MONITORING OF RADIONUCLIDES IN SOIL IN THE VICINITY OF FLY ASH DEPOSITION SITES

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1. Introduction

Elevated values of activity concentration of natural radionuclides in fly ashes from coal - fired power plants are well documented [1]. Some part of coal ashes is used in a variety of application the largest of which is the manufacture of building materials. However, remarkable amounts of fly ashes and bottom slags are stored in the waste disposal sites.

The rapidly increasing quantities of wastes generated by three Lodz power plants ca. $1.7 \cdot 10^5$ Mg in 1995 are a major concern for Lodz district environment [2]. In the relatively small area of 1500 km^2 there are 21 municipal and industrial waste dumping sites. Improper management of these sites can pose threat to the underground waters as well as contamination of air and adjacent soil from the migrated dust particles.

The aim of this study was monitoring of the natural radionuclides and ^{137}Cs concentration in the vicinity of three already closed and recultivated fly ash dumping sites in order to evaluate hazard from the possible migration of fly ashes outsite the deposition site. These three sites were as follow:

1. Byszewy (site No. 13) with capacity of $3.5 \cdot 10^5$ Mg; exploited in the period of 1989 - 1990 (covered with ca. 20 cm layer of soil) and recultivated in 1991.
2. Kalonka (site No. 20) with capacity of $1.8 \cdot 10^5$ Mg; exploited in the period of 1985 - 1986 (covered with ca. 20 cm layer of soil) and recultivated in 1987 - 1988.
3. Stoki (site No. 21) with capacity of $7.0 \cdot 10^4$ Mg; exploited in 1994 (covered with ca. 20 cm layer of soil) and recultivated during next year.

2. Materials and methods

Three samples from different places within each of three dumping sites were collected from 100 cm^2 surface and 5 cm depth layer. The similar samples were also collected in 5, 10, 30 and 150 m distance from the eastern, northern and southern borders of the sites. In few cases additional samples from 5 - 10 cm and 10 - 15 cm depth were taken. Soil samples were dried at 110°C for 6 h, then sieved through 1 mm mesh to remove the roots, other organic materials and stones. Homogenized soil was weighed in typical 0.5 L Marinelli plastic containers and kept for at least 3 weeks to reach ^{226}Ra - ^{222}Rn equilibrium before counting. The 500 g soil samples were analyzed by γ - ray spectrometry in order to detect radionuclide activity concentration from ^{232}Th and ^{238}U series including ^{210}Pb as well as ^{40}K and ^{137}Cs. Radiometric analysis were carried out using the Canberra spectrometer with an REGe detector. Resolution was 0.9 keV for the 122 keV peak and relative efficiency was 20% for the 1.33 MeV peak. The spectrometer was calibrated for given geometry by addition of the mixed gamma standard SRM - 1 (POLATOM, Poland) and homogenization of the sample. Additionally the accuracy of the calibration was checked by measurement of two IAEA reference materials: IAEA - 375 (Th, U and radionuclides in soil) and RGU - 1 (U - ore, diluted with silica) and it was found that relative deviations in the activity concentrations were in $0.5 \div 8$ % range.

3. Results and discussion

The distribution of the activity concentration for several radionuclides in Kalonka dumping site and its vicinity is shown on Fig. 1. The same distribution were measured for two other sites and the average values of activity concentrations are given in Table 1.

Fig. 1. Concentration of some radionuclides in surface soil in the vicinity of Kalonka dumping site

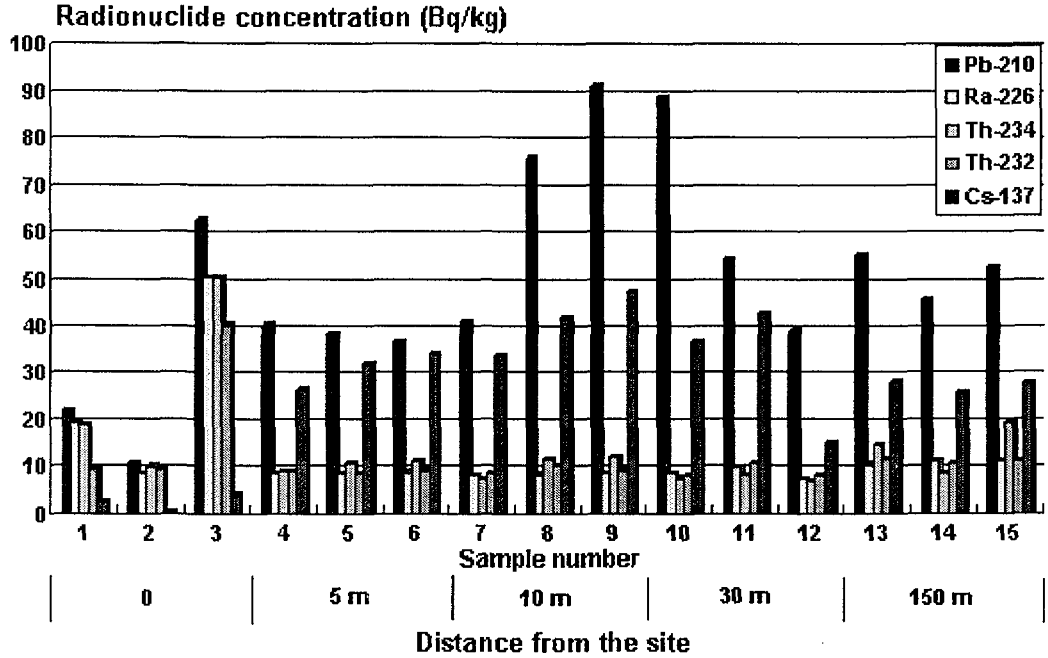

Table 1. Average radionuclide concentration in surface soil in the vicinity of two other dumping sites [Bq/kg]

