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Bioremediation of Environmental Pollutants

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ABSTRACT

Bioremediation is a method which utilizing the life forms to kill or expel contamination from waste. It is vital to comprehend that this type of waste remediation utilizes no poisonous chemicals, in spite of the fact that it might utilize a living organism that can be detrimental in specific situations. In other words, we can say that bioremediation is the use of living microorganisms to degrade environmental pollutants or to prevent environment from pollution. It is an important technology for removing pollutants from the environment and thus restoring the original natural surroundings so that the environment can be prevent from pollution. It can be divided into three phases or levels. Firstly, by natural attenuation in which the contaminants are reduced by native microorganisms without any human augmentation, secondly the biostimulation is employed where nutrients and oxygen are applied in the systems to improve their effectiveness and to accelerate the process of biodegradation. Finally, during bioaugmentation microorganisms are added in the systems. The techniques of bioremediation are now widely being applied to remove the pollutants or contaminants from the environment.

KEYWORDS: *bioremediation, environmental, pollutants, biostimulation, bioaugmentation, bioreactor, phytoremediation, bioventing, bioleaching*

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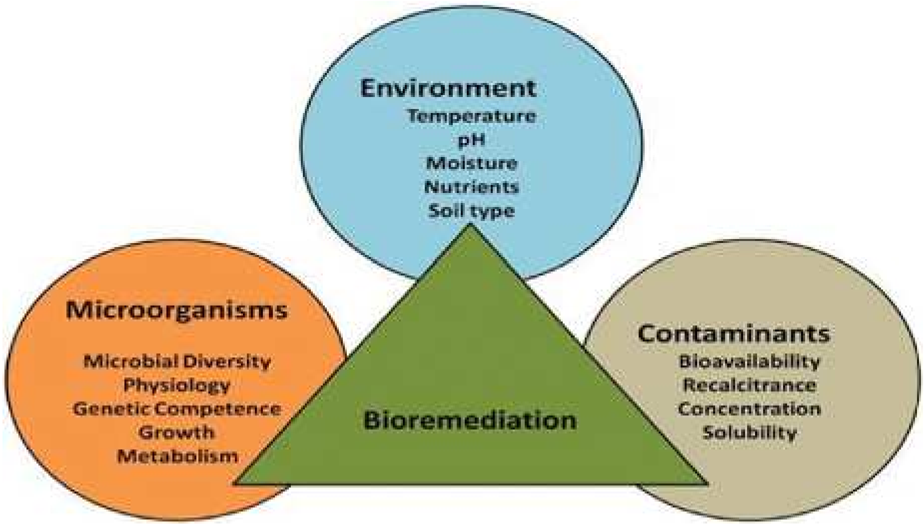
Types of Bioremediation

There are much more than nine types of bioremediation, yet the accompanying are the most well-known ways in which it is utilized. The list of some of the bioremediation techniques are as follows:



Phytoremediation: Phytoremediation is a process of utilization of plants to expel contaminants. The plants can draw the contaminants from the soil and water into their structures and clutch them, adequately expelling them from soil or water.

Bioventing: Bioventing is an in situ remediation technique that includes blowing of air through soil to expand oxygen rates in the waste. It works well with light contaminants as which can evaporate easily. It is a very efficient approach to neutralize certain oxygen sensitive metals or chemicals with the help of microorganisms.

Bioleaching: This technique includes expelling metals from soil with the help of living life forms especially bacteria. Certain sorts of life forms attract to heavy metals and other type of contaminants and ingest them. This technique has widely being used to remove the metals like lead, zinc, cobalt, lead, gold etc.

Landfarming: This technique involves placing the contaminants soil in a biocell which is consisting of a linear surrounded by a berm. After that the soil placed on the linear and turned periodically to help the microorganism to breakdown the pollutants.

Bioreactor: The utilization of uniquely outlined containers to hold the waste while bioremediation happens.

Composting: Containing waste so a characteristic decay and remediation process happens.

