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Removal of heavy metals from Industrial Effluent using *Salvinia molesta*

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Abstract : Phytoremediation is the natural ability of certain plants to bio-accumulate, degrade, (or) render harmless contaminants in soils, water, (or) air. Hydrophytes due to their large amount of existence in the ecosystem and it used as an indicator for the removal of heavy metals from the industrial effluents. The effluents coming out from industries had high concentration of chromium, lead, copper and cadmium. In the present study, the concentration of chromium, lead, copper, and cadmium before and after treatment were analysed using Atomic absorption spectrophotometer (AAS). The obtained results revealed that the content of heavy metals (less than 10 ppm) was within the permissible levels, except chromium and lead. The results revealed that *Salvinia molesta* can grow healthy with the accumulation of these metals.
Keywords: Heavy Metals, Industrial Effluent, *Salvinia molesta*, AAS.

Introduction

Environmental pollution due to heavy metal is a global issue at present. One of the most significant reason for heavy metal pollution in ecosystem and irrigated lands is a direct discharge of untreated and contaminated sewage and industrial effluents[1,23-40]. The study of pollutant uptake and biological indicators of heavy metals in aquatic ecosystems has been a subject of interest in recent years. Regulatory decision concerning the environment hazardous of most potential contaminants have been found using photo toxicity data for aquatic plants[2]. Most heavy metal is non degradable in the nontoxic end products. Therefore, their concentration must be decreased to levels that are acceptable before being discharge into the environment. Many researchers and industrialist are working towards recovery of these heavy metals because of their inherent value as a precious metal [3]. Some of the most common methods of removal of contaminants are chemical precipitation, membrane filtration, adsorption, ionic exchange and electrochemical filtration. Most of these process lack a monetary advantage and extremely inefficient at low concentration. These disadvantages have brought about the need of developing alternative low cost water treatment techniques [4]. Hence removal of heavy metals from environment using Phytoremediation(or) bio accumulation process is advisable.

The ability of appliance to bio-accumulate, degrade and run the harmless soil, air and water contaminants is called phytoremediation [5]. Phytoremediation uses specific plants that has the ability to bio accumulate various heavy metal like lead, Cadmium, Chromium, Arsenic etc and its various radio–isotopes, to clean soil and water contaminated with these metals. It is one of the most rapidly developing and cost effective technologies. The recent research is on the ability of certain chelating agent that improves heavy metal uptake by soil grown plant is promising to make this technology a commercial reality in the near future. Living plants can be considered as solar pumps that can extract concentrate specific elements from the environment. The interdisciplinary cooperation between molecular biologists, plantbiochemist, soil Chemists, Agronomist and Environmental Engineers are making phytoremediation possible. Safe processing of harvested plant tissue by drying ashing and composting will help reduce the volume of toxic waste generated to mere fraction of many more invasive remediation techniques. Also the ability of reclamation of some heavy metals from the ash further reduces the generation of hazardous waste and increase revenue [6]. There is a large no. of factors that effects of phytoremediation. These include but are not limited to the availibity and accessibility of contaminants for Rhizomes microorganism, the extent of soil contamination and uptake into roots [7]. But of the most sensitive ecosystem to be affected by heavy metals is the aquatic ecosystems [8]. Phytoremediation is employed for cleanup of large number of sites that are contaminated with radio isotopes [9]. Studies are being done on the ability of plant roots to absorb heavy metals from the soil thereby behaving as natural phytoremediation[10]. Despite it being a very cost effective, environment friendly and aesthetical pleasing approach for most developing countries, phytoremediation is yet to become a commercially technology in India[11].

