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PLANTS AND MICROBIAL INTERACTION - A WAY TO CONTROL POLLUTION

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ABSTRACT: Plants and microbes are one of the most important components of our ecosystem. Plants do not live alone in the ecosystem but also interact in many ways with microorganisms like fungi and bacteria. The most common interaction between them is that of mutualistic beneficial type where both plants and microbes derive benefit from each other. This beneficial interaction between them can help in controlling environmental pollution. Pollution not just causes human health problems but also leads to environmental degradation with disastrous consequences. Bioremediation, defined as the phenomenon of action of microbes to degrade the environmental pollutants, is a natural method of cleaning the pollutants. In this review we will discuss the application of plant microbe interaction in controlling pollution and carbon sequestration. It can be done without the removal and transport of polluted soil and also without disturbing important soil structure. Along with this, it also results in mineralization of the pollutant with the help of microbes. The application of bioremediation has recently increased because of better understanding of microbial actions in the soil. This interaction leads to development of sustainable resources and also cleans up pollutants from air, water and soil. These techniques are much more economical and environment friendly ways to control the menace of pollution.

Keywords: Bioremediation, carbon sequestration, microbe and plants interaction.

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1.INTRODUCTION

In today's world we are facing a number of environmental problems related to air, water and soil quality degradation, stress on ecosystem, and global warming. Over the years there is increase in

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environment instability due to human activities and it is affecting the humanity and even other forms of life also. The pollution of our environment has been associated with a number of health problems and therefore is one of the critical challenges that humanity faces [1, 2]. These environmental issues need to be immediately tackled and need innovative scientific action and policies that can lead on to development of new and environment friendly solutions for these pressing problems. The practice of using plants and microorganisms to clean the contaminated soil, water and air has been developed recently [3]. The bioremediation is becoming more popular than the conventional methods of engineering based remediation methods like decontamination of soil and water by removing, incineration and burial in landfills which are expensive and labour intensive, as it is an environment friendly naturally occurring processes by which plants and their microbial rhizosphere flora remove organic and inorganic pollutants [3-7]. Since it is solar energy driven process, it is cheaper and easy to implement and therefore has become very popular in developing countries.

Bioremediation

This technology involves the use of plants and microorganism in cleaning up of environmental pollutants like heavy metals, chlorinated compounds and organic compounds etc from the soil and water without displacing the sewage. Important things to be taken into account before applying this method is the study of nature of the pollutant, soil structure, nutrient content and the type of microbes in the polluted site [8-10]. This process of cleansing of pollution is divided into two types: phytoremediation (plants) and rhizoremediation (plant and microbe interaction).

1.**Phytoremediation:**

It is an environment friendly technique which uses natural or genetically engineered plants to clean the pollutants from the soil, water and air. The main pollutants which are targeted by this method are heavy metals and organic compounds which are accumulated in the tissues of the plants and are then metabolized to harmless non-toxic compounds. The plants that can be used for phytoremediation have to be fast growing with high biomass, dense roots systems, high levels of degrading enzymes and tolerant to pollution.

There are various processes involved in Phytoremediation [11-15]. These are as following

1. Phyto-sequestration: ability of plants to sequester certain contaminants in the root zone.
2. Phyto-extraction: In this process, the plants extract pollutants and accumulate them in their tissues, followed by harvesting of the (above ground) plant material leading on to removal of the soil pollutant.
3. Phyto-stabilization: use of plants to stabilize pollutants in soil
4. Phyto-transformation: breakdown of organic contaminants sequestered by plants via metabolic processes within the plant
5. Phyto-stimulation: breakdown of organic contaminants in the soil via enhanced microbial activity in the plant root zone or rhizosphere

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6. Rhizo-filtration: use of hydroponically cultivated plant roots to remediate contaminated water through absorption, concentration, and precipitation of pollutants

Organic pollutants are released into the environment because of various human activities like spills, explosions, pesticides, herbicides, industry and these compounds may be degraded in the root zone of plants or taken up by plants followed by degradation, sequestration, or volatilization [3]. Similarly, inorganic pollutants are an important concern as they cannot be degraded, but can be phyto-remediated via sequestration in harvestable plant tissues. Polluted waters also can be phyto-remediated include sewage and municipal wastewater, agricultural runoff/drainage water, and industrial wastewater. Plants can also be used to clean air pollution. Plant leaves have the ability to adsorb/absorb air pollutants, and the microbes on leaf surface and in leaves (endophytes) can biodegrade or transform air pollutants into less or nontoxic molecules[16-19]. Many industries especially mining, heavy industry, and agriculture release heavy metals such as cadmium and lead into the environment and for effective removal of these pollutants plants that can tolerate high level of pollutants are necessary. To engineer plants with enhanced metal tolerance and accumulation properties, some workers have described transgenic plants can be used in a safer way in phytoremediation [20, 21]. Transgenic poplars (*Populus* sp.) have been developed which over express enzymes commonly involved in the metabolism of toxic compounds. These engineered plants show enhanced performance in the metabolism of trichloroethylene and thus helps in removal of many toxic volatile organic pollutants including vinyl chloride, carbon tetrachloride, chloroform and benzene. There are various advantages of this technique as it is very safe and natural way of cleaning the pollutants. Along with this it is also cost effective and much cheaper process as compared to the traditional methods. Phytoremediation, although cheaper and promising, has few limitations also. Firstly, the plants that cleanse the pollutants have to be at the same place where pollutants are. Hence, the soil should allow plant growth to happen and sometimes the soils have to be made amenable for plant growth by amendments [3, 6, 7, 13, 19, 20, 22-24]. The phyto-cleansing is also limited by the root depth and the areas beyond the reach of roots cannot be cleaned. This limitation can be avoided by deep planting of trees or pumping up the polluted ground water for plant irrigation. Moreover, the bioaccumulation of heavy metals in plants can also enter the food chains and can have harmful consequences.

