International Journal of Microbiology and Biotechnology
2026, Vol. 11, No. 3, pp. 134–150
https://doi.org/10.11648/j.ijmb.20261103.15

Research Article

A Hygiene and Health Problem: Lead and Cadmium in Wild Edible Mushrooms in an Apennine Valley of the Northwest Emilia (Italy)

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Abstract

This work, with clear environmental objectives, describes the mycological and chemical-analytical activity carried out over a decade (2002-2011) in a pristine valley of the Apennines after the establishment of first-class unhealthy industries which, unfortunately, at the time did not have all the technical measures in force nor did the control bodies have the necessary tools (for example drones). The research aimed to quantify Pb and Cd in fungi, known metal accumulators already used after Chernobyl to detect Cesium 134 and Cesium 137. Cd and Pb are two toxic heavy metals regulated by EU regulations with with very specific limits. To better assess contamination, we took into account climatic factors, prevailing winds and landform to reach our conclusions. Collections and determinations (mycological and chemical) of the mushrooms were performed according to ISO 17025. It should be highlighted immediately that for reasons of space and to make reading less demanding, only values exceeding EU limits are shown and the comparison is limited to the first two years of monitoring and the last 3 years. The work demonstrates the need for careful environmental assessment by Municipal or District Technical Offices to be compared with that presented by industries intending to establish themselves in the area.

Keywords

Contamination, Lead, Cadmium, Mushrooms, Order, Family, Genus, Species

1. Introduction

In these times, much attention is paid to the foods we consume in relation to many pathologies that affect consumers today and which can be traced back to an unwise or even unhealthy diet.

The mushroom, a natural product of the woods, would at first glance appear to be a healthy and uncontaminated food but has sometimes been shown - like other products - to have significant health problems, generally due to external environmental factors.

In fact, together with many beneficial factors such as vitamins, essential amino acids, magnesium, potassium, selenium,

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Received: 30 March 2026; **Accepted:** 6 May 2026; **Published:** 22 September 2026

fungi often have residues of pesticides, radioactivity, and harmful heavy metals, not to mention parasites, molds, and bacteria.

Among these contaminants, two of the most dangerous according to the EU are Pb and Cd, in fact provided for in the various EU Regulations that set the limits of contaminants on food (the same limits are reported in the ISTISAN Reports 96/36).

Lead and cadmium in fungi are mainly inorganic as they derive from the nature of the soil (e.g. volcanic nature) in which the fungus grows and develops but also from external contamination of industries. Fortunately, both in our archives and in those of the ARPA of Parma and in those of the IZS-LER-Sez. of Parma, no very frequent or serious problems are highlighted, given that the most affected mushrooms are generally not consumed, with a few exceptions (so-called "minor mushrooms"), in the mountains or concern growth in very limited areas.

This research starts from afar as already in 1993 the CSPLFM, the former ASL n.6/PR, the Analytical Snc Laboratory and the former PMP of Parma had begun monitoring in points considered at risk (at the time the main problem was tetraethyl lead) with samples taken along the roads connecting the Ovest mountain to Fidenza and Fornovo Taro.

The checks also concerned other parameters whose analytical results are not reported here and other data relating to inedible mushrooms that are outside this publication but which remain available in our archives.

The desire to dwell a lot on some species stems from the fact that they are present in the national list (Annex 1, DPR.376/'95) and are the most common in mountain areas where the fungus is most consumed both fresh and preserved throughout the year and from here the possible sanitation problem arises.

Therefore, harvesting in urban and surrounding areas is dangerous, where unhealthy 1st class plants or industries are often located.

The definition that the regulations mean by "heavy metals" is very generic and not very "chemical". If there are no disputes about the term "metal", there is more confusion about the attribute "heavy". More practical is the current EU legislation, which indicates which chemical elements (metals and non-metals) a laboratory should research on the various samples but obviously many other elements can perform toxicity actions equal to those already regulated, but not yet taken into consideration (Lanthanum for example).

For sanitation purposes it will therefore be good to consider "heavy metal" any metal and non-metal that has toxic effects on the human organism.

In this work, since the fungus is studied as a "food" we must then consider only one route of exposure: ingestion.

The main aim of this work is therefore to raise awareness among collectors of the dangers of picking mushrooms in at-risk areas and among Public Health Officials to inform citizens of the obvious risks they know well.

The original limits set in the tables according to EC Reg. N°1881/2006 are till 02.07.2008; after have been corrected according to EC Reg. N°629/2008 for the Pb and Cd till 2011 (end of this technical work).

Table 1. *Maximum levels of Pb and Cd contamination.*

3.1.10	Vegetables, excluding those of the genus Brassica, leafy vegetables, aromatic herbs and mushrooms (27).	0,1 mg/kg (max content on fresh weight)
Cadmium (Cd)		
3.2.14	Vegetables and fruit, excluding leafy vegetables, herbs, mushrooms, stem vegetables, pine nuts, root vegetables and potatoes (27)	0,05 mg/kg (max content on fresh weight)
Reg.EC No.629/2008 amending Reg.EC 1881/2006 reads as follows:		
Lead (Pb)		
3.1.11	Vegetables of the genus Brassica, leafy vegetables and the following mushrooms (27): Agaricus bisporus, Pleurotus ostreatus, Lentinula edodes	0,3 mg/kg (max content on fresh weight)
3.2.15	OMISSIS……., mushrooms, stem vegetables, root vegetables and potatoes (27)	0,05 mg/kg (max content on fresh weight)
3.2.17	Leaf vegetables, herbs, celeriac and the following mushrooms (27): Agaricus bisporus, Pleurotus ostreatus, Lentinula edodes	0,2 mg/kg (max content on fresh weight)
3.2.18	Mushrooms, excluding those listed in point 3.2.17 (27)	1,0 mg/kg (max content on fresh weight)
Reg.EC n.488/2014 amending the two previous Reg.EC provides as follows:		
Cadmium (Cd)		

