Concept of a Surface Water Monitoring at the Former Uranium Mining Site Schlema-Alberoda

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Abstract. After the remediation works at the Schlema-Alberoda Mining Site the existing water monitoring has to be modified. The monitoring has to focus on the main contaminated streams. The separation of contaminated and not contaminated streams an their distribution in surface respectively underground portions allows the determination of the real transported load of radioactive and toxic compounds. The principle of load determination is the more suitable concept in the assessment of discharges like in industry and waste water treatment (EU) .

Introduction

The Schlema-Alberoda Mine in Saxony, East Germany, was closed in 1990 due to the end of uranium production in the former GDR (Meyer et al 1998). As a result of the exploitation of the mine about 40 dumps were left in the Schlema-Alberoda area. After the remediation works at Mining Site in the last decade the existing water monitoring has to be modified. Due to the geochemical situation of the explorated deposit the main contaminants are uranium and arsenic. The current water monitoring is characterised by sampling points in surface water, groundwater and flooding water serving during the remediation as:

- surface water: observation of the quantity and quality mainly at the drainage systems of the dumps and the rivers nearby
- ground water: oberservation of the ground water quantity and quality in the weathered rock zone underlaying the dumps and the unweathered rock zone of the former uranium deposit
- flooding water: observation of the water level, water quality and temperature in the flooded Schlema-Alberoda Mine and oberservation of the quantity and composition of the sludge in the water treatment plant.

Due to the end of the flooding of the mine and the remediation works of the dumps (covering with mineral soil and recultivation by planting) there will be three types of water in future:

- Mine water of the shafts reaching the surface. This type is treated.
- Seapage water of the dumps. This type is partly collected in drainage systems. The other part is reaching the bottom of the dumps and flowing into the unweathered rock zone causing regional diffuse contaminant transport into the nearby rivers.
- Surface water, which will not be influenced by contaminants, because the path is interrupted (water, which flow on top of the mineral soil cover of the dumps and are collected in surface water drainage systems).

Considering the contaminant transport only mine and dump water (flooding and seapage water) will be of relevance for the subsequent monitoring in future.

Site Characterisation

Hydro(geo)logical Setting and Contaminant Transport

The Schlema-Alberoda area is characterised by paleozoic micas and phyllites, which were formed during the variscic orogenesis. The rock is fractured and clayey weathered from the surface into a depth of 2 to 30 m. The shaft 371 reaches down to about 1800 m. In the end of 2004 about 94 % of Schlema-Alberoda Mine were flooded. The dumps containing the mining waste are situated around the shafts in the Schlema-Alberoda area. Upstream and downstream of the dumps monitoring points (wells and surface water sampling points) were installed. These monitoring points describe the water flowing in the dumps, the rock aquifer and the weathering zone of the phyllites. Based on the measured data the contaminant impact on ground and surface water can is monitored.

The dumps are partly situated in former river valleys. The regional drainage river system is the Zwickauer Mulde. In most parts of the dumps, an impermeable basement is missing. Percolating dump water can directly enter the phyllite. Referring to pumping tests, the mean hydraulic conductivities of the underlaying unweathered rock zone range from 10^{-7} to 10^{-8} m/s, with elevated values of 10^{-5} m/s in tectonic structures. The weathered loamy zone has a permeability of $10^{-7}…10^{-6}$ m/s. The dump material reaches an average permeability between $10^{-4}…10^{-3}$ m/s. The phyllite can be described as fracture aquifer. Recharge takes place throughout the study area by infiltration of precipitation and vertical leakage. An artesic ground water table has formed in the loamy weathering zone, locally. So the hydrogeological setting of the area is characterised by absence of a regional natural groundwater body. Due to this situation there is no regular use of natural groundwater in the Schlema-Alberoda area.

Overview on the Current Monitoring

Fig. 1 shows the hydrological setting including monitoring points at the former Uranium Mining Site Schlema-Alberoda.

