Climatic induced changes of radiological and chemical properties in an uranium tailing deposit – Equipment and first results –

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Abstract. Monitoring systems usually used to control tailings, primarily pore water pressure gages and observation wells, are not self evidently representative for mechanical considerations. Therefore an effective risk assessment and risk management is necessary to get additional information to determine indicators for critical situations. Several tailings observations showed an alteration in chemical and radiological parameters during rising saturation induced by climatic changes. These parameters are appropriate to stress indices. A systematically research on correlations between changes in stress indices and the phreatic surface is part of the research activities of the Bauhaus University in Weimar.

The contribution presents the principle of this kind of monitoring, the soil mechanical background, details of the equipment and first results.

Introduction

Tailings are disposed waste materials of the mining industry. They are the fine-grained residue of the milling process. These kind of residues apply the huge amount of 40 % of the solid waste materials world wide. The coarse materials of the tailings are often used to rise the existing dam of the tailings impoundment in which the fine grain tailings are spilled as a suspension.

The mine tailings facilities pose considerable risk potential to the environment and human lives. In the past several failures occur during the operation process, after use, closure and remediation. In particular old tailings have two fundamental risk potentials:

- Continuously or periodical climatic induced transport of pollutants into the air or water over a long period of time
- Sudden release and distribution of contaminated sediments after the bursting of the impoundment as causes of structural failure or overtopping

A fundamental question is also the long term behaviour of tailing deposits. There are only low experiences till now because of the age of tailing facilities.

Problem

In Germany especially in Saxonia and Thuringia there are several old small or medial tailing impoundments with strong radiological and/or chemical contaminated tailings. The choice for the tailing-sites was often made without geological, hydro geological and hydrological consideration. Typical for these constructions are that the coarse fraction of the tailings are used for dam rising without any stability considerations. The material itself has no certificates. Therefore the dam construction sometimes has a low quality. The further improvement of safety is then strongly connected with high investments. The necessary intervention actions suppose that an amount of geotechnical data exist. This information can be get either from extensive site investigation or from monitoring.

The common monitoring uses pore-water pressure gages and observation wells. It is possible with it to control contingently suitable parameters for an analysis of the safety of the tailings dam. The disadvantage is that due to the extreme heterogenic soil structure in tailings impoundments the locally measured phreatic surfaces as well as pore water pressures are not self evidently representative for mechanical considerations. A global prediction of the location of the phreatic surface is impossible. It is to mention that beside the geometry the pore water pressure is the most important parameter for stability considerations. For risk assessment and risk management it is furthermore necessary to monitor continuously and in real time additional parameters which are indicators for critical situations. Several observations on tailing facilities showed an alteration in chemical and radiological parameters inside the saturated and unsaturated zone during rising saturation. These parameters are appropriate to stress indices.

Monitoring concept

The actual research activities at the Bauhaus University in Weimar want to investigate two fundamental questions

- Are there secured correlations between rising saturation induced by climatic changes and radiological, chemical- and/or physical properties?
- Are there any extreme impacts on dam stability during extreme climatic conditions and how can we monitor these?

To get answers to these questions a multiparameter monitoring concept were developed which monitors the pathway soil/atmosphere and soil/seepage water. The idea behind this is that there exist an interrelationship between radon exhalation on the surface, precipitation and water content as well as radon exhalation into seepage water, chemical properties, precipitation and level of phreatic surface. During a precipitation event the contact area soil/atmosphere will be blocked by water (high water content/low water tension). As a reason of that the radon exhalation rate will be limited. A build up of higher radon concentration in soil atmosphere will occur. During percolation the soil water content decreases in the upper layer and the air permeability increase. The accumulated radon will have a sudden break through after the water percolates into the soil.

