GORTANIA - Atti Museo Friul. Storia Nat.	11('89)	119-126	Udine, 30.VI.1990	ISSN: 0391-5859

P.L. NIMIS, D. GASPARO, C. GIOVANI, R. PADOVANI

RADIOCONTAMINATION MAPS OF MACROFUNGI IN NORTH-EASTERN ITALY (FRIULI-VENEZIA GIULIA) FOLLOWING THE CHERNOBYL ACCIDENT*

CARTE DELLA RADIOCONTAMINAZIONE DEI MACROMICETI NELL'ITALIA NORD-ORIENTALE (FRIULI-VENEZIA GIULIA) IN CONSEGUENZA DELL'INCIDENTE DI CHERNOBYL

Abstract — Two maps showing the distribution of contamination by radiocesium in wild macrofungi within the Friuli-Venezia Giulia Region (North-eastern Italy) are presented. Both maps have been obtained by programs of authomatic cartography; one is based on radiocontamination data (37 sampling stations), the other has been obtained applying to the precipitation data relative to the first 10 days after the Chernobyl accident (135 meteorological stations) a mathematical function relating precipitation and contamination. A third map is presented, showing the reliability of the two contamination maps; this, based on the deviation point by point of the contamination values attributed to each point in the two contamination maps, shows a good correspondence between real data and the model. The maps can be used to detect "high risk areas" where the probability of collecting contaminated material is higher.
Key words: Chernobyl, Friuli-Venezia Giulia, Italy, Macrofungi, Radioactivity.

Riassunto breve — *Questo lavoro presenta due mappe della radiocontaminazione dei macromiceti saprobi nel Friuli-Venezia Giulia: la prima è basata sui dati di contaminazione relativi a 37 stazioni di campionamento nel 1986. La seconda è stata ottenuta applicando ai dati relativi alle precipitazioni cadute nei primi 10 giorni dopo l'incidente di Chernobyl (135 stazioni meteorologiche) una funzione matematica tra precipitazioni e contaminazione dei funghi. L'affidabilità delle due mappe viene discussa sulla base di una terza mappa, che mostra la deviazione, punto per punto, dei valori di contaminazione attribuiti ad un dato punto nelle due carte di contaminazione; la mappa di affidabilità mostra una buona corrispondenza tra la mappa di contaminazione basata sui dati reali e quella di contaminazione basata sul modello. Le mappe della contaminazione possono venir utilizzate per individuare delle "zone a rischio" dove è più probabile la raccolta di materiale fortemente contaminato.*
Parole chiave: *Chernobyl, Friuli-Venezia Giulia, Italia, Macromiceti, Radioattività.*

* Lavoro finanziato dalla Direzione Regionale dell'Igiene e Sanità del Friuli-Venezia Giulia e dal Centro Regionale di Sperimentazione Agraria di Pozzuolo del Friuli (UD).

Introduction

A first survey on the contamination of macrofungi by radiocesium in Friuli-Venezia Giulia (North-eastern Italy) following the Chernobyl accident was carried out in the late summer of 1986. The results revealed a high variation of the radiocontamination values both among different species collected in the same station, and among specimens of the same species collected in different stations (NIMIS et al., 1986). The efficient use of macrofungi as biomonitors of radiocontamination obviously depends on the possibility of explaining the main factors affecting the high variation of contamination data. According to NIMIS et al. (1986; 1988), these are:

a) depth of the mycelium: saprophytic fungi with superficial mycelium have the highest contamination values, followed by mycorrhizal symbionts with shallow-rooted Coniferae and with deep-rooted broadleved trees, respectively; this is related to the fact that after the Chernobyl accident radiocesium was concentrated in the upper horizon of the forest soils; different mycelium depths explain the high variation of contamination values among different species of the same station;
b) precipitation fallen in the first 10 days after the Chernobyl accident. NIMIS et al. (1986; 1988) could demonstrate a good correlation between average contamination values of different stations and the amount of precipitation. This factor explains a great deal of the variation in radiocontamination among individuals of the same species collected in different stations.

