Heavy Metals Removal from Wastewater using Aquatic Plants

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Abstract— Water pollution is the serious issue. In last some decade, a lot of or so many resources has been done on the potential of aquatic plant for pollutants removal. Aquatic plants successfully used for wastewater treatment. It is very useful to removing pollutant like heavy metals, suspended solids, BOD, and organic matters. This paper has been mainly focused on the removal of heavy metals from waste water using aquatic plant. Aquatic plant could grow in sewage; they absorb and digest the pollutants in waste water, thus diverting sewage effluents to clean water. Thus, the plant or set up is a natural water purification system, which can be stabilized at a fraction of the cost of a conventional sewage treatment facility.

Key words: Macrophytes, Absorption, Adsorption, Heliophytes, Phyto-Extraction, Bioaccumulators

I. Introduction

Pure water problem has been increases all over the world and lot of country may remain by water around 2025 'Ref [17]'. Water scarcity becomes more important when recognizing that the surface water pollution is a worldwide problem 'Ref [18]'. To handle these problems, several measures for sustainable water resources utilization has been developed, of which reuse of waste water is currently one of the top priorities 'Ref [14]'. Domestic and industrial discharges are me surely two causes of metals in the water environment 'Ref [4]'.

At low concentration, the presence of heavy metals in water is very toxic and harmful. Pollution of biosphere with toxic metals has accelerated dramatically since the beginning of industrial revolution. An aquatic plant, water hyacinth (Eichhornia crassipes) which could successfully use for remove pollutant from water thus has great importance in waste water treatment. It has a huge potential for removal of the pollutants from waste water 'Ref [3]'.

II. Research Significance

This research paper is focused on study the capacity of water hyacinth in removing dissolved solids, heavy metals mainly chromium and copper from waste water, BOD to achieve this objective, this aquatic plant was grown in synthetic waste water prepares by adding varying concentrations ions of Cr and Cu. The concentrations of heavy metals, pH, BOD and TDS were noted in the waste before and after cultivating aquatic plant and compared the result with standard values.

III. Literature Review

Any water could be waste that has been adversely affected in quality. It comprises liquid waste discharge by agriculture, industry, domestic, residence, commercial properties and can encompass a wide range of potential, contamination and concentrations 'Ref [9]'. Retreated waste water can be again use as drinking water in industry and in the rehabilitation of natural ecosystem 'Ref [15]'.

After that the nature has a fantastic capacity to deal with waste water even pollution with trillion of gallons of polluted and dirty water, it can not to do work alone. There are many sciences for waste water treatment that can help in preserving the physical, chemical and biological integrity of water but the efficient and ecofriendly methods lacked in this regards.

A. Ecological Factors

Our earth and environment has its own capability of resource recovery and reuse. As like nutrients in nitrogenous and phosphorus waste water compound are recycled into usable biomass by means of the ecological food chains functioning in aquatic.

Aquatic plant could grow best in warm waters rich in micronutrients. 4 to 10 pH value is very suitable for aquatic plants. This important characteristic enables eichhornia crassipes to treat different types of waste water. 27-30C is the optimal temp for growth the aquatic plant. Optimal air temp is 21-30C. If its plan in colder climates then it would be necessary to build green house for maintaining optimal temp for plant growth and development. Water hyacinth also needed low air humidity from 15% to 40% for undisturbed growth.

B. Water Hyacinth

1) Taxonomy

Division	Magnoliophyta
Order	Pontederiales
Family	Pontederiaceae
Genes	Eichhornia
Super order	Commelinanae
Subclass	Commeinidae
Class	Lilioprida

Table 1: Taxonomy

Water hyacinth which name eichhornia was derived from well-known 19th century politician J.A.F eichhorn "Ref[8] which is fast growing perennial aquatic macrophyte. It having too fast reproduction potential and plant have tendency to double the own population in only twelve days. Its known for ability to grow in severe polluted water. E. crassipes is well studied as an aquatic plant that can improve the effluent quality from oxidation ponds and as a main component of one integrated advanced system for the treatment of municipal agriculture and industrial waste water "Ref[6]".

C. Morphology

Eichhornia is an aquatic vascular plant with rounded, upright and shiny green leaves and lavender flower similar to orchids. Each one carried six to eight spirally arranged succulent leaves that are produced sequentially on a short vertical stem. Petioles are bulbous and spongy with many air spaces which allow plants to float on a water surface "Ref.[6]"

Top petal has gold yellow spot bordered with blue line root system of water hyacinth is dark blue in color with numerous stolons. Measured from flower top to roof top E. crassipes usually reach the height of 1.5 m and more. When grown in waste water, the hyacinth is smaller and it often reaches heights no more than 0.5-1.2 m. Growth of water hyacinth is primarily dependent on the ability of the plant to use solar energy, nutrient composition of water, culture methods and environmental factors. Plant growth is described in two ways, firstly by reporting the percentage of water surface covered of a period of time and second is more useful method is by reporting the plant density in units of wet plant mass per unit of surface area.

