Environmental Push for Green: A Microbial Exploratory Solution through Upcoming Technologies

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ABSTRACT

Environmental push for green does not mean only to reduce, reuse and recycle. Instead, it demands us to explore innovative strategies by utilizing available naturalresources in a long sustainable manner to regain our original environmental scenario with efficient energy optimization, minimal generation of waste and healthy living which indirectly solves the issue of global warming. Keeping this aspect in mind, tremendous discoveries in the field of new groups of microbes like actinomycetes from plants, animals, soil, water and airhave rapidly increased. The relevant, appropriate applications of these microbes are yet to be established.However, the researchers are just beginning to pioneer how these microbial communities can be linked to various functions in ecosystems through new interdisciplinary approachesthat include emerging trends like biotechnology and nanotechnologyin advanced research which might evolve a significant contribution in the field of global technological revolution for a safe green future.

This research topic invariably summarizes the excellence of microbial treasure isolated from environmental resources and their applications in antimicrobial, biodegradation and bioremediation activities employing varied biotechnological, nanotechnologicaland bioengineering methodologies.

Keywords

Global warming, Microbes, Biotechnology, Nanotechnology, Bioengineering.

1. INTRODUCTION

Indian biodiversity which was glorified and extolled for its natural richness and utilitarianism is under severe threat due to rapid and massive urbanization nowadays. Urbanization evolves out of deforestation, construction of new infrastructure projects, buildings, factories, land degradation etc.,consequently leading to never ending human migration. As a result, there arises extreme energy consumption and over-accumulation of waste, leading to enormous pollution which has become an international issue at present, for the developing countries. In spite of discovering many scientific techniques for proper garbage disposal, the issue remains unsolved. Thus, aiming to combat these adverse conditions, new discoveries of microbial resources with respect to its environmental applications have been promotedthrough recent interdisciplinary approaches leading to minimal detrimental impact on the natural environment.

2. MICROBIAL EXPLORATION

Currently, the study of microbial diversities (bacteria, fungi, actinomycetes, etc.) seem to be more active these days as they produce industrially useful metabolites such as antibiotics and enzymes targeting environment conservation, besides their ecological significance to biodegradation as mentioned below.

Table 1.List of microbes with applications

Endophyte	**Activity**	**Ref**
Streptomyces NRRL 30562	Antibiotic	[19]
Streptomyces albidoflavus	Antifungal	[18]
Streptomyces laceyi	Antitumor	[17]
Streptomyces galbus R-5	Defense response	[22]
Streptomyces sp. VITDDK1,2	Biosurfactant	[23]
Bacillus cereus, *Pseudomonas*sp, *Streptococcus lactis*, *Aspergillusniger*,	Polythene biodegradation	[21] [20]
Taxomycesandreanae	Anticancer	[14]
*Streptomyces*NRRL 30562	Antimalarial	[16]
Cytonaema sp.	Antiviral	[15]
Paenibacillusmacerans;Bacilluspumilus.	Bio control of plant diseases	[28]
Sulfolobussolfataricus	Biofuels	[24]
Trichodermareesei	Biofuels; Biodegradation	[26]
Burkholderiaphytofirmans PsJN	Plant growth promotion	[25]
Bacillus megaterium	Bioplastic, (PHB)	[12]
Bacillus cereus	Biocement	[27]
Geobactersulfurreducens	Bioelectricity Bioremediation	[13]
Shewanellaputrefaciens	Bioelectricity; waste water treatment	[11]

2.1 Biotechnological Approach

In addition to selective isolation of microbes capable of producing biofuels and possessing natural biodegradable capacity, many researchers have engineered the existing microbes and plants by incorporating environmentally favorable genes specific to the function, For example, take Bt cotton, where the cotton plant has been incorporated by a foreign gene obtained from *Bacillus thuringiensis*leading to effective economically important crop protection, against a variety of crop pests, causing lesser damage to the environment, compared to chemical pesticides. This is a sort of plant vaccination. Same way, genetic manipulation studies are going on by incorporating waste degrading genes which leads to enhancedbio and phytoremediation along with the sustainable production of nonfood crops for biomass and biofuel production.

2.2 Nanotechnological Approach

Similar to transgenic approaches using gene gun, many targeted nanotechnology based drug delivery systems were performed without harming healthy cells. Later, nanotechnology based innovations were designed to combat pollution and detect toxic substances. Even a nanoparticle coated biodegradable plastics or antimicrobial depolluting nano-coatings reportedly offer non-toxic, eco-friendly functionalities.

