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RESEARCH ARTICLE

ENVIRONMENTAL BIOTECHNOLOGY FOR CONTROL OF ENVIRONMENTAL POLLUTION.

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Abstract

With an increasing awareness about adverse effects of pollutants on living organisms, reclamation or remediation of environment contaminated with hazardous pollutants has become a global concern. Environmental problems continue to exist for several decades, and environmental biotechnology has come up as an emerging field worldwide using microbial activity as biological treatment in solving environmental problems. Environmental pollution by solid waste, industrial effluents and various unwanted chemicals, persistent organic pollutants (POPs) like Polyaromatic hydrocarbons (PAHs), pesticides, Polychlorinated biphenyls (PCBs) etc. is a major problem. The basic knowledge on how microbial activity can be used for wastewater treatment, biofilters for odour removal, and for biodegradation of environmental organic pollutants can prove useful in pollution control. In recent research several microorganisms have been found to completely mineralize the pollutants; and genomic and proteomic studies have helped in understanding of microbial catabolic activity for removal of pollutants. Identification of genes responsible for a particular function and their multiplication using recombinant DNA technology has opened new horizons in microbial degradation of pollutants. Microbial catabolic activity depends on various environmental factors like temperature, pH, nutrients, type of microorganisms, and chemical properties of the pollutant. The implementation of aerobic as well as anaerobic microbial activities exploited for their catabolic ability to treat biodegradable waste or pollutants has become an efficient, economical and environment friendly technique. In this review, we discuss various applications of biotechnology to improve remediation the polluted environment.

Introduction:-

Today, large amount of organic compounds have been synthesized and these compounds if directly released in the environment prove to be very toxic. Environmental problems due to various pollutants continue to exist for several decades. Environmental problems due to increasing contamination day by day, major reasons for this environmental contamination is increasing rate of industrialization and urbanization and increase in population. Increasing various industries and modern agricultural techniques involving pesticides have resulted in enhanced release of toxic compounds in environment. Industrial effluents (treated and untreated) from various chemicals industries involved

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in manufacturing of dyes, paints, fertilizers and pesticides pharmaceutical industries and other industries are the main sources of environmental pollution. This waste is known to affect the water, air and soil. Environmental pollution by solid waste, industrial effluents and various unwanted chemicals, persistent organic pollutants (POPs) like Polyaromatic hydrocarbons (PAHs), pesticides, Polychlorinated biphenyls (PCBs) etc. is a major global problem. Pollution due to PAHs (polycyclic aromatic hydrocarbons) in environment has become seriuos problem due to its toxic, carcinogenic and mutagenic nature. Polycyclic aromatic hydrocarbons are composed of fused benzene rings in linear, angular, or cluster arrangements, are one class of organicpollutants that are considered the most hazardous due to their toxic, mutagenic, and carcinogenic properties (Haritash & Kaushik, 2011). It has been seen that agriculture and industries release various chemicals in the environment that are hazardous and lead to contamination of water, soil and affect crop production (Kamaludeen *et al.,* 2003). Pesticides are the chemicals which are used to control or kill pests like rodents, nematodes, bacteria, fungi, birds etc. These chemicals remain in the environment for very long time, enter into the food chain and they show accumulating nature after their application (Kannan *et al.,* 1994). PCBs are used in various industries, dielectric fluid in capacitors and transformers, accidental spill or improper effluent disposal contaminate the environment including soil, ground water, lakes etc. They are lipophilic and cause bioaccumaulation in fatty tissues of fish, birds, animals and humans. Human are affected by exposure of PCBs contaminated food and water (Erickson, 1986).Soild waste, industrial effluent containing various hazardous chemicals and all other pollutants causing environmental problems continue to exist and it is necessary to control them.

