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CHERNOBYL RADIOISOTOPES IN MACROMICETES IN THE SURROUNDINGS OF COMO LAKES AND OTHER SITES.

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Abstract: The study is based on the measure of the Cs-134, Cs-137 content in samples belonging to species of macromicetes, collected in 13 Stations in Lombardy and in Trentino; most samples have been collected in autumn 1986; a number of samples has been collected in autumn 1987 and 1988. Significant differences in contamination are recorded both among species collected in the same station, and among average values of the stations themselves.
The differences among stations are tentatively correlated with the amount of precipitations in the days followingthe Chernobyl disaster. Comparison is made among the 1986 data and the data of the following years.
In many samples the presence of Ag-110 (metestable) is evidenced; the concentration of K-40 naturally occuring radioisotype is measured for most samples.
A brief discussion of the results is presented.

Foreword

A number of authors have studied the dispersion of radioisotopes in north Italian territory, following the accident in the atomic power station at Chernobyl, Ukraine. (Facchini et al. 1987).

The radioactive cloud reached the eastern Northitalian regions on april, 29 th 1986, and spread over the alpine valleys and in the Po plain in the early days of may. In a few days the cloud was dispersed by the winds and washed out by the rain. Radioisotopes reached the ground either by the dry deposition mechanism or by the wash out due to the rain. The dry deposition is related, with the aerosol diameter, with the status of the ground: so we find a more intense fall-out on the grassy ground and in the woody land, but a faible one in the stony grounds.

The rains wash out the aerosols in a large space up to the clouds height.

Rain was very intense over the alpine chain and particulary in eastern Friuli, in Lombardy and Piedmont, around the Lakes territory.

The fall out composition is pratically the same over a large territory, over the Alps and in the plain: the composition of radioisotope fall out is reported in Table I.

Table I — Composition of fall-out; Cs-137 =1

Zr + Nb - 95	Ru - 103	Ru - 106	Ag - 110	Sb - 125	I - 131
0.064	1.64	0.41	0.011	0.048	4.15
Te + I - 132	Cs - 134	Cs - 137	Ba + La - 140		
4.51	0.46	1	0.89		

The purpose of the present paper is the analysis of the radioisotope levels, mostly Cs-137 and Cs- 134, in the macromicetes.

A wide analysis of the macromicetes has been done by Nimis et al. (1986) in many stations the woody lands of Friuli; the results show strong differences in the Cesium levels either related to the territory but also to the different mushroom families.

The present analysis in referred to macromicetes collected in the territories around the Lake of Como and the Lago Maggiore and a few other sites; most samples are collected in the autumn 1986, a few months after the Chenorbyl accident; other samples are collected in autumn 1987 and 1988. The work results from the collaboration of three Institutes:

- samples around the Como lake and Valtellina are collected by the Circolo Micologico Lariano Plinio il Vecchio and analysed by the Institute of Applied Physics of the Milan University;
- samples in the Como territories and in the Groane, north of Milan are collected by the Unità Sanitarie Locali and examinated by the Presidio Multinazionale Igiene Prevenzione;
- samples collected around the Lago Maggiore are due to the Servizio Radioprotezione of the Joint Research Center of Ispra and there analysed;
- finally a few samples are collected by one of the authors (M.G.) in Piné di Trento.

The samples and the measurements

The mushrooms, generally a few samples of the same species, are homogeneized and put in special containers: the fresh quantity is around of 1 kg.

The analysis of the radioisotopes is made through the gamma spectrometer.

Different installations for gamma spectra, all based on Germanium devices, are used by the operating groups; the spectrometers have been calibrated and intercalibrated.

The levels of Cs-134 and Cs-137 are detected when the concentration is above a few Becquerel/kg fresh.

Oter radioisotopes as Ag-110 (metastable state) have been evidenced in a few samples; in all mushroom samples there is evidence of Potassium and the radioactive K-40 has been measured in most cases.

The ratio Cs-137/K-40, referring both radioisotopes in Becquerel/kg, is then obtained.

The data are given separately for each operating group, and for each station.

