Phytoremdiation Species And Their Modification Under By Weed Varying Climatic Condition: A Changing Scenario

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Abstract: The major reasons for environmental contamination are population explosion, increase in industrial and other urban activities. One of the consequent effect of these activities is heavy metal pollution. It is one of the serious issue to be discussed by the scientists and academicians that how to solve this problem to protect the environment. As heavy metals are non-biodegradable so they require effective cleanup technology. Most of the traditional methods such as excavation, solidification and burial are very costly or they simply involve the isolation of the metals from contaminated sites. Among different technologies, phytoremediation is best approach for removing metal contamination from environment. It involves plants to remove, detoxify or immobilize metals from environment. Weed plants are found to be play very important role in metal remediation. They get affected by climatic variation which is also a consequent effect of environmental pollution. The physiology of plants as well as physiochemical properties of soil gets affected by varying climatic condition. Therefore, the present review gives the information on metal remediation processes and how these process particularly phytoremediation by weed plants get affected by climatic changes.

Index Terms: climate change, immobilization, metals, pollution, remediation, toxicity, weed.

1. Introduction

Heavy metal is a basically a group of metals and metalloids (semi metal) having atomic density greater than 4 g cm^{-3}, or 5 times or greater than that of water [1],[2]. The natural sources of heavy metals are rocks, soils, sediments, and water. The anthropogenic sources include industrial effluents, fertilizer, pesticides and other urban activities shown in figure 1.

Figure 1: *Anthropogenic sources of heavy metals*

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The ecosystem pollution by heavy metals is a threat to the environment as they are persistent in the ecosystem and lead to food chain contamination [3],[4]. Some metals such as zinc (Zn), copper (Cu), nickel (Ni), manganese (Mn) etc. act as nutrients but their higher concentrations are toxic for environment. However, some heavy metals are very toxic even at their low concentration such as cadmium (Cd), mercury (Hg), arsenic (As), chromium (Cr) etc. These toxic metals have no role in the plant physiology as well as they should be removed from the environment through various processes. Different techniques should be applied to reduce the metal contamination from environment. Some technologies such as excavation, solidification and burial are very costly and they simply isolate the metals from contaminated sites. Other method such as soil washing, but it causes harmful effect on biological activity, soil structure and fertility, and it also very costly. Among different technologies, phytoremediation is found to be cost effective technique to reduce the metal contamination from environment. It involves the use of plants to remove or neutralize pollutants from a contaminated site and it can be defined as a treatment that uses naturally occurring plants to decrease the hazardous substances from environment.

2. Phytoremediation by using weed species

Phytoremediation is techniques to remove heavy metals by harvesting the plant biomass grown at contaminated site [5]. The characteristic of phytoremediating plants should be fast growing, deep rooted, easily propagated and it can accumulate large amount of heavy metals. These plants called as hyperaccumulator. The hyperaccumulator plant should be classified on the basis of some characters:

- The concentration in the shoots (stems or leaves) of a hyperaccumulator should be 10,000 mg kg^{-1} (Zn and Mn), >1000 mg kg^{-1} dry mass (As, Pb, Cu, Ni, and Co), 100 mg kg^{-1} (Cd), 1mg kg^{-1} (Au), respectively [6].
- Metal concentrations in the shoots of a plant should be higher than those in roots [7].
- Enrichment factor (concentration in plant/soil) should be > 1 [8].

- A hyperaccumulator should have high tolerance to toxic contaminants. For the plants tested under experimental conditions, their aboveground biomass should not decrease significantly when growing in contaminated soils [8].

Weeds are classified as more effective for the remediation of metal contaminated sites because as compared with other hyperaccumulator crops that have some limitations to play their role in removal of contaminants such as small aboveground biomass, slow growth and a long maturity phase whereas weed species can grow quickly and have large biomass under favourable condition [9]. By growing some weeds along with the edible crops the risk of heavy metal contamination can be reduced because these weeds restrict the entry of heavy metals into the edible crops [10]. As compared with other crops, weed species possess stress resistant properties, and it can maintain growth under adverse conditions.

2.1 Metal accumulating weeds

To eliminate pollutants from agroecosystem weeds are applied recently. There are many studies that have reported the role of weeds in accumulation of heavy metals from the contaminated site. Metal uptake pathways and detoxification shown by figure 2. The weed species such as water hyacinth (Eichhornia crassipe), redroot amaranth (Amaranthus retroflexus L.), and maidenstears (Silene vulgaris) had a strong uptake of Cu, Zn, and Cr in heavy metal polluted soil [11]. Ingole and Bhole [12] have also found that the aquatic weed Eichhornia crassipes grown in wastewater could strongly accumulate heavy metals. Weed

