Biosorption: A Promising Green Approach

Unfortunately, the science particularly chemistry, despite numerous contributions to the well-being and progress of humanity, has been blamed for the present ills of the world. In fact, it is not chemistry or science or technology but our past mistakes of increasing only the production without considering the simultaneous generation of large amounts of side products or waste which have underlined us as the culprit. Basically unscientific and careless rapid urbanization, industrialization, and agriculturalization are major threats to the environment. It is not the need of poor but the greed of rich nation, which has been the main cause of environmental degradation of the world.

Chemists, since 1990, have started addressing complicated environmental issues in a safe and an economically profitable manner under various names like Clean Chemistry, Environmentally Benign Chemistry, Sustainable Chemistry, Come Back to Nature, Gray to Green Chemistry, Green Technologies, Eco-friendly Techniques, Green Processes, and more popularly Green Chemistry. Green Chemistry is a special contribution of chemists to the conditions for sustainable development, incorporating an environmentally benign design approach to all aspects of chemical industry. The word Green Chemistry was coined jointly by Prof. Paul T. Anastas and Prof. John C. Warner, which means "The invention, design and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances."

To combine technology with environmental safety is one of the key challenges of the new millennium. There is a global trend of bringing technology into harmony with the natural environment, thus aiming to achieve the goals of protection of ecosystem from the potentially deleterious effects of human activity and finally improving its quality. The magic plants are around and waiting to be discovered and commercialized. They are now recognized and accepted as storehouses of infinite and limitless benefits to human beings. These natural systems are often referred to as *Green Technologies* as they involve naturally occurring plant materials. *Biosorption* is one such important phenomenon, which is based on one of the 12 principles of Green Chemistry, i.e., "Use of renewable resources."

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Prof. Paul T. Anastas (Green Chemistry Institute, American Chemical Society, Washington) and Prof. John C. Warner (University of Massachusetts, Washington) have given 12 principles of Green Chemistry.

Twelve Principles of Green Chemistry

- Design for energy efficiency
- Less hazardous chemical synthesis
- Use of renewable feedstocks
- Atom economy
- Safer chemistry
- Safer solvents and auxiliaries
- Designing safer chemicals
- Use of selective catalyst
- Reduced derivatives
- Design for degradation
- Prevention is better than cure
- Real-time analysis for pollution prevention

A great deal of attention has been garnered in recent years due to rise in environmental awareness and consequent severity of legislation regarding the removal of toxic metal ions from wastewater. It can occur in both plant and microbial species.

It was only in the late 1990s that a new science, biosorption, that could help to remove and recover heavy metals came into existence. It can efficiently and effectively sequester dissolved metals out of dilute complex solutions with high efficiency and also quickly. Biosorption can be defined as "a non-directed physicochemical interaction that may occur between metal/radionuclide species and microbial cells." Natural materials that are available in large quantities or certain waste from agricultural operations may have potential to be used as low-cost adsorbents, as they represent unused resources that are widely available and

environmentally friendly (Kratochvil and Volesky 1998). Availability is a major factor to be taken into account to select biomass for clean-up purposes (Volesky and Holan 1995). Some biosorbents can bind and remove a wide range of heavy metals with no specific priority, whereas others are specific for certain types of metals. When choosing the biomass for metal biosorption experiments, its origin is a major factor to be taken into account (Keith et al. 1979).

Biomass can come from

- ⋆ industrial waste, which should be free of charge.
- ⋆ plants easily available in large amounts in nature and of quick growth.
- ⋆ agricultural waste products.
- ⋆ organisms of quick growth, especially cultivated for biosorption process.

The biosorption process involves a solid phase (biosorbent) and a liquid phase (solvent, normally water) containing dissolved species to be sorbed (sorbate, metal ions). Due to higher affinity of the sorbent for the sorbate species, the latter is attracted and bound there by different mechanisms. The process continues till equilibrium is established between the amount of solid bound to the sorbate species and its portion remaining in the solution. The degree of sorbent affinity for the sorbate determines its distribution between solid and liquid phases. In biosorption, the use of non-living biomaterials containing metal-binding compounds would have the advantage of not requiring tremendous care and maintenance as well as being useful in remediating toxic high levels of contaminants that would otherwise kill live systems (Basso et al. 2002). However, live biological systems work well for low concentrations; they cannot survive the high levels that are found in seriously contaminated areas and industrial effluents (Fourest and Roux 1992).

Biosorption clearly shows that from most perspectives, plants are ideal for environmental cleanup: capital cost is low, ongoing operational costs are minimal, implementation is easy and non-invasive, and public acceptance is high (Veglio and Belochini 2001; Volesky 1999).

- High efficiency
- Minimization of chemical and/or biological sludge
- Regeneration of biosorbent
- Possibility of metal recovery
- Competitive performance
- Heavy metal selectivity

All these show that biosorption is a new and vibrant technology having great potential. To realize this, it will be necessary to understand the various processes

that are involved in it. This may require a multidisciplinary approach and diverse fields of plant biology.

> Biosorption based on metal binding to accumulate heavy metals from waste water through metabolically mediated means is proved to be potential biosorbents
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> Volesky (1987)