ACTA SCIENTIFIC AGRICULTURE (ISSN: 2581-365X)

Volume 3 Issue 12 December 2019

Review Article

Use of Biotechnological Tools for Environmental Cleanup

Mehtab Muhammad Aslam*, Joseph K Karanja, Junaite Bin Gias Uddin, Madiha Zaynab and AqaiKalan Hassanyar

College of Life Sciences, Fujian Agriculture and Forestry University, China

***Corresponding Author:** Mehtab Muhammad Aslam, College of Life Sciences, Fujian Agriculture and Forestry University, China.

Received: November 05, 2019; **Published:** November 13, 2019

DOI: 10.31080/ASAG.2019.03.0721

Abstract

Manipulation of living organisms to get beneficial products for the health of human being and better life style is Biotechnology. Today among one of the world's problem is environmental pollution which is one of the major concern. Due to this reason ecological balance is severely disturbed. Contaminants pollute air, water and soil thus resulting in ozone depletion, greenhouse effect, global warming and acid rain. Petroleum hydrocarbons, toxic heavy metal, groundwater pollutant, polycyclic aromatic hydrocarbons these are the major toxins. Microorganisms have natural ability of enzymatic degradation that can convert complex substances into simpler ones. Plants are also beneficial because of their model system and the major benefit of having contacts with these containments through roots. Bioremediation is biotechnological process to get rid of pollutants or to detoxify them in to less harmful products by using the microorganisms especially fungi and bacteria and also some plants specie that can tolerate and accumulate the heavy metal contaminants. The *Trichoderma* spp. are fungi which are usually found on plant roots and in soils. They have resistance to many agrochemicals and also resistant to wide range of toxicants such as cyanide and heavy metals. The success lies in the metabolic diversity which is occurring in this group of fungi. A good understanding regarding these processes will likely result in use of less expensive and safer means to preserve environment and most likely increase in the yields of crop in contaminated sites. There is still need of improvements in bioremediation processes.

Keywords: Bioremediation; Environmental Pollution; Plants; Biotechnology; Contaminants

Introduction

Biotechnology involves the living organisms such as bacteria or plants or other unicellular or simple multicellular organisms. We can choose our desire strain to get our desire product as well as we can genetically modify a strain to make it more useful and appropriate for our product. From the past few decades human activities have polluted the environment with hazardous and toxic contaminants due to which entire biological system is being affected. As a result ecological balance is severely disturbed [1].

Biotechnological tools are used to synthesize traditional products by manipulating the genetic bases of living organisms. Chen., *et al.* 2005 clearly elaborated that environmental biotechnology involves the use of microorganisms to improve environmental beauty [2]. With the advent of advance technologies from molecular and microbial biology has enabled researchers to solve environmental problems e.g. degradation/detoxification of waste by the use of living organisms [3]. Bioremediation is branch of biotechnology which can remove pollutants and hazardous material from water and soil through microorganisms and also protects ecosystem. Composting is an anaerobic microbe based processes that converts complex organic compounds into simple forms which can be easily disposed of into natural environment or used as manure for soil improvement.

Now a day, as the world population is increasing day by day, our waste product is also increasing and playing a significant role in making our environment dirty and vulnerable to protect the life. Xenobiotic (pollutants e.g. dioxins), chlorofluorocarbons and NAPL (non-aqueous phase liquid) contaminants are destroying our environment day by day, they belong to our daily life routine, and they must degrade properly [4]. It is reported that, white root fungi (*Trametes versicolor* and *Phanerochaete chrysosporium*) and their enzymes (ligninase, laccase and peroxidase) plays vital role in the degradation of xenobiotic compounds e.g. single or multiple pesticides. Xenobiotic compounds have many sub-structures which are similar to lignin, white root fungi enable degradation of these hazardous compounds [5].

Microorganism are not only involved in degradation of hazardous materials, plants are also involved in breakdown of complex molecules and immobilize waste materials from soil/water this process is known as phytoremediation. As it is reported that, overexpression of two bacterial genes (arsC and gECS1) in *Arabidopsis thaliana* which codes arsenate reductase and gglutamylcycteine synthase respectively, which enables this plant to capture arsenate and degrade it [6]. It is postulated that; transgenic plants significantly contribute to environmental safety [7]. Biotechnology somehow solves these problems and plays a significant role in environmental remediation by helping us to clean up environmental pollution and maintain natural ecosystem.

List of techniques powered by biotechnology

Here is the list of techniques in which biotechnology can help us in various ways such as by preparing genetically modified microorganisms and plants also. Such as Landfill, Biosensors, Bioremediation, Compositing, Oil eating bugs, Biodegradation of xenobiotic, Bio mining, Designer bugs, Pollution control, Treating industrial waste, Bio scrubbing, Pest control and bio pesticides, Weed control, Restoration of denuded areas, Viral pesticides, Bio fertilizers, Bio diversity and conservation technologies etc. All above technologies involve the use of genetically modified organisms; they could be microorganisms or plants; they could also involve different strains of yeast. Insects and mammalian cell lines could be useful too. The most importantly we use bacteria and its different strains. Because we can grow them in large quantities and their genome study is not a tough job. We can modify them easily. They give us large quantity of products due to rapid growth rate [8].