3.2.1	OMISSIS……, mushrooms and seaweed (27)	0,05 mg/kg (max content on fresh weight)
3.2.3	OMISSIS …….and the following mushrooms: Agaricus bisporus, Pleurotus ostreatus, Lentinula edodes (27)	0,2 mg/kg (tenore max sul peso fresco
3.2.4	Mushrooms, excluding those listed in 3.2.3 (27)	1,0 mg/kg (max content on fresh weight)

2. EFSA and the Implications of the Lead for Health

The Scientific Panel on Contaminants (CONTAM Panel) of the European Food Safety Authority (EFSA) [2] has published a scientific opinion on the possible health risks in relation to the presence of Lead in food. The opinion concludes that current levels of Lead exposure constitute a low or negligible risk to the health of most adults, but that there are potential concerns about possible effects on the neurodevelopment of young children. Lead is an environmental contaminant found both in nature and as a result of human activities such as mining. Since the '70 years, measures have been taken in Europe to regulate Lead levels in petrol, paints, food cans and pipes, achieving a remarkable result in reducing exposure. However, some concerns remain due to the fact that Lead can enter the food chain. The European Commission therefore requested EFSA to assess current levels of exposure to Lead, through food and other sources, and to determine whether the current reference level for public health protection, known as the "provisional tolerable weekly dose" (Provisional Tolerable Weekly Intake or PTWI) was still adequate.

The CONTAM group considered that it is cereals, vegetables and drinking water that contribute most to dietary exposure to Lead for the majority of the European population. Non-dietary exposure to Lead was judged less important for adults, although house dust and soil may be important sources of exposure for children.

The group identified a reduced intelligence quotient (IQ) in young children and elevated blood pressure in adults as the key key health effects on which to base their assessment. After a review of the available data, the Expert Group considered that PTWI was no longer adequate. A new reference level could not be established, as there is no clear threshold below which the group could exclude adverse effects. The group therefore compared current exposure estimates for different population groups with the exceeded levels at which adverse effects may occur. Therefore the group concluded that there are potential concerns in particular regarding neurodevelopmental effects in fetuses, infants and children.

Note: The same considerations are reported by ISS/Salute in the publication of 24 0tt0bre 2018, about Pb. [5].

3. EFSA and the Acceptable Weekly Intake for Cadmium in Food

The European Food Safety Authority's Panel on Contaminants in the Food Chain has reduced the Acceptable Weekly Intake (TWI) [1] for cadmium to 2.5 micrograms per kilogram of body weight (µg/kg bw), based on the analysis of new data. The TWI is the dose at which no adverse effects are expected. Average dietary exposure to cadmium in European adults is approximately this level. Exposure among certain subgroups (such as vegetarians, children, smokers, and people living in highly contaminated areas) may, however, exceed the TWI by up to twofold. The Panel concluded, however, that even for these groups, the risk of adverse effects is extremely low. The Panel further concluded that, at the population level, current exposure to cadmium should be reduced.

The European Commission asked EFSA [3] to assess the risks to human health posed by the presence of cadmium in food, to assist risk managers in the process of reviewing maximum permitted levels of cadmium in food. EFSA was also asked to indicate the relative importance of other sources of cadmium exposure and to consider the exposure conditions of specific population groups, including children.

Cadmium is a heavy metal that enters the environment from both natural sources, such as volcanic emissions and rock erosion, and from industrial and agricultural activities. It is found in air, soil, and water and can subsequently accumulate in plants and animals. Cadmium is primarily toxic to the kidneys, but can also cause bone demineralization and has been classified as a human carcinogen by the International Agency for Research on Cancer. Food is the main source of cadmium exposure for non-smokers. Cereals and cereal products, vegetables, nuts and legumes, starchy roots and potatoes, as well as meat and meat products, are the major contributors to human exposure. High levels have also been found in other foods (e.g., algae, fish and seafood, dietary supplements, mushrooms, and chocolate), but because they are consumed in smaller quantities, they are not considered significant sources of exposure.

Note: The same considerations are reported by ISS/Salute in the publication of 24 0tt0bre 2018, about Cd. [4]

4. Materials and Methods

4.1. Procedure

The collected mushrooms, are immediately determined on site following the keys of the following texts:

1) M.Moser [6]: Guide to mushroom determination (ed Saturnia/ TN, Italy, 1980);
2) M.Sarnari [12]: Genus Russula in Europe (vol.I, Ed. AMB/TN-Italy, 1998;
3) M.Sarnari [13]: Genus Russula in Europe (vol.II, Ed. AMB/TN-Italy, 2005;
4) A.Cappelli [14]: Agaricus - Fungi Europaei (Ed.Candusso/ Saronno- Italy 1984;
5) P.Neville&S.Poumarat [15]: Amaniteae - Fungi Europaei (Ed.Candussso/Saronno- Italy 2004.

The posthumous revision of the nomenclature is based on Funga Nordica [8] (Ed. Nordsvamp – Copenhagen /DK, 2008). Finally after the determination the mushrooms were cleaned with a plastic brush and then wrapped in foil for transport to the laboratory (a PBI T° ≤4°C portable car refrigerator was in use for long routes and storage times). In the laboratory, the stems were quickly washed with cold water to remove soil and humus residues. The jambs were then dried with disposable paper and then with cold blow-drying air. At this point, the first weighing of the sample to be examined was performed, and the mushrooms were then cut and dried at 40 ℃-50 ℃ for 8-10 hours in an ascending current of hot air (in a Valla dryer).