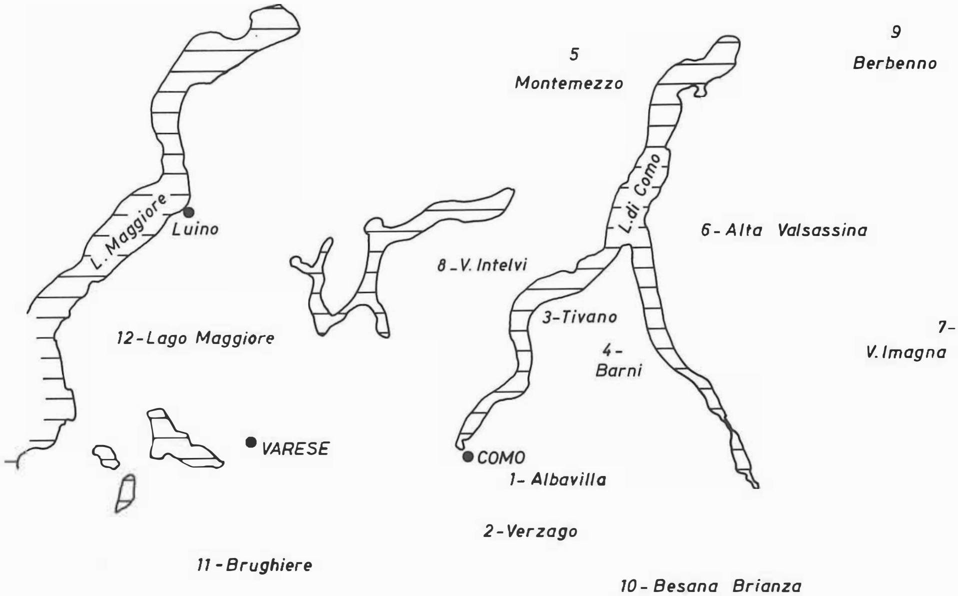

Fig. 1 — Map of Stations

The stations are in Table II, where the characteristic of the sites are also briefly indicated; in Figure 1 we report a map showing the sampling areas in Lombardy.

Table II - Stations.

Station n.	1	Hills around Como: chestnuts, oaks, beechs altitude 400 m
Station n.	2	Woods south of Como: chestnuts, oaks, pines altitude 200 m
Station n.	3	Piano del Tivano: beechs, alders, hornbeams hazels altitude 1000 m
Station n.	4	Mountains around Canzo chestnuts oaks, pines altitude 1000 m
Station n.	5	Alto lago: beechs, oaks, chestnuts altitude 300 m
Station n.	6	Alta Valsassina: chestnuts, pines, firs altitude 1000 m
Station n.	7	Valle Imagna: oaks, chestnuts, hornbeams altitude 800 m
Station n.	8	Valle Intelvi: oaks, chestnuts, pines altitude 800 m
Station n.	9	Bassa Valtellina: oaks, chestnuts altitude 400 m
Station n.	10	Besana Brianza: oaks, pines altitude 200 m
Station n.	11	Brughiera Saronno, Busto Arsizio: pines, oaks, chestnuts altitude 150 m
Station n.	12	around Lago Maggiore and Lago di Varese: pines, chestnuts, oaks altitude 150 m
Station n.	13	Piné near Trento: pines and red firs altitude 900-1800 m

Table III — Cs-137 fall-out in open grassy soils, Becquerel/m^2

Como	34300	Melide	59000
M. Bisbino	85100	Porlezza	40400
Bellagio e Perlo	69600	Chiavenna	49100
Piano Tivano	36100	Ardenno	32400
Lasnigo	24600	Pedesina	37700
Cantù	13500	Tirano	11130
Olginate	14500	Bolzano	9000
Bergamo	55600	Tarvisio	33000
Ispra	16600	Raccolana	41200
Angera	12800	Resia	38650
Malpensa	22500		
Luino	28200		

The intensity of fall-out has been measured in many stations both in Lombardy and in other Northitalian regions.

The fall-out, given in Becquerel/square metre is generally referred to grassy plain open soils; we report in Table III the Cs-137 data for the alpine stations related to the present analysis and refer for a more extended analysis to Facchini et al. 1987.