2.3 Bioengineering Approach

Combining bioscience with engineering skills has enabled the development of biosensors.That is, a new generation ofanalytical devices, coupling biological recognition elements to physical signal transducers. Besides in the direct application of whole microorganisms, even the genetically modified microbes are used to assess environmental toxicity with the help of biosensors.

3. APPLICATIONS

3.1 Biodegradation

The concept of bioremediation involves cleaning the contaminated environment using various microbes. One of the major environmental threats is the slow/least rate of degradation or non-biodegradability of the organic materials like plastics which takes up to 1000 years for natural degradation in the environment. The contamination of soil due to dispersal of industrial and urban wastes generated by the human activities is of great environmental concern [2]. Three types of polymer degradation methods such as photo degradation, thermo-oxidative degradation and biodegradation are followed where biodegradation is the cheapest process. Various microbes take part in biodegradation process, where one breaks up the polymer into smaller monomers, one utilizes them and excretes waste by-products and the other utilizes those excreted waste. The microbial enzymes and genes responsible for polythene degradation needed to be characterized so that they can be transferred to other easily available microbes to enhance the polythene degrading capacity.

Even though many types of plastics including polyurethane are recyclable, they often end up in landfill waste. Researchers from Yale University found out an endophytic fungi namely *Pestalotiopsismicrospora,* which eats plastic by breaking it up using serine hydrolase enzyme even in anaerobic condition leaving no waste thereby leading to easy disposal of wastages like electronic gadgets that are being buried in the ground [30].

New research by Dr O'Connor from University College Dublinand his team suggests that, a particular bacteriumthat can break Styrofoam down into green by-products could be used to make a new kind of biodegradable plastic [29].Styrofoam is a material made from polystyrene containing carbon and hydrogen but not in a form that the soil bacteria *Pseudomonas putida* can readily digest. Hence, scientists' performed pyrolysis by heating the polystyrene into liquid styrene carbon compound that the bacteria can eat and kept feeding them. After reaching a healthy size, the scientists stopped feeding which stimulated the bacteria to store carbon and leading the carbon to a conversion into a biodegradable plastic named polyhydroxyalkanoate, or PHA.This plastic is better than other recycled material whereby, reducing the landfilled petrochemical based plastic waste with no deleterious effects to the environment.

3.2 Bioelectricity

There is an increasing demand of renewable energy in our society. Microbial fuel cell (MFC) technology represents a new trend by generating electricity from waste using microbes as catalysts. When bacteria oxidize a substrate, they remove electrons. After getting separated from oxygen, bacteria growing on an anodetransfer electrons to cathode that is exposed to air which ultimately leads to generation of electric current. As mentioned in Table 1, the waste water was utilized for the bioelectricity production by *Shewanellaputrefaciens.*

3.3 Biofuel

The demand for oil production increases as the countries continue to develop. This decreasing supply and rising demand will escalatethe price of oil and other fossil fuels, which might be tough to contain. Fossil fuels are non-renewable resources which produce enormous quantities of greenhouse gaseslike carbon dioxide, methane, etc.,on burning, leading to adverse effects like pollution and global warming. For all of these reasons, there is great demand for renewable energy sources especially biofuels. Since a huge amount of non-edible wastes are necessary to recycle, scientists have turned their attention to ubiquitous microbes for screening their cellulase producing ability to convert cellulosic wastes into biofuels.Even though the microbes like archaeon *Sulfolobussolfataricus*and fungus *Trichodermareesei*, secreted huge quantities of cellulase enzyme, they are not easily available. Hence, researchers started looking at the ways to modify the available microbes genetically, using transgenic approaches.