Distance [m]	Byszewy						Stoki					
	^{210}Pb	$^{226}Ra^{a}$	^{234}Th	$^{232}Th^{b}$	^{137}Cs	^{40}K	^{210}Pb	$^{226}Ra^{b}$	^{234}Th	$^{232}Th^{b}$	^{137}Cs	^{40}K
Dumping site	21.5 ±0.4	14.2 ±0.1	14.2 ±0.1	15.4 ±0.2	2.8 ±0.1	316.0 ±6.2	24.5 ±0.9	23.7 ±1.1	23.1 ±0.5	22.8 ±1.0	1.1 ±0.2	331.0 ±2.5
5	24.0 ±2.5	18.2 ±2.1	20.6 ±2.6	18.3 ±1.6	2.0 ±0.1	321.7 ±14.1	20.5 ±1.7	13.1 ±0.3	15.6 ±0.2	14.6 ±0.4	4.0 ±0.1	341.0 ±3.3
10	26.4 ±1.1	21.6 ±8.0	19.8 ±2.9	17.7 ±2.2	3.8 ±0.4	335.3 ±19.9	23.8 ±1.5	14.5 ±0.5	15.8 ±1.3	15.8 ±0.1	4.5 ±0.3	347.0 ±9.1
30	15.5 ±4.2	14.6 ±2.3	13.7 ±2.1	14.1 ±1.9	1.6 ±1.4	268.7 ±27.9	24.2 ±1.9	17.9 ±0.7	20.1 ±0.7	23.4 ±0.4	1.4 ±0.4	480.0 ±29.0
150	30.1 ±2.0	12.9 ±0.8	13.7 ±0.3	14.0 ±0.3	13.4 ±1.4	302.3 ±4.6	40.6 ±10.0	35.0 ±10.3	33.6 ±8.2	29.8 ±6.6	3.9 ±2.6	414.7 ±25.8

a) $^{226}Ra = (^{214}Pb + ^{214}Bi)/2$
b) $^{232}Th = (^{208}Tl + ^{212}Pb + ^{228}Ac)/3$

As it is evident from the presented Fig. 1 and Table 1 no remarkable differences in the surface soil concentrations of radionuclides within the dumping sites and an adjacent area have been found, except of ^{210}Pb outside the Kalonka site. The average concentrations of ^{40}K, ^{232}Th and ^{234}Th were close to those determined for eastern part of Poland [3]. It proves that the vertical migration of deposited radionuclides toward surface of soil and then outside of the waste sites is negligible for Byszewy and Stoki sites. The slightly higher specific activities of ^{210}Pb in comparison to its predecessor ^{226}Ra in surface soil is a normal situation as a result of ^{222}Rn emanation from land surfaces and return of its daughter ^{210}Pb to the earth's surface [4,5]. In the case of deposited fly ashes with elevated concentrations of ^{226}Ra: 68 to 154 Bq/kg in comparison with average ^{226}Ra concentration in surface soil ca. 20 Bq/kg such emanation can be more intensive, if covering layer of soil is not sufficient. No significant differences in ^{210}Pb / ^{226}Ra ratio for surface soil within and outside of Byszewy and Stoki sites (average values 1.5 ± 0.4 and 1.35 ± 0.25, respectively) have been found. However, for Kalonka, which is upheaval type site those ratios were: 1.2 ± 0.2 and 6.3 ± 1.6 outside. The higher migration of ^{222}Rn from Kalonka site was confirmed by measurement of the soil profiles activity ratio for that site and samples taken in 150 m distance from its border. The results are shown in Table 2.

Table 2. The ^{210}Pb / ^{226}Ra ratio versus soil depth for Kalonka site

Soil depth [cm]	^{210}Pb / ^{226}Ra in Kalonka site	^{210}Pb / ^{226}Ra in 150 m distance
0 - 5	1.2	4.7
5 - 10	1.26	2.5
10 - 15	1.65	1.6

As it is evident from the Table 2 the higher values of ^{210}Pb / ^{226}Ra ratios are observed for the soil samples taken from surface to 10 cm depth outside the dumping site.

4. Conclusions

1. Determination of natural radionuclides in vicinity of the fly ash dumping site can be used for evaluation of the recultivation quality.
2. ^{210}Pb / ^{226}Ra ratio in surface soil is an useful indicator for evaluation ^{222}Rn emanation from the dumping site and consequently for Rn hazard for neighbouring population.
3. In the case of Kalonka site the additional Rn exhalation rate and Rn outdoor concentration measurements should be performed for final assessment of recultivation work quality.
4. Contamination of the soil by ^{137}Cs after Chernobyl accident is negligible for Lodz area in comparison with eastern part of Poland.

5. Acknowledgment

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6. References

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