The fall-out data are indicative of the Cesium level in the areas in proximity of the sampling stations.

The data are however not exactly related to the stations; an incertitude of 30% can be estimated.

We report in the Table also the fall-out in a few sites in Friuli and in Bolzano, data which will be utilized in the following.

Results and discussion

The Cs-134 and Cs-137 concentrations are reported in Tables IV-VII; for a number of samples the K-40 concentration is reported.

The data are referred to each station and to a given macromicetes species; Tables A refer to the 1986 sampling, Tables B to 1987 and Table C to 1988.

From the general examination of the results, we notice that for K-40 there is a certain uniformity among the quantities absorbed by the various species (indipendently on their life-cycle and on the environment); on the contrary we notice a remarkable variability in the absorption of Cs-137, with the consequence of a remarkable variation of the ratio Cs-137/K-40.

This ratio in the most part of the mushrooms is lower than 1, but in the species where we have found the highest contents in Cs-137 the ratio becomes quite greater.

It is interesting to notice that mushrooms collected in the same area, which belong to different species, show different contents of Cs-137. A typical example concerns *Amanita muscaria* and *Amanita phalloides*, picked up in the sampe pinewood near Montagnaga di Piné, where the samples of the two species were intermingled.

Table IV — Samples from Circolo Micologico Plinio il Vecchio

A) Autumn 1986

	K-40	Cs-137	Cs-134	Cs-137/K-40
Station n. 1				
Armillariella mellea	166	45	20	0.27
Cantharellus cibarius	217	192	67	0.88
Cortinarius praestans	98	28.5	7.4	0.29
Fistulina hepatica	144	28	6.3	0.19
Gyroporus castaneus	163	14	6	0.08
Leccinum aurantiacum	172	35	13	0.20
Lepiota procera	171	58	25	0.34
Lycoperdon maximum	164	7.4	3.3	0.04
Polyporus umbellatus	92	6.7	0.17	
Polyporus pes caprae	81	27	13	0.33
Tylopilus felleus	81	661	177	8.16
Xerocomus badius	217	2586	1073	11.90
Station n. 2				
Amanita muscaria	*	155	41	-
Clitocybe nebularis	126	126	58	1.0
Coprinus comatus	78	6.3	2.6	0.08
Lactarius circellatus	99	24	11	0.24
Lactarius quietus	126	1698	729	13.40
Lactarius quietus	218	4181	1624	19.20
Lepiota puellaris	102	7.4	2.6	0.07
Lepista nuda	104	54	27	0.52
Lepista glaucocana	226	1761	752	7.79
Paxillus involutus	118	83	55	0.70
Russula sardonia	137	1058	444	7.72
Russula nigricans	55	155	59	2.81
Tricholoma portentosum	166	55	32	0.33
Xerocomus badius	97	2926	1225	30.16
Station n. 3				
Boletus edulis	111	166	63	1.49
Bovista plumbea	62	91	40	1.46
Lycoperdon saccatum + perlatum	57	66	28	1.15
Station n. 4				
Amanita muscaria	37	137	55	3.70
Amanita muscaria	123	257	86	2.08
Hebeloma sinapizans	76	1003	287	13.19
Lactarius quietus	87	3430	1469	39.42
Suillus granulatus	41	175	68	4.26
Station n. 5				
Boletus erythropus	98	216	46	2.20
Station n. 7				
Lepista glaucocana	92	1498	625	16.28
Station n. 9				
Boletus edulis	80	37	5.2	0.46
Clavaria botrytis	129	22	6	0.17
Hydnum imbricatum	155	214	21	1.38
Leccinum aurantiacum	157	147	55	0.93
Polyporus ovinus	133	15.2	6.3	0.11

