Phytoremediation Of Uptake Of Heavy Metal (Copper) By Water Hyacinth (Eichhornia Crassipes)

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Abstract— Due to increase in industrialization, the pollution due to heavy metals in the environment has increased. Heavy metals are toxic pollutant which can many health damage to flora and fauna including human. Conventional techniques for remediation of waste water are very costly and also negatively affect the environment. This paper aims on the potential of the Water hyacinth (Eichhornia crassipes) for the uptake of heavy metal (copper) and remediation of waste water by phytoremediation. Water hyacinth was exposed 20 mg/l copper for 12days. Here bioaccumulation by the plants is used for remediation process and after this bio-extraction can be done. The application of 1mg/l EDTA in the water increased the removal by 0.06-3.5 times as compared to the controlled condition.

Keywords— *Phytoremediation, EDTA, Heavy metals*

INTRODUCTION

The metal whose atomic number is more than 20 and whose density is more than 5 g per cubic centimeter is called heavy metals. Most of the heavy metals are highly soluble in water ,toxics and also carcinogenic[1]. To fulfill the demand of human, industrialization has increased in last few decades. The metals use has also increased for which the effluent containing heavy metals generated from industries has also increased. Industrial activity like cleaning milling, electroplating, coating and anodizing etc generates copper (Cu), platinum (Pl), silver (Ag), nickel (Ni), lead (Pb), chromium (Cr), cadmium (Cd); printing circuit boards generates Titanium (Ti), lead (Pb), and nickel (Ni); petroleum refining industries generates nickel (Ni), chromium (Cr), Vanadium (V). When the untreated effluent is discharge to the environment, it can leach and pollute the water bodies. The heavy metal can enter the food chain and can cause many serious health issues including cancer, nervous system damage, and organ failure and also lead to death[2].

Heavy metals are very dangerous to the environment. Arsenic (atomic number 33) when exposed to water and food can cause diabetes, heart problem and cancer. Lead (atomic number 82) contamination has long term effect and non biodegradable. High amount of Pb^{2+} is very toxic to flora and fauna including humans. It brings health issues like brain damage and retardation. Cadmium (atomic no. 48) when inhaled in excess injures the tissue, cause damage to DNA, kidney tubule, gastrointestinal disorder and cancer in liver. Copper (atomic no. 29) contamination limits the survival of plants in that area. It hampers the growth and production of farmlands depending on the acidity and organic matter in the soil. It also interrupt the soil activity including the soil microbes.[3][4]

Phytoremediation is the remediating technique used to reduce the concentration or toxic effects of contaminants in the environment by plants and associated soil microbes. Water hyacinth is floating aquatic plant. It can grow maximum 1 m height above the water surface and 2.5 m root. Phytoremediation is economic and eco-friendly technique for the removal of contaminates from river or waste water[5].

LITERATURE SURVEY

In this research work, investigation of Phytoremediation on heavy metals has been carried out. Here the removal of toxic contaminate from the water is focused with sustainable and cost effective process.

Yue-bing Sun et al. 2009[6] investigated the accumulation and uptake of heavy metals from the contaminated soil which was irrigated with industrial wastewater by chelator in pot-culture experiment. Here for the Phytoremediation involving Phytoextraction, the Sedum alfredii Hance was used for hyper-accumulator plant. The effect of chelators on the growth and uptake capacity of heavy metal like Cd, Cu, Pb and Zn was studied. The chelator EDTA with 5 and 8 mmol/kg and citric acid with 5 and 8 mmol/kg concentration was mixed with soil. It was reported that by the addition of chelator the mobility and accumulation of heavy metal taken this experiment was enhanced. The accumulation was increased by 2.37 to 4.86 times in cadmium, 0.09 to 3.73 times in copper, 0.33 to 5.06 times in lead and 3.71 to 6.06 times in zinc as compared to controlled condition. It showed maximum value with 8mmol/kg CA for cadmium and zinc accumulation, 5mmol/kg CA for lead.

Jung-Chun Chen et al. 2010[7] reported the influence of chromium(Cr^{3+}) speciation on Cr Phytoremediation with Ipomonea aquatica by Hydroponic experiment. Here the seeds of I.aquatica were germinated with Hoagland's nutrient solution without EDTA for 14days. The growth of seed was recorded. By MINEQL+ Cr speciation was estimated. The relationship between Cr speciation and accumulation was estimated by statistic regression and found that root accumulates high concentration of chromium at 10mg/l of Cr^{3+} and 10^{-4} of EDTA by Statistic regression. The inter-relation with Chromium and EDTA (Cr–EDTA) speciation, and chromium and chlorine (Cr-Cl) speciation was analyzed by Pearson correlation. Also the correlation with shoot and Cr-Cl speciation was also analyzed. The accumulation of Chromium at root level was inhibited at high concentration of chlorine.

