Rice Research: Open Access
ISSN: 2375-4338
Mohanty, J Rice Res 2015, 3:3
DOI: 10.4172/2375-4338.1000e116

Editorial Open Access

Phytoremediation - An Innovative Approach for Attenuation of Chromium Toxicity and Rice Cultivation in Mining Areas

Mohanty M*

Department of Botany, Dhenkanal Autonomous College, Utkal University, Dhenkanal-759001, Odisha, India

***Corresponding author:** Monalisa Mohanty, Post Graduate, Department of Botany, Dhenkanal, Odisha, India, Tel: +919861077321; E-mail: 18.monalisa@gmail.com

Received date: May 4, 2015; **Accepted date:** May 6, 2015; **Published date:** May 10, 2015

Editorial

Industries play a vital part in progress of human civilization. The process of industrialization leads to several detrimental effects on human health and environment with its toxic discharges. Among several developing countries, India is considered as a country having huge natural resources with emerging industrial avenues for satisfying the growing demands of ever-increasing population. As a result of huge quantities of pollutants released through various industrial and mining activities our environment is getting degraded day-by-day. Because of commercial application of minerals, Government has augmented more mining activities along with rapid industrialization process. However, as a fall out, heavy metal-contaminated land is an important environmental health issue in India. In view of severe pollution problems, arising due to various anthropogenic, industrial and mining activities with special reference to opencast mining activities, a number of eco-friendly biotechnological interventions are employed to combat these pollution problems. It is a major concern of researchers worldwide to attenuate various toxic pollutants from environment by application of innovative tools and techniques. Bioremediation technology, phytoremediation technique, biosorption techniques, phytomining/biomining techniques, development of pollution resistant transgenic crops, biotic and abiotic stress resistance in modified organisms or by natural means, microbial applications for environmental sustainability are important among those novel biotechnological approaches.

Phytoremediation is a novel, economic, and environment friendly technology for removing toxic metals from hazardous waste sites and contaminants from soil. It employs the use of higher plants for cleaning up the contaminated environment. The emerging phytoremediation technology has put much emphasis on attenuation of hexavalent chromium ($Cr6+$) which is highly toxic and carcinogenic. Consequently, the low cost technology i.e. in situ approach of phytoremediation is attractive as it offers site restoration, partial decontamination and maintenance of the biological activity and physical structure of soils. It is potentially cheap, feasible and there is the possibility of bio-recovery of metals.

Contamination of soil and water in chromite mining areas is a widespread and serious problem. Mine waste water contaminated by hexavalent Chromium (Cr-VI/Cr6+) not only possesses major environmental and human health problems but also affect the growth and productivity of plant communities. Chromium toxicity results in inhibition of plant growth and metabolism, which includes stunted growth, chlorosis, reduced crop yield, delayed germination, senescence, premature leaf fall, biochemical lesions, loss of enzyme activities and reduced biosynthesis of metabolites [1-6]. Immobilization or extraction of heavy metals by physicochemical techniques is expensive and often appropriate only for small areas where, rapid and complete decontamination is required. Researchers attempted to detoxify and reduce the Cr6+ contamination level from discharged mine waste water by the use of different plants [6] through phytoremediation technique. In one of such in situ phytoremediation approach by Mohanty et al. [7], paragrass and water hyacinth can be used as tools of rhizofiltration and phytoextraction to combat the problem of in situ Cr contamination at South Kaliapani Chromite mine area of Odisha, India. The study provides the idea of biomass-based phytoextraction using high-biomass-producing paragrass species growing luxuriantly under field conditions with high root accumulation capacity. The results of field experiments conducted at experimentally designed cultivated plots of paragrass [6] indicate that Cr uptake and bioaccumulation differ significantly with plant ages. These could be used as hyperaccumulators for reduction of Cr from contaminated soil and mine waste water due to high bioconcentration of Cr in plant tissues. Moreover the drought tolerant paragrass species can withstand short term flooding and water logging and is highly tolerant to saline or sodic soil conditions. So it is an excellent phytoremediation tool for reclamation of contaminated soil. The Cr accumulation in paragrass can be verified from the BCF, TAR and Ti values [7]. The extensive and massive fibrous root systems of paragrass are the helpful means for filtering out the pollutants through rhizofiltration mechanism at the mining sites. Paragrass showing high biomass had a strong tolerance to Cr can be used as a tool of phytostabilisation for reclamation of heavy metal contaminated mining sites. The results indicate that the plant species differ significantly in Cr uptake capacity. The Cr accumulation in different test plants also differ as verified from their respective BCF, TAR, and Ti values. The extensive and massive fibrous root system of water hyacinth could be a helpful means for filtering out the pollutants at the mining sites for the mine waste water to be used for irrigation purposes and cultivation of rice in those contaminated sites.