These results were confirmed by an analogous study carried out in Belgium, by GUILLITTE et al. (1987). The results of another survey carried out in 1987 by NIMIS et al. (1988), showed that the additional precipitation fallen within one year caused a migration of radiocesium into deeper layers of the soil profiles; as a result, the contamination of mycorrhizal species tends to increase, that of saprophytic species to decrease with time.

The main problem concerning the use macromycetes as biomonitors of radioactive deposition lies in the very high variability of the contamination data. Once the main factors affecting radiocontamination of macrofungi in the survey area have been understood, their use as biomonitors becomes possible. This paper presents two contamination maps of the Region, obtained by programs of authomatic mapping: the first map is based on the average contamination values of saprophytic species in the 37 sampling stations; the second map has been obtained from the precipitation map (135 stations), applying to precipitation data a mathematical function relating precipitation values and contamination of saprophytic fungi. The reliability of these maps is discussed on the basis of a third map showing the deviation, point by point, of the data attributed to each point in the two contamination maps.

Data and methods

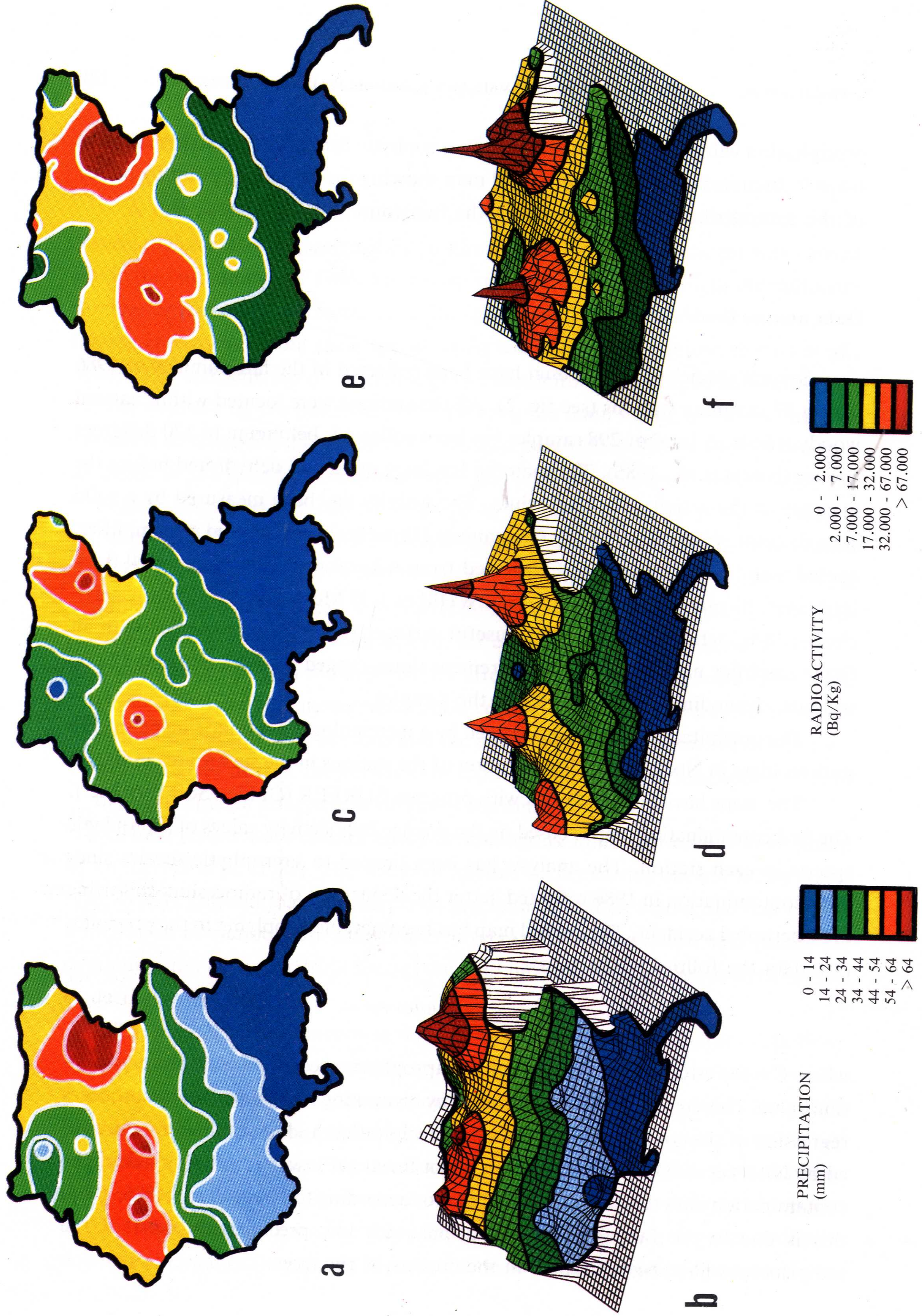
Several species of macrofungi have been collected in the late summer of 1986 within 37 sampling stations (see fig. 2). All the stations were located within natural woody stands. A total of 298 samples has been collected, belonging to 120 different species (NIMIS et al., 1986). The material has been dried and dehydrated before the measure of the activity of radiocesium. The activity has been measured by a solid state detector, wich is an Intrinsic Germanium (Tennellec) with inserted pre-amplifier, cooled with liquid nitrogen and protected from natural radiation by a cm 10 thick lead layer. Its main characteristics are: FWHM at 1.33 MeV, 1.88 KeV, relative efficiency: 18%, active volume: 83 cm^3, useful surface: 19 cm^2; it is connected with an Ortec amplifier mod. 578. The measurement times ranged between 600 and 32.000 seconds, depending on the activity of the samples.

