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Chemical Fertilizers and its removal from Environment using Microbial Approach- Review

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Abstract

To meet the increasing food demands, the agricultural sector is bound to employ enormous quantities of fertilizers that have thus far demonstrated undesirable environmental impacts. The use of fertilizers, including chemical fertilizers and manures, to enhance soil fertility and crop productivity has often negatively affected the complex system of the biogeochemical cycles. Application of chemical fertilizers in imbalanced ratio consumes the indispensable part of the nutrients in soil reducing the amount of minerals and vitamins in the food items.Some technologies have also been used such as high-temperature incineration and chemical use for decomposition (e.g., base-catalyzed dechlorination and UV oxidation). These techniques can be effective in reducing level of wide range of contaminants (namely chlorinated solvents, petroleum, polynuclear aromatic hydrocarbons, ketones, PAHs, TNT, of public acceptance RDX, HMX, BTEX, inorganic nitrogen (NO_3, NH_4), explosives, pesticides, herbicides and heavy metals) however, this shows several demerits such as technical These processes generate large volume of hazardous sludge and do not lead to ultimate destruction of the pollutants. To overcome these drawbacks, a much better perspective is to completely destroy the pollutants, or to transform them into some biodegradable substances. This approach can be achieved by using a technique known as bioremediation. The process of bioremediation depends on the metabolic potential of microorganisms to detoxify or transform the pollutant, which is further dependent on accessibility and bioavailability The process of remediation can be enhanced by the addition of various microorganisms (called seeding or inoculation) to a polluted environment to promote increased rate of biodegradation. Currently, a wide range of microorganisms (bacteria, archaebactreia, yeasts, fungi and algae) and plants are being studied for use in bioremediation processes.

1. INTRODUCTION

There has been rapid climb within the earth's population that has now reached approximately 7.0 billion (Gerbens-Leenes et al. 2002) and is anticipated to approach 9.5 billion by 2050. Global food requirements have also rebelled and therefore the awaited per capita food requirement is probably going to double by 2050 (Brown et al. 2009). Meanwhile, arable lands decline due to industrialization, urbanization, desertification and land degradation from heavy flooding (Jieet al. 2002). These menacing factors intimidate global food security and demand a sturdy response. Multifaceted steps have already been taken worldwide to meet the provocation of food security with tempering to improve agricultural systems. To encounter the increasing food demands, the agricultural sector is bound to use exceedingly large quantities of fertilizers that have thus far exhibited unpleasant environmental impacts. Hence, it is of chief significance to develop systems that boost production and reduce environmental issues (Chienet al. 2009). Controlled release fertilizers may be one such solution as they are believed to intensify crop yield while reducing the environmental pollution caused by the hazardous emissions (NH_3, N_2O etc.) from current fertilizer applications (Shaviv et al. 2005)**.**The use of fertilizers, including chemical fertilizers and manures, to magnify soil fertility and crop productivity has often pessimisticallyaffected the complex system of the biogeochemical cycles (Perrott et al. 1992; Steinshamn et al. 2004). The excessive use fertilizer has caused leaching and run-off of nutrients, especially nitrogen (N) and phosphorus (P), leading to environmental degradation (Tilman 1998; Gyaneshwar et al. 2002). Important reasons for these problems are low use efficiency of fertilizers and the continuous long-term use. Despite the negative environmental effects, the total amount of fertilizers used worldwide is predicted to increase with the growing world population due to the need to produce more food through intensive agriculture that requires large quantities of fertilizer (Vitousek et al. 1997; Frink et al. 1999). In the last five decades, the rate of nitrogen, phosphorus, and potassium (NPK) fertilizer application has increased tremendously. The International Fertilizer Industry Association reported that the three countries with the highest fertilizer use in 2006 were China, India, and USA, consuming 50.15, 21.65, and 20.83 million tons of NPK fertilizer, respectively, compared with consumption in 1961 of 1.01, 0.42, and 7.88 million tons, respectively (http://www.fertilizer.org/ifa). The provocation therefore is to continue agricultural productivity in a way that curtails the detrimental environmental effects of fertilizers. There are some in progress attempt along this line from different collaborator—government, scientific community, farmers, civil society, and industry. Legislation aimed at protecting the environment from nutrient run-off has been ratified by some governments, and policies based on this prescription are being applied. For example, in conformity with the Federal Clean Water Act of 1972, some US states now called for that agricultural site assessment indexes must include P source coefficients (Sharpley et al. 2003; Maynard and Hochmuth 2007) so that fertilizers, manures, and biosolids applied to agricultural soils can be appraised in accordance with their potential to escalate nutrient flee.

Soil contains an outsized number of microbial species also as other organisms that together form a highly complex ecosystem. Microorganisms are essential for nutrient recycling, healthy plant development, and decomposition of organic matter (Ahmad et al 2007). However, environmental conditions and cultivation practices are likely to influence the microbiome, leading to alterations in soil characteristics or ecosystem (Wang et al. 2011). Application of chemical fertilizers is one among the foremost adopted regimes in developing intensive agriculture nowdays (Adesemoye et al 2009; da Costa et al. 2013). However, the continual long-term use of chemical fertilizer has led to several unexpected effects. For instance, the productivity-cost doesn't scale linearly and leads to an enormous waste of natural resource. Additionally, many plenty of synthetic nutrients that are loaded to soil yearly aren't absorbed by plants. About up to 50% of N and 90% of P are reported to escape from crop fields and escape into the atmosphere or water sources, thereby causing the generation of greenhouse emission , eutrophication in aquatic system and salinization in soil (da Costa et al. 2013; Simpson et al. 2011). Besides, the excessive application of chemical fertilizer results in food safety and quality decline problems, like nitrate accumulation in vegetal products. Indeed, several studies have demonstrated that organic farming, which strictly prohibits synthetic fertilizers, provides an alternate that has the potential to attenuate the negative influence from by using chemical fertilization, and therefore the products from the organic farming systems are generally endowed with improved nutritional properties (Caris-Veyrat et al. 2004; (Luthria et al. 2010; Vallverdú-Queralt et al. 2012; Oliveira et al. 2013). for instance , the work of Caris-Veyrat et al.4 reported that organic tomatoes had higher contents of carotenoids, polyphenols and vitamin C than those from the traditional farming agriculture. However, organic farming is usually related to lower yield of crops and thus a better cost. Therefore, the utilization of chemical fertilizers isn't ready to be eliminated once a substantial food production is predicted (Adesemoye et al. 2009; Ruano-Rosa et al. 2015). Another current proposition for solving the agro-environmental problem is that the integrated nutrient management that doesn't aim to thoroughly remove synthetic fertilizers within the near future instead suggests using microbial inoculations to scale back the quantity of fertilizers applied (Adesemoye et al. 2009). Research suggests that the huge use of inorganic fertilizers world-wide is related to the buildup of contaminants, e.g. arsenic (As), cadmium (Cd), fluorine (F), lead (Pb) and mercury (Hg) in agricultural soils (Udeigwe et al. 2015). Within the USA, consistent with a survey of 51 major river basins and aquifer systems by the US Geological Survey, pesticides were detected 97% of the time in samples from stream water in agricultural areas (Gilliom et al. 2007). In Japan, pesticides were frequently detected within the air of residential environments and childcare facilities following the appliance of pesticides—this is according to the findings that outside pesticide applications are major contributors to indoor pollution in agricultural communities (Kawahara et al. 2005).

