Biogeosciences Discuss., 12, 17851–17856, 2015
www.biogeosciences-discuss.net/12/17851/2015/
doi:10.5194/bgd-12-17851-2015

Biogeosciences Discussions
Open Access
EGU

Ideas and perspectives: truffles not radioactive

U. Büntgen[1,2,3], M. Jäggi[4], U. Stobbe[5], W. Tegel[6], L. Sproll[5], J. Eikenberg[4], and S. Egli[1]

[1]Swiss Federal Research Institute WSL, Dendroecology Group, Birmensdorf, Switzerland
[2]Oeschger Centre for Climate Change Research OCCR, Bern, Switzerland
[3]Global Change Research Centre AS CR, Brno, Czech Republic
[4]Paul Scherrer Institute PSI, Villigen, Switzerland
[5]Deutsche Trüffelbäume, Radolfzell, Germany
[6]Institute of Forest Sciences IWW, Freiburg University, Freiburg, Germany

Received: 30 September 2015 – Accepted: 28 October 2015 – Published: 10 November 2015

Correspondence to: U. Büntgen (buentgen@wsl.ch)

Published by Copernicus Publications on behalf of the European Geosciences Union.

Abstract

Although ranging among the most expensive gourmet foods, it remains unclear if Burgundy truffles (*Tuber aestivum*) accumulate radioactivity at a harmful level comparable to other fungi. Here, we measure the ^{137}Cs in 82 *T. aestivum* fruitbodies from Switzerland, Germany, France, Italy and Hungary. All specimens reveal insignificant radiocaesium concentrations, thus providing an all clear for truffle hunters and cultivators in Europe as well as dealers and customers from around the world. Our results are particularly relevant in the light of recent cultivation efforts and the fact that forest ecosystems are still highly contaminated with ^{137}Cs, for which mushrooms are the main pathways to human diets.

Study

Extensive cultivation efforts of the Burgundy truffle (*Tuber aestivum* Vittad.) far beyond its traditional homeland in France aim at supplementing wildlife harvests for the growing demand of a globalized market (Hall et al., 2003). Despite the rapidly increasing economic interest in this ectomycorrhizal ascomycete, most of the hypogeous life cycle is, however, not yet understood (Stobbe et al., 2012, 2013). Together, with a general lack of ecological insight, it remains unclear if truffles are accumulating radioactivity at a harmful level comparable to other fungal species and subsequent components of the trophic food web (Dighton et al., 2008; Hohmann and Huckschlag, 2005; Strebl and Tataruch, 2007; Steiner and Fielitz, 2009; Mietelski et al., 2010).

Since the Chernobyl accident in 1986, large parts of Europe's topsoil are radioactively contaminated (De Cort et al., 1998; Evangeliou et al., 2013), with high radionuclide levels still implying concerns for ecotoxicology and human health. Some ectomycorrhizal and saprotrophic fungi appear particularly prone to mediating and incorporating radiocaesium 137 (^{137}Cs) (Dighton et al., 2008), with different melanin contents and mycelium depths contributing to species-specific rates of radio-resistance and ^{137}Cs accumulation (Mietelski et al., 2010). In regions where aerosol fallout after Chernobyl was most intense, not only mushrooms but also later components in the food chain, including game meat of red deer, roe deer and wild boar, still exceed the ^{137}Cs tolerance value of 600 Bq kg^{-1} (Hohmann and Huckschlag, 2005; Strebl and Tataruch, 2007; Steiner and Fielitz, 2009).

Here, we measure ^{137}Cs activity concentrations of 82 *T. aestivum*, harvested by trained dogs between 2010 and 2014 in natural habitats and plantations across Switzerland, Germany, France, Italy and Hungary (Fig. 1a). Individual fruitbodies were cleaned and grinded for γ-spectrometry. After correction for the decay rate, all specimens reveal insignificant ^{137}Cs values below the detection limit of 2 Bq kg^{-1} (determined by the background noise, counting efficiency, processing time and sample weight). This result suggests an all clear for Burgundy truffle hunters and cultivators in Europe as well as dealers and customers all over the world.

