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NATURALLY OCCURING RADIONUCLIDES AND BASIC CHARACTERISTICS OF SOIL AND ASH SAMPLES NEARBY COAL-FIRED POWER PLANTS

Ivana Vukašinović*[a], Dragana Todorović[b], Nataša Nikolić[c]
[a]University of Belgrade, Faculty of Agriculture, Belgrade, Serbia
[b]University of Belgrade, "Vinča" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Belgrade, Serbia
[c]Bioagricert S.r.l., Casalecchio di Reno (BO), Italy
*Corresponding author e-mail: ivanavu@agrif.bg.ac.rs

INTRODUCTION

Deposition of (fly and bottom) ash generated after coal combustion in the coal fired power plants (CFPP) in Serbia is carried out in active and passive lagoons. Ash waste mixed with water is directly transported to the lagoon currently active and the other one is passive in the stage of temporary inactivity for technical consolidation of ash and drainage. Since revegetation improves physical and chemical characteristics of ash waste [1], it was assumed that ash and soil samples would be more appropriate to compare according to their properties if conditions for vegetation development are met. Samples were taken from the soil close to (<2 km) and further from (>2 km) CFPPs and ash from the flat area of associated passive lagoon and their basic characteristics were determined. Simultaneously, ^{238}U, ^{226}Ra, ^{210}Pb and ^{232}Th activity concentrations were measured as it is known that after elimination of the organic component of the coal in the process of combustion naturally occurring radionuclides could be enhanced up to 10 times in the coal ash. It was analysed whether there were: a) any differences between ash and soil according to measured parameters and ii) any relations between investigated radionuclides activity concentrations and basic properties regardless of sample type.

MATERIALS AND METHODS

- Area in the vicinity of four CFPPs from Serbia was under study in this work: „Nikola Tesla A" and „Nikola Tesla B" situated on the Sava River bank, TE „Kolubara" on the Kolubara River and TE "Morava" on the right bank of the Velika Morava River.
- Ash and soil were sampled from the area covered with grass from the surface horizon (0-10 cm)
- The pH-reaction, content of carbonates and organic matter were analysed using standard procedures.
- Particle size distribution analysis was conducted by combined pipette and sieve techniques.
- Activity concentrations were determined by applying the gamma spectrometry method using HPGe detectors (Canberra Industries, USA) with 18%, 20% and 50% relative efficiency and energy resolution of 1.8 keV at the 1332 keV ^{60}Co peak.

RESULTS

- The mean pH of ash (7.9) differed significantly (p<0.01) from that in soil (7.3) (Table 1)
- The mean OM and $CaCO_3$ content was not significantly different between ash and soil
- Sand particles (2000–50 µm) were most abounded in the samples of ash
- The mean content of silt, coarse (50–10 µm) and fine (10–2 µm), was not statistically different
- Mean clay (<2 µm) content was significantly higher in soil (28.3%) than in ash (3.6%).
- ^{238}U, ^{226}Ra, ^{210}Pb and ^{232}Th activity concentrations in ash and soil were comparable to the analogue results reported elsewhere [2].