The slices had then been shredded and oven dried at 105 ℃ and stored in a dryer with fresh silica gel.

1 gram (dw) of these powders was then treated in a microwave mineralizer with 5 ml of concentrated HNO_3, according to the procedure fixed for the DiigiPrep [10] instrument by the specific manual, using the various available potencies for a time of at least 90'; same ISO/CEI 17025 procedure already applied for our previous research and already published in Micologia e Vegetazione Mediterranea by Gema/Avezzano- Italy in the 1966 (Vol.XI, n.1). [7]

The mineralized product was then brought to volume with double distilled H20 in a calibrated 25 ml flask and then analyzed. The analytical references have always been the AOAC Methods 17th Edition (2000) [11].

The archive under investigation reported that before 2001 the analyses were conducted with GFA AS (Graphite and HGA 400 Perkin Elmer) of the public laboratory ARPA in Parma (Dr. Sara Reverberi and Dr. Gianmarco Curti (┼), then from 2010 with ICP in the Chemical Laboratory of the IZS-LER in Parma, while the 2017 data with ICP / Thermo-Scientific of Analytical Snc in Borgotaro with the DigiPrep procedure for plant products.

4.2. Legend

All data are in mg/kg (ppm) dry weight (dw)

For these mushrooms the estimated ratio:

Fresh weight: Dry weight = 10:1, it is established based on practical criteria and specific knowledge.

The number below the date indicates the collection location.

Data (rows) in red are for edible species only after pre-boiling and cooking and/or ±suspicious.

4.3. NOTES

The nomenclature used (in many cases now outdated) reflects the time in which the analyses were carried out and this allows us to trace exactly the analytical data recorded at the time (Traceability).

We highlighted the values, which, despite the dry/fresh ratio =1/10, indicated that the EU limit had been exceeded.

VERY IMPORTANT NOTE: The limit values, originally marked in the tables as underlined according to Reg.EC n ° 1881/2006, were then corrected after 02.07.206 according to Reg.EC n ℅629/2008 emending Reg.EC 1881/2006 (and confirmed by Reg.EC n ℅488/2014 for the Cd).

Work in collaboration with the AUSL / PR ended in 2011.

Each year's data was regularly sent to the ER Region which had included this research in the health program.

As regards the Agaricaceae, some data, are reported on ResearchGate by L.Cocci & L.Vescovi in an article published in January 1997 [9].

2001/2002 - Mushrooms collections

Table 2. *Family Boletaceae Chevalier.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
B.	aereus	08.02(21)	1,1	3,7
B.	aestivalis	08.02(13)	30	2,3
B.	erythropus °°	10.01(3)	1,3	0,1
B.	erythropus °°	10.01(5)	0,2	0,7
B.	fragrans * °	08.02(12)	8,0	2,3

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
L.	quercinum	10.02(13)	1,3	0,73
L.	scabrum	10.01(7)	0,3	0,5
X.	ferrugineus	08.02(3)	1,5	0,97

Table 3. *Family Agaricaceae Fr.*

	SPECIES	Date (Loc.)	Pb ppm	Cd ppm
A.	campestris	10.01(6)	0,6	9,6
A.	campestris	08.02(10)	6,2	1,0
A.	silvaticus	10.02(18)	6,3	0,83
M.	permixta	10.01(4)	1,1	1,4
M.	procera	08.02(21)	1,0	0,54

Table 4. *Family Lycoperdaceae Chevall. (now Agaricaceae Fr.).*

	SPECIES	Date (Loc.)	Pb ppm	Cd ppm
L.	perlatum	10.02(22)	0,7	0,5
L.	piriforme	10.02(2)	1,3	0,49

Table 5. *Family Amanitaceae Roze.*

	SPECIES	Date (Loc)	Pb ppm	Cd ppm
A.	caesarea	08.02(16)	4,8	5,9
A.	rubescenss	08.02(16)	1,4	0,44
A.	rubescenss	10.02(26)	1,0	0,84

Table 6. *Family Coprinaceae Roze ex Overeem (now Agaricaceae Fr.).*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
C.	comatus	10.02 (23)	2,1	0,48

Table 7. *Family Hygrophoraceae Roze ex Mre.*

	SPECIES	Date (Loc.)	Pb ppm	Cd ppm
H.	eburneus	10.01 (2)	1,9	0,5

Table 8. *Family Tricholomataceae Roze ex Overeem.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
T.	rutilans	10.01 (8)	1,4	0,4

Table 9. *Family Cantharellaceae Schroeter.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
C.	cibarius	08.02(18)	1,0	0,19
C.	cibarius	10.02(2)	1,0	4,9
C.	cornucopioides	08.02(18)	4,1	0,38
C.	cornucopioides	09.02(9)	2,7	0,4
C.	lutescens	10.02(2)	1,3	1,7
C.	tubaeformis	10.02(9)	1,4	0,56

Table 10. *Family Hydnaceae Chev.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
H.	repandum	10.02(14)	0,3	0,09
H.	repandum	10.02(15)	1,4	0,43
H.	rufescens	10.02(2)	1,1	0,56
H.	rufescens	10.02(4)	1,4	3,0

Table 11. *Family Russulaceae Roze.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
L.	deliciosus	10.02(8)	0,8	0,24
L.	mitissimus	10.02(8)	1,4	0,29
R.	aeruginea	10.01(7)	1,4	0,3
R.	alutacea	10.01(4)	1,5	0,5
R.	alutacea	09.02(23)	5,3	2,8

