

DETERMINATION OF GROSS A AND B ACTIVITIES IN SOIL SAMPLES FROM DRAŽLJEVO LANDFILL (POWER PLANT GACKO)

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Abstract

The concentrations of the natural radioactivity in 8 different soil samples collected from Dražljevo landfill near the coal-fired power plant Gacko (Republic of Srpska) were determined. The instrumentation used to count the gross alpha and gross beta activities was α / β low level proportional counter Thermo Eberline FHT 770 T. The obtained results show that the gross alpha and gross beta activities ranged from 66.7 to 102.4 Bq/kg and 285.7 to 607.4 Bq/kg, respectively.

Keywords: *Gross alpha, gross beta, soil, natural radioactivity*

Introduction

Monitoring of any release of radioactivity material to the environment is necessary for environmental protection. Measurement of natural radioactivity in soil is very important to determine the amount of change of the natural background activity with time as a result of any radioactivity release (Yalcin and Gurler, 2007).

A significant part of the total dose contribution in the form of natural sources comes from terrestrial gamma radionuclides. Only nuclides with half-lives comparable with the age of the earth or their corresponding decay products, existing in terrestrial materials, such as ⁴⁰K, ²³⁸U and ²³²Th radionuclides, are of great interest (Janković et al., 2008).

The concept of technologically enhanced natural radioactivity (TE NORM) was introduced in the mid-seventies. It represents the unintentional exposure to natural sources of radiation which would not exist without the technological activity (UNSCEAR, 2000). Earlier studies have shown that the main sources of technologically enhanced natural radioactivity are coal-fired power plants and artificial fertilizers applied in agriculture. Coal-fired power plants have been neglected as a radiation source for a long time.

They became important for investigations as a result of the advancement of the scientific

knowledge of biological effects of radiation on humans and after dose limits reduction in international recommendations and standards. Coal combustion in power plants leads to a redistribution of natural radionuclides originating from coal, and to their concentration in ash and slag. The basic problem of technologically enhanced natural radioactivity caused by coal-fired power plants is the increase of the background gamma radiation level. Therefore, the local population is exposed to higher gamma radiation doses than in absence of coal-fired power plant (Janković et al., 2011).

In the combustion process, most of the mineral material in coal is converted into ash. Coal, like most materials found in nature, contains trace quantities of naturally occurring radionuclides, ²³⁸U, ²³²Th and ⁴⁰K (Mondal et al., 2006). Combustion of coal thus enhances

natural radiation in the vicinity of the coal-fired power plants by release of these radionuclides and their daughters into the surrounding ecosystem.

Gacko coal basin is located in Gacko Valley in the southeastern part of the Republic of Srpska. It covers an area of about 40 km², at an altitude of about 940 feet in a typical karst area. The area is characterized by a distinctive climate, where temperatures range from -30 to +37 °C, with an average atmospheric precipitation of 1 750 mm per year. The terrain is mostly flat. The Dražljevo landfill is poorly positioned, the distance from the power plant Gacko 6.5 km and 210 m height difference, also located above the dispositional primary source of water supply of the population located downstream ("Vrba" and "Klinje"). Area Dražljevo former ash landfill is approximately 300 000 m². Thickness of the buried humus layer is about 10–15cm. The smaller northwestern part of the (landfill entrance) there is no humus (Plan aktivnosti TE Gacko, 2007).

The aim of this study was to determine the level of gross alpha and beta activity in soil samples taken from various locations of the Dražljevo landfill. Since the Dražljevo landfill is located near the reservoirs which is used for water supply, it is necessary to periodically monitor the content of radionuclides in samples from the landfill.

Materials and methods

Soil samples were collected during May 2012 from various locations of the Dražljevo landfill near power plant Gacko. The sampling location is shown in Figure 1. Samples were taken at the surface of the landfill, in areas with vegetation and without vegetation, and on the south side and the north side of the landfill. Samples were taken from two depths of 0–10 cm and 10–20 cm, with a probe. Thickness of the buried humus layer is about 10–15 cm. At the smaller northwestern part (the entrance to the landfill) there is no topsoil or vegetation, but the rest of the landfill is under the humus and vegetation. It is interesting that on the slopes of the southern exposure of the landfill, vegetation is less frequent than the northern exposure of the landfill.



Figure 1. The former ash landfill "Dražljevo"

The soil samples (about 2 kg) were placed into polyethylene bags and transported to the laboratory. After removing the stones and vegetation, all soil samples were dried up to 105 °C during 24 h. The samples were sieved through a stainless steel sieve (diameter 3 mm) and reduced to a powder. About 1 g of powdered soil of each sample was transferred into a stainless-steel planchet. Technically alcohol was used to evenly spread the soil on the planchet. Planchet was put under the UV lamp to evaporate alcohol and then the planchet

placed directly into the detector. The counting time was 3600 s for gross alpha and beta activities.