In most developing countries, the pollution caused by agricultural chemicals is even more serious (Tunstall-Pedoe et al. 2004, Tirado etal. 2008). The usage volume of fertilizers and pesticides in China has been the recorded because the highest within the world. Specifically, its chemical fertilizer usage volume has reached quite 59 million tons and pesticide quite 1.8 million tons (National Bureau of Statistics of P. R. China 2014). Alarmingly, the entire utilization rate of fertilizers and pesticides is merely ~35% (Ministry of Agriculture of P. R. China 2016), and thus, any fertilizer and pesticide losses are likely to contaminate soil, surface water and groundwater. In China, estimates indicate that contaminated arable acreage is ~150 million acres, accounting for 8.3% of the entire arable land within the nation (He CC. Food security-Century Challenge and Response 2013). Additionally, nearly half the groundwater resources are inordinately polluted by agricultural chemicals, which seriously threaten the security of beverage in China, especially in rural areas. (Rother, 2008) reports that consequences of an increased use of agricultural chemicals transcend the environment. Farmers in developing countries are experiencing, either short-term or long-term, health effects from exposures to agricultural chemicals, including severe symptoms (e.g. headaches, skin rashes, eye irritations) and a few chronic effects (e.g. cancer, endocrine disruption, birth defects).

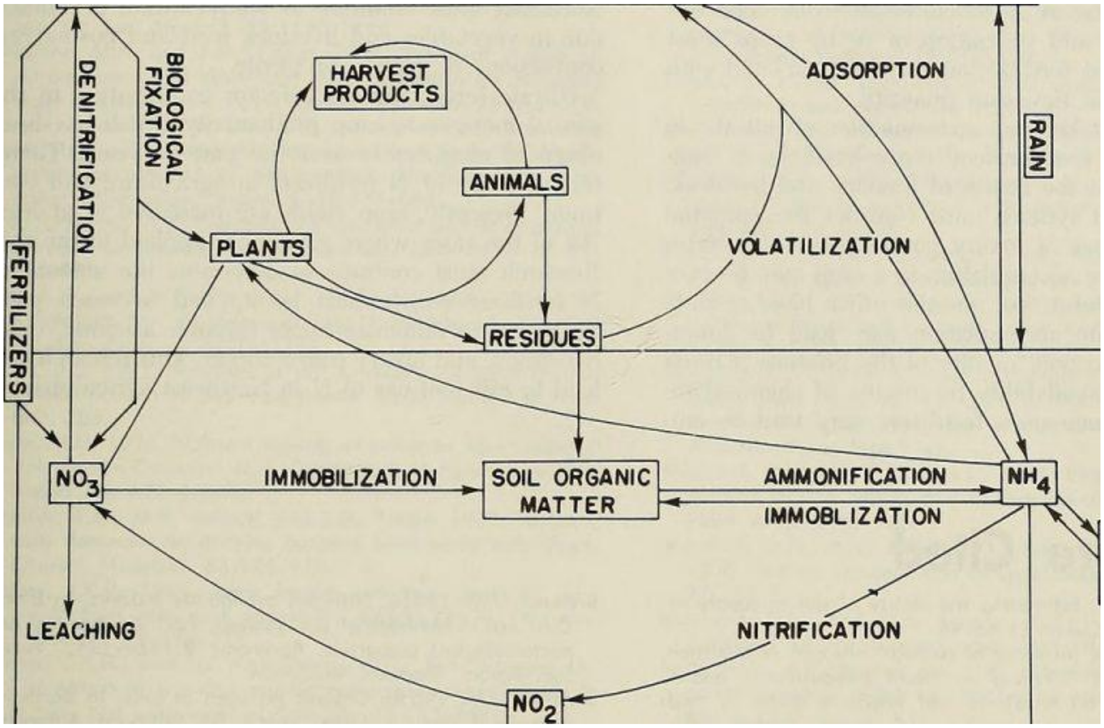

Fig: How do fertilizers affect the environment.

Policy makers recognize that the excessive and unsystematic application of agrichemical inputs, pesticides and fertilizers in particular, is an obstacle to the development of sustainable agriculture, and poses a threat to the environment and humans alike. Several countries have enacted policies to regulate the usage volume and types of agricultural chemicals (Carey et al. 1985, Gong et al. 2011). For instance, in the USA, the 1972 Federal Environmental Pesticide Control Act (FEPCA) and subsequent amendments acknowledge the negative effects of pesticide applications on both the environment and human health, regulate the use of pesticides and enforce compliance against banned pesticide products. The 2003, European Union Regulation EC No. 2003/2003 establishes that electrical conductivity fertilizers should meet a specific criteria in terms of nutrient content, safety and absence of adverse effects to the environment (Ciavatta et al. 2012). In 2015, the Chinese Ministry of Agriculture introduced the ‘Action to Achieve Zero Growth in the Application of fertilizer’ and ‘Action Plan for Zero Growth in the Application of Pesticide’, which both set specific goals, strategies, plans and relevant safeguard measures for controlling the usage of agricultural chemicals by year 2020 (Ministry of Agriculture of P. R. China

2015). In India, deposits of sufficiently enriched phosphatic rocks are limited and hence it imports 2 million tons of rock phosphate annually. About 98% of cropland in India is deficient in available forms of soil phosphorus and only 1-9% has high phosphorus status. Intensive cropping pattern during this green and white revolution has also resulted in widespread deficiency of phosphorus. Although various amendments are available for management of P in several soil, all are costlier and practically difficult. Thus, albeit the entire soil P is high and also if P fertilizers are applied regularly, pH dependent chemical fixation determines the number of obtainable P. The holistic P management involves a series of strategies involving manipulation of soil and rhizosphere processes, development of P efficient crops and improving P recycling efficiency. Microbial mediated P management is an ecofriedly and price effective approach for sustainable development of agricultural crop.

