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RESEARCH ARTICLE

A REVIEW:PHYTOREMEDIATION: USING AQUATIC PLANTS TO CLEAN UP POLLUTED WATER

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ABSTRACT

Overpopulation, industrialization and urbanization is main cause of degradation of natural resources. Environment is polluted continuously with heavy metals and organic pollutants which become serious problem because it threatens the living organisms. Different techniques are used for remediation of polluted water which are expensive and also has negative impact on ecosystem. Phytoremediation is cost effective, economically viable and environment friendly. The aquatic saprophytes such as water hyacinth, duck weed and butterfly ferns are hyper accumulator and produce greater biomass and can be used for water treatment. These can accumulate As, Ni, Cu, Pb, Zn, Hg and Cr and can be used to accumulate, detoxify and immobilize pollutants from waste water.

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INTRODUCTION

Now a days the pollution and shortage of water become environmental problem. Water become polluted both by natural as well as anthropogenic activities, natural sources include soil erosion, urban runoff and volcanic activities while human factors include textile industries, electroplating, nuclear power plant, refining and many other factors. (Akpor *et al*., 2014) Chemical and physical methods used for water treatment are highly cost effective. So environmental friendly and economic alternate methods are used for this purpose which include phytoremediation. Many aquatic and wetland plants have ability of phytoremediation and phytofiltration (Wang *et al*., 2002). Phytoremediation is process by which aquatic plant enhance water quality by accumulating heavy metals and transferring them into their biomass (Kathleen and deaner 2001). From polluted water heavy metals are accumulated into plants by rhizofiltration (Lone, 2008).

Heavy metals

Any metal that cannot be degraded biologically and causes many environmental problems are called heavy metals. Heavy metals occur as natural constituent of earth crust. To reduce the heavy metals toxicity and their removal from contaminated and soil is important for protection of environment (Hemasharma 2014; Duruibe, 2007). From fertilizers and industrial waste heavy metals enter into the environment which threat the nature because they accumulate at high levels. Heavy metal pollution become global problem. Approximately 20 metals are considered as toxic which threatens the human health. Zn, Pb, Co, Cd, Fe and Cr are most common heavy metals which are toxic even at low concentration and abundantly present in in waste water (Singh *et al*., 2012). Heavy metals enter into the human body through direct ingestion of soil, using vegetables grown in contaminated soil and dust inhalation (Roozbahani *et al*., 2015)

Phytoremediation

phytoremediation is the use of plants to degrade, transfer or remove the pollutants and heavy metals from soil and water. In this technology living organisms including microorganisms and plants are used to remove, detoxify or reduce the harmful product from the environment (Parmer and Singh 2015). Substances which are subjected to phytoremediation include heavy metals (Zn, Ni, Cu, Hg and Cd), radioactive chemical elements (Sr, Cs, U), pesticides, herbicides, petroleum hydrocarbons (BTEX) and industrial organic waste (Favas *et al*., 2014). It is cost effective, nondestructive, environment friendly and solar energy driven technology to clean up the environment. (Etim 2012)

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Table 1. Sources and effect of heavy metals on human health

Heavy metals	Natural sources	Anthropogenic sources	Effects on human health	References
Lead (Pb)	Volcanic eruption	Mining operation, combustion, smelting, industrial products, lead paints, lead piping and lead batteries, plumbing	Lead is absorbed into blood stream and cause many diseases such as anemia, nephritic syndrome, kidney problem and hepatitis	Mudgal *et al*., 2010, Tong *et al*., 2000, Durube *et al*., 2007
Arsenic (As)	Volcanic activities,	Smelting of metals, pesticides, combustion of low grade coal,	Inhibit the production of ATP, cause anti immune syndrome	Zirmacki, 1998, Durube *et al*., 2007
Cadmium (Cd)	Volcanic eruption	Metal electroplating, steel industry, application of phosphate fertilizer, refining, smelting,	Chest pain, bone defects (osteoporosis), increased blood pressure and renal dysfunction	Durube *et al*., 2007, Mudgal *et al*., 2010
Zinc (Zn)	Geothermal sources.	Mining, smelting, electroplating industry,	Bloody urine, diarrhea, bloody, anemia, kidney and liver failure.	Durube *et al*., 2007, Mudgal *et al*., 2010
Mercury (Hg)	Volcanoes, geothermal sources, peat and wood burning, emission from industries.	Burning of biomass, caustic soda production plant, medical and industrial waste, cement plant, ferrous and non ferrous metal manufacturing	Spontaneous abortion, Neurological disorder, cause damage to CNS and brain, gingivitis	Pirrone *et al*., 2010, Durube *et al*., 2007
Nikle (Ni)	Forest fire, seasalt, vegetation exudates, volcanic eruption,	Industrial waste material, fertilizer, lime, asbestos mining and milling	Asthma, irritation of nasal membrane, pneumoconiosis	Lone *et al*., 2008