The precipitation data were obtained by a metereological monitoring net of 135 stations (data in NIMIS et al., 1986, location of the stations in the survey area in fig. 2).

The maps have been obtained with program SURFER (Golden Software Inc.). The first contamination map is based on the average radioactivity values of saprophytic species in each station. The analysis has been limited to saprophytic species since their contamination in 1986 reflected better the deposition of radiocesium following the Chernobyl accident. The second map has been obtained applying to the precipitation data the following function:

$$C = 2599\ e^{(0.051\ P)}$$

where C is the estimated contamination of saprophytic species, and P is the precipitation value. This function has been obtained by computing an exponential least squares regression of the correlation data between precipitation and contamination published by NIMIS et al. (1988). The relation is not linear: at low precipitation values the contamination data tend more rapidly to zero; according to NIMIS et al. (1986; 1988) this is due to the fact that in the stations with low precipitation most of the radioisotopes have been retained in the crowns of the trees.



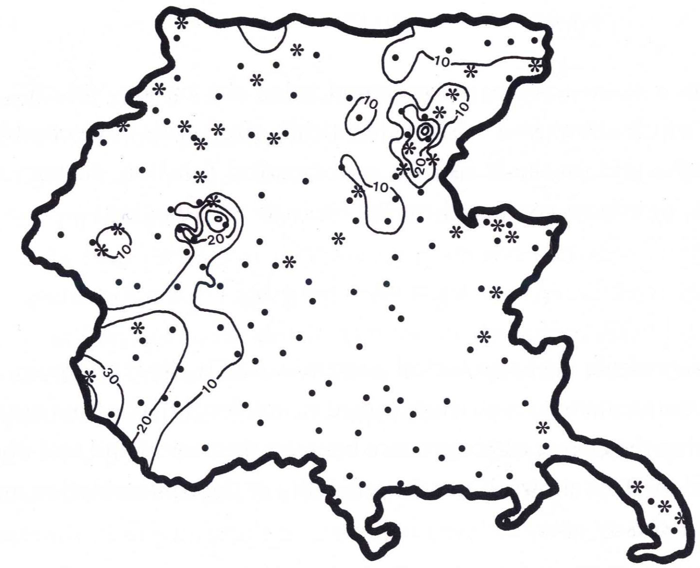


Fig. 2 - Map showing the deviation between the values attributed to each point in the contamination maps based on observed data (fig. 1 b, c), and on theoretical data (fig. 1 e, f) (see text). The dots indicate the location of the metereological stations, the asterisks the location of the stations in which macrofungi were sampled.