Microorganisms are an integral component of the soil P cycle and are important for the transfer of P between different pools of soil P. Phosphate Solubilzing Microorganisms (PSM) through various mechanisms of solubilization and mineralisation are ready to convert inorganic and organic soil P respectively (Khan et al. 2009a) into the bioavailable form facilitating uptake by plant roots. It is important to determine the actual mechanism of P solubilisation by PSM for optimal utilization of these microorganisms in varied field conditions. Hence it's imperative to raised understand the plant-soil-microbial P cycle with the aim of reducing reliance on chemical P fertilizers. This has led to increased interest in the harnessing of microorganisms to support P cycling in agro ecosystems.

Sustainable development of a society in general and its economy in particular is contingent upon judicious use of its natural resources (Flint 2013; Muthoo 1990). One of the greatest challenges in contemporary development initiatives is to maintain ecological balance for the present as well as the future generation (Ospina 2000; United Nations Sustainable Development 2012). This is so because the decisions on development strategies often favour achieving economic goals with less importance to the environment (Brundtland 1987; Strange and Bayley 2008). Causing anthropogenic and ecological damage, including injudicious use of natural resources, and lack of their proper management are evident during the course of development in many of the countries. More specifically, over exploitation of natural resources is a common practice in contemporary development initiatives (Diamond 1999). Hence, the approaches to development need to be interdisciplinary and holistic (Donaldson et al. 2005), particularly considering that environmental aspects cannot be seen in isolation of the socio-economic conditions (O'Brien et al. 2009).

The problem is more critical in India as the country supports approximately 16 percent of world's total human population with nearly 2.5 percent of the total geographical area (UNEP 2001) causing considerable pressure on natural resources. Steady population growth coupled with widespread incidence of poverty and inappropriate policies and management of natural resources is expected to result in excessive pressure on the country's stock of natural resources. Such pressure is estimated to be the maximum in the world by 2020 (World Bank 2008). Increasing emphasis on input intensive agricultural practices with high yielding variety seeds appear to be a critical problem in this regard as these seeds require large-scale use of chemical fertilizers and water. Constraints to bringing in more area under cultivation and deficiency of various macro and micro nutrients in soils have forced Indian farmers to use more chemical fertilizers to increase yield (Planning Commission of India 2011). This a matter of serious concern as sustained growth agricultural production and yield requires use of essential plant nutrients in right quantity, in appropriate proportion and at right time following the right methods (Jaga and Patel 2012).

Although the 'Green Revolution' technologies had considerable positive impact initially, excessive use of chemical fertilizer in the states like Punjab and Haryana has caused destruction of useful microorganisms, insects and worms in soil. This has not only disturbed soil texture and its physicochemical properties, but also caused serious damage to the sector in respect of both quantity and quality of production. For example, growth of agriculture sector in Punjab has stagnated since the 1990s (Kumar and Singh 2010) largely due to improper combination of various inputs like chemical fertilizers. There was huge demand for foods in one hand and the farmers' aspiration for high profit on the other. As a result, the farmers used unlimited ground water as well as excessive chemical fertilizers and pesticides to increase production and yield. Positive effects of chemical fertilizers on production and yield motivated the farmers further towards greater use of these inputs. The consequence of such excessive use of chemicals beyond the limit of consumption of the plants has been absorption of the same by the soil causing secondary effects to the soil itself and the plants. As it is recognized within the literature, the harmful effects of excessive application of chemical fertilizers are likely to be the following:

1. Waterways and nearby water bodies are often adversely suffering from use of excessive chemical fertilizers from chemical escape through rain water. As a result, the quantity of oxygen is reduced within the water resulting in hypertrophication to the aquatic system. The living organisms existing within the water spend the oxygen. Such depletion of oxygen can cause death of majority of aquatic organisms including fish (Harrison et al. 2002).

2. CO_2 and laughing gas, greenhouse gases, are often released within the atmosphere by over and repetitive application of nitrogenous fertilizer beyond the crop's assimilation capacity contributing to heating and erratic climate (Doll and Baranski 2011).

3. Acidification of soil can happen thanks to decrease of organic matter within the soil by excessive use of chemical fertilizers causing threats to survival of plants (Velthof et al. 2011).

4. Application of chemical fertilizers in imbalanced ratio consumes the indispensable a part of the nutrients in soil reducing the quantity of minerals and vitamins within the food items (Das et al. 2009).

During the last 50 years, there has been two remarkable landmarks concerning paradigm shift in agriculture sector — (1) successful implementation of the land reforms programmes, and (2) a really high rate of growth of the population. Potentials of land reforms towards promoting growth of the agriculture sector and simultaneous reduction of poverty has been observed in many developing countries. Since large farms are less productive and productivity is low in tenant farms (Bardhan and Mookherjee 2007), it had been expected that redistribution of land would increase production within the sector.

