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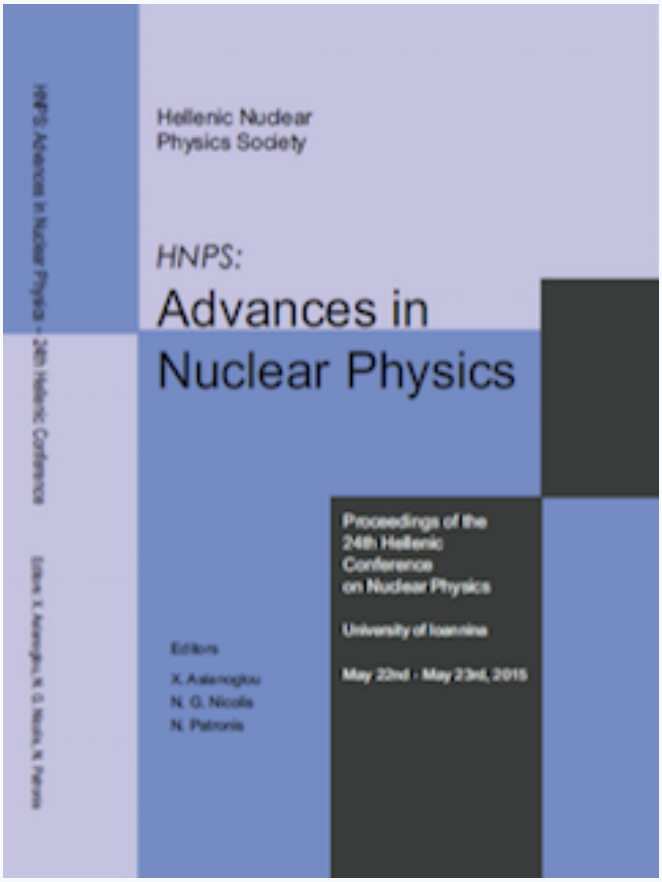

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A PRELIMINARY STUDY OF MOSSES AS BIOMONITORS OF ^{137}CS ACTIVITY IN THE AIR OF IOANNINA CITY

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Abstract Mosses were collected during the winter months of 2014 and 2015 from various locations in the center and outskirts of the city of Ioannina, to serve as biomonitors of ^{137}Cs activity released from the combustion of biomass fuel in the atmospheric air. Statistical analysis of the obtained activity concentrations revealed differences between sampling locations and sampling periods, which may be attributed to different practices in the use of wood and wood by-products fuel for household heating.

Keywords mosses, wood combustion, air pollution, ^{137}Cs activity, Ioannina

INTRODUCTION

Mosses are considered as excellent bio-monitors of atmospheric heavy metals [1], persistent organic pollutants (POPs) [2] and radioactive contamination from both natural and artificial sources [3-5]. Among the pollutants released in the atmosphere, the long-lived radioactive isotope ^{137}Cs was a major component of the fallout from the Chernobyl accident, introduced into the forest ecosystems of Europe. The ongoing recession, which hit Greece after 2009, among other implications, has forced the residents of urban areas to turn from oil to wood for domestic heating due to oil price rise following over-taxation [6]. Numerous households turned to the cheapest unprocessed or processed wood and wood by-products, due to lower tax. However, the combustion of wood has led to the deterioration of urban air quality during the winter months [7].

The objective of the present study was the measurement of ^{137}Cs activities in mosses collected in the center and outskirts of the city of Ioannina in order to monitor the radioactivity released in the atmospheric air from the combustion of biomass fuels.

EXPERIMENTAL DETAILS

During the winter months of the years 2014 and 2015, moss samples of about 40 g dry weight were placed into cylindrical plastic containers and were measured using a broad energy range HPGe detector (Canberra BE3825) with a relative efficiency of 26 %, and an energy resolution of 1.9 keV at 1.33 MeV. Acquired spectra were used to calculate ^{137}Cs activity concentration in mosses, analyzing the 661.66 keV photo-peak (Fig.1).