Some examples of genetically engineered microorganisms in bioremediation

Soil is the residency of various types of organisms. They could be complex as insects and simple like earth worms. They could be visible as former and could be invisible, but performing a great role in maintenance and fertility of soil, like bacteria. Most of the enzymatic reactions that involve substrate are accidental and do not deliver the energy important by the cells to run their *metabolism* efficiently. So human made contaminants such as chlorobiphenyls which are present in the environment by somehow being a part of our metabolism [9].

These enzymes contain many different substrates for their performance and have a very complex structure, that's why they remain in study for decades. So serious modification is made in these enzymes by changing their respective genes in genome of different organisms mostly bacteria. Dioxin dioxygenase of *Sphingomonas* sp. strain RW1 was the first enzymes thought to be capable of carrying out an angular dioxygenating, that is, oxygenation at a pair of adjacent carbon atoms, one of which is involved in one of the bridges between the two benzene rings. The desired genes are now characterized and whereas genes coding for multicomponent dioxygenase are usually gathered, those coding for dioxin dioxygenase were unexpectedly scattered throughout the chromosome [10].

Another relatively identification is made for lineage of ring-activating dioxygenases has been modified genetically to contain, between the genes coding for the electron transport chain of a naphthalene dioxygenase, genes coding for subunits of an enzyme catalyzing a separate step in the pathway, that is, salicylate 5-hydroxylase. Even other unrelated naphthalene and phenanthrene systems from *Rhodococcus* sp. NCIMB 12038 and *Burkholderia* sp. strain RP007 have been described, but no substrate specificity profiles have been given. There are so many examples of using microorganisms for bioremediation. We can manipulate organisms easily we can make everything from these organisms by modifying their genome. Because their genome does not require so many regulators as eukaryotic genome require, we can change the strain and easily manipulate their genome.

Some examples of genetically modified plants

In recent years, hairy roots (HRs) have been fruitfully used as research tools for selecting the abilities of different plant species to tolerate, accumulate, and/or remove environmental pollutants, such as TNT, PCBs, pharmaceuticals, dyes from textile, phenolics, radionuclides, and heavy metals.

Plants are beneficial because of their model system and the major benefit of having contacts with these containments through roots. By taking the advantage of hairy roots some metabolic and catalytic pathways involve the uptake of pollutants, changing their morphology, storing the pollutants in different plant organs and conjugation. Plant roots release many chemicals such as peroxidases and laccases which act as enzymes which trap and degrade the pollutants. Biotechnology is making genetically engineered plants with their genome is modified in such a way that they can tolerate and disintegrate heavy non degradable pollutants [11].

Agrobacterium-Ti plasmid transformation increase the chance of efficient embryo formation with a 1000-fold reasonable speed in *Pinus abies*. This happens by disarming the *Agrobacterium tumifaciens* strains and by modifying its *vir* genes. Embryonic *Pinus taeda* culture is able to get GUS expression 10 folds higher than normal. Co-cultivation of *P. strobus* embryogenic tissue with *A. tumefaciens* carrying a 35S-35S-AMVgus: nptII fusion also resulted in the regeneration of efficiently transformed somatic embryos compounds produced by industrial waste [12]. *Pinus abies,* Oak, scots pine has improved soil property by accumulating heavy metals (Zn, Pb, and Cd) by plants.

How we can protect our environment?

This is the most important question for all of us. There is many agenesis exist that set rules and regulations for the entire world. Like EPA (environmental protection agency) in USA. But the protection could only be done with the help of individuals. Everyone in this world should know the state of our environment and should be able to draw strategies to protect it. Media and governmental factors should provoke the sense and idea of environmental protection. We should use the vehicles of biodegradable fuels. We should use bio plastics in our daily routine so that they should not remain in the earth for years. We should grow transgenic plants that help us in removing pollutants as well as provide free oxygen to breath. As transgenic plants have enormous benefit related to agriculture production but it also has some impact on health issues. We should establish labs so that we can easily modify the genome of bacteria to make them tolerant and bearable for harsh environment [13].

Future prospects and challenges in bioremediation

Bioremediation, is a profound branch of biotechnology, which fundamentally involves the manipulation of micro-organisms for improvement of contaminated site, usually with bacteria as degraders and also different other organisms like soil animals and plant roots, which play important role in scattering the bacteria, thus contributing co-substrates and nutrients for bacteria effective in process of degradation [8]. The overwhelming challenge is

the production of enzymes having novel functions. Normally, the research focuses on the altering of enzymes so, it can accomplish reaction complementary to desired one. Therefore, it may be troublesome to implement biomedical engineering to bioremediation of novel contaminants that are not biodegradable. Phytoremediation may consider as non-troublesome approach for environmental cleanup and improving soil property.