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
R.	cyanoxantha	08.02(16)	1,4	1,7
R.	cyanoxantha	10.02(20)	1,5	0,48
R.	integra	10.01(2)	1,6	0,3
R.	romellii	08.02(23)	3,9	2,4
R.	rosacea	08.02(21)	1,4	0,9
R.	rosacea	09.02(13)	1,4	0,37
R.	vesca	10.01(2)	1,2	7,7
R.	vinosobrunnea	10.012(1)	2,2	1,7
R.	virescens	10.01(2)	0,7	3,8

Table 12. *Family Helvellaceae Dum.*

	SPECIES	Date (Loc.)	Pb ppm	Cd ppm
H.	crispa	11.01(22)	5,0	3,8

Two record Mushrooms for Lead content

Figure 1. *Russula alutacea.*

Figure 2. *Helvella crispa.*

Table 13. *Family Agaricaceae Fr.*

	SPECIES	Date (Loc.)	Pb ppm	Cd ppm
L.	leucothites	2008(23)	1	1,2
M.	excoriata	2008(65)	2	0,7
M.	konradii	2008(52)	1	6,9
M.	konradii	2008(69)	2	0,6

	SPECIES	Date (Loc.)	Pb ppm	Cd ppm
M.	procera	2007(16)	1	0,5
M.	procera	2007(21)	3,2	0,9

Table 14. *Family Agaricaceae Fr. (now Lycoperdaceae Bercht. & J. Presl).*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
L.	perlatum	2007(21)	3,1	1,1
L.	perlatum	2007(53)	1,0	0,3
L.	piriforme	2007(21)	2,0	0,8

Table 15. *Family Agaricaceae Fr.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
C.	comatus	2008(72)	<1	4,5

Table 16. *Family Entolomataceae Kotl. et Pouz.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
C.	prunulus	2008(70)	2	0,5
E.	saepium	2007(66)	2	0,9
E.	saepium	2007(66)	2	0,9

Table 17. *Family Hygrophoraceae Roze ex Mre. (now Cuphophyllaceae (Z.M. He & Zhu L. Yang) Vizzini, Consiglio & P. Alvarado.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
H.	niveus	2008(8)	13	0,5

Table 18. *Family Tricholomataceae Roze ex Overeem.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
A.	ostoyae	2008(52)	2	6,1
C.	nebularis (*)	2007(21)	1	0,5
C.	nebularis	2007(57)	1	0,5

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
C.	nebularis	2008(52)	2	0,7
L.	inversa (**)	2008(52)	1	0,4
L.	nuda (*)	2008(21)	1	9,4
L.	nuda (*)	2008(52)	3,1	0,4
L.	sordida (*)	2008(52)	3,2	0,5

Table 19. *Family Hericiaceae Donk.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
H.	erinaceus	2008(19)	1,0	<0,1

Table 20. *Family Russulaceae Roze.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
R.	chloroides	2008(52)	10	0,9
R.	cyanoxantha	2008(52)	1,0	0,3
R.	delica	2008(1)	2	0,3

Table 21. *Family Polyporaceae Fr. ex Corda.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
T.	versicolor	2007(57)	1,0	0,2
T.	versicolor	2008(52)	4,0	0,3

Table 22. *Family Tuberaceae Bercht. & J. Presl 1820.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
C.	meandriformis	2007(68)	<1	4.2

C./ Choiromyces (edible only after prolonged cooking; in some countries, even in the EU, it is consumed normally)

2009-2010-2011 - MUSHROOMS COLLECTIONS (For correct nomenclature see previous tables)
BASIDIOMYCOTA

Table 23. *Family Boletaceae Chevalier.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
B.	aestivalis	2010(92)	1,71	0,715
B.	Appendiculatus (*)	2009(75)	1,12	0,24
B.	Appendiculatus (*)	2009(22)	1,94	0,45
B.	edulis	2009(16)	2,02	2,42
B.	edulis	2010(8)	0,554	4,29
B.	erythropus (/)	2011(21)	7,85	0,167
B.	erythropus (/)	2011(88)	2,67	0,297
B.	Luridus (//)	2011(16)	2,53	0,230
L.	crocipodium (* ٩)	2010(21)	5,77	0,128
X.	chrysenteron (^)	2009(49)	0,33	5,03

Table 24. *Family Gomphidiaceae Maire ex Jülich.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
C.	rutilus	2011(21)	1.03	0,289

Table 25. *Family Agaricaceae Fr.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
A.	aestivalis	2010(89)	8,18	16,5
A.	albertii (=urinascens)	2010(95)	0,123	11,8
A.	campestris	2009(79)	2,64	0,48
A.	cupreobrunneus	2009(79)	1,22	0,48
M.	procera	2010(89)	5,85	0,656
M.	procera	2011(13)	4,30	1,30
M.	procera	2011(67)	1,97	0,661

Table 26. *Family Amanitaceae Roze.*

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
A.	rubescens	2011(21)	1,28	1,14

Table 27. Family Entolomataceae Kotl. et Pouz.

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
C.	prunulus	2011(67)	1,70	1,56

Table 28. Family Tricholomataceae Roze ex Overeem.

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
C.	nebularis	2010(8)	1,62	1,30
Ly.	fumosum	2010(8)	1,90	6.61

Table 29. Family Hydnaceae Chev.

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
H.	rufescens	2011(22)	3,33	0,132

Two fungi with critical Cadmium content

Figure 3. Agaricus campestris.

Figure 4. Rozites caperata (*), now Cortinarius caperatus (Pers.) Fr.

