International Research Journal of Plant Science (ISSN: 2141-5447)
Vol. 14(3) pp. 01-05, July,2023
DOI: http:/dx.doi.org/10.14303/irjps.2023.16
Available online @ https://www.interesjournals.org/plant-science.html

Review Article

Mycoremediation-An Effective Tool to Decontaminate Environment: A Review

Bhagwat W Chavre*

Department of Food Science and Technology, Maratha Vidya Prasarak Samaj's Arts, Commerce and Science College, Nashik, India

E-mail: chavrebhagwat@gmail.com

Abstract

Fungi are the most diverse group of living organisms having a wide adaptability in variety of environmental conditions. Fungus successfully made a way in the life of human being through its wide range of applications in food processing, drug production, enzyme technology and many more fields. They are widely being used in each and every aspect of human life and having a huge role fulfilling needs of growing population. In the present article an attempt is made to discuss one more novel application of fungi, mycoremediation. It is evident from the literature screening that, they plays very important role in the biodiversity and productivity of plants which is ultimately leads to regulation of different food chains in nature. A variety of fungal species has a capability to degrade different types of pollutants from environment by using their metabolic products like lignin degrading enzymes. In the present situation ever polluting environment can be decontaminated by using fungus which is a cost effective and eco-friendly way.

Keywords: Mycoremediation, Decontamination, Environment, Fungi, Pollution.

INTRODUCTION

Fungi are ubiquitous, achlorophyllous, spore-bearing eukaryotes composed of chitin containing cell wall. Over 120,000 species were identified till today. Fungi are considered as one of the most adaptable groups of organisms and also as an essential component of soil because they decompose organic matters and provide nutrients to plants. Apart from this, they are plays important role for the production of various environmental products such as antibiotics, drugs, pigment production, food industry and bioremediation. In the present article, the special application of various fungi is discussed. Author gone through many articles based on fungal bioremediation and an effort is taken to gather information about use of various fungi to decontaminate soil. Different types of Metals are present in the soil in different forms including free metal ions, oxalates, carbonates and hydroxides. The degree of their toxicity on living organisms is based on their relative availability. Their availability is depends on pH, organic matter and clay content of the soil. Soil micro fungi are able to tolerate concentration of various metals and restrict entry of metals into the cells by extracellular metal sequestration (Yakop et al., 2019). Population explosion and rapid development in the developing countries resulted in the loading of large quantum of contaminants and recalcitrant compounds like Polyaromatic Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs), Polychlorinated Dibenzp-Dioxins (PCDDs) and heavy metals in the environment. To treat such contaminated environment some physicochemical methods can be effectively used but are not feasible in large scale (Tigini et al., 2006).

Received: 25-Mar-2020, Manuscript No. IRJPS-23-8572; **Editor assigned:** 30-Mar-2020, Pre QC No. IRJPS-23-8572 (PQ); **Reviewed:** 13-Apr-2020, QC No. IRJPS-23-8572; **Revised:** 03-Jul-2023, Manuscript No. IRJPS-23-8572 (R); **Published:** 31-Jul-2023

Citation: Chavre BW (2023). Mycoremediation-An Effective Tool to Decontaminate Environment: A Review. IRJPS. 14: 16.

Bioremediation is one of the important, efficient and feasible solutions to treat and remove pollutants from the environment and soil. Fungi act as decomposer and symbionts in all ecosystems including soil due to their robust morphology and diverse metabolic capacity. So, mycoremediation is a form of bioremediation in which fungus are well suited for the purpose of treatment of contaminated soils (Deshmukh et al., 2016).

Xenobiotic compounds are produced in high amount annually and remains persistent in the environment. Wastewater, landfill leachates and solid wastes are the main sources of xenobiotic compounds. Different types of xenobiotic compounds are phenols, plastics, hydrocarbons, paints, dyes, pesticides, insecticides, paper and pulp mill wastes pharmaceutical remains etc. Xenobiotic compounds can show some carcinogenic and mutanogenic effects. The treatment on such compounds can be done by using different biological processes which is also referred as bioremediation (Viswanath et al., 2014).

LITERATURE REVIEW

Different types of fungal species reported for various types of waste bioremediation

Shivanand et al. carried out an excellent study on fungal isolation and its applications in possible bioremediation. They isolated fungi from different sources including forest, coastal, mycorrhizal, and endophytic ecosystems. It is clear that, different types of habitats contain diverse fungal species. It is evident from the study that, forest ecosystem contains common fungal species like, *Aspergillus*, *Penicillium*, *Trichoderma* and *Fusarium*, *Penicillium*, *Cladosporium* etc. The fungal species commonly observed from coastal areas are *Scutellospora*, *Glomus*, *Gigaspora*, *Sclerocystisetc* and from freshwater river contains species like *Aspergillus*, *Penicillium*, *Thielavia*, *Fusarium*, etc. Many mycorrhizal fungi also isolated from different higher plants including orchids. Endophytic fungal strains like *Alternaria*, *Fusarium*, *Pestalotiopsis* are also found grown abundantly in the tissues of different higher plants. It is reported that, different species of fungi are highly beneficial for degradation of pollutants including oil spills and different types of alkanes. Coastal fungal species including, *Alternaria alternate*, *Aspergillus flavus*, *A. niger*, *Penicillium chrysogenum*, *Trichoderma harzianum* are most common species involved in it. Anthracene is completely degraded by *Penicilliun oxalicum*.