Applications of Biotechnology is to remove pollutants from environment or to transform toxic pollutants into less toxic substances. Biodegradation or bioremediation is application of microbial activity which can be defined as a technique involving the use of various different microorganisms to remove, neutralize or mineralize the environmental pollutants from the polluted or contaminated sites. Various research studies have been done in which it is found that microorganisms have the ability to completely mineralize the pollutants. It involves the breakdown of organic compounds through biotransformation into less complex metabolites, and through mineralization into inorganic minerals, H_2O, CO_2 (aerobic) or CH_4 (anaerobic) (Alexander, 1994). Biodegradation or the remedial technique to remove pollutants from the environment requires different microorganisms having capability to adapt contaminated environment and to use pollutants efficiently. The bioremediation of a pollutant and its rate depends on the environmental conditions, number and type of the microorganisms, nature and chemical structure of the chemical compound being degraded. The bioremediation of a pollutant and its rate depends on the environmental conditions, number and type of the microorganisms, nature and chemical structure of the chemical compound being degraded. To understand the technique of bioremediation to remove hazardous and persistent environmental pollutants various studies have been conducted. Biotechnological applications of genomics, proteomics and metagenomics have been found useful to study microbial activities responsible for pollutant biodegradation. Bioremediation is a technique that offers the ability to remove or destroy hazardous contaminants using natural microbial activity or microbial enzymes so that environment return to its original condition (Gupta *et al.,* 2003). The technique of bioremediation is simple as compared to other physical and chamical techniques, low cost and it can be used on the contaminated site. This biodegradation technique depends on microorganism growth that are indigenous to contaminated sites and capable to degrade pollutants from the site (Agarwal, 1998). The technique of bioremediation is also found useful in heavy metal removal from waste, it has been found that *Pseudomonas spp.*can remove heavy metals from waste water, effluent and soil (Chester *et al.,* 2014). Hence bioremediation technique has been considered as a good method to clean up sites contaminated by hazardous chemical substances. This review is an overview of environmental applications of biotechnology. Environmental remediation, pollution prevention, detection and monitoring with regard to the achievements are among the perspectives in the development of biotechnology.

Sources of Environmental Pollutants

Sources for environmental pollutants are vary widely from natural to anthropogenic. Pollutants extensively occur in soil, air and water. All the effluents (treated and untreated) from various chemicals industries like manufacturing dyes, paints, fertilizers and pesticides pharmaceutical industries and other industries, land fire, oil seeps etc. are the main pollutant.Increasing agriculture and manufacturing industries has involved in increased release of many different xenobiotic compounds to the environment, excess load of these hazardous xenobiotic compounds or waste to water, air or soil has result in scarcity of clean water and contamination of soil that limit crop production (Kamaludeen*et al.,* 2003). There is an increase in contamination of water, soil and air due to various pollutants, the main reason behind it is the population explosion, industrialization and urbanization. As the population continues to increase, there is excessive use of natural resources i.e. water, air and land. To fit the demands of increasing

population there is increase in agriculture and different industries, use of automobiles, due to this it becomes difficult to maintain environmental quality. Industrial spills and leaks, storage tanks and pipes, landfills, burial areas and dumps, BTEX- Benzene, Toluene, Ethyl-benzene, Xylene, herbicides and pesticides, heavy metals (Cd, Cu, Pb), explosives (RDX, TNT), agricultural chemical wastes (DDT), petroleum hydrocarbons (Gas, Deisel), PAHs and PCBs are some sources of environmental pollution. These various industrial and agricultural wastes have become a major threat to environment affecting air, water and soil, waste disposal and industrial effluent treatment is global problem that is faced by all industries.