Table IVB

B) Autumn 1987

	K-40	Cs-137	Cs-134	Cs-137/K-40
Station n. 2				
Amanita muscaria	147	70	16.6	0.47
Amanita citrina	136	757	209	5.56
Clitocybe nebularis	105	159	48	1.51
Clitocybe clavipes	37	1850	592	50.00
Cortinarius praestans	116	68	15	0.58
Hypholoma sublateritium	101	195	40	1.93
Lactarius quietus	292	7666	2290	26.25
Lactarius quietus	121	2229	641	18.42
Lactarius chrysorreus	163	2272	626	13.93
Lactarius turpis	71	104	30	1.46
Lepiota naucina	102	31	10	0.30
Lepista nuda	101	13	5	0.13
Lycoperdon perlatum	63	59	16	0.93
Paxillus involutus	67	481	144	7.18
Suillus bovinus	114	620	187	5.43
Tricholoma saponaceum	191	107	15	0.56
Tricholoma portentosum	160	190	37	1.18
Xerocomus badius	146	10309	3236	70.60
Xerocomus badius	109	3353	997	30.76
Xerocomus badius	92	1258	381	13.67
Xerocomus rubellis	171	132	37	0.77
Station n. 5				
Xerocomus badius	85	1184	385	13.92
Station n. 9				
Clavaria botrytis	161	32	6	0.20
Boletus edulis	128	240	54	1.87
Lepiota procera	249	476	160	1.91

Table IV C

C) Autumn 1988

	K-40	Cs-137	Cs-134	Cs-137/K-40
Station n. 1				
Xerocomus badius	192	1984	406	10.3
Xerocomus badius	163	1694	358	10.3
Station n. 2				
Amanita muscaria	64	390	77	6.0
Armillariella mellea	78	22	4	0.28
Clitocybe nebularis	60	63	15	1.05
Hypholoma sublateritium	47	42	8	0.89
Lactarius crysorreus	105	3024	641	28.8
Russula sardonia	93	930	195	10.0
Tricholoma portentosum	189	148	18	0.78
Xerocomus badius	92	3515	758	38.2
Station n. 5				
Tricholoma colossus	66	88	12	1.33
Xerocomus badius	83	467	93	5.62
Station n. 9				
Clitocybe clavipes	89	2568	537	28.8
Pholiota caperata	130	403	22	3.1
Xerocomus badius	132	1753	316	13.2

Table V — Samples from U.S.S.L.

A) Autumn 1986

	K-40	Cs-137	Cs-134	Cs-137/K-40
Station n. 2				
Boletus edulis	*	286	113	-
Lepiota procera	*	18	14	-
Lycoperdon saccatum	*	46	21	-
Lycoperdon maximum	*	7	-	-
Suillus bovinus	*	1953	889	-
Xerocomus ferrugineus	*	97	28	-
Station n. 4				
Armillariella mellea	*	186	68	-
Armillariella mellea	*	30	13	-
Boletus edulis	*	338	133	-
Boletus edulis	*	181	49	-
Lycoperdon saccatum	*	66	-	-
Station n. 6				
Boletus edulis	*	129	54	-
Boletus edulis	*	49	18	-
Boletus edulis	*	31	14	-
Station n. 8				
Lepiota procera	*	63	30	-
Lycoperdon maximum	*	255	125	-
Station n. 9				
Armillariella mellea	*	145	66	-
Station n. 11				
Armillariella mellea	*	79	40	-
Boletus edulis	*	131	54	-
Clitocybe nebularis	*	36	15	-
Hydnum repandum	*	1159	455	-
Leccinum aurantiacum	113	33	13	0.29
Lepiota procera	*	93	44	-
Lepiota procera	109	15	6	0.14
Station n. 12				
Clitocybe nebularis	120	38	16	0.31
Clitocybe nebularis	179	15	5	0.08
Cortinarius praestans	90	37	18	0.41
Hydnum repandum	142	1563	231	11.00
Lepista nuda	120	1082	425	9.01
Xerocomus badius	162	1566	574	9.66
Xerocomus badius	*	1074	477	-

Table V - Samples from U.S.S.L.

B) Autumn 1987

	K-40	Cs-137	Cs-134	Cs-137/K-40
Station n. 2				
Clitocybe nebularis	*	96	24	-
Clitocybe nebularis	*	133	-	-

Table V — Samples from U.S.S.L.