S. Dipu et al. 2012 [8] investigated the removal capacity of heavy metals by the aquatic plant by constructing a wetland. The heavy metals involved in the study were lead, copper, arsenic and cadmium. The removal capacity of the plants without chelating agent were examined and compared with removal capacity of the plant in the presence of chelating agent. It was reported that Typha sp. showed comparatively greater removal for all of the heavy metals than the other. The addition of chelating agent increased the removal process by improving the bioavailability. Among aquatic plants, removal of lead was higher by water hyacinth, arsenic by Azolla sp., and copper and cadmium by Pistia sp.

Musarrat Naaz et al. 2015 [9] scrutinized the importance of rhizofiltration, bioaccumulation kinetics and uptake factor of heavy metals (copper and zinc) in water hyacinth. Water hyacinth was exposed with 0.5ppm concentration of zinc and copper was exposed for 12 days. By Toxicokinetics and uptake factors, it was found that water hyacinth works efficiently for the removal of cooper and zinc. After 3days of exposure, copper accumulation was 0.248µg/g and zinc accumulation was 0.266µg/g. After 12 days, copper accumulation found to be 0.255µg/g and that of zinc was 0.2562µg/g. It was observed that average bioaccumulation rate is maximum for copper than zinc.

Theeta Sricoth et al. 2017 [10] studied the ability to remove nutrients, organics, and heavy metals from wastewater by mixture of Eichhornia crassipes and Typha angustifolia. The experiment was carried-out for physicochemical properties such as pH, temperature, Chemical Oxygen Demand (COD), Dissolve Oxygen (DO), Biological Oxygen Demand (BOD), Total Phosphate, Total Organic Carbon (TOC), Total Kjeldahl Nitrogen TKN, nitrate, nitrite, conductivity, and heavy metals (lead, cadmium and zinc) concentrations. After 7 days, AP treatment showed that the turbidity was decreased by the root zone. 91% of BOD was reduced over 21 days. Both plant showed similar amount of accumulation also showed similar hydrogen content nearly 6% and carbon content nearly 35%. The accumulation of zinc was high followed by cadmium followed by lead. Due to high calorific value of Typha angustifolia, it can be used as energy sources.

Tarek M. Galal et al. 2017[11] investigated the potential of P. stratiotes for bioaccumulation and rhizofiltration of heavy metals from water. The plant mean shoot to root biomass was 10. The phsico-chemical analysis of sample was done monthly in pH, DO and temperature. Highest pH i.e. 8.18 and DO 12.5mg/l was observed during May whereas highest temperature 34.6 0 C and lowest water level 49.4 cm during June. High value of salinity 42.8mS/cm was reported during January whereas the lowest value was 3.3mS/cm in November with high water level 180.9cm. It was reported that the concentrations at the shoot in the plant follows the order: Cadmium (Cd) > Cooper (Cu) > Cobalt (Co) > Zinc (Zn) > Nickel (Ni) > Manganese (Mn) > Lead (Pb) > Iron (Fe) > Chromium (Cr) whereas at the root level follows the order: Cd > Cu > Co > Ni > Zn > Pb > Cr > Mn > Fe. It was also found that the BCF was greater than 1000 except Chromium and lead. The translocation factor did not exceed one except lead and cooper. The rhizofiltration potential was greater than 1000 for iron and 100 for chromium, lead and copper. The positive correlation between iron and copper in sample water with the plant with high value of BCF and Rhizofiltration potential was observed. It was also reported that the P. stratiotes showed high potential for removal of toxic metals.

MATERIALS AND METHODS

Preparation of the Plant

Water hyacinths were used for this experiment were harvested from Power channel, Burla, Sambalpur, India. These plants were cleaned with distilled water for 5-7 times to remove the dirt.

Experimental setup

For controlled condition, containers with 20 mg/l concentration of copper were prepared. Water hyacinths were introduced to the sampled water. Second setup was done by adding 1mg/l EDTA to the water. The water concentration was recorded in every 3 days for 12 days.

CALCULATION OF BIOACCUMULATION KINETICS

The heavy metals kinetics in the whole plants was calculated by measuring the concentration in the water. The observed value was the put into the first order kinetic equation. [9]

$$k = \frac{2.303}{t} \log \frac{Co}{Ct}$$

"Co" is the initial heavy metal concentration in the water, "Ct" is the heavy metal concentration in water at time "t," and "k" is the first order rate constant and "t" is the time in days.

Also uptaking factor was also calculated by the comparing the concentration.

