Biotechnological Approaches may Alleviate Lignin, a Major Toxicant Released from Paper Industry

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From the 2nd century onwards, the Chinese developed the first papermaking process since then there is huge global demand for paper which has consequently led to the variety of chemical pollution of aquatic environments by paper mills as well as deforestation. During pulping various harsh chemicals are in use that may accumulate in the surrounding environment and thus may have detrimental effects upon the ecosystem and its inhabitants [1], thus negatively impacting resident aquatic species and human as well. There are several reports where fish populations exposed to these effluents were having huge decline in their rate of reproduction because of decline in eggs formation [2]. Lastly, the accretion of toxic and mutagenic chemicals in the lakes proved harmful to microorganisms and phytoplankton, resulting in the disruption of the natural food chain [3,4].

Dioxins used in bleaching are supposed to be highly toxic and carcinogenic, and have bad health impact on 90% human population include reproductive, developmental, immune and hormonal problems through food chain [5]. After this Totally Chlorine Free (TCF) bleaching process was adapted, but still fully chlorinated organic compounds cannot be eliminated, including dioxins, from effluent. While modern Elemental Chlorine Free (ECF) have reduced chlorinated organic compounds (AOX) emissions of less than 0.05 kg per tonne of pulp produced, but most of the developing country do not achieve this level of emissions. Within the EU, the average chlorinated organic compound emissions for ECF plants reported is 0.15 kg per tonne [6].

In these cases Biotechnology may be used where it can provide alternative cleaner technologies. Various biotechnological processes using cell or enzymes now days are in use to remove the lignin without damaging valuable cellulosic fibers e.g. A Lignin Degrading and Modifying enzyme (LDM) was isolated from Phanerochaete chrysosporum and was used similarly Methyloccus capsulatus has been used for converting alkene into alkene oxides in plastic industry. Another microbes Pseudomonas isolated from soil microorganism effectively degrades various xenobiotics e.g. phenols, biphenyls, organophosphates, naphthalene etc. Some other microbial strains are also known to have the capacity to degrade xenobiotics such as Mycobacterium, Alcaligenes, Norcardia etc. The ability of surface bacteria to degrade a given mixture of pollutants in ground water is dependent on various factors, the type and concentration of compounds, electron acceptor and the duration of bacteria exposed to contamination.

In recent years, various Genetically Engineered Microorganisms (GEMs) have been used to enhance bioremediation process. One such was development of 'superbug' in 1970s, by Chakrabarty and his team from strain of bacterium Pseudomonas and another strain was ATCC 1915 for the degradation of vanillate (which is a waste product from paper industry) and Sodium Dodecyl Sulfate (SDS, a compound used in detergents). White rot fungus has good ability to degrade the lignin efficiently degraded either by selective delignification or by simultaneous delignification process [7]. Still they have not been employed at large scale to remove these toxicants.

Recently, Lignin [8] has been suggested to use as fuel since it has the combustion heat of 26.6 KJ/g, and also among all other natural polymeric compounds that contain carbon, hydrogen and oxygen. In other words energy in lignin is just equivalent to ethanol (30 KJ/g). This conversion into biofuel was made possible because of novel innovative activation technology (patented). Thus the lignin can be used as a fuel substitute for benefitting waste from paper mill industry without foreseeable harmful effects.

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