In the experiments with schultenite, the concentration of As(V) reached 15.5  $\mu M/L$  in the absence and 76.2  $\mu M/L$  in the presence of phosphates, opposite to the concentration of Pb(II) which was 17.5 and 0.3  $\mu M/L$ , respectively. The reaction results in crystallization of aggregates of pyromorphite crystals indicating homogeneous nucleation from the solution. This indicates that immobilization of Pb is associated with the release of As(V) into the solution.

In the experiments with mimetite at pH=3 the concentration of As(V) reached 29.2  $\mu M/L$  in the absence of phosphates and 74.0  $\mu M/L$  in their presence. The concentration of Pb(II) was 45.0 and 0.2  $\mu M/L$ , respectively. Hexagonal crystals found on the surface of mimetite contain P, As, Pb, and Cl (SEM/EDS). This suggests the formation of pyromorphite-mimetite solid solutions: there is relatively small difference in  $\log K_{sp}$  of these minerals, -79.6 and -76.3 [2], respectively.

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[1] Ma *et al.* (1993) *Environ. Sci. Technol.* **27**, 1803–1810.

[2] Flis *et al.* (2007) *Geochim. Cosmochim. Acta* **71**(15), A285.