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Ljubiša Balanović
Dejan Tanikić

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PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the 54th International October Conference on Mining and Metallurgy (IOC 2023), scheduled to take place at the picturesque Bor Lake, Serbia, from October18th to 21st 2023.

The collaborative efforts of the University of Belgrade, the Technical Faculty in Bor, and the Mining and Metallurgy Institute Bor have meticulously organized this year's IOC. Our focus remains unwavering on showcasing the latest research findings and advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines. Our primary objective is to foster a dynamic environment where academics, researchers, and industry professionals can come together to share their knowledge, experiences, and innovative ideas while exploring opportunities for collaborative research endeavors.

Our conference agenda is rich and diverse, encompassing plenary sessions, engaging invited lectures, technical presentations, enlightening oral and poster sessions, informative technical tours, a diverse exhibition, and memorable social gatherings. At the heart of this event lies our strong commitment to sustainable development within the mining and metallurgy sector. We are dedicated to exploring ecologically conscious methodologies, responsible resource extraction practices, and cutting-edge technologies that reduce the industry's environmental impact and enhance the well-being of local communities.

The conference proceedings comprise 129 papers authored by individuals from universities, research institutes, and industries in 22 countries. We are proud to welcome participants from Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Greece, India, Iran, Kazakhstan, Libya, North Macedonia, Montenegro, Morocco, Romania, Russia, Slovakia, South Africa, Spain, Turkey, United States, and, of course, Serbia.

We are excited to host the 8th International Student Conference on Technical Sciences (ISC 2023) as part of IOC 2023. This event offers students from Serbia and the wider region a unique chance to showcase their research and discuss the future of their fields with experts.

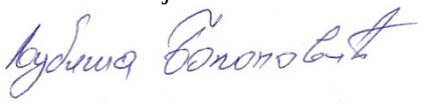
We sincerely thank the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia for their generous financial support. In addition, we express our profound gratitude to all our sponsors, exhibitors, and friends of the Conference for their contributions and unwavering support for playing a pivotal role in ensuring the success of IOC 2023.

We would like to express our heartfelt thanks to all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions in shaping IOC 2023.

We look forward to welcoming you to the 55th International October Conference on Mining and Metallurgy (IOC 2024), which will be held in October 2024.

On behalf of the 54th IOC Organizing Committee,

Prof. dr Ljubiša Balanović



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ANALYSIS OF GROSS ALPHA AND GROSS BETA ACTIVITY IN SAMPLES AROUND FORMER URANIUM MINE GABROVNICA

Nataša Sarap, Marija Janković, Vojislav Stanić, Ivana Jelić, Marija Šljivić-Ivanović

Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, Radiation and Environmental Protection Department, Mike Petrovića Alasa 12-14, 11001 Belgrade, Serbia

Abstract

Gabrovnica, uranium mine near Kalna in the Eastern Serbia was a natural ore with uranium content. Exploitation of the uranium ore in this region was started in the 1960s and it was terminated in 1996. The aim of this work was to analyze radiological characterization of environmental samples around uranium mine Gabrovnica. Soil samples were taken in the autumn of 2022 and spring 2023, while surface soil samples (Gabrovnička River) were taken continuously for six month (July-December 2022 and January-June 2023). All samples were analyzed in order to determine gross alpha and gross beta activities and measured on ultra low level gas proportional counter Thermo-Eberline FHT 770T.

Keywords: *Gabrovnica; environmental samples; gross alpha and gross beta activity*

1. INTRODUCTION

Exploitation of the uranium ore was started in the 1960s in the region of Stara Planina Mountain (Eastern Serbia) in the vicinity of the Bulgarian border. The first investigated location was Aldina reka, while in 1951 uranium ore occurrences were discovered in Mezdreja. Uranim ore exploitation was carried out in three uranium mines: Mezdreja, Srneći Do and Gabrovnica. The area surrounding the town of Kalna on Stara Planina Mountain represents a location characterized by the increased content of natural radionuclides. Gabrovnica is situated north from Mezdreja, on the left side of the Gabrovnička River at about 1.5 km from its running into the Timok River [1]. Gabrovnicka River is the right tributary of the Trgoviški Timok [2]. The Gabrovnica mine had a plant processing about 200 t/day of ore [1].

Knowledge of impacts on the natural environment from uranium mining in general, is essential. An assessment of impact in terms of contaminated soil, surface water, groundwater, lake sediments, etc. or activity levels and doses are very important and directly linked to potential uptake of radionuclides by humans, principally from soils and water. Radionuclides could be taken up and concentrated by plants in the vicinity, thereby posing a potential risk to vegetation as well as to animals higher in the food chain, including humans [3].