1.2 TECHNIQUES USED FOR THE REMOVAL OF CHEMICAL FERTILIZERS FROM ENVIRONMENT

There are various methods by which contaminated sites can be clean up and one such method is conventional technique. This system removes the contaminated soil to a landfill or covers the contaminated sites. However, this may create significant risks in the excavation, handling, and transport of hazardous material. In addition, it is expensive and very difficult method to find new landfill sites for the final disposal of material. Another technologies have also been used such as high-temperature incineration and chemical use for decomposition (e.g., base-catalyzed dechlorination and UV oxidation). These techniques can be effective in reducing level of wide range of contaminants (namely chlorinated solvents, petroleum, polynuclear aromatic hydrocarbons, ketones, PAHs, TNT, of public acceptance RDX, HMX, BTEX, inorganic nitrogen (NO3, NH4), explosives, pesticides, herbicides and heavy metals) however, this shows several demerits such as technical complexity, lack, increased contaminants exposure to site workers and nearby residents (Vidali et al. 2001). Various other physico-chemical treatments such as coagulation with alum or lime followed by adsorption on powdered activated carbon (PAC) is reported to yield high removal efficiency for phenolics and COD. These processes generate large volume of hazardous sludge and don't cause ultimate destruction of the pollutants (Mehta et al. 2009). To beat these drawbacks, a much better perspective is to completely destroy the pollutants, or to rework them into some biodegradable substances. This approach are often achieved by employing a technique referred to as bioremediation. This acts as an option to clean environment and its resources by destroying various contaminants using natural biological activity. It’s considered as safer, cleaner, cost effective and environment friendly technology which generally have a high public acceptance and can often be carried out at any site. (According to van Dillewijn et al. 2007)

1.2.1. MICROORGANISM

"Bioremediation" is defined because the process by means of varied biological agents, primarily microorganisms to degrade the environmental contaminants into less toxic forms. The first patent for a biological remediation agent was registered in 1974, using a strain of Pseudomonas putida (Prescott et al. 2002) to degrade petroleum. In 1991, about 70 microbial genera were reported to degrade petroleum compounds (US Congress Office of technology assessment; 1991) and almost an equal number has been added to the list within the successive 20 years (Kumar et al. 2011). U.S. EPA has defined bioremediation agents as microbiological cultures, enzyme and nutrient additives that significantly increase the speed of biodegradation to mitigate the effect of varied pollutants. the most advantages of bioremediation over conventional treatment includes: low cost, high efficiency, minimization of chemical and biological sludge, selectivity to specific metals, no additional nutrient requirement, regeneration of biosorbent and the possibility of metal recovery (Kratochvil et al 1998). Bioremediation can occur on its own in nature (natural attenuation or intrinsic bioremediation) or can be spurred via addition of fertilizers for the enhancement of bioavailability within the medium (biostimulation). Bioventing, bioleaching, bioreactor, bioaugmentation, composting, biostimulation, land farming, phytoremediation and rhizofiltration are all samples of bioremediation technologies (Li et al. 2011). On the idea of removal and transportation of wastes, bioremediation technology can be classified as in situ and ex situ. In situ bioremediation involves treatment of contaminated material at an equivalent site, while ex situ involves complete removal of contaminated material form one site and its transfer to another site, where it has been treated using biological agents. When both the methods have been compared, it was found that the rate of biodegradation and consistency of process outcome differs between in situ and ex situ methods. With the necessity for excavation of contaminated samples for treatment, the value of ex situ bioremediation is comparatively high as compared to in place. In situ and ex situ, both the bioremediation methods depends essentially on microbial metabolism, however, so far in place methods are preferred over ex situ for ecological restoration of contaminated soil, water and environment (Vidali et al. 2001). The main advantage of using biological sources is its ability to multiply and magnify in terms of initial inoculum as compared to physical and chemical means of treatment. The method of bioremediation depends on the metabolic potential of microorganisms to detoxify or transform the pollutant, which is further hooked in to accessibility and bioavailability (Antizar-Ladislao et al. 2008). The process of remediation can be enhanced by the addition of various microorganisms (called seeding or inoculation) to a polluted environment to promote increased rate of biodegradation. Currently, a good range of microorganisms (bacteria, archaebactreia, yeasts, fungi and algae) and plants are being studied for use in bioremediation processes.

Microbes are widely utilized in the method of environmental clean-up and are referred to as bioremediators. the method of bioremediation involve the utilization of microorganisms which are native to the contaminated sites by providing them sufficient nutrients and a few chemicals essential for their growth and development. This enables them to destroy the pollutants present in the contaminated sites (Chen et al. 2009; Kim et al. 2007). Amongst bacteria, Bacillus (Gupta et al. 2001), Pseudomonas (Jayashree et al. 2012), and Streptomyces (Selatnia et al. 2004) acts as a potent metal biosorbents.

Table 1. Examples of bacteria, archaebacteria and yeast widely used and studied in bioremediation

Organisms	**Genus/species**	**Toxic Chemicals/Elements**
Bacteria	*Arthrobacter*sp.	p-nitrophenol
	Bacillus sp.	Cu, Zn, Cd, Pb, Fe, Ni, Ag, Th, Ra and U
	*Citrobacter*sp.	U
	Cupriavidusmetallidurans	Zn and Cu
	Escherichia coli	Zn and V
	Escherichia hermannii	V and Zn
	Enterobacter cloacae	Pb, Cu, V and Cr
	Exiguobacteriumaurantiacum	phenolics, heterocyclics and (PAHs)
	Geobactermetallireducens	Fe
	Micrococcus sp.	Th and U
	Pseudomonas aeruginosa	Cd, Pb, Fe, Cu, U, Ra, Ni, Ag, Zn, Th and Atrazine
	Ralstoniaeutropha	2,4-Dichlorophenoxyacetic acid

	Streptomyces sp.	Cu, Zn, Cd, Pb, Fe, Ni, Ag, Th, Ra and U
	Zoogloearamigera	Pb, Cu and Cr
Archeabacteria	*Filo crenarchaeota*	Cd, Cu, Ni, and Zn
Yeast	*Candida utilis*	Cd
	Hansenulaanomala	Cd
	Rhodotorulamucilaginosa	Zn and Cd
	Rhodotorularubra	Hg
	Streptomyces sp.	Pb
	Saccharomyces cerevisiae	Cu, Zn, Cd, Pb, Fe, Ni, Ag, Th, Ra, U and Hg

The removal of heavy metals cations from industrial waste water or recovery of metals from their solutions are often accomplished by methods that use microorganisms as cation sorbents (Babel et al. 2003). The mechanisms of metal binding to microbial biomass is split into three types (i) intracellular accumulation (this process requires live cells), (ii) sorption or complex formation on cell surface (it takes place on both live and dead cells) and (iii) extracellular accumulationor precipitation (the process may require viable cells) (Kratochvil et al. 1998; Kujan et al. 2005). Yeasts are readily available source of biomass which shows the power to resist under unfavorable environment. Many metals and metalloids are often accumulated by yeasts and a few of them are essential for structural and catalytic functions, whereas others are of no metabolic importance (Chatterjee et al. 2011). Yeasts also are known for dye decolourization of food industry effluents mainly by three mechanisms like biosorption, bioaccumulation and biodegradation. The removing mechanisms of dyes color from industrial effluents, by yeast cells are either through absorbtion or adsorbtion at the cell surface (Donmez et al. 2002).