Mechanism of Phytoremediation

There are different mechanisms through which plants uptake and accumulate heavy metals. Which are as follows:

1: Phytoextraction: In this mechanism the plant uptake contaminants by roots and then translocate theses contaminants to plant tissues (Singh *et al*., 2014). It is also known as phytoaccumulation, phytosequestration and phytoabsorption, and phytoabsorption. There is higher concentration of contaminants in roots than shoot. (Bruce E. Pivetz, 2001). In this strategy plant absorb contaminant and store in harvestable part of root or shoot system. (Oh *et al*., 2014)

2: Phytosatbilization: It is also known as in place inactivation. It is used for remediation of sediments, soil and sludge and sediments. This process reduces the bio availability of heavy metals into food chain by reducing their migration and mobility to ground water. Phytostabilization can occur through the precipitation, sorption and complexation. It is used for treatment of (Pb, Cd, As, Cu, Cr and Zn). In phytostabilization roots and root exudates prevent the spreading and leaching of contaminants by immobilizing the contaminant through accumulation, adsorption and precipitation of contaminats within root zone. It reduces and stop mobilization of contaminants and limit their diffusion. (Ohetal 2014, Singh *et al*., 2014)

3: Rhizofiltration: This mechanism is used to cleanup extracted ground water, waste water and surface water having low concentration of contaminants (Ensley, 2000). This technique can be used for Cu, Zn, Pb, Ni and Cr. These metals are primarily retained within plant roots (Jadia and Fulekar 2009). In this technique plants remain in hydroponic system and contaminants are filtered by roots (Parmer and Singh 2015). In this technique both land and aquatic plants are used to concentrate, sorb and precipitate pollutants from waste water. (Akporetal 2014)

4: Phytovolatilization: In this technique some metals such as Hg, As and Se are absorbed by the roots, converted into nontoxic form and released into environment (Favas *et al*., 2014). The plants that have ability to evapotranspirate contaminant and volatile hydrocarbons are used for Phytovolatilization. This technique has some limitations because pollutants are not completely eliminated from environment but only transfer from soil to atmosphere from where it can again be redeposit (Parmer and Singh 2015). The main advantage of this technique is that it converts pollutants from their highly toxic form into less toxic form. (Etim 2012)

5: Phytodegradation: It is also known as phytotrans formation because in this technique pollutants or complex are broken down into simple compounds and then transferred into plant tissue (Etim 2012). In this technique plants and micro organisms that are associated with plants degrade the pollutants. (Luqmanetal 2013)

