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Research Article

Mycoremediation: A Green Technology Approach.

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ABSTRACT

Protection of an environment is a major concern of this era. Understanding of ecological problems influenced by waste of industries has forced many countries to frontier the expulsion of noxious outcomes. Mycoremediation plays an important part in dealing of these hazardous possessing many different noxious material like hydrocarbons, phenolic derivatives etc. Fungus may be capable of simply settle and debase large range of waste e.g. smoke, wood cuts, waste paper etc. Fungus consumes various noxious compounds as their source of nutrition and converts complex matter into simpler ones. Fungi has ability of conversion, this ability was analyzed by the growth of fungal isolates on an artificial media, containing substrate like Cellulose and Xylan. In order to eliminate toxic heavy metals and other toxic compounds from soil, this technique used as an addition to treat industrial waste, the technique mycoremediation, is promising as possible approach for less expensive technique to remove contaminants from soil. A number of the experiments done by using fungi, generally white rot fungifor crackdown poisonous land reported from various studies. The white rot fungus therefore efficient in humiliating a large variety of organic substances, is because of their ability to excrete certain enzymes that have ability to degrade hazardous compounds.These enzymes have a less substrate specificity that is why they can operate on a range of substances that are mostly parallel to lignin substances. Those enzymes that are present in the system occupied for humiliating lignin include manganese peroxidase (MnP), lignin-peroxidase (LiP), different hydrogen peroxide (H_2O_2) producing enzymes. The process of humiliation can be improved more by adding different sources of carbon such as straw and sawdust at polluted areas. An additional advantage of using fungus for biodegradation of pollutant is their trouble-free budding capability in fermenters and thus appropriate for large scale production. Mycoremediation is an advance technology and its disadvantage has calculated least but its remedy to reduce pollutants is in trails. The aim of this review is to elaborate the pros and cons of bioremediationhow microbes can be revolutionized and play an efficient role in recycling of pollutants.

Keywords: Environment, fungi, remediation, cleanup, pollutants

[I] INTRODUCTION

The overall environment is undergoing through vast trauma due to the development of many industries and urbanization as well as increase in population with limited natural resources. The ecological troubles are miscellaneous and occasionally precise with indication to space and time. The nature of environmental problems give new challenges and approach to every technique applied to overcome the problems. Microbiology and Biotechnology gives hope for the care of environmental protection[1] [2]. Several techniques like bioremediation are one of the fine applications of biotechnologythere are numerous that are in a roundabout way helpful for pollution avoidance, waste treatment and ecological remediation[3].

1.2. Pollution:

Environmental problems can be describe as following (waste coming from industries, sewage drainage, effluents, agricultural waste, waste matter from kitchen and wastage of peels of food) and utilize some chemicals for different purpose in the variety of chemical fertilizers, pesticides, insecticides, noxious stuff from industries. Noxious chemicals from environment like halogens, polychlorinated biphenyls (PCBs), and some other inorganic & organic contaminants which may get to the soil, air and water and have an effect on the environment in many conduct and is eventually aggressive [3] [4] [5].

The underground water is increasingly becoming contaminated due to water contaminants coming from industries. Some substances may get contact with surroundings in a low proportion and get conducted to food chain, biomagnification or bioaccumulationhave freshly detect contaminants, dichlorodiphenyl trichloroethane (DDTs), polychlorinated biphenyls (PCBs), and their byproducts, metabolites and some other contaminants from the family of halogens such as 1,2bis (2,4,6-tribromophenoxy) ethane (BTBPE), 2,3,4,5,6-pentabromoethylbenzene (PBEB), hexabromobenzene (HBB), dechlorane plus (DP), pentabromotoluene (PBT), and polybrominated diphenyl ethers (PBDEs), found in marine food chain from an Ecological pollutants cleaning regions in China [6] [7] [8].

There are three ways through which contaminated sites can be dealt; first the trouble should be recognized than the character of contaminant and finally the choice for finest techniques according to the contaminant.

The desire to remediate sites of contamination leading anew technologies, efficiently degradation of the contaminants [9] [10].

1.1. Bioremediation

The term Bioremediation is related to waste degrading and managing technique, it involves a use of cultivatedmicroorganisms chosen for their capability to metabolite the particular pollutant [11].

The method of bioremediation rely on the nature of the pollutants which can be of different types like agricultural chemicals, chlorinated compounds, different dyes and gases of green house, heavy metals, hydrocarbons, plastics and sewage waste [12].

Several studies based on bioremediation pays attention on hydrocarbons because of spreading pollution in soil and groundwater[13].

