NUKLEONIKA 2010;55(2):243–246

ORIGINAL PAPER

Influence of coal-fired power stations on the concentration of radioisotopes in the environment

Grzegorz Mazur,
Paweł Mazur

Abstract. Radioactive contamination of the environment means a higher concentration of radioisotopes with regard to background level. Undoubdtedly, the incidental or permanent emissions of radionuclides to the environment are the sources of radioactive pollution. In this connection the diversity of radioisotopes distribution in nature can be observed. The key aim of the presented work was to ascertain the presence of radioactive elements and their decay products in the environment. Nuclides were emitted by selected conventional coal-fired power plants located in the south of Poland. The samples from the neighbourhood of three power plants and a sample from "clean" territory were measured. Additionaly, we measured the concentration of ^{137}Cs istotope descended from the Chernobyl disaster.

Key words: coal-fired power plant • radioactivity • environment contamination

G. Mazur✉
College of Interfaculty Individual Studies
in Mathematics and Natural Sciences,
University of Warsaw,
93 Żwirki i Wigury Str., Room 156,
02-089 Warsaw, Poland,
Tel.: +48 22 554 0715, Fax: +48 22 554 0716,
E-mail: mazur.grzesiek@gmail.com

P. Mazur
Laboratory of Molecular Modelling,
Department of Organic Chemistry,
Institute of Chemistry,
University of Silesia,
9 Szkolna Str., 40-006 Katowice, Poland

Received: 30 September 2009

Introduction

The life in the 21st century carries the consequence of using many goods and conveniences of the technocratic world. Doubtless, electric energy is one of such good. According to the principle of conservation of energy, we have to use different sources of energy with the aim of production of electric current. Most frequently the energy contained in mineral fuels or nuclear energy is being used [6, 14]. The activity of institutions producing electricity causes the necessity of liquidation and utilization of combustion exhausts. Dusts emitted to the atmosphere by coal-fired power stations are since a pretty long time dangerous and a serious problem for the environment [7]. It seems that not only smog, but heavy metals are also emitted by the institutions burning coal as a fuel. Radioactive elements are also the product of coal combustion. The problem of building nuclear power stations causes the protests of ecologists in the world. The attention devoted to the influence of the combustion gas on the radioactivity of the environment is insufficient. Coal-fired power stations except CO_2 and NO_x emit to the atmosphere the dust which is the product of coal combustion. Coal-fired power stations spread around the pollution and moves the radioisotopes to local ecosystems at a distance of several kilometers and farther [12]. Conducted measurements aimed at elucidating the relation between the radioactivity of conventional coal-fired power stations on the terrain of Poland and the radioactivity of the environment.

Major goals

The main object of this project was to investigate the influence of coal-fired power plants on radioactive contamination of the environment in the industrial and non-industrial areas. An attempt to evaluate the share of coal-fired power station in the contamination of Polish soils with radiocaesium. In addition, the extent of radioisotope accumulation in a model mushroom species (Slippery jack) was evaluated. In addition, the authors were also trying to find probabilistic explanation of the radiocaesium influence on potassium natural equilibrium with the ^{137}Cs and ^{40}K radioisotope activities in the stipe and cap of Slippery jack. Besides, the authors were trying to find explanation of the migration way of radium and thorium decay products in the technological process of coal-fired power station.

Samples

Taking into account the availability and extent of accumulation of radioisotopes, a mushroom species, Slippery jack and forest soil, were selected as the environmental samples. The industrial samples (coal, furnace slag, electrical precipitator dust) were obtained from three coal fired-power stations. Soil samples were collected at a distance of 1 m form the mushroom fruitbodies to avoid the influence of mycelium on the composition of the soil. In addition, the caps and stipes of mushrooms were analyzed separately. Before the measurements, the furnace slag, coal, and mushrooms were dried at a temperature of 92°C and treated in order to obtain homogeneus preparations.

