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Assessment of the radiological impact of gamma and radon dose rates at former U mining sites in Tajikistan

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ABSTRACT

An assessment of the radiological situation due to exposure to gamma radiation, radon (^{222}Rn) and thoron (^{220}Rn) was carried out at former uranium (U) mining and processing sites in Taboshar and at Digmai in Tajikistan. Gamma dose rate measurements were made using various field instruments. ^{222}Rn/^{220}Rn measurements were carried out with field instruments for instantaneous measurements and then discriminative ^{222}Rn/^{220}Rn solid state nuclear track detectors (SSNTD) were used for longer representative measurements. The detectors were exposed for an extended period of time in different outdoor and indoor public and residential environments at the selected U legacy sites. The results showed that gamma, ^{222}Rn and ^{220}Rn doses were in general low, which consequently implies a low to relatively low radiological risk. The radiation doses deriving from external radiation (gamma dose rate), indoor ^{222}Rn and ^{220}Rn with their short-lived progenies did not exceed national or international standards. At none of the sites investigated did the average individual annual effective doses exceed 10 mSv, the recommended threshold value for the general public. A radiation hazard could be associated with exceptional situations, such as elevated exposures to ionizing radiation at the Digmai tailings site and/or in industrial facilities, where gamma and ^{222}Rn/^{220}Rn dose rates could reach values of several 10 mSv/a. Current doses of ionizing radiation do not represent a hazard to the health of the resident public, with the exception of some specific situations. These issues should be adequately addressed to further reduce needless exposure of the resident public to ionizing radiation.

1. Introduction

In this study an assessment of the radiological situation was conducted at the former uranium (U) mining sites of Taboshar and Digmai in Tajikistan, sites at which important mining and milling activities occurred/were carried out in the former Soviet Union. To make a reliable assessment of current radiation doses received by the resident population living at or in the close vicinity of the tailings and waste rock deposits, gamma dose rates, indoor radon-Rn (^{222}Rn) and thoron (^{220}Rn) measurements were carried out within the framework of a NATO SfP project (RESCA) and joint collaboration project between Norway, Kazakhstan, Kyrgyzstan and Tajikistan (JNKKT) on the Legacy of Uranium Mining Activities in Central Asia (UMB-JSI Draft Report, 2011; Salbu, 2013).

Indoor ^{222}Rn, ^{220}Rn and their short-lived decay products, together with gamma radiation represent the largest contribution to the doses of ionizing radiation of the resident public currently living in the environment impacted by former U mining and milling activities in Tajikistan.

Various active and passive instruments were used to measure instantaneous concentrations of Rn in the living environment. To obtain reliable average annual concentrations, discriminative ^{222}Rn/^{220}Rn solid state nuclear track detectors (SSNTD) were exposed for an extended period of time, including at least three seasonal periods (autumn, winter and spring), in different public and residential environments of the selected U legacy sites. The indoor environments included public institutions, such as schools, kindergartens and hospitals, as well as private dwellings

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and houses. Gamma dose rate measurements were conducted in the outdoor environment and indoors by positioning $^{222}Rn/^{220}Rn$ detectors at chosen locations.

At both investigated sites, the tailing and waste rock deposits are located within or in the close vicinity of residential areas of the present day populations. At the investigated sites, members of the resident public might have used radioactive materials, e.g. waste rock for building and street surfaces, and tailings residues as a material for construction purposes, which could significantly contribute to elevated radiation doses in the living (indoor) environment.

The measurements were started in the spring of 2006 and concluded in the summer of 2009. The study aimed at a reliable assessment of radiation doses due to indoor $^{222}Rn/^{220}Rn$ and gamma exposure to ionizing radiation at the investigated U legacy sites in Tajikistan. A risk assessment for the resident public was made on the basis of the results obtained.

2. Materials and methods

2.1. Description of the sites investigated

Two former U mining, exploitation and tailing sites located in northern Tajikistan (Fig. 1) were selected for this study: the *Taboshar* U mining and extraction site situated at the southern edge of the Kuramin Mountains close to the Uzbek – Tajik border and only a few km from the town of Taboshar, and the *Digmai* tailings disposal site, situated close to the village of Gaziyon (population about 3000) and about 10 km from Khudjand city (population about 250,000), often referred to as the northern capital of Tajikistan. The *Taboshar* site includes large U mining areas, where a pit lake was created, four tailings piles and a large *in situ* extraction site situated about 1 km from the pit, close to Taboshar town and the village of Old Taboshar (population about 2000) as described by Skipperud et al. (2013).