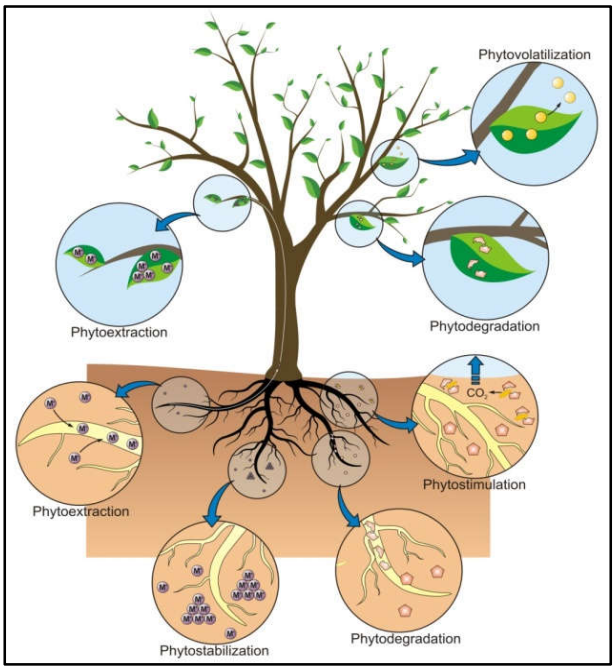

Fig.1. Schematic representation of mechanisms of Phytoremediation

Table 2. Uptake of trace elements by aquatic plants

Scientific name	Botanical name	Heavy metals uptake	References
Esthwaite waterweed	Hydrillaverticillata	As, Pb, Zn, Cr	Lee *et al*. (1991) and Dixit and Dhote (2010)
Star duckweed	Lemnatrisulca L.	Zn	
Water hyacinth	Eichhorniacrassipes	Fe, Cu, Zn, Pb, Cd, Cr, Ni, Hg, Pb	Hg Wolverton and McDonald (1978), Muramoto and Oki (1983), OCHEKWU *et al*. 2013
Butterfly fern	Salviniarotundifolia	Pb(ll)	Banerjee and Sarker (1997) and Dhir (2009)
Butterfly fern	Salvinianatans	As, Ni, Cu, Hg(II)	Sen and Bhattacharyya (1993), and Rahman *et al*. (2008c)

Plants having phytoremediation ability

Aquatic plants are widely used to remediate polluted water because they accumulate heavy metal. Azollafiliculoides is commonly known as red fern or large mosquito fern which is dark green to raddish fern and float on the surface of water. Azolla has symbiotic relationship with algae (Khosravi 2005). It is heterosporous floating fern. It can be handled easily and used for cleaning the industrial and synthetic waste water because it can accumulate Pb(II) and also reduces the organic matter (Banerjee and sarker 1997). Salvinianants is free floating fern havinf no true roots. Leaves are brown and dissected which are submerged and perform the function of roots. It rapidly grow in stagnant and nutrient rich water and used for waste water treatment (Jampeetonga and Brix, 2009). Eichhorniacrassipes. L have significant socio economic and ecological effect. It is used for the production of biogass, water purification, fertilizer, animal fodder and fireboard (Tham 2012). It has great tolerance to pollution (Rahman and Hasegawa 2011). Due to presence of fibrous root system and large biomass it can accumulate heavy metals more effectively so used for the treatment of polluted water (Lone *et al*., 2008). Pistiastratiotes which is commonly known as water lettuce and JalKumbhi and belongs to family Araceae. It is perenial free floating plant abundantly present in subtropical and tropical regions. It is widely used for the treatment of heavy metals (Farnese *et al*., 2013). It also has great medicinal value and used for the treatment of many diseases and infections. It also had ability to remove heany metals and neutrients from drainage ditches and sewage sludge. This free floating plant is used as fertilizer, in medicines and phytoremediation (Khan *et al*., 2014). Duck weed is small angiosperm plant having no distinct leaves and stem and float freely on the surface of water. It belongs to family Lemnaceae. The plant body appears small leaf like structure known as frond having one or two roots. It has great potential to accumulate heavy metals than other aquatic plants (Chaudhary and Sharma 2014; Rahman and Hasegawa 2011). Duck weed can accumulate high concentration of Cu, Cd and Se but poor accumulator of Pb and Ni. (Lone *et al*., 2008)

Conclusion

This review was based on discussing the sources and impact of heavy metals on human health. Entrance of heavy metals to waste water had adverse impact on life and health of humans and animals due to their toxicity. Long term and cheaper technologies are required to protect the environment and our natural resources. Phytoremediation is environment friendly technology that uses green plants to clean up the contaminated environment. In phytoremediation plants reduce, degrade, break down and remove contaminants from waste water and make it able to use by using their different parts such as roots, leaves, cell wall, shoot and stomata. The commonest phytoremediation processes are phytodegradation, rhizofiltration, Phytoextraction, phytostabilization, rhizodegradation and phytovolitazation.

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