Our findings, in agreement with previous, local-scale evidence from Italy (Lorenzelli et al., 1996), are surprising as mycorrhizal mushrooms play a key role in the radioecology of natural ecosystems (Fig. 1b). Hypogeous deer truffles (*Elaphomyces granulatus*), for instance, range amongst the most contaminated fungi (Hohmann and Huckschlag, 2005; Strebl and Tataruch, 2007; Steiner and Fielitz, 2009). Reasons for non-radioactive *T. aestivum* possibly involve species-specific requirements for soil structure and chemistry, together with mycelium depth, melanin content and/or the lack of ^{137}Cs binding pigments. It has also been argued that calcium carbonate reduces the soil-plant transfer of ^{137}Cs, while its availability for plants is high in nutrient-poor organic soil horizons (Mascanzoni, 2001, 2009).

Truffles generally fruit near the surface of calcareous substrate (Stobbe et al., 2012, 2014). Nevertheless, more insight is needed into the chemical composition of truffle fruitbodies and their symbiotic interaction with host roots (Büntgen and Egli, 2014), considering potential effects on the cycling of ambient ^{137}Cs from both Chernobyl and atmospheric testing in the 1950s and 1960s. These, and associated tasks surrounding the hidden world of truffles appear timely in the light of recent cultivation efforts (Hall et al., 2003; Stobbe et al., 2013), as well as the fact that forest ecosystems still provide ample ^{137}Cs for uptake with mushrooms representing the main pathway to human diets (Mascanzoni, 2009). Further relevance emerges from the environmental contamination of Fukushima and a higher transfer rate of radionuclides under global warming.

Author contributions. U. Büntgen designed and wrote the study with input from all authors. M. Jäggi and J. Eikenberg performed isotopic measurements.

Acknowledgements. We are thankful to all truffle hunters who kindly provided *T. aestivum* fruitbodies. F. Hagedorn and M. Hayes reviewed earlier manuscript versions. Supported by the WSL-internal DITREC project and the Ernst Göhner Foundation.

References

Büntgen, U. and Egli, S.: Breaking new ground at the interface of dendroecology and mycology, Trends Plant Sci., 19, 613–614, 2014.

De Cort, M., Dubois, G., Fridman, S. D., Germenchuk, M. G., Izrael, Yu. A., Janssens, A., Jones, A. R., Kelly, G. N., Kvasnikova, E. V., Matveenko, I. I., Nazarov, I. M., Pokumeiko, Yu. M., Sitak, V. A., Stukin, E. D., Tabachny, L. Ya., Tsaturov, Yu. S., and Avdyushin, S. I.: Atlas of caesium deposition on Europe after the Chernobyl accident, Luxembourg, Office for Official Publications of the European Communities 1998, ISBN 92-828-3140-X, Catalogue number CG-NA-16-733-29-C, EUR 16733, 1–63, 1998.

Dighton, J., Tugay, T., and Zhdanova, N.: Fungi and ionizing radiation from radionuclides, FEMS Microbiol. Lett., 281, 109–120, 2008.

Evangeliou, N., Balkanski, Y., Cozic, A., and Møller, A. P.: Simulations of the transport and deposition of ^{137}Cs over Europe after the Chernobyl Nuclear Power Plant accident: influence of varying emission-altitude and model horizontal and vertical resolution, Atmos. Chem. Phys., 13, 7183–7198, doi:10.5194/acp-13-7183-2013, 2013.

Hall, I. R., Yun, W., and Amicucci, A.: Cultivation of edible ectomycorrhizal mushrooms, Trends Biotechnol., 21, 433–438, 2003.

Hohmann, U. and Huckschlag, D.: Investigations on the radiocaesium contamination of wild boar (*Sus scrofa*) meat in Rhineland-Palatinate: a stomach content analysis, Eur. J. Wildl. Res., 51, 263–270, 2005.