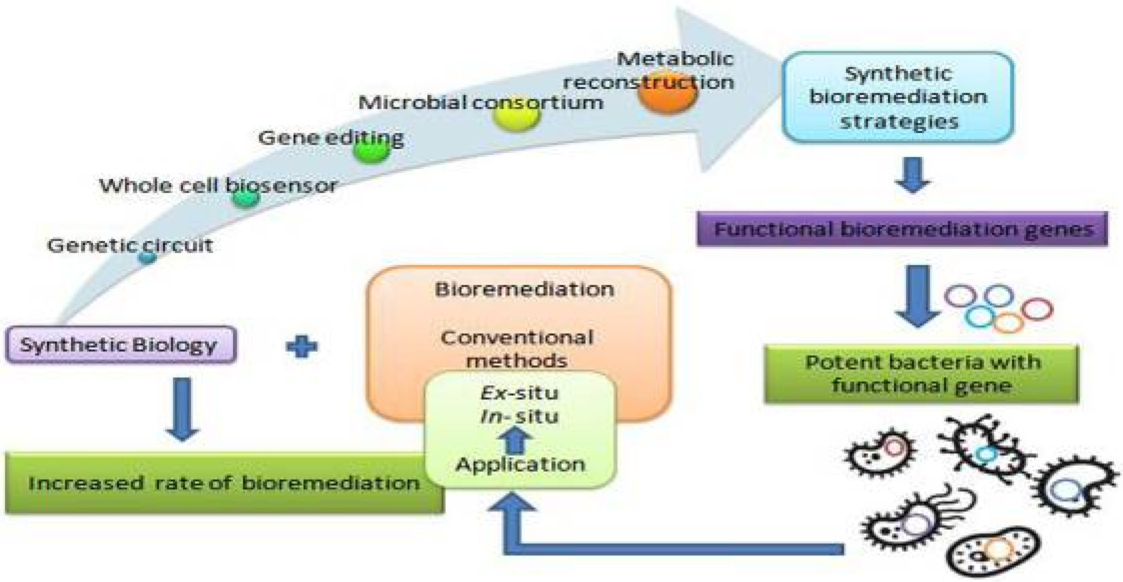
Bioaugmentation: Adding microorganisms and living organisms to fortify the same in waste to permit them to assume control and purify the region.

Rhizofiltration: The utilization of plants to expel metals in water.

Biostimulation: The utilization of organisms intended to expel contamination connected in a medium to the waste.