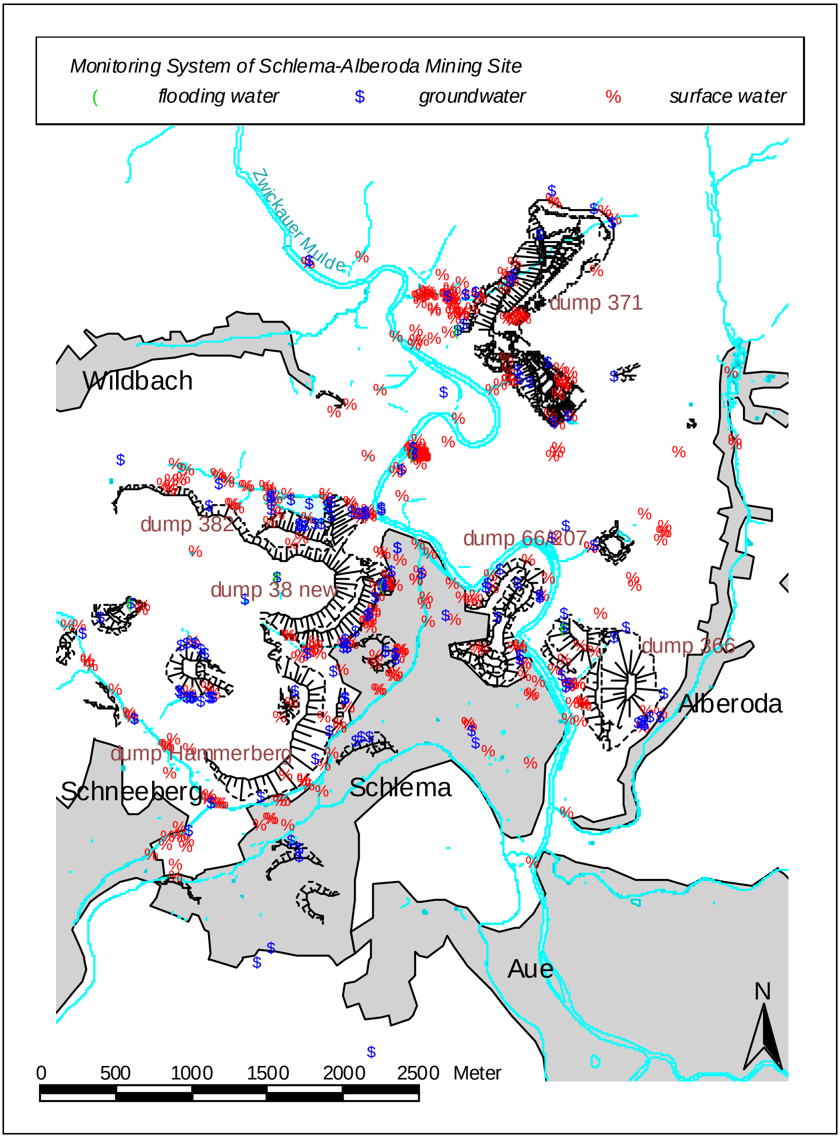

Fig. 1. Hydrological setting including monitoring points at the former Uranium Mining Site Schlema-Alberoda.

Relevant Streams and Contaminant Transport

Fig. 2 shows the mine flooding scheme of the Schlema-Alberoda site. This water is influenced by mining components, uranium and arsenic mainly. The flooding water is not causing an environmental impact because it is treated.

After covering and the development of various plants on the surface of the dumps the main path of contaminated water is the interflow in the underground.

Proportion of Mining and Dump Water

Considering the actual water management in the Schlema-Alberoda area the proportion of mining and dump water can be described as follows:

- treated flooding water of the Schlema-Alberoda Mine:
- surface water mixed with seapage water of dump 371:
- drainage water of Borbach Valley:
- drainage water of dump 366:
- mining water of flooded historical mining of the Schneeberg Mine:

The proportion of these streams is determined by uranium and arsenic loads.

There has to be considered, that the flooding water of the bordering historical mining site Schneeberg (explorated in the Middle Ages), has an own hydraulic transfer off the mine (defined level), which is not in the responsibility of Wismut GmbH. As the measured water volumes show the main water amount is caused by

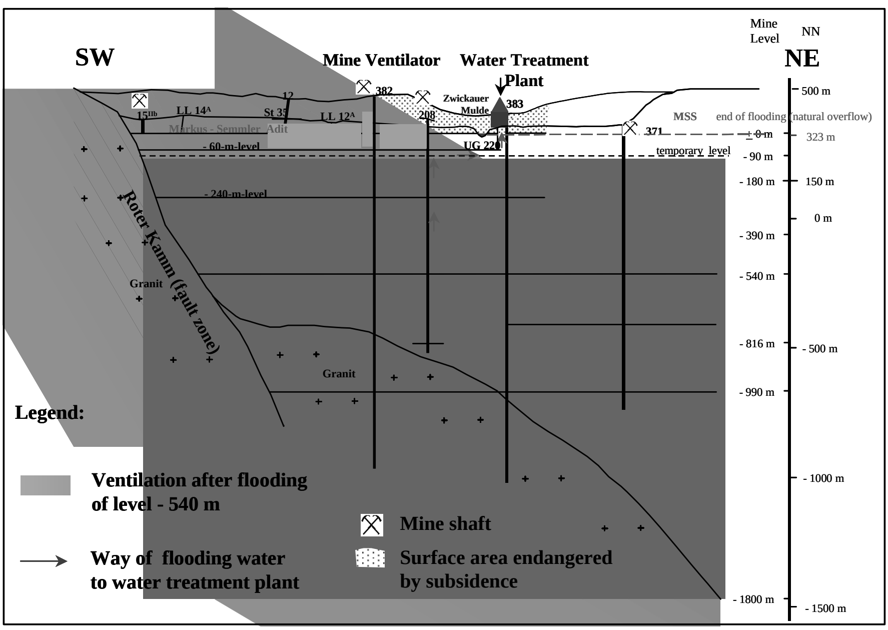

Fig. 2. Mine flooding scheme of the Schlema-Alberoda site.