The environmental samples were collected in the vicinity of the following coal-fired power station: Power Station in Łagisza, Turów Power Station and Opole Power Station, "clean samples" were collected in the Świętokrzyskie Voivodeship. For the samples with volume higher than 0.5 dm^3, a Marinella container was used, for mushrooms samples cylinder geometry was used instead.

Methods applied

To achieve the goals of study, 47 environmental and industrial samples have been collected. Samples were analyzed by means of low-background semiconductor-based detectors (HPGe) made of high-purity germanium [1]. Gamma spectrometric measurements were carried out in co-operation with three laboratories. For mushrooms, the detection lasted about 2 h, for other samples 48 h. This method does not require the application of any radiochemical method. Preparation of sample, was mostly limited to the desiccation process and homogenization only.

Results

For the mushroom samples, the activity of ^{40}K and ^{137}Cs has been analyzed only, for the rest of samples, the isotopes ^{214}Bi, ^{214}Pb and ^{228}Ac were additionally

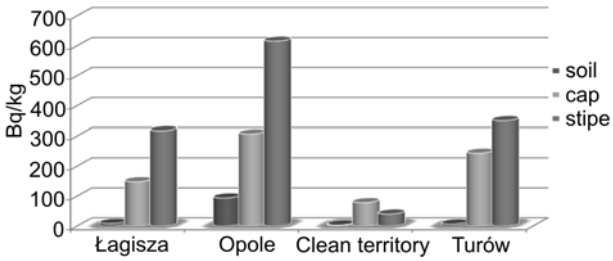

Fig. 1. Activity of ^{137}Cs in soil, stipe and cap of Slippery jack.

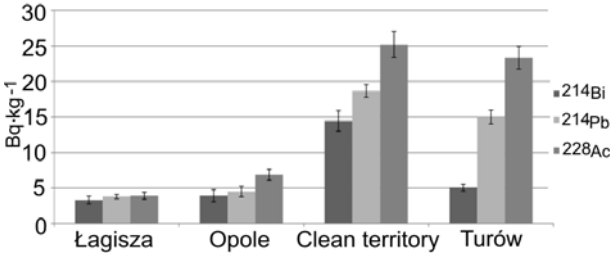

Fig. 2. Activity of ^{214}Bi, ^{214}Pb and ^{228}Ac in soil.

analyzed. Figure 3 presents the activities of potassium and caesium for stipe and cap samples. Potassium is a natural element which contains 1% of radioactive ^{40}K, and naturally occurs as the cation. Its presence is essential for the physiology of organisms, so the activity of this isotope is similar in both fungus parts. This mainly occurs due to the unequal affinity of membrane transporters to Cs^+ and K^+ [5]. Despite simple anatomy, fungal fruting body seems to show a high selectivity in the ionic transport as well. However, we can observe a decreased level of potassium, when the activity of caesium grows, this implies that caesium must be chemically similar to potassium. The problem of caesium/potassium discirmination in fungi, with respect to the group phylogenesis [3], seems to be unsolved and requiers further studies on a greater number of species (Fig. 4). A practical goal of such studies is to consider the possibility of application of mushrooms in bioremediation. Figure 3 presents the activities of these two radionuclides in the soil. The highest activity of ^{137}Cs in the soil, 100 Bq/kg, has been noticed in the Opole area. High activity of caesium in parts of Slippery jack is observed even at lower activities of the soil. In the Opole province area, the observed activity in stipe is six times higher than the activity of soils (Fig. 1). Radioactive contamination of the soils in Poland is mainly due to the Chernobyl NPP accident in 1986 [2]. We should consider if the operating of coal-fired power stations has an influence on the concentration of radioisotopes

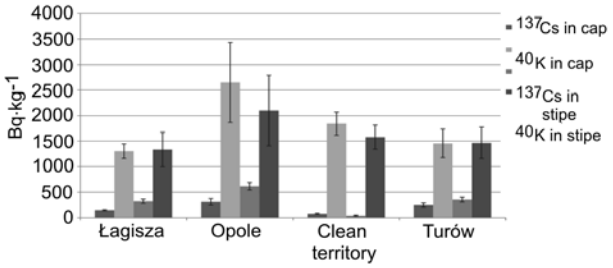

Fig. 3. Activity of ^{137}Cs and ^{40}K in cap and stipe of Slippery jack.