Cr accumulation and BCF generally increased with increasing external Cr levels in soil as well as the age of plants. BCF (10,924) and Ti values (32.09) were highest for water hyacinth [7]. The Ti values of different plants indicated that the root to-shoot translocation of Cr was very high after 100 days of growth period, which indicates their ability to translocate Cr from the root to the shoot, or to compartmentalize it, in order to continue the absorption of Cr from the substrate [7]. A better translocation is advantageous to phytoextraction as it can reduce Cr concentration and thus reduce the toxicity potential to the root, and translocation to the shoot is one of the mechanisms of resistance to high Cr concentration [8,9]. Ti was highest in water hyacinth plants. All of the plants showed a general trend of fall in Ti with an increase in chromium concentration and days of exposure to Cr [7]. The BCF of Cr increased with an increase in time, this means that Cr accumulated up to maturity. The amount of chromium decreased with an increase in time, which depicts that the accumulation of chromium was non-linear and showed a negative correlation. The BCF values for roots were generally maximum than the leaves, stems, and grains of the plants during 125 days of growth. TAR, Ti, and BCF values were found to be high for rice plants treated with chemical fertilizers [6,7]. The recovery of Cr can be interpreted from the values of TAR, which was maximum (8.29 mg kg−1 dry biomass per day) in paragrass [7]. Thus, paragrass and water hyacinth can be used as tools of rhizofiltration and phytoextraction to combat the problem of in situ Cr contamination. This study by Mohanty et al., [7] provides the idea of biomass-based phytoextraction using high-biomass-producing paragrass species growing luxuriantly under field conditions with high root accumulation capacity. The results indicate that the plant species differ significantly in Cr uptake capacity. The Cr accumulation in different test plants also differ as verified from their respective BCF, TAR, and Ti values.

Induced phytoextraction using chelating agents is another effective phytoremeediation technique for removal of toxic heavy metals from soil which can be interpreted from Total Accumulation Rate (TAR) values. The total accumulation rate (TAR) for Cr was enhanced with the supplementation of DTPA in rice and wheat, whereas the application of EDDHA was found effective for increasing the accumulation rate of Cr in green gram seedlings [7]. This study demonstrates the role of chelating agents in lessening the toxic effects of Cr^{6+}. The chelating agents supplemented with Cr^{6+} in the nutrient culture medium enhanced the Cr bioavailability in plants under in vitro condition. Mohanty and Patra [10] studied that heavy metals induce several physiological and biochemical alterations in crop seedlings could be alleviated by supplementing chelating agents in the nutrient solution. Different crop plants respond variedly to the diverse chelate treatments, depicting their individual bioaccumulation ability. The high degree of Cr bioaccumulation, increased proline biosynthesis, enhanced antioxidant enzyme activities, and the stunted seedling growth with low pigment status indicated that Cr^{6+} induced toxicological effects in developing crop seedlings. To combat against such toxicity effects, the application of chelating agents could be an effective measure as an induced phytoextraction approach. Studies by several researchers revealed the beneficial and effective roles of chelating agents in stimulating plant growth and metabolism as well as in enhancing Cr bioaccumulation in roots and shoots. These chelated chromium compounds can overcome the toxicity problems of chromium to a greater extent, and could beneficial for growth of several crop plants after removal of pollutants.

Further phytoremediation strategies are carried out to reduce chromium bioavailability in plants. This provides a suggestive measure for the farmers who grow rice crops at the chromium contaminated sites. Rice is a major staple food in India. Heavy metal contaminated sites severely affect the growth and yield of rice and restrict its annual production. It has been suggested that using innovative phytoremediation techniques heavy metals can be removed.

References

1. Zayed A, Lytle CM, Qian JH, Terry N (1998) Chromium accumulation, translocation and chemical speciation in vegetable crops. Planta 206: 293-299.
2. Zayed AM, Terry N (2003) Chromium in the environment: factor affecting biological remediation. Plant Soil. 249:139-156.
3. Mohanty M, Jena AK, Patra HK (2005) Effect of chelated chromium compounds on chlorophyll content and activities of catalase and peroxidase in wheat seedlings. Ind J Agr Biochem 8: 25-29.
4. Mohanty M, Pattnaik MM, Misra AK, Patra HK (2009) Chromium detoxification from mine waste water by rice - A case study at South Kaliapani chromite mine area, Sukinda, Orissa. e-Planet 7: 26-31.
5. Mohanty M, Pattnaik MM, Mishra AK, Patra HK (2011a) Chromium bioaccumulation in rice grown in contaminated soil and irrigated mine waste water - A case study at South Kaliapani chromite mine area, Orissa, India. Int J Phytoremediat 13: 397-409.
6. Mohanty M, Patra, HK (2011) Attenuation of Chromium Toxicity by Bioremediation Technology. Rev Environ Contam Toxicol 210: 1-34.
7. Mohanty M, Pattnaik MM, Mishra AK, Patra HK (2012). Bioconcentration of Chromium - An in situ Phytoremediation Study at South Kaliapani Chromite Mining Area of Orissa, India. Environ Monit Assess 184: 1015-1024.
8. Ghosh M, Singh SP (2005a) A review on phytoremediation of heavy metals and utilization of its by-products. Appl Ecol Environ. Res 3: 1-18.
9. Ghosh M, Singh SP (2005b) Comparative uptake and phytoextraction study of Soil induced chromium by accumulator and high Biomass weed species. Appl Ecol Environ Res 3: 67-79.
10. Mohanty M, Patra HK (2012) Effect of Chelate assisted Hexavalent Chromium on Physiological changes, Biochemical alterations and Cr Bioavailability in Crop Plants - An in vitro Phytoremediation Approach. Bioremediat J 16: 147-155.

This article was originally published in a special issue, entitled: **"Recent Advances in Rice Nutrition and Chemistry"**, Edited by Shuvasish Choudhury