TRANSFER OF AN INDUSTRIAL MARKER, FROM ATMOSPHERE TO LIFE

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Introduction

For long periods of time, before the Anthropocene, the atmospheric transfers of dusts and the quantitative changes on atmospheric dust composition were only depending on geological, biological and climatic events. However, since the industrial revolution, some changes depending on mankind in relation to his industrial activities have induced some dangerous situations through the local accumulation of (potentially) toxic elements (PTE). This has been demonstrated for radionuclides, severely toxic elements such as Hg or Cd but also for PTE such as Cu, Zn and Sb. Nowadays, in places of intense industrial and economic activities, it is almost impossible to understand the relations between each element deposition due to different past and present sources and the potential danger for human health and the different compartments of the ecosystems. It seems then necessary presently to focus on the study of simpler situations where one source is strongly characterized by the presence inside the whole emission mixture of one type of product, as specific as possible. This product will play the role of a marker and can be followed all along the transfers between the different compartments constituting food chains or ecosystems. For this purpose, in a site heavily contaminated by steel industry, we addressed three questions: (1) the identification of a typical marker of the industrial deposits (Catinon et al., 2014), (2) the spatial heterogeneity of the deposit, and (3) the transfer of the elements contained in the deposit to cows through the consumption of herbage and soil (Ayrault et al., 2016).

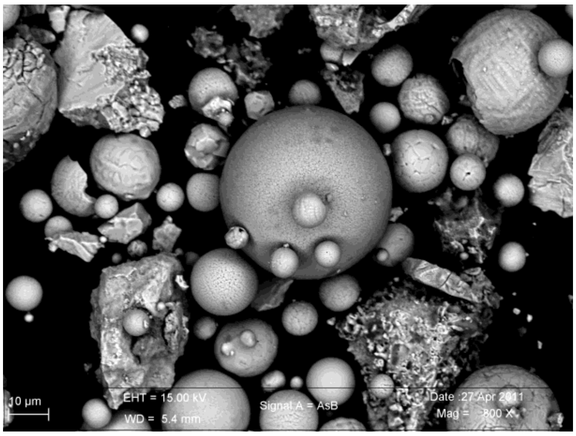
Methods

Since 1865, an intense steel industry has been developing in the Giers River valley (S.E. of France). The large metallurgic plant is located at the bottom of the valley in the small town of Chateauneuf. To establish the typical signature of the steel plant emission, the strategy was to cross chemical analysis of the bulk deposit (ICP-MS analysis after total digestion) with imaging and micro-analysis of the deposit particles (SEM-EDX). The distribution of the tracer and the elemental contaminants in deposited samples was comparatively studied in five villages surrounding the smelter. The role of collecting supports used for sampling has been played by tombstones in the graveyards of each village. In an enclosed 3 ha pasture, located on the site the deposit has the highest industrial tracer concentration, cow dungs were sampled periodically. Another herd was grazing in a pasture located in a site where the typical industrial signature is not present in the atmospheric deposit. The cow dung from this site was sampled once, for comparison.

Results

The industrial marker was constituted by the small droplets mainly made of Fe with potentially traces of Cr, Ni, Mn. These technogenic magnetic particles (TMP) were emitted at high temperature (1500 °C) and which gave perfect crystallized, well-recognizable spheres, formed during cooling. The magnetic properties of these structures were used to isolate them from the deposits. The typical shape of the TMP allows an unequivocal identification of industrial emission. This approach allowed to document the spatial distribution of the deposit of industrial origin. The contribution of the TMP to the deposit reached its highest value (8% w.) 500 m away from the source but decreased rapidly with distance, was found 0.1% 10 km away. A calculation of the anthropogenic elements fraction (Catinon et al., 2009) in the deposit and in the dung gave the ratio for each element between the TMP and the rest of the anthropogenic mixture. The SEM-EDX study allows to evaluate the diameter of the TMP and express the concentration of TMP with size enabling the entry in the respiratory system of mammal animals. Furthermore, we found that the TMP content of the dung is ~5 times more that the figure that could be infers from the grazed grass content. The origin of this discrepancy is that cows absorb a noteworthy amount of soil upper layer (Wilkinson et al., 2003). For a constant emission having occurred for years, the soil accumulation represents the result of a deposition flux increasing the stock and of a degradation flux decreasing it. The resulting stock controls the flux of entry of the TMP constituents into food chains and ecosystems. Furthermore, we studied the accumulation at different soil depth and the deposition on plant leaves.

Figure 1. Scanning electron microscope photograph of the technogenic magnetic particles in the cow dungs from Chateauneuf.



Conclusion

All these measurements suggest a global contamination of all the steps of food chains and ecosystems. Grazing and dung emission seems to maintain a high contamination level of the upper soil layer, reaching evidently earthworms, saprophytic animals and microorganisms.

References

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