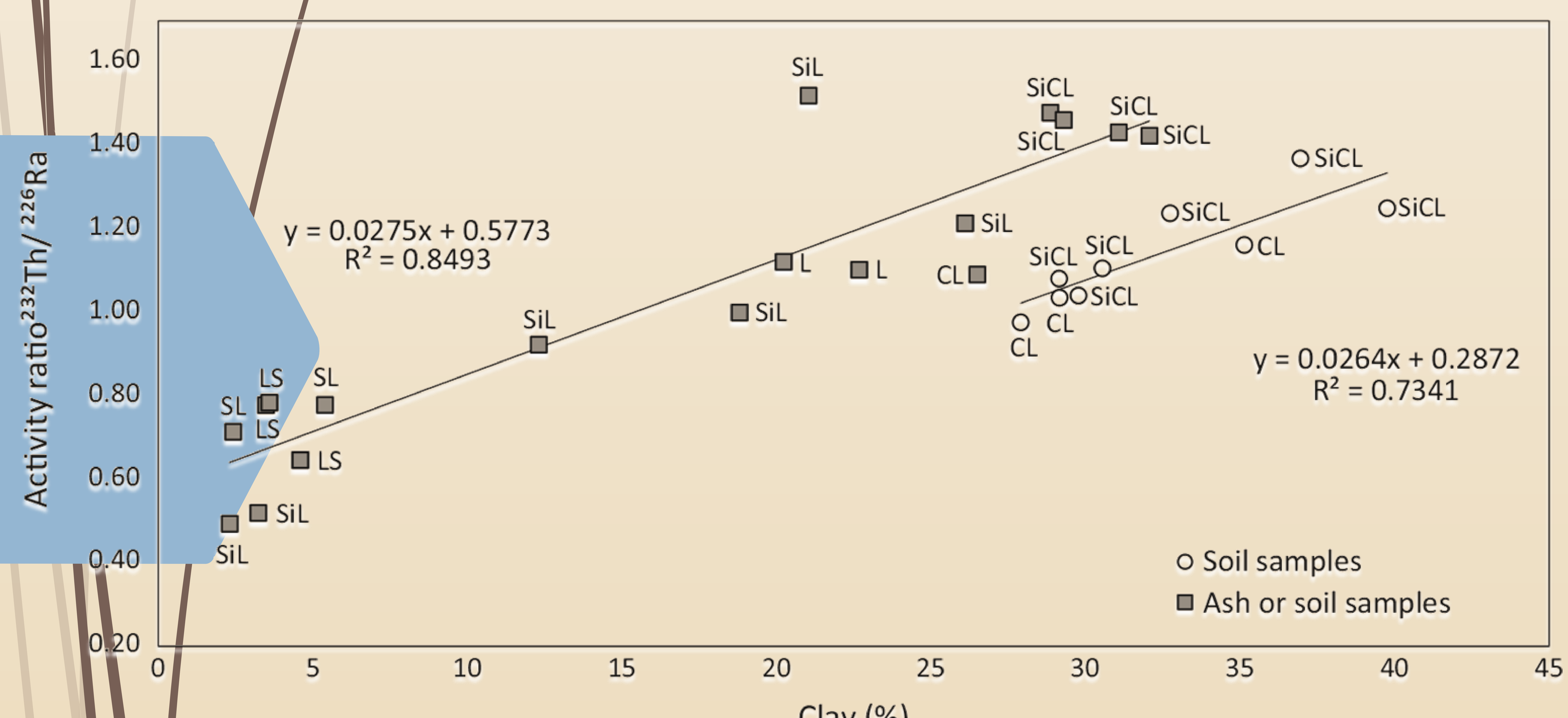

Figure 1. Changes of $^{232}Th/^{226}Ra$ activity ratios ($Bqkg^{-1}$/ $Bqkg^{-1}$) of investigated samples of soil and ash with percentages of clay (%). Texture of investigated samples was Loamy Sand (LS) and Sandy Loam (SL) for ashes and Loam (L), Silt Loam (SiL), Silty Clay Loam (SiCL) and Clay Loam (CL) for soils.

Table 1. The ANOVA test results of basic properties and natural radionuclides activity concentrations of ash and soil samples. The geometric mean (bold letters) is presented for log–normal distribution and the arithmetic mean for normal distribution.

	Soil	Ash	F –ratio	p –value
2000–50 µm (%)	**12.0** (1.6–42.3)	**56.0** (13.3–79.6)	28.22	<0.0001
2000–200 µm (%)	**6.7** (0.1–24.8)	**20.3** (2.7–43.6)	10.73	<0.01
200–50 µm (%)	**10.4** (0.1–33.5)	**35.7** (10.6–57.1)	29.63	<0.0001
50–2 µm (%)	54.7 (30.6–77.4)	36.8 (16.9–75.8)	7.7	<0.05
50–10 µm (%)	28.2 (14.1–62.6)	19.0(8.8–39.7)	-	-
10–2 µm (%)	26.4 (5.0–41.9)	17.8 (6.6–36.1)	-	-
<2µm (%)	28.3 (12.3–39.8)	3.6 (2.3–5.4)	87.39	<0.0001
<10µm (%)	54.7 (27.1–74.6)	25.0 (10.4–63.7)	21.45	<0.001
OM (%)	3.3 (1.2–5.3)	3.5 (0.6–7.3)	-	-
$CaCO_3$ (%)	**1.9** (0–15.0)	**1.5** (0–4.4)	-	-
pH (H_2O)	7.3 (6.1–7.9)	7.9 (7.3–8.4)	9.66	<0.01
pH (KCl)	6.5 (5.4–7.2)	7.5 (6.2–8.2)	15.95	<0.001
^{238}U ($Bqkg^{-1}$)	**38.2** (24–56)	**106.3** (46–190)	66.10	<0.0001
^{226}Ra ($Bqkg^{-1}$)	**38.7** (25–56)	**102.9** (42–167)	66.62	<0.0001
^{232}Th ($Bqkg^{-1}$)	**45.9** (24–71)	**73.7** (52–130)	20.3	<0.001
^{210}Pb ($Bqkg^{-1}$)	**46.5** (30–92)	**83.5** (32–258)	9.43	<0.01

- It was noticed that $^{232}Th/^{226}Ra$ activity ratios were increasing with percentages of clay
- Two statistically significant linear models were distinguished (p<0.001) (Figure 1)
- Regression line slopes were similar (α_1=0.0275 vs. α_2=0.0264)
- The intercept was about two times higher for „upper" line (β_1=0.5773 vs. β_2=0.2872)
- This suggested that $^{232}Th/^{226}Ra$ ratios are always increasing with the clay content while ^{226}Ra removal from surface layers varies between samples considering well known low mobility of ^{232}Th in the environment.

CONCLUSIONS

Differences between samples of soil and ash collected near CFPPs and coal ash disposal sites are found regarding their pH, sand and clay content, but not regarding coarse and fine silt, $CaCO_3$ and OM content at the 95% confidence level. Activity concentrations of ^{238}U, ^{226}Ra, ^{210}Pb and ^{232}Th were always significantly higher in ash than in soil as it was expected. For investigated samples, results of linar regression analyses of $^{232}Th/^{226}Ra$ activity ratios vs. percentages of clay indicated that some soils were modified due to proximity of CFPPs based on their higher radium's mobility and hence availability to plants („upper" regression line) which is different from the rest of the soils where radium is part of more resistant fractions of soil („lower" regression line).

REFERENCES

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