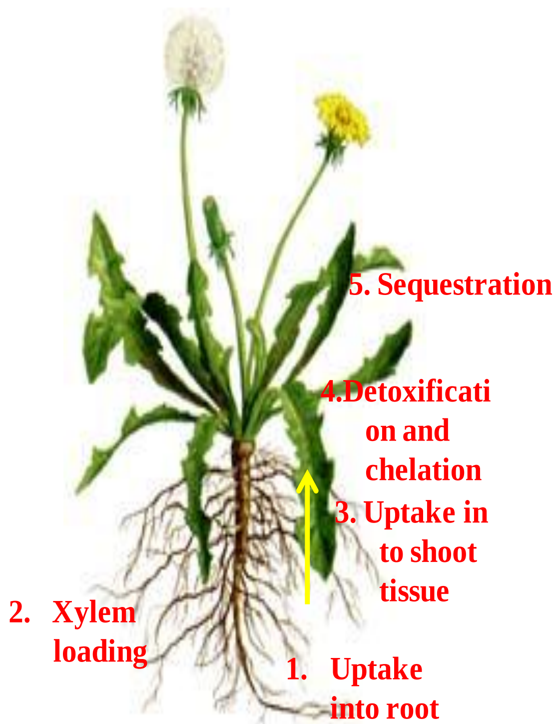

Figure 2: *Different pathways of metal uptake and detoxification in weed plant*

hyperaccumulators such as dandelion (Taraxacum mongolicum) black nightshade (Solanum nigrum L.) and canadian horseweed (Conyza canadensis L.) were also found to be tolerate single Cd and Cd-Pb-Cu-Zn combined pollution and had high Cd-accumulative ability [13]. Wei et al. [14] have studied the hyperaccumulating characteristics of some weed species through pot culture and a sample-analysis experiment. The result showed that Taraxacum mongolicum and Rorippa globosa indicated some Cd hyperaccumulative properties. Sahu et al. [15] have studied the ability of seven hyperaccumulator macrophytes weeds (Spirodela polyrhiza, Hydrilla verticillata, Baccopa monnieri, Eichhornnia crassipes, Ipomoea aquatica, Limnanthemun cristatum, Marselia minuta) grown in the heavy metal contaminated channels of three different industries (Hindustan Aeronautical Ltd., Eveready Ltd., and Scooter India Ltd. located in the inner area of Lucknow City, U.P., India. Accumulations of heavy metals depend upon the plant species and the metal concentration in the media. It was found that among all species Eichhornnia crassipes and Spirodela polyrhiza plants were found to be the best accumulators at each contaminated site [15]. Dixit and Tiwari [16] have found that a aquatic weed water hyacinth (Eichhornia crassipes) accumulates large amount of heavy metals like Lead (Pb), Chromium (Cr), Zinc (Zn) and Manganese (Mn) from the contaminated water bodies located at Shahpura lake of Bhopal, India. The presences of higher concentration of these metals in the aquatic weed suggest its capacity to absorb metallic ions from polluted water. They have suggested that, use of aquatic weeds to remediate the heavy metals is a sustainable technique as well as cost effective also [16]. Pot-culture experiment was conducted at the Shenyang Station of Experimental Ecology, Chinese Academy of Sciences, Shenyang, P.R. China. It was found that the Bidens pilosa and Kalimeris integrifolia [17] and Conyza Canadensis [18] have some basic properties of Cd hyperaccumulator. O'Kaffe and Bendell-Young [19] compared the accumulation and partitioning of cadmium (Cd) in a Ranunculus repens having fibrous root and Geranium robertianum having tap root system. The fibrous root of R. repens has the potential to take up almost 3-fold the amount of metal as compared to the tap root of G. robertianum. Due to this difference R. repens to be an effective accumulator of Cd as compared to G. robertianum. Ghose and Singh [10] studied the ability of weeds in comparison to indicator plant species for phytoextraction of cadmium. Results concluded that Ipomoea carnea was more effective in removing Cd from soil than Brassica juncea. Samples of C. odorata were collected from different sites in Bo Ngam lead mine that is located in Thongphapum district, Kanchanaburi province, western Thailand by Tenhan et al. [20].They found that plants from field collection accumulated 1377 and 4236 mg kg^{-1} Pb in their shoots and roots, respectively, and could tolerate soil Pb concentrations up to 100000 mg kg^{-1}. After a systematic identification by Wie et al. [9] it was determined that Oenothera biennis and Commelina communis were Cd-excluders and Taraxacum mongolicum was a Zn-excluder. Mishra and Tripathi [21] have studied that Eichhornia crassipes can be used for removing Cr and Zn. They have taken four concentrations of Cr and Zn, i.e. 1.0, 5.0, 10.0 and 20.0 mgl^{-1} in single metal solution. These plants were able to remove up to 95 % of zinc and 84 % of chromium during 11 days incubation period.

