

Lignocellulosic Materials: The Cherry on the Cake of Biosorption

Garima Mahajan* and Dhiraj Sud

In the most recent decade the utilization of lignocellulosic substances for the sequestering of heavy metal ions and toxic dyes has gained momentum. These substances are the most suitable and preferred candidates and are valued by researchers around the world due to their great potential and capabilities. Hundreds of the lignocellulosic materials have been explored either in their natural form or after modifying them physically or chemically. Whether studies have involved synthetic metal ion solutions or real industrial wastewater loaded with heavy metal ions, cellulosic sorbent materials have been demonstrated as the best cheap, reusable, and sustainable choice in a competition with synthetic-chemical-based, technology-intensive options. The character of easy availability and the phenomenal components acting as functional moieties for the binding of persistent metals or dyes have led to their utilization that takes advantage of “waste to waste clean development mechanisms”. There has been a great need to investigate the kind of substances that may come out as winners in the race to achieve sustainability; lignocellulosic substances have achieved competitive levels of performance in wastewater remediation.

Keywords: Lignocellulose; Biosorption; Heavy metals; Synthetic dyes

Contact information: Department of Chemistry, Sant Longowal Institute of Engineering and Technology, Longowal, Sangrur-148001, INDIA; Corresponding author: garima8mahajan@hotmail.com

Contribution of Lignocellulosic Materials

Environmental contamination by heavy metal ions and synthetic dyes, along with the resulting in rising health problems and other adverse impacts, has prompted researchers globally to gear up in a search for solutions. After many years of study, biosorption is emerging as one of the most suitable options, and it appears to have some advantages over various conventional water treatment technologies such as ion exchangers, chemical precipitation, reverse osmosis, electro-dialysis, *etc.* The advantages can be traced to limitations in conventional processes, such as low efficiency, sensitivity to operating conditions, production of secondary sludge, and the costs of disposal of byproducts from each treatment option. Initially biosorption was mainly limited to the use of micro-organisms only. Various kind of bacterial, fungal, and algal biomasses were used for the removal of metal ions and dyes from synthetic as well as real industrial effluents. Considerable potential was examined by various researchers for these naturally occurring and abundantly available small creatures. The microorganisms were used either in their natural form or they were used in an immobilized form. The most explored candidates have been *E.coli*, *Bacillus*, *Pseudomonas*, *Streptomyces*, *Chlamydomonas*, *Sargassum*, *Aspergillus*, *Cladosporium*, and *Rhizopus* sp. These processes have to be

very specific in terms of handling of the micro-creatures as well as the temperature and other operational conditions in order to achieve the best outcomes. Further the use of live biomass in terms of bioaccumulation has been very challenging due to technical specifications.

Thus, later on in 1990's a new paradigm has developed in terms of using nonliving lignocellulosic and cellulosic waste residues to act as the potential saviors of the environment. These substances have been used as the best suitable, potential options due to basic components present such as cellulose, hemi-cellulose, lignin, extractives, lipids, proteins, simple sugars, water-swelling hydrocarbons, starch-containing materials, and a variety of functional groups that can facilitate complexation. Interactions with the functional groups can play a role in the sequestering of heavy metals as well as toxic synthetic non-biodegradable dyes.

Biosorption is a multi-fold process that involves a solid phase (sorbent) and a liquid phase (solvent) containing a dissolved species to be sorbed. The numerous mechanisms involved in the process are adsorption by physical forces, chemisorption, complexation, adsorption on surface and pores, ion exchange, and chelation, *etc.* Various characterization studies such as FT-IR, CHN, XRD, SEM, and TEM have confirmed the presence of alcoholic, acetoamido, hydroxyl, amide, carboxylic, phenolic, sulphhydryl, and carboxyl groups having very strong affinity for metal and dye complexation. A number of potential lignocellulosic substances has been used in recent years such as saw dust, rice bran, wheat straws, *Arachis hypogea* shells, *Delbergia sisso* pods, *Acacia saligna* pods, sugarcane bagasse, soyabean hulls, cotton stalks, sunflower hulls, hazelnut shells, hard wood, rose wood, and corncobs, *etc.* All of these substances have been explored relative to the promising potential of lignocellulosic substances for waste water treatments. These materials have been tried not only in their native form, but their flexible nature also has further opened the enhanced responsive properties when modifications were done. These modifications include physical, structural, chemical, and thermal alterations. Options for the conversion of native forms of cellulosic materials have included coagulation or flocculation into the form of beads or pyrolysis in the absence of oxygen to form carbon adsorbent products. Such modifications have allowed great versatility in the preparation of absorbent materials.

Thus, in light of the above deliberation, lignocellulosic substances have emerged as a technically strong, economically viable, environmentally sustainable, and internationally recommended choice in the field of environmental remediation.