2. Rhizo-remediation

Although some success has been reported using plants alone in bioremediation but the use of plants in conjunction with bacteria offers much potential for cleaning various pollutants [25, 26]. It is a process where the microorganisms degrade the pollutants in the rhizosphere. Microorganisms in association with plant roots help in the cleaning up process. During this mutually beneficial process the exudates and nutrients derived from the plants stimulate the growth of bacteria, which in turn result in more efficient degradation of pollutants. Microbes in the rhizosphere can degrade many

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types of contaminants like Parathion, Pyrene, Anthracene, oils and fuels etc. According to hypothesis when a suitable rhizosphere strain is inoculated together with a suitable plant (e.g. bacteria on seeds of plant), these bacteria settle on the root together long with the normal indigenous population and thus enhance manifold the cleansing process of pollution. Bacteria of the genus *Pseudomonas* are commonly associated genera of root-associated bacteria, and have been found in the rhizosphere of wild and cultivated plants. *Pseudomonas putida* KT2440 is an efficient root colonizer of a wide variety of plants and is frequently used as in studies focusing on rhizoremediation as the grasses and the leguminous plants can harbour large number of bacteria in their root system [27]. Microbes help in reducing pollutants by various methods including reducing the toxic form of metals into a nontoxic form, enhancing the metal uptake by increasing their bioavailability and stabilizing metals in the rhizosphere so that they are not taken up by plants [28]. There are many factors that limit rhizo-remediation. This process is limited by the soil's properties, microbial population, and presence of nutrients. The plant root exudates are one of the important factors and release of these exudates as well as their nature from roots depends on the age of the plant. The concentration and solubility of the contaminants, source of energy (carbon and nitrogen) for the microbes and soil properties, like pH, temperature, humidity, and soil texture are also important factors limiting rhizo-remediation [28]. The process of rhizoremediation can be enhanced by use of genetically engineering plants and microbes as well as engineered soil using soil amelioration techniques which increases plant and microbial growth. The soil health can be enhanced through the amendment of nutrients and this can enhance the growth of plants responsible for rhizo-remediation.

Carbon sequestration by plant-microbe interaction

It is another plant-microbe interaction where atmospheric carbon is deposited as plant root material subsequently incorporated into the microorganisms present in the soil and the organic matter in the soil [29, 30]. Under the influence of high level of carbon dioxide level in atmosphere, the plants lead to rhizodeposition of it. This carbon is present in form of organic compounds in the soil and makes it healthy. The unsustainable land practices and faulty agricultural practices can lead to release of carbon from organic matter into atmosphere and thus increasing atmospheric carbon. This leads to carbon deficit in the soil and this lost carbon can be reabsorbed from the atmosphere by the process called carbon sequestration. Specific compounds released by roots of the plants can enhance microbial activity by providing substrates for co-metabolism and may also have enzymatic properties that can breakdown contaminants, e.g. increased degradation of phenanthrene by oat exudates, pyrene by corn exudates, atrazine by poplar exudates and 2-chlorobenzoic acid by wild rye exudates This method of carbon sequestration will certainly contribute in reducing atmospheric carbon dioxide concentration. However, this type of plant–microbe interaction is still in its infancy and more research is needed to assess the conditions as well as impact of successful application of

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carbon sequestration.

2. CONCLUSION

The application of bioremediation and plant microbe interaction to control pollution has recently increased because of better understanding of microbial actions in the soil. This interaction leads to development of sustainable resources and also cleans up pollutants from air, water and soil. These techniques are much more economical and environment friendly ways to control the menace of pollution. The use of genetic engineering to create genetically engineering plants and microbes as well as engineered soil using soil amelioration techniques which increases plant and microbial growth can further improve the quality of phyto-remediation. This is an interesting field of pollution control that is in infancy and the future seems to be very bright.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans were used for studies that are base of this research.

CONSENT FOR PUBLICATION

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AVAILABILITY OF DATA AND MATERIALS

The authors confirm that the data supporting the findings of this research are available within the article.

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CONFLICT OF INTEREST

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