Proceedings of RMBSEFEWS & Indian J.Sci.Res.: 81-83, 2018 ISSN: 0976-2876(Print)
ISSN: 2250-0138(Online)

TECHNOLOGICAL AND BIOTECHNOLOGICAL APPROACHES FOR ENVIRONMENTAL CONSERVATION AND POLLUTION ABATEMENT

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ABSTRACT

Bio-technology comprises of integrated application of theoretical and practical knowledge of biochemistry, microbiology,physiology, genetics and chemical engineering to exploit the properties of microbes and cell cultures for various beneficial technological uses. Environmental bio-technology is a very broad field which includes environmental monitoring and safety, waste treatment and recovery, restoration of environmental quality, substitution of non-renewable resource- base with renewableresources,research and development of various processes for the benefit of mankind with due regard to socio-economic, legal and environmental safety considerations. Environmental Bio-technology has a great potential in transformation and enhancement of resource-base, reduction of energy consumption, pollution abatement, enhancement of biomass production and conservation of non-renewable resources, generation of useful organic chemicals from bioconversion of biomass etc. Some of these applications have indirect beneficial effects on wider problems such as global warming, acid rain and climatic changes. The most important feature of bio-technology is that it is not capital intensive and is within the reach of the less privileged countries which have vast natural resources and abundant man power. However, uncontrolled or accidental release of genetically engineered micro-organisms or their hosts derived from recombinant deoxyribonucleic acids (DNA) technology into natural environment can be hazardous to natural ecosystems. Hence, due care should be taken regarding environmental safety and legal aspects with the help of legislative measures. At the same time, due care should also be taken to see that over-regulations do not discourage scientific and technological innovations on one hand and also to see on the other hand, that over-enthusiasm does not vitiate the legitimate concerns of environmental safety and social harmony.

KEYWORDS: DNA, Environmental Bio-technology

Bio-technology encompasses a wide specialized disciplines from old fermentation processes to the latest techniques of genetic engineering. Bio-technology has received tremendous attention in recent years due to its immense potentialities and applications in aquaculture, agriculture, immunology, forestry, chemical production, pollution control etc. Genetic engineering is the fundamental basis for the modern bio-technology. Genetic engineeringinvolves the ability to transfer specific genes from one kind of organism to another thereby producing new biological properties.

Many types of bacteria possess small fragments of deoxyribonucleic acid (DNA) which are called plasmids. These Plasmids exist in the cell cytoplasm and are not associated with the cell chromosome or nucleus. The plasmids generally contain genetic information for a relatively few cell properties and are responsible for the ability of bacteria to become resistant to antibiotics. The plasmids are capable of being transmitted rapidly to bacterial populations. Plasmids have been successfully isolated from one kind of bacterium and then inserted into a different kind of bacterium. The cell receiving the plasmids in this way often acquires properties from the donor cell due to the plasmid-borne genetic information. The plasmid molecule is cut by using a specific enzyme called restriction endonuclease. The genetic material of another cell containing information for formation of the desired product is cut into fragments by the endonuclease. The plasmid and gene fragment molecules so produced are mixed together and treated with an enzyme that joins fragments of DNA together. This results in re-formation of the plasmids containing pieces of the genetic information of the cell. This recombinant Plasmid is then introduced into a bacterium, usually the one from which it was originally isolated. The bacteria are now allowed to grow and multiply.

Genetic engineering offers unlimited possibilities for the creation of new kinds of bacteria tailored to perform some useful functions. For instance, the gene for producing insulin has been transferred from animal cells into the bacterium'EscherichiaColi' by the above technique which enabled commercial scale manufacture of insulin. The amino acids and phenylalanine and aspartic acid that constitute the sugar substitute"aspartame" are produced by

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genetically engineered bacteria. Bio-technology has made possible the large-scale production of anticancer and antiviral agents. Similarly, some important hormones which are present in human body in infinitesimally minute quantities can now be produced on a commercial scale by using genetically engineered bacteria.

METHODOLOGICAL APPROACHES, BIO-TECHNOLOGY AND POLLUTION CONTROL

Biological processes have been in vogue for over a century for the treatment of municipal and industrial wastes rich in organic matter. Anaerobic processes are widely used to convert concentrated sludges into biogas rich in methane. Biological processes for treatment of a variety of waste waters are extensively in use today. Genetically engineered micro-organisms (GEMs) are coming into vogue for the treatment of toxic or concentrated wastes and other refractory wastes such as those containing Xenobiotic compounds. For removing specific types of pollutants selectively, new types of proteins, peptides and biomimetic adsorbers are being developed using bio-technology. Similarly, new types of micro-biosensors and control systems are being developed for the continuous monitoring and automation of water treatment processes.Important applications of bio-technology in pollution control and waste management include:

(a) Improvement of existing processes, such as use of bio-sciences and biochemical engineering to obtain knowledge about the application of mixed cultures such as (I) improvements in sewage treatment (ii) use of starter cultures for treatment processes (iii) use of immobilised microbial cells in waste water treatment.