[II] BIOREMEDIATION AND OXYGEN CONTENT

Aerobic microbes that play role in the presence of oxygen bring about biodegradation with some microbes i.e. *Sphingomonas, Pseudomonas, Alcaligenes Mycobacterium* and *Rhodococcus*. These microbes renowned for their degradative ability and are frequently reported to degrade hydrocarbons and pesticides. These microorganisms utilize the contaminants as their supply of energy in their growth. Some aerobic bacteria like methylotrophs that are cultivated by the utilization of methane gas as their energy source.

Anaerobic microorganisms cause degradation of pollutants in the deficiency of oxygen (O_2). Anaerobic bacteria interestingly choose on a large scale to use for the removal of contaminants such as polychlorinated biphenyls (PCBs), dechlorination of the chloroform and trichloroethylene (TCE). Lignolytic fungus is the type of fungi that have the capacity to degrade a tremendously various range of noxious environmental contaminants.

Some latest studies on bioremediation showed that degradation of crude oil in damp surfaces of petroleum reservoir, anaerobic microorganisms carry out an important adaptation process that generate heavy oil with some major economical penalty through the degradation of syntrophic hydrocarbons joined to hydrogen trophic methanogenesis.

2.1. Characteristics of Bioremediation

The technique of bioremediation has been broadly used for decontamination of surface soil, marine systems as well as fresh water and ground water and contaminated land ecosystems. Initially, these techniques of remediation were developed to treat contamination caused by petroleum hydrocarbons that alter these hydrocarbons to chemical substances that are not hazardous for environment and bioremediation of soil may be enhanced by fertilizing or seeding with suitable microbes.

This process is known as improved bioremediation. Intrinsic bioremediation, which utilizes already accessible microbes at the working site is more costly method for decontamination of land. Even in the most contaminated soil, naturally present microbes are enough to do activity to clean the soil. Once the soil has been seeded with some factors like oxygen content, controlled temperature and water. They can be used to speed up the process of removing contamination.

Treatment	Approximate cost in euro per ton soil
Chemical	12 – 600
Biological	5 – 170
Solidification	17 – 171
Physical	20 – 170
Thermal	30 – 750

Table: 1. Techniques of bioremediation are cost efficient than other technologies

Generally, process of treatment relies from 2 to 48 months. Physical processes that involve washing of soil and soil vapors removal are tremendous processes last often for one year. The process of solidification is almost immediate. Bioremediation does not require chemicals or heat treatments that cause harm to environment, they can only use when present in the solution. It has positive effects on soil fertility and structure with the limited efficiency.

[III] PROS AND CONS OF BIOREMEDIATION

Though the process of bioremediation gives new ideas and technology to overcome the problems and is being innovate into a new green technology, microbes has been broadly used to treat waste products for more than decades. The treatment of wastewater from industry which relies on the utilization of microbes in restricted systems, which breakdown the organic substances in wastewater bythe plants containing chosen amount of microbes [14].

3.1. Pros of Bioremediation

The technique of bioremediation offers a number of benefits than old remediation techniques like landfilling etc. The classof chemicalsand their tendency to biodegrade certain compounds are summarized in table no 2. Often, bioremediation can be done on spot of contamination thus removing cost of transportation.Finally, this technique of bioremediation can be merged with other technologies in the treatment of complex waste [15].

Solid state fermentation isrecommended for advancement of lignocellulosic residues by means of culture of basidiomycetes or throughprotein improvement and alteration of substances into feed of animal [16].

Chemical class	Examples	Biodegrability
Polyaromatic hydrocarbons	Toluene	presence & absence of O2
Ketones & esters	Propanone	presence & absence of O2
Petroleum hydrocarbon	Oil	presence of O2
Chlorinated solvent	Trichloroethane	presence of O2
Polychlorinated biphenyls	Arochlors	(methanotrophs), anaerobic (reductive dechlorination)
Metals	Lead	Not degradable
Radioactive materials	Uranium	Not degradable biologically
Corrosives	Caustic soda	Not degradable biologically
Asbestos	Resins	Not degradable biologically

Table: 2. Classes of chemicals and their ability to biodegrade

3.2. Cons of Bioremediation

Similar to the majority of the technologies of treatment, there are some disadvantages of bioremediation. Some compounds e.g. highly toxic chlorinated compounds and heavy

compounds, sometimes these are not willingly variable to bio-dilapidation. Moreover, microbial humiliation may be leading to the formation of more noxious compounds as comparedto the older compounds. Like,under the absence of oxygen trichloroethane go through a chain of microbes settled some reactions results in order to get rid of atomsof chlorine from a compound. This process is known as reductive dehalogenation.Vinyl chloride (VC) is the last product of these reactions is well- known cancer causing agents. For this reasonbioremediation is an exhaustive strategy, should be modified to target the specific compounds to avoid the negative effects on environment. Therefore, starting expense for judgment and viability of bioremediation should be evaluate and it may be more to the cost connected with common techniques (e.g. air stripping).

