



Public effective dose assessment using gross alpha and beta radioactivity levels of drinking water in Albania

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Abstract

The presence of radionuclides in water poses a potential risk for health effects, especially when these radionuclides are deposited in the human body through drinking. To assess public effective dose due to gross alpha and beta in water, 65 tap water samples were collected from different areas in the different cities of Albania. According to Albanian legislation the gross alpha/beta radio-activity concentration, should be below the level of 0.1 Bq/L and 1 Bq/L respectively for human consumption.

The instrumentation used to count the gross α and gross β activities was an α/β counter of the Ultra-Low Level α/β Counter, MPC 9604, Protean Instrument Corporation, multiple detector type with 4 sample. The gross alpha and beta concentrations found varied from 0.010 ± 0.002 to 0.092 ± 0.012 Bq/l and from 0.107 ± 0.093 to 0.643 ± 0.067 Bq/l, respectively in samples. The public effective dose assessment showed values of dose to ingestion of alpha and beta emitter radionuclides lower than the recommended value of dose for drinking water 0.1 mSv/y.

Key words: Water samples, Gross alpha-beta radioactivity, Gas proportional counters

Introduction

The presence of radioactivity in water from both natural and artificial sources is very important for biological effects of radiation on humans and environmental protection. Water is one of the essentials that support all forms of plant and animal life (1) and it is obtained from two principal natural sources; surface water such as freshwater lakes, rivers, streams and ground water.

Uranium (²³⁴U, ²³⁸U), radium (²²⁶Ra, ²²⁸Ra), potassium (⁴⁰K) and radon (²²²Rn) are all soluble in surface waters such as wells, lakes and rivers. Radon present in water sources is readily released into outdoor air as it passes over rocks and soils. Naturally occurring radionuclides in drinking-water usually give radiation doses higher than those provided by artificial radionuclides. (3) These dependent upon the amount of radionuclides present in source rock, soils and other natural and artificial radionuclide materials that the water comes in contact (4).

Therefore, there is the need to determine the concentration of alpha and beta radiations in water. Gross α and β activities are very useful parameters for the preliminary screening of waters. For these reasons, firstly, gross α and β activities in water resources need to determine without regard to the identity of specific radionuclides. According to the recommended guideline (5), and national legislation activity concentrations should be 0.5 Bq L⁻¹ for gross α and 1.0 Bq L⁻¹ for gross β activity concentrations in drinking water (6). Although the contribution of drinking-water to total exposure to radionuclides is very small, the health risks associated with the presence of naturally occurring radionuclides in drinking water should also be taken into consideration. The use of these screening levels is recommended, as this maximizes both the reliability and the cost effectiveness of assessing the radionuclide content of drinking water.

In Albania, the health criteria of water intended for human consumption were published in governmental mandates (7, 8). These mandates made compulsory the monitoring of gross alpha and beta activity concentration and specific radio elements at various sampling frequencies in superficial water. Also, the companies that sell bottled water from national sources are obliged by law to certify every three years the quality of the water from a radioactive point of view.

Material and methods

Albania is mostly mountainous, with a mean elevation of 764 m above sea level (a.s.l.). There are many peaks above 2,000 m a.s.l. located in the northern, eastern and southern parts of the country. The highest peak reaches an elevation of 2,751 m (Mt. Korabi).

Sample 01 originates from the source of Gajd, Berat Flysch sand./clay. mixed with calc. rock

Sample 03 the source is in the upper part of the left slope of the Drinos valley, in the contact of limestone rocks with those of limestone. The precipitation-atmospheric waters that fall in the eastern part of the Kurvelesi mountain range, through the karstic caves, penetrate deep into the limestone rocks and feed this source. Sample 04 the source originates at an altitude of 1350 m in Qafshatama mountain. The water penetrates from the depths of the earth through magmatic rocks from where it is naturally filtered and enriched with mineral salts. Sample 05 Flows from the well-known spring water from Nëmërçka mountain, 2482 m above sea level. It comes from the source of Vrizi in Nepravishte of Gjirokastra city. Sample 08 originates from the source "Kroi i hijes" in Qafë Mali, Puka city, flows from the great depths of the earth, filtered naturally by the underground rocks in the heart of the mountains and preserved from the effects of environmental pollution.

Sample Selita water fills at a height of over 1000 m above sea level, in the heart of the Tirana Highlands. The karst pits of this mountain serve as a natural filter, giving the water the ideal combination of physico-chemical elements. Selita is a balanced water with high oxygen content. This fact sets it apart from others and makes it even healthier. Also, it is rich in calcium, magnesium, silicon, potash and many other minerals. Sample 01 Cond water is obtained from the basin of the Gajde area in Berat and is subjected to a rigorous processing process with Americantechnology consisting of 11 stages. Sample LA 11 lajthiza water originates from Mount Roshi in Lajthiza of Puka, which is located in an area completely surrounded by mountains where their height reaches 1600 m above sea level. Naturally filtered from igneous rocks. Sample GGj 16 Glina the source of clay is the oldest and most famous in Albania. What makes clay water special is its rich content in minerals, which are less and less available in the processed foods we consume in modern times. Glina water is particularly rich in calcium, a mineral which, together with magnesium, is very important for cardiac function and blood pressure control

Sample preparation for gross alpha and gross beta determination

According to (9), the total dissolved solids should not exceed a surface density of 5 mg/cm² for gross alpha determination and 10 mg/cm² for gross beta determination. Accordingly, an aliquot of 100 mL of each sample was evaporated to dryness at 800 C, and the final concentration of the total dissolved solids (mg/L) was determined. Afterwards, based on the concentration of the total dissolved solids, an appropriate test aliquot of each sample was chosen and was slowly evaporated in a special hot plate avoid spattering. The total dissolved solids were then transferred to a 2-in.-diameter planchet (measurement geometry), using 8 M NHO₃ to carefully wash the beaker. The planchets were then oven-dried at 1050 C and then weighed and stored in a desiccator before analysis.

