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Technical Report

Natural radioactivity measurements and dose calculations to the public: Case of the uranium-bearing region of Poli in Cameroon

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ABSTRACT

The objective of this work is to carry out a baseline study of the uranium-bearing region of Poli in which lies the uranium deposit of Kitongo, prior to its impending exploitation. This study required sampling soil, water and foodstuffs representative of the radioactivity exposure and food consumption patterns of the population of Poli. After sampling and radioactivity measurements were taken, our results indicated that the activities of natural series in soil and water samples are low. However, high levels of ^{210}Po and ^{210}Pb in foodstuffs (vegetables) were discovered and elevated activities of ^{40}K were observed in some soil samples. All components of the total dose were assessed and lead to an average value of 5.2 mSv/year, slightly higher than the average worldwide value of 2.4 mSv/year. Most of this dose is attributable to the ingestion dose caused by the high levels of ^{210}Po and ^{210}Pb contained in vegetables, food items which constitute an important part of the diet in Northern Cameroon. Consequently, bringing uranium ore from underground to the surface might lead to an increased dose for the population of Poli through a higher deposition of ^{222}Rn decay products on leafy vegetables.

1. Introduction

Naturally occurring radionuclides of terrestrial origin are present in various degrees in all media in the environment, including the human body itself. Geological and hydrogeological conditions can sometimes lead to their enrichment in the environment, creating uranium or thorium deposits over a geological time scale. All minerals and raw materials contain radionuclides of natural origin, of which the most important for the purposes of radiation protection are the radionuclides in the ^{238}U and ^{232}Th decay series and ^{40}K. For most human activities involving minerals and raw materials, the levels of exposure to these radionuclides are not significantly greater than normal background levels. Such exposures, while having been the subject of much research, are not of concern for radiation protection. However, certain activities can give rise to significantly enhanced exposures that may need to be controlled by regulation. It is for instance the case of the activities related to uranium mining. Material giving rise to these enhanced exposures has become known as naturally occurring radioactive material (NORM) (IAEA, 2008). Uranium deposits are exploited in many regions of the world and used as nuclear fuel after ^{235}U enrichment. Their exploitation raises concerns related to waste management and environmental contamination by NORM. Site remediation after uranium mining and milling proves to be a major issue of radiological protection with a risk essentially associated with the daughter products of uranium.

Many studies reveal the impact of uranium mining and milling in the environment (Vandenhove et al., 2006; Martin et al., 2004; Gorjanacz et al., 2006; Uzunov et al., 1992; Vaupotic and Kobal, 1999; Veska and Eaton., 1991; Carvalho et al., 2007; Winkelmann et al., 2001). However, this impact cannot be well established without performing natural radioactivity measurements onsite and in the vicinity of the site prior to mining operations.

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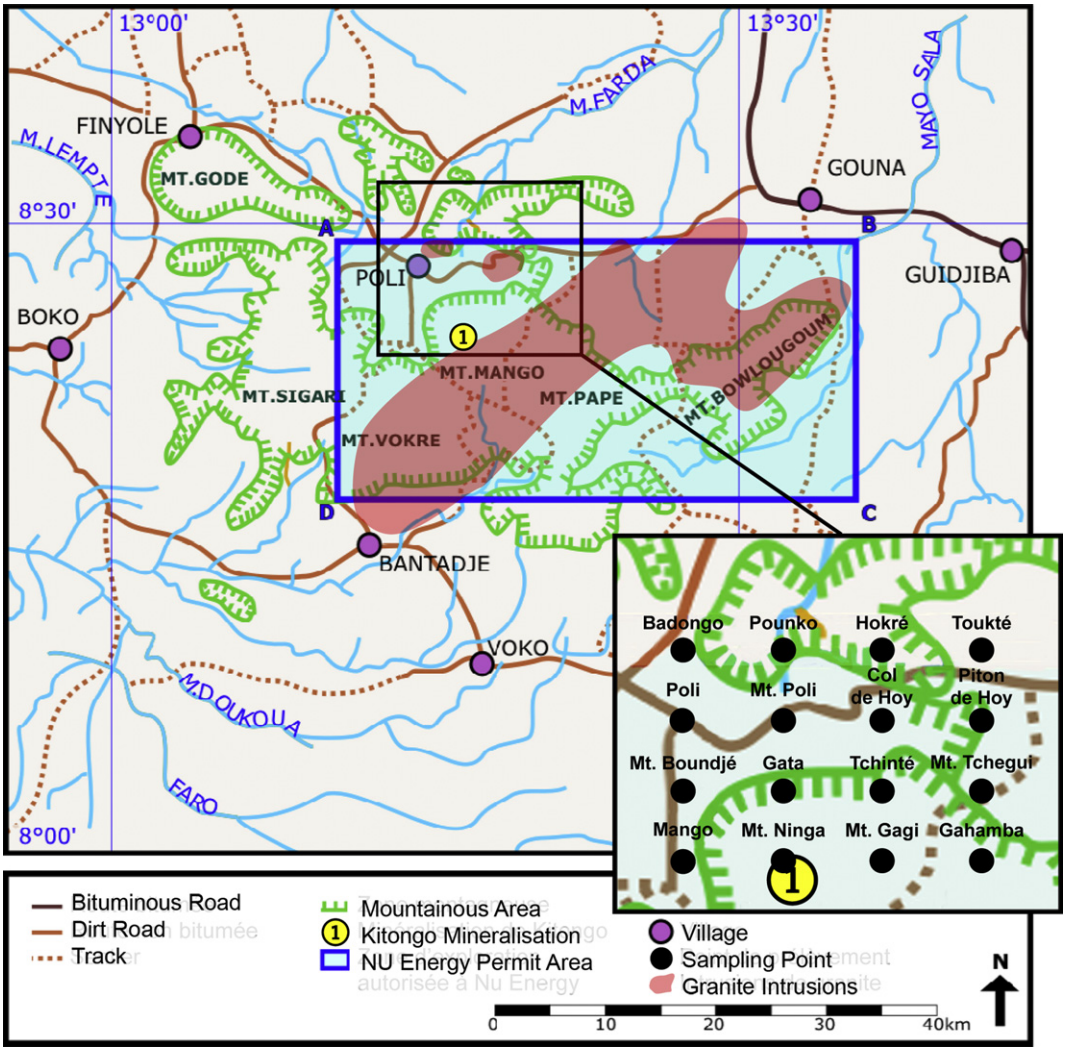