1.2.2. ALGAE AND FUNGI

Algae and fungi plays important role in returning the environment to its original state altered by various contaminants. The method of phycoremediation is defined because the use of algae to get rid of pollutants from the environment or to convert them into harmless form. Phycoremediation during a much broader sense is that the use of micro or macroalgae for the removal or biotransformation of pollutants, including nutrients and xenobiotics from wastewater and CO2 from air. Algae are highly adaptive and may grow autotrophically, heterotrophically or mixotrophically in any environment. In natural environments, algae play a serious role in controlling metal concentration of lakes and oceans. It possess the power to degrade or accumulate toxic heavy metals and organic pollutants like phenolics, hydrocarbons, pesticides and biphenyls from the environment, leading to higher concentrations within themselves as compared to surrounding water (Shamsuddoha et al. 2006). Pollutant degrading mixotrophic algae are excellent agents for remediation and carbon sequestration (Subashchandrabose et al. 2013). An alga fixes CO_2 and produce O_2 by the method of photosynthesis and increases BOD level in contaminated water alongside the efficient removal of more than nutrients (Fathi et al. 2013). Algae plays important role in pH correction, sludge removal and TDs reduction, whereas inconventional treatment, separate methods or stages are required. Amongst algae, blue chlorophyte or cyanobacteria are vulnerable to various physical and chemical alterations of sunshine, salinity, temperature and nutrient composition. Recently, there has been increasing worldwide interest in using cyanobacteria as an economic and low-maintenance remediation technology for contaminated and polluted sites. Cyanobacteria are used efficiently for remediating dairy waste water by converting the dissolved nutrients into biomass. However, the beneficial application of cyanobacteria in bioremediation of contaminated waters, either natural aquatic environments or industrial effluents.

Table 2. Examples of algae and fungi widely used and studied in bioremediation

Organisms	**Genus/species**	**Toxic chemicals/elements**
Algae	*Ascophyllumnodosum*	Pb, Cu and Cr
	Anabaena inaequalis	Cr
	Chlorella vulgaris	Cd, Ag, Cu, Th, Zn, Pb, Ni, Ra, Fe and U
	Cladophoraglomerata	Cu, Pb, Cd, Cr, Ni, Fe, Zn, Mn, Sr and Cs
	Cyanobacteria	Pb, Hg and Cd
	*Nostoc*sp.	Hg, Pb , Cd and Gammahexachlorocyclohexane
	Oedogoniumrivulare	Cr, Ni, Zn, Fe, Mn Cu, Pb, Cd and Co
	*Oscillatoria*spp.	Cu, Pb, Cd and Co
	*Sargassum*spp.	Pb, U, Cd, Ni, Zn, Cu and Cr
	Scenedesmusobliquus	Cd and Zn

	Spirogyra spp.	Ni, Cr, Fe and Mn
	*Spirulina*spp.	Pb and Cd
Fungi	*Aspergillustereus*	Cr
	Aspergillusniger	Pb, Zn, Cd, Cr, Cu, Ni and Chlorpyrifos
	Funaliatrogii	Hg, Cd and Zn
	Ganodermalucidumk	Cr and Cu
	Penicilliumchrysogenum	Pb, Fe, Ni, Ra, Th, U, Cu, Zn, Ag, and Cd
	Phanerochaetechrysosporium	2,4-dicholorophenol
	Pleurotusostreatus	PAHs and Orange 3, 4-(4-nitrophenylazo) aniline
	*Rhizopus*sp.	Cr

Another sort of bioremediation is mycoremediation which uses fungal mycelium to decontaminate or filter the toxic industrial waste from contaminated area. The fungal mycelia secrete various extracellular enzymes and acids that break down the lignin and cellulose. The key to mycoremediation is to work out the proper fungal species to focus on a selected pollutant. Fungi (Ligninolytic fungi) like the white rot fungus PhanaerochaetechrysosporiumandPolyporus sp. are promising candidates for bioremediation, because it shows the power to degrade a particularly diverse range of persistent or toxic environmental pollutants like petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), explosives, polychlorinated biphenyls (PCBs), and organochlorine pesticides(Wu et al. 2007; Ayu et al. 2011).

2. CONCLUSION

Bioremediation is taken into account to be very safe and helpful technology because it relies on microbes that occur naturally within the soil and pose no threat to environment and therefore the people living therein area. The method of bioremediation is often easily administered on site without causing a serious disruption of normal activities and threats to human and environment during transportation. Bioremediation is a smaller amount expensive than other technologies that are used for clean-up of hazardous waste. Albeit various sources of bioremediation like bacteria, archaebacteria, yeasts, fungi, algae and plants are available but, the biological treatment alone isn't sufficient enough to treat the pollutants or contaminated sites. Every biological forms features a different growth requirements (temperature, pH and nutrients) so we'd like to isolate those forms, which may culture easily within the lab, with minimal requirement and may be useful in treating sort of pollutants. As natural resources are major assets to humans their contamination resulted in future effects of pollution (noise and radiation), heating, ozone depletion and greenhouse gases. The decontamination of those natural resources is important for the conservation of nature and environment using bioremediation process. Thus, there's an urgent got to study the effect of varied microorganisms together against various pollutants for the conservation of natural resources and environment management.

