Terrestrial Radioactivity and Dose Calculation to the Public: the Case of the United States

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Abstract

Studies on terrestrial radiation level and radionuclide distribution in United States were performed. Information based on airborne gamma ray spectrometry surveys is reviewed and analyzed to provide baseline data on radiation level and distribution of primordial radionuclides such as ^{232}Th, ^{238}U and ^{40}K in the soils. A total of 3,102 counties designated by their Federal Information Processing Standard code were surveyed for their natural radioactivity content and about 40-million lines of data were reprocessed to determine the associated radiation hazards in the United States

Introduction: What are Natural Sources of Radiation (NSR) and why do we measure them?

- NSR derive from radio-isotopes synthesized during the creation of the solar system
- NSR is the largest source of radiation dose (83%)
- NSR is used as standard in evaluating the impact of man-made radiation
- To determine the health impact on the population
- To have reference values

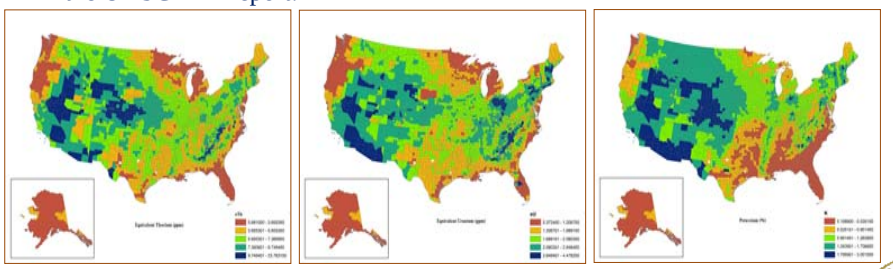
Methods and Data Processing

- **The method is known as airborne gamma-ray spectrometry (AGRS)**
- **During the surveys the aircraft flew a regular grid along a pattern of parallel lines ("flight lines")**
- **Detector: thallium-doped NaI crystal**
- **In total, nearly 40 million records were extracted and converted from Geosoft database format to shapefile using ESRI's ArcMap software**
- **Korn shell code and FORTRAN subroutines were implemented for statistical analysis**

Illustration of a detection system in AGRS (This experimental setup does not necessarily reflect the one used during the NURE program)

Results and discussion

The observed highest values of equivalent Uranium (eU-238), equivalent Thorium (eTh-232) and Potassium (K-40) are higher compared to their corresponding world average valued of 40 Bq/kg, 40 Bq/kg and 580 Bq/kg set in the UNSCEAR report.

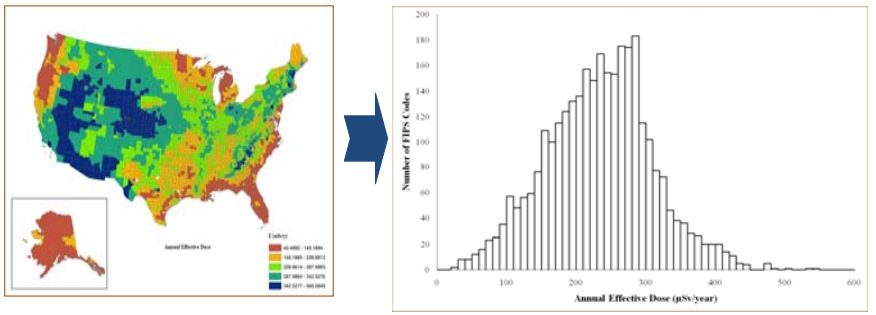


Distribution of Terrestrial Radioactivity in the USA

The absorbed dose rate 1 m above the ground and the effective dose are obtained as follows:

$$D\ (nGy/h) = \sum A_x \times C_x \quad \text{and} \quad E\ (\mu Sv/y) = 0.7 \times 365 \times 24 \times D$$

Ax (Bq/kg) are the mean activity of equivalent 238U, equivalent 232Th and 40K, and Cx (nGy/h per Bq/kg) their corresponding dose conversion factors.



Frequency distribution of Annual Effective Dose

Conclusions

Based on airborne gamma ray spectrometry surveys covering almost all the United States, it has been possible to:

- Assess external photon dose rates in U.S counties
- Identify areas with high exposure levels
- Determine a population-weighted average effective dose value of 234±75 μSv/y, which differs from the NCRP reported value (280 μSv/y) by 16%.
- Identify that there are large variations in annual effective dose in the U.S.

Absorbed dose rate (nGy/h)	Annual Effective dose (μSv)/y	Reference
7 ≤ D ≤ 94 Pop-weighted average=38±12	41 ≤ E ≤ 565 Pop-weighted average= 234±75	This work
50	280	NCRP, 1987
Range: 18-93 worldwide average = 55	480	UNSCEAR, 2000

Acknowledgments: This work has been carried out at the Pacific Northwest National Laboratory through the DOE-FIU Science & Technology Workforce Development Initiative and financed by the US Department of Energy under Grant No. DE-FG01-05EW07033. Special thanks go to Dr. L. Lagos for making this work possible.