Groundwater and Soil Contamination by Heavy Metals in Former Uranium Mining Site, Eastern Thuringia, Germany

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ABSTRACT

This article deals with heavy metal pollution in groundwater and soil affected by former uranium mining activities in Eastern Thuringia, Germany. During mining, sulfide minerals were oxidized and dissolved later on by flooding during the following termination forming acid mine drainage (AMD). AMD infiltrated into the soil, and polluted the water-soil system with high concentration of Rare Earth Elements (REE) and heavy metals. The solubility and mobility of heavy metals in soil and groundwater play a key role for prediction of their bioavailability and toxicity.

The groundwater aquifer is relatively close to the surface. The soil above the groundwater is considered as the main source of contamination. Hence, 190 groundwater samples were collected from the area to provide the characteristics of groundwater. Furthermore, 88 soil samples have been eluted with different solutions (water and NH4NO3), 40 chemical and physicochemical features including pH, and metals including REEs were analyzed in groundwater and soil leached. The data were subjected to cluster and factor analysis to determine the relation between REE and other metals or physicochemical factors. The REE patterns obtained through normalization to PAAS (Post Archean Australian Shale) were used as a tool to study the water-soil interaction.

As the result, there are high similarities between REE and Al, Cu, Fe, U and Y. REE and the other metals concentration are pH value dependent and have inverse relation with this value. The groundwater samples are more similar to the elution with aqua solution of NH4NO3 than to the water samples that show that groundwater is the result of more processes than only dissolution of soluble minerals, but also interaction with different soil compounds.

Keywords: Heavy Metals, REE, Statistical analysis, Water- Soil System, Elution.

INTRODUCTION

The former mining site Ronneburg in eastern Thuringia, Germany, produced 113000 t uranium during 40 years mining activities (1947-1989) with the highest production around 7000 t in the 1960s (Jakubick et al., 2002; Lange, 1995, Kahlert 1992).

The mining activities caused big changes in the hydrogeology of the area. Excavation put the rocks into oxidizing conditions (Geletneky 2002). Hence, under the influence of the oxygen, the rain water and also bacterial reactions, pyrite oxidation leads to the production of sulphuric acid. This sulphuric acid led to high sulphate concentrations in the drainage water of the heaps. Hence, uranium and various other heavy metals were being mobile under such conditions. This acid solution, which is enriched with heavy metals is called acid mine drainage (AMD). Due to its yellowish reddish colour by iron hydroxides, this solution is also known as “yellow boy” (Geletneky 2002; Kahlert, 1992).