(b) Treatment of toxic wastes using genetically improved organisms (GEMs) e.g.Genes which can bring about degradation of toxic environmental pollutants (e.g.toluene,chloro-organics, halogenated pesticides etc.) have been identified. For degradation of toxic chemicals, enzymes are encoded by specific genes present on Plasmids. One Plasmid cannot degrade all the toxic compounds of different groups. The plasmids are grouped into four categories as follows :

(I) OCT plasmid which degrades oxane, hexane and decane.
(ii) XYL Plasmid which can degrade xylenes and toluenes.
(iii) CAM Plasmid which can decompose camphor.
(IV) NAH Plasmid which can degrade naphthalene.

Dr.Anand Mohan Chakraborty (an Indian borne American Scientist) was successful in synthesizing an oil eating superbug by introducing Plasmids from the four different strains as above by successive conjugation into a single cell of "P.Putida".This superbug can degrade all the four types of substrates. The superbug was first produced on a large scale in the laboratory mixed with straw and dried before storage. In 1990, these Microbes were used for cleaning up of an oil spill in water in Texas (U.S.A.).When the straw containing the superbug microbes is spread over oil slicks, the straw gets soaked with the oil and the bacteria degrades the various chemical compounds constituting the oil into harmless products. Thus, the oil spill is cleaned up.

(c) Recovery of useful products from waste materials e.g.Recovery of Methane,metals etc. from waste materials.

(d) Development of new catalysts, new bioreactors, novel bio-sensors and automation of waste water treatment processes e.g. (I) use of immobilised organisms and heavy metals as new catalysts and bioreactors, (ii) use of traces of toxic organics as new sensors and (iii) design of cadmium binding synthetic adsorbents which imitate cysteine rich cadmium binding peptides synthesised by plant and yeast cells which respond to cadmium stress. Development of such bio-sensors can help to automate the adsorber systems by detecting the saturation of the adsorber system and trigger a controller to divert the flow of the influent to a second adsorber system while regenerating the firstadsorber.

BIOREMEDIATION

Industrial operations generate complex and toxic pollutants which accumulate in natural systems. The toxic wastes thus generated are usually treated by physico-chemical processes. Bioremediation is the microbialclean-upapproach.It employs biological agents to render hazardous wastes to non- hazardous or less hazardous wastes .Microbes can acclimatize themselves to toxic wastes and new resistant strains develop naturally. Such strains can be used for pollution control and environmental protection. Bioremediation engineers from the Bio Trol Company in the USAused.Flavobacterium to remove pentachlorophenol from contaminated soil. Aeration of the soil helped the process. American microbiologists found Microbes referred to as GS-15 which can metabolise uranium directly. The micro-organisms were used in a bioreactor to treat the uranium containing waste water from

a nuclear weapon manufacturing plant. The organisms can be used for waste water treatment in uranium mining. Scientists from Southampton University in England developed micro-organisms which when grown with added nutrients in the presence of metal-laden waste water were found to accumulate the metal ions in their coats, thereby reducing the metal ion concentration in the waste water. Abandoned cars in Junk-yards (which run in millions) are posing disposal problem in Germany. The engines breakdown easily but their plastic shells made of duroplastics (not thermoplastics) can't be destroyed easily .Burning them would emit toxic gases .Micro-organisms which will digest the resin constituent of duroplastics are being developed .

Various strains of bacteria and fungi are being experimented to treat pollutants such as Vinyl Chloride, PCBs,Oil Spills etc. Some fungi,even as dead biomass were found to trap metallic cations in solution due to their peculiar cell wall composition. Many fermentation industries produce fungal biomass of an unwantedbyproduct which can be utilized for this purpose. For instance, the biomass of fungi, "Rhizopusarrhizus"can absorb about 130mg per gram of the dry biomass. The Bio recovery Systems Company patented a product calledAlgasore for absorbing heavy metal ions from ground water or waste water. Algasorbis prepared by trapping dead algae in silica gel. The trapping of the algal cells as above protects the cells from being destroyed by other micro-organisms. Algasorb functions like a commercial ion-exchange resin and the sorbed heavy metal ions can be stripped out easily. Some algae and bacteria can accumulate large quantities of metals. E.g.pseudomonasaerugenosa can accumulate uranium and Thiobacillus can accumulate silver. Mixture of microbes and enzymes are used to clean up chemical wastes such as detergents, pesticides, dioxin,paper mill wastes, oil etc. Microbial processes was used for removing Sulphur from coal. Sulphur present in coal used in thermal power plants is known to contribute to acid rain. White rot fungus phanerochaetechyrsosporium, when placed in nitrogen-deficient medium can degrade DDT, dioxane, halogenated aromatic rings etc. producing carbon dioxide.

CONCLUSION

Any advanced technology is often accompanied by benefits to the mankind, as well as risks to the environment. Some of the environmental problems can assume trans-national dimensions and also may cause social and environmental imbalance. Hence, for the efficacious and safe utilization of bio-technology which is a multi-discplinary field of far reaching consequences, it is essential to carefully select safe and useful genetically engineered micro-organisms for applications to specific waste treatment targets of special environmental significance.

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