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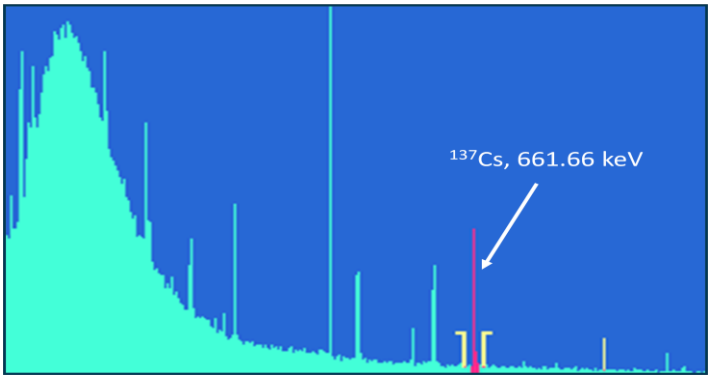

Fig. 1. A typical gamma-ray energy spectrum, showing the ^{137}Cs peak in a moss sample

RESULTS AND DISCUSSION

The activity concentration of ^{137}Cs (Table 1) measured in mosses collected in the winter of 2014 ranged from 1.3 to 43.8 Bq/kg in the city-center and from 3.7 to 32.2 Bq/kg in the city outskirts. In 2015, the ranges were 1.8-15.2 Bq/kg in the city-center and 8.9-21.2 Bq/kg in the city outskirts. Mean values and ranges are presented graphically in Fig.2.

Variations in activity concentrations between sampling locations and sampling periods were examined through a Students' t-test. No statistically significant difference between the city-center and city outskirts was evidenced in the winter of 2014, while activity concentrations were significantly lower in the city-center compared to the city outskirts in the winter of 2015 (see Table 1, Fig. 2). Activity concentrations in the city-center were also significantly lower in 2015 compared to 2014, while in the city outskirts no statistically significant differences between the two sampling periods was observed.

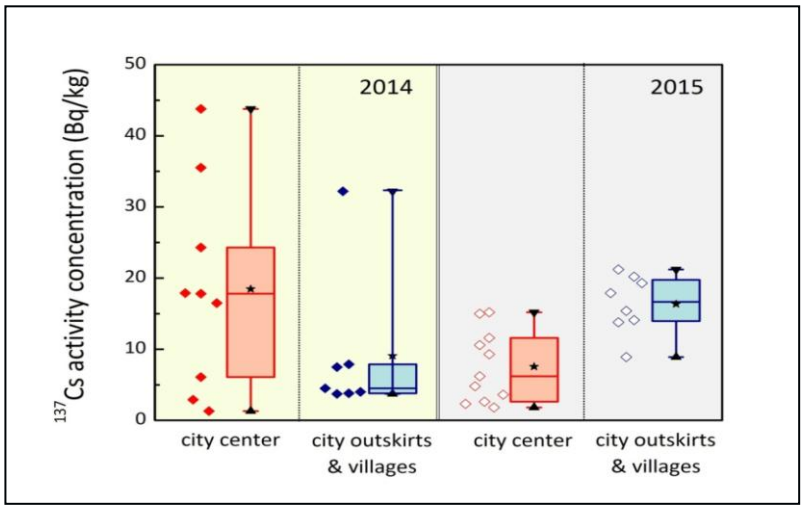

Fig. 2: ^{137}Cs activity concentrations measured in mosses at the city of Ioannina. Boxes and whiskers indicate the 25%-75% and 5%-95% range of the data distribution, respectively.

Table 1: Activity concentrations of ^{137}Cs measured in mosses at different locations and different sampling periods. Mean values, standard deviations (SD) and ranges (Min-Max) are given in Bq/kg. Statistically significant differences, established through students' t-tests, are also indicated.

		^{137}Cs concentrations (Bg/kg)		
Winter	Location	Mean	SD	Min-Max
2014	City center	18.4*	14.4	1.3-43.8
	City outskirts & villages	9.1	10.3	3.7-32.2
2015	City center	7.5*,**	5.0	1.8-15.2
	City outskirts & villages	16.4**	4.1	8.9-21.2

CONCLUSIONS

The differences in ^{137}Cs concentrations observed during this study are attributed to the locations of the collected samples (city center/dense population, city-outskirts/less dense population, villages/less population/wood burning the sole heating energy source). Findings indicate that ^{137}Cs air radioactivity concentrations in the city center were reduced in 2015, which may be attributed to the decrease of the over-taxation of heating oil and the decrease of the use of wood and wood by-products fuel for household heating. In the city outskirts, however, where wood burning may be the main heating energy source, the phenomenon was not observed.

The presence of ^{137}Cs in the air indicates the presence of excess wood smoke particles, which are associated with a range of negative health effects, including increased morbidity and mortality from pulmonary and cardiovascular diseases [8, 9]. Recently, the International Agency for Research on Cancer (IARC) has classified indoor emissions from household combustion of biomass fuel (mainly wood) as probably carcinogenic to humans [9]. In conclusion, the resulting air pollution due to wood combustion and the consequent health problems in the community are some of the serious side-effects of the financial crisis.

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