Decommissioning of Uranium mill tailings ponds at WISMUT (Germany)

Albrecht Neudert, Ulf Barnekow

WISMUT GmbH, Jagdschänkenstr. 29, D-09117 Chemnitz, Germany,
E-mail: a.neudert@wismut.de

Abstract. Approximately 577 ha of Uranium mill tailings ponds containing approx. 154 Mio. m^3 of mill tailings were left as part of the legacy of the uranium mining and milling in Eastern Germany. The decommissioning of these tailings ponds belongs to the most challenging tasks of the entire Wismut remediation project. The remediation activities started in 1990 with defence measures against acute risks, environmental investigations and development of first site specific remediation concepts. Resulting from the site specific remediation concepts WISMUT GmbH decided to prepare for dry decommissioning in situ for all of the mill tailings ponds. Dry decommissioning of tailings ponds consists of the following basic decommissioning steps: expelling of pond water and seepage catchment including water treatment; interim covering of exposed tailings surfaces including dewatering of unconsolidated fine slimes by technical means; re-contouring of dams and ponds and final covering including landscaping and vegetation. This paper presents the development and the principal design of the decommissioning of the large Uranium mill tailings ponds and the progress achieved by WISMUT.

Introduction

From 1951 to 1990 the former Soviet-German Wismut company processed a total of about 216,000 t of uranium in two large mills located near Seelingstädt (Thuringia) and Crossen (Saxony). Tailings dams were erected for separate disposal of uranium mill tailings from soda-alkaline and from acid leaching. The tailings ponds Culmitzsch A and B, Trünzig A and B near Seelingstädt and the tailings ponds Helmsdorf and Dänkritz 1 near Crossen cover a total area of about 577 ha and contain about 154 Million m^3 of uranium mill tailings. First decommissioning activities started in 1991 including defence measures against acute risks, environmental investigations and development of first site specific remediation concepts. Resulting from the site specific remediation concepts WISMUT GmbH decided to prepare for dry decommissioning in situ for all of the tailings ponds. Decommissioning of tailings ponds consists of the following basic decommissioning steps: expelling of pond water and seepage catchment including water treatment; interim covering of exposed tailings surfaces including dewatering of fine tailings by technical means; re-contouring of dams and ponds and final covering including vegetation. The entire decommissioning of all the uranium mill tailings ponds subject to the WISMUT act, dated Oct. 31, 1991, will cost assumingly EUR 770 Million and is foreseen to be completed by ca. 2015. This paper presents the development and principal design of tailings pond decommissioning and progress achieved by WISMUT GmbH.

Characterization of mill tailings ponds and tailings properties

Most of the uranium mill tailings ponds were erected in old open pits surrounded by either autostable tailings dams or by waste rock dams. Only the Helmsdorf tailings pond is located in a natural valley closed by a dam before. Uranium ore was processed by soda-alkaline leaching or by acid leaching followed by neutralization before tailings disposal. Tailings were usually discharged from the surrounding into the tailings ponds. Due to the historic discharge regimes coarse-grained tailings settled near the discharge spots creating thick sandy tailings beaches. Distant from the discharge spots fines settled below water table forming up to several 10 m thick fine tailings layers. The transition zones in between the tailings beaches and the fine tailings consist of an interlayering of thin fine tailings layers and thin sandy tailings layers.

Fig. 1 shows the tailings ponds Helmsdorf (foreground) and Dänkritz 1 (background) near Crossen in 2003. Fig. 2 shows from the foreground to the background the tailings ponds Trünzig B and A and Culmitzsch A and B in 2004.

Basic technical data of the tailings ponds, data for characterizing contaminants content in the tailings as well as typical geotechnical properties of fine tailings are presented in the following Table 1 to Table 3.

Fig. 1. Tailings ponds Helmsdorf and Dänkritz 1 (background) in 2003.

Fig. 2. Tailings Ponds Trünzig and Culmitzsch in 2004.