Fusarium oxysporium shows major bioremediation efficiency. Sashirekha and Usmani with their research proved it. Fungus can tolerate the pH range from 5 to 11 means it can adapt itself to acidic and basic pH conditions. It has metal tolerance index for zinc 3.7% to 51% ppm and 1% to 53% for lead (Cornejo et al., 2017). *Scedosporium apiospermum*, *Penicillium* spp and *Aspergillus* spp. have proved experimentally to be effective to degrade Polychlorinated Biphenyl (PCB) present in historically contaminated soil (D'annibale et al., 2006).

The diversity of habitat and ability for secreting multitude of enzymes makes fungi potential candidates for bioremediation. White rust fungi like *Phanerochaete chysosporium*, *Tramtes versicolor*, *Bjerkandera adjusta* and *Pleurotus* sp. can produce various lignolytic enzymes can be used for the bioremediation of pharmaceutical and personal care products which can result in effects such as bioaccumulation, acute and chronic toxicity. The lignolytic enzymes from white rust fungi have been applied for transformation of organic pollutants such as pesticides using biopurification system. Some species of white rust fungi such as *Coriolus versicolr*, *Hirschioporus larincinus*, *Inonotus hispidus* etc. are used for decolourization of dye effluents. Many species of white rust fungi have been reported to be used in reduction of total phenolics, cresolate, petroleum hydrocarbons and high molecular weight PAH fractions. Marine fungus, *Trichoderma harzianum* has the capacity to transform pentachlorophenol whereas the *Mucor*, *Aspergillus* and *Penicillium* show bioremediation potential for water soluble crude oil fractions. Different types of enzymes secreted by white rust fungi are also causes degradation of different types of xenobiotic compounds present in the soil and environment. Such enzymes include lignin peroxidase, manganese peroxidase, oxidase, laccases etc (Ghanem et al., 2016).

Young reported that, extracellular enzymes secreted by white rot fungi during lignin decay can be used as promising agent for oxidizing pollutants. He used *Punctularia strigosozonata*, *Irpex lacteus*, *Trichaptum biforme*, *Phlebia radiate*, *Trametes versicolor* and *Pleurotus ostreatus* species of white rot fungi. All species tested have degraded C 10 alkane, C 14 alkane and polycyclic aromatic hydrocarbon phenanthrene. Bioremediation and detoxification of wastewater originated from textile industry have been practiced by using white- rot fungus to make water reusable. The decolonization capacity of white rot fungus *Coriolus versicolor* was confirmed by them through agar plate and liquid batch studies. *Phanerochaete chrysosporim*, *Pleurotus ostreatus*, *Trametes versicolor*, *Bjerkandera adusta*, *Lentinulaedodes*, *Irpex lacteus*, *Agaricus bisporus*, *Pleurotus tuberregium* and *Pleurotus pulmonarius* are some mushroom white rot fungi used for the purpose of bioremediation and to degrade different xenobiotic compounds (Tkavc et al., 2018).

Fungal laccases are blue multicopper oxidases which catalysze the monoelectric oxidation of a broad spectrum of substrates like polyphenols, aromatic and aliphatic amines etc. can be used as a tool for bioremediation. Laccase fro white rot fungus *Trametes*

hirsute is used to oxidize alkanes. Laccase from *Flavodon flavus* is useful in decolourization of several synthetic dyes. Fungal laccases are applicable in variety of fields like paper and pulp industry, textile industry, xenobiotic degradation and bioremediation (Siddiquee et al., 2015).

Ligninolytic fungi are highly useful in the bioremediation of contaminated soils. The most important role of ligninolytic fungi in nature is to regulate global carbon cycle. Naturally the ligninolytic fungi produce some extracellular enzymes which degrade wood material, plant litter as well as soil humic substances. Same enzyme can be utilized to degrade other recalcitrant organic compounds such as toxic metals. By using lignolytic fungi, it could be possible to widen the applicability of bioremediation even to Persistent Organic Pollutants (POP), PAHs and PCDD rich soils.