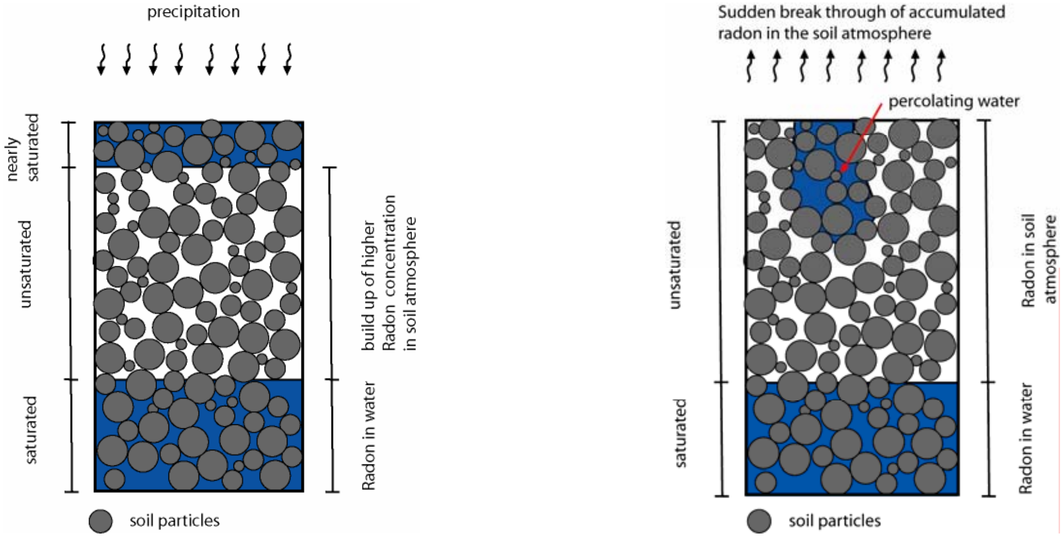


Fig 1: Radon exhalation after precipitation on the contact area soil atmosphere

An increasing level of phreatic surface causes on the one hand a convective transport of radon in soil atmosphere on the other hand a change of redox-potential, pH and electric conductivity (EC) in the groundwater. The rising saturation will edging out the radon gas in the soil atmosphere. Therefore an increase of radon exhalation will occur. At the same time the contaminants in the unsaturated soil get during rising saturation into solution. As a reason of that the transport of contaminants from tailing will increase.

For verification of the monitoring concept a partly continues working monitoring system was installed in a test field where the conditions are well defined.

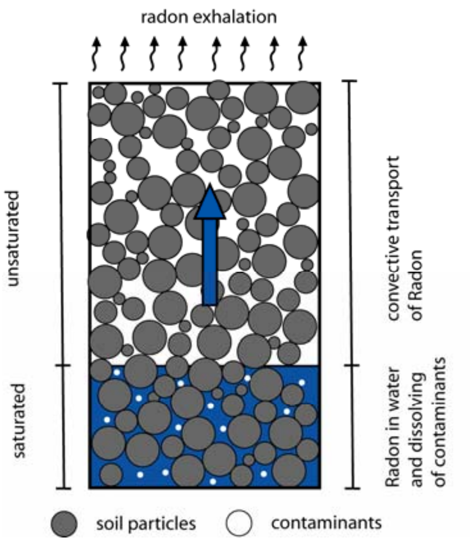


Fig 2: Transport of radon and contaminants during rising saturation

Test-Site Schneckenstein

In cooperation with the Saxonian State Authority for Environment and Geology (LfUG), SARAD GmbH in Dresden and TU Bergakademie Freiberg, the Bauhaus-University Weimar created a monitoring system at an exemplary uranium tailing impoundment.

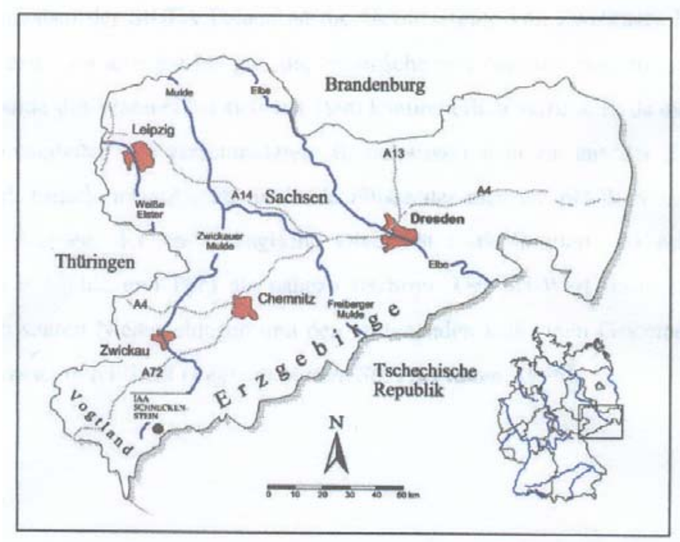


Fig 3: Location of Schneckenstein [1]

The test-site is located in Schneckenstein in the south west of Saxonia. The IAA (industrial mining waste deposit plant) Schneckenstein is an old uranium mine impoundment in the valley of Bodabach with an altitude of 740 and 815 m as. l. It has been opened up by the Soviet Union forces in 1948 and is already closed since 1957. The IAA Schneckenstein is separated into two tailing facilities the IAA2 constructed 1948 and a larger one IAA1 from 1951.

