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Status of Remediation Approaches

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Remediation states for the removal of pollutants from the environment. Remediation can be done in various ways such as by using waste biomass for sorption of pollutants or by living organisms like plants, microbes that cause degradation of pollutants. Bioremediation implies the use of microbes in the removal of heavy metals, industrial wastes and any other type of toxic wastes from the environment. These microbes may be used in viable and non-viable form, natural and modified form. Microbes used in natural form, faced many challenges related to their survival and tolerance to harsh environmental conditions.

In the last decade, several modifications have been made in the microbes by using recombinant DNA technology. For example, gene of interest is introduced in the microbes in order to make them suitable for bioremediation. When these types of genes are introduced in indigenous microbes, then these microbes acquire the ability to degrade or remediate the pollutants along with the ability to survive in harsh conditions. Researchers also did some modifications in the various metabolic pathways for enhancing their bioremediation capabilities [1]. These modified microbes are genetically different from the wild strain and have the ability to produce more efficient enzyme compared to wild strain for the purpose of bioremediation. It is now known that metabolic pathways are controlled by the enzymes. The production of enzymes is associated with the presence of genes. Expression of genes in wild strains and GEMs microbes by transcription and translation process leads to the production of appropriate enzymes that are responsible for bioremediation. These microbes have reported to be used at lab scale in for treating the pollutants in bioreactor. The researchers worked on the improvement of the performance of bioreactor at lab scale. In these bioreactors, various conditions are analyzed and optimized for the growth of microbes.

A lot of work is going on genetically engineered microbes and bioremediation approaches associated with it [2]. However, there has been a little development over the past decade in performing the studies at pilot scale and implement the microbes to the field for bioremediation purpose. All these bioremediation processes limited to lab scale study only. The question is - Why do these developed methods not transferred to sites for bioremediation? What are the problems associated with it? The main problem is associated with the uncontrolled growth of GEMs in the field. To solve this problem, scientists developed suicidal GEMs which lyse after the bioremediation of pollutants. There are many problems associated with it. For e.g., it is very important to get governmental permission. In many countries, government does not allow the spread of microbes in the field for the purpose bioremediation because of the risk associated with the release of toxic compounds which produced due to the degradation of toxic pollutants. Second risk is associated with the transfer of introduced genes to the other organisms and release of an introduced antibiotic resistance marker in the field [3].

Another problem is associated with the survival of the microbes in the environment along with indigenous population. Genetically modified microbes are developed that are suitable to grow and degrade the pollutants in laboratory controlled conditions, however, occasionally are not efficient in surviving in natural environmental condition. Furthermore, a lot of chemicals are required in order to modify environmental conditions according to the requirement of GEMs which is not economic and feasible.

To solve the problems associated with GEMS application, the researchers focused on the production of enzymes that can be used for bioremediation purpose. Many enzymes such as cellulase, ligninase, amylase, different types of reductases, oxidases, hydrolases etc. have been isolated for the purpose of bioremediation. However, these are also not applied to the field due to the increase cost of production. Further, enzyme individually was not found to be effective in remediating pollutants. Enzymes are not as effective as microbes because microbes can produce a variety of enzymes according to modified environmental conditions and availability of substrates. A single enzyme application is not feasible approach to remove variety of pollutants from the environment. Besides, technology is not feasible due to increased cost of production of enzymes.

In the last decade, tremendous growth has been made in the field of nanotechnology. Nanoparticles possess unique physical and chemical properties and considered as promising agent for remediation of pollutants. Nanoparticles have high surfaces to volume ratio [4,5] and hence, these are useful for remediating the pollutants. Besides this, nanoparticles possess optical, electronic and magnetic properties. These properties can be utilized for making biosensors which can sense the environmental pollutants and can detect the pollutants from the environment. After the detection suitable approaches can be developed for remediating pollutants. Nanoremediation approaches have developed for various pollutants. However, these are limited to lab based studies only, like bioremediation approaches [6]. Development of nanoparticles and their application in the field is not a cost effective technique. Practical challenges associated with the use of nanoparticles need to work out properly in order to do to remediate the pollutants. Second major problem with the application of nanoparticles is-toxicological effects of nanoparticles. It is noted that nanoparticles are developed from heavy metals like Cu, Ag, Au, etc., and therefore, these must be tested in the lab for the presence of toxicity. Nanoparticles must not be toxic when applied in the environment because there is risk of transfer of toxicity from field to vegetation on applying nanoparticles.

Therefore, it is necessary to overcome the limitations associated with the remediation approaches in order to transfer the developed method to the field. At the same time, researchers must focus on the toxicological aspects along with the physico-chemical characteristics.

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