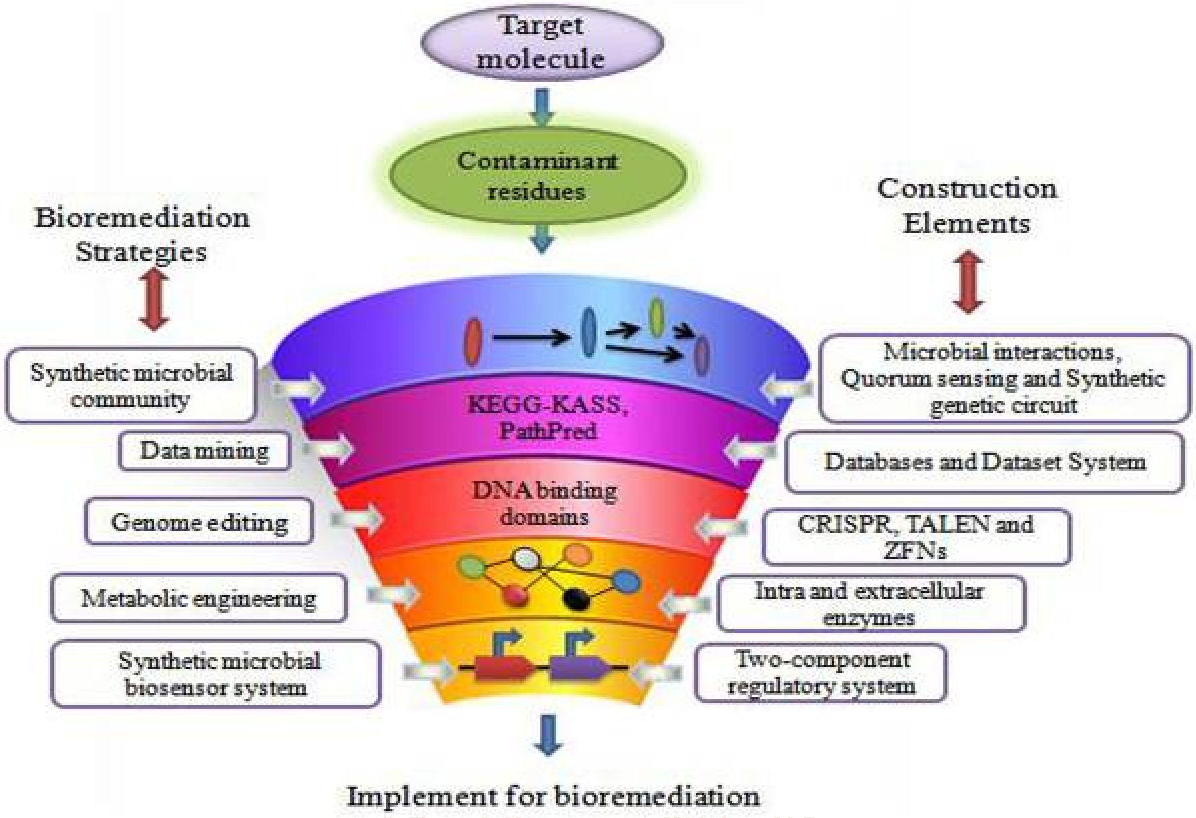
INTRODUCTION

The global population continues to rise at an astonishing rate, with estimates suggesting it will be in excess of 9 billion in 2050. The intensive agricultural and industrial systems needed to support such a large number of people will inevitably cause an accumulation of soil, water and air pollution. Estimates have attributed pollution to 62 million deaths each year, 40% of the global total, while the World Health Organization (WHO) have reported that around 7 million people are killed each year from the air they breathe. Water systems fare little better, with an estimated 70% of industrial waste dumped into surrounding water courses. The world generates 1.3 billion tonnes of rubbish every year, the majority of which is stored in landfill sites or dumped into the oceans.[1]



Bioremediation uses micro-organisms to reduce pollution through the biological degradation of pollutants into non-toxic substances. This can involve either aerobic or anaerobic micro-organisms that often use this breakdown as an energy source. There are three categories of bioremediation techniques: in situ land treatment for soil and groundwater; biofiltration of the air; and bioreactors, predominantly involved in water treatment.

Cleaning up oil-polluted soil is an example of where stimulating microbial growth can be used to good effect. Research has shown that poultry droppings can be used as a biostimulating agent, providing nitrogen and phosphorous to the system, which stimulates the natural growth rate of oil-degrading bacteria. Systems like these may prove cheaper and more environmentally friendly than current chemical treatment options[2]



Air is polluted by a variety of volatile organic compounds created by a range of industrial processes. While chemical scrubbing has been used to clean gases emitted from chimneys, the newer technique of 'biofiltration' is helping to clean industrial gases. This method involves passing polluted air over a replaceable culture medium containing micro-organisms that degrade contaminates into products such as carbon dioxide, water or salts. Biofiltration is the only biological technique currently available to remediate airborne pollutants.

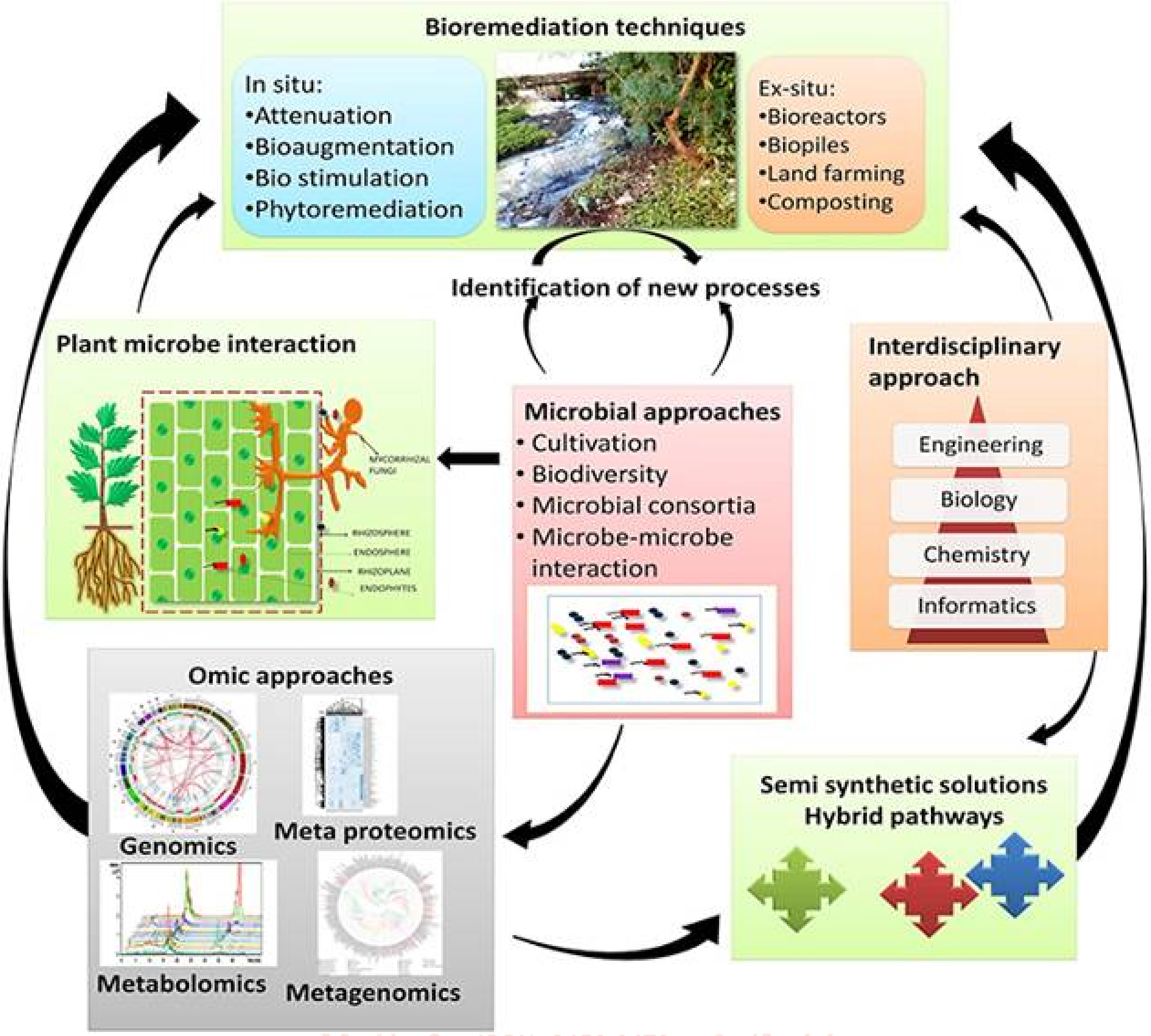
Wastewater entering a treatment plant is aerated to provide oxygen to bacteria that degrade organic material and pollutants. Microbes consume the organic contaminants and bind the less soluble fractions, which can then be filtered off. Toxic ammonia is reduced to nitrogen gas and released into the atmosphere.[3]