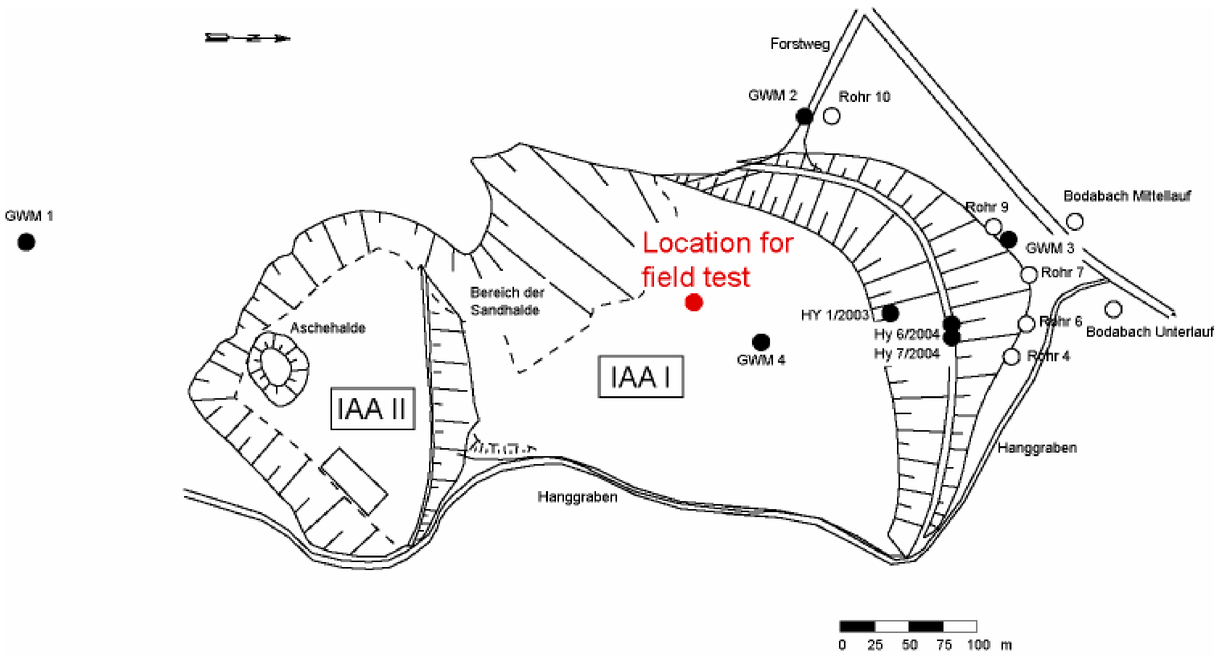


Fig 4: Location plan of test-site Schneckenstein

At the test-site there are already several observation wells and drainages installed where chemical properties of seepage water inside the deposit, dam and upstream of the deposit can be monitored.

Also at the Bodabach River downstream of the tailings impoundment chemical and radiological parameters can be monitored. The new monitoring system is installed in this test-site at the IAA1 (see fig. 4 and fig. 5). At this test-site it is possible to monitor the parameters listed in table 1.