3. References

- A. Shaviv, Controlled release fertilizers, IFA International Workshop on Enhanced-Efficiency Fertilizers, Frankfurt, International Fertilizer Industry Association, Paris, France, 2005.
- Ahmad R, Jilani G, Arshad M, Zahir ZA, Khalid A. Bio-conversion of organic wastes for their recycling in agriculture: an overview of perspectives and prospects. Ann Microbiol. 2007; 57:471–479.
- Altomare C, Norvell WA, Bjorkman T, Harman GE (1999) Solubilization of phosphates and micronutrients by the plant growth-promoting and biocontrol fungus TrichodermaharzianumRifai 1295–22. Appl Environ Microbiol 65:2926–2933
- Antizar-Ladislao B, Spanova K, Beck AJ, Russell NJ. Microbial community structure changes during bioremediation of PAHs in an aged coal-tar contaminated soil by invessel composting. IntBiodeteriorBiodegrad. 2008;61:357-364.
- Aseri GK, Jain N, Panwar J, Rao AV, Meghwal PR (2008) Biofertilizers improve plant growth, fruit yield, nutrition, metabolism and rhizosphere enzyme activities of pomegranate (Punicagranatum L.) in Indian Thar Desert. SciHortic 117:130–135
- Ayu KR, Tony H, Tadashi T, Yasuhiro T, Kazuhiro M. Bioremediation of crude oil by white rot fungi *Polyporus*sp. S133. J MicrobiolBiotechnol. 2011;21(9):995-1000.
- Babel S, Kurniawan TA. Low-cost adsorbents for heavy metals uptake from contaminated water: a review. J Hazard Mat. 2003;97:219-243.
- Bakker PAHM, Raaijmakers JM, Bloemberg GV, Hofte M, Lemanceau P, Cooke M (2007) New perspectives and approaches in plant growth-promoting rhizobacteria research. Eur J Plant Pathol 119:241–242
- Bardhan P, Mookherjee D (2007) Land reform and farm productivity in West Bengal. Unpublished manuscript, Boston University

- Barea JM, Azcon R, Azcon-Aguilar C (2002) Mycorrhizosphere interactions to improve plant fitness and soil quality. Antonie van Leeuwenhoek 81:343–351 BiochemEng J. 2004;19:127-135.
- Biswas JC, Ladha JK, Dazzo FB (2000) Rhizobia inoculation improves nutrient uptake and growth of lowland rice. Soil SciSoc Am J 64:1644–1650
- Brundtland GH (1987). Report of the world commission on environment and development: Our common future. United Nations
- C. Jie, et al., Soil degradation: a global problem endangering sustainable development, J. Geogr. Sci. 12 (2) (2002) 243–252.
- Canbolat MY, Bilen S, Cakmakci R, Sahin F, Aydin A (2006) Effect of plant growth-promoting bacteria and soil compaction on barley seedling growth, nutrient uptake, soil properties and rhizospheremicroflora. BiolFertil Soils 42:350–357
- Carey AE, Kutz FW. Trends in ambient concentrations of agrochemicals in humans and the environment of the United States. *Environ Monit Assess* 1985;5:155–63.
- Caris-Veyrat, C. *et al*. Influence of organic versus conventional agricultural practice on the antioxidant microconstituent content of tomatoes and derived purees; consequences on antioxidant plasma status in humans. *Journal of Agricultural and Food Chemistry* **52**, 6503–6509 (2004).
- Chatterjee S, Gupta D, Roy P, Chatterjee NC, Saha P, Dutta, S. Study of a lead tolerant yeast strain BUSCY1 (MTCC9315). Afr J Microbiol Res. 2011;5:5362-5372.
- Chen J, Shiyab S, Han FX, Monts DL, Waggoner CA. Bioaccumulation and physiological effects of mercury in *Pterisvittata*and *Nephrolepisexaltata*. Ecotoxicol. 2009;18:110-121.
- Ciavatta C, Manoli C, Cavani L, et al. .Chromium-containing organic fertilizers from tanned hides and skins: a review on chemical, environmental, agronomical and legislative aspects. *J Environ Prot*2012;03:1532–41.
- da Costa, P. B. *et al*. The effects of different fertilization conditions on bacterial plant growth promoting traits: guidelines for directed bacterial prospection and testing. *Plant and Soil* **368**, 267–280 (2013).
- Das A, Munda GC, Patel DP (2009) Technological options for improving nutrient and water use efficiency. ICAR Research Complex for NEH Region, Umiam-793103,Meghalaya. Retrieved from http://www.kiran.nic.in/pdf/publications/Water_Use_Efficiency.pdf. Accessed 20 Dec 2014
- Diamond JM (1999) Guns, germs and steel: the fate of human societies. Norton, New York
- Dobbelaere S, Croonenborghs A, Thys A, Ptacek D, Vanderleyden J, Dutto P, Labandera-Gonzalez C, Caballero-Mellado J, Anguirre JF, Kapulnik Y, Brener S, Burdman S, Kadouri D, Sarig S, Okon Y (2001)

Response of agronomically important crops to inoculation with Azospirillum. Aust J Plant Physiol 28:871–879

- Doll JE, Baranski M (2011) Field crop agriculture and climate change. Climate change and agriculture fact sheet series E3149, Michigan State University Extension, East Lansing
- Donaldson A, Heathwaite L, Lane S, Ward N, Whatmore S (2005) Holistic approaches to understanding diffuse land management issues: a framework for interdisciplinary working. Centre for Rural Economy Discussion Paper Series 2, Centre for Rural Economy, University of Newcastle, Tyne, pp 1–14
- Donmez G. Bioaccumulation of the reactive textile dyes by *Candida tropicalis*growing in molasses medium. Enzyme Microb Technol. 2002;20:363-366.
- Fathi AA, Azooz MM, Al-Fredan MA. Phycoremediation and the potential of sustainable algal biofuel production using wastewater. Am J Appl Sci. 2013;10(2):189-194.
- Flint RW (2013) Basics of sustainable development. In practice of sustainable community development. Springer, New York, pp 25–54
- Frink CR, Waggoner PE, Ausubel JH (1999) Nitrogen fertilizer: retrospect and prospect. ProcNatlAcadSci 96:1175–1180
- Gilliom RJ. Pesticides in U.S. streams and groundwater. *Environ SciTechnol*2007;41:3408–14
- Glick BR, Todorovic B, Czarny J, Cheng Z, Duan J, McConkey B (2007) Promotion of plant growth by bacterial ACC deaminase. Crit Rev Plant Sci 26:227–242
- Gong P, Liang L, Zhang Q. China must reduce fertilizer use too. *Nature* 2011;473:284–5.
- Gupta VK, Shrivastava AK, Jain N. Biosorption of chromium (VI) from aqueous solutions by green algae *Spirogyra* species. Water Res. 2001;35(17):4079-4085.
- Gyaneshwar P, Kumar GN, Parekh LJ, Poole PS (2002) Role of soil microorganisms in improving P nutrition of plants. Plant Soil 245:83–93
- Harrison P, Bruinsma J, de Haen H, Alexandratos N, Schmidhuber (2002). World agriculture: towards 2015/2030. Retrieved from http://www.fao.org/docrep/004/y3557e/y3557e11.htm. Accessed 11 Jan 2015
- He CC. *Food security-Century Challenge and Response*. Social Science Academic Press, 2013.
- Jaga PK, Patel Y (2012) An overview of fertilizers consumption in India: determinants and outlook for 2020-a review. Inter J ScientiEngTechnol 1(6):285–291
- Jayashree R, Nithya SE, Rajesh PP, Krishnaraju M. Biodegradation capability of bacterial species isolated from oil contaminated soil. J Academia Indust Res. 2012;1(3):140-143.