Salvinia molesta is a perennial free floating weed that is native to South Eastern Brazil. Its highly accelerated vegetative reproduction has earned the title of a various serious weed in most regions outside its natural habitat. The first case of salvinia molesta infestation was initially observed in the 1950 at veli lake in trivandrum,kerala and was awarded the pest status in 1964.Its ability to chock up the rivers and canals have both direct and indirect effects on the aquatic ecosystem[12]. It grows in slow moving water (or) still water like ponds, lakes, rivers and prefers nutrient rich water such as eutrophic water and polluted water. It grows best at pH less than 7.5 [13] and the Optimum temperature range is 25-36^{o}C [14] *Salvinia molesta* can be used for the treatment of blackwater effluent in eco-friendly sewage system [15,16].The objectives of this study is to find the concentration of heavy metals in salvinia molesta by using Atomic Absorption spectrophotometer(AAS). The metals chosen for this study were chromium, copper, lead and cadmium, since they are extremely toxic even in very small amount.

Figure 1:Pictorial View of *Salvinia molesta*

Materials and Methods

Experimental Set Up for Heavy Metal Uptake of fabricated tank:Salvinia molesta was collected from leather industrial area in Kerala, India. The plants were cleaned using distilled water and kept for about ten minutes in $KMnO_4$ solution (1%). The plant was initially subjected with fresh water in tank for about one month and then, the second generation of the plant- *Salvinia molesta* was used for the effluent treatment. Five liters of the effluent was added to the constructed tank for treatment. Triplicate of each experimental setup and a control using fresh water was also maintained. The initial concentration of heavy metals in the plant and effluent was analyzed in the first day itself. After 15 days of treatment, final concentration of heavy metals in effluent sample and plantwas analyzed using Atomic Absorption Spectroscopy (Varian 880, AAS).

*Reagents and Standards Stock Solution:*Analytical grade reagents were purchased from Merck chemicals private limited. Standard sample solutions of Cd, Pb, Fe, Zn, and Mn (1000 mg/mL) were prepared. All the solutions were prepared by using double distilled water.

*Standard solution preparation:*Metals like Cr, Pb, Cu and Cd were collected in the form of salts as shown in the tabular column from Environmental Quality Management Laboratory at VIT University, Vellore. The fraction of molecular weight of the salt to the atomic weight of the metal gives the amount of salt required to prepare the 1000ml of stock solutionThe standard solutions of 20, 20, 60, 80 and 100 ppm were prepared from the stock solutions for each salt.

*Estimation of Heavy Metals in Effluents:*The heavy metals/metalloid in the effluent *viz*. lead, cadmium, copper and chromium were analysed before and after treatment by AAS after digestion of plant materials by diacid method [17,18]. The whole plant sample was washed in deionized water dried (24 hrs at 80°C) immediately to stabilize the tissue and stop enzymatic reactions. After drying, sample was ground to pass a 1.0 mm screen using the appropriate Wiley Mill. After grinding, the sample was thoroughly mixed and a 5-8-g aliquot withdrawn for analyses and storage. Weighed 0.5 to 1.0 g of dried (80°C) plant material that has been ground (0.5 to 1.0 mm) and thoroughly homogenized and place in a tall-form beaker or digestion tube. Added 5.0 ml concentrated HNO_3 (70.4%) and cover beaker with watch glass (or) place a funnel in the mouth of digestion tube and allow to stand overnight or until frothing subsides. Place covered beaker on hot plate or digestion tube into block digester and heat at 125°C for about one hour. Removed the digestion tube and allowed cooling. Added 1 to 2 ml 30% H_2O_2 and digest at the same temperature. Repeated heating and 30% H_2O_2 additions until digest is clear. Add additional HNO_3 as needed to maintain a wet digest. After sample digest is clear, removed watch glass and lowered temperature to 80°C. Continued heating until near dryness. Added dilute HNO_3 (30%), and deionized water to dissolve digest residue and bring sample to final volume.

Analysis of heavy metals using AAS: Metals like Cr, Cd, Cu, and Pb were analyzed using AAS which is equipped with flame and graphite furnace. The metal content in the sample were determined by using Air-Acetylene flame. The temperature parameters and the inert argon gas flow were maintained as peras per manufacturer recommendation.