RESULT AND DISCUSSION

The water concentration was calculated in every 3 days for 12 days. Two procedures were followed for calculation of concentration that is titration and colorimetric test.

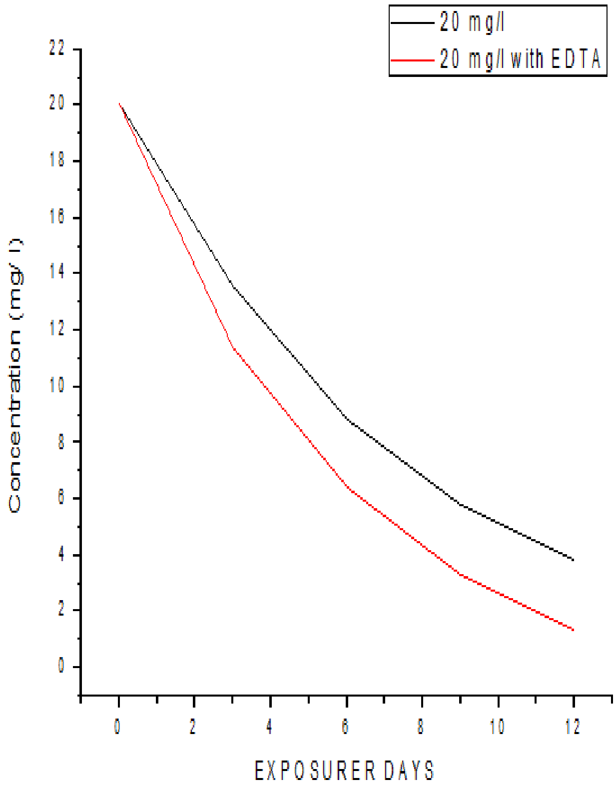

Fig. 1 *Removal of copper by Water Hyancith in 12 days*

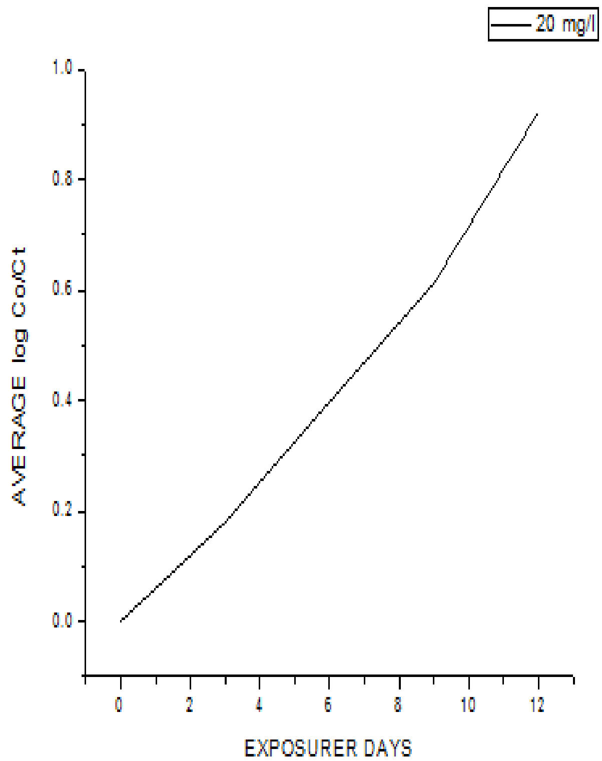

Fig. 2 *Toxicokinetic Study of Bioaccumulation of Cu at Different Duration of Exposure with 20 mg/l.*