[IV] CLASSIFICATION OF BIOREMEDIATION TECHNOLOGIES

Broadly bioremediation is classified as in-situorex-situ. Ex-situ technology relate to those treatments which is similar to the physicalremoval of the contamination to clean the site for recycling process. As compare to ex-situ, in- situ techniques involves the removal of the contaminated material within an area. While few sites can be controlled without any hurdles and maintained with ex-situ technologies [17].

Bioaugmentation	At contaminated place, harvesting of bacterial culture, used as an ex situ remediation technique.
Biofilteration	Utilization of microorganism in a bioreactor to treat air pollution.
Bioreactors	Degradation by a microbes in a fermenter mostly used to treat contamination in a liquid.
Biostimulation	In soil or groundwater, remediation of contamination is carried out by microbial cultivation by adding extra nutrients, both ex situ and in situ.
Composting	Aerobic (presence of oxygen) process involves harvesting of emerging agent and mixed with contaminated compounds.
Bioventing	Treatment process of polluted land by thawing oxygen in land to mediate growth of microorganism and its function.
Mycoremediation	Method to degrade hazardous compounds by growing fungal species that utilize those compounds as their energy source.

Table: 3. Bioremediation treatment technologies

[V] MICROBIAL CONSORTIUM FOR BIO-REMEDIATION TECHNIQUE

Due to the right choice of action skill, all techniques of bio-remediation rely on restrict microbes in the exact place with required environmental circumstances for degradation of contaminant. The right microorganisms are those that have the abilities to humiliate the pollutants. Even though it is commonly conventional that higher than 80% of the total microbes are not known. To humiliate the pollutants, microbes should be harvested very close to the pollutants. The presence of right microbe in the right place, the surrounding circumstances ought to support the activities of the microbes. Factors included temperature, pH, inorganic nutrients and electron acceptors that can be altered to optimize the environment are processing with the technique[17]. The different isolated strains of activated sludge consortium has been done and studied.

[VI] AN APPROACH TO BIOREMEDIATION TECHNIQUES

The victorious achievement of techniques for the removal of a contaminants will surround a multidisciplinary efforts requiring from expertise in chemical engineering, geology, environmental engineering, soil science and microbiology. To utilize successful bioengineering techniques for the cleaning of environmental contamination, the first stage is to achieve a complete understanding of the medium properties of the product to be treated for the removal contaminants.

Researchers said that the performance assessing of advance technologies of remediation is a vital part of localized remediation. According to their

performance assessing could be tough to carry out if there are no fix limitation of remediation objectives e.g. reduction of excretion of masses towards the contaminant source [18].

The material needed for monitoring the system of bioremediation should have the following examination:

Daily: Examination of the system parts i.e. nutritional levels within the cleanup system, pumps and valves, piping, maintaining the pH, temperature, dissolved oxygen, maintaining the flow and pumping rates.

Monthly: Regularly observing the subsequent variables during the experiment and also the side place of experiment wells: pH, assembly of contaminants, oxygen, temperature, available nutrient concentrations and aerobic heterotrophic bacterial population density.

Quarterly: Accomplish a sequence of soil analysis for the subsequent variables: available mineral nutrient concentrations, contaminant deliberation, pH, soil moisture and aerobic heterotrophic bacterial population density. Afterward, any alteration in the remediation technique will be according to the results from this analysis.

[VII] GREEN TECHNOLOGY PRINCIPLES

Green technology rising bygreen chemistry and can be elaborate by the consumption of a list of principles that is used to reduce the use of toxic compounds in the manufacturing of chemical compounds[19].

The concept of green chemistry is helpful in resolving the wide range of problems. 'The 12 Principles of Green Chemistry' that gives us the useful plan for working scientists, chemists andengineers in expanding how these green composite of various compounds process thetechnology and use for various techniques and commodity that are viable and inexpensive whereas reducing contaminants from the environment. The relation between green engineering & green chemistry is very strong in fortify that incomes and outcomes together for resources, flow of energy and economic stability are as naturally secure[20].

7.1. Introduction to fungi

Fungi have all the naturally active components for the breakdown of contaminant material and they are anessential part of the soil food chain. Forest floor is expanded with the litter of leaves by the action of season which are not useful for the plants and do not let the other plants to grow on that litter filled floor. These leaf litters are difficult to break or to be digest, any diet they consume are sheltered in them. An important agent for converting this leaf litter is fungi. Mycelium which is a vegetative part of fungus have white threads that decay dead woods etc [21].