Bioremediation is not a new technique, but as our knowledge of the underlying microbial reactions grow, our ability to use them to our advantage increases. Frequently, bioremediation requires fewer resources and less energy than conventional technology, and doesn't accumulate hazardous by-products as waste. Bioremediation has technical and cost advantages, although it can often take more time to carry out than traditional methods.[4]

Observations

Microorganisms play an important role on nutritional chains that are important part of the biological balance in life. Bioremediation involves the removal of the contaminated materials with the help of bacteria, fungi, algae and yeast. Microbes can grow at below zero temperature as well as extreme heat in the presence of hazardous compounds or any waste stream. The two characters of microbes are adaptability and biological system made them suitable for remediation process [2]. Carbon is the main requirement for microbial activity. Bioremediation process was carried out by microbial consortium in different environments. These microorganisms comprise *Achromobacter*, *Arthrobacter*, *Alcaligenes*, *Bacillus*, *Corynebacterium*, *Pseudomonas, Flavobacterium*, *Mycobacterium*, *Nitrosomonas*, *Xanthobacter*, etc.[5,6]

Ex-situ bioremediation techniques involve digging pollutants from polluted sites and successively transporting them to another site for treatment. Ex-situ bioremediation techniques are regularly considered based on the depth of pollution, type of pollutant, degree of pollution, cost of treatment and geographical location of the polluted site. Performance standards also regulate the choice of ex-situ bioremediation techniques.[7]

