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R. PADOVANI, C. GIOVANI, M.R. MALISAN, C. BINI, S. CESCO, †A. MAGGIONI, C. MONDINI

## ASSESSMENTS OF PARAMETERS AFFECTING CAESIUM TRANSFER FROM SOIL TO PLANTS IN MOUNTAIN AREAS OF N.E. ITALY

### INDAGINE SUI PARAMETRI CHE INFLUENZANO IL TRASFERIMENTO SUOLO-PIANTE DEL CESIO IN AREE MONTANE DEL FRIULI-VENEZIA GIULIA

**Abstract** - The influence of geopedological situations, chemical-agricultural and floristic characteristics and influence of development and distribution of root system on the uptake of radiocaesium by plants were investigated. Transfer Factors (TF) from soil to plant for Cs-137 were calculated; distribution of Cs-137 on the soil profiles and in some families of plant were also showed. The relevance of the litter layer of soil in the uptake of Cs-137 was pointed out.

**Key words:** Soil to plant transfer, Cs-137, Cs-134, Chernobyl.

**Riassunto breve** - Viene analizzata l'influenza di parametri pedologici, chimico-agricoli e floristici sul trasferimento del Cesio radioattivo dal suolo alle piante. Sono stati scelti otto siti in prati stabili della zona montana del Friuli-Venezia Giulia e sono stati determinati i parametri suddetti oltre alla concentrazione di Cs-137 nel suolo e nei vegetali. Inoltre sono stati studiati lo sviluppo e la distribuzione delle radici nei diversi orizzonti pedologici e la concentrazione dello stesso radionuclide in alcuni gruppi di fanerogame. Viene messa in luce, in particolare, l'importanza che la densità radicale nel cotico ha nell'assorbimento del radiocesio da parte delle piante.

**Parole chiave:** Trasferimento suolo-pianta, Cs-137, Cs-134, Chernobyl.

## Introduction

Data from monitoring of environmental radioactivity in Friuli-Venezia Giulia region in the years following Chernobyl accident allowed the individuation of mountain sites where the constituents of food chain forage-milk-meat showed significative contamination with caesium radioisotopes (PADOVANI et al., 1988a and b).

In these sites superficial Cs-137 contamination of soils differs at the most by a factor 2, whilst concentrations in forage from corresponding areas can differ by 2 orders of magnitude.

The same range in the values of TF was founded by SANDALLS et al. (1990). In that case they found a correlation between the TFs values and the organic matter content. Moreover

they found that the exchangeable potassium affects the uptake of Cs-137. FRISSEL et al. (1990) analyzed the following parameters: pH, organic matter content, litter layer and soil nutrient status. They also showed a correlation of TFs values with the organic matter content when organic matter content is higher than 15%.

According to SCHULLER et al. (1988) - who performed a stepwise multiple regression analysis among the TFs values and several soil parameters - 67% of the variance of TF was explained by soil pH.

In order to investigate the reasons of the TFs values differences a collaboration between the Regional Laboratory for Environmental Radioactivity control and the Institute of Vegetal Production of the University of Udine has been started. This work shows some of the results of this collaboration.

### Materials and methods

Monitoring of mountain areas of the region allowed the identification of 8 sites among those with high or low TF.

The following aspects were investigated in every site, via sampling of soils and vegetals:

- morphological and physico-chemical characteristics of soils;
- qualitative and quantitative floristic analysis;
- hydrological parameters;
- development and distribution of root systems;
- Cs-137, Cs-134 and K-40 contents in plants, roots and soils.

Forages were harvested in undisturbed fields on 0.50 m<sup>2</sup> surface and dried; productivity from every site was calculated.

As far as soil was concerned, 4 cores were sampled on each site (total surface: 0.0195 m<sup>2</sup>); the organic layer was separated and the remaining sample was divided in the following fractions: 0-5 cm, 5-15 cm, 15-25 cm, 25-45 cm and - where feasible - 45-65 cm. Samples were dried, sieved at 2 mm and divided in coarse fragments, roots and fine earth.

