Five Years of Monitoring Cs-137 And Cs-134 In Moss And Soil Samples In The Campania Region Of Italy After The Chernobyl Accident.

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INTRODUCTION

In Italy of May 1986 after the Chernobyl accident the whole deposition of Cs-137 was between 185 kBq/m² and 40 kBq/m² only in same regions of Northern Italy (Friuli-Venezia-Giulia, Lombardy, Piedmont) and between 40 kBq/m² and 1 kBq/m² in the other regions, the highest values were recorded in the central regions of Umbria, Marche, Campania (1).

The Department of Environmental Radioactivity of the Central Laboratory of the Italian Red Cross belongs to the National Network for the Monitoring of the Environmental Radioactivity in Italy, co-ordinated by the National Environmental Agency (ANPA). The Department of Environmental Radioactivity took part in the National Campaigns for the monitoring of the environmental gamma radioactivity to evaluate the deposit of artificial radioactivity on the Italian territory after the Chernobyl accident.

Studying the soil in order to evaluate the radiocontamination of an area has always been a priority in this kind of analyses checking the soil requires complex sampling and measuring methods and needs long elaboration time because of the geological composition of rocks with natural radioisotopes (2).

The experience carried out at national and international level demonstrated that mosses can be used to map the radioactive fall-out (3).

Studies were also done on mosses which appeared to have some advantages with respect to lichens. In particular, living organisms by bioindicators have been used as mosses (bryophytes) (4).

Mosses are organisms that contain of chlorophyll and therefore photosynthetic. Mosses generally live in environmental sub-air, they do not have roots and a vascular system to allow the transport of material from substratum through diffusion and absorption the water from the atmosphere (5).

After the Chernobyl accident the situation of artificial deposition in Italy has changed considerably. In order to make a new map of radioactivity contamination in the soil, the radioecological campaigns were organised all over the Italian territory to initiate a completely new zero point in Italian regions (6).

The present work aimed at using specific types of mosses which act as a passive devise to collect radioactive particles. Mosses are found in all mountain ecosystems in Italy and in other countries. Soil and moss samples were taken from the same sites.

In this study Hypnum cupressiforme and Homalotecium sericeum mosses were used as bioindicators, available in all Italian ecosystems. The soil and moss samples were gathered according to a national standard procedure (7,8).

The monitoring of gamma radioactivity for the Campania region (Central Italy) was delegated to the Department of Environmental Radioactivity in co-operation with the Ministry of Agriculture and Forestry and with the help of the Department of the State Forestry Corp of Campania.

This paper presents the first data of the concentration of the artificial radionuclides Cs-137 and Cs-134 in mosses and soils collected in the Campania region in four different localities (S.Gregorio Matese, Laviano, Piaggine and Vesuvio) after the fallout of the Chernobyl accident. The data refer to the surveys carried out from 1992 to 1998.

MATERIALS AND METHODS

During this research four campaigns for the monitoring of the environmental gamma radioactivity were done in the years 1992/93, 1993/94, 1995/96, 1997/98. The measures reported in this paper are referred to 140 samples of mosses and 20 samples of soil.

The mosses and soil were collected in four States Forest Corp in the provinces of Salerno, Caserta and Napoli at Laviano, Piaggine, S.Gregorio Matese and Vesuvio. The sampling sites chosen were all located at the centre of open flat areas away from trees or buildings.

The 1st Campaign concerned the site of S.Gregorio Matese, while the other campaigns were carried out also in the sites of Laviano, Piaggine and Vesuvio. In the 1st and 2nd Campaign only moss samples were gathered 15 in each site altogether.

In the 3rd Campaign both 15 moss samples and representative composite samples in each site were gathered. In the 4th Campaign both mosses and soil were gather for the analysis of composites (Tab. 1).
Table 1. Monitoring Campaigns in the region of Campania
(M=moss – Mc= moss composite - S=soil – Sc= soil composite)

<table>
<thead>
<tr>
<th>Year</th>
<th>Campaign I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992-93</td>
<td>M</td>
<td>M</td>
<td>M &amp; Mc</td>
<td>Mc &amp; Sc</td>
</tr>
<tr>
<td>1993-94</td>
<td>M</td>
<td>M</td>
<td>M &amp; Mc</td>
<td>Mc &amp; Sc</td>
</tr>
<tr>
<td>1995-96</td>
<td>M</td>
<td>M</td>
<td>M &amp; Mc</td>
<td>Mc &amp; Sc</td>
</tr>
<tr>
<td>1997-98</td>
<td>M</td>
<td>M</td>
<td>M &amp; Mc</td>
<td>Mc &amp; Sc</td>
</tr>
</tbody>
</table>

The species of the mosses picked up are *Hypnum cupressiforme* and *Homalotecium sericeum* because they are perennial (Fig. 1, 2).