the flooding water. So the amount of controlled water is much higher than the amount of diffuse migrating water. It is expected, that this situation will last in future, because the cavities in the geological underground force the regional groundwater recharge. Since the start of the water treatment in the end of 1999 the loads of substances are decreasing. On basis of experiences of former mine floodings it is expected that the contaminant transport will reach background values after decades, naturally.

Prognosis of the Water Quality

The prognosis of the water quality of flooding and dump water was prepared by geochemical modeling on the base of the measured monitoring data. The concentrations of uranium and arsenic in the flooding water have decreased since august 2000 (see Figs. 3 and 4).

A halving of the concentrations took place since start of the flooding. It was calculated that the water treatment will last up to 25 years. The contaminant transport of the dumps has decreased in correlation to the covering of the dumps. After interruption of the water path way the concentrations of uranium and arsenic have reduced down to 4,3 mgU/l and 230 µgAs/l (see figure 5). These loads are calculated for the water, which is drained off the dump 366 (largest dump in remediation).

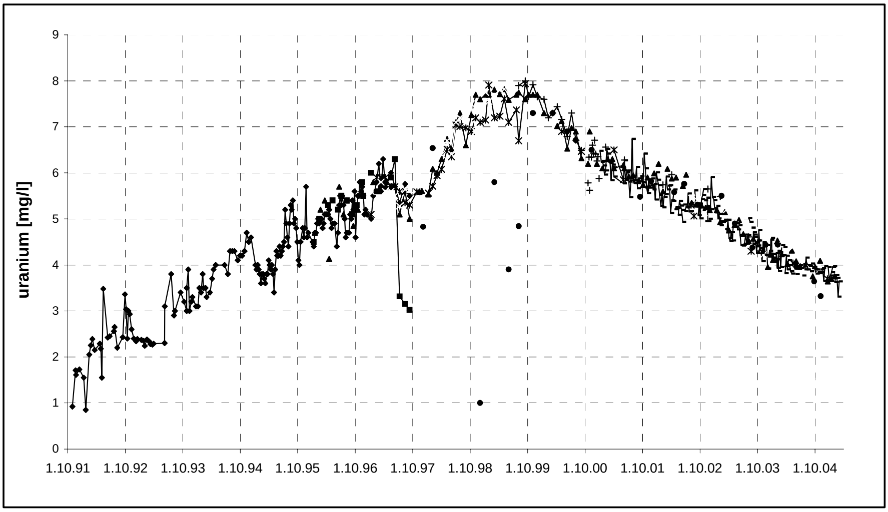

Fig. 3. Development of the uranium concentrations in the flooding water of Schlema-Alberoda-Mine.

Consequences for the Subsequent Monitoring

Assessment of Contamination

The results of the current monitoring show, that emissions of the mining site cause impacts on the Zwickauer Mulde, primary. The emission of contaminants is focused on selected streams and cause metal and arsenic loads leaving the catchment. These loads are decreasing due to remediation works.

Main task of the subsequent monitoring will be an adjustment to the main load streams of contaminants. The separation of contaminated and not contaminated streams and their distribution in surface respectively underground portions allows the determination of the real transported load of radioactive and toxic compounds. The structure of the subsequent monitoring depends also on the catchment characteristics, the mean residence time of ground and surface waters and the chemical changes in the waters during passage of the catchment. Assessing these concentrations one has to consider the elevated natural background in the Ore Mountains (Neitzel et al. 2002).

Relevance of the EC Water Framework Directive

The remediated areas will be administrated by the freestate Saxony in future. So the subsequent water monitoring has to consider the demands of the EC Water Framework Directive (Schneider et al. 2003). Of special meaning is the objective of attaining, or maintaining the good status in the European water bodies. A subsequence monitoring has to focus on these tasks. The resulting demand for the subsequent monitoring is to control the emission trends considering the dominating load streams. That means in case of the Schlema-Alberoda site the monitoring of uranium and arsenic in the dump interflow.

In consideration of the EC Water Framework Directive the main aims are the improvement of the surface water quality of the Zwickauer Mulde and the protection of the ground water under notice of the natural background.