Various methodological procedures were applied in order to determine the contamination of waters in the area of the abandoned mines (geoecological, radiological, geochemical and hydro chemical investigations were carried out in the study area). In order to analyze radioactivity contents of natural radionuclides, gamma spectrometry were applied [4-6]. In that case, it is possible to determine the concentrations of individual radionuclides present in environmental samples. It is not known whether gross alpha and gross beta activity was analyzed in soil and water samples in the vicinity of Gabrovnica mine, which is the aim of this paper.

2. EXPERIMENTAL

Soil sampling was carried out in the immediate vicinity of former mine Gabrovnica (Hydrometallurgical plant) (43° 26′ 25″ N and 22° 25′ 30″ E) using the method of representative

samples, from three depths: surface layer 0-5 cm, 5-10 cm and 10-15 cm during October 2022 and April 2023.
Surface water samples from Gabrovnička River were sampling once a month and the analysis was done in a composite six-month sample. Sampling were done upstream of the Hydrometallurgical plant (43° 26′ 32″ N and 22° 25′ 40″ E) and downstream of the Hydrometallurgical plant (43° 26′ 24″ N and 22° 25′ 29″ E) during the period July-December 2022 and January-July 2023.
Soil sample preparation includes cleaning from grass and stones, and samples were dried in the ven at the temperature of 105°C to constant mass, and sifted through the 2 mm sieve. A certain mass of homogeneous sample was weight in a Alluminium planchet and fixated with -alcohol [7].
For water samples method EPA was applied [8]. An aliquot of a preserved water sample is evaporated to dryness and ashed at 450 °C. Samples were placed in a Alluminium planchet and fixated with alcohol.
For the gross alpha and gross beta activity measurements, the gas low-level proportional counter Thermo-Eberline FHT 770T was used. The counting gas is a mixture of 90 % Ar and 10 % methane. Efficiencies were determined using the certified radioactive calibration standards ^{241}Am and ^{90}Sr (9031−OL−334/11 and 9031−OL−335/11, respectively, Czech Metrology Institute), traceable to the Bureau International des Poids et Mesures (BIPM). The counting efficiency was 26 % for alpha and 35% for beta radiation. Measurement time was 14400 s, by 4 independent detectors simultaneously. Measurement uncertainty was expressed as an expanded measurement uncertainty at the confidence level of 95% (k=2).

3. RESULTS AND DISCUSSION

Results for gross alpha and gross beta activity for water samples are presented in Table 1. In six-months composite samples, lower values for gross alpha activity was obtained for samples taken upstream of the Hydrometallurgical plant for both investigated period. The same trend was observed also for gross beta activity. A greater difference between the results was obtained for those taken in the second half of 2022 for the samples downstream of the Hydrometallurgical plant, compared to those taken in the first half of 2023. For the samples taken upstream, that difference is smaller.

Table 1 - Gross alpha and gross beta activity in surface water samples

Surface water sample Gabrovnička River	**Gross alpha activity (Bq/l)**	**Gross beta activity (Bq/l)**
Upstream of the Hydrometallurgical plant July-December 2022	0.022 ± 0.005	0.057 ± 0.009
Downstream of the Hydrometallurgical plant July-December 2022	0.279 ± 0.017	0.454 ± 0.022
Upstream of the Hydrometallurgical plant January-July 2023	0.032 ± 0.006	0.073 ± 0.006
Downstream of the Hydrometallurgical plant January-July 2023	0.072 ± 0.009	0.116 ± 0.008

In Serbian Legislation, the allowed values for gross alpha and gross beta activity are defined only for drinking water (0.1 Bq/l for gross alpha and 1 Bq/l for gross beta) [9]. The gross beta activity is mainly due to the presence of ^{40}K but also ^{137}Cs, while the gross alpha activity in samples originates from the decay chains of ^{238}U and ^{232}Th.
The obtained results for gross alpha and gross beta acivity in soil samples from different depths for autumn 2022 and spring 2023 are presented at Figures 1 and 2. Samples are marked with S1: 0-5 cm; S2: 5-10 cm; S3: 10-15 cm. Gross alpha activity is higher for samples taken in autumn, with the fact that this difference is the largest for the sample S1 (0-5 cm depth). For gross beta

activity, for the soil samples S1 and S3 higher values were obtained for samples taken in autumn, while for sample S2 gross beta activity is higher for sample taken in spring. Gross alpha and gross beta activity for samples taken in spring increase with depth increasing, which indicates the fact that there was a migration of radionuclides in depth. The situation is slightly different with the samples taken in autumn, where there was a decrease in activity at a depth of 5-10 cm, and then an increase again at a depth of 10-15 cm.

