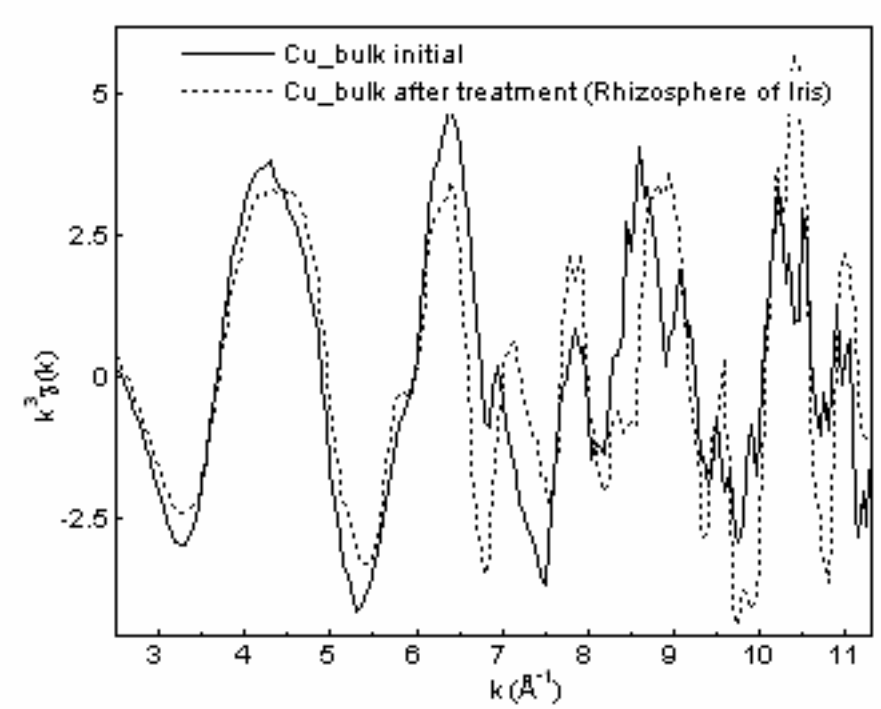
This project is led by Tatiana Kirpichtchikova, who will defend her Ph.D. thesis during the first quarter of 2005. At present, she is finalizing a first article on the speciation of Zn in the contaminated soil before phytoremediation. A second article, on the speciation of Zn in the same soil after phytoremediation, is in preparation and should be completed by Christmas. A third article on the speciation of Cu before and after remediation will be drafted for the thesis document and finalized in 2005.

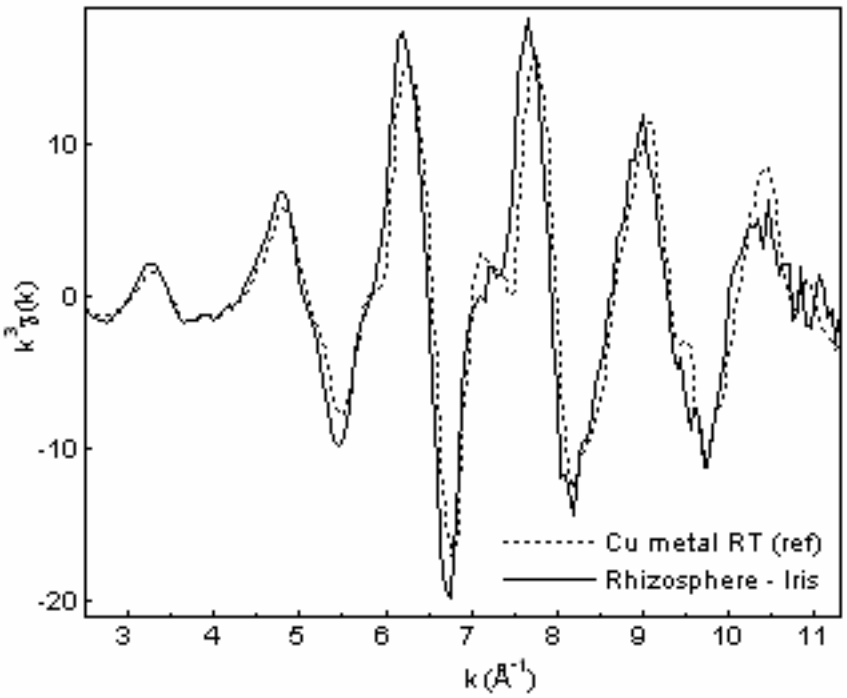
The aim of the experiments was to study the molecular-basis of a phytoremediation technology developed by the Site et Concept company (now Phytorestore: http://www.phytorestore.com/). The process is proprietary, but a brief description of the experimental setup is as follows. Sixteen cubic meters of a soil, which was irrigated for 100 years with wastewater from the city of Paris, were deposited in a pilot site and treated chemically and with plants, to remove the labile fraction of Zn and Cu and to stabilize the remaining fraction in sparingly soluble forms. The remediating metal-extracting solutions leached out from the treated soil were collected in a peat pot. This technology is now in operation to treat solid urban wastes from a number of cities in France, and soon in China (Benjing and Shangai). Determining the solid-state speciation of heavy metals before, during and after phytoremediation is clearly important to improve the existing technique and foster the development of spin-off technologies.

A collection of good data has been harvested during Tatiana Kirpichtchikova's thesis and, as mentioned above, will be consolidated in three publications. The most important, and unexpected, result has been the identification of elemental Cu and Zn particles formed as a result of the activity of plant roots. These particles are 5 to 10 micron in size and are made up of nanometer-sized grains. We have been extremely careful at preventing radiation damage, in particular by recording spectra at low temperature with the He cryostat available on the beamline, and by cross-checking our result by micro-XRD on a low flux beamline.