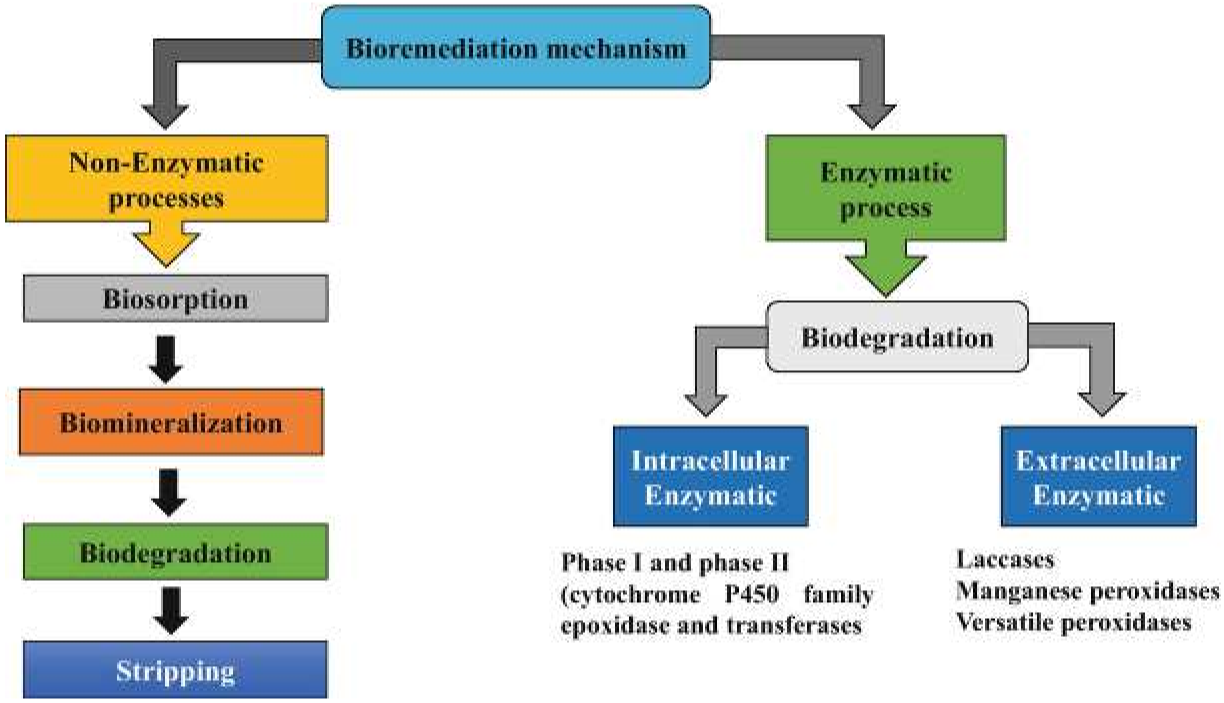


Intrinsic bioremediation also known as natural reduction is an in-situ bioremediation technique, which involves passive remediation of polluted sites, without any external force (human intervention). This process deals with stimulation of indigenous or naturally occurring microbial population. The process based on both microbial aerobic and anaerobic processes to biodegrade polluting constituents containing those that are recalcitrant. The absence of external force implies that the technique is less expensive compared to other in-situ techniques.

The second approach involves the introduction of certain microorganism to the site of contamination. Genetically Engineered microorganisms used in the in-situ bioremediation accelerate the degradation process by enhancing the physicochemical conditions to encourage the growth of microorganisms.[8,9]

Discussion

DNA microarray is widely known as a DNA chip or a biochip is one of the most promising methods in functional genomics. It is an assortment of microscopic DNA spots deposited or synthesized in a two dimensional or three-dimensional arrays on a solid surface like glass, silicon chips, or nylon membrane by covalent or non-covalent interactions. It allows the analysis of multiple genes at once without PCR amplification of the individual genes. DNA microarrays have been reported to be used to assess the physiology and catabolic gene expression profile of microorganisms isolated from environmental samples .[10]



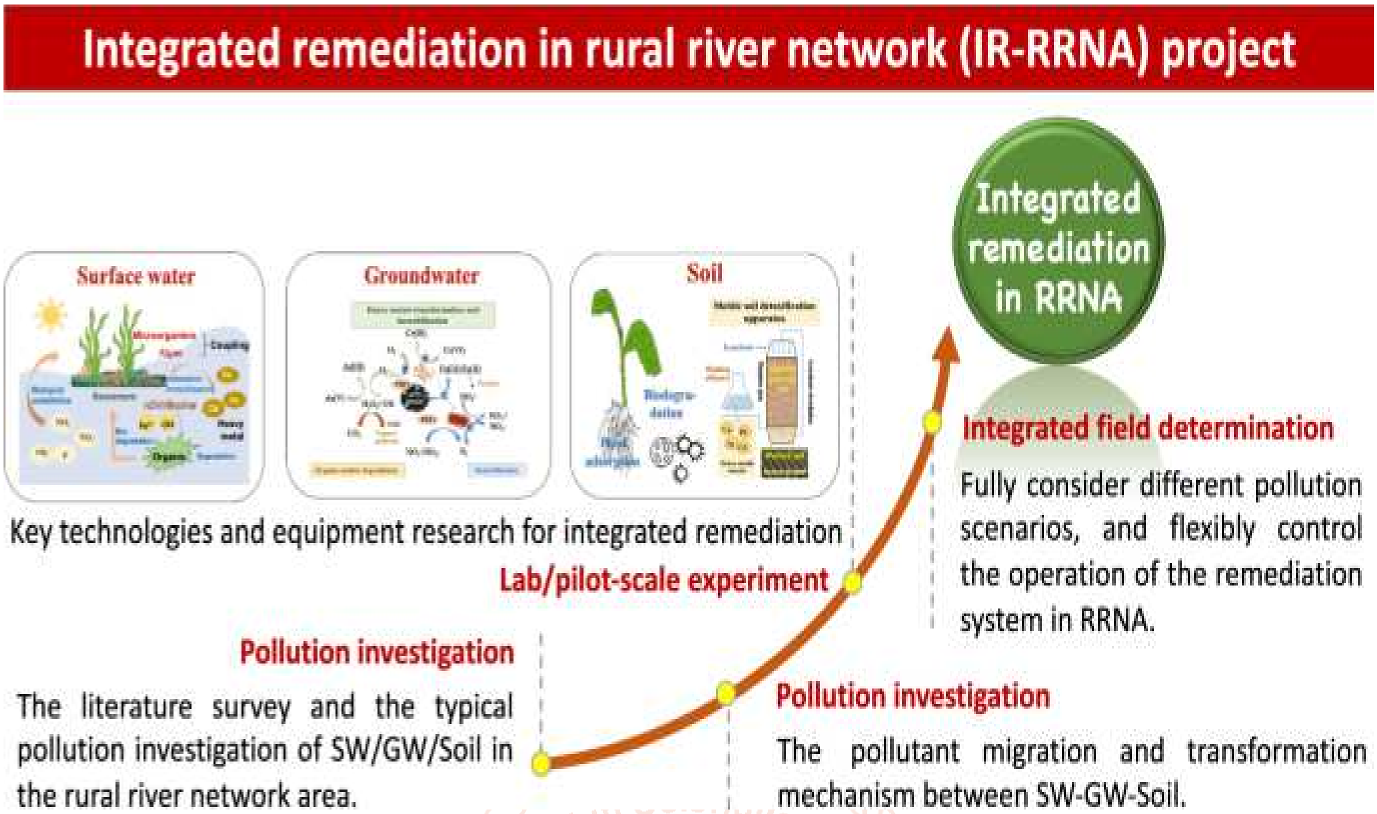
It is an ease quality chip microarray created by the business head Affymetrix to recognize different bacterial and archaeal organisms from complex microbial communities. It gives a progressively quick, complete, and precise testing method for samples retrieved from the environment without the use of any culture techniques. These chips contain large information of genes and are widely used in hybridization-based identification and study of mutations and polymorphisms like single nucleotide polymorphisms or disease- pertinent mutations analysis. They have been used to study microbial profile in extreme biological systems like sun powered salterns, industrial effluents, olive-mill squanders, coral reefs, etc.