Decommissioning Aims

The decommissioning of the uranium mill tailings ponds is to meet the following most relevant decommissioning aims:

a) a maximum over-all radioactive dose of 1 mSv/a to the population enclosing all relevant exposure paths including water path, air path and soil path
b) water released from the sites into the hydrographic net must meet the respective limit values for contaminants to the long term as prescribed by the authorities responsible
c) decommissioning aims met must be granted to the long term (for a period of 200 years up to 1000 years)

Evaluation of the given situation and risk assessment

Extensive environmental, radiological and hydrogeological investigations started in 1991 immediately after the end of the uranium mining and processing period. The investigation results as well as the results of immission measurements on the existing situation were documented in a newly developed environmental data base. The site specific risk assessment proved, that the mill tailings caused unacceptable high radioactive doses to the surrounding environment like:

a) particularly unacceptable radon exhalation rates, direct radiation rates and radioactively contaminated dusting in the air near surface
b) unacceptable contaminant seepage from the tailings ponds into the surrounding aquifers and contaminated runoff to the receiving streams.

Tabel 1. Basic technical data of uranium mill tailings ponds.

mill tailings pond	tail. vol. ($\times 10^6$ m³)	area (ha)	max. tail. thickness (m)	type of tail. pond	process.
Helmsdorf	45	201	50	valley type	*2)
Dänkritz 1	4,6	27	23	ring dam type	*2)
Culmitzsch A	61,3	158	72	filled open pit	*1)
Culmitzsch B	23,6	76	63	encl. by dams	*2)
Trünzig A	13	67	30	filled open pit	*1)
Trünzig B	6	48	23	encl. by dams	*2)
total	153.5	577			

*1) acid leaching *2) = soda-alkaline leaching + neutralization

Tabel 2. Volumes, masses and average contents of contaminants in uranium mill tailings.

solids		liquids	
total tailings mass (solids+liquids)	ca. 165 Mio t	pond water:	
		volume in 1995	13 Mill m^3
		volume in 2005	ca. 0.5 Mill m^3
mass of U	15340 t	ave. U-content	3.2 mg/l
activity of Ra	15.1* 10^{14}Bq	ave. activity of Ra	1.7 Bq/l
		vol. of pore water	70 Mill m^3
ave. U-content	0.009 mass %	ave. U-content	9 mg/l
ave. Ra-activity	9000 Bq/kg	ave. Ra-content	4 Bg/l
mass of As (only TP Helmsdorf)	7.590 t	As-content (only TP Helmsdorf)	30 mg/l

Tabel 3. Geotechnical parameters of uranium fine tailings.

Parameter	TP Helmsdorf	TP Culmitzsch A
processing type	soda-alkaline leaching	acid leaching
Soil group (DIN18196)	TA, UA, TM	UA, TA
water content	0,45 ... > 1,2	0,50 ... > 1,8
liquid limit	0,50 ... 0,60	0,60 ... 0,75
plasticity limit	0,20 ... 0,24	0,22 ... 0,30
void ratio e	1,5 ... > 3,5	2 ... > 5
compression index C_C	0,4 ... 0,55	0,6 ... 0,85
Permeability k_f	1*E-7...1*E-9	2*E-7...5*E-10

Based on the site specific risk assessment the measures needed were classified as defence measures against acute risks to the environment/population to be taken in a short term period or as decommissioning measures to grant decommissioning aims after closure to the long term. The defence measures needed were designed immediately and realized in a short term. Defence measures against acute risks enclosed the following activities:

- interim covering of all subaerially exposed tailings surfaces to reduce radon exhalation, direct radiation and radioactively contaminated dusting
- complete reconstruction or new construction of catchment systems to catch the entire seepage and runoff from the the tailings ponds
- Geotechnical investigations on dam stability to prove dam stability to the short term with respect to static and dynamic (seismic) loads.
- Construction of water treatment plants to treat the catched seepage and runoff as well as for expelling pond water with regard to uranium, radium and, if needed, also arsenic.
- Installation of fences surrounding the sites to avoid access to the public
- Installation of extensive monitoring systems in the surrounding to monitor the effects of the tailings ponds to the surrounding before and during further decommissioning activities

