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Microbial Interventions for sustainable bioremediation strategies

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Introduction:

The word "bioremediation" refers to the cleanup processes that microbial facilitate in various contaminated environments (Kumar et al. 2019). In this process microbial activity needed that's why we can say this microbiological remediation, in this process enzymes syntheses is done by microbes to enhance the breakdown of big chemical compounds into small form. (Dangi et al. 2019).

A common and efficient way to remove dangerous sludge from a polluted area is through bioremediation (Sharma et al. 2020). Bioremediation is process in which microbal activity are used to detoxification of hazardous chemicals into less or no hazardous compounds with effective and ecofriendly nature. In situ or ex situ for environmental remediation, microorganisms transform contaminants into less dangerous forms or completely into water and carbon dioxide. Hydrolases, dehalogenases, proteases, and lipases are a few of the enzymes that are used in bioremediation. These enzymes have demonstrated potential for converting halogenated, agrochemical, polymer, dye, and detergent compounds into less hazardous forms.

The main idea is the degradation and transformation of pollutants into less hazardous forms. Depending on cost, site characteristics and the type and quantity of pollutants for both in- and out-of-situ bioremediation. A bioremediation approach that is appropriate for the circumstance is consequently adopted. For affective success of the bioremediation, it depends on the ecological factors and procedures include biopiles, biostimulation, bioaugmentation, bioventing & bioattenuation. Bioremediation the most effective, environmentally friendly and economical approach of pollution control.

Environmental pollution

In recent decades, environmental degradation has intensified due to rising human influences such as population growth, unstable intensive agriculture, urban development, habitat destruction, industrial growth, and careless use of energy resources, among other anthropogenic sources. Chemical fertilizers, poisonous materials, radioactive waste, pesticides, herbicides, and insecticides, as well as gas emissions and lubricants, are a few of the toxins that pose a danger to the environment and general public health. In fact, thousands of polluted sites have been found, and many more are predicted to be found in the coming decades. Widespread environmental concerns have been raised as a result of the release of anthropogenic contaminants into the air, soil, and water.

Inorganic substances like nitrate, phosphates, and salt, as well as heavy metals like arsenic (As), copper (Cu), zinc (Zn), and phenolic compounds, as well as pesticides and organic substances like halogenated hydrocarbons, petroleum hydrocarbons, polycyclic aromatic hydrocarbons, phenolic compounds, xenobiotics, volatile organic compounds (VOCs), as well as nitro aromatic compounds and PCBs. Polluted ecosystems have a detrimental effect on the development and maintenance of soil microorganisms, soil productivity and composition, vegetation, aquatic species, and component biogeochemical cycles, all of which have an impact on sustainability and health effects.

Bioremediation

If we are to sustain the long-term development of our current socioeconomic system, the removal of toxins from contaminated areas is a need. Numerous physical and chemical techniques (such as soil and water, land filling, soil washing, trenching, combustion, adsorbents, flocculation, co-precipitation, sieving, photo degradation, and oxidation/reduction) are employed to remove contaminants, but these techniques are not only costly and time-consuming, but also fall short of offering a complete answer. As mankind works to find a long-term solution for needing to clean up and restore damaged ecosystems, the need to understand the microbial degradation process of dangerous chemicals has developed over time.

As opposed to other conventional methods, bioremediation uses naturally occurring microorganisms like fungi, bacteria, or related enzymes to clean up polluted soil, sediment, and streams (USEPA 2006; 2012). Given that it enables partial purification, the preservation of biological processes, the physical structure of soils, and the reintroduction of microorganisms, it is an ideal waste management method. In phytoremediation techniques, organisms are cultivated alongside harmful pollutants to increase the breakdown and/or elimination of both organic and inorganic pollutants.

A metabolic process called bioremediation combines biological elements to remove or neutralise contaminants from the ecosystem. The term “remediation” refers to the process of treating the problem and includes “biological” microorganisms such as fungus, algal, & bacterial. Using living things to remove or neutralise toxins from a damaged region is referred to as “bioremediation.”According to Reference, “Bioremediation is a’strategy for treating’ that uses naturally occurring bacteria to break down hazardous compounds into minor toxic or non-toxic components.”

