Content of $^{90}\text{Sr}$ and $^{137}\text{Cs}$ in Sediments and Soils from the Vicinity of the NPP Kozloduy during the Period 2008–2010

R. Kotova, R. Kamenova-Totzeva, V. Badulin
National Center of Radiobiology and Radiation Protection, 3 Sv. Georgi Sofiyski Str., 1606 Sofia, Bulgaria

Abstract. The systemic radiation monitoring of the environment in the vicinity of the Kozloduy NPP is exceptionally significant part of the radiation protection. For monitoring purposes and in accordance with the control program annually samples are being analyzed to determine the content of anthropogenic long-lived radionuclides of a biological significance such as $^{90}\text{Sr}$ and $^{137}\text{Cs}$. The goal of performing radio-ecological studies is to assess the impact of gaseous and liquid effluents during the normal operation of the nuclear power plant and to determine the potential radiological risk to the population in this region and to the population as a whole.

In this paper are presented the results from the analyses of the content of $^{90}\text{Sr}$ and $^{137}\text{Cs}$ in soils and bottom sediments at 17 sampling sites, located from 6 to 90 km around the Kozloduy NPP in four Bulgarian districts. The obtained results of the investigation and analyses for the period 2008–2010 are shown in tables and figures. Annual results are compared with those from previous years, as well as with data from the pre-operational period of the Kozloduy NPP.

Keywords: NPP Kozloduy, soils, bottom sediments, $^{90}\text{Sr}$, $^{137}\text{Cs}$.

1 Introduction

Since 1972 until now National Centre of Radiobiology and Radiation Protection (NCRRP) in Sofia carries out systemic radiation monitoring and control of environmental objects in the vicinity of the Kozloduy NPP [1–7].

The main goal of this work is to present the obtained results from the investigation of the content of anthropogenic long-lived radionuclides of a biological significance such as $^{90}\text{Sr}$ and $^{137}\text{Cs}$ in environmental objects. These radioisotopes should be most closely guarded against release into the environment. They both have half-lives of around 30 years, which is the worst range for half-lives of radioactive contaminants. In a study of bottom sediments important information is obtained about the accumulation of radionuclides in aquatic ecosystems and soils research provides information on the accumulation of radionuclides in the terrestrial ecosystem.

Bottom sediments and soils are being analyzed to determine the content of $^{90}\text{Sr}$ and $^{137}\text{Cs}$ for three years period 2008–2010. The samples were collected at 17 points in the surveillance zone – from 6 to 90 km in the region of the nuclear plant. Sampling sites are located in four Bulgarian districts – Vidin, Montana, Vratsa and Pleven. The annual results are compared with those from previous years, as well as with the data from the pre-operational period of the Kozloduy NPP.

2 Materials and Methods

Sites of sampling included in the monitoring program are selected on the basis of demographic and meteorological characteristics of the area and sampling points are located at a distance of 6 km to 90 km from the NPP. They are shown in Figure 1.

Bottom sediments were collected from the internal rivers – Tsibritsa, Ogosta, Lom and Iskar and from the upper and lower stream of the Danube, to the location of the Kozloduy NPP. Uncultivated soils were examined as the content of $^{90}\text{Sr}$ and $^{137}\text{Cs}$ is defined in the surface layer of a thickness of 10 cm. The soils of the sampling points on the Danube river are soils of land flooded by the river. For the period 2008–2010 are analyzed as a total of 153 soils and bottom sediments (Table 1), sampling twice per year in spring and autumn. The total number of the analyses is 266.