The following parameters were observed or measured:

- 1) geopedological characteristics of sampling sites (altitude, slope, exposure, rockiness, stoniness, erosion, land use, geological substrate, physiography);
- 2) horizons belonging to each profile and their morphological characteristics (thickness, lower layer, color structure, consistency, coarse fragments, roots, porosity, biological activity, cracks, slickensides);
- 3) soil classification according to USDA Soil Taxonomy;
- 4) physico-chemical properties: texture, pH in water, pH in KCl, total carbonate, organic carbon, organic matter, cation exchange capacity, exchangeable bases, exchangeable acids;

- 5) hydrological parameters as derived upper limit, lower limit-plant extratable, maximum available water.

Each of the 200 harvested samples was analyzed using gamma spectrometry with intrinsic Germanium detectors.

### Results

Table I shows TFs of Cs-137 from soil to forage and superficial contaminations in the 8 sites. As it can be seen, TFs change by 2 orders of magnitude and there are no correlations with deposition.

| Site             | Transfer Factor<br>(m <sup>2</sup> /kg) | Surface Contamination<br>(Bq/m <sup>2</sup> ) |
|------------------|-----------------------------------------|-----------------------------------------------|
| Rutte Piccolo 1  | 0.001                                   | 17700                                         |
| Rutte Piccolo 2  | 0.002                                   | 21600                                         |
| Val Raccolana 1  | 0.018                                   | 18600                                         |
| Val Raccolana 2  | 0.009                                   | 22900                                         |
| Val Resia 1      | 0.155                                   | 8100                                          |
| Val Resia 2      | 0.037                                   | 21200                                         |
| Moggio Udinese 1 | 0.052                                   | 14100                                         |
| Moggio Udinese 2 | 0.010                                   | 6900                                          |

Tabl. I - Cs-137 transfer factors from soil (Bq/m<sup>2</sup>) to forage (Bq/kg d.w.) and superficial contaminations (Bq/m<sup>2</sup>) in the considered 8 sites.

- *Fattori di trasferimento del Cesio 137 dal suolo (Bq/m<sup>2</sup>) al foraggio (Bq/kg d.w.) e contaminazione superficiale (Bq/m<sup>2</sup>) negli 8 siti considerati.*

| Site             | Gramineae              |                  | Leguminosae            |                  | Other species          |                  |
|------------------|------------------------|------------------|------------------------|------------------|------------------------|------------------|
|                  | Cs-137<br>(Bq/kg d.w.) | Abundance<br>(%) | Cs-137<br>(Bq/kg d.w.) | Abundance<br>(%) | Cs-137<br>(Bq/kg d.w.) | Abundance<br>(%) |
| Rutte Piccolo 1  | 14                     | 31.5             | 40                     | 3.2              | 22                     | 65.3             |
| Rutte Piccolo 2  | 42                     | 40.8             | 102                    | 3.8              | 33                     | 55.4             |
| Val Raccolana 1  | 326                    | 85.4             | 408                    | 0.4              | 408                    | 14.2             |
| Val Raccolana 2  | 255                    | 35.5             | 196                    | 5.6              | 211                    | 58.9             |
| Val Resia 1      | 1028                   | 32.3             | 1592                   | 24.9             | 1237                   | 42.8             |
| Val Resia 2      | 1019                   | 55.2             | 790                    | 5.0              | 455                    | 39.8             |
| Moggio Udinese 1 | 854                    | 55.5             | 77                     | 1.7              | 591                    | 42.8             |
| Moggio Udinese 2 | 41                     | 23.1             | 51                     | 27.1             | 86                     | 49.7             |

Tabl. II - Cs-137 concentrations in the plants in the considered 8 sites divided into Gramineae, Leguminosae and all other species and percentage of abundances of families in each site.

- *Concentrazioni di Cesio 137 nelle piante degli 8 siti divise in Graminacee, Leguminose e tutte le altre specie e percentuali di abbondanza delle famiglie in ciascun sito.*