Dry decommissioning in situ

While realizing the defence measures needed further extensive investigations were carried out for developping site specific decommissioning concepts. For this different decommissioning options were evaluated. Sophisticated cost-benefit analyses were prepared taking into account the environmental risks after closure, decommissioning costs and time needed for realisation of the different decommissioning options. By the mid 1990´s WISMUT identified the dry decommissioning in situ for to be preferable for all of the mill tailings ponds.
After having received the approval of the permitting authorities on the decision to plan for dry decommissioning in situ decommissioning steps were prepared individually by WISMUT based on further detailed investigations and evaluations. Since then the individual decommissioning measures and constructions have been and are currently designed step-wise. The principal decommissioning steps of the dry decommissioning in situ are presented with the flow sheet in Fig. 3

Interim covering

Interim covering of exposed sandy tailings beaches joins both the defence measure to avoid dusting and the decommissioning measure to create a trafficable surface. Interim covering of fine tailings surfaces is needed to create a trafficable surface for any further decommissioning works. Due to expelling the pond water subaerial tailings surfaces dry out during dry seasons thus consolidating the upper tailings layers near surface and increasing their trafficability. After a while a geotextile and a geogrid are being placed. In the following drainmats or the first thin permeable interim cover layer is placed on top of the geogrids to grant lateral drainage due to further loading. Then the next interim cover layers consisting of thin layers of waste dump material are placed progressively on the entire pond area. The velocity of progressive interim covering on fine tailings depends on the time-dependent consolidation and dewatering of fine tailings thus increasing their shear-strength. The placement of the first interim cover layer on the fine tailings surface is of critical importance for the over-all decommissiong progress. With respect to workers safety a saftey factor eta ≥ 1.3 (acc. to DIN 4084) is to be guaranteed during all stages of ongoing construction works. To speed up the increase of shear strength with time vertical wick drains are stitched in the fine tailings to a depth of ca. 5 m. Before interim covering time-dependent consolidation of fine tailings had been predicted based on geotechnical modeling taking into account the large strain deformations of fine tailings due to loading. Resulting from these models the most critical pond areas were identified. In those pond areas the initial layer of the interim cover was placed under water using swimming barges.

Re-contouring

The dams of the tailings ponds are re-contoured with respect to the long term. For all large tailings ponds of WISMUT dam reshaping has to be designed with respect to seismic stability to the long term. For this the maximum credible earthqake has been taken into account. Reshaped tailings dams are foreseen to be covered. The stability of this cover is to be proven as well. In addition erosion stability of the dams and of any cover placed on the reshaped dam is to be proven. Dam reshaping is currently ongoing by either reshaping the dams inside the pond area or by a combination of dam buttressing of the lower dam slopes and cutting the upper dam slopes inside the pond area.

Re-contouring of the ponds creates a new landscape granting a stable surface runoff to the long term. For designing this new landscape time-dependent settlements and deformations of the underlying tailings during and after decommissioning phase are to be taken into account. A runoff catchment system consisting of ditches and, if needed, runoff retention ponds is to be designed. On certain areas of thick fine tailings layers embankment fills have been placed or will be placed. In order to speed up consolidation of fine tailings along the main ditches for diversion of future runoff deep vertical wick drains were or will be stitched in the weak fine tailings. On Trünzig A tailings pond a 1100 m long and up to 11 m thick embankment fill is currently being placed. Vertical wick drains were stitched in the tailings down to a depth of max. 27 m. The upper part of this embankment fill will be cut after the the fine tailings will have been sufficiently consolidated to place the final cover.