Certainlyfungi is the single creature by God that decay wood.Certain acids and enzymes excreted by mycelium that have ability to degrade cellulose and lignin. A material known as humus released by the breakdown of wood and leaves [22].

Aspergillus and other molds are extremely active in decaying starches, cellulose, hemicellulose, and other compounds.*Aspergilli* can breakdown such difficult compoundsuch as chitin, keratin, fats and oils. Human origin substrate like paper and textiles are willingly degraded by these molds when the method goes on and this procedure is often referred as Biodeterioration.

7.2. Mycoremediation

There are many studies in the world of science demonstrated that various species of fungus are capable to help in detoxifying various pollutants present in the environment including heavy metals, pesticides, effluents and some accidental petroleum spills like disaster happened in the Exxon-Valdes. The process of using fungi in the process of remediation termed as Mycoremediation.It is a process of using fungi to convert the polluted area into non-polluted ones[23].

This technique also helps in removal of heavy compounds from the land and surroundings by fruiting bodies of fungi [24].

In 1969, scientist studied the area suffered from flood in the city of Italy and revealed 74% isolates of *Aspergillus versicolor*from the damaged area[22].

To attain a victorious mycoremediation the right specie of fungi must be selected to remove particular pollutant, from which an easy process of screening has been assessed. Laboratory studies shows that fungal mycelial networks of all fungi may modify the molecular composition and structures of soil pollutants and other nutrient sources. During their metabolic breakdown they excrete certain toxins, providing a suitable output to facilitate their withdrawal from the affected areas at sensible levels of natural economy and with the smallest amount of effects on the surrounding.

[VIII] PRONS AND CONS OF MYCOREMEDIATION

Mycoremediation is a process having many applications that are beneficial for environment butbefore going through this process of remediation we should know the advantages anddisadvantages of this technique. To know where and how the technique is useful or harmful all points should be known and must be applied before using this approach.

8.1. PRONS

Cost effective: This is an obvious advantage of Mycoremediation. It is a low cost technique as compare to other bioremediation techniques because it does not require new buildings, new structures, new houses and other new products and materials. As fungal spores are relatively cheap and easy to get therefore it is a low cost technique. Fungi will expand within the soil with its own reproducing ability in a short time. No other expenses are needed to start the process of mycoremediation. A small portion of fungus or fungal spores only can be helpful to remediate the entire contaminated surface.

Safe in use: This technique does not require the process of digging and disposing therefore it is safer than the other techniques of remediation. Moreover this technique does not produce secondary waste streams therefore no extra cleanup required. No machinery is required therefore it is an easy method and safer than other technologies. Results are not harmful therefore humans and animals are not affected.

Reusable products

The products obtain after applying the technique of mycoremediation are safe and can be reused for further processing like land scaling, road underlayment etc. This technique converts the toxic compounds to non-toxic one therefore these products are not harmful to humans and animals if reuses them.

Fast results

This technique give results more rapid than other techniques. The results are visible by focusing on improvement and mitigation of odor at the site of performance. This technique requires weeks.

Quiet

This technique does not require any machinery, any structure or any other noise therefore it is quieter than other alternatives. This technique does not create any disturbance on nearby livings thus is more beneficial for environment as well as for the nearby habitats.

Environmentally friendly

This technique is natural and does not bring various corrosives and other chemicals in the surroundings. The fungus system moves toward to treat harmful substances owing to any pollutant and eventually reestablish the usual purpose and equilibrium of the system gather the pollutants within level with the ecology.

8.2. CONS

Not approved

Organization that presently wants to use the skills are finding it a tough sell because this technology is still unproven and most often people wants to use authentic technologies.

Relevancy

There are multiple approaches for the removal or recycling; and certain are appropriate in specific

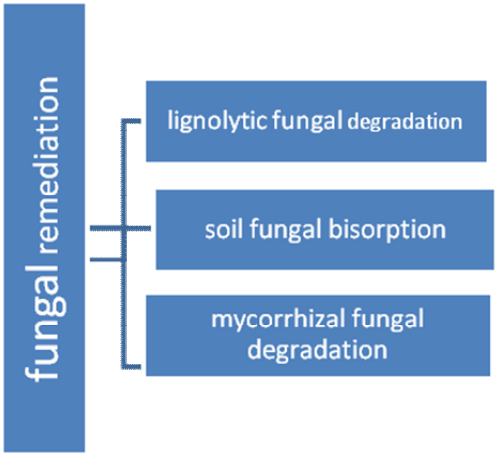
conditions e.g. multiple approaches are there for residue remediation that describe for building of factories that twist the impure sediments and incineration plants or into helpful things such as tiles, gas etc.