| Site             | pH<br>in H <sub>2</sub> O | CaCO <sub>3</sub><br>(%) | Organic-C<br>mg/g | Organic<br>matter<br>(%) | C.E.C.<br>meq/100g | Exchangeable<br>basis<br>meq/100g |
|------------------|---------------------------|--------------------------|-------------------|--------------------------|--------------------|-----------------------------------|
| Rutte Piccolo 1  | 5.43                      | 0                        | 78.42             | 13.48                    | 28.92              | 24.74                             |
| Rutte Piccolo 2  | 6.45                      | 0                        | 63.05             | 10.84                    | 24.59              | 25.29                             |
| Val Raccolana 1  | 7.16                      | 71.30                    | 66.42             | 11.42                    | 35.44              | 39.16                             |
| Val Raccolana 2  | 7.25                      | 73.71                    | 88.76             | 15.27                    | 38.17              | 49.75                             |
| Val Resia 1      | 6.92                      | 33.87                    | 154.86            | 26.63                    | 52.85              | 71.34                             |
| Val Resia 2      | 6.98                      | 43.27                    | 166.25            | 28.59                    | 70.53              | 76.02                             |
| Moggio Udinese 1 | 6.70                      | 1.42                     | 187.08            | 32.18                    | 68.82              | 76.48                             |
| Moggio Udinese 2 | 6.77                      | 0                        | 212.73            | 36.59                    | 64.42              | 83.06                             |

Tabl. III - Some of the soil parameters considered and their values for the organic layers in the 8 sites.

- Alcuni dei parametri dei suoli considerati e i loro valori per gli strati organici negli 8 siti.

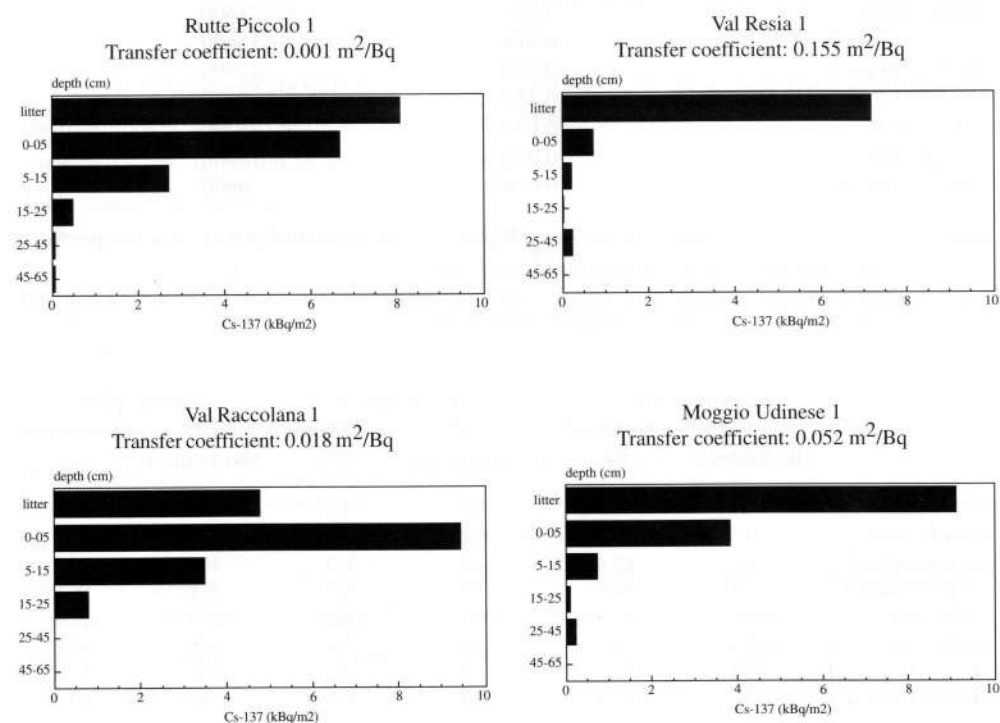


Fig. 1 - Cs-137 concentration profiles (Bq/m²) and Cs-137 transfer factors from soil to forage (m²/kg) in 4 of the 8 investigated sites.

- Profili di concentrazione di Cs-137 (Bq/m²) e fattori di trasferimento dal suolo al foraggio (m²/kg) in 4 degli 8 siti investigati.

Table II shows Cs-137 plant content in the 8 sites, divided into Gramineae spp., Leguminosae spp. and all the other species and the percentage of abundance in each site.

Fig. 1 shows some of the Cs-137 concentration profiles of the same 8 sites. It can be noticed that Cs-137 concentration profiles are quite different from one another and are not correlated to the corresponding TF value.