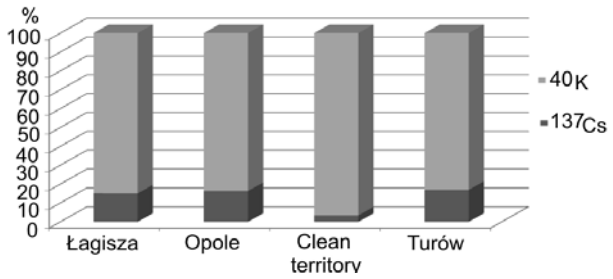

Fig. 4. Share of ^{137}Cs and ^{40}K in *Suillus luteus* (stipe and cap).

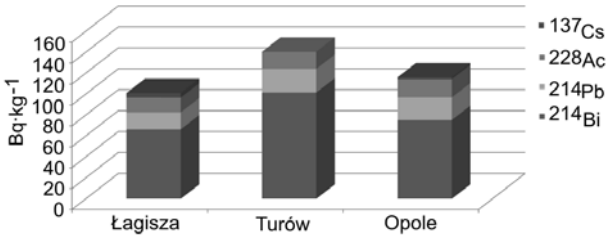

Fig. 5. The isotopic composition of selected radioisotopes in furnace slag used in the power stations involved.

in the environment. ^{228}Ac, ^{214}Pb and ^{214}Bi are the radioisotopes which were detected in the coal fuel (Fig. 1) [10]. Figure 2 shows the activities of those isotopes in the examined soil. ^{214}Pb and ^{214}Bi are in the same decay family with ^{226}Ra which is emitted by power stations with dusts [9, 11], ^{228}Ac is a daughter product of ^{232}Th and it belongs to the natural decay family. The highest measured activity of this isotopes was observed in the clean region sample. This outstanding activity is probably caused by the combustion exhausts which come from individual users of coal. Due to the high activity of ^{214}Pb, ^{214}Bi and ^{228}Ac [8] in coal from the Turów power station (Fig. 5) we can notice a high level of concentration of these isotopes. This implies that the brown coal used in the Turów Power Station is more radioactive than the hard coal used in the power station in Łagisza and power plant in Opole (Figs. 5–7).

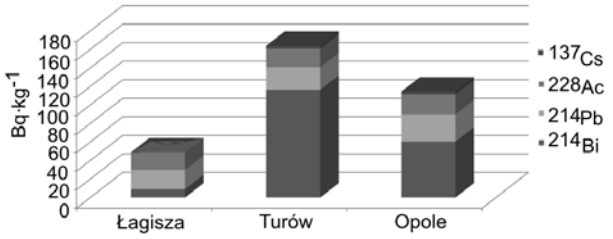

Fig. 6. The isotopic composition of selected radioisotopes in dust used in the power stations involved.

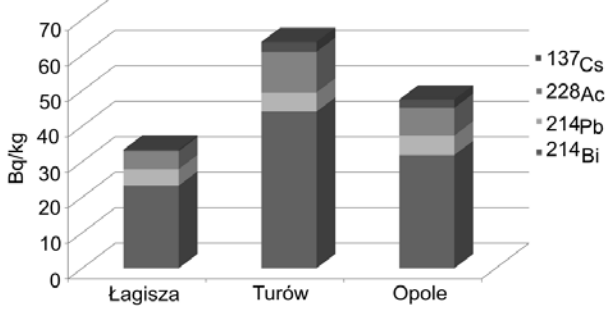

Fig 7. The isotopic composition of selected radioisotopes in coal used in the power stations involved.