Efficiency

Bio systems are in no way 100 percent capable that is hard for user to recognize and to decide the method according to their requirement.

Surrounding environment

The utilization of ordinary scheme can rush into troubles with the aggressive atmosphere in various areas or among often efficiency in intense habitat[25].



Hierarchy: 1. Classification of fungi on the basis of remediation

[IX] CLASSIFICATION OF FUNGI ON THE BASIS OF REMEDIATION

9.1. Lignolytic fungal degradation

In nature, the second most abundantly found aromatic polymer is 'lignin' with the structure of three dimensions made up of phenyl propanoid units bond together ether and C-C bonds. Such complicated structure helps to protect plant cell by microbial attack. The oxidation process which is mediated by lignolytic enzymes is required for the degradation of recalcitrant lignin. Lignolytic enzymes consist of lignin peroxidase (liP), versatile peroxidases, laccase (lcc), and manganese peroxidases (MnP) are excreted by fungus named "white rot fungi"[26].

Only some of them, chiefly *Trametes versicolor* and *Phanerochaete chrysosporium*, have been focused with reference to their molecular biology of lignolytic enzymes [27].

Various other species of fungus like *ascomycetes, basidiomycetes*has the energy to degrade lignocellulosic materials found in paper and pulp effluents & dead wood.

[X] FUNGI AND LEGNOLYTIC ENZYMES

10.1. White root fungus

The specie of fungus that is responsible for causing white rot is present in the groups of some Ascomycota, namely the Xylariaceae and major groups of the Basidiomycota. After discovery of lignolytic enzymes of white rot fungus (*Phanerochaete chrysosporium*) projected the use of this technique of remediation by fungi. This specie was examined extensively and founded that this was the foremost fungus which is linked with dilapidation of organic pollutants [28].

10.2.*Trametes versicolor*

Trametes versicolor related to the group of basidiomycetes and is very efficient white rot specie in nature[29].

T.versicolor cause fast white rot attack in fall trees such as beech, birch and birch. Because of producing laccase enzyme and high tolerance to pentachlorophenol, it has been widely used in mycoremediation. Many studies showed that *P.ostreatus, P.eryngii, and P. chrysosporium* are the species that produces proteases that seem to participate in the complex lignolytic mechanism [30].

10.3. Brown rot fungi

Brown Rot Fungi belongs to the class Agaricomycetes. It is also a wood decaying caused utterly by Basidiomycetes. This group of brown rot fungi belongs to the Polyporales, Gloeophyllales andAgaricales. After some alteration of lignin, cellulose and hemicellulose can be degraded and only 6 % of total wood decaying fungi can do so. Decayed wood lost its growing strength after alterations by polymer degradation.

Many species of fungi has been observed for heavy metals such as, *Neurospora crossa, Phanerochaete chrysosporium, Aspergillus carbonarius, lentinus sajor-caju, Aspergillus niger, Rhizopus spp, Saccharomyces cerevisiae, Botrytis cinerea,* and *Mucor spp*[31].

All of them have the capability to absorb heavy metals like lead, silver, cobalt and copper. Current research shows that *S.cerevisiae* is able to absorb 92% of lead Pb, 100% of copper and 68% Mo ions from the solution within one hour of experiment. It also has the ability to absorb Cd and Co ions. Their competence as an adsorbent depends on the affinity, specificity and ability including physical and chemical nature. The strains of *Penicillium* as soil fungi shows skill to generate extracellular enzymes. Some of these strains do not have the ability to oxidize, but also degrade hydrocarbons such as halogenated compounds, poly aromatic hydrocarbons and phenol. Catabolism of PAHs by strains of *penicillium* involves cytochrome P450 monooxygenase enzyme systems.

[XI] APPLICATIONS OF MYCOREMEDIATION

11.1. Mycoremediation and use of household batteries

The rapid increase in household electronic devices has demand the additional production, use of easy and cheap to use as a source of power. These transportable power sources are known as cell or batteries and the most frequently used cell in the house is electrochemical cell and Alkaline AA battery. The disposal of these batteries causes harms to the environment. As people dispose them in the bin and then these batteries ends up in the landfills. The harsh climate induces a crack in the protective coating of a battery that results in the leakage. The toxic component that can seep out of the battery is LEACHEATE. Another two most hazardous components are Zinc fumes & Potassium Hydroxide (KOH). Furthermore before 1996, these cells contain minute amount of mercury [32].

An enlarged period of batteries in landfills will potentially seep out these toxins that permit them to seep into the ground and pollute the underground water. One feasible way out to conquer this difficulty is the use of technique mycoremediation. *Pleurotus ostreatus* does certainly have the ability to humiliate the harmful wastage found in household batteries.