- Kawahara J, Horikoshi R, Yamaguchi T, et al. . Air pollution and young children's inhalation exposure to organophosphorus pesticide in an agricultural community in Japan. *Environ Int*2005;31:1123–32.
- Kennedy IR, Pereg-Gerk LL, Wood C, Deaker R, Gilchrist K, Katupitiya S (1997) Biological nitrogen fixation in nonleguminous field crops: facilitating the evolution of an effective association between Azospirillum and wheat. Plant Soil 194:65–79
- Khan AA, Jilani G, Akhtar MS, Naqvi SMS, Rasheed M: Phosphorus solubilizing bacteria: occurrence, mechanisms and their role in crop production. *J AgricBiolSci* 2009, 1(1):48-58.
- Kim SU, Cheong YH, Seo DC, Hu JS, Heo JS, Cho JS. Characterisation of heavy metal tolerance and biosorption capacity of bacterium strain CPB4 (*Bacillus* spp.). Water Sci Technol. 2007;55(1):105-111.
- Kratochvil D, Volesky B. Advances in the biosorption of heavy metals. Trends in Biotechnol. 1998;16:291-300.
- Kratochvil D, Volesky B. Advances in the biosorption of heavy metals. Trends in Biotechnol. 1998;16:291-300.
- Kujan P, Prell A, Šafa H, Sobotka M, Ezanka T, Holler P. Removal of copper ions from dilute solutions by *Streptomyces noursei*mycelium. Comparison with yeast biomass. Folia Microbiol. 2005;50:309-314.
- Kumar A, Bisht BS, Joshi VD, Dhewa T. Review on bioremediation of polluted environment: a management tool. Int J Environ Sci. 2011;1:1079-1093.
- Kumar S, Singh P (2010) Inclusive agricultural growth: district-wise agricultural productivity analysis in Punjab. In: Proceedings of National Workshop on Inclusive Agricultural Growth: Regional Perspective, pp 21–51
- Li Y, Li B. Study on fungi-bacteria consortium bioremediation of petroleum contaminated mangrove sediments amended with mixed biosurfactants. Adv Mat Res. 2011;183:1163-1167.
- Lucy M, Reed E, Glick BR (2004) Application of free living plant growth-promoting rhizobacteria. Antonie van Leeuwenhoek 86:1–25
- Luthria, D. *et al*. Influence of conventional and organic agricultural practices on the phenolic content in eggplant pulp: Plant-to-plant variation. *Food Chemistry* **121**, 406–411 (2010).
- M.E. Brown, B. Hintermann, N. Higgins, Markets, climate change, and food security in West Africa, Environ. Sci. Technol. 43 (21) (2009) 8016–8020.
- Malakoff D (1998) Coastal ecology: death by suffocation in the Gulf of Mexico. Science 281:190–192
- Maynard DN, Hochmuth GJ (2007) Knott's handbook for vegetable growers, 5th edn. Wiley, Hoboken, New Jersey, pp 65–68, 92– 101

- Mehta V, Chavan A. Physico-chemical treatment of tar-containing wastewater generated from biomass gasification plants. World AcadSciEng Technol. 2009;57:161-168.
- Mills HA, Jones JB (1996) Plant analysis handbook II: a practical sampling, preparation, analysis, and interpretation guide. Micromacro Publishing, Athens, Georgia, USA, pp. 6-18, 69, 81.
- Ministry of Agriculture of P. R. China. *Notice of the Ministry of Agriculture on Printing and Distributing the Action Plan for Zero-growth of Chemical Fertilizer Use to 2020 and the Action Plan for Zero-growth of Pesticide Use to 2020*. Ministry of Agriculture, 2015. http://www.moa.gov.cn/zwllm/tzgg/tz/201503/t20150318_4444765.htm.
- Ministry of Agriculture of P. R. China. *Trends of Agricultural Science and Education: Key Period Report about Controlling Agricultural Non - point Source Pollution*. Ministry of Agriculture of P. R. China, 2016. http://www.moa.gov.cn/ztzl/mywrfz/jbxx/201604/t20160419_5098842.htm.
- Muthoo MK (1990) Economic considerations and environmental policy implications in the management of renewable natural resources. Unasylva 41(163):50–57
- National Bureau of Statistics of P. R. China. *China statistical yearbook 2013*. China Statistics Press, 2014.
- O'Brien K, Hayward B, Berkes F (2009) Rethinking social contracts: building resilience in a changing climate. EcolSoc 14(2):12
- Oliveira, A. B. *et al*. The impact of organic farming on quality of tomatoes is associated to increased oxidative stress during fruit development. *PLoS ONE* **8**, e56354 (2013).
- Ospina GL (2000) Education for sustainable development: a local and international challenge. Prospects 30(1):31–40
- P. Gerbens-Leenes, S. Nonhebel, W. Ivens, A method to determine land requirements relating to food consumption patterns, Agric. Ecosyst. Environ. 90 (1) (2002) 47–58.
- Perrott KW, Sarathchandra SU, Dow BW (1992) Seasonal and fertilizer effects on the organic cycle and microbial biomass in a hill country soil under pasture. Austr J Soil Res 30:383–394
- Planning Commission of India (2011) Crop husbandry, agricultural inputs, demand and supply projections and agricultural statistics for the Twelfth Five Year Plan (2012–2017). Retrieved from http://planningcommission.nic.in/aboutus/committee/wrkgrp12/agri/crop_husbandry.pdf. Accessed 25 Dec 2014
- Prescott LM, Harley JP, Klein DA. Microbiology. 5th ed. pp. 1014, McGraw-Hill, New York; 2002.988
- Rodriguez H, Fraga R (1999) Phosphate solubilizing bacteria and their role in plant growth promotion. BiotechnolAdv 17:319–339