	K-40	Cs-137	Cs-134	Cs-137/K-40
Fistulina hepatica	< 113	182	35	> 1.60
Lactarius vellereus	< 66	883	128	> 13.30
Leccinum scabrum	< 89	1827	546	> 20.50
Lepiota procera	*	64	-	-
Lepista nuda	160	50	13	0.31
Lycoperdon saccatum	291	682	< 41	2.34
Paxillus involutus	181	407	133	2.24
Paxillus involutus	73	26	8	0.35
Xerocomus badius	324	2704	811	8.34
Station n. 10				
Auricularia Auricula -Judae	181	208	84	1.15
Pholiota mutabilis	122	138	56	1.13
Polyporus squamosus	69	15	5	0.22
Stropharia ferrii	253	369	145	1.46
Tricholoma georgii	80	807	< 24	10.00

Table VI — Samples from C.C.R. (Ispra)

A) Autumn 1986

Station n. 12

	Cs-137 aver.	Cs-134 aver.
Amanita muscaria	48.1	22.2
Amanita vaginata	22.2	7.4
Armillariella mellea	88.8	37.0
Boletus aereus	8.1	6.3
Boletus edulis	107.8	34.3
Boletus erythropus	118.4	55.5
Boletus impolitus	10.0	4.4
Boletus luridus	92.5	37.0
Boletus purpureus	62.9	14.8
Cantharellus cibarius	888.0	292.3
Cantharellus lutescens	625.3	262.7
Clitocybe clavipes	5698.0	2664.0
Clitocybe nebularis	103.6	37.0
Collybia velutipes	25.9	3.7
Gyroporus cyanescens	13.0	4.1
Hydnum repandum	1480.0	580.9
Ixocomus elegans	427.4	112.5
Ixocomus luteus	111.0	48.1
Leccinum aurantiacum	170.2	66.6
Leccinum scabrum	1058.2	414.4
Lepiota procera	59.2	25.9
Lepiota naucina	447.7	185.0
Lycoperdon perlatum	129.5	51.8
Lycoperdon maximum	5.2	3.7
Marasmius oreades	155.4	70.3
Pleurotus ostreatus	25.9	7.4
Psalliota campestris	282.7	127.7
Russula cyanoxantha	151.7	40.7
Russula virescens	62.9	18.5
Tricholoma columbetta	151.7	55.5
Tricholoma portentosum	126.9	32.9
Tricholoma saponaceum	237.5	93.2
Xerocomus badius	1658.7	682.1
Xerocomus chrysenteron	7.3	3.7
Xerocomus subtomentosus	1653.9	666.0

Table VI — Samples from C.C.R. (Ispra)

B) Autumn 1987

Station n. 12	Cs-137 aver.	Cs-134 aver.
Armillariella mellea	21.2	6.2
Boletus edulis	371.5	95.0
Clitocybe clavipes	7512.0	2480.0
Hydnum repandum	423.5	124.9
Leccinum scabrum	47.0	13.0
Sparassis crispa	139.5	40.6
Suillus bovinus	2317.6	731.9
Tricholoma portentosum	69.0	21.4
Xerocomus badius (n. 9 samples)	2540.3	768.0

Table VII - Samples from Piné di Trento

A) Autumn 1986

	K-40	Cs-137	Cs-134	Cs-137/K-40
Montagnaga				
Amanita muscaria	63	24	3.7	0.38
Amanita phalloides	79	178	60	2.25
Suillus bovinus	43	94	28	2.18
Lactarius vellereus	82	8	4	0.10
Russula sanguinea	72	32	8.5	0.44
Stramaiolo				
Amanita muscaria	31	10	3.7	0.33
Polyporus ovinus	89	35	5	0.40

B) Autumn 1987

	K-40	Cs-137	Cs-134	Cs-137/K-40
Montagnaga				
Amanita muscaria	128	34	5	0.26
Amanita phalloides	170	689	181	4.5
Cantharellus tubiformis	-	318	82	-
Cantharellus lutescens	118	696	197	5.90
Clitocybe candida	76	5	-	0.07
Craterellus cornocupioides	204	37	6	0.18
Lycoperdon perlatum	82	-	-	0.00
Stramaiolo				
Amanita muscaria	86	24	3	0.28
Russula mustelina	146	32	3	0.22

The Cesium level should depend first of all on the content of this radioisotope in the soil but also on the specific characteristic of the mushrooms species.