11.2.Mycoremediation and soil contamination

One more main pollutant of soil is Crude oil that is produced in the outcome of removal and dealing out of the oil in industry. The extensive use of products made of petroleum and diesel has come out in the form of soil contamination thus, environment through various routes including accidental spills, leaching landfills, improper waste disposal, leakage from underground storage tanks and pipelines. Some constituents of fuel may come in contact with human and animals by ingestion, inhalation, or by skin contact and may cause neurological, renal, respiratory risk and hepatic problems. Root elongation and germination are two serious stages in the development of plants that are sensitive to ecological contamination [33].

Mushroom contains some enzymes which are able to utilize complex organic compounds which take place as farming wastes and byproducts of industries. The significance of non-poisonous mushrooms has amplified due to the advance in farming technology which makes the use of agricultural and industrial residues promising by recycling them as substrates for agriculture, as a result in little cost manufacturing and a nonstop market [34].

11.3. Mycoremediation and wastewater sludge

The biggest contamination problem is one of the wastewater sludge. Many investments are funded by the management of wastewater sludge which results in the form of an important technological challenge. The known experiments and tools used for disposal of wastewater sludge are sun drying, land disposal, application in crop field,

incineration, land filling and sea disposal. Nothing was working to overcome this problem entirely because of the fact that it has been emerging with some sort of harmful pollutants to the groundwater as well as atmosphere.

Currently, some highly developed techniques membrane filtration, flocculation and such as chemical treatments are being practiced for their disposal, settling and dewatering. These techniques are helpful in detoxifying toxic chemicals. Advance techniques are expensive as well as sophisticated, and some of them are not suitable for removal of toxic substances [35].

Additional processing with microbes is less expensive and cause less disruption at the site. By processing biologically, the microorganisms take a vital role to breakdown textile wastewater and solids. Recent research shows that by the use of spore suspension of filamentous fungi in liquid culture by using technique liquid state bioconversion (LSB).

This technique however have good results on the treatment of wastewater nevertheless, skilled with pre sterilized household wastewater sludge. Presterilization process develop change in structure and properties and thus not suitable to use at commercial level in treating plants. Hence somewhat new approach is desirable and will be appropriate in ordinary or uncooked wastewater sludge state of affairs. The current technique mycoremediation works best at commercial scale and is also environmentally friendly and economical.

11.4. Mycoremediation and paper pulp waste

Around the globe, the industry of paper is well known as the most polluted industry. Owing to their cause of polluting environment paper and pulp industry is being part of studying both local and global environment. The nature of the effluents of paper industry is pretty multifaceted as it is composed of numerous organic components e.g. hemicelluloses, cellulose, lignin andresin that are not easy to be humiliated. Microorganisms offer an economical, environmentally pleasant and simpler strategy to reduce ecological harms and are helpful in degradation of noxious compounds. Mycoremediation plays an important part in breakdown many poisonous compounds like pesticides, polychlorinated biphenyls, petroleum hydrocarbons, phenol derivatives, heavy metals, and so on. Fungal organisms use these noxious compounds as their source of nutrition and helps in converting their complex nature to non-complex ones [36].

This treatment of remediation by the use of fungus is economical rather using expensive chemicals.

[XII] IN SITU MYCOREMEDIATION

12.1. Bioventing

An aerobic degradation of earthpollution is inspired by adding oxygen to the surface in the process of bioventing. This can be done by extracting or injecting air in the course of unsaturated soil in an inert system. To treat the contamination of soil, this technique named as bioventing is designed. Soil contamination can be occurred by volatile non-haloganic organic material, herbicides, pesticides and by oil/fuels. The cost of bioventing is around $16 per cubic work area of land and utilize an inexpensive utensils that can be unchecked for longer time. Furthermore, this technique got the acceptance of public. The technology desires the existence of native organisms able of humiliating the pollutants of notice. Moreover, this is essential that the pollutants can be accessible to the degrading agent e.g. fungi and not firmly absorbed by land.

This technique is not as successful to treat those lands where the water content is far above the ground, and soils with very small content of moisture. Finally, this technique is not appropriate in area where a concentration of inorganic salts is high, organic compounds are present as they obstruct the growth of microorganisms. Conversely, some researchers have verified the qualities of bioventing as a mycoremediation technique.

12.2. Biostimulation

This technique is planned mostly to treat groundwater and soil pollution by herbicides, fuels and pesticides. This procedure is useful for organic haloganic compounds but are sometimes fewer efficient. This technique used as native organisms able of humiliating the desire pollutants, it is essential that the pollutants must exist in that agent and not tightly absorbed to the soil.