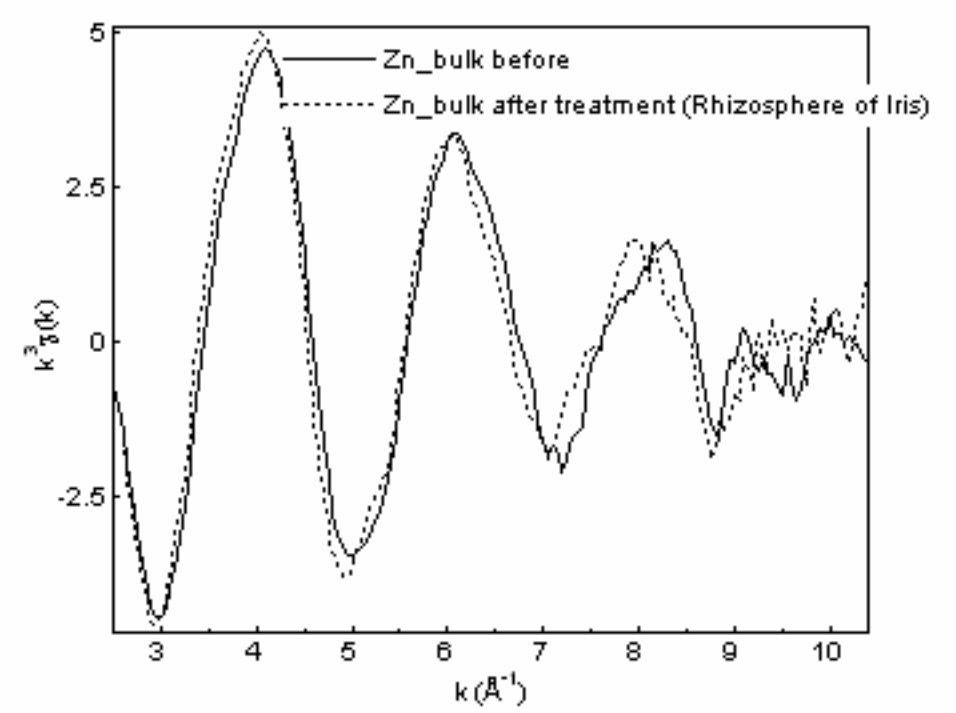
This program is highly successful since, after the City of Paris and the Region Ile-de-France, which funded the phase I of the project (i.e., Tatiana Kirpichtchikova's thesis), the ADEME decided to support the phase II, which consists to study the form of metals in the peat pot (cf. the new proposal by Camille Daubord).



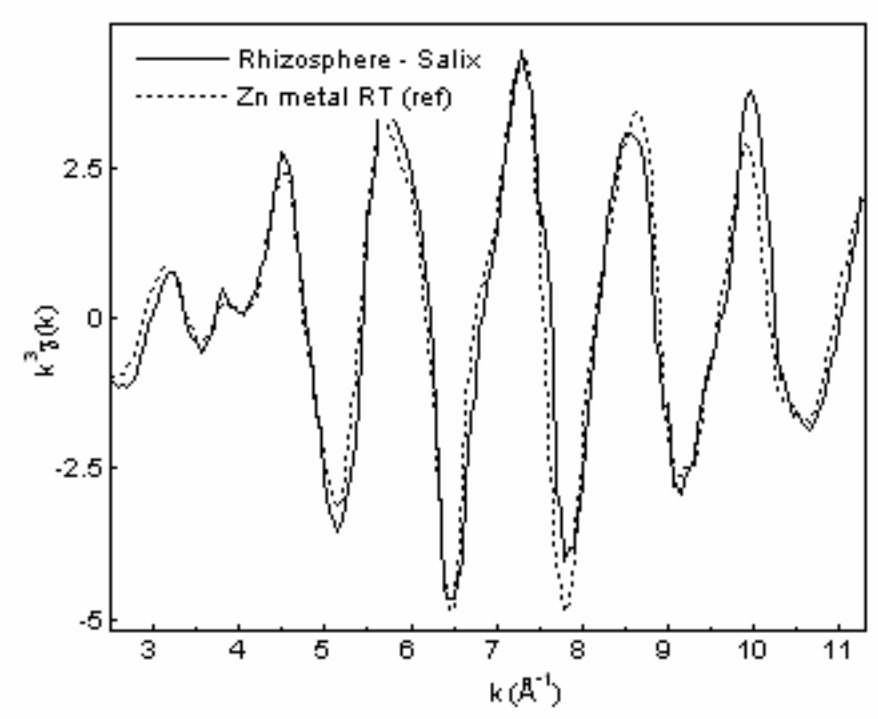
Powder Cu-EXAFS spectra of the soil before and after treatment by phytoremediation. The dip at ~6.8 $Å^{-1}$ and the maximum at about 7.8 $Å^{-1}$ in the spectrum from the treated soil are due to elemental Cu.



Micro-EXAFS spectrum from a Cu particle in the rhizosphere of iris, demonstrating the formation of elemental Cu.



Powder Zn-EXAFS spectra of the soil before and after treatment by phytoremediation. The proportion of elemental Zn is clearly lower than that of elemental Cu.



Micro-EXAFS spectrum from a Zn particle in the rhizosphere of Salix, demonstrating the formation of elemental Zn.