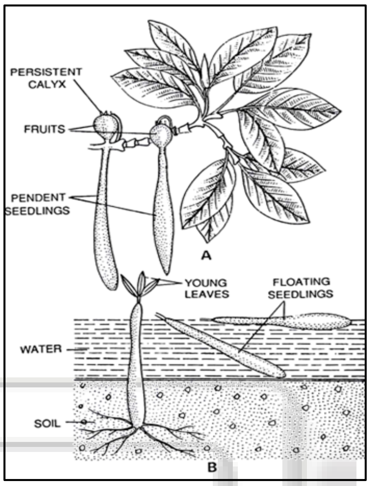

Fig. 1: Morphology of Water Hyacinth

Water hyacinth is mainly reproduced by generative means in its natural habitat and it produces large no. of seeds. The flowering period lasts for about fifteen days. When under the water surface and seeds are released directly into the water. Each inflorescence contains normally 1 to 20 seeds capsules and capsules caries 3 to 250 seeds. In spite of the production of this large number of seeds there are only 3 to 3.4 seeds per plant each year that could eventually able to germinate.

D. Effects of Heavy Metals

There are great concern of biotoxic effects in human biochemistry. The term “Heavy metals” is defined as the metallic element that has a relatively high density and is toxic or poisonous even at low concentration. Heavy metals are enter in human body through food, water, air and bio accumulate over a period of time “Ref [10]”

Heavy metals include cadmium(cd), zinc(Zn), lead(Pb), mercury(Hg), arsenic(As), silver(Ag), iron(Fe), copper(Cu), chromium(Cr) and the platinum group elements “Ref[11]”. If heavy metals concentrations will rise in drinking water then it will be effect on human health. Higher dose of heavy metals are causes of anemia, liver and kidney damages and can even damages circulatory and nervous systems “Ref[7]”.

E. Mechanism of Waste Water Treatment using Water Hyacinth

Water hyacinth uptake contaminants and store in its biomass. These plants are called bioaccumulations as they accumulate the contaminants in their tissue “Ref[5]”. They have high tolerance against contaminants like heavy metals from polluted water bodies is called phyto extraction. The uptake of contaminants is by three methods:-

1) Root Absorption

Water hyacinth has capability to grow quickly and can be harvested to provide rich and valuable compost. Water hyacinth has also been used for the removal or reduction of nutrients, organic compound, heavy metals and pathogens from waste water.

The roots absorb water together with the contaminants in water. That aquatic plant roots having the carboxyl groups induces a significant cation exchange through cell membrane and this might be the mechanism of moving heavy metals in the root system where active absorption take place. The root structure of water hyacinth or other aquatic plant optimum surface and living atmosphere for suitable environment for aerobic bacteria to function. Aerobic bacteria feed on nutrients and produced inorganic compound which in turn provide food for plants.

2) Foliar Absorption

In addition to root absorption, plant could also derive low amounts of some contaminants through foliar absorption. They are passively absorbed through stoma cells.

3) Adsorption

The fibrous and feathery roots not only trap suspended solids and bacteria, but provide attachment sites for bacterial and fungal growth. The contaminants get absorbed to the root surface by the bacteria present there. It is also due to ionic imbalance across the cell membrane.

IV. SET UP OF EXPERIMENTS

Water hyacinth had been collected from three different local ponds. The experiments were conducted in tank as well as in jars. This was done in order to find out the efficiency of the plant in removing the pollutants when they were used as single plants in jars and also when they are used collectively in tanks.

A. Aquatic Plant Grown in Tank

A natural wet land was simulated in an RCC tank in which the water hyacinth was grown. A tank size 3.5×3×1 m having capacity of 10.5 m3 will be constructed. The tank was filled with 9000 liters of water. Then the water hyacinth collected was grown in the tank.

Fig. 2: Aquatic Plant Grown in Tank

B. Water Hyacinth Grown in Jars

Eight quart size jars will be needed the capacity of 1.5 liter of water containing chromium (2ppm) and copper (6 ppm). The jar with Cr and copper were then sorted separately into four treatments with two jars in each treatments. The sample collected were placed in three of the four treatments and two jars without plants as controls as shown in Fig-3 and Fig-4

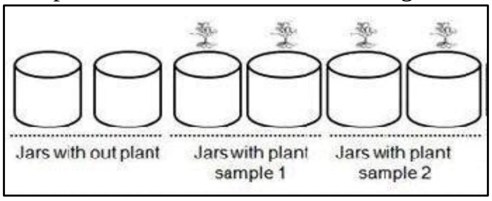

Fig. 3: Experimental Set Up

The changes in pH, Cr, Cu, TDS and BOD concentrations were found out at regular intervals using APHA methods. The standards procedure was carried out with known concentrations of Cu & Cr.