Table 30. Family Russulaceae Roze.

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
R.	aeruginea	2010(8)	3,50	0,467
R.	alutacea	2011(67)	2,99	0,337
R.	amoenicolor	2011(21)	0,746	17,1
R.	cyanoxantha	2009(75)	1,13	6,25

	SPECIES	Date(Loc.)	Pb ppm	Cd ppm
R.	cyanoxantha var.pelteraui	2009(8)	2,56	2,52
R.	cyanoxantha	2010(8)	1,61	0,514
R.	cyanoxantha	2010(38)	1,41	1,85
R.	cyanoxantha	2011(87)	1,70	1,02
R.	cyanoxantha var.variata	2011(89)	1,53	1,30
R.	grisea	2009(75)	1,00	11,20
R.	grisea	2011(13)	3,50	0,163
R.	hetherophylla	2010(94)	0,363	5,52
R.	ochroleuca	2011(13)	4,94	0,452
R.	olivacea	2010(20)	0,830	0,953
R.	rubroalba	2009(75)	1,31	0,68
R.	vesca	2009(84)	2,33	14,76
R.	violeipes	2010(89)	2,76	3,82
R.	violeipes var.citrina	2009(75)	5,76	11,81
R.	vinosobrunnea	2010(89)	3,73	1,60
R.	zvarae	2009(20)	1,31	0,54

Two more fungi with critical Cadmium content

Figure 5. *Lycoperdon perlatum loc.28.*

Figure 6. *Agaricus aestivalis loc.89.*

5. Discussion

Given that we are deliberately talking about official sampling and analysis (AUSL/PR, PMP/PR - ARPA/PR) carried out before 2011, the analytical data confirm two different degrees of danger in the consumption of wild mushrooms.

As we will see later, there are also two different evaluations:

a general one on all the fungal flora of the Valley, another limited to a particular critical area.

The parameter Pb.

The assessment for Pb is more complex and broadens as the EU limit for fresh (fresh) product is now 0.1 ppm; therefore, minor environmental contamination of air (smokes) or soil is sufficient to make the sample "out of standard".

Let us therefore immediately examine the Valtaro valley panorama as a whole to obtain an overview of the situation.

We performed the analyses not only in 2001-2002 and 2009-2010-2011 but also in the intervening years, but we only report a comparison between those dates to see if the presence of unhealthy industries in those 10 years brought problems.

Analyzed the overall landscape, let's now examine the most critical areas.

The localities that were most affected in those years, in percentage terms, were 2), 8), 9), 10), 16), 21) and 23).

With the exception of 8 (Penna Mount) and 89), the others are located on a theoretical line that connects the Tarodine Valley from the Brattello Pass to the Vona Valley up to Pian del Monte and the Varacola Valley up to the Santa Donna Pass.

To understand the causes, we must first examine the prevailing winds on this path.

In late autumn-winter, the "tramontana" predominates, descending from the Vona Valley and entering the exposed and open Tarodine Valley (north/northeast - south/southwest direction).

In area 21), the watershed between Emilia and Tuscany, in fact approximately 30% of the samples are contaminated, while in area 5) (same habitat), lateral to this "wind", no problems are found on 14 samples of different species.

In spring and early autumn, with the arrival of the "marine" wind, the light wind descends from the Brattello Pass along the Tarodine Valley and enters the Vona Valley (north/northeast direction), but this brings with it much less contamination.

6. Conclusions

The Borgotaro industrial area is located right in the center of the Taro Valley, so any pollution produced, in the form of emissions authorized in this area, can penetrate the valleys bordering this valley depending on the prevailing seasons and winds. The problem began many years ago (1880-1910) with the construction of a large cement factory to support the PR/SP railway line, which until the 1970s whitewashed the "Borgotaro" area with cement dust. The problem began many years ago (1880-1910) with the construction of a large cement factory to support the PR/SP railway line, which whitewashed the "Borgotaro" area with cement dust until the 1970s.

In the 1970s, a first Ceramic was authorized and located in the district of S. Rocco, and a few years later, a second Ceramica was built and licensed in an industrial area adjacent to the area most frequented by local prospectors.

In loc. 13) n. 3 out of 8 samples of Boletaceae exceed the EU limit and also 2 out of 3 samples of Russula (2 out of 2 in loc. 16, immediately below).

Furthermore, in the same area, C. piperatus, H. aurantiaca, L. perlatum, L. piriforme, L. umbrinum, M. procera, R. rosacea and X. badius also exceeded EU limits for lead during the monitoring years.

Climbing 500 metres at Vighini (location 16, on the same slope) we observe that A. caesarea exceeds the limit by 4.8 times, M. konradii by 3.2 times and T. acerbum by 2.8 times. Other edible mushrooms (including B. edulis) exceed the limit of 0.1, which necessitates an assessment of the health problem.

B. aestivalis deserves a separate discussion, as it presents an anomalous peak (30 ppm) at locality 13), which appears strange, especially in a wooded area about 1000 m above sea level, but which follows the theoretical line connecting the Vona Valley with the Tarodine Valley.

These unique and “incorrect” data were discarded in the arithmetic means as they were too discordant and perhaps caused by someone's crazy gesture (download).

Very interesting and realistic is the trend over the years that we have evaluated using dry Boletaceae as a reference throughout the Taro Valley.

The average of the values in the years 2001-2002 was 1.06 ppm; in 2003 it had dropped to 0.70 ppm; in 2004 it dropped again to 0.34 ppm; in 2009 it was 0.49 ppm, at the end of 2011 it returned to 0.71 ppm (so 0.071 ppm on fresh).