Utilized of microbes in bioremediation

Microbes like bacteria, fungi, alga, and yeast to remove hazardous chemicals by bioremediation process. Microorganisms can develop in a wide range below zero as well as in extreme heat when there are dangerous compounds or any disposal sites present. Due to their adaptability and biological function, microbes are well suited for cleanup operations (Prescott et al. 2002). Carbon is the key component of microbial action. In many different environments, microbial consortiums carried out bioremediation (Singh et al. 2014**)**. Among these bacteria are Alcaligenes, Achromobacter, Bacillus, Arthrobacter, Corynebacterium, Flavobacterium, Nitrosomonas, Pseudomonas, Xanthobacter, Mycobacterium and others (Ahmad et al. 2018) (Fig. 1).

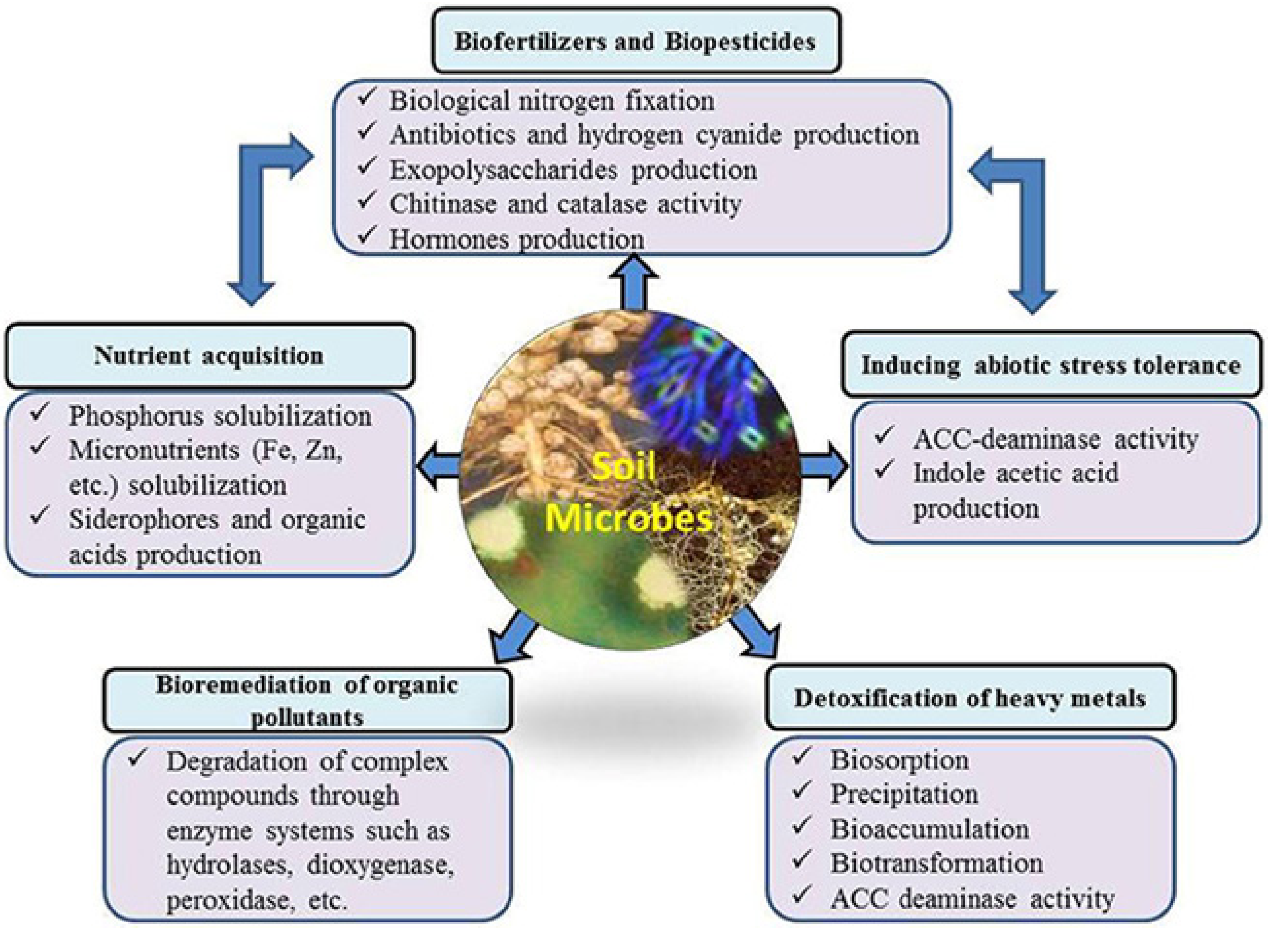

***Figure.1 Microbial community importance and mechanisms of action for environmental health** (Ahmad et al. 2018)*

Various organisms which include in bioremediation:

Aerobic

Aerobic microorganisms as Mycobacteria, Acinetobacter, Sphingomonas, Pseudomonas, Nocardia, Flavobacterium and Rhodococcus broken down the complex compounds. The degradation of herbicides, hydrocarbons, alkyls, and polycyclic aromatic compounds by these microorganisms the majority of these bacteria use to degrade pollutants as a energy and carbon source.

Anaerobic

Use of anaerobic organisms is less common than that of aerobic bacteria. Aerobic microorganisms are also increasingly being used for bioremediation of polychlorinated biphenyls, chlorinated aromatics, and dechlorination of solvents like trichloroethylene and chloroform, which convert contaminants into less harmful forms (Table1.).

Table 1) The main microorganism groups involved in biodegradation.

S.No.	Pollutant compounds	Microorganisms	Effect
1.	Benzene	*Desulfobacterium* spp. *Geobacter* spp.	Benzene can be mineralized into CO2 in 5 days. Under Fe(II) reduction circumstances, oxidize benzene.
2.	Toluene	*Azoarcus* spp. *Geobacter metallireducens*	The first toluene oxidation pure culture Transient nitrate-reducers that oxidize toluene