The samples were measured after 30 min to prevent water uptake from the possible presence of nitrates. The samples were measured using an MPC-9604 ultra-low background gas-flow proportional counter (Protean Instrument Corporation) with passive (lead) and active (guard detector) shielding. The background for gross alpha and gross beta activity concentrations were respectively 0.1 and 0.7 cpm. Calibration of the proportional counter for measuring gross alpha and beta activities involves several steps, such as selecting the appropriate values of the bias, plateau, and discriminants. The operating high voltage of the detector was set at 1,455 V. This proportional counter distinguishes events originating from alpha and beta decays by analyzing the pulse height.

Effective dose equivalent

The annual effective dose equivalent Def (Sv y⁻¹) associated with radiation exposure through the ingestion of water was estimated to assess the health risk for adults using the equation (1):

$$Def = \Lambda\alpha/\beta \times IRw \times CF \quad (1)$$

Where: $\Lambda\alpha/\beta$ is gross alpha/beta activity (Bq L⁻¹); IRw – intake of water for one person in one year (L y⁻¹); CF – age-dependent effective dose conversion factor (Sv Bq⁻¹). In this work, the annual consumption rate (IRw) was estimated at the value of 730 L, according to (5) for an adult person (age >17 years). Therefore, to calculate the annual internal dose, we considered that alpha gross activity is due to ²²⁶Ra and ²¹⁰Po and beta gross activity due to ²²⁸Ra and ²¹⁰Pb, which are emitters with the highest effective conversion factors CF in table 1.

Results

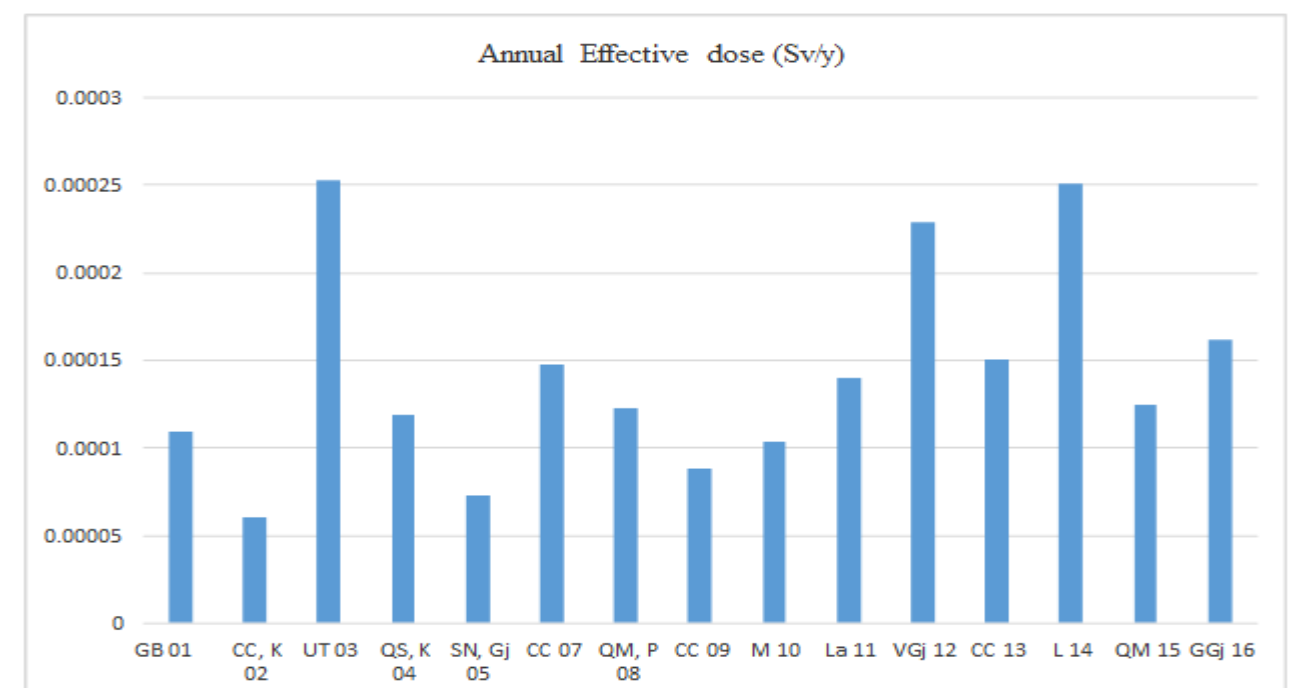


Figure 1 The annual effective dose (mSv y⁻¹) due to intake of gross alpha and beta from drinking water

This study has shown that gross α and gross β activity concentrations in drinking waters in analyzed samples are good, satisfying the WHO regulations and national requirements for drinking water.

Screening levels for the samples of drinking water studied here are in the range 11 ÷ 71 mBq/L and 90 ÷ 450 mBq/L, respectively for gross alpha activity and gross beta activity. The recommended annual effective dose of 0.1 mSv/year were also not exceeded. (13)

This is not the first study of gross α and gross β radioactivity concentrations in drinking water but is the first study with annual effective dose calculation with some assumptions.

The data obtained in this study is the baseline which can be used to evaluate possible future changes.

In some publications of researchers from other countries, it was found that even though the values of alpha and beta concentration do not exceed the limit, the annual effective dose values are in some cases above 0.1 mSv/y.

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