Results and Disscussion

Heavy metal content in *Salvinia molesta* sample was determined using atomic absorption spectrometry, using a considerably simple sample preparation procedure. The results of uptake of heavy metals like lead, copper cadmium and chromium by plant is described in this section. Bio-concentration factor of the aquatic plant was also quantified. The concentrations of different heavy metals in the effluent was given in the Table 1.

Table 1: Concentration of Heavy metals in the effluent

S.No.	Heavy Metals	Concentration(ppm)
1.	Copper	1.092 ± 0.026
2.	Chromium	2.201±0.0024
3.	Lead	2.974 ± 0.018
4.	Cadmium	0.251 ± 0.017

Industrial effluents are one of the important sources of soil and water contamination. The industrial wastewater usually contains high level of hazardous material, removal of which is not possible with routine treatments. Industrial water in case of entrance into the soil, surface and ground water, cause pollutions and poison food chain. Additionally, limitation of fresh water and increasing population, treatment and recycling of raw sewage makes essential. Metal accumulations by hydrophytes could be affected by metal concentrations in water and sediments. The ambient metal concentration in water is the major factor influencing the metal uptake efficiency. In general, when the metal concentration in water increases, the amount of metal accumulation in plants also increases. The heavy metal concentrations in various effluents were comparatively higher. The increased salinity induces protective mechanisms, which influence the ability of the plant to bio-accumulate metals. Rai [21] reported 70-94% decrease in cadmium, when *Azolla pinnata* was used for phyto-remediation in thirteen days of treatment. Shugeng et al. [22] observed significant decrease in the concentration of cadmium and lead by *Canna* species.

Uptake of heavy metals from industrial effluent:

Lead : Initial concentration of lead in industrial effluent was 2.974 ppm. On treatment with *Salvinia molesta* based CT (Constructed Tank), there is a significant decrease in lead concentration of the effluent. The initial concentration of lead in *Salvinia* species was 2.974 ppm and after treatment, the concentration was decreased to 1.924 ppm.

Copper : In case of copper, the initial concentration was 1.092 ppm, which then increased to 2.035 ppm.The initial concentration of copper in *Salvinia* sp. was 1.092 ppm and after treatment with industrial effluent the concentration increased to 2.035 ppm.

Cadmium : Cadmium concentration in industrial effluent was 0.251 ppm. CT using *Salvinia*sp. was very effective in removing the cadmium from the effluent, finally the cadmium concentration was reduced into 0.018 ppm.

Chromium : The initial concentration of chromium in *Salvinia* sp. was 2.021 ppm and after treatment with industrial effluent the concentration decreased to 1.052 ppm.

Table 2: Uptake of heavy metals from industrial effluent by *Salvinia molesta*

S.No.	Heavy Metals	Concentration (ppm)	
		Before treatment	After treatment
1.	Copper	1.092 ± 0.026	2.035± 0.014
2.	Chromium	2.201±0.0024	1.052± 0.022
3.	Lead	2.974 ± 0.018	1.924± 0.012
4.	Cadmium	0.251 ± 0.017	0.018± 0.018

Based on the results, mentioned in the table 2, metals like chromium and lead were in higher limits. The concentration was found to be higher, because of the pollution due to industries. From the results, we can clearly confirm that *Salvinia molesta* consumed the heavy metals like chromium, cadmium, copper and lead, but still there is no change in the growth regulation process. This is one of the best evidence for the accumulation of heavy metals by *Salvinia molesta*. On the other side, the plant contains high percentage of lipids nearly 50-60%, which can be used for the production of biodiesel.

Conclusion

From the result, it can be concluded that this plant can be used as bioindicators for heavy metals. The analyzed plant samples from the specified locations have an insignificant amount of chromium and Lead, although a relative higher content was observed in a contaminated environment, but still below the toxicity level. Therefore, it is appropriate to analyze the content of heavy metal in herbal plant, in order to decrease the possibility of heavy metal toxicity to the people. This study proves that the plant accumulates metals in assimilation organs and roots. Thus, they can be recommended as indicators for determination of pollution levels of the environment.

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