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Research Article

Copper Hyperaccumulating Plants From Barak Valley, South Assam, India For Phytoremediation

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ABSTRACT

Copper is an essential trace mineral which at high doses can be extremely toxic. Cu pollution of soil and water can be both natural and anthropogenic. Existing technologies for Cu remediation such as leaching, solidification/stabilization and excavation are expensive, time consuming, labour intensive and soil disturbing. However, phytoremediaton of Cu from contaminated site is a lucrative and emerging concept which is not only cost effective but also ecofriendly. It is based on the fact that certain plants, during the process of nutrient uptake, remove pollutants from the environment. Such species can hyperaccumulate pollutants in their root, shoot and leaves. Several plant species of Barak Valley, South Assam, in the north east part of India, possess substantial hyperaccumulating potential that can be used for Cu phytoremediation from soil and water. Present study thus explores phytoremediation potential of such plants found in this region.

Key words: Copper, Hyperaccumulator, Phytoremediation.

INTRODUCTION

Copper (Cu) is an essential trace mineral that is important for both physical and mental health, yet, at high doses it can be toxic to living organisms[1]. Cu is not biodegradable, eventually reaches hazardous concentrations and accumulates in the environment. Free Cu causes toxicity as it generates reactive oxygen species such as superoxide, hydrogen peroxide and the hydroxyl radicals that damage proteins, lipids and DNA. Its ingestion beyond the permissive level causes various types of acute and chronic disorders and health hazards in flora, fauna and human beings. Ingestion of excess of Cu causes gastro-intestinal disorders, mucosal irritation, haemolysis, hepatic and nephro toxicity as well as central nervous system irritation followed by depression[2]. The levels of Cu in the environment are elevated due its emissions from natural as well as manmade sources. The contamination of air, soil and water, by Cu is contributed from mining, milling, refining of copper ores, electroplating industries, petroleum and refining, industrial smelts, namely iron and steel fertilizer industries. Cu is also discharged into the effluents of various industries like chlor-alkali, electroplating, paints, dyes, metallurgy, pesticides, fertilizers and mining. Municipal discharges also contribute a major share in water pollution due to copper[3].

Keeping in mind the above scenario of Cu pollution, continuous efforts have been made to develop technologies to remediate Cu that are easy to use, sustainable and economically feasible. Physicochemical approaches have been widely used for cleaning polluted soil and water, especially at a small scale. Currently, conventional remediation methods of heavy metal contaminated soils include electro-kinetical treatment, chemical oxidation or reduction, leaching, solidification, vitrification, excavation, and off-site treatment. These clean up processes of heavy metal pollution are expensive and environmentally destructive[4]. The use of plant species for cleaning polluted soils and waters, named as phytoremediation, has gained increasing attention since last few decades, as an emerging cheaper technology[5,6]. Metal accumulator plant species are usually referred to as hyperaccumulators that concentrate metals in their above-ground tissues to levels far exceeding those present in the soil or in nonaccumulating species growing nearby. Such species can hyperaccumulate pollutants in their root, shoot and leaves. Phytoremediation of heavy metals may take one of several forms: phytoextraction, rhizofiltration, phytostabilization, and phytovolatilization. Phytoextraction refers to processes in which plants are used to concentrate metals from the soil into the roots and shoots; rhizofiltration is the use of plant roots to absorb, concentrate or precipitate metals from effluents; phytostabilization is the use of plants to reduce the mobility of heavy metals through absorption and precipitation by plants, thus reducing their bioavailability and phytovolatilization is the uptake and release into the atmosphere of volatile materials such as mercury- or arsenic-containing compounds[7].

There are around 400 plant species known worldwide to accumulate metals in large amounts [8,9]. Many plants from India have shown the capacity to withstand relatively high concentration of contaminants without toxic effects[10]. However, very few works are being done to enlist such hyperaccumulators from Barak Valley. Barak Valley is river valley situated by the river Barak in Southern Assam, in the northeastern part of India. The place is rich in plant diversity. The present study, thus, aims to find such copper hyperaccumulators, both aquatic and terrestrial, from this region.