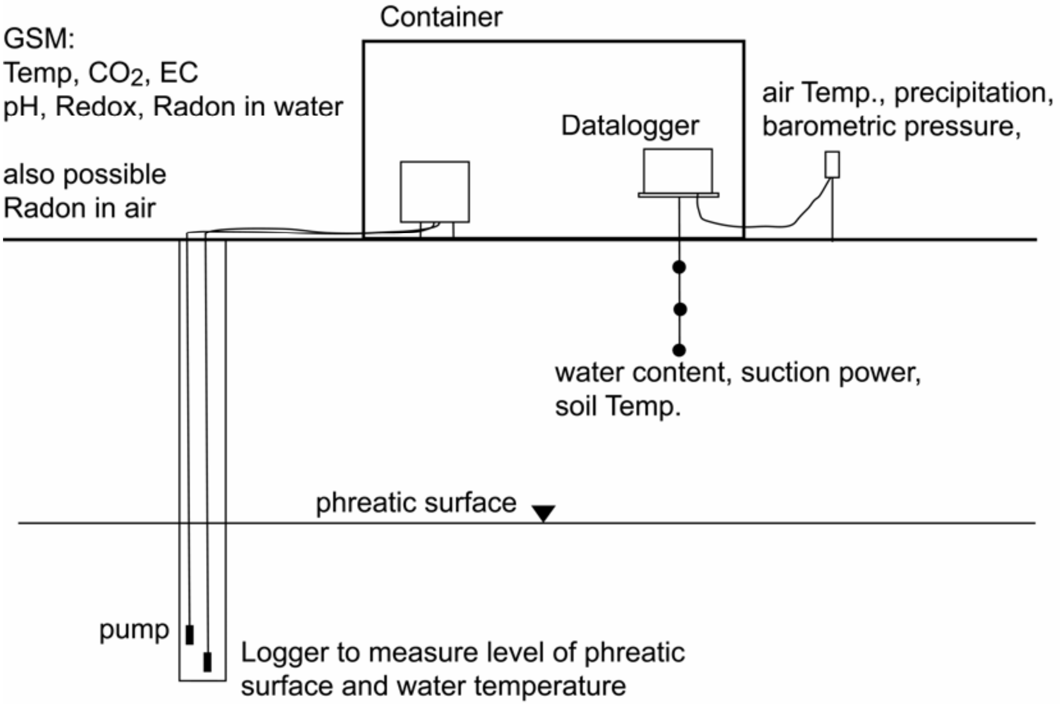


Fig 5: Layout of monitoring station in test-field

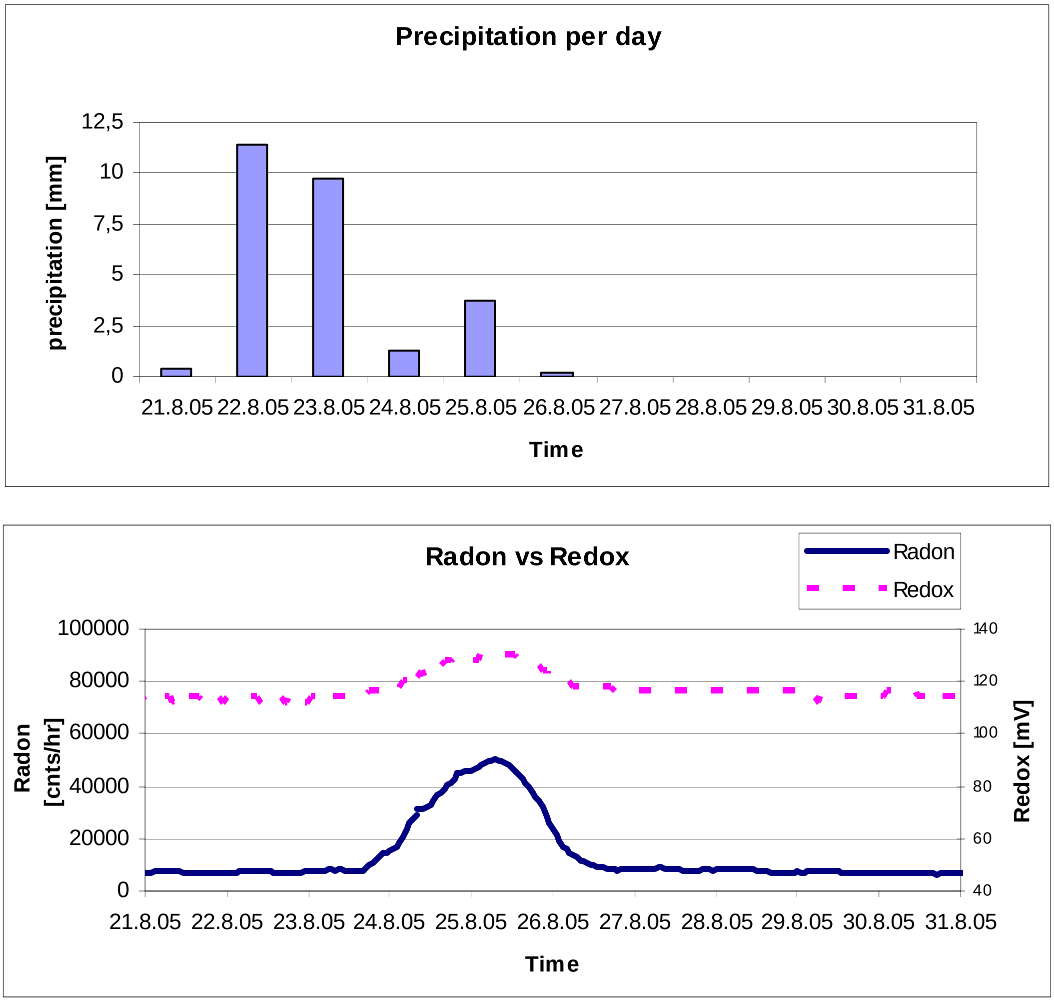
Table 1: Monitored parameters in test-field

