RADIATION SAFETY STUDIES OF WOODEN BURNING MATERIALS

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Introduction

The Chernobyl nuclear power plant accident resulted in radioactive pollution of forest ecosystems in Latvia and its neighbour countries with artificial radionuclides ^{137}Cs and ^{90}Sr [1]. With the growing transition to renewable energy resouces - one of which is burning of wood, wooden chips and pellets for heating, it is important to know the concentration of artificial radionuclides in used wooden fuel materials and disposed combustion ashes, as well as their compliance with EU and national radiation safety regulations.

Objectives

- Determination of artificial radionuclide ^{137}Cs and ^{90}Sr activity concentration in wooden burning materials and their ashes.
- Comparison of ^{137}Cs and ^{90}Sr activity of Latvian origin wooden burning materials with that of imported ones.
- Comparison of obtained results with allowed activity level provisioned in national regulations.

Measurement methods

Sampling. Samples for laboratory activity measurements were taken from various trees growing in Latvian ecosystem (pines, firs, birches): pieces of wood trunks and bark at various heights, birch leaves, conifer tree needles, wooden chips, their combustion ashes, as well as electrostatic air filters capturing combustion fumes. All samples were dried at 105 ºC temperature to achieve constant weight. For ^{90}Sr activity measurements, the ^{90}Sr radioactive decay daughter product ^{90}Y was extracted from samples via radiochemical methods.

^{90}Sr activity was determined by scintillation method with the Packard LSC TRI-CARB2770 beta spectrometer.

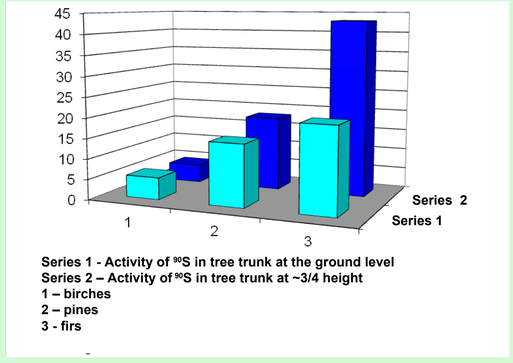
^{137}Cs activity concentration was determined with the gamma-spectrometry method using pure germanium (HPGe) detectors and Ortec gamma spectrometer. Minimal detected ^{137}Cs activity - 0.3 Bq/kg, measurement uncertainty - within 3-10 %.

In order to facilitate prompt radiation control of wooden burning materials, the experimental authomatic dosimetry gate system RDV with DoziWood software and the dose rate meter RadEye G-10 has been developed and installed at one of Riga thermal power plants. The RDV system enables testing of a wagon with wooden chips in two minutes. The minimal detected activity is 10 Bq/kg.

Results

Comparison of measured ^{90}Sr activity in the trunks and bark of pines, firs and birches at different heights (Fig.1) shows that the highest ^{90}Sr concentration is in the bark of firs, and the lowest – in the bark of birches. The ^{90}Sr concentration maximum for all trees was observed at ~3/4 height of the corresponding tree trunk.

Results of ^{137}Cs activity measurements show that in Latvian timber it varies from 2 to 60 Bq/kg. The highest ^{137}Cs concentration was determined in conifer trees, especially in their needles (Fig. 2). However, the observed ^{137}Cs activity is ~5 times lower than that of the natural ^{40}K radionuclide (Fig. 3).



^{90}Sr activity in the bark of trees in dependence form height above the ground

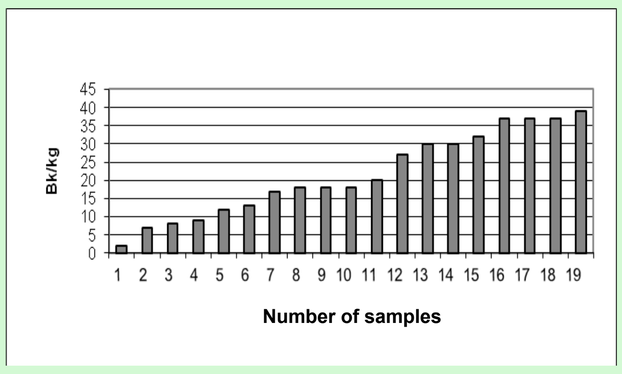


Fig. 2. ^{137}Cs activity (C) in conifer tree needles. Activity range from 2 to 39 Bq/kg, average activity C_{av}=21,6 Bq/kg

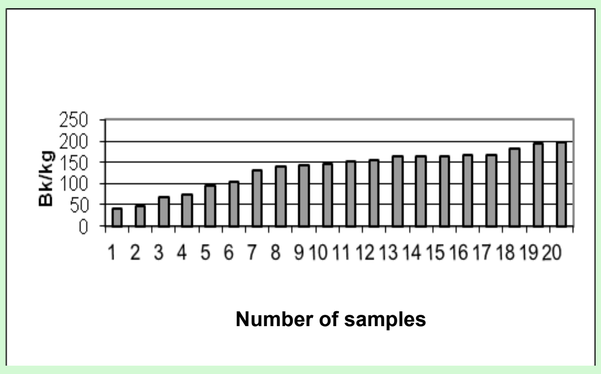


Fig. 3. ^{40}K activity (C) in conifer tree needles. Activity range from 40 to 197 Bq/kg, average activity C_{av}=135 Bq/kg

Measured activity of ^{137}Cs in wooden chips, which presently is the most used form of wooden fuel in Latvian comunal heating plants, was from 0.3 to 9.0 Bq/kg for Latvian origin chips, and from 3 to 30 Bq/kg for chips imported from Belorussia.

The ash coefficient of measured wooden chip samples was assessed to be from 1:10 up to 1:300. This coefficient depends strongly on the type of wood, as well as on the quality of fuel (e.g., if it includes tree bark, or contains mineral contaminants). Therefore, the activity of wooden ashes could be ~100 times higher than that of the used fuel. It can cause problems with ash disposal and be a source of radioactive environment pollution. Moreover, radioactivity of ashes depends not just on the level of radioactive contamination of the fuel, but also on its technological characteristics (moisture, content, mechanical properties, etc.) as well as on the type of furnace and combustion process.

Uncertainty of laboratory measurement results mostly comes from sampling due to irregular distribution of radioactivity in woodchip loads. However, the averaged monthly ^{137}Cs activity of ashes measured in the laboratory (C_{av}=2573 Bq/kg) is in good agreement with the result (C_{av}=2636 Bq/kg) obtained for ashes of the same wooden chip loads using the developed authomatic radiation gate RDV.

Conclusions

- The allowed ^{137}Cs contamination level for timber imported into Latvia to use as biomass fuel is 10 Bq/kg for dry material and 1000 Bq/kg for its ashes [2]. For disposal of ashes one should take into account the increased concentration of natural ^{40}K radioactivity as well [3]. The obtained results show that ^{137}Cs concentration in the Latvian origin wooden burning materials and their ashes is below the level provisioned in national regulations and is below the ^{40}K activity as well.
- The developed authomatic gate system allows one to perform operative radiation control of wooden fuel with minimal detected activity 10 Bq/kg which is in good agreement with laboratory measurement results.
- The measured ^{137}Cs activity of most samples of imported (from Belorussia) woodchips and their ashes exceeded the allowed level ~3 times.
- Regular radiation control should be recommended in termal plants using larger amounts of wooden fuels, especially imported from countries with high radioactive contamination risk territories.

References

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