The *Digmai* tailings dump is also located close to Chkalovsk (population about 25,000), where U was extracted from ores of different origin at the SOE (State Owned Enterprise) Mining Metallurgy Plant of Vostokredmet.

2.1.1. Taboshar

The Taboshar U mine is one of the oldest mines in the territory of the former USSR. It was opened in 1936 and active mining took place from 1945 to 1965. The territory is occupied by open cast mines and mine shafts, dump pits, waste areas with crushed rock wastes, as well as wastes from *in situ* processed U ores. The total area constitutes of about 54 ha, containing approximately 10 million tonnes of U ore waste after alkaline or acidic leaching extraction (UNDP, 2009).

Following *in situ* U extraction, a “yellow mountain” of “LOM” (Low-grade Ore Mill) wastes was formed, a large 40 m metres high cone-shaped tailings pile containing about 2 million tonnes of ground light yellow residue materials (Fig. 4). This tailings pile has been exposed to wind and water erosion for more than 40 years and the dispersal of radioactive materials can be found at distances of several kilometres from the site. The whole Taboshar waste area includes unsecured open pits, ruined industrial facilities and four tailings facilities (Fig. 2).

The open cast mine is currently filled with water (ground water, precipitation), and the Pit Lake (800 m length × 240 m width × 60 m depth) represents a water reservoir in this arid region. Fish from the Pit Lake are sometimes consumed by the local residents, and domestic animals such as cows, sheep and goats graze the surroundings and drink the pit water.

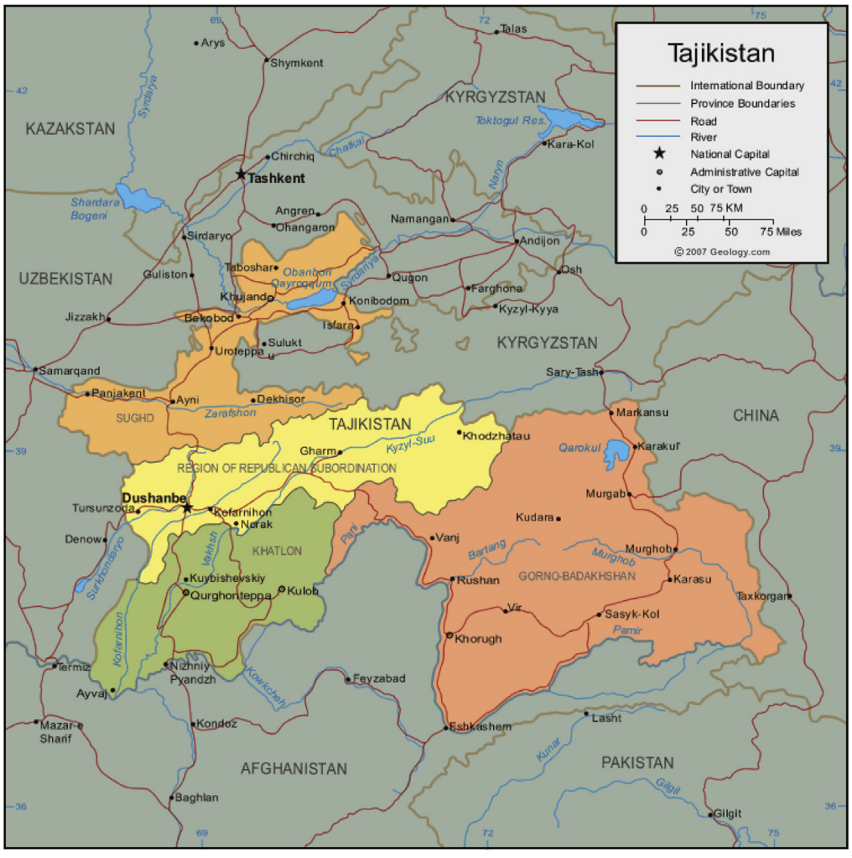

Fig. 1. Uranium legacy sites, Taboshar and Digmai, in Tajikistan included in the NATO RESCA and the JNKKT projects.