The process of biostimulation is not so suitable in region where the quantity of inorganic salts is high, organic compounds or heavy metals are there as they difficult the development of microorganisms. The approximation of water-based medium flow from the soil may lift up movement of microorganisms and insist healing of underlying groundwater. Modern studies on the function of biostimulation for humiliating numerous pollutants generally supported the value of this method,study on constant analysis of Carbon isotope that decolorize trichloroethylene (TCE) going on in in-situ biostimulation test areas during biostimulation [37].

Scientist have examined the efficiency of this process in recycling an oil pollutantsby *Spartina alterniflora* in an optimum maintenance stages by using phosphorus & nitrogen catalyst for speeding up oil removal, and then have evenly resolute the part of nutrients in increasing recycling in the nonexistence of wetland plants[33].

12.3. Air sparging

This is the process of degradation in the presence of oxygen by delivering oxygen to contaminated groundwater. This is proficient by adding air below to the level of water content. This technique is principally design to the removalof groundwater contamination by fuels, herbicides, organics and pesticides. Air sparging is an old remediation technique to treat ground water[38].

The procedure may be useful to treat halogenated organics, but is ineffective. The cost of this process is less than $1 per 1,000 in cheering conditions and is low cost alternative of this remedy. The technology uses cheapest equipment.

12.4. Natural attenuation

Natural attenuation is a useful technique that emphasizes on monitoring of the process named natural remediation, also called as bioattenuation, in situ mycoremediation and passive remediation. This process is include in in situ remedy that utilize natural process to enhance in pollution from hazardous chemical and to decrease that quantity of contaminants in contaminated site. In this way ecological contaminants are not disturbed as this process works on them. The procedure of natural attenuation are habitually divided as degradable or non-degradable. Non-degradable procedures cause a decline in concentrations of contaminants whereas destructive processes destroy the contaminants [39].

12.5. Phytoremediation

Phytoremediation technique use by means of groundwater treatment and plants in soil is a comparatively advanced and recent concept and up till now be widely established in the market. Due to this, mostly information regarding phytoremediation comes from laboratory research and field work (Table 4). On the other hand, the prospective of phytoremediation for economical, easy and efficient soil and underground water treatment is provoking substantial attention. Phytoremediation can be applied for the site of contamination with radionuclide, excess nutrients and organic contaminants e.g. toxic heavy metals, BTEX compounds, chlorinated solvents, nitrotoluene ammunition wastes, and non-aromatic petroleum hydrocarbons.

Pollutant(s)	Plant species used
Copper, arsenic, Cadmium	*Loliumperenne*
Phosphorus, nitrogen	*Oenenathe javanica Phyla Greene, Thalia geniculata f. rheumoides Shuey*
2,4,6-TNT	*Vetiveria zizanioides*
Copper, lead, zinc, cadmium	*Paulownia tomentosa*

Phenol	*Vetiveria zizanoides*
Anthracene	*Loliummultiflorum*
Arsenic species	*Pteris cretica*
2,6-dinitrotoluene	*Arabidopsis thaliana*
Chromium	*Helianthus annuus*
Contaminated soil with Dibenzofuran	*Cynodon dactylon, Agrostis palustris, Zoysia japonica, Trifolium repens*
Recalcitrant Polyaromatic Hydrocarbons	*Festuca arundinacea, Panicum virgatum, Curcubita pepo Raven*

Table: 4. List of plants that are used in phytoremediation process to reduce pollutants

[X111] EX-SITU BIOREMEDIATION

13.1. Composting

It can be define as a restricted microorganism decomposition method in the presence of oxygen with the configuration of steady natural resources that can be used as conditioner of soil. Most factors within the management of this method cuddle ecological parameters (wet content, temperature, aeration and pH scale) and substrate nature variables (size of a particle&C/N magnitude relation) [40].

The majority commodities of the biological metabolism are greenhouse gas, H_2O and significant amount of warmth. This process occurs in interconnected pores and organic particles and also the pores are half filled by air.Underneath best circumstances, this process yield from the psychrophilic status all the way through these 3 phases:

(a) The average temperature part.

(b) The warm temperature part.

13.2. Vermistabilisation

The process vermicomposting is that technique of exchange of unpreserved substance by earthworms into vermicompost. Within this technique, a main part of the nutrients enclosed inside the natural substance is reborn to additional bioavailable form. Initially, in this process worked when once earthworm ruptures the substrate right along to tiny fragments before engulfing the substrate. This will increase in expanse of the substrate, catalyst actions and facilitating microorganism. The contaminated material is then eaten up and undergo a technique of enzymatic digestion that led to be varied species of microbes and enzyme gift within the worm's gut [41].