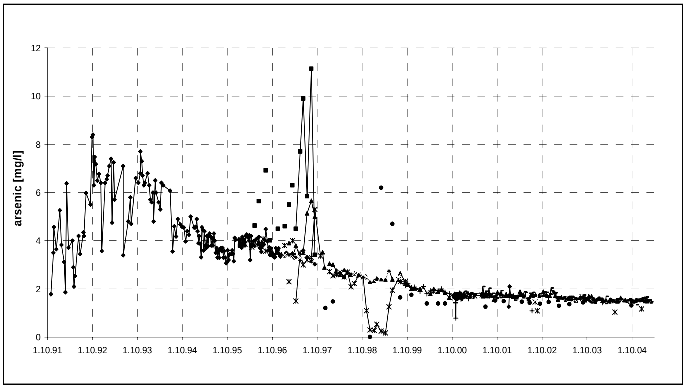

Fig. 4. Development of the arsenic concentrations in the flooding water of Schlema-Alberoda-Mine.

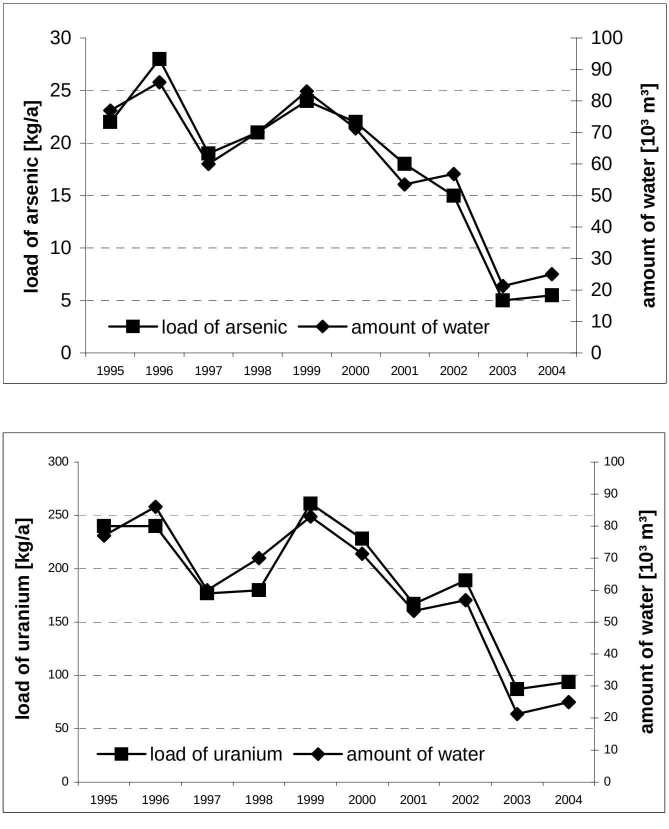

Fig. 5. Decrease of the contaminant transport of the dump 366.

Critical Levels and Critical Loads Concept

The current monitoring (especially in case of emission control) is mainly focused on the assessment of critical levels (concentrations), also in case of small emission streams. This view is one-sided, because it doesn't consider the often observed trend of decreasing loads of radioactive and toxical compounds by simultaneously increasing or stagnant concentrations due to remediation work (for instance covering of dumps). This effects will be strengthened after the end of remediation. The load determination is the basic concept for an objective assessment in the EU (see IPPC) in industry and waste water treatment. This procedure is continued in the European Water Framework Directive by the demand of management plans for water bodies. In case of the critical loads concept (e.g. Juggings et al 1995) the critical load of a compound will be focused on sensitive aquatic biota. In the EU the discharging industries and waste water treatment plants are registered in the European Pollutant Emission Register EPER register currently. So the emissions in a water body can be assessed as sum of all emitters in the catchment. That means a splitting of the contribution of the emissions due to the portion of the total emission. In practice that means, that a emitter based stream flow analysis is needed.

Conclusions

In future a subsequent monitoring at the Schlema-Alberoda Mining Site has to be modified into a reduced long term monitoring. On this way the subsequent monitoring has to adjust to the known main stream flows and the mainly transported loads of radioactive and toxic compounds. For future decisions in connection with remediation strategies a discussion to the loads concept (instead of levels/concentrations) especially with the public authority is inevitable.

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IMWA was founded 1979 in Granada/Spain as a result of interest shown in the increasing problems associated with water in the mining industry at the "First International Mine Drainage Symposium". Since then we have organised a congress every three years. IMWA also holds annual symposia and workshops on topical subjects which have included: Hydrogeology of Coal Basins; Mine Water and Pumping; Acid Mine Water; First African Mine Water Symposium; Water Resources at Risk; Engineering in Karst; Mine Water and Environment.

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