- Rother HA. South African farm workers' interpretation of risk assessment data expressed as pictograms on pesticide labels. *Environ Res* 2008;108:419–27.
- Ruano-Rosa D. & Mercado-Blanco J. Combining Biocontrol Agents and Organics Amendments to Manage Soil-Borne Phytopathogens. In: Meghvansi M., Varma A. (eds) Organic Amendments and Soil Suppressiveness in Plant Disease Management. *Soil Biology*, vol **46**. Springer, Cham (2015).
- S. Chien, L. Prochnow, H. Cantarella, Recent developments of fertilizer production and use to improve nutrient efficiency and minimize environmental impacts, Adv. Agron. 102 (2009) 267–322.
- Saubidet MI, Fatta N, Barneix AJ (2002) The effect of inoculation with Azospirillumbrasilense on growth and nitrogen utilization by wheat plants. Plant Soil 245:215–222
- Selatnia A, Boukazoula A, Kechid BN, Bakhti MZ, Chergui A, Kerchich Y. Biosorption of lead (II) from aqueous solution by a bacterial dead *Streptomyces rimosus*biomass.
- Shaharooma B, Naveed M, Arshad M, Zahir ZA (2008) Fertilizerdependent efficiency of Pseudomonads for improving growth, yield, and nutrient use efficiency of wheat (Triticumaestivum L.). ApplMicrobiolBiotechnol 79:147–155
- Shamsuddoha ASM, Bulbul A, Huq SMI. Accumulation of arsenic in green algae and its subsequent transfer to the soil-plant system. Bangladesh J Med Microbiology. 2006;22(2):148-151.
- Sharpley AN, Weld JL, Beegle DB, Kleiman PJA, Gburek WJ, Moore PA Jr, Mullins G (2003) Development of phosphorus indices for nutrient management planning strategies in the United States. J Soil Water Conser 58:137–152
- Simpson, R. J. *et al*. Strategies and agronomic interventions to improve the phosphorus-use efficiency of farming systems. *Plant and Soil* **349**, 89–120 (2011).
- Steinshamn H, Thuen E, Bleken MA, Brenoe UT, Ekerholt G, Yri C (2004) Utilization of nitrogen (N) and phosphorus (P) in an organic dairy farming system in Norway. AgricEcosys Environ 104:509–522
- Strange T, Bayley A (2008) Sustainable development: linking economy, society, environment. OECD, Paris **OECD Insights**
- Subashchandrabose SR, Ramakrishnan B, Megharaj M, Venkateswarlu K, Naidu RR. Mixotrophic cyanobacteria and microalgae as distinctive biological agents for organic pollutant degradation. Environ Int. 2013;51:59-72.
- Tilman D (1998) The greening of the green revolution. Nature 396:211–212

- Tirado R, Englande AJ, Promakasikorn L, et al. . Use of agrochemicals in Thailand and its consequences for the environment. *Green Piece Research Laboratories Technical Note*. 2008 http://www.greenpeace.to/publications/GPSEA_agrochemical-use-in-thailand.pdf.
- Tunstall-Pedoe H, Woodward M, Tavendale R, et al. . Pesticide pollution remains severe after cleanup of a stockpile of obsolete pesticides at Vikuge, Tanzania. *Ambio A J Hum Environ* 2004;33:503–8.
- Udeigwe TK, TebohJM, EzePN, et al. .Implications of leading crop production practices on environmental quality and human health. *J Environ Manage* 2015;151:267–79.
- UNEP (United Nations Environment Program) (2001) State of the environment, India 2001. Retrieved from http://www.envfor.nic.in/sites/default/files/soer/2001/ind_land.pdf. Accessed 26 Jan 2015
- United Nations Sustainable Development (2012) The future we want. United Nations General Assembly, Sixty-sixth session, Agenda item 19
- US Congress Office of technology assessment, bioremediation for marine oil spillsbackground paper, OTA-BP-O-70 (Washington, DC: U.S. Government Printing Office);1991.
- Vallverdú-Queralt, A., Medina-Remón, A., Casals-Ribes, I. &Lamuela-Raventos, R. M. Is there any difference between the phenolic content of organic and conventional tomato juices? *Food Chemistry* **130**, 222–227 (2012).
- Van Dillewijn P, Caballero A, Paz JA, Gonzalez-Perez, MM, Oliva JM, Ramos JL. Bioremediation of 2,4,6 trinitrotoluene under field conditions. Environ Sci Technol. 2007;41:1378-1383.
- Velthof G, Barot S, Bloem J, Butterbach-Bahl K, Vries W, Kros H (2011) Nitrogen as a threat to European soil quality. Eur Nitrogen Assess Sour Eff Policy Perspect Chap 21:495–509
- Vidali M. Bioremediation-An overview. Pure Appl Chem. 2001;73(7):1163-1172.
- Vitousek PM, Aber JD, Howarth RW, Likens GE, Matson PA, Schindler DW, Schlesinger WH, Tilman DG (1997) Technical report: human alteration of the global nitrogen cycle: sources and consequences. EcolAppl 7:737–750
- Wang W, Niu J, Zhou X, Wang Y. Long-term change in land management from subtropical wetland to paddy field shifts soil microbial community structure as determined by PLFA and T-RFLP. Pol J Ecol. 2011; 59:37–44.Adesemoye, A. O. &Kloepper, J. W. Plant–microbes interactions in enhanced fertilizer-use efficiency. *Applied Microbiology and Biotechnology* **85**, 1–12 (2009)
- World Bank (2008) India-a new way of cultivating rice. Retrieved from http://web.worldbank.org/archive/website01291/WEB/0__C-712.HTM. Accessed 10 Mar 2015

- Wu J, Yu HQ. Biosorption of 2,4-dichlorophenol by immobilized white-rot fungus *Phanerochaetechrysosporiyum*from aqueous solutions. Bioresour Technol. 2007;98(2):253-259.
- Wu SC, Cao ZH, Li ZG, Cheung KC, Wong MH (2005) Effects of biofertilizer containing N-fixer, P and K solubilizers and AM fungi on maize growth: a greenhouse trial. Geoderma 125:155– 166