These data speak for themselves as the activity of the unhealthy industries present, with the anti-dust and anti-smoking means of the time, +brought the situation back to the time of the Cement Factory.

Let us now examine the Cd parameter

The mushrooms that would have exceeded the 1 ppm limit when fresh are 13 out of more than 500 samples analyzed and all treated with the same procedure of both collection and preparation and analysis. The contaminated samples (≈2.5%) are not located in a restricted area but range throughout the Taro Valley.

This indicates that it is not a specific contamination of some company but must all be referred to the geological nature of the soil and the ability of individual species to selectively find certain metals in the soil by absorbing the mineral salts present. The anomalies in loc.89) however need to be more studied and in-depth.

7. Collections AREAS, Altitude, and Habitat

1) Alpe (Municipality of Bedonia), 1000 meters above sea level; habitat: predominantly chestnut.
2) S.Donna (Municipality of Borgotaro), 900 meters above sea level; habitat: hornbeam, beech, pine.
3) Valdena (Municipality of Borgotaro - PGI area), 700 meters above sea level; habitat: predominantly chestnut.
4) Gotra (Municipality of Albareto - PGI area), 650 meters above sea level; habitat: Turkey oak, poplar, chestnut.
5) Baselica (Municipality of Borgotaro - PGI area), 700 meters above sea level; habitat: chestnut, pine.
6) Branzone (Municipality of Valmozzola), 600 meters above sea level; habitat: Turkey oak.
7) Nola (Municipality of Albareto - PGI area), 1000 meters above sea level; Habitat: chestnut, birch, poplar, silver fir.
8) Monte Penna (Municipality of Bedonia), 1300 m above sea level; habitat: silver fir, beech.
9) Pian del Monte (Municipality of Borgotaro), 800 m above sea level; habitat: Turkey oak, chestnut, pine.
10) Prato delle Cotiche (Municipality of Pontremoli - PGI area), 1000 m above sea level; habitat: silver fir, pine, beech.
11) Case del Freddo (Municipality of Borgotaro - PGI area), 550 m above sea level; habitat: chestnut, Turkey oak.
12) Grondola (Municipality of Pontremoli), 600 m above sea level; habitat: chestnut.
13) Monte Molinatico (Municipality of Borgotaro - PGI area), 1300 m above sea level; habitat: chestnut, beech.
14) Taglio (Municipality of Borgotaro), 700 m above sea level; Habitat: Turkey oak, chestnut tree.
15) Stabielle (Municipality of Borgotaro), 650 m above sea level; Habitat: Turkey oak, chestnut tree.
16) Vighini basso (Municipality of Borgotaro - PGI area), 750 m above sea level; Habitat: chestnut tree.
17) Vighini alto (Municipality of Borgotaro - PGI area), 900 m above sea level; Habitat: chestnut tree.
18) Val Vona-S.Pietro (Municipality of Borgotaro), 700 m above sea level; Habitat: Turkey oak.
19) Lame-Monticelli (Municipality of Borgotaro), 650 m above sea level; Habitat: Turkey oak, chestnut tree.
20) Buzzò (Municipality of Albareto), 750 m above sea level; Habitat: chestnut tree.
21) Passo del Bratello (in the Municipality of Borgotaroi), 950 m above sea level; Habitat: chestnut, beech, pine, silver fir.
22) Pontolo (Municipality of Borgotaro), 600 m above sea level; habitat: chestnut, pine.
23) Borgotaro-West/Southwest outskirts, 450 m above sea level; habitat: black pine, Turkey oak.
24) Tiedoli (Municipality of Borgotaro), 600 m above sea level; habitat: Turkey oak, pine.
25) Abbazia-Borgotaro, 420 m above sea level; habitat: pine, Turkey oak.
26) Rovinaglia (Municipality of Borgotaro), 700 m above sea level; Turkey oak, chestnut.
27) Porcigatone (Municipality of Borgotaro), 750 m above sea level; Turkey oak, hornbeam.
28) Ravezza (Municipality of Tornolo) 720 m above sea level; Turkey oak, chestnut tree.
29) Pieve di Campi (Municipality of Albereto); 450 m above sea level; Turkey oak, alder, poplar, black pine.
30) Mt. Tomarlo (Municipality of Begonia); 1420 m above sea level; beech.
31) Marzuola (Municipality of Tornolo); 550 m above sea level; Turkey oak, chestnut tree.
32) Lago Buono-basso (Municipality of Borgotaro); 800 m above sea level; Turkey oak, chestnut tree.
33) Stradella (Municipality of Bardi); 700 m above sea level; Turkey oak, chestnut tree.
34) Comune (Municipality of Bardi); 650 m above sea level; Turkey oak, chestnut tree.
35) Belforte (Municipality of Borgotaro); 740 m above sea level; Turkey oak, chestnut tree.
36) Fontana del Faggio (Municipality of Albareto); 1000 m above sea level; beech, silver fir, chestnut.
37) Costa dei Rossi (Municipality of Albareto); 600 m above sea level; Turkey oak, black pine.
38) Passo dei Due Santi (Municipality of Albareto); 1200 m above sea level; beech, chestnut.
39) Lago Buono-alto (Municipality of Borgotaro); 900 m above sea level; Turkey oak, chestnut, hazelnut.
40) Case Mirani (Municipality of Albareto); 650 m above sea level; Turkey oak, chestnut.
41) Cavanna (Municipality of Borgotaro); 600 m above sea level; Turkey oak, Prunus.
42) Strela (Municipality of Compiano); 680 m above sea level; Turkey oak.
43) Loc. Franchi (Municipality of Bore); 800 m above sea level; Turkey oak, chestnut.
44) Ghirardi (Municipality of Albareto); 600 m above sea level; Turkey oak, downy oak, chestnut tree, black pine.
45) Valbona (Municipality of Berceto); 800 m above sea level; Turkey oak, chestnut tree.
46) Tugo (Municipality of Berceto); 950 m above sea level; Turkey oak, chestnut tree.
47) Cento Croci Pass (Municipality of Tornolo); 1000 m above sea level; chestnut tree, black pine.
48) Case Mantecali (Municipality of Tornolo); 650 m above sea level; Turkey oak.
49) Monte Zuccone (Municipality of Tornolo); 1200 m above sea level; chestnut tree.
50) Loc. Riboni (Municipality of Albareto); 600 m above sea level; Turkey oak, chestnut tree.
51) Tornolo (Municipality of Tornolo); 700 m above sea level; chestnut.
52) Miramonti (Municipality of Tornolo); 900 m above sea level; black pine, chestnut.