It is the most extensive DNA microarray accessible for contemplating microbial communities related to biogeochemical cycling, ecosystem management, environmental restoration, and remediation, etc. It can be utilized to study microbial association in soil, water, air, human and animal sources. It does not entail any preceding information of the microbial community and can detect less abundant microorganisms preventing annotation bias. The process is comparatively fast, and uses either DNA or RNA and utilizes 56,990 gene sequences from 292 functional genes consuming 27,812 probes. GeoChip uses key enzymes or genes to spot various microbe mediated mechanisms for biogeochemical cycles of nitrogen, sulfur, phosphorus, etc. resistance mechanisms for heavy metals like silver, cadmium, copper, mercury, nickel, lead, zinc, etc. degradation pathways to identify and track the degradation of xenobiotics frequently found in the environment.[11,12]

Environmental pollutants concentration in water, soil, and air increased rapidly due to anthropogenic activity. The increased concentrations of environmental pollutants due to anthropogenic activities in different spheres of the Earth poses health risks to all living beings. To reduce the environmental and human health risk potential some novel in-situ or ex-situ remediation technology is necessarily demanded. In recent years, bioelectroremediation technologies such as microbial fuel cells, enzymatic fuel cells, microbial electrolysis cells, and plant microbial cells have gained popularity in sustainable remediation. This article emphasizes the potential of bioelectroremediation systems for the removal of different environmental contaminants from polluted soil and wastewaters. The efficiency of some of the novel bioelectroremediation technologies and their mechanistic understanding has been discussed. This review mainly focusses on the removal of emerging pollutants such as heavy metals, pesticides, aromatic compounds, dyes, etc. [11,13]