It appears interesting, to investigate the relation between the Cs-137 content and the biologic characteristic of the various species. We find relevant Cesium levels in micorrizic species as *Xerocomus badius* but very low levels in other micorrizic ones as *Gyroporus castaneus* and *Tricholoma portentosum*.

Similar large variations in Cesium levels are found in saprophitae: large levels in *Lepista glaucocana*, in *Clitocybe clavipes* and very low levels in other saprophitae as *Lepista nuda*.

The depth of the mycelium in soil and the Cesium penetration in underground should play an important role.

On the other side we observe low Cesium levels in parasitic species, as *Fistulina hepatica, Armillariella mellea:* in appears that the quantity of radioisotopes absorbed by higher plants is not remarkable for the parasitic mushrooms.

For a given species it is interesting to test a possible relation between the Cesium level in macromicetae and the fall-out level in the area itself. The comparison can be done, with accuracy, only in a few cases: we have at our disposal the data for a given species in a few sites only; moreover the fall-out data are quite uncertain: A similar analysis has been made by Nimis (Nimis et al. 1986) for the Friuli mushrooms; these authors show a rough relation where higher is the estimated fall-out level, higher is the Cesium content in mushrooms.

A linear relation between fall-out and cesium in mushrooms can be established by considering together our results, those of Nimis and data given by Bellù and Moroder (Bellù, Moroder 1986).

The comparison is given for three species: *Amanita muscaria, Hebeloma Sinapizans, Xerocomus subtomentosus*. As shown in Table VIII the mushrooms picked up in the areas where Cesium presence is very high, higher than in other areas, show us higher levels than the mushrooms picked up in the grounds where the presence of Cesium is more limited.

In the Friuli upper valleys we had strong rains on april 29th when the radioactive cloud was arriving from east and we had similarly strong rains in the Como' Lake territory in the first days of may 1986; in other sites as Bolzano we had a low fall-out level, related to the dry deposition.

The results of Table VIII are presented in Fig. 2: linear dependence between the total fall-out and the Cesium concentration in mushrooms is observed; quite interesting is the fact that the intercept of the straight lines are not at zero fall-out, but correspond roughly at the dry fall-out value around 8000 Bq/m^2.

Other species show this linear dependence, such as *Amanita phalloides*.

In other cases, as for *Armillariella mellea,* the Cesium levels seem to be independent on the Cesium content in soil; we recall however that these mushrooms are parasitic.

Another interesting comparison can be done between the 1986 levels and the 1987 and 1988 ones. The comparison is made for mushrooms of the same species and collected in the same site. Selecting the data from tables IV-VII we have formed

Table VIII — Cs-137 concentration in macromicetae and in soil

	Bq/kg	Bq/m²
Amanita muscaria		
- Bolzano	5	8700
- Friuli sito 4 (passo del Pura)		
sito 18 (Val d'Ayer)	37	13000-13600
- Piné (2 valori)	17	15400
- Ispra	48	18600
- Groane comasche	135	23300
- Friuli sito 27 (Fusine)	54	28600
- Monti Lariani est.	197	68000
Hebeloma sinapizans		
- Siti Friuli 8 (Castelmonte)		
e 9 (M.Matajur)	90	10100
- Sito Friuli 3 (Ampezzo)	389	13000
- Monti lariani est.	1002	68000
Xerocomus subtomentosus		
- Bolzano	17	8700
- Friuli 8 (Castelmonte)		
e 10 (M. Matajur)	235	10100
- Ispra	1654	18600
- Friuli 33 (Uccea)	1125	19000