Conclusions

To sum up, there is no direct evidence for any significant increase of environmental radioactivity due to the work of conventional coal-fired power stations. Although coal-fired power stations may release radioisotopes to the environement, the amounts emitted do not increase the natural background radiation provided that modern exhaust treatment systems are fitted [4]. Coal-fired power stations are not the unique consumer of coal used as combustible. There are many individual coal users who release combustions exhausts directly to the atmosphere creating a threat to the environment. Radioactive contamination of the soils in Poland is mainly due to the Chernobyl NPP accident in 1986 and nuclear weapon tests [13]. This statement is supported by the finding that the highest measured activity of ^{137}Cs was four times higher than the highest activity of ^{228}Ac, probably originating from the coal combustion. Due to the direct contact with the soil, radionuclides are strongly accumulated in the stipes of fruiting mushrooms. Mushrooms appear to be hyperaccumulators of radionuclides and their considerable activities are observed even at low background level soil contamination.

Acknowledgment. The authors would like to acknowledge the assistence of Mr Jerzy W. Mietelski, PhD, DSc from the Institute of Nuclear Physics in Kraków. Thanks are also due to Mr Michał Bazała, MSc, Mr Romuald Stęborowski, MSc and Mr Zygmunt Szefliński PhD, DSc (University of Warsaw), and Mr Jerzy Dorda, MSc (University of Silesia).

References

1. Adrovic F, Prokić M, Ninković MM, Glisić R(2004) Measurements of environmental background radiation at location of coal-fired power plants. Radiat Prot Dosim 112:439–442
2. Bazała MA, Bystrzejewska-Piotrowska G, Čipáková A (2005) Bioaccumulation of ^{137}Cs in wild mushrooms collected in Poland and Slovakia. Nukleonika 50;S1:S15–S18
3. Bystrzejewska-Piotrowska G, Urban PU, Stęborowski R (2003) Discrimination beetwen ^{137}Cs and ^{40}K in the fruiting body of wild edible mushrooms. Nukleonika 48:155–157
4. Hedvall R, Erlandsson B (1996) Radioactivity concentrations in non-nuclear industries. J Environ Radioact 32:19–31
5. Mietelski JW (2003) Nuclear spectrometry studies of bioavailability of radionuclides form "fuel-like hot particles" in forest environment. (DSc Thesis). IFJ Report no. 1921/B. IFJ, Kraków (in Polish)
6. Mishra UC (2004) Environmental impact of coal industry and thermal power plants in India. J Environ Radioact 72:35–40
7. Papastefanou C, Charalambous S (1984) On the escaping radioactivity from coal power plants (CPP). Health Phys 46:293–302
8. Papp Z, Dezso Z (2003) Estimate of the dose-increment due to outdoor exposure to gamma rays from uranium progeny deposited on the soil around a coal-fired power plant in Ajka Town, Hungary. Health Phys 84:709–717
9. Papp Z, Dezso Z, Daroczy S (2002) Significant radioactive contamination of soil around a coal-fired thermal power plant. J Environ Radioact 59:191–205

10. Peplow M (2006) Counting the dead. Nature 440:982–983
11. Pires do Rio MA, Amaral ECS, Fernandes HM, Rochedo ERR (2002) Environmental radiological impact associated with non-uranium mining industries: a proposal for screening criteria. J Environ Radioact 59:1–17
12. Shleien B (1970) An evaluation of internal radiation exposure based on dose commitments from radionuclides in milk, food and air. Health Phys 18;3:267–275
13. Sun K, Steck DJ, Field RW (2009) Field investigation of surface-deposited radon progeny as a possible predictor of the airborne radon progeny dose rate. Health Phys 97:132–144
14. Uğur A, Ozden B, Yener G *et al*. (2009) Distributions of ^{210}Pb around a uraniferous coal-fired power plant in Western Turkey. Environ Monit Assess 149:195–200