Geophysical Research Abstracts
Vol. 12, EGU2010-3155, 2010
EGU General Assembly 2010

Preliminary study of a radiological survey in an abandoned uranium mining area in Madagascar

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The region of Vinaninkarena located in central Madagascar (47º02'40"E, 19º57'17"S), is known to be a high natural radioactive area. Uranium ore was extracted in this region during the 1950s and the early 1960s. In the mid-1960s, mining activities were stopped and the site abandoned. In the meantime, the region, which used to be without any inhabitants, has recently been occupied by new settlers with presumed increase in exposure of the local population to natural ionizing radiation. In order to assess radiological risk, a survey to assess the soil natural radioactivity background was conducted during the year 2004. This study was implemented in the frame of the FADES Project SP99v1b_21 entitled: Assessment of the environmental pollution by multidisciplinary approach, and the International Atomic Energy Agency Technical Cooperation Project MAG 7002 entitled: Effects of air and water pollution on human health.

Global Positioning System (GPS) was used to determine the geographical coordinates of the top soil samples (0-15cm) collected. The sampling was performed using a multi integrated scale approach to estimate the spatial variability of the parameters under investigation (U, Th and K) using geo-statistical approach. A total of 205 soil samples was collected in the study site (16 km2).
After humidity correction, the samples were sealed in 100 cm3 cylindrical air-tight plastic containers and stored for more than 6 months to reach a secular equilibrium between parents and short-lived progeny (226Ra and progeny, 238U and 234Th). Measurements were performed using a high-resolution HPGe Gamma-detector with a 30% relative efficiency and an energy resolution of 1.8 keV at 1332.5 keV, allowing the determination of the uranium and thorium series and 40K. In case of secular equilibrium, a non-gamma-emitting radionuclide activity was deduced from its gamma emitting progeny. This was the case for 238U (from 234Th), 226Ra (from 214Pb and 214Bi) and 232Th (from 228Ac, 212Pb or 208Tl).
Furthermore, in order to assess the radiological effect, the kerma rate in the air at 1 m above ground level was calculated for each sampled points using standard activity-kerma rate conversion coefficients for uranium, thorium series and potassium. Geostatistical interpolation tools (e.g. Inverse Distance Weighting power 2 and Ordinary Kriging) were used to optimize the data set mapping.
The measured Potassium-40 activity was 333 Bq kg-1 $\pm$ 95% (Mean $\pm$ Coefficient of Variation), the Uranium activity was 195 Bq kg-1 $\pm$ 53% and the Thorium activity was 139 Bq kg-1 $\pm$ 29%. The world average concentrations are reported by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) as 400 Bq kg-1 for 40K, 35 Bq kg-1 for 238U and 30 Bq kg-1 for 232Th. The results show that generally, 40K concentrations in soils of the area are slightly lower than the world average value, whereas uranium and thorium series activities are noticeably higher.
On average the kerma rate reaches 143 nGy h-1 with a standard deviation of 41 nGy h-1 and a coefficient of variation of 28%. The information obtained was mapped and the dose exposition was also assessed for the local settlers.

Key-words: soil contamination, environmental radioactivity, radioecology, dose exposure.