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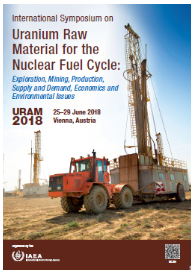

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REMEDIATION OF FORMER URANIUM MILL TAILINGS FACILITIES: CONCEPTS AND LESSONS LEARNED

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INTRODUCTION

Between 1946 and 1990 in total 216,300 t U were produced by mining and milling facilities in the Eastern part of Germany[1]. A Soviet and later Soviet-German-joint-Stock company was responsible for the uranium production in the German Democratic Republic prior to the German unification when uranium production was stopped due to economic and political reasons. As successor of the uranium mining company Wismut GmbH is responsible for the remediation of the legacies of these former activities in the densely populated areas of the German federal states Thuringia and Saxony. The remediation activities are funded by the Federal Budget due to a decision of the German Parliament Bundestag made in 1991 allocating a total budget of 6.2 billion € [1].

The remediation of the 4 biggest mill tailings facilities Helmsdorf, Dänkritz 1, Trünzig and Culmitzsch with a total ca. 160 Mio m³ of tailings stored at an area of 570 ha is part of this remediation project. Generally, the design of these tailings facilities was carried out not considering base sealing. The millings residues were dumped in former open pits where up to 57 m high dams were partly erected to create additional storage volume. The processing sludge was transported through pipelines to the tailings facilities and discharged predominantly from the outer rim of the ponds resulting in a separation of the material by grain size with fine particles mostly found in the centre of the ponds leading to variable geotechnical and geochemical conditions within the tailings facilities.

At the Seelingstädt site as one of the two main milling sites processing was done using either an acidic or alkaline processing scheme which depended on the ore composition. The residues of these schemes were dumped separately resulting in 2 ponds within the two separate tailings facility Trünzig and Culmitzsch located at the Seelingstädt site. Tailings from acidic processing were neutralized before being discharged.

While the works at the tailings facilities in Helmsdorf, Dänkritz 1 and Trünzig are nearly completed contouring and covering works at Culmitzsch are still ongoing.

GENERAL REMEDIAL SOLUTION

The remediation of the former tailings facilities follows the same general strategy while the particular technical solutions are adapted to the site specific conditions. Apart from the long-term geotechnical stabilisation of the tailings facilities remediation activities have to ensure that the additional equivalent dose rate to the general public from all pathways has to be below 1 mS/year according to the radioprotection ordinance [2].

First securing measures against acute risks were implemented starting in 1991 when the beach areas were covered with an interim cover to stop deflation of fine radioactive particles. In parallel additional effort was put in collection and treatment of contaminated waters. The mining and milling objects are situated in a densely populated area imposing a high risk to the general public.

Based on a cost benefit analysis made in the mid 1990s the dry in-situ remediation was chosen as the general technical approach for stabilisation and final closure. The analysis was made based on the conditions of the Helmsdorf site where it was found that dry in-situ remediation is the most appropriate in terms of total costs among the potential remediation scenarios [3]. The dry in-situ remediation of tailings facilities requires a set of technological steps. Expelling supernatant water, interim covering and geotechnical stabilisation of the dams and the tailings are preconditions for a safe access to the site but require also an extended time frame. With sufficient bearing capacity contouring earthworks can proceed to gain a long-term stable morphology ensuring the safe discharge of surface waters and protecting the facility from erosion. A final cover on top of the contoured facility is required to control the infiltration of precipitation water and to ensure sufficient conditions for stable vegetation. This approach was generally adopted at all tailings management site under the responsibility of Wismut. The necessary activities as well as the status achieved e.g. at the Seelingstädt site are documented in more detail in [4].

An important aspect at all sites is the collection and treatment of seepage as well as contaminated surface and groundwaters. An extensive technical system including treatment plants utilising lime treatment is available at all sites. This water collection and treatment system is expected to be necessary also in the long-term to ensure capturing contaminated waters irrespective of the individual remediation solution.

SITE SPECIFIC APPROACH

While the general remediation approach is implemented at all sites a number of differences can be found locally due to site specific conditions. The differences mainly consider the requirements for reduction of the infiltration of precipitation into the deposited tailings material which are defined specifically for each site. Especially at the Thuringian site in Seelingstädt the covering concepts were intensively discussed between Wismut and the permitting authorities which were supported by a consultant providing an extensive peer assessment. As a result of this time consuming process basic requirements for planning of the final contour and cover of the tailings facilities were established. This has led to differences in the cover concepts followed at the different sites but also at the single facilities themselves.