Fig. 1. Sampling strategy for the uranium-bearing region of Poli including the town of Poli and the Kitongo deposit. The points A, B, C and D circumscribe area (6,710 km^2) where the German Federal Institute for Geosciences and Natural Resources (BGR) undertook an aerial survey [Gehnes and Thoste, 1981; Oesterlen, 1985; Thoste, 1985].

Since 1950 many geological studies for the prospecting and assessment of the uranium potential of the Kitongo deposit, situated in the region of Poli in Cameroon, have been conducted (Gehnes and Thoste, 1981; Thoste, 1985; Oesterlen, 1985). Although the project of exploiting the site is about to become a reality (Meadon, 2006), no study on the radiological impact of this deposit has yet been undertaken. Therefore, the main objective of the present work is to carry out the first part of a baseline study of the uranium-bearing region of Poli. This study requires sampling soil, water and foodstuffs, which are representative of radioactivity exposure pathways and food consumption patterns of the surrounding population. Measuring the radioactivity of these samples enables us to assess the annual dose received by the population from both external sources and ingested food. In this context, a procedure for measuring U and Th isotopes using alpha spectrometry has been specially developed for this study and already published elsewhere. Furthermore, knowing the high radiotoxicity of ^{210}Pb and ^{210}Po, two methods for measuring ^{210}Po using alpha spectrometry and ^{210}Pb using gamma spectrometry were developed and also published elsewhere (Saïdou et al., 2007). Finally, the indoor radon concentration was measured in a few dwellings in order to estimate the overall annual dose received by the public.

2. Materials and methods

2.1. Sampling

Poli is situated at 490 m above sea level near the boundary of the high central plateau and the plain of northern Cameroon. The plains around Poli are typical savannah grassland with occasional trees. The Kitongo deposit is located in the northern part of Cameroon, some 15 km southeast of Poli. The Kitongo deposit could contain more than 13,000 t U_3O_8 at an average grade of 0.1% U_3O_8 (Oesterlen, 1985; Meadon, 2006).

To carry out precise and reliable radioactivity measurements, sampling must be carefully performed in order to be representative of the entire site. The uranium-bearing area was zoned during a uranium prospecting run and corresponded to a surface of 6,710 km^2 as illustrated in Fig. 1 (Gehnes and Thoste, 1981; Oesterlen, 1985; Thoste, 1985). In the present work, a surface of 144 km^2 was sampled according to a square grid where soil samples were collected every 4 km. Each sample was collected from the top 5 cm of a 1 m^2 area, and provided a dry mass of around 500 g. On one given location (Gata), a soil profile was sampled (0–5 cm, 5–10 cm, 10–15 cm, 15–20 cm and 20–25 cm of depth) to study the vertical distribution of the radioactivity. In total, 20 soil