After sampling the soils and bottom sediments are air dried, cleared out of stones, roots and other impurities.
Content of $^{90}\text{Sr}$ and $^{137}\text{Cs}$ in Sediments and Soils from the Vicinity of the NPP Kozloduy during the Period 2008-2010

Table 1. Analytical methods for analyses of environmental objects

<table>
<thead>
<tr>
<th>Environmental objects</th>
<th>Number of samples</th>
<th>Gamma spectrometry of $^{137}\text{Cs}$</th>
<th>Radiochemistry of $^{90}\text{Sr}$</th>
<th>Total number of analyzes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom sediments</td>
<td>55</td>
<td>IEC 61452 (1995-09)</td>
<td>ILVM$^a$</td>
<td>110</td>
</tr>
<tr>
<td>Soils</td>
<td>78</td>
<td>IEC 61452 (1995-09)</td>
<td>ILVM$^a$</td>
<td>156</td>
</tr>
</tbody>
</table>

Note: $^a$ ILVM – Internal laboratory validated method

The accuracy of all applied analytical procedures is systematically checked by participation in national and international inter-laboratory comparisons organized by IAEA, IRRM, WHO and etc. [9,10].

3 Results and Discussion

The annual results from the analysis to determine of the activity concentration of $^{90}\text{Sr}$ and $^{137}\text{Cs}$ in bottom sediments are presented in Figures 4 and 5 and for soils samples – in Figures 6 and 7. The obtained results for the period 2008-2010 are shown and compared with the upper limit of natural background content of $^{90}\text{Sr}$ and $^{137}\text{Cs}$ in bottom sediments and soils with a bold red line on the same figures.

3.1 Bottom sediments

The annual content of $^{90}\text{Sr}$ (Figure 4) in bottom sediments from the Danube varies within the ranges from 0.21 ± 0.06 Bq/kg$^1$ (Ostrov, 2008) to 0.81 ± 0.09 Bq/kg$^1$ (Novoselo, 2009). The annual content of $^{137}\text{Cs}$ (Figure 5) is between 4.02 ± 3.87 Bq/kg$^1$ (Baykal, 2010) to 29.33 ± 4.70 Bq/kg$^1$ (NPP, 2008). In terms of the internal rivers the content of $^{90}\text{Sr}$ is in the range of 0.22 ± 0.08 Bq/kg$^1$ at the river Tsibritsa (2008) to 1.26 ± 0.14 Bq/kg$^1$ at the river Lom (2009). The annual content of $^{137}\text{Cs}$ is between 1.58 ± 0.71 Bq/kg$^1$ at the river Tsibritsa (2010) to 10.98 ± 0.81 Bq/kg$^1$ at the river Lom (2008).

In previous years [5-7] (2003-2007) the annual content of $^{90}\text{Sr}$ in bottom sediments from the Danube is in the ranges of 0.14 ± 0.05 Bq/kg$^1$ (Baykal, 2003) to 0.50 ± 0.08 Bq/kg$^1$ (NPP, 2006) and from 0.20 ± 0.05 Bq/kg$^1$ at the river Tsibritsa (2005) to 0.81 ± 0.08 Bq/kg$^1$ at the river Lom (Lom, 2007) for the internal rivers. The annual content of $^{137}\text{Cs}$ varies between 0.86 ± 0.25 Bq/kg$^1$ (Lom, 2007) to 40.97 ± 28.70 Bq/kg$^1$ (NPP, 2005) for the Danube and from 1.95 ± 0.91 Bq/kg$^1$ at the river Tsibritsa (2007) to 16.30 ± 15.41 Bq/kg$^1$ at the river Lom (2005) for the internal rivers [5,7].

The annual concentrations of $^{90}\text{Sr}$ in bottom sediments are in the range of values recorded in the previous periods [4-7] and are lower than the measured in pre-operational period of the plant – 5.4 ± 0.2 Bq/kg$^1$ for the internal rivers and 2.6 ± 0.6 Bq/kg$^1$ for the Danube [1]. In com-
Figure 4. Annual content of $^{90}$Sr in bottom sediments from the region of the Kozloduy NPP.

Figure 5. Annual content of $^{137}$Cs in bottom sediments from the region of the Kozloduy NPP.
Content of $^{90}\text{Sr}$ and $^{137}\text{Cs}$ in Sediments and Soils from the Vicinity of the NPP Kozloduy during the Period 2008-2010

Figure 6. Annual content of $^{90}\text{Sr}$ in soils from the region of the Kozloduy NPP.