Figure 1. *Hypnum cupressiforme*  
Figure 2. *Homalotecium sericeum*

The samples were gathered in late autumn (November – December) from rocks and show horizontal growth, with formation of carpet thickness between 2 - 4 centimetres. The samples have not received any chemical treatment and after drying up in the open air have been utilised. The moss samples were gathered according to a national standard procedure (7).

The treatment of the soil samples was directed at gathering a representative sample of the quantity of soil taken in order to evaluate the concentration of the radionuclides deposited (composite sample). Five samples per site were gathered at a distance of 10 metres one another: 4 samples at the angles of a square and 1 samples at the centre of the square. The soil samples were gathered mying 0.0225 m² and 0.0625 m² surface templates.

All samples were weighed on site (fresh weight). Later the samples were dried up-when (dried weight) they reached the constant weight a 2mm sieving was carried out. All the material discarded (skeleton) was weighed and put away in order to assess the value of the surface measured.

The samples of mosses and soil underwent gamma ray spectrometry analysis. The measures were carried out using high purity Germanium detector (Hp), relative efficiency 25 %, in a well of 10 centimetres thick lead. A detector was calibrated using a calibration standard in the liquid form (Marinelli 1000cc and 500cc) through the participation in National Intercomparison. For the samples, the counting error is expressed with an accuracy of ###1%. Consequently the samples were placed in Marinelli Beakers in the volume of 500cc and 1000cc. The count time was 72,000 sec (20 hours). The environmental background was excluded from all the measures.

The concentration of the artificial Cs-137 and C-134 radionuclides of mosses and in the soil was reported on the 1st July of each year and is expressed in Bq/m². The counting time, which is ratherlong, allowed to obtain a standard deviation with a peak of height intensity of Cs-134 of ###10%.
RESULTS AND DISCUSSION

The following results, concerning the two radionuclides, were obtained from the gamma spectrometry analysis of moss samples:

1992/93 (1st National Campaign – S.Gregorio Matese) the average regional concentration value for Cs-137 was 528.70 Bq/m$^2$ and for Cs-134 was 30.05 Bq/m$^2$ (9).

1993/94 (2nd National Campaign) the average concentration values were: 561.80 Bq/m$^2$ of Cs-137 and 24.94 Bq/m$^2$ of Cs-134 (S.Gregorio); 368.16 Bq/m$^2$ of Cs-137 and 18.30 Bq/m$^2$ of Cs-134 (Laviano); 308.90 Bq/m$^2$ of Cs-137 and 12.73 Bq/m$^2$ of Cs-134 (Piaggine); 248.93 Bq/m$^2$ of Cs-137 and 10.64 Bq/m$^2$ of Cs-134 (Vesuvio) (Fig.3).

The average regional concentration value for Cs-137 was 371.95 Bq/m$^2$ and for Cs-134 of 16.6 Bq/m$^2$.

1995/96 (3rd National Campaign - S.Gregorio Matese, Laviano, Piaggine and Vesuvio) the average concentration values were: 296.97 Bq/m$^2$ of Cs-137 and 0.14 Bq/m$^2$ of Cs-134 (S.Gregorio); 51.90 Bq/m$^2$ of Cs-137 and 0.09 Bq/m$^2$ of Cs-134 (Laviano); 303.90 Bq/m$^2$ of Cs-137 and 3.77 Bq/m$^2$ of Cs-134 (Piaggine); 280.35 Bq/m$^2$ of Cs-137 and 5.36 Bq/m$^2$ of Cs-134 (Vesuvio) (Fig.4).

The average regional concentration value for Cs-137 was 233.28 Bq/m$^2$ and for Cs-134 of 2.34 Bq/m$^2$. 

Figure 3. Values of the means of Cs-17 and Cs-134 in mosses in four localities (Campania region - Italy). 

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3
n the 3rd Campaign also moss composite samples were examined. The average concentration values were: 132 Bq/m² of Cs-137 and 0.07 Bq/m² of Cs-134 (S.Gregorio); 21.12 Bq/m² of Cs-137 and 0.93 Bq/m² of Cs-134 (Laviano); 132.59 Bq/m² of Cs-137 and 5.57 Bq/m² of Cs-134 (Piaggine); 119.59 Bq/m² of Cs-137 and 5.11 Bq/m² of Cs-134 (Vesuvio).

1997/98 (4th Campaign) only moss composite samples were examined. The average concentration values were: 131.99 Bq/m² of Cs-137 and 0.78 Bq/m² of Cs-134 (S.Gregorio); 42.81 Bq/m² of Cs-137 and 0.18 Bq/m² of Cs-134 (Laviano); 105.13 Bq/m² of Cs-137 and 0.85 Bq/m² of Cs-134 (Piaggine); 410.75 Bq/m² of Cs-137 and 0.03 Bq/m² of Cs-134 (Vesuvio) (Fig.5).

