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# The effect of remediation on water from a former Portuguese uranium mine area

Ana Neiva (1,2), Paula Carvalho (1,2), Isabel Antunes (3), António Santos (2), Marina Cabral-Pinto (1,4)

(1) Geobiotec, University of Aveiro, Aveiro, Portugal (neiva@dct.uc.pt; paulacscarvalho@gmail.com; marinacabral@sapo.pt), (2) Department of Earth Sciences, University of Coimbra, Coimbra, Portugal (neiva@dct.uc.pt; paulacscarvalho@gmail.com; antsantos@portugalmail.com), (3) CERENA/FEUP, Polytechnic Institute of Castelo Branco, Castelo Branco, Portugal (imantunes@ipcb.pt), (4) CNC-Centre for Neuroscience and Cell Biology, University of Coimbra, Portugal (marinacabral@sapo.pt)

The old Senhora das Fontes uranium mine consists of quartz veins containing autunite down to a depth of 40 m. But below, uraninite, Fe-saleeite and black uranium oxides occur in small veinlets or forming elongated nodules. The mine was exploited underground and was closed down in 1971. However, the ores from this mine and two others were treated by the heap-leach process in this area until 1982. Seven dumps containing 33,800 m3 of material were left in the area. The remediation process was carried out from May 2010 to January 2011. During this process, the relocation of the material deposited in dumps took place and was covered with erosion resisting covers. Groundwater and surface water were collected just before the remediation at November of 2009 and February 2010, in the wet season, at the beginning of the remediation, at May and June of 2010, and also after the remediation, at May and June of 2011, in the dry season. Ten wells, four springs and seven streams were chosen to collect water samples. However, some points were occasionally dry and a total of 113 water samples were obtained. The pH of groundwater and surface water was acid-to-alkaline, before, at the beginning and after the remediation, but decreased with the remediation, whereas Eh increased. In general, the uranium concentration was up to 116 $\mu$g/L in groundwater and up to 83 $\mu$g/L in surface water, before the remediation, in the wet season. The uranium water concentration increased up to 272 $\mu$g/L and 183 $\mu$g/L in the former and the latter, respectively, at the beginning of the remediation, in the dry season of 2010, due to remobilization of mine dumps and pyrite and chalcopyrite exposures, which caused the pH decrease. However, the uranium concentration decreased in groundwater and surface water at the north part of the mine area, after the remediation, in the dry season of 2011, but increased in both, particularly in groundwater up to 774 $\mu$g/L in the south and southwest parts of the area, due to remobilization of sulphides that caused metals and As to migrate to the groundwater flow. Uranium is adsorbed in clay minerals of the streams. The geochemical modelling indicates that uranium is also adsorbed in goethite. But after the remediation, the saturation indices of oxyhydroxydes decrease as pH decreases. After the remediation has finished, Cd, Co, Cr, Ni, Pb, Zn, Cu, As, Sr and Mn concentrations also decreased in groundwater and surface water at north of the mine area, supported by the speciation modelling which shows the decrease of most divalent species. But U, Th, Cd, Al, Li, Pb, Sr and As concentrations increased in groundwater and surface water located at south and southwest of the mine area. Groundwater and surface water are contaminated in U, Cd, Cr, Al, Mn, Ni, Pb, Cu and As before and after the remediation. The contamination increased at south and southwest of the area, but decreased in the north after the remediation.