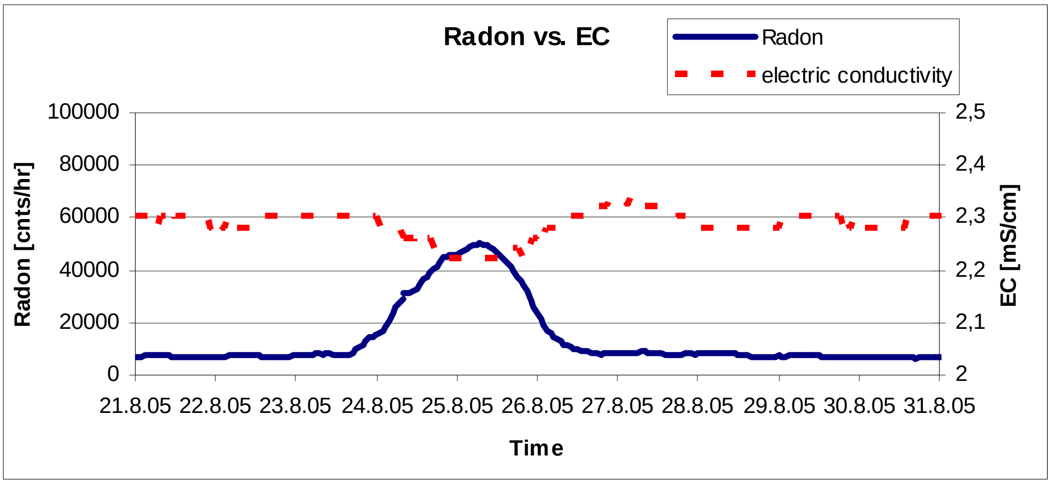
Pathway soil/atmosphere	Pathway soil/seepage water
• Barometric pressure • Air temperature • Rate of precipitation • Radon exhalation • Water content • Water tension • Soil temperature	• Radon/Thoron concentration • Redox potential • Electric conductivity (EC) • pH • Level of phreatic surface • Water temperature

Nearly all parameters can be monitored continuously. A GSM-modem at the station allows the controlling of collected data for the pathway soil/seepage water from the office.

First results

The first measured data (Fig. 5) show a strong dependence between precipitation, rising saturation and the measured parameters. About one day after a precipitation event the radon concentration in the groundwater increase rapidly. In the same moment the redox-potential increases while the electric conductivity and the pH decrease. The results indicate that the selected monitoring system can be used to solve the above mentioned problem.





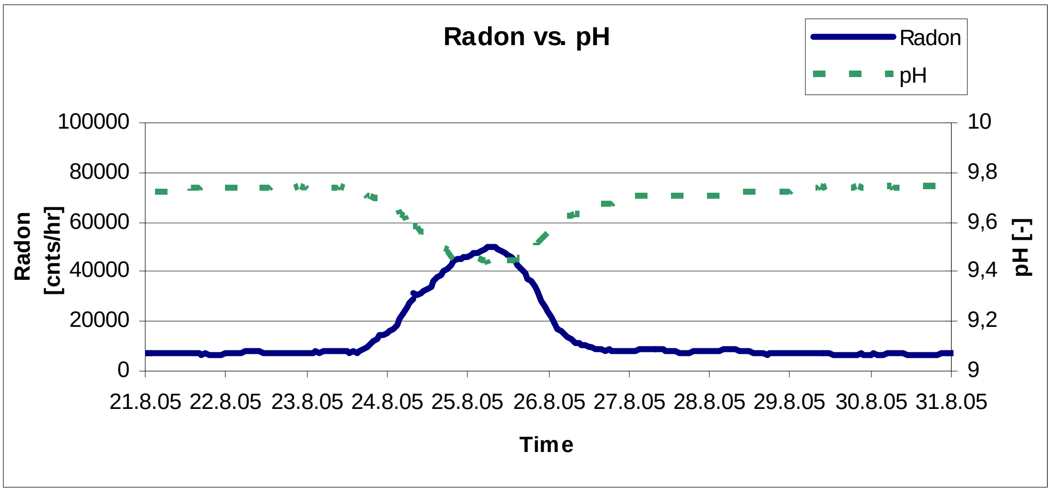


Fig 6: First results

Conclusions and next steps

The next steps for the research project are the installation of additional sensors and a detailed analysis of the monitored and recorded data. Under consideration of the evaluation of the recorded data sets the monitoring program will be restricted to the relevant parameters and observation locations.

The installed monitoring system already shows that there are correlations between precipitation and rising saturation, radiological, chemical- and physical properties. The system is able to measure continuously and the data are collected in real time. The future work has to be the quantification to stability relevant parameters.

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