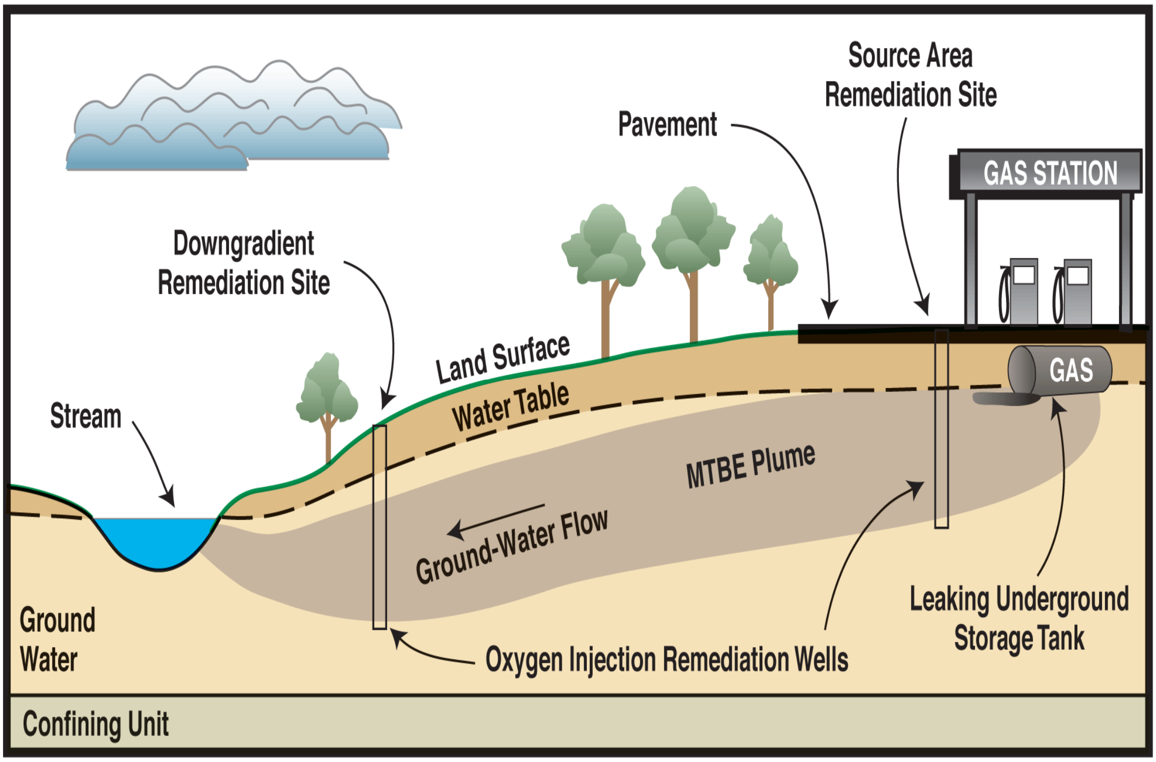
Results

Environmental pollution generated the need to search for new environmentally friendly, low-cost, and more efficient environmental clean-up techniques for its removal or reduction. Bioremediation, a branch of environmental biotechnology, is nowadays considered as one of the most promising alternatives. This technology uses the amazing ability of microorganisms or plants to accumulate, detoxify, degrade, or remove environmental contaminants. Bioremediation provides the transformation and/or even removal of organic and inorganic pollutants, even when they are present at low concentration.

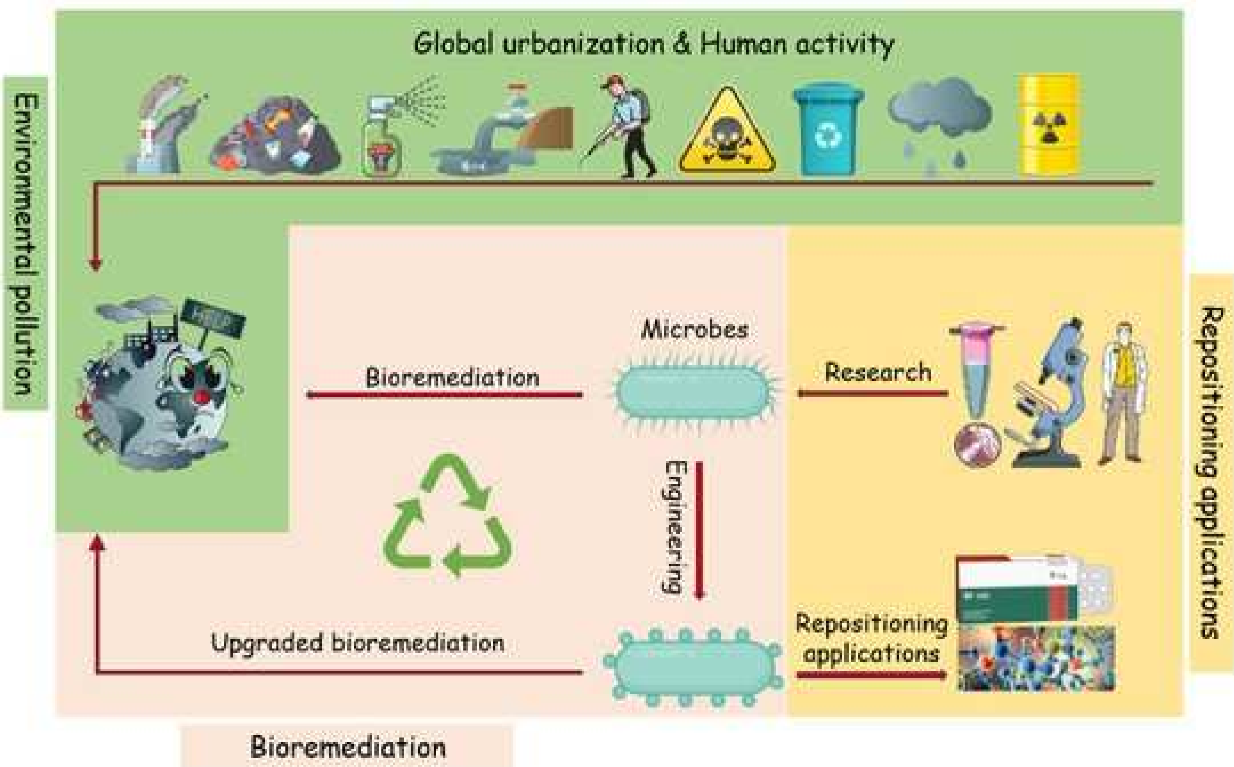


Continuous efforts are still made to understand the mechanisms by which microorganisms and plants remove or transform environmental pollutants. Thus, the purpose of this special issue was to explore different visions on bioremediation, while addressing recent advances and new ideas in the perspective of efficient process scale-up in view of application at larger scales. Many researches have been done in remediation of different environments which outline new findings in the biotechnology field. [14,15]