Seguel et al. concluded by their research that, arbuscular mycorrhizal fungi such as *Claroideoglomus claroideum* along with *Oenothera picensis* plant contributes to phytostabilize the copper in the contaminated soils. Autochthonous filamentous fungi are highly useful in bioremediation of a soil historically contaminated with aromatic hydrocarbons. Petruccioli et al. isolated nine fugal strains from an aged and heavily contaminated soil to study their degradative potential. It was observed that the strains like *Allescheriella* sp., *Stachyobotrys* sp. and *Phlebia* sp. fungi led to a significant decrease in soil toxicity by removing different types of aromatic hydrocarbons including naphthalene, dichloroaniline,o-hydroxybiphenyl and 1,1-binaphthalene (Hossain et al., 2016).

Apart from above different types of contaminants, fungi can be used to repair the sites contaminated by acidic radioactive wastes. The radioactive wastes are highly acidic and mixed with heavy metals are continuously leaking in the environment causing contamination of soil as well as groundwater. It is not possible to cleanup such radioactive sites by physicochemical processes due to danger and high expenses. So, some radiation resistant bacterial strains like *Deinococcus radiodurans* can be used to treat such soils but have some limitations. They are very sensitive to low pH and can't survive. So, finally some strains of yeast are reported for bioremediation which are resistant to ionizing radiation. *Rhodotorula taiwanensis* is most specialized fungus applicable for the treatment such a polluted site (Umana et al., 2016).

Filamentous fungal biomass has a great potential to produce large amount of biomass on the contaminated water with different types of metals with which these are able to absorb metals like Pb, Zn, Cd, Cu, Cr, As and Ni. Many fungal species have been reported such as *Trichoderma autroviride*, *T. harzianum*, *T. virens* and *Aspergillus niger*, that are used for bioremediation of polluted areas. Other fungal species including *Penicillium*, *Rhizopus*, *Mucor*, *Saccaromyces* and *Fusarium* have also shown the capacity to biosorb different types of metals present in the waste water. Polycyclic Hydrocarbons (PAHs) are widespread pollutants raising public health concerns because of their chronic toxicity and environmental problems due to their persistence and accumulation in the ecosystem. The filamentous soil fungi like *Talaromyces* helices have shown the capacity to degrade organic pollutants including PAH. Fungus will have some major limitations while bioremediation such as high chemical stability and low bioavailability of PAHs. This limitation has been overcome by Baranger et al. by the microfluidic approach in which Benzo [a] Pyrene (BaP) are used to mimic polluted soil microenvironment. Sharma and Malvia, reported the bioremediation of tannery wastewater by Chromium (Cr) resistant fungal isolate *Fusarium chlamydosporium*.

DISCUSSION

Akwaji et al., reported that, *Penicillium* sp. can biodegrade the hydrocarbons present in spent engine oil. Soil is added with different concentrations of spent engine oil inoculated with *Penicillium* sp. In that soil they seeds of *Telfeira occidentalis* plant was sown and assessed for growth performance. It was observed that, after 28 days of plant growth, the added spent engine oil was no longer detected. The plant began producing pods because *Penicillium* sp. could degrade hydrocarbons of spent oil completely. Teresa reported that, petroleum substances are the main source of pollutants stored in old waste pits which are responsible for degradation of biological life in the area of storage. The non pathogenic bacteria and fungal species can be used for the biodegradation of such petroleum hydrocarbons. *Aspergillus sydowii*, *Cladosporium cladosporioides* and *Phanerochaete chrysosporium* are some fungal species used for the purpose. *Aspergillus ustus* and *Alternaria alternate* have been tested against diesel fuel by Kaled et al. According to their study, the two fungal strains can degrade 92%-100% diesel after 7 days. The degradation process was enhanced using fungal consortium of both the strains (Brunner et al., 2018).

Due to resistance to biological process, plastic waste in the environment is a significant threat. Brunner et al. reported the ability of some fungal strains found on floating plastic debris to degrade plastic. The fungal strains are collected and identified genetically and used to test their ability to degrade polyethylene and polyurethane. Results of the tests have shown that, none of the strain was able to degrade polyethylene however four strains were able to degrade polyurethane. Out of four strains three were litter saprophytic which includes *Cladosporium cladosporioides*, *Xepiculopsis graminea*, and *Penicillium griseofulvum*. One strain that is, *Leptosphaeria* sp. was the plant pathogen. The fungus strains collected from other than plastic source also shows the ability to degrade the plastic. *Agaricus*

bisporus, *Marasmius oreades* and *Pestalotiopsis microspora* are such fungal species.

Podospora anserina is a special type of fungus which reproduces only by sexual means, non-pathogenic, cosmopolitan species is used for the bioremediation of soils which are contaminated with aromatic amines. Fungus has its arylamine N-acetyl transferase 2 enzyme which has ability to detoxify the highly toxic pesticide residues 3,4-dichloroaniline present in the soil. 3,4 dichloroaniline belongs to the class of aromatic amines.