Possibly, such venture maybe possible in future when our information regarding protein folding, structure-function, dynamics and mechanism is considerably improved. One of the main challenge is that bioremediation is only limited to the compounds which are biodegradable. All compounds are not susceptible to complete and rapid degradation. Current approaches modern techniques like proteomics, metabolomics and genomics can contribute novel facts regarding complicated interactions, specifically the competence of *Trichoderma* to sense environment and microbial community and tolerate different inorganic and organic contaminants at high concentration. The use of *Trichoderma* for administering contaminated sites for cultivation should become valid in near future, because they can be developed cheaply in huge quantities on industrial scale and devised for field use [14].

It may focus on the data mining of ongoing data so that it may provide further insight into the processes of bioremediation. The development of novel algorisms is needed for the numerical simulation and numerical modeling. Protocols should be standardized for analysis, storage, transmission and data collection. Novel biomarkers should be identified because these markers can be used for diagnosis of bioremediation mechanisms. Biomarkers can be substantial enzymes, functional genes and indicator metabolites which are produced during bioremediation processes. Assimilation of data produced by various Omics techniques. By assimilation of proteomics, functional genomics, metabolomics data and transcriptomics we may be capable to contribute towards better microbial bioremediation scheme [4,15].

Conclusions

The aquatic environment is especially vulnerable to pollutants. Biotechnological applications have been successfully used to cleanup pollutants from environment most preferably through bioremediation and phytoremediation process. Microorganism are key players which code enzymes that enables degradation of hazardous material e.g., oxidoreductase/hydrolase have been studied extensively. This review provides descriptive information on environmental cleanup process involved in the biodegradation of toxic pollutants by using biotechnological applications.

Conflict of interests

The authors have no conflict of interests to declare.

Author Contributions

MMA conceived the study and prepared the manuscript draft and contributed crucial components to the manuscript. All authors critically reviewed the manuscript and approved the final draft.

Bibliography

1. Khalilian M., *et al*. "High potential application in bioremediation of selenate by Proteus hauseri strain QW4". *Iranian Journal of Microbiology* 7.2 (2015): 94.
2. Chen W., *et al*. "Environmental biotechnology: challenges and opportunities for chemical engineers". *AIChE Journal* 51.3 (2005): 690-695.
3. Bharagava RN., *et al*. "Introduction to industrial wastes containing organic and inorganic pollutants and bioremediation approaches for environmental management". *In Bioremediation of Industrial Waste for Environmental Safety* (2020): 1-18.
4. Ma J and Zhai G. "Microbial bioremediation in omics era: opportunities and challenges". *Journal of Bioremediation and Biodegradation* 3 (2012): e120.
5. Magan N., *et al*. "Environmental factors and bioremediation of xenobiotics using white rot fungi". *Mycobiology* 38 (2010): 238-248.
6. Hooker BS and Skeen RS. "Transgenic phytoremediation blasts onto the scene". *Nature Biotechnology* 17.5 (1999): 428.
7. Frérot H., *et al*. "Specific interactions between local metallicolous plants improve the phytostabilization of mine soils". *Plant and Soil* 282 (2006): 53-65.
8. Romantschuk M., *et al*. "Means to improve the effect of in situ bioremediation of contaminated soil: an overview of novel approaches". *Environmental Pollution* 107 (2000): 179-185.
9. Bayat Z., *et al*. "Immobilization of microbes for bioremediation of crude oil polluted environments: a mini review". *The Open Microbiology Journal* 9 (2015): 48.
10. Sharma S. "Bioremediation: features, strategies and applications". *Asian Journal of Pharmacy and Life Science* (2012).
11. Samanta SK., *et al*. "Polycyclic aromatic hydrocarbons: environmental pollution and bioremediation". *TRENDS in Biotechnology* 20 (2002): 243-248.
12. Poupin MJ and Arce-Johnson P. "Transgenic trees for a new era". In Vitro Cellular and Developmental Biology-Plant 41 (2005): 91-101.
13. Mendez MO and Maier RM. "Phytostabilization of mine tailings in arid and semiarid environments—an emerging remediation technology". *Environmental Health Perspectives* 116 (2008): 278.
14. Russell JR., *et al*. "Biodegradation of polyester polyurethane by endophytic fungi". A*pplied and Environmental Microbiology* 77 (2011): 6076-6084.
15. Singh P and Nautiyal C. "A novel method to prepare concentrated conidial biomass formulation of Trichoderma harzianum for seed application". *Journal of Applied Microbiology* 113 (2012): 1442-1450.

Volume 3 Issue 12 December 2019