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Atmospheric dispersion of radon around uranium mill tailings of the former Pridneprovsky Chemical Plant in Ukraine

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ABSTRACT

Simulations of atmospheric dispersion of radon around the uranium mill tailings of the former Pridneprovsky Chemical Plant (PChP) in Ukraine were carried out with the aid of two atmospheric dispersion models: the Airviro Grid Model and the CALMET/CALPUFF model chain. The available measurement data of radon emission rates taken in the territories and the close vicinity of tailings were used in simulations. The results of simulations were compared to the yearly averaged measurements of concentration data. Both models were able to reasonably reproduce average radon concentration at the Sukhachivske site using averaged measured emission rates as input together with the measured meteorological data. At the same time, both models significantly underestimated concentrations as compared to measurements collected at the PChP industrial site. According to the results of both dispersion models, it was shown that only addition of significant radon emission rate from the whole territory of PChP in addition to emission rates from the tailings could explain the observed concentration measurements. With the aid of the uncertainty analysis, the radon emission rate from the whole territory of PChP was estimated to be between 1.5 and 3.5 $Bq \cdot m^{-2} s^{-1}$.

1. Introduction

The State Industrial Enterprise Pridneprovsky Chemical Plant (PChP) was one of the largest uranium processing chemical plants in USSR (Voitsekhovich and Lavrova, 2009). That enterprise worked from 1948 to 1991. After the collapse of the USSR, the PChP was split into several companies, and uranium processing was stopped. Since that time radioactive materials were stored in 9 tailings and their total radioactivity which include isotopes of ^{238}U, ^{234}U, ^{226}Ra, ^{210}Po, ^{230}Th was estimated as $3.2 \cdot 10^{15}$ Bq (Voitsekhovich and Lavrova, 2009; Lavrova and Voitsekhovych, 2013). One tailings facility ('Dniprovske') is situated close to the Dnieper River. Besides the radioactivity stored in tailings, there are contaminated buildings and other facilities at the PChP territory which were involved in the uranium processing. At the same time, the PChP (Fig. 1) is located about 1 km from Dniprodzerjinsk city (recently this city was renamed to 'Kamianske', but in the manuscript, we will keep the old name for consistency with other research works related to PChP). Therefore there is ongoing work regarding safety assessments and remediation planning of the uranium processing facilities of the PChP (Molchanov et al., 2010; Lavrova and Voitsekhovych, 2013; Bugai et al., 2014; Pérez-Sánchez et al., 2015).

Atmospheric dispersion of radon (^{222}Rn), which is the decay product of radium (^{226}Ra), contained in radioactive wastes at the PChP territory, is one of the possible exposure pathways for the personnel working at the industrial site of the former PChP as well as for the population residing nearby. In previous work (Kovalets et al., 2010), the simulations of atmospheric dispersion of radon originating from the uranium tailings of PChP were carried out with the CALPUFF/CALMET model chain (Scire et al., 2000). The available measurements of emission rates were used in simulations. Those measurements were collected in 2008 in the frame of the National

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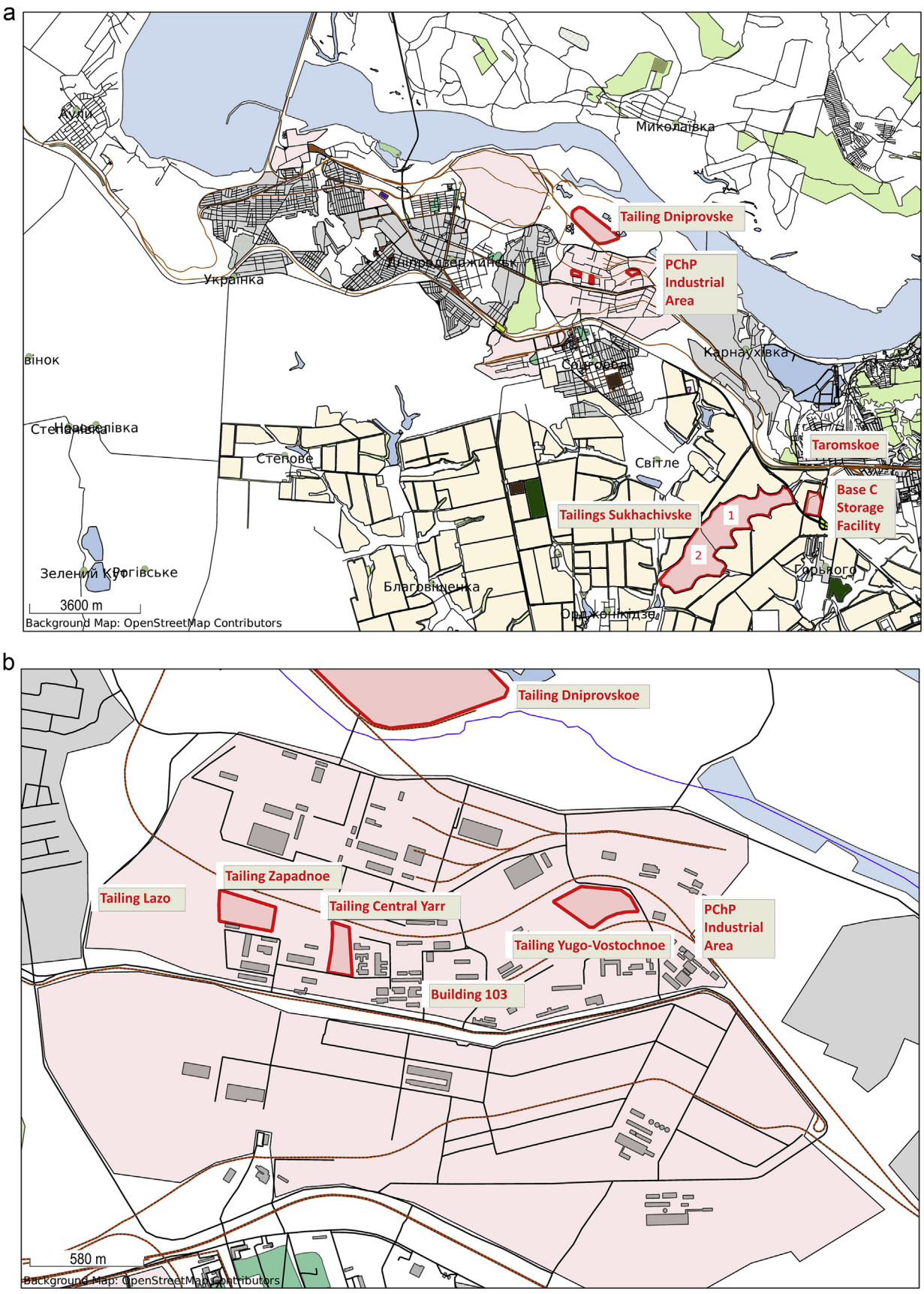

Fig. 1. Map of parts of Dniprodzerzhinsk with the tailings and Pridneprovsky Chemical Plant area highlighted (top); map of the tailings inside the Pridneprovsky Chemical Plant area (bottom).