3. How the climate changes influence the phytoremediation process by weed?

Climate changes such as variation in temperature, rainfall and gaseous concentration may affect the growth of weed plants and consequently affect its phytoremediation property. All plants show some adaptation towards warmer temperatures and drier soil conditions or shift their range with the climate change. Weeds show more tolerance against warmer temperatures. Each species show different ways of competition between species. Weeds are usually very competitive and establish new populations when natural or desirable plant species decline. Growth of weed species is favored with increasing tendency of fire and drought. Change in the climatic condition may also favour some native plants to the extent that they may become weeds. Growth of some weed species is stimulated by higher levels of carbon dioxide. Woody weeds are more benefited from increased carbon dioxide than grasses. Table 1 provides a summary of how climate change may affect the distribution of significant weed species.

Table 1: *Potential impacts of climate change on weeds distribution*

Botanical name	Common name	Region	Impact
Prosopis julijlora	Mesquite / Jangai kikar	Invasive weeds in Asia	Growth is increased with higher temperature
Triantherna portulacastrum	Horse purselane	Invasive weeds in Asia	Its growth is favoured at temperature above 35ºC
Cirsiumarvense	Canada thisle	Invasive weeds in the continental United States	Stimulation of growth under higher concentration CO_2
Rubus fruticosus	Blackberry	Invasive weeds in Southern Australia	Expected to move southwards and to higher altitudes because it is sensitive to higher temperatures and drought
Lantana camara	Lantana	Invasive weeds in Southern Australia	Expected to continue its move southwards into high-rainfall zones of Northern New South Wales
Parthenium hysterophorus	Carrot grass	Invasive weeds in Asia	Its germination is triggered by higher temperature and moderate available soil moisture
Acacia nilotica	Prickly acacia	Invasive weeds in Southern Australia	Expected to move southwards and into arid areas
Nassella neesiana	Chilean needle grass	Invasive weeds in Southern Australia	Expected to increase its range because it is highly invasive (long lived, seed dispersed by wind and water) and drought tolerant

Weeds with efficient seed dispersal systems due to wind, water and birds will invade more quickly than weeds that rely on vegetative dispersal. An increase in extreme events, such as cyclones, storms and associated floods, may increase the dispersal of weed species that depend upon wind and water to move seeds or pollen. Genetic diversity of weed species is greater than crop plants. Consequently, if an environmental resources such as light, water, nutrients or carbon dioxide changes within the environment, weeds will show a greater growth and reproductive response. Due to presence of C4 photosynthetic pathway weed species will show a smaller response to atmospheric CO_2 relative to C3 crops. For all weed/crop competition studies where the photosynthetic pathway is the same, weed growth is favored as CO_2 is increased [22]. Increasing temperatures leads to expansion of weeds into higher latitudes or higher altitudes. Due to presence of low temperature aggressive weeds that are currently found in the south are limited in the northern states by low temperatures. Studies have shown that itchgrass, a profusely tillering, robust grass weed could invade the central Midwest and California with only a 3° warming trend [23]. Witch weed, a root parasite of corn, is limited to the coastal plain of North and South Carolina. With an increase of temperature of 3° this parasite could become established in the Corn Belt with disastrous consequences. The current distribution of both Japanese honeysuckle and kudzu is limited by low winter temperatures. Global Warming could extend their northern limits by several hundred miles. Variation in temperature and carbon dioxide have significant direct (CO_2 stimulation of weed growth) and indirect effects (climatic variability) on weed biology. With the climatic variation there is change in the distribution pattern of weed species. Therefore it is very important to know that which type of climatic condition prevailing in the contaminated area for choosing the type of weed species, so that it can grow well and show their best performance in removal of the metals from contaminated areas. It will be possible to harvest safe agricultural products from soils contaminated by heavy metals by transplanting the functional genes with these excellent characteristics of weed species into tissues of a crop [24].

4. Conclusions

Nowadays, heavy metals pollution of soil and water is an environmental concern worldwide. Metals and other inorganic contaminants are among the most common forms of contamination found at waste sites, and their remediation in soils and sediments are technically difficult. The high expenditure of existing cleanup technologies led to the search for new cleanup strategies that have to be potentially low-cost, low-impact and environmentally sound. Phytoremediation does not have the destructive impact on soil fertility and structure that some more vigorous conventional technologies have such as acid extraction and soil washing. The climate change due to environmental pollution may affect the soil micro-organisms and in turn the soil physicochemical characteristics. Modification in the climatic condition may favor some native plants species to the extent that they may become weeds. Weeds show more tolerance against warmer temperatures. Climate changes also affect the growth of weed plants and consequently affect its phytoremediation property. There is change in the distribution pattern of weed species with variation in climatic conditions. Therefore, it is very important to know that which type of prevailing climatic condition in the contaminated area for choosing the suitable type of weed species, so that it can grow well and show their best performance in removal of the metals from contaminated areas.

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