Gross alpha and beta activity in soil samples were determined by α / β low level proportional counter Thermo Eberline FHT 770 T. Calibration was performed by using standard source of ^{90}Sr (EM145, Prague) with an activity of 189.4 Bq on the day 01.08.2z11. for beta activity and standard source of ^{241}Am (EM445, Prague) with an activity of 224 Bq on the day 1. 8. 2011. for alpha activity. The counting gas was a mixture of 90 % argon and 10 % methane. The counting efficiencies for the system are 23 % for alpha and 33 % for beta. The background of each detector was determined by counting an empty planchet for 3600 s. To assure that radiological monitoring are reasonably valid, quality assurance programs necessary. These programs are needed to identify deficiencies in the sampling and measurement processes. Quality of sampling and measurement and calculated uncertainty are very important for predicting the dose for population. In addition, validation monitoring aims to prove whether the results are acceptable. The accuracy and reproducibility of gas proportional counter were verified on a periodic basis – every week. Total background count rate without a source is monitored to verify that the detector and shield have not been contaminated by radioactive materials. Alpha and beta efficiencies of gas proportional counter were checked with ^{241}Am and ^{90}Sr sources respectively.

Gross alpha and beta activity was calculated using the following formula:

$$A_{\alpha\beta} = \frac{I}{m} \quad (1)$$

where $A_{\alpha\beta}$ is the activity of the sample (Bq/kg), m is the mass of the sample in planchet, I is given by the formula:

$$I = \frac{(N - B)}{ef} \quad (2)$$

where N is the count rate for the sample (1/s), B is background (1/s) and ef is the efficiency of the detectors for alpha and beta measurements.

Minimum detectable activity was calculated by the equation (3):

$$MDA = \frac{LLD}{m} \quad (3)$$

where LLD is the detection limit (1/s) and m is the mass of the sample.

Measurement uncertainty determined as expanded measurement uncertainty was 30–40 % for alpha and 15 % for beta.

Results and discussion

The results of measurements the gross alpha and gross beta activities for 8 soil samples collected from different locations of the Dražljevo landfill, are presented in Table 1. The activity concentrations are expressed in Bq/kg. As can be seen from Table 1 that the gross β activity is generally higher than the gross α activity. The gross alpha and gross beta activities varied between 66.7 and 102.4 Bq/kg and between 285.7 and 607.4 Bq/kg, respectively.

Table 1. The gross alpha and beta activity concentrations of soil samples from Drazljevo landfill (Bq/kg).

Sample location	Gross alpha activity	Gross beta activity
southern exposure (0–10 cm)	78.8 ± 16.4	562.0 ± 39.0
southern exposure (10–20 cm)	101.8 ± 20.5	502.7 ± 39.6
northern exposure (0–10 cm)	67.2 ± 14.6	607.4 ± 42.7
northern exposure (10–20 cm)	70.1 ± 14.7	374.3 ± 30.2
part with vegetation (0–10 cm)	102.4 ± 19.4	543.9 ± 39.8
part with vegetation (10–20 cm)	71.3 ± 15.6	495.3 ± 37.7
part without vegetation (0–10 cm)	72.8 ± 16.3	309.6 ± 29.8
part without vegetation (10–20 cm)	66.7 ± 15.5	285.7 ± 28.6

For comparison, the results of the gross α and gross β activity concentrations in soil samples from different studies are presented in Table 2.

Table 2. Comparison of results for the gross alpha and beta activities (Bq/kg) in soil samples between Drazljevo landfill and other studies

Origin	Gross alpha activity	Gross beta activity	Reference
Dražljevo (Republic of Srpska)	66.7 – 102.4	285.7 – 607.4	This study
Obrenovac (Serbia)	–	93 – 262	Vuković et al., 1996
Van (Turkey)	686 – 4713	73 – 11773	Zorer et al., 2009
Marmara (Turkey)	–	500 – 830	Yalcin et al., 2007

Our results for the gross alpha activity in soil samples are lower than Van (Turkey). The gross beta activity is between the minimum and maximum values obtained in other studies, except for Obrenovac. World Health Organization recommends for the limits of gross alpha and gross beta radioactivity concentration in drinking water below 0.5 and 1.0 Bq/L, respectively (WHO, 2004; Official Gazette of the Republic of Serbia, 2011). Given the fact that in the Republic of Srpska there is no regulation for limit values for gross alpha and beta activity in the soil, we can not know that what is the limit value of the total beta activity which can represent hazard to population.

We know that the total beta activity in the soil samples is certainly great because of the presence of natural radionuclides ^{40}K in the soil (Janković et al., 2008). Beside the ^{40}K , in soil samples ^{90}Sr and ^3H can be found. The contribution of ^{40}K in total beta activity can be determined by gamma spectrometry.

Conclusion

The main target of this study was to determine the gross alpha and beta activities in soil samples from Dražljevo landfill in the Republic of Srpska. The obtained values for the

gross alpha and beta activity ranged between 66.7–102.4 and 285.7–607.4 Bq/kg, respectively. It was found that the concentrations of gross alpha and gross beta radioactivity in soil samples were relatively lower than those in Turkey, but higher than Serbia. This is the first detailed study of the gross alpha and beta activity concentrations in soil samples of Dražljevo landfill. It is necessary to continuously monitor the natural radioactivity in the environment samples from Dražljevo landfill, due to the impact of radiation on the population.

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