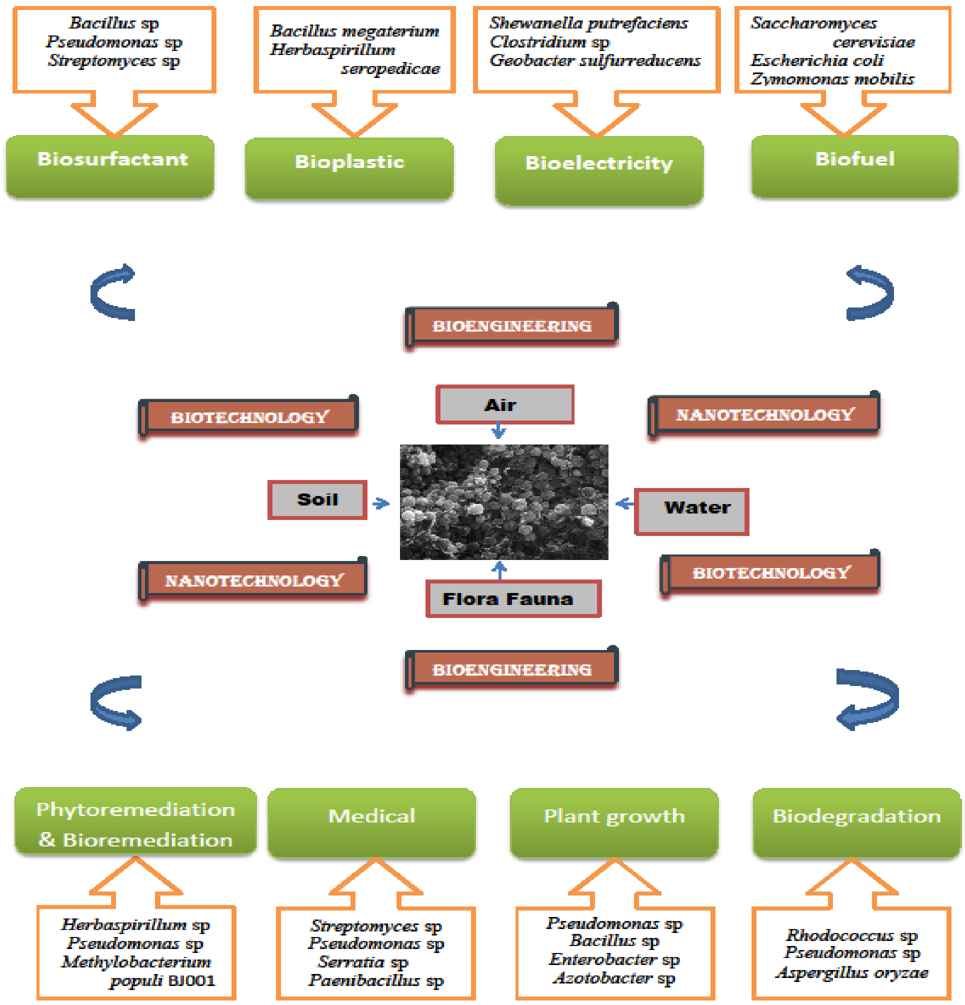

Fig 1:Schematic diagram of the different plant–bacterial endophyte interactions that have been studied and their applications

3.4 Bioremediation &Phytoremediation

Pollutants or contaminants in environment are easily treated by bioremediation process using microbes. But heavy metals like cadmium and lead are not easily remediated using microbes. In this condition, phytoremediation plays a vital role since they accumulatethese toxins in their above-ground parts, which are then harvested or even recycled for industrial use. This process can be monitored by indirectly measuring the oxidation reduction potential. Decrease in its level confirms remediation process.

Table 2.List of pollutants that have been associated with bacterial endophyte phytoremediation strategies [1]

Compound	Plant association	Organism	Reference
Mono & Di chlorinated benzoic acid	*Elymusdauricus*	*Pseudomonas aeruginosa*R75	[3]
2,4-D	*Populus*	*P. putida* VM1450	[4]
Methane, TNT, RDX, HMX	*Populusdeltoids nigra* DN34	*Methylobacter populi* BJ001	[5]
MTBE, BTEX, TCE	*Populus cv. hazendans*	*Pseudomonas* sp	[6] &[7]
Toluene	*Populus*	*B. cepacia*	[8]& [10]
TCP, PCB	Wheat	*Herbaspirilla* sp. K1	[9]

4. CONCLUSION

Because of increasing pollution and waste accumulation, we are losing the treasure of biodiversity day by day. Looking at the hydrophobic principle of the lotus leaf, scientists designed a NanoNuno umbrella. Same way, we must analyze the never-ending clues that the nature offers in plentyso that they could be adopted and applied to future methodologies.

So, this is the right time to carry out effective research works in the field of biodegradation at the earliest by screening beneficial microbes from natural resources, especially rare, endangered, threatened and fast vanishing flora and fauna, before they become extinct. Also we need to develop, protect and preserve these flora and fauna, as they might turn out to be the treasure house of the products in demand.

Hence it is high time we explore the possibilities to utilize these microbes through bio mimicry to gain more eco-friendly, less wasteful and more efficient products than those available today for a healthy greener future.

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