Synchrotron radiation & environmental science

Piero Lattanzi
Università di Cagliari

Environmental science is a broad term encompassing an extreme variety of complex phenomena straddling the border between physical (physics, chemistry and Earth science) and life sciences. In this sense, environmental science is inherently a truly interdisciplinary science. Because of this intrinsic complexity of processes and materials, the early stage of environmental studies has mostly seen the empirical description of behaviour at the bulk scale. In the last decades, however, there has been an increasing awareness that basic understanding of environmental materials and processes is essential for a full appreciation of the phenomena. Such a basic understanding requires investigation down to the micro-, nano- and atomic scale. This concept is summarized by the current definition of molecular environmental science (MES). Synchrotron-based techniques are fundamental to this type of approach, indeed the development of MES was largely made possible and stimulated by progresses and accessibility of synchrotron light facilities. These techniques enable the study of typically complex environmental samples (e.g., mixed mineral-organic systems such as soils, poorly crystalline and/or nano-structured materials, bio-films, solid-liquid interfaces).

In principle, any synchrotron-based technique is potentially applicable to environmental research. Traditionally, one of the most widespread applications has been X-ray absorption spectroscopy (XAS), in particular EXAFS, used to define the local atomic structure of an eco-toxic element in a specific matrix. This information is important to try and predict the behaviour of this element in ecosystems (e.g., mobility, retention, uptake by living organisms). X-ray diffraction was also commonly employed (for phase identification, monitoring of phase transformation in time-resolved experiments, etc.). On the other hand, with the development of third generation sources, X-ray microscopy (both “soft” and “hard”) and, in general, micro-techniques (micro-diffraction, micro-fluorescence, micro-XAS) became increasingly available, and their application in environmental science is booming. Other applied techniques include the study of surfaces through grazing incidence beam, X-ray standing waves, X-ray photoelectron spectroscopy, and more. In my presentation, I will make a necessarily limited number of examples of such applications; because of my background, they will be strongly shifted toward the Earth science component (mineralogy, geochemistry) of environmental science.