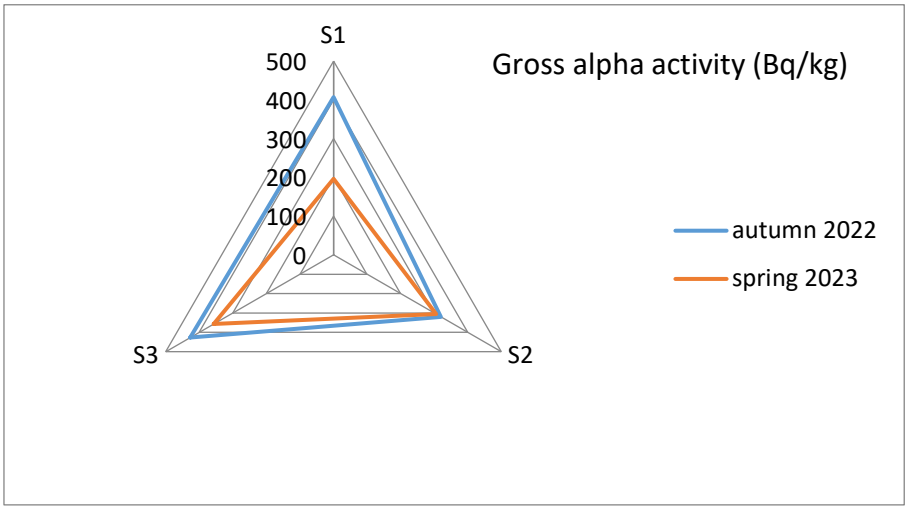

Figure 1 - Gross alpha activity in soil samples

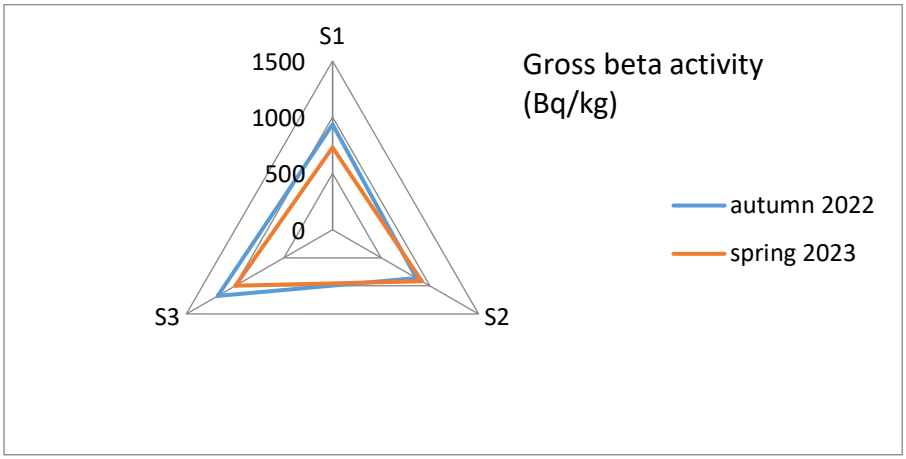

Figure 2 - Gross beta activity in soil samples

The impacts on the environment from uranium mining are not all related to the radionuclide content alone. The presence of other contaminants may also have an influence on the environment. The other effects may include: the chemical toxicity of the radionuclides, including uranium; the chemical toxicity of heavy metals and metallic compounds; the chemical toxicity of non-metallic minerals and compounds in the ore or introduced during processing (e.g. sulphuric acid, kerosene); acidity, resulting from sulphidic (ore) minerals; increased turbidity in surface waters; increased salinity [3]. In order to assess the radiological impact on the environment in the vicinity of abandoned mines, constant monitoring is necessary.

4. CONCLUSION

Soil samples in the vicinity of former mine Gabrovnica and surface water samples from Gabrovnička River were analyzed using screening method gross alpha/beta activity, in order to assess the radiological impact on the environment. Results show that gross alpha and gross beta activity in water are higher for the samples taken downstream of the Hydrometallurgical plant. Given the fact that there are no prescribed limits for the permitted values for gross alpha and gross

beta activity in rivers, the comparison can only be made in relation to the values defined for drinking water. The gross beta activity is mainly due to the presence of natural radionuclide ^{40}K but can also contain artifical radionuclide ^{137}Cs or ^{90}Sr, while the gross alpha activity originates from the decay chains of ^{238}U and ^{232}Th. In this regard, in soil samples, greater activity is observed with increasing depth, which means that radionuclides have migrated from the surface layer.

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