Figure 7. Annual content of $^{137}\text{Cs}$ in soils from the region of the Kozloduy NPP.
parison with $^{90}$Sr the registered concentrations of $^{137}$Cs in bottom sediments continue to remain higher as a result of the global fallout and the Chernobyl accident than the measured values in pre-operational period of the plant – $5.6 \pm 0.4$ Bq/kg$^{-1}$ for the internal rivers and $3.6 \pm 1.4$ Bq/kg$^{-1}$ for the Danube [1].

3.2 Soils

The annual content of $^{90}$Sr in soils (Figure 6) from the region of NPP Kozloduy is between $0.14 \pm 0.06$ Bq/kg$^{-1}$ (Lom, the Danube, 2009) to $2.93 \pm 0.13$ Bq/kg$^{-1}$ (Novo selo, the Danube, 2010). The annual content of $^{137}$Cs (Figure 7) varies in more widely ranges than $^{90}$Sr – from $1.35 \pm 0.17$ Bq/kg$^{-1}$ (Cherven bryag, 2009) to $50.15 \pm 13.79$ Bq/kg$^{-1}$ (Kozloduy, the Danube, 2008).

In previous years [5-7] (2003-2007) the annual content of $^{90}$Sr in soils is in the ranges of $0.23 \pm 0.06$ Bq/kg$^{-1}$ (Baykal, the Danube, 2005) to $3.96 \pm 0.49$ Bq/kg$^{-1}$ (Novo selo, the Danube, 2004). The annual content of $^{137}$Cs in soils also varies in more widely ranges from $2.09 \pm 0.27$ Bq/kg$^{-1}$ (Pelovo, the Iskar river, 2005) to $82.50 \pm 17.68$ Bq/kg$^{-1}$ (Novo selo, the Danube, 2004) [5,7].

The annual concentrations of $^{90}$Sr in soils are in the range of values recorded in the previous periods [4-7] and are commensurable with the measured in pre-operational period of the plant – $5.0 \pm 0.4$ Bq/kg$^{-1}$ [1]. In comparison with $^{90}$Sr the registered concentrations of $^{137}$Cs in soils continue to remain higher as a result of the global fallout and the Chernobyl accident than the measured values in pre-operational period of the plant – $7.6 \pm 0.6$ Bq/kg$^{-1}$ [1].

4 Conclusions

• During the period 2008-2010 the obtained results for content of $^{90}$Sr and $^{137}$Cs in analyzed bottom sediments and soils are below the upper limit of the background content of these radionuclides in environmental objects.

• The results of the analysis of the content of $^{90}$Sr and $^{137}$Cs in soils in the area of the Kozloduy NPP show that there are no considerable quantitative changes registered, caused by radioactive gaseous discharges from the plant. They do not produce any noticeable changes of natural background [11], originating from atmospheric nuclear weapons tests and the Chernobyl accident. Therefore for the period 2008-2010 radioactive atmospheric gaseous discharges from the NPP did not influence the concentration of radionuclides in objects from the terrestrial ecosystem.

• Do not register quantitative changes caused by liquid radioactive discharges from nuclear power plant over the content of $^{90}$Sr and $^{137}$Cs in the bottom sediments of the internal rivers and of the Danube in the period 2008-2010. The measured concentrations of $^{90}$Sr and $^{137}$Cs in bottom sediments attest to the lack of influence of liquid radioactive discharges from the Kozloduy NPP on the content of $^{90}$Sr and $^{137}$Cs in objects from the aquatic ecosystem.

• Annual exposure of the critical group of members of the public resulting from liquid radioactive discharges, estimated as individual dose for screening purposes, does not exceed $10^{-6}$ Sv/a, therefore presenting little risk to the population even with conservative risk assessment estimates.

References