Lorenzelli, R., Zanbonelli, A., Serra, F., and Lamma, A.: ^{137}Cs content in the fruit bodies of various *Tuber* species, Health Phys., 71, 956–959, 1996.

Mascanzoni, D. J.: Long-term ^{137}Cs contamination of mushrooms following the Chernobyl fall-out, Radiaanal. Nucl. Chem., 219, 245–249, 2001.

Mascanzoni, D. J.: Long-term transfer of ^{137}Cs from soil to mushrooms in a semi-natural environment, Radiaanal. Nucl. Chem., 282, 427–431, 2009.

Mietelski, J. W., Dubchak, S., Blazej, S., Anielska, T., and Turnau, K.: ^{137}Cs and ^{40}K in fruiting bodies of different fungal species collected in a single forest in southern Poland, Envir. Radiactiv., 101, 706–711, 2010.

Steiner, M. and Fielitz, U.: Deer truffles – the dominant source of radiocaesium contamination of wild boar, Radioprotection, 44, 585–588, 2009.

Stobbe, U., Büntgen, U., Sproll, L., Tegel, W., Egli, S., and Fink, S.: Spatial distribution and ecological variation of the re-discovered German truffle habitats, Fungal Ecol., 5, 591–599, 2012.

Stobbe, U., Egli, S., Peter, M., Sproll, L., and Büntgen, U.: Potential and limitations of Burgundy truffle cultivation, Appl. Microbiol. Biot., 97, 5215–5224, 2013.

Strebl, F. and Tataruch, F. J.: Time trends (1986–2003) of radiocesium transfer to roe deer and wild boar in two Austrian forest regions, Envir. Radiactiv., 98, 137–152, 2007.

BGD

12, 17851–17856, 2015

BGD
12, 17851–17856, 2015

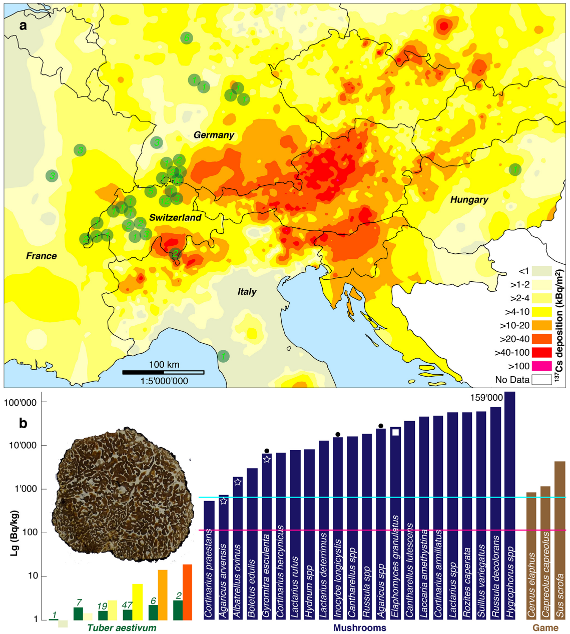

Figure 1. Truffle location and ^{137}Cs contamination. **(a)** Distribution of 82 truffle sites (green spots) superimposed on ^{137}Cs surface deposition after Chernobyl (De Cort et al., 1998). **(b)** Mass-specific mean ^{137}Cs detection limit (after ∼ 20 h) of truffle fruitbodies (∼ 45 g) classified after local deposition levels (numbers refer to the amount of samples per deposition level), together with published ^{137}Cs contamination values of edible and toxic (black dot) mycorrhizal and saprotrophic (white star) above- and belowground (white square) mushrooms (Dighton et al., 2008; Steiner and Fielitz, 2009; Mascanzoni, 2001), as well as game meat (Strebl and Tataruch, 2007). Horizontal lines are tolerance values for food (100 Bq kg^{-1}) and fungi/game (600 Bq kg^{-1}).