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Table 1: Copper hyperaccumulating terrestrial plant species

Plant name	Common name	Family
Brassica juncea (L) Czern.	Indian mustard	Brassicaceae
Brassica napus L.	Canola	Brassicaceae
Brassica rapa L.	Turnip	Brassicaceae
Brassica campestris L.	Wild mustard	Brassicaceae
Raphanus sativus L.	Radish	Brassicaceae
Brassica oleracea L.	Cabbage	Brassicaceae
Helianthus annuus L.	Sunflower	Asteraceae
Helianthus indicus L.	Sunflower	Asteraceae
Calendula officinalis L.	Pot marigold	Asteraceae
Tagetes erecta L.	Marigold	Asteraceae
Ricinus communis L.	Castor	Euphorbiaceae
Typha latifolia L.	Cattail	Typhaceae
Datura innoxia Mill.	Dathura	Solanaceae
Zea mays L.	Corn	Poaceae

Table 2: Copper hyperaccumulating aquatic plant species

Species	Common name	Family
Eichhornia crassipes (Mart.) Solms	Water hyacinth	Pontederiaceae
Pistia stratiotes L.	Water lettuce	Araceae
Lemna minor L.	Duck weed	Lemnaceae
Ipomoea aquatica Forssk.	Water spinach	Convolvulaceae
Ipomoea carnea G. Forst.	Morning glory	Convolvulaceae
Bacopa monnieri (L.) Pennell	Brahmi	Scrophulariaceae
Hydrilla verticillata C.Presl	Waterweed or Hydrilla	Hydrocharitaceae
Nelumbo nucifera Gaertn.	Lotus	Nelumbonaceae

METHODOLOGY

Both terrestrial and aquatic plant species with hyperaccumulative potential for copper were collected from Barak Valley, South Assam, northeast India by field survey, literature survey and identified by standard plant taxonomy manuals[11].

RESULTS AND DISCUSSION

The present study has listed Cu hyper accumulating terrestrial and aquatic plants species (Table 1 and 2). The study found members of Brassicaceae, Asteraceae, Euphorbiaceae, Typhaceae, Solanaceae and Poaceae family in the contaminated sites. Amongst the plants, the Indian mustard (*Brassica juncea*) is extensively studied for phytoremediation purposes because of its fast growth, high biomass and efficiency[12]. Phytoremediation potential of *Raphanus sativus* was discussed in works of Ogra *et al.,* 2007[13]. Salt *et al.,* 1995 described the Cu phytoremediation potential of sunflower, *Helianthus annuus*[14]. Hybrid marigold, *Tagetes erecta* has also been used for metal phytoremediation[15]. Castor (*Ricinus communis*) is a species belonging to the Euphorbiaceae family. It is an easily disseminated and dispersed plant, and has proven to be tolerant to heavy metals[16]. Phytoremedial properties of *Typha latifolia* was shown by Guedes *et al.,* 2009[17]. In a study, root exudates from *Datura innoxia* have been shown to degrade soil pollutants[18,19]. Phytoremediation potential of *Zea mays* was reviewed[20]**.** They found high Cu hyperaccumulation by *Zea mays*.

Present study also found the aquatic plant families Pontederiaceae, Araceae, Lemnaceae, Convolvulaceae, Scrophulariaceae, Hydrocharitaceae and Nelumbonaceae to have hyperaccumulating potential. Amongst aquatic plants, water hyacinth (*Eichhornia crassipes*), due to its fast growth and large biomass production, has potential to cleanup various wastewaters as well as heavy metals[21]. Duckweed (*Lemna trisulca*) of the family *Lemnaceae*, is another aquatic plant with an excellent potential for phytoremediation of heavymetals[22]. Phytoremedial properties of water lettuce (*Pistia stratiotes*)[23] and water lilies (*Nymphaea spontanea*)[24], have been studied to determine their potential in accumulating heavy metals. Both the study showed positive results. Potential of *Ipomoea aquaticain* for Cr phytoremediation was also studied[25]. The present study found all these plant species in the region which can be used for uptake of Cu from contaminated soil and water.

Phytoremediation, has been reported to be an effective, in situ, non-intrusive, low-cost, aesthetically pleasing, ecologically benign, socially accepted technology to remediate polluted soils[26,27]. It also helps prevent landscape destruction and enhances activity and diversity of soil microorganisms to maintain healthy ecosystems, which is consequently considered to be a more attractive alternative than methods that are currently in use for dealing with heavy metal contamination[28,14]. Phytoremediation takes advantage of the unique, selective and naturally occurring uptake capabilities of plant root systems, together with the translocation, bioaccumulation

and pollutant storage/ degradation abilities of the entire plant body. Several plant species of north east India, both terrestrial and aquatic, possess substantial hyperaccumulating power that can be used for Cu phytoremediation from soil and water. Only the need of the hour is rapid research and development in this emerging field.

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