- *Carta della deviazione, punto per punto, tra valori di contaminazione attribuiti ad ogni punto sulla base dei dati reali (fig. 1 b, c) e di quelli teorici (fig. 1 e, f) (v. testo). I punti rappresentano le stazioni metereologiche, gli asterischi le stazioni di raccolta dei macromiceti.*

Fig. 1 - a, b) Maps of the precipitations fallen in the Friuli-Venezia Giulia Region in the first 10 days following the Chernobyl accident, based on the data of 135 metereological stations (see fig. 2).

c, d) Maps of the contamination by radiocesium of saprophytic fungi in the Friuli-Venezia Giulia Region, based on the average contamination data from 37 sampling stations, relative to the late summer of 1986 (see fig. 2).

e, f) Maps of the theoretical contamination of saprophytic macrofungi in the Friuli-Venezia Giulia Region, obtained applying a function between precipitation and contamination to the precipitation data used to construct the maps of fig. 1 a,b (see text).

a, b) Carte delle precipitazioni nei primi dieci giorni seguenti l'incidente di Chernobyl nel Friuli-Venezia Giulia, basate sui dati di 135 stazioni metereologiche, la cui localizzazione è mostrata in fig. 2.

c, d) Carte della contaminazione da radiocesio dei macromiceti saprofiti nel Friuli-Venezia Giulia, basate sui valori medi di contaminazione in 37 stazioni di campionamento; i dati si riferiscono a misure effettuate nella tarda estate del 1986. Per la localizzazione delle stazioni di campionamento v. fig. 2.

e, f) Carte della contaminazione teorica da radiocesio dei macromiceti saprofiti nel Friuli-Venezia Giulia, ottenuta applicando ai dati di precipitazione una funzione matematica tra precipitazione e contaminazione (v. testo).

The two maps have been compared using the option "Math" of program SURFER, which allows two existing, identically sized grids to be combined to form a third output grid on the basis of a mathematical function. In our case, the two input grids have been compared on the basis of the function:

$$C_{ij} = 100 \quad | A_{ij}-B_{ij} |$$

where A_{ij} represents the hypothetical contamination in the ij grid point, and B_{ij} the measured contamination, both transformed to unit lenght. The final output is a third map, showing the degree of congruence between theoretical and real distribution of contamination. This allows to test the reliability of the contamination maps for each point of the survey area.

Results and discussion

The precipitation map is shown in fig. 1 a,b: in the first 10 days following the Chernobyl accident the highest precipitations were on the first ridges of the outer Pre-alpine chains, with values above mm 64, and peaks up to mm 100. The inner Carnic and Julian Alps, the Friulian Plain and the Karst District were affected by much lower precipitations.

The maps obtained from the real contamination data of macrofungi by radiocesium are shown in fig. 1 c,d: the areas with highest contamination values (above 67.000 Bq/kg dry weight) are located in the Tramonti Valley (Carnic Pre-alps) and in the Raccolana Valley, in the outer Julian Alps. The inner Carnic Alps have contamination values between 2000 and 7000 Bq/kg dry weight, the Friulian Plain and the Karst District have an average contamination below 2000 Bq/kg dry weight. The map of the theoretical contamination is shown in fig. 1 e,f.

Considering that the consumption of wild mushrooms is a tradition of the local population, the maps of fig. 1 c-f could be used to delimit "high risk areas" where the probability of collecting contaminated material is higher.

The maps of fig. 1 have been drawn by program SURFER, which operates an extrapolation from the data relative to the single stations. It is obvious that the attribution of a given portion of the survey area to a given class of values has not the same degree of reliability for each point of the map. The precipitation map is probably much more reliable, since the density of metereological stations is much higher than the density of sampling stations utilized in the survey of 1986. Considering that the maps of fig. 1 could have a direct relevance for the local population as far as mushroom consumption and collecting are concerned, it is important to indicate clearly the parts of the map with lower reliability, i.e. those where the extrapolation of observed contamination data is less supported by the theoretical data. Fig. 2 shows a "reliability map" reporting the distribution of the deviation, point by point, between observed and theoretical contamination in the respective maps; there is a very good correspondence between the two maps; the areas with lowest reliability are limited to restricted portions of the region. Low reliability values might be due to two main reasons: a) insufficient density of sampling stations; b) deviation between observed contamination data and expected theoretical values: this might depend on local factors such as the differences between estimated and actual precipitation in the sampling points, or the influence of local microgeomorphological pattern on the contamination of saprophytic macrofungi.