During the treatment of wastewater with high ammonium concentrations, as is the effluent originating from anaerobic digestion of pig slurry, the presence of free ammonia (NH3 or FA) and/or free nitrous acid (HNO2 or FNA) can affect the performance of the partial nitrification process. Thus, in the paper titled "Effect of Free Ammonia, Free Nitrous Acid, and Alkalinity on the Partial Nitrification of Pretreated Pig Slurry, Using an Alternating Oxic/Anoxic SBR" by M. Belmonte et al., the authors applied a strategy allowing the use of organic matter to partially remove nitrite (NO2 −) and nitrate (NO3 −) generated during oxic phases. Stable partial nitrification was achieved during the treatment of the effluent of an anaerobic reactor fed with pig slurry. In the paper titled "Identification of Multiple Dehalogenase Genes Involved in Tetrachloroethene-to-Ethene Dechlorination in a Dehalococcoides-Dominated Enrichment Culture," M. Ismaeil et al. investigated a Dehalococcoidesdominated enrichment culture (designated "YN3") that it dechlorinates tetrachloroethene (PCE) to nontoxic ethene (ETH) with high dechlorination activity. [16] The metagenome of YN3 harbored 18 rdhA genes (designated YN3rdhA1–18) encoding the catalytic subunit of reductive dehalogenase (rdhA), four of which were suggested to be involved in PCE-to-ETH dechlorination based on significant increases in their transcription in response to CE addition. Moreover, metagenome data indicated the presence of three coexisting bacterial species, including novel species of the genus Bacteroides, which might promote CE dechlorination by Dehalococcoides.[17]



Thirty-one mercury-resistant bacterial strains were isolated from the effluent discharge sites of the SIPCOT industrial area showed in an article "Bioremediation of Mercury by *Vibrio fluvialis* Screened from Industrial Effluents." An interesting outcome of this study was that the strain *V. fluvialis* demonstrated, on one hand, a high bioremediation efficiency in the detoxification of mercury from mobile solutions and, on the other hand, a low resistance against antibiotics. Hence, *V. fluvialis* can be successfully applied as a strain for the ecofriendly removal of mercury. In the paper titled "Effect of Hydraulic Retention Time on Anaerobic Digestion of Wheat Straw in the Semicontinuous Continuous Stirred-Tank Reactors," A scientist selected a range of process parameters such as the biogas production, methane content, pH value, and volatile fatty acids (VFAs) component and demonstrate their influence on Hydraulic Retention Time (HRT) in two operation modes of STR (Stirred-Tank Reactors). [18,19] In addition, the degradation of cellulose, hemicellulose, and crystalline cellulose in digested wheat straw was also investigated. The obtained results indicated that HRT is an important parameter that affects the performance and stability in the anaerobic digestion of wheat straw.



Recent approaches using low sulfidogenic bioreactors to both remediate and selectively recover metal sulfides from acidic mine drainage are reviewed this article. The manuscript titled "Recent Developments for Remediating Acidic Mine Waters using Sulfidogenic Bacteria" also highlights the efficiency and drawbacks of these types of treatments for metal recovery and points to future research for enhancing the use of novel acidophilic and acid tolerant sulfidogenic microorganisms in AMD treatment. We hope that this collection of papers provides to the readers a valuable scientific source and support addressing current practices, advances, and new perspectives applicable in the treatment of environmental pollution and we hope it can also help specialists in the field of biotechnology towards sustainable scale-up.[20,21]

Conclusion

Despite its short-comings, its pertinence in this world is unquestionable in the light of present day environmental hazards.[22,23] Bioremediation provides a technique for cleaning up pollution by enhancing the same biodegradation processes that occur in nature. So by developing an understanding of microbial communities and their response to the natural environment and pollutants, expanding the knowledge of the genetics of the microbes to increase capabilities to degrade pollutants, conducting field studies of new bioremediation techniques which are cost effective, and dedicating sites which are set aside for long term research purpose, these opportunities offer potential for significant advances. There is no doubt that bioremediation is in the process of paving a way to greener pastures[24,25]

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