3.	Xylene	*Desulfosarcina variabilis, Desulfosarcina acetonicum*	o- and m-xylene becomes mineralized
4.	Polycyclic aromatic hydrocarbons	*Variovorax* *Sphingomonas* *Pseudomonas Acidovorax* *Bordetella*	Naphthalene degrades completely, whereas three to five ring PAHs degrade partially.

5.	Chlorinated pesticides	*Klebsiella pneumonia, Nocardia vulgaris, Clostridium* sp., *Aerobacter aerogenes*	destroys other chlorinated pesticides and DDT, the only source of C. deteriorates DDT
6.	Phenol and Toluene	*Burkholderia* JS150	Model of individual substrate degradation using Monod kinetics
7.	Toluene Toluene Effect of temperature and pH on the degradation; degradation	*Exophiala oligosperma, Paecilomyces variotii*	Effects of pH and temperature; breakdown with different sources of nitrogen
8.	Benzene	*Planococcus* sp. strain ZD22 Benzene Biodegradation of benzene under extreme conditions; Luong	Severe benzene bioremediation; Luong model-based biodegradation kinetics

9.	Ethylbenzene	*Thauera*-related	Methylbenzene gets totally mineralized due to denitrifying microorganisms.
10.	Polychlorinated biphenyls	*Desulfitobacterium dehalogenans*	Encircling Cl of OH-PCBs with dehalogenates
11.	Pentachlorophenol	*Desulfitobacterium frappieri*	PCP elimination of 90–99% producing 3-CP

Bioremediation and it's Approaches

Several microorganisms are used in a process known as bioremediation to break down and/or detoxify harmful substances either sequentially or continuously. In simpler terms, it refers to the acceleration of usual metabolic processes by microorganisms (like fungus and bacteria), green plants (a process known as phytoremediation), or their enzyme activity, which breaks down or transforms toxic substances into less toxic byproducts like Water (H2O), biomass, carbon dioxide (CO2), inorganic salts, and other less hazardous byproducts (metabolites). Therefore, the recommended method for repairing and cleaning up polluted areas to an environmental protection is quickly becoming the use of microorganisms to digest and detoxify toxins (Megharaj et al. 2011).

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