

# Utilization of autochthonous sulphate-reducing bacteria in uranium mine site remediation.

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Since 1984 uranium was produced by acidic in-situ leaching in the uranium mine Königstein (Saxony). This mining method led to a change of chemical state of the pollutants within the deposit. A great mobile pollutant-potential evolved and heavy metal release occurred at mine flooding. Mine water, which is presently cleaned by a conventional pump & treat system, is furthermore contaminated with sulphate and iron. Because the mine is situated within a groundwater-aquifer, a low concentrated, long-term pollutant discharge is expected after finishing the active water treatment. To prevent a hazard of the adjacent groundwater, an innovative remediation strategy is necessary.

The characterisation of the microbial diversity in the mine site was done by [Seifert, 2008]. In their investigations diverse bacterial communities dominated by *Deltaproteobacteria* class, like *Desulfovibrio*, *Desulfobacca*, *Desulfomonile*, could be identified in sandstone and sludge samples. Thus autochthonous sulphate reducing bacteria were detected in the mine.

In our concept the bioremediation potential of these microorganisms should be utilized to inhibit the discharge of the pollutants and thus to improve water quality within the mine site. By addition of reactive material (zero-valent iron) the oxidized and acid mine water will be reduced and neutralized, partially. In this hydrochemical milieu, the corrosive induced hydrogen generation stimulate the metabolism of autochthonous autotrophic sulphate reducing bacteria. Subsequent sulfide formation causes precipitation of reduced minerals (mackinawite, heavy metal sulfides, uraninite) and leads to immobilization of the pollutants by sorption and precipitation. Alteration and partial oxidation of the minerals assure heavy metal immobilization after terminating the technical measures.

Sequential extraction [Kassahun, 2007] of the mine sandstones and sludges showed that most of the pollutants prevail in dissolvable fractions or are bound to ironoxides. This type of bonding change in the corrosive stimulated, biological induced, mineral precipitation process. This remediation pathway was verified in the laboratory in batch scale. A system of mine sandstones, iron(hydr)oxide sludge and mine water was combined with reactive zero-valent iron (grey cast iron powder). Microbial sulfate reduction was observed after a lag-phase of about 60 days in all batch tests. It could be verified by black sludge precipitation and isotopic investigations of the residual sulphate. A fast immobilization of the pollutants occurred in the test systems. Solid analyses by X-ray Photoelectron Spectroscopy (XPS) and sequential extraction showed, that the pollutants were immobilized in reduced mineral phases. Uranium for example was mainly specified as uraninite in the solid. Furthermore the XPS-investigations identified ironmono-sulfides within the black sludge, which partly altered to irondisulfides within a time scale of 175 days. The laboratory experiments showed, that the metabolism of autochthonous sulphate reducing bacteria could be stimulated by reactive iron containing material. Mineral precipitation and pollutant immobilisation occurred as expected.

For mine remediation the reactive zero-valent iron should be able to spread throughout the whole mine site. That's why the iron powder is embedded within a porous, silica based carrier material, like cellular glass. An additional water glass based coating retards the iron corrosion in the acidic mine water. Such a reactive material assures the migration of the iron and its corrosion products. The extensive stimulation of sulphate reducing bacteria is therefore possible. Currently the described reactive material system is in development. So the industrial application of the presented remediation strategy will be feasible.

## References

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