Accepted for Oral Presentation and Pubblication on the Book of Abstract of ICEEM'08 (9th-12th September 2015)

BIOREMEDIATION OF RADIOACTIVITY IN CONTAMINATED ENVIRONMENTAL MEDIA

Sara Zanni, Alessandra Bonoli

DICAM - Department of Civil, Chemical, Environmental and Materials Engineering
Terracini Street 28, 40131 Bologna, Italy, +390512090479, sara.zanni7@unibo.it

Bio-remediation tools are widely regarded as a new hope for complex remediation scenarios and recalcitrant contaminants. Demonstrations of the removal and immobilization potentiality of inorganic contaminants by microbial transformations, sorption and mineralization have been gathered show the potential of both natural and engineered microbes as bioremedial tools (Barkay et al).

Different studies in laboratories and in natural environments have shown a high affinity of microbial biomass for actinide elements, heavy metals, and radionuclides. Published results (Sarró et al.) suggest that biofilm communities in spent nuclear fuel pools are directly involved in the accumulation of radionuclides from the water. The two main mechanisms involved in microorganisms-radionuclides interaction are biosorption and bioaccumulation. The former is a metabolically independent physical process at the cell surface, which implies passive sequestration of metals and radionuclides, while the latter is an energy-dependent process involving intracellular accumulation. Biosorption is, at present, the most practical and widely used approach for the bioremediation of heavy metals and radionuclides (Barkay et al).

Sarró 's results suggest that biofilm are able to proliferate on metallic solid support in water, in spite of the radioactive and oligotrophic conditions of the water, and they are able to retain radionuclides, which accumulate on the surface of metallic support sampled.

The radionuclides and toxic metals released into solution are immobilized by enzymatic reductive precipitation, biosorption and redistribution with stable mineral phases in the waste, making remediation goals achievable by first precipitation (Citrobacter sp., for instance, has been proved to successfully precipitate uranyl phosphate) and then immobilization of inorganic contaminants; second, concentration and thus reduction in volume of contaminated matrices; and third, compartmentalization of heavy metals or radionuclides to an environment matrix in which their harm is reduced (Barkay et al).

Microbial precipitation of metals and radionuclides as minerals of sulfide, hydroxide, phosphate and carbonate have potential and documented applications in bioremediation, while biosorption is an effective treatment of wastewater.

Immobilized activated sludge has been evaluated by New Jersey Institute of Technology (Rus) as a potential biosorbent for the removal of heavy metals from liquid waste streams. The method of immobilization consists of entrapment of the microorganisms in calcium alginate beads. A bench-scale system was developed and tested to optimize the biosorption process, gaining promising results for heavy metals, such as lead and chromium. The very same bacteria consortium, mixed with selected, but non engineered strains, fungi and enzymes, has been included into biomass preparation for U-ox proposed by U-Earth (www.u-earth.eu), which is expected to act as immobilizing agent for radionuclides dispersed into air and water. Soil bacteria (such as Ralstonia and Burkholderia) have been classified by the Microbial Genomics Research, DOE (Department of Energy, USA) [http://www.microbial genome.org/organisms.shtml] as microorganisms potentially useful for bioremediation of several compounds and elements, even radioactive ones.

The bioreactors proposed are classified as "Immobilized cell bioreactors" and work with a combination of convection (for handling oxygen and larger particles) and, as a main mechanism, the biological digestion of hazardous materials captured. When applied to air contamination treatment, these plants miniaturized, in fact, use the bio-oxidation to destroy gases, volatile organic compounds (VOC), odors, and remove particulates and heavy metals using electrical attraction and biological. No further ionization is generated, nor electrostatic charging (which increase the danger of airborne components), but is exploited the natural surface charge of the particles. The correct sizing and positioning of bioreactors contributes to the superposition of the individual units, increasing the overall effectiveness of the system and giving space to anticipate a positive outcome in application for airborne radioactivity in exposed indoor environment (hospitals, for instance).

The application on water would be addressed to collect radioactivity into a concentrated medium, which would become easier to be managed and, therefore, less harmful to environment and human health. An extensive testing period in controlled conditions is required before proceeding to the field application in real radioactivity polluted sites. Thus to identify sorption and concentration rate, together with possible final disposal solution for centrate. Due to the safety issue related to radiations, lab-scale application involves heavy metals which behavior could be assimilated to radionuclides and give important information about the up-scaling on the system in real case scenarios, i.e. post nuclear accident scenario. A specific focus on heavy metal and, therefore, radionuclides, separation from sea water is under study, in order to meet the current conditions of seawater surrounding Japan.

The bio-remediation of contaminated environmental media is to be acquired in compliance with local regulations and safety measures, provided that concentrating the radioactive polluted medium implies possible higher emission, but it would grant, nevertheless, the restoration of an environmental conditions compatible with ecosystem and life.