Earthworms are exposed to ventilate or bioturbate soils and therefore get better in its organic processes. Earthworms conjointly hold back process throughout those organic pollutants that are binded to soils and therefore endorse the bioavailability and dispersion of natural contaminants to the humiliating microbes. Earthworm species like *Eisenia fetida, Lumbricus rubellus, Allobophora chlorotica, Lumbricus terrestris,* and *Eisenia tetraedra* are found to get free of severe metals (Hg, Cd, Pb and Cu) and small contaminants just like polyaromatic hydrocarbons from the soil.

13.3. Phenol derivatives

Phenols are synthetically and naturally made hydrocarbons. Microbes that are skilled in degrading the phenol both aerobic and anaerobic. Some phenol degrading aerobic microbes are harvest and their pathway of degrading phenolic area is established. Chlorophenols are bring into the setting by their advantage of use to kill undesired pathogens and as by-products of atomic number 17 also use as bleaching agent within the pulp and paper industry. Below anaerobic conditions chlorinated phenols will endure subtractive dechlorination once appropriate electron-donating substrates area unit accessible[42].

Two main ways of phenol units utilized by microbes that are an aerobic bacterium for the purpose of degradation of chlorophenols. Low amount of chlorinated phenols area unit at first effected by monooxygenases and yielding chlorocatechols.

13.4. Bioremediation of pesticides

The pesticides are constantly in use and cause rigorous destruction to the setting causing human weakness harmfully condensed on agricultural production and reduced fields. Bioremediation and phytoremediation both measure the organic phenomenon processes that generally used as a

treatment for pesticides contaminated places. The consumption of phytotechnology to correct these lots of persistent pesticides is just rising. Still, hinders there, together with the potential of toxicity of some herbicides that were originally developed however destroyed stuff. As its low cost bioremediation possibility, composting associate in nursing biobeds square measure more and more is being evaluate for approach to rectify pesticides.

The method of composting with success destroyed 70-89% of pirimiphos-methyl at intervals the 1st 54hr of the method of composting, whereas the whole breakdown of chemical needed more or less 440hrconjointly inferred that variety of chemical, physical, and bio mechanisms involve in breakdown of pirimiphos-methyl within the setting and these encompass mineralization, abiotic transformation, leaching, adsorption, volatization and humification. Throughoutthe process of composting of green wastes, especially, the degradation of pirimiphosmethyl is speedy by altering high temperatures throughout the thermophilic stage of the method[43].

13.5. Slurry phase bioremediation

This technology related to the remedy to treat polluted land within the maintained atmosphere. Isolated soil is approachto separate wastes, rocks and water is mixed to a preset leveldependent upon the amount of the pollutants, the speed of microbe to degrade pollutantsdegrade and the nature of the land. Typically slurries consist of ten to four-hundredth solids.

Variables like pH and temperature, negatron acceptors and nutrients area unit supplementary to the reactor and area unit managed to control biological processes. Each reaction either in aerobic or anaerobic environment could also be utilized. Target chemicals embody solvents, wood preservations, petrochemicals, fossil oil hydrocarbons, different organic chemicals, explosives and chemicals.

[XIV] CONCLUSION AND FUTURE PROSPECTIVE

Industrialization is the main cause of ecological pollution of natural surroundings. Several organic contaminants such as pesticides, herbicides, inorganic contaminants, polyaromatic hydrocarbons and polychlorinated biphenyls are confrontation to humiliation and represent continuing toxicological danger to humans as well as animals.

Mycoremediation has grown into an attractive, green and hopeful remediation of such polluted sites byconventional chemical and physical techniques as it is less expensive and it is able to degrade specific contaminants without damaging the habitat of that environment. Conversely, the technique of mycoremediation have restrictedapplications because of the limitation forced by environmentally variability and the less potential of biodegradation and feasibility of naturally present microbes.

This aim of this review is just to approach the advance technology to reduce pollution and not to deal with baggy literature on basic tools of bioremediation and mycoremediation, but somewhat to return to the basics of bioremediation and mycoremediation and show that the applications of bio treatment is using very frequent because of its qualities become important than the disadvantages. For the progress of bio remedial methods to achieve something on commercial stage, it is difficult to connect multiple disciplines e.g.environmental microbiology, biochemistry andmicrobial physiology.

These disciplines bring together in a biochemical processes and manufacturing. If we summarize,mycoremediation techniques are in ongoing to expand the production and scientific work that gives the basis to assess the framework of technology and at the same time in explanation and mitigating the valid reasons by which scientists use these techniques for the well-being and beneficiary of a community.

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