Natural radioactivity measurements of various ground water samples

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1. Introduction

Water is one essential part of our day-to-day life. Used in many types of activities and of course for drinking, water is essential for the growth and support of human life. It is well documented that natural radioactivity it's a phenomenon that occurs often in nature. Through its course, the water erodes underground rocks that contain radioisotopes of various elements like ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K. This is the main reason why the water must be periodically subjected to radiological analyses. This creates the need of strict regulations on the radioactivity of the water to assure its quality. Also, children are more effected by a high radioactive water source then an adult person.

2. Method and Samples

The water samples that were used during the experiments were provided by various customers from various areas like Eastern Carpathians and Transylvania, that requested gross alpha-beta (made possible by using MPC-2000-Ortec-Protean detector) and gamma spectrometry (made possible by using HPGe Ortec detector) analyses. The samples were grouped in carbonated and still water. The laboratory has implemented standard and routine methods to achieve good analytical results (ISO 9696, ISO 9697, ISO 10704 and ISO 17025). The water samples were slowly evaporated and the dry residue was used for the measurements. In both types of measurements an acquisition time between 60 000 s and 300 000 s was used in order to achieve low minimum detectable activity. The MPC-2000-Ortec-Protean detector determines the gross activity of alpha and beta radiation thus being unable to point out which radionuclides are present in the samples.

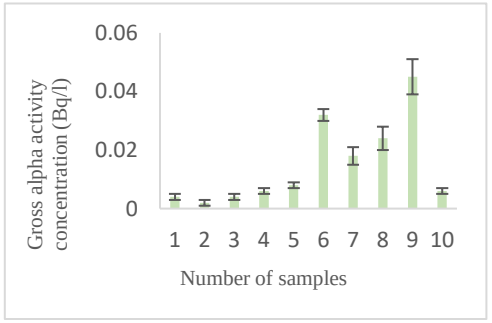
Gamma spectrometry, by analysing the gamma spectra, is able to determine which gamma decay radioisotopes are present in a sample and their associated activity. Since some the isotopes of interest have almost no direct gamma decay (their energy is unobservable in a spectrum, and the yield is extremely low), they are analysed trough their daughters. For ^{238}U it is analysed ^{214}Bi and ^{214}Pb and for ^{232}Th, ^{228}Ac, ^{212}Pb and ^{208}Tl.

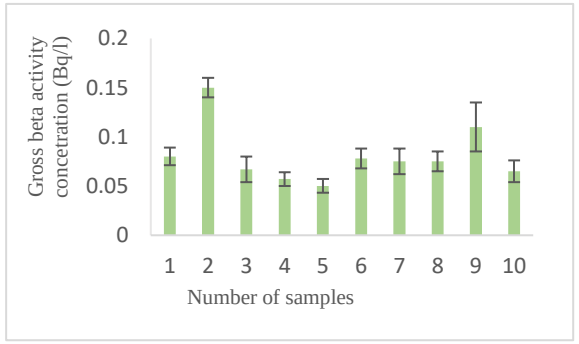
3. Data and graphs:

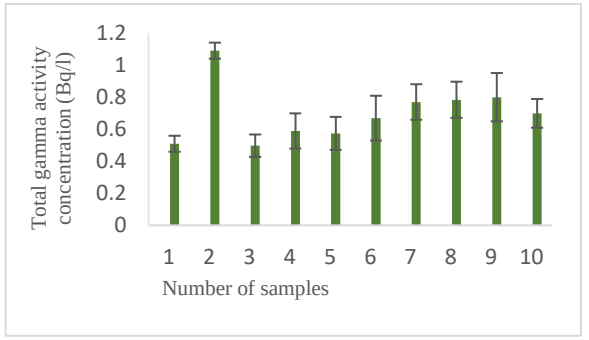
The annual effective dose is calculated by:

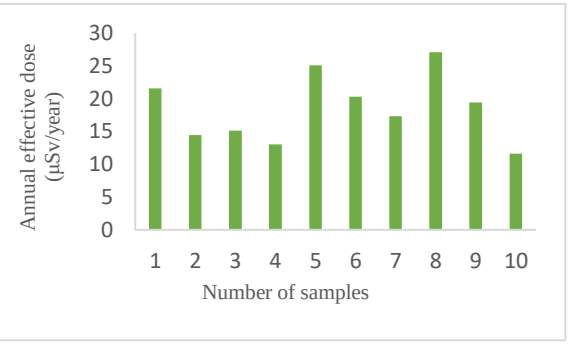
$\mathbf{D_{EFF}}[\mu Sv/an] = \sum_i [A_i(\frac{Bq}{l}) \cdot C(\frac{l}{yr}) \cdot F_i(\frac{\mu Sv}{Bq})]$, where A_i is the activity concentration of the 'i' radionuclide, C is the annual average of water that one person consumes in a year and F_i is the dose coefficient for a specific age.

Samples No.	Alpha activity (Bq/l)	Uncertainty (Bq/l)	Beta activity (Bq/l)	Uncertainty (Bq/l)	Gamma Activity (Bq/l)	Uncertainty (Bq/l)	Dose (µSv/year)
1 (still water)	0.004	0.001	0.08	0.009	0.51	0.05	21.59
2 (still water)	0.002	0.001	0.15	0.01	1.09	0.05	14.44
3 (still water)	0.004	0.001	0.067	0.013	0.498	0.07	15.15
4 (still water)	0.006	0.001	0.057	0.007	0.59	0.11	13.01
5 (carbonated water)	0.008	0.001	0.05	0.007	0.574	0.103	25.06
6 (carbonated water)	0.032	0.002	0.078	0.01	0.67	0.14	20.32
7 (carbonated water)	0.018	0.003	0.075	0.013	0.77	0.11	17.34
8 (carbonated water)	0.024	0.004	0.075	0.01	0.784	0.113	27.08
9 (still water)	0.045	0.006	0.11	0.025	0.8	0.15	19.42
10 (still water)	0.006	0.001	0.065	0.011	0.7	0.09	11.63









4. Conclusions

The results obtained from the gross alpha-beta measurements showed values between 0.002 ± 0.001 and 0.045 ± 0.002 Bq/l, with an average of 0.015 ± 0.003 Bq/l for alpha, respectively 0.05 ± 0.01 and 0.15 ± 0.02 Bq/l, with an average of 0.10 ± 0.03 Bq/l for beta. All uncertainties are given for k=1. These values are within the European quality standards, below 0.1 Bq/L for gross alpha activity and 1 Bq/L for gross beta activity. For gamma radiation measurements the obtained spectra were analysed with GammaVision software and the resulted activity concentrations for ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K were used to calculate ingestion doses associated with these natural radionuclides, considering the annual consumption rate of 150 l/yr for infants, 350 l/yr for children and 500 l/yr for adults. Thus, the dose values obtained for ingestion of water were between 11.0-27.0 µSv/year, with an average of 18.5 µSv/year. In all cases the values were well below the reference level of the committed effective dose (100 µSv/yr) recommended by the international regulations.