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Long-term water treatment at uranium mining sites

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Water treatment at active or closed uranium mining sites is required whenever the effluent from a mine, a waste depository or any other entity reveals higher concentrations than permitted under the respective Water Act or with respect to dose calculations according to the radiation protection regulations. Decision criteria for the selection of the optimal treatment approach are site-specific and include (a) type and concentrations of the contaminants to be removed, (b) possibility or requirement to recover certain components, (c) flow rate and contaminant loads to be removed, (d) time frame at which water treatment is needed, (e) fluctuations of water composition, contaminant load and/or flow rate, (f) type and amount of residues produced. The list of 'best available technologies economically achievable'(BATEA) has been collected most recently for the Canadian mining industry (Hatch 2014). The most commonly used active treatment process worldwide is lime treatment. This technology produces contaminant-laden iron and/or gypsum-rich sludge which has to be properly managed and disposed. Most lime operations internationally are HDS (high density sludge) plants. Yet there are several locations with other treatment technologies, such as ion exchange or reverse osmosis, but their application is restricted to localized cases. Besides the minimization of emissions, preferred mine water treatment concepts are intended to recover the mineralization loads not as waste but rather as valuables, such as uranium, metals, fertilizers or sulphur. Passive treatment is often the choice for low flow or low pollution waters and for remote abandoned mine sites, however, those options are not applicable for all types of mine water, and treatment efficiency can be limited due to seasonal changes in the systems parameters.

Water treatment is a crucial activity in the context of the remediation at uranium legacy sites. One of the most prominent projects of that kind is the Wismut Environmental Remediation Program in Germany. This program is focused on the remediation of mining legacies at several former production complexes which were operational between 1946 and 1990. While all mines and mills have been decommissioned and physical remedial work is to a large extent complete, long-term water management will continue to require the provisions of considerable funds. In order to ensure compliance with protection goals for receiving streams and aquifers Wismut GmbH currently operates six water treatment plants (WTP) and the associated systems for water catchment, delivery and discharge as well as for the conditioning and disposal of treatment residues. Total annual water treatment throughput during the period 2010 - 2014 amounted to approximately 20 million m^3 of contaminated waters. At all WTPs currently in operation, the separation of key contaminants such as uranium, arsenic, radium-226 as well as of iron, manganese and other heavy metals involves precipitation technologies in various modifications. Only at the former Königstein underground ISR operation site uranium is still separately recovered. Management of mine waters requiring treatment is the number one core task of the long-term water management activities.

The ongoing retrofitting of WISMUT's 1st generation treatment plants relies on one or several of the following factors: (a) changes in quantity and/or quality of waters to be treated, (b) cost optimization, (c) tightening of treatment standards, (d) advances on state of the art technology. Smaller satellite WTP's are now being operated by remote control and remote surveillance. Projected technological adaptions in existing facilities are aimed first and foremost at improving uranium removal and optimizing residue disposal. Process combinations of ion exchange and fixed bed adsorption are under consideration as alternative technology. Technologies for sulphate removal are primarily triggered by the need to reducing neutral salt loads. Newest research focuses on membrane-based techniques in combination with precipitation and/or evaporation of retentates. Other key activities comprise the process optimization regarding energy consumption. In addition, the utilization of renewable energies is also under review, such as the use of the geothermal potential of mine waters for heat supply.

One of the sustainability goals of the Wismut remediation program stipulates that remedial operations shall lead to a self-sustaining system status which will dispend with active measures in the long term and carry low residual risks. To achieve this, extensive research is undertaken to enhance natural attenuation processes in mining influenced water bodies. For instance, a technology to inject alkaline and reducing solutions was developed for the remediation of the Königstein mine and successfully tested in a field test. Another potential technological approach is based on stimulating a microbially catalyzed autotrophic reduction-oxidation process chain within a reactive zone. Prospects to initiate and sustain a microbially catalyzed reductive uranium immobilization are indeed realistic as is impressively shown at the Pöhla mine: Spontaneous reductive uranium precipitation produces uranium concentration levels of < 50 µg/l in emerging flood water for almost two decades.

Country or International Organization

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