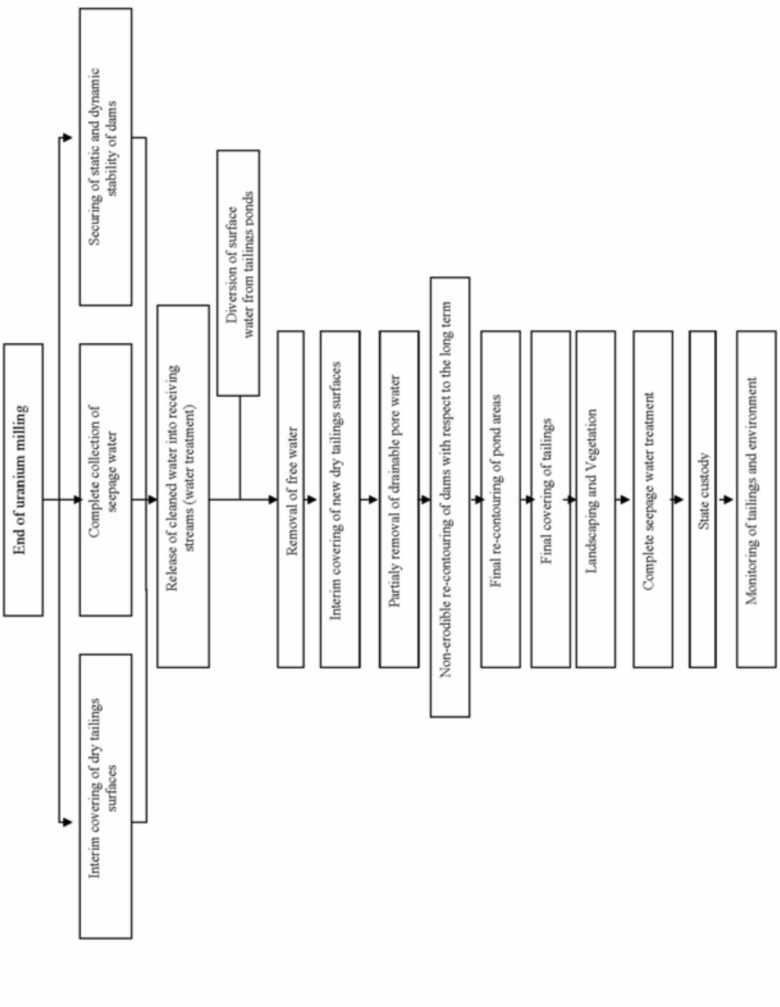

Fig. 3. Flow sheet of dry decommissioning in situ.

Final covering

The final cover is the last important construction step of dry decommissioning in situ. Among other functions it shall mainly:

a) avoid any direct contact of tailings to humans or animals to the long term
b) guarantee a stable vegetation granting storage and evapotranspiration of water from precipitation
c) reduce infiltration of precipitation water through the final cover into the tailings

For more than five years WISMUT evaluated the performance of many different final cover types in several test fields of 200 m^2 including the following final cover types: store-and-release cover, capillary barrier cover, cover types including a sealing layer. The evaluation of the daily measurements of runoff, water content and soil suction with depth and percolation through the final cover and of all relevant meteorological parameters showed the advantage of the store-and-release cover system for final covering WISMUT´s tailings ponds with regard to the site specific and regional climate conditions. For example the store-and-release final cover to be constructed on the Helmsdorf tailings pond starting from May 2005 consists of a storage layer of sufficient thickness and plant available water content. The regional climate is characterized by a dry summer/autumn season and by a wet winter/spring season. Cohesive earthen materials are used for constructing the storage layer. The thickness and compaction degree of the placed cohesive earthen storage layer are dimensioned with respect to the climate conditions. During dry summer/autumn season the plant available water content in the storage layer is completely reduced by evapotranspiration. During wet winter/spring season the precipitation is stored in the storage layer. In principle the annual storage capacity of the store-and-release cover can be calculated by the final cover´s plant available water content times its thickness. More than five years of testing showed that the store-and release covers meet the design requirements. They are in particular stable against drying out, frost effects and time-settlements and deformations of the underlying tailings.

State of decommissioning progress

Up to date 90% of seepage and runoff from the tailings ponds is continuously being catched and treated. 95% of the pond water has already been expelled, treated and discharged to the receiving streams. 75% of tailings surfaces have been interim covered. Re-contouring of dams and ponds is currently ongoing on the Trünzig, Helmsdorf and Dänkritz 1 tailings ponds. Large embankment fills were and will be constructed on certain tailings ponds including installation of deep vertical wick drains to speed up settlement of thick fine tailings layers. The final cover is currently being placed on the Trünzig A tailings pond and is going to be placed on the Helmsdorf and Dänkritz 1 tailings ponds starting in May 2005. Fig. 5 shows the state of re-contouring of the Trünzig tailings ponds in autumn 2004. The entire pond is interim covered. Nearly all the dams have been reshaped. Construction of the large embankenment fill is ongoing.

Fig. 4. Trünzig tailings pond in autumn 2004.

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Akademiestraße 6, 09599 Freiberg, Germany
http://www.tu-freiberg.de dekan3@fggb.tu-freiberg.de

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Start: winter term

Job opportunities

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