The main focus in determining the site-specific cover concept was the expected long-term contaminant release from the sites. It was found that this release very much depends on the properties of the tailings material itself and therefore varies widely over the facility. Another important factor was the availability of appropriate contouring and cover materials at the individual sites. Preference was given to locally available materials. Mine waste rocks and processing residues available from former mining activities were used for contouring and partly as cover material depending on the radiological composition and technical requirements. This allowed reducing the mining induced footprint at the sites and the import of material from other sources. On the other hand it required an adopted logistics to supply the materials with the required geotechnical and radiological characteristics depending on the respective remediation progress. At the Seelingstädt site tailings were disposed in former uranium open pits. A part of the waste rock material from the overburden here is to be classified as radioactive material. Material with elevated radiological content was used for contouring while the cover was constructed using waste rock material with specific activity less than 0.2 Bq/g or material from external sources.

At the Seelingstädt site the reduction of the infiltration rate was at a special focus. In contrast to the implementation of the evaporative cover concept at other Wismut tailings management sites with a storage layer as the main functional layer the cover system at the Culmitzsch tailings facility is far more complex. By adapting the final contour offering steeper and shorter slopes as well as constructing an additional sealing and drainage layer the predicted infiltration rate is reduced by more than 75 % compared to the original mainly evaporative cover concept. In addition to more specific material requirements for the various functional layers the effort for implementation of such a cover system increased considerably. Therefore, this cover system is implemented only on top of the more sandy tailings beaches with a higher hydraulic conductivity over the tailings profile. The areas with finer tailings will have significantly lower hydraulic conductivities in long term when compaction and pore water release will be finished. This process is enforced by additional drainage measures in line with contouring to generate a long term stable tailings surface and to achieve the sealing properties of these layers. As consequence of this self sealing the seepage rates are reduced more significantly as it could be achieved in the long term by a highly engineered cover system. This allows to take credit while constructing the final cover on these parts with less stringent requirements for the infiltration rates to be achieved in the long term.

PRESENT AND FUTURE CHALLENGES

With construction works coming to an end the harmless surface water run-off has to be ensured in the long-term. This has to consider the quality and quantity of the waters released from the former tailings facilities. While the retention of the impact of heavy rainfall events is an important design criteria for the contouring as well as additional measures of temporary storage of runoff waters the compliance with the requirements for the water quality have to be proven for the surface as well as seepage waters.

Management of newly developed landscape at the sites is required even after the end of the construction works. A landscape development concept is one of the requirements for the necessary permits covering nature conservation aspects, too. This concept defines the after-use while allocating areas as open grass land or for forestry. The implementation of the landscape development concept is a lengthy process and requires effort for the necessary management and maintenance. This is essential even with the main concept of a close to nature development of the sites but with the pre-defined nature conservational prospects to be achieved based on the permitting documents.

Water collection, treatment and residual storage is a task extending over the end of the construction period. Irrespective a successful implementation of the remediation activities at the site a necessity of water treatment is clearly expected due to the long-term release of pore water from static sources in the tailings facility as well as the remaining inflow of water to the deposited tailings material. In addition groundwater with elevated concentrations in the aquifers is found downstream of the tailings influenced by seepage waters during the uranium production period. The concentrations will decrease slowly due to limited inflow from the covered tailings facility and its immediate surroundings.

Over a long period uranium was in the main focus concerning the contaminant release. Meanwhile salt load becomes more of a concern. While treatment of waters for uranium in seepage waters is state of the art and could be implemented effectively reduction of salt content faces technological and economic challenges especially in terms of a long-term stable storage of the residues. There is no feasible technological option available under the present site conditions. Because of continuous tightening of the environmental standards and requirements additional long-term effort will be needed over the time frame of the remediation works at the site itself.

After finishing the construction works environmental monitoring and maintenance is required due to the provisions made in the permitting process. On one hand the remediation success has to be demonstrated. Otherwise the achieved status after remediation has to be ensured by regular maintenance of the constructed elements. While simple cover systems solely based on a sealing and evaporative cover concept should show a natural behaviour adjusted to the specific site conditions for other engineered elements with specific functions as drainage or water discharge a potential deterioration has to be avoided and maintenance is required for the eternity.

DISCUSSION AND CONCLUSIONS

Operation of uranium mill tailings storage facilities impacts not only the radiological conditions at the site but also other environmental media. Remediation faces complex requirements aimed at reduction of potential risks and present impacts in combination with the need to stimulate the long-term use of the site under strict economic constraints. As the examples of the legacies of former mining and milling sites show a sound closure concept defining the status to be achieved after operation is not just necessary for the mining permits but also essential baseline for the operator. However the time frame of remediation activities clearly extend over the period of construction works and has to be considered in terms of effort and costs at an early stage of the planning procedure. These long-term activities in most cases comprise monitoring and maintenance especially at sites with radiological hazards but can also require a costly water management and treatment. A sound funding for these activities has to be ensured.

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