The average regional concentration value for Cs-137 was: 172.67 Bq/m² and for Cs-134 was lower than the minimum detectable activity (M.D.A.).

In the 4th Campaign the following results, concerning the two radionuclides, were obtained from the gamma spectrometry analysis of soil composite samples: 1500.9 Bq/m² of Cs-137 and 1.72 Bq/m² of Cs-134 (S.Gregorio); 459.93 Bq/m² of Cs-137 and 1.5 Bq/m² of Cs-134 (Laviano); 329.60 Bq/m² of Cs-137 and 1.3 Bq/m² of Cs-134 (Piaggine); 1882.80 Bq/m² of Cs-137 and 6 Bq/m² of Cs-134 (Vesuvio) (Fig.6).

The average regional concentration value for Cs-137 was: 1043.31 Bq/m² and for Cs-134 was lower than the minimum detectable activity (M.D.A.).
Figure 6. Values of the means of Cs-17 and Cs-134 in soils in four location (Campania region - Italy).

In the samples examined the value of M.D.A. of Cs-134 (0.13 Bq/kg) was given to calculate the evaluation of the mean.

All the data of the four campaigns show a decrease of Cs-137 concentration; this is more noticeable in some localities. In particular the localities of S. Gregorio Matese and Laviano show a similar trend. Piaggine indicates decrease only in the last campaign. Vesuvio presents an unusual trend.

The trend of Cs-134 values is more uniform, but for Piaggine and Vesuvio this decrease is less evident (Fig.7, 8).

Figure 7. Trend of the mean of Cs-137 in four localities during four campaigns.
CONCLUSION

The first relevant datum is that, in the Italian region of Campania the average Cs-137 value found at S.Gregorio Matese in the 1st National Moss Campaign 1992/93 is comparable to the one of the region of Latium in the same campaign, and confirm the estimated rainfall data in Italy in 1986 after the Cernobyl accident (6) (Fig.9,10).

Fig. 8. Trend of the mean of Cs-137 in four localities during four campaigns.

Fig. 9. Map of fallout in Central Italy after Chernobyl

Fig. 10. Map of fallout in Italy after Chernobyl.

(From Atlas of Caesium 137 contamination of Europe after the Chernobyl accident EUR 16733 - 1996 (1).)
Our data of the 1st National Moss Campaign are according to those of the other Regional Laboratories of the National Network (Table 2).

<table>
<thead>
<tr>
<th>REGION</th>
<th>Cs-137 (Bq/m²)</th>
<th>Cs-134 (Bq/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOMBARDY</td>
<td>6,000</td>
<td>400</td>
</tr>
<tr>
<td>PIDMONT</td>
<td>5,800</td>
<td>400</td>
</tr>
<tr>
<td>FRIULI-V.GIULIA</td>
<td>5,400</td>
<td>380</td>
</tr>
<tr>
<td>TRENTINO</td>
<td>3,500</td>
<td>250</td>
</tr>
<tr>
<td>VENETO</td>
<td>3,000</td>
<td>210</td>
</tr>
<tr>
<td>VALLE D’AOSTA</td>
<td>1,300</td>
<td>90</td>
</tr>
<tr>
<td>E.ROMAGNA</td>
<td>940</td>
<td>70</td>
</tr>
<tr>
<td>ALTO ADIGE</td>
<td>750</td>
<td>50</td>
</tr>
<tr>
<td>CAMPANIA</td>
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<td>30</td>
</tr>
<tr>
<td>LATIUM</td>
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<td>35</td>
</tr>
<tr>
<td>UMBRIA</td>
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<td>25</td>
</tr>
<tr>
<td>TUSCANY</td>
<td>330</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 2. Cs-137 and Cs-134 activity in mosses in different regions of Italy in 1992/1993 (6).

here is a decrease of Cs-134 in the 4 localities. The lowest detectable activity found in the last campaign confirms the radioactive decay time of this radionuclide (2.062 years) (10).

oreover the different results found in the localities of S. Gregorio and Laviano in comparison with those ones of Piaggine and Vesuvio could be due to differences in the exposure and characteristics of the soil.

n this work are presented the first values obtained from the study of soil and mosses, bioindicators of radiocontamination. Nation-wide standardised methods were applied. We are currently working on the relevance of the differences found between the results of the means of the gamma spectrometric analyses done on 15 moss samples and on the composite samples of both mosses and soil.

ith these results it was possible to evaluate the zero point value of Cs-137 and Cs-134 in Campania following the fallout after the Chernobyl accident and monitor the trend up to 1998.

urther studies are in progress in order to compare our data with the results obtain from the National Network.

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