Fig. 4: Experimental set up

V. Results & Discussions

The experimental results of various tests conducted are shown below-

Cr(ppm)	BOD	Cr	TDS	pH
0.03	4 mg/l	0.08 ppm	89 mg/l	7.5

The results given in above table showed that the quality of the water sample collected is within the WHO standards. So the study was carried out by adding known concentrations of heavy metals i.e 2 ppm of Cr & 6 ppm of Cu.

A. *Results of the Experimental Carried out with Chromium in the Tank*

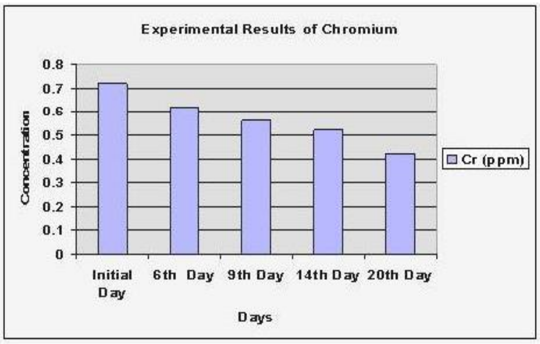

Fig. 5: Variation of Chromium Concentration in the Tank

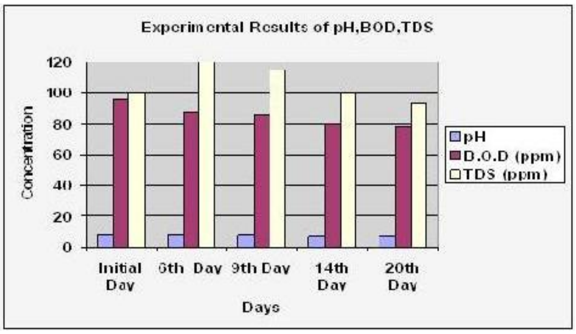

Fig. 6: Variation of pH, BOD, TDS in the Tank

Results of copper in tank.

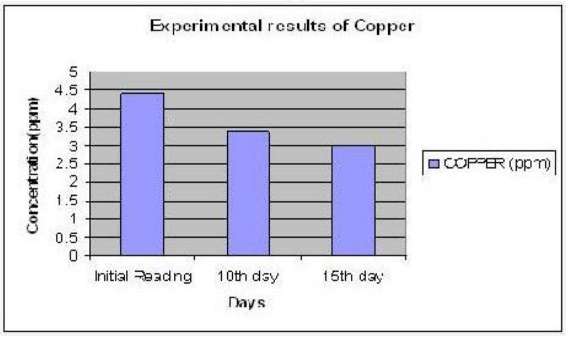

Fig. 7: Variation of Copper Concentration in the Tank

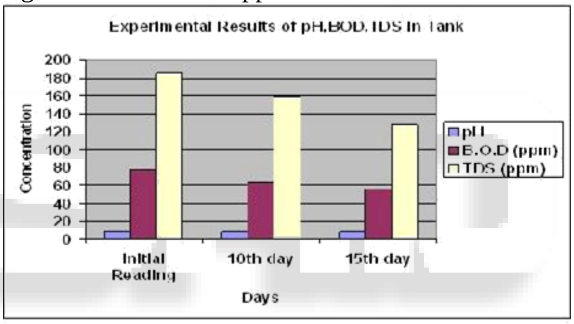

Fig. 8: Results of pH, BOD, TDS in Tank

Results of experiments carried out in jars with Cr.

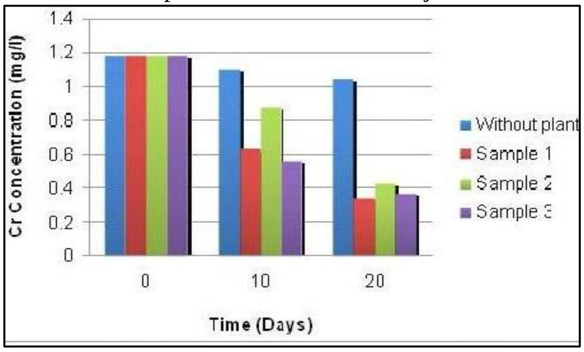

Fig. 9: Results of Chromium

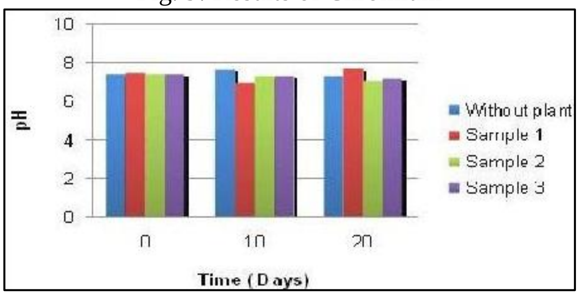

Fig. 10: Results of pH