Table III shows some of the parameters that were considered in the study and their values for the Corg-rich layers in the 8 considered sites. Analysis of data show no linear correlation between the chemico-physical characteristics and the TFs. Also the hydrological characteristics seem to have no relevance in the uptake of Cs-137 from soil to plants. For some of the parameters the lack of the correlation with the TFs - i.e. pH, organic matter, percentage of clay - can depend on the rather small range of values in the considered sites.

A large number of characteristics of the plants - roots and epigeal parts - were also investigated. Fig. 2 shows the radical densities in the same sites of fig. 1.

Analysis shows significant correlation between TFs values and the root density in the Corg-rich layer ( $r = 0.94$ ,  $p = 0.0006$ ).

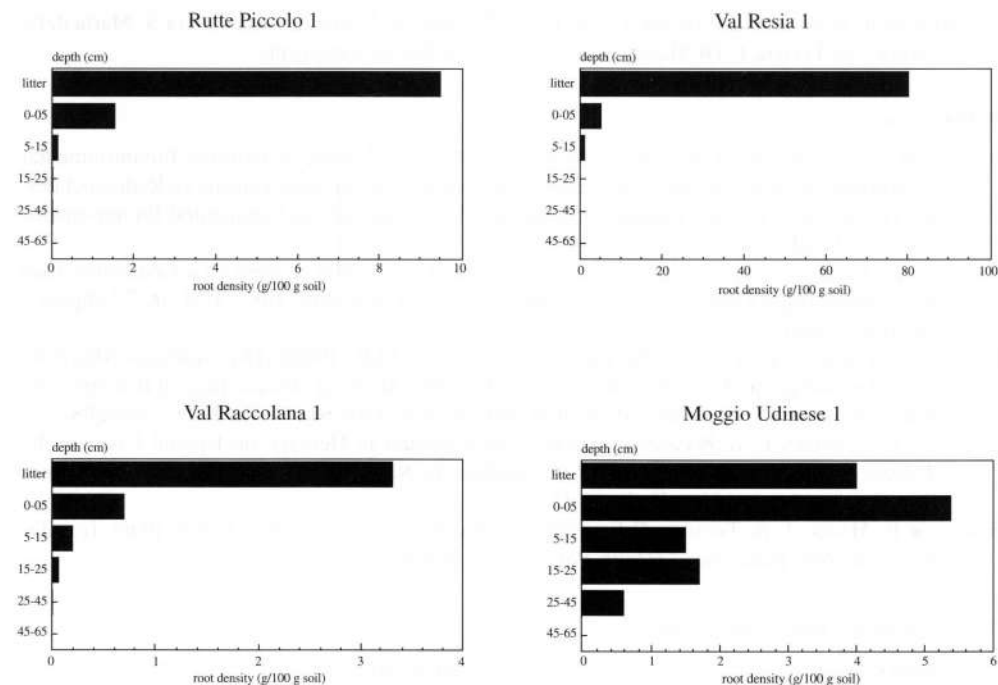


Fig. 2 - Radical densities (g/kg) in the profiles considered in fig.1.

- Densità radicale (g/kg) nei profili considerati in fig. 1.

Moreover, TFs are well correlated with the product of the thickness of the Corg-rich layer and the radical density in the same layer ( $r = 0.94$ ,  $p < 0.0001$ ).

## Conclusions

The floristic composition of forages, the thickness of the Corg-rich layer and the radical density seem to have particular relevance on the Cs-137 uptake of plants from soil. One hypothesis is that in the organic layer Cs-137 availability and radical density are higher than in the other soil layers. As a consequence the profile of contamination and the characteristics of the soils are less important than the floristic parameters and the density and depth of roots.

On the basis of these results other samplings and analysis will be performed.

The assessment of parameters affecting Cs-137 uptake from soil to plant could be useful for the optimization of previsional models (nowadays employed in radioprotection) describing the contamination transport in the environment and food chains.

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Authors' addresses - Indirizzi degli Autori:

- Renato PADOVANI  
- Concettina GIOVANI  
- Maria Rosa MALISAN  
Azienda Ospedaliera - Servizio Fisica Sanitaria  
Centro di Rif. Reg. controllo radioattività ambientale  
P.le S. Maria della Misericordia, I-33100 UDINE

- Stefano CESCO  
- †Angelo MAGGIONI  
- Claudio MONDINI  
Department of Vegetal Production  
University of Udine  
Via delle Scienze 208, I-33100 UDINE