53) Prato (Municipality of Bedonia); 900 m above sea level; chestnut.
54) Bergotto (Municipality of Berceto); 850 m above sea level; black pine.
55) Volpara (Municipality of Bedonia); 920 m above sea level; chestnut.
56) S. Maria del Taro (Municipality of Tornolo); 780 m above sea level; black pine.
57) Groppo della Donna (Municipality of Berceto); 800 m above sea level; Turkey oak, chestnut.
58) Tasola (Municipality of Bedonia); 850 m above sea level; chestnut.
59) Vignole (Municipality of Borgotaro); 600 m above sea level; poplar, lariccio pine.
60) Anzola (Municipality of Bedonia); 750 m above sea level; chestnut, Turkey oak.
61) Piana dei Berti (Municipality of Berceto); 800 m above sea level; black pine.
62) Fagiolo (Municipality of Bedonia); 750 m above sea level; chestnut, Turkey oak.
63) Frascara (Municipality of Borgotaro); 410 m above sea level; chestnut, fir.
64) Grezzo (Municipality of Bardi); 650 m above sea level; chestnut, Turkey oak.
65) Brunelli (Municipality of Borgotaro); 600 m above sea level; Turkey oak.
66) Monti (Municipality of Bedonia); 850 m above sea level; chestnut, Turkey oak.
67) Tarsogno (Municipality of Tornolo); 800 m above sea level; chestnut tree.
68) Valbona (Municipality of Berceto); 800 m above sea level; chestnut tree, oaks.
69) Corti (Municipality of Bardi); 750 m above sea level; chestnut tree, Turkey oak.
70) Seminary Park (Municipality of Bedonia); 550 m above sea level; chestnut tree, fir tree, cedar tree.
71) Pradonico (Municipality of Borgotaro); 1200 m above sea level; beech.
72) Piani di Tiedoli (Municipality of Borgotaro); 500 m above sea level; Turkey oak.
73) Noveglia (Municipality of Bardi): 550 m above sea level; Turkey oak, chestnut.
74) Sivizzano (Municipality of Fornovo T.); 300 m above sea level; Turkey oak.
75) Pian delle Vigne (Municipality of Berceto); 800 m above sea level; Turkey oak, chestnut tree.
76) Ramiola (Municipality of Medesano); 200 m above sea level; Turkey oak.
77) Tovi (Municipality of Borgotaro); 700 m above sea level; Turkey oak, chestnut tree.
78) Lozzola (Municipality of Berceto), 500 m above sea level; Turkey oak, chestnut tree.
79) Boschetto (Municipality of Albareto), 500 m above sea level; chestnut tree.
80) Loc. Montevac à (Municipality of Bedonia); 850 m above sea level; Turkey oak.
81) Codogno (Municipality of Albareto), 600 m above sea level; Turkey oak.
82) Pradonico in Val Vona, (Municipality of Borgotaro); 800 m above sea level; chestnut tree.
83) Montegroppo (Municipality of Albareto), 750 m above sea level; chestnut tree.
84) Prato delle Femmine (Municipality of Bardi); 900 m above sea level; Turkey oak, hornbeam, hazelnut tree.
85) Roncole (Municipality of Albareto), 600 m above sea level; chestnut tree.
86) S. Martino (Municipality of Valmozzola); 680 m above sea level; Turkey oak, chestnut tree.

In Bleu: DX-Taro, the nature of the soil is siliceous with a high potassium content.

In Red: SX-Taro, the nature of the soil is moderately calcareous with normal potassium content and with prevalent tree flora consisting of Quercus cerris (Fagaceae Family).

Very Important Note: The limit values, originally evaluated in the tables (and underlined to highlight them) according to Reg.EC n ° 1881/2006, were then corrected after 02.07.2008 according to Reg.EC n ℃629/2008 amending Reg.EC 1881/2006 (and confirmed by Reg.EC n ℃488/2014 for the Cd).

Ecology of the Territory

DX (right Taro): 1) Q.cerris, 2) Castanea sativa, 3) Wild Fagus, 4) Abies Alba, 5) Pinus nigra.

1) Quotes: 1) 440-700 mslm, 2) 500-1000 mslm, 3) 900-1740 mslm, 4) 900-1320 mslm, 5) 800-1000 mslm.
2) Dominant Winds: West/ North-West and North-North East / South-South West) (in winter).
3) Soil nature: siliceous with high potassium content.

SX (Left Taro): 1) Quercus cerris, 2) Castanea sativa, 3) Wild fagus, 4) Ostrya carpinifolia, 5) Pinus Nigra.