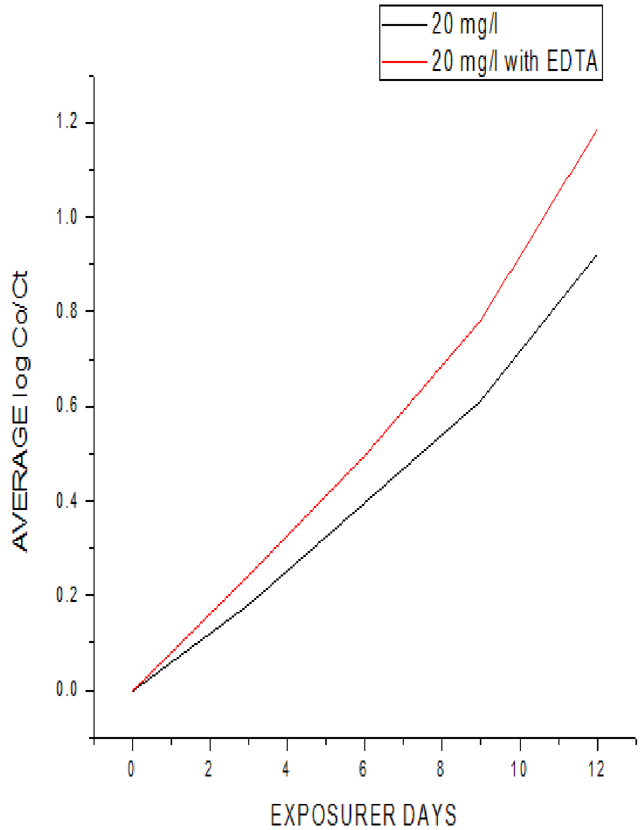

Fig. 3 *Toxicokinetic Study of Bioaccumulation of Cu at Different Duration of Exposure with 20 mg/l with EDTA.*

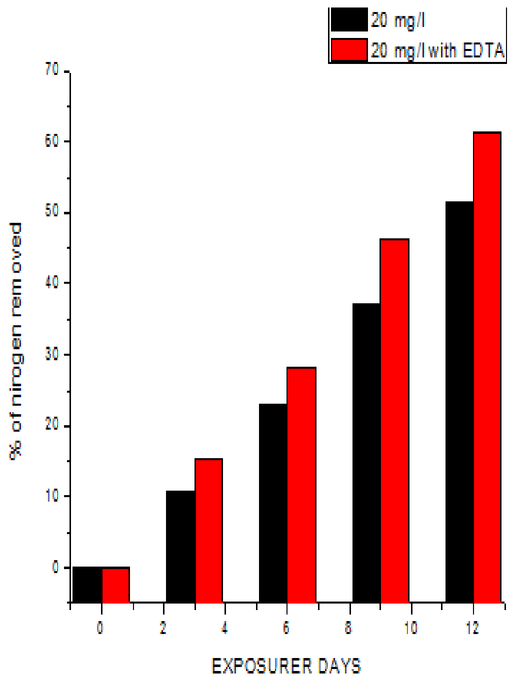

Fig. 4 *Percentage nitrogen removal at different duration with 20mg/l without and without EDTA.*

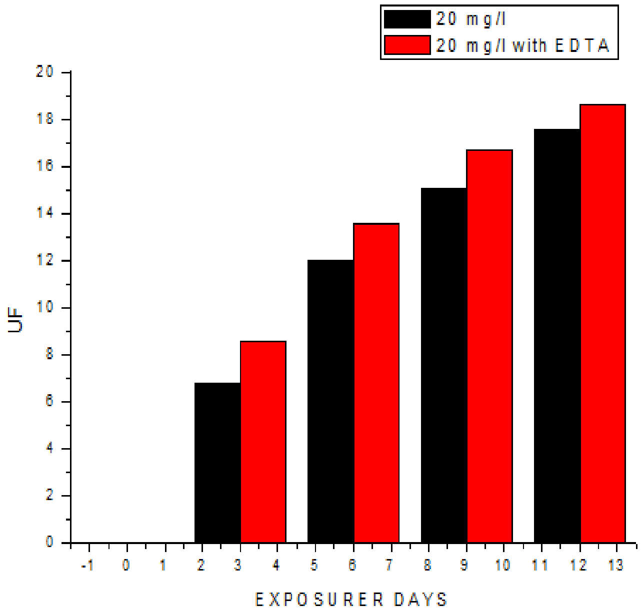

Fig. 5 *Uptake factor of Cu at different duration of exposure with 20 mg/l .*

Average log (Co/Ct) values observed that bioaccumulation in the water hyacinth of Cu increased steadily with days of exposure. The copper accumulation varied from 0.4mg/l to 17.99 mg/l. There is a remarkable increase in uptake factor when exposed to EDTA. Chelating agent (EDTA) increases the removal process and also accelerates the uptaking capacity of the water hyacinth. It was also found that when the copper concentration was more than 500 mg/l the plant can survive for more than 5days. It was also observed that the nitrogen was removed at favorable pH due to biofilm. The organic and inorganic contaminates was removed to great extend.

CONCLUSION

By using Phytoremediation technology for removal of heavy metal, seems effective way for cleaning contaminated region.. It is more advantages when compared with other commonly used conventional methods. Some convention method makes water more acidic and produces huge amount of sludge.[12] By the method the heavy metals can be removed up to 90%. It can also reduce electrical conductivity, TDS, BOD etc. By this technique the heavy metals can be easily extracted than any other conventional methods. This method is eco-friendly and economic than any method. Phytoremediation proved to be advance and low-cost treatment which can remove sediments, organic and inorganic contaminate. By this technology the water quality can be improved.

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