NIMIS et al. (1988) have shown that in the survey area radiocesium tends to migrate into the soil profile, and that the migration rate depends primarily on precipitation. The data presented in this paper refer to the situation at the end of 1986, i.e. to the deposition pattern. Considering the long half-life of Cs 137 and the fact that most edible species are in mycorrhizal symbiosis with deep-rooting trees, the contamination risk deriving from the consumption of edible mushrooms is subject to variation depending on the species and on the quantity of rain fallen in the collecting stations since the Chernobyl accident. Another survey of the radiocontamination by mushrooms within the Region is foreseen for the next future, to obtain further informations on the evolution of contamination processes of direct relevance for public health.

Manoscritto pervenuto il 27.III.1990.

Acknowledgements

The authors wish to thank Mr. F. Bersan (Dept. of Biology, University of Trieste) and Dr. E. Cebulez (Dept. of Chemistry, University of Trieste) for their help during the 1986 survey, Mrs. G. Bolognini for the assistence in data elaboration and Prof. D. Lausi for critical remarks on the manuscript.

RIASSUNTO — La contaminazione da radiocesio dei macromiceti in conseguenza dell'incidente alla centrale nucleare di Chernobyl varia fortemente tra diverse specie della stessa stazione e tra individui della stessa specie raccolti in stazioni diverse. Ciò dipende da due fattori principali: a) profondità del micelio: le specie maggiormente contaminate sono quelle saprofite a micelio superficiale, seguite dai simbionti micorrizogeni con alberi di conifere e di latifoglie; b) la quantità di precipitazioni cadute nei primi 10 giorni dopo l'incidente: esiste una buona correlazione tra quantità di precipitazioni e contaminazione delle specie saprofite, e questa può venir espressa da una funzione matematica di tipo non lineare.

Vengono presentate due carte di contaminazione dei macromiceti saprofiti nel Friuli-Venezia Giulia, ottenute attraverso un programma di cartografia computerizzata: la prima è basata sui dati reali di contaminazione ottenuti da una campagna di monitoraggio effettuata in 37 stazioni alla fine del 1986. La seconda è stata ottenuta applicando la funzione che collega i dati di precipitazione a quelli di contaminazione ai dati relativi alle precipitazioni nei primi 10 giorni dopo l'incidente di Chernobyl (135 stazioni metereologiche). L'affidabilità delle due carte di contaminazione viene discussa sulla base di una terza carta, che riporta, punto per punto, i valori di deviazione tra la contaminazione attribuita al punto sulla base dei dati reali e dei dati teorici. Le due carte mostrano un ottimo grado di congruenza. Esse possono venir usate per individuare delle zone a rischio, dove è più alta la probabilità di raccogliere campioni fortemente contaminati.

Literature cited

GUILLITTE O. et al., 1987 - La radiocontamination des champignon sauvages en Belgique et au Gran-duché de Luxembourg après l'accident nucleaire de Tchernobyl. *Mem. Soc. Roy. Bot. Belg.*, 9: 79-93.

NIMIS P.L., GIOVANI C. & PADOVANI R., 1986 - La contaminazione da Cesio-134 e Cesio-137 nei macromiceti del Friuli-Venezia Giulia nel 1986. *Studia Geobot.*, 6: 3-121.

NIMIS P.L., GIOVANI C., PADOVANI R., BERSAN F. & CEBULEZ E., 1988 - Utilizzo dei macromiceti come bioindicatori della migrazione del Cesio radioattivo negli orizzonti pedologici. *Arch. Bot. Ital.*, 64 (3-4): 181-191.

Indirizzi degli Autori - Authors' addresses:

— Prof. Dott. Pier Luigi NIMIS
— Dott. Dario GASPARO
Dipartimento di Biologia
dell'Università degli Studi
Via A. Valerio 34, I- 34127 TRIESTE
— Dott. Concettina GIOVANI
— Dott. Renato PADOVANI
U.S.L. Nr. 7 "Udinese" Servizio di Fisica Sanitaria
Ospedale S. Maria della Misericordia, I-33100 UDINE