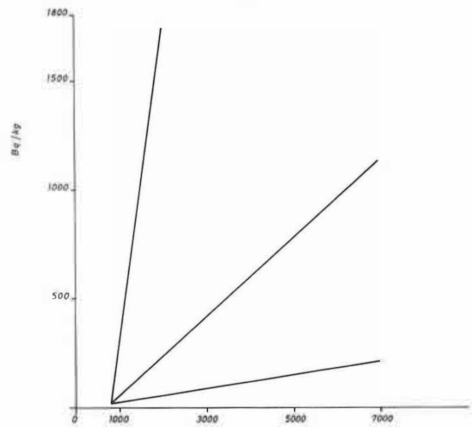

Fig. 2 — Relations between Cs-137 in soils (abscisse) and in 3 mishroom species (Amanita muscaria, Hebeloma sinapizans and Xerocomus subtomentosus, see text).

Table IX, where we generally observe a stationary Cesium level in 1987, but also a possible decrease of Cesium levels in 1988 samples. It is necessary to recall that in woodland Cesium persists for long times. Moreover, the deeper penetration of Cesium in soil can possibly offer a more rich Cesium content to the mushrooms hyphae.

Table IX — Cs-137 levels in macromicetae: comparison autumn 1986 - autumn 1987 - autumn 1988

	1986	1987	1988
Station n. 1-2			
Amanita muscaria	155	70	390
Armillariella mellea	45	--	22
Clitocybe nebularis	126	96-159	63
Cortinarius praestans	28	68	--
Fistulina hepatica	28	182	--
Hypholoma sublateritium	--	195	42
Lactarius crysorreus	--	2272	3024
Lactarius quietus	1698-4181	2229-7666	--
Lepiota procera	18-58	64	--
Lepista nuda	54	13-50	--
Lycoperdon saccatum	46	682	--
Paxillus involutus	83	26-481	--
Russula sardonia	1058	--	930
Tricholoma portentosum	55	190	148
Xerocomus badius	2586-2926	1258-10309	1694-3515
Station n. 5			
Xerocomus badius	--	1184	467
Station n. 9			
Boletus edulis	37	240	--
Clavaria botrytis	22	32	--

As a last point we investigate the ratio between the Cesium isotopes, Cs-134/Cs-137. The ratio between the Cs isotopes in fall-out and in soil when referred to may 1986 was c.a. 0.45.

The decay of Cs-134 shall reduce this ratio in a predictable way when considering the autumn of 1986 and then the autumn of 1987 and 1988.

When considering that the measurements are referred to december we have the following values of the ratio (R):

ratio Cs-134 / Cs-137	december 1986	R = 0.37
	december 1987	R = 0.26
	december 1988	R = 0.19

We can observe that in most mushrooms samples the ratio of the two Cesium isotopes reflects the fall-out composition.

Let us consider for instance the data for: Cs-134/Cs-137 average ratio (R):

Xerocomus badius	1986: 0.40	(5 samples)
	1987: 0.30	(6 samples)
	1988: 0.20	(5 samples)
Amanita muscaria	1986: 0.36	(4 samples)
	1987: 0.23	(1 sample)
	1988: 0.19	(1 sample)
Clitocybe nebularis	1986: 0.39	(5 samples)

	1987: 0.27	(3 samples)
	1988: 0.24	(1 sample)
Lactarius quietus	1986: 0.41	(3 samples)
	1987: 0.29	(2 samples)

The predicted value is generally verified where the Cs-137 level is sufficiently high; in miscellaneous samples, 34 samples with Cs-137 concentration greater than 100 Bq/Kg, the average ratio is:

1986 average R = 0.375

In samples and in species where the Cs-137 level is quite low, statistical errors and incertitudes do not give a precise value of the ratio R.

In *Armillariella mellea* a species with low Cs-137 level, many measurements are available; we obtain for 1986:

Lombardy values (6 samples)	R = 0.43
Friuli values, (from Nimis, 21 samples)	R = 0.37
average	R = 0.40
For 1987 (1 sample)	R = 0.29
For 1988 (1 sample)	R = 0.18

On the contrary in a number of species, and particularly when Cs-137 level is low, there are anomalous values of the ratio R and an excess of Cs-137 over Cs-134.