1) Quotes: 1) 440-750 mslm, 2) 500-800 mslm, 3) 900-1100 mslm, 4) 600-900 mslm, 5) 600-1000 mslm.
2) Soil nature: moderately calcareous.
3) Dominant winds: North-East/South-West and South-West/North-East (limited to Varacola valley and Vona valley).

Map: DX Taro - Borgotaro District / Vighini-Pontolo/Molinatico Mount.

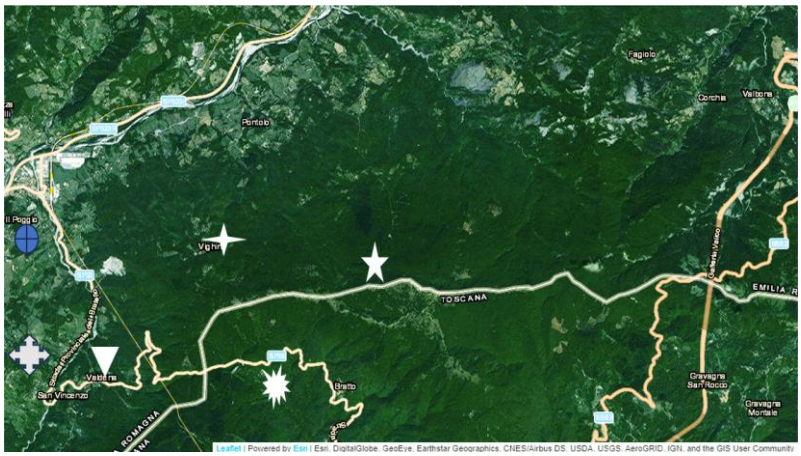

Figure 7. *DX Taro Map.*

DX Taro: the road (▽) is that of the Brattello Pass -1050 mslm (Borgotaro/Pontremoli) in Tarodine river Valley
Crusader Circle: West/South-West Outskirts of Borgotaro-450-500 mslm (23)
Cross: Rovinaglia - 815 mslm / Stabielle - 723 mslm (26.15)
4-pointed star : Vighini - 1010 mslm (16)
5-pointed star : M.Molinatico (13) -1535 mslm
Sun : Brattello Pass /Prato delle Cotiche -1150 mslm (21.10)

Mappa: SX Taro -Borgotaro District /S.Donna pass/Tiedoli/Valmozzola

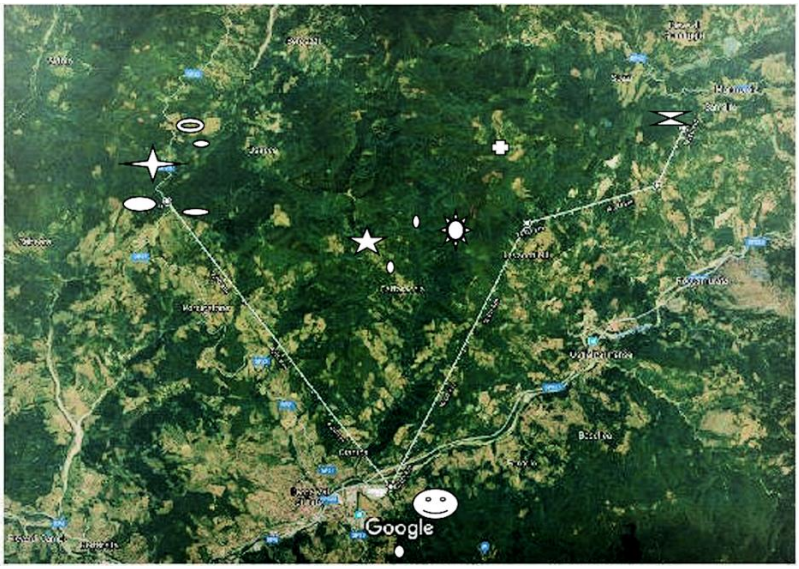

Figure 8. *SX Taro Map.*

Double Circle : Prato Femmine/Noveglia (92.75)
Cross: Tiedoli - 660 mslm (24.73)
4-pointed star : S.Donna pass - 939 mslm(2)
-pointed star : upper Vona valley - 930 mslm Pian del Monte(18.84) Sun : Tovi (84.10)
Hourglass : Valmozzola(95) - 696 mslm
Laughing Face : Borgotaro Industrial Area - 410 mslm
Small white ellipses (flat and/or straight) indicate widespread but small contamination.
Borgotaro S.Donna pass, Varacola stream valley
Borgotaro Pian del Monte, Vona stream valley

The attached map highlights with a black dot the samples collected in the indicated location and which exceed the EU limits in the fresh (raw).

Drops (and white circles) indicate samples collected at the indicated location and exceeding EU limits in the fresh (raw) by at least 4-5 times.

The tree flora up to 900 m above sea level is made up of chestnut trees; above this, mainly beech.

Note:

-Annual rain in DX and SX Taro: poor

Abbreviations

mslm Altitude in Meters Above Sea Level

Acknowledgments

Members of the former Parma PMP who have collaborated on this research since 2001; ARPA of Parma which then performed numerous analyses until 2009 and in particular Dr. Chim. Sara Reverberi; AUSL of Parma (Borgotaro- Fornovo Taro district) for the constant aid in this work and to dr Francesco Bellù (┼), Bozen), prof. Ursula Peintner (University of Innsbruck), prof. R.Poeder(┼), (University of Innsbruck), who contributed to the collections and to "certain" determinations of fungi.

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Cinzia De Luca: Resources, Validation, Writing – original draft

Filippo Galli: Writing – original draft, Writing – review & editing

Fabrizio Negri: Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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