Use of pesticides and herbicides is an effective method to control different types of pests including weeds. Bout overuse of those can cause harms to environment. The increased concentration of pesticides and herbicides in the soil can be controlled by using bioremediation. Gokhan, carried out a research on the application of some selected fungi on bioremediation of herbicide chlorsulfuron. According to his study, the fungal species such as *Penicillium thrichoderma*, *Penicillium simplicissimum*, *Penicillium talaromyces*, *Metacordyceps chlamydosporia*, *Stachybotrys chartarum* and *Alternaria alternata* are effectively involved in the degradation of the herbicide chlorsulfuron.

CONCLUSION

Soil and water are the very important components required for the plant growth. Agriculture production is highly affected by quality and quantity of soil and water. Due to industrialization, urbanization, mining, overuse of fossil fuels and modern agriculture different types of contaminants like toxic metals, hydrocarbons, pesticides, herbicides, aromatic amines, plastics, radioactive wastes and many other types of life threatening waste are mixed and continuously being released in soil and water. The treatment of such harmful wastes by using physicochemical methods has some limitations and may gives rise to secondary pollutants in the environment. Bioremediation is an effective and efficient way to minimize such type of contaminants in the soil. Fungi are cosmopolitan in nature and can grow at acute adverse conditions where other microorganisms cannot grow. Many white rot, filamentous, lignolytic, arbuscular mycorrhizal and other fungal species can be effectively used to reduce concentration of variety of life threatening contaminants saturated in variety of soils and water resources.

This approach is very useful to make contaminated soil usable for crop production. Thousands of acres of land contaminated by variety of pollutants may be converted in to fertile land leads to increase agricultural production and important to meets needs of growing population. Water is another necessary component required for living organisms and crop production. Due to various manmade calamities, natural water resources are getting contaminated by different types of wastes. Polluted and contaminated water can be purified by minimizing the concentration of different types of pollutants dissolved and suspended in it. This can be achieved by using different types of fungal species especially, filamentous fungi.

REFRENCES

Yakop F, Taha H, Shivanand P (2019). Isolation of fungi from various habitats and their possible bioremediation. Curr Sci. 116: 733-740.

Tigini V, Prigione V, Di Toro S, Fava F, Varese GC (2009). Isolation and characterisation of Polychlorinated biphenyl (PCB) degrading fungi from a historically contaminated soil. Microb Cell Fact. 8: 1-14.

Deshmukh R, Khardenavis AA, Purohit HJ (2016). Diverse metabolic capacities of fungi for bioremediation. Indian J Microbiol. 56: 247-264.

Viswanath B, Rajesh B, Janardhan A, Kumar AP, Narasimha G (2014). Fungal laccases and their applications in bioremediation. Enzyme Res. 2014.

Cornejo P, Meier S, Garcia S, Ferrol N, Duran P, et al (2017). Contribution of inoculation with arbuscular mycorrhizal fungi to the bioremediation of a copper contaminated soil using *Oenothera picensis*. J Soil Sci Plant Nutr. 17: 14-21.

D'annibale A, Rosetto F, Leonardi V, Federici F, Petruccioli M (2006). Role of autochthonous filamentous fungi in bioremediation of a soil historically contaminated with aromatic hydrocarbons. Appl Environ Microbiol. 72: 28-36.

Ghanem KM, Al-Garni SM, Al-Zahrani MA (2016). Bioremediation of diesel fuel by fungal consortium using statistical experimental designs. Polish J Environ Stud. 25.

Tkavc R, Matrosova VY, Grichenko OE, Gostincar C, Volpe RP, et al (2018). Prospects for fungal bioremediation of acidic radioactive waste sites: characterization and genome sequence of *Rhodotorula taiwanensis* MD1149. Front Microbiol. 8: 2528.

Siddiquee S, Rovina K, Azad SA, Naher L, Suryani S, et al (2015). Heavy metal contaminants removal from wastewater using the potential filamentous

fungi biomass: A review. J Microb Biochem Technol. 7:384-395.

Hossain K, Quaik S, Ismail N, Rafatullah M, Avasan M, et al (2016). Bioremediation and detoxification of the textile wastewater with membrane bioreactor using the white-rot fungus and reuse of wastewater. Iran J Biotechnol. 14: 154.

Umana EJ, Akwaji PI, Markson AAA (2016). Bioremediation of spent engine oil contaminated soil by using fungus, *Penicillium* sp. Int Lett Nat Sci. 59.

Brunner I, Fischer M, Ruthi J, Stierli B, Frey B (2018). Ability of fungi isolated from plastic debris floating in the shoreline of a lake to degrade plastics. PloS One. 13: e0202047.