Let us consider *Boletus edulis* in 1986:

3 samples with Cs-137 < 100 Bq/Kg	R = 0.31
7 samples with Cs-137 100 - 338 Bq/Kg	R = 0.36

The ratio R decreases when the Cs-137 concentration is lower; this behaviour can be observed, for a number for species, even from Nimis' results and particularly for: *Hebeloma sinapizans, Hebeloma birrum, Hygrophorus eburneus, Tricholoma vaccinum.*

A confusing element can be the presence in soil and then in mushrooms of residual Cs-137 related to the fall-out of the decade 1955-65, due to the experimental nuclear explosions in atmosphere. This Cesium is still in woodland; the old Cs-137 is present in the underground, at a depth of a few centimeters.

It is possible that given mushrooms species absorb in sensible quantity the Cesium at this depth. For proving this point, we have examinated samples of mushrooms picked up in the year 1985, before Chernobyl, and in the year 1986, after Chernobyl, in the same site. The comparison was performed on samples of *Boletus edulis* collected in Ora di Trento; the data obtained, for dried samples are the following:

- samples of 1985	K-40	677	Cs-134	—	Cs-137	27
- samples of 1986	K-40	585	Cs-134	26	Cs-137	214

Table X — Ratio Ag-110 (m) / Cs-137 in macromicetae samples

Lactarius quietus	0.003 - 0.004
Xerocomus badius	0.003
Russula sardonia	0.006
Lepista glaucocana	0.01
Amanita muscaria	0.01 - 0.03
Lepista nuda	0.07
Paxillus involutus	0.11
Clitocybe nebularis	0.09 - 5.6
Lepiota procera	0.22 - 1.8
Bovista plumbea	0.24
Lycoperdon perlatum	0.27
Lycoperdon maximum	0.7 - 1.1
Lycoperdon saccatum	3.5

The data are given in Becquerel/dried Kg.

It appears that a given quantity of Cesium 137 was still present in the 1985 samples.

In these species the old Cesium 137 influences the isotopic composition and the ratio R is reduced. But when the recent Cesium 137 reaches higher levels, the old Cesium plays a minor role and the ratio Cs-134/Cs-137 approaches the expected values.

We conclude this discussion observing that in a few species, as *Hydnum* or *Sarcodon imbricatum* the ratio R remains constantly below the predicted values.

From Nimis results we have in 1986:

Cs-137	38-208	Bq/Kg	R = 0.10
Cs-137	291-376	”	R = 0.15
Cs-137	812	”	R = 0.11

the measurements given by us (Table IV A) give:

Cs-137	214	Bq/Kg	R = 0.10

Let us finally discuss the level of Ag-110: in most species Ag-110 has not been observed, i.e. is the level of this isotope is below the sensitivity threshold of the Germanium spectrometer; however, in a few samples the Ag is present in large quantity and the ratio Ag-110/Cs-137 is quite higher in the mushrooms than in the ground fall-out.

In Table X we have collected these remarkable data.

Riassunto: lo studio è basato sulla misura del Cesio - 134 e del Cesio - 137 in campioni di macromiceti, appartenenti a specie diverse. I campioni sono raccolti in 13 siti della Lombardia, in territori attorno al Lago di Como e al Lago Maggiore e alcuni campioni in Piné di Trento. La raccolta di maggior impegno è fatta nell'autunno 1986, pochi mesi dopo l'incidente di Chernobyl; raccolte successive sono datate nell'autunno 1987 e 1988. Le raccolte sono state fatte: dal Circolo Micologico Plinio il Vecchio, di Como: dalle Unità Sanitarie di Como e Varese e dal Servizio Radioprotezione del Centro Comune di Ricerca di Ispra.

Significative differenze nei livelli di Cesio sono osservate per campioni di differenti specie e anche nelle differenti stazioni di raccolta.

I valori vengono interpretati con difficoltà in ragione delle tipologie dei macromiceti e con riferimento al livello di radioisotopi nel terreno, questi legati alle intensità delle pioggie nei giorni del passaggio della nube di Chernobyl. In alcuni campioni è stato rilevato anche l'Ag-110 e in molti di essi è stata misurata la concentrazione di K-40, un elemento questo presente in natura.

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