Biotechnology and Environment

Today, the requirement for sustainable, cost efficient, effective and eco-friendly technique for pollutant removal is rapidly increasing. Biotechnology is a field which provides large prospects for treatment of contaminated environment i.e. water, air, soil or sediments. Environmental biotechnology is a well-known field, techniques such as composting and wastewater treatment process are examples of environmental biotechnology. It is the application of biological science and its use in man-made technologies in which various microorganisms are used to enhance or improve the quality of environment. Similarly, bioremediation (a natural process) is also an application of biotechnology in which living microorganisms such as bacteria, fungi, algae and protozoa are used to degrade hazardous environmental contaminants into less toxic or non-toxic compounds under optimum conditions (Mueller *et al.,* 1996; Haritash& Kaushik 2016). Various environmental researchers prefer microorganisms for pollution control because of their relatively low cost or inexpensive catalytic properties. Microorganisms have catabolic enzymes which are involved in pollutant degradation by their metabolic activities. Microorganisms which are involved in bioremediation could be isolated from polluted sites or from a place different from polluted site (McFarland *et al.,* 1996). The main applicationof environmental biotechnology is in wastewater treatment process, soil treatment to remove pollutants from soil and removal of gaseous pollutants using microbiological catabolic activity. As compared to other cleaning techniques i.e. chemical or physical techniques, bioremediation is more efficient and cost effective technique (Kamaludeen*etal.*,2003).Biotechnology helps in environmental pollution control through biodegradation or biotransformation of toxic compounds like organics, metals, oil and hydrocarbons, dyes, detergents etc. (Surekah*et al.,* 2012).

In last two decades, various studies have been done which are focused on isolation and identification of microorganisms and plants that can use pollutants as their energy source. Natural microorganisms are used for bioremediation, these natural microorganisms can be either indigenous or extraneous (introduced). Microorganisms for bioremediation are selected carefully on the basis of chemical nature of pollutant (Prescott *et al.,* 2002). The microbial activity as biological treatment in solving environmental pollution is affected by various factors. Some factors are related to contaminant like physical and chemical characteristics of the contaminant whether the contaminant is synthetic or natural, its density, solubiliy, structure etc. Some factors are related to environmental conditions that include pH, temperature, moisture, nutrients etc., and the type of microorganisms or the composition of microbial community (biomass concentration and enzyme activities). The microorganism must be present with all favorable environmental factors for effective pollutant degradation (Boopathy, 2000). We can also use genetic engineering to improve the ability of degradation by microorganisms.

Treatment with Genetically Engineered Microorganisms (GEMs)

Bioremediation is the treatment process where biological systems are utilized for clean-up of environmental pollutants. Like other technologies, bioremediation also has its limitation. Sometimes naturally occurring microbial populations are not appropriate or not active enough for bioremediation of pollutants which are resistant to microbial attack (Dejonghe et al., 2000). Development in molecular biology i.e. genetic engineering alter the properties of naturally occurring microorganisms to modify the regulatory mechanisms, to assemble various degradative enzymes isolated from different microorganisms into single microorganism and to produce novel strains with desirable properties. Genetic engineering include construction of novel pathways and modification of degradative enzymes for pollutant degradation; improvement of genetic stability of catabolic activities of microorganism increasing the bioavailability of contaminants/pollutants and efficiency (Timmis and Pieper, 1999; Chen *et al.,* 1999). Gene coding 2,4-dintirotoluene degradation pathway from *Burkholderia* sp. strain was engineered in *Pseudomonas fluorescens*. 2,4-dintirotoluene was found completely degraded when it is provided as sole nitrogen source to recombinant strain. The recombinant strain or genetically engineered strain was superior to *Burkholderia* in 2,4-dintirotoluene degradation (Monti et al., 2005). *Deinococcusradiodurans*has been engineered with the genes encoding toluene dioxygenase from *Pseudomonas putida* F1. This genetically engineered microorganism was found to effectively oxidize toluene, chlorobenzene and 3,4-dichloro-1- butene in a highly irradiating environment (Lange et al., 1998).

Therefore, using genetic engineering we can create genetically engineered microorganisms which are being considered for bioremediation of polluted environment.

Conclusion:-

Bioremediation ismost favorable, low-cost and effective technology for removal or cleaning up of various pollutants.Therefore, further investigation is required to understand the microbial activities responsible for degradation process. Before attempting to employ bioremediation technology, one needs to conduct a thorough characterization of the environment where the contaminant exists, including the microbiology, geochemistry, mineralogy, and hydrology of the system. Bioremediation is the tool to transform the hazardous compounds to less hazardous/non-hazardous forms and it is an approach to degrade/remove pollutants in an eco-friendly manner. Continuous biomonitoring of the environment and biological control methods should be developed rather than chemical methods. If bioremediation is used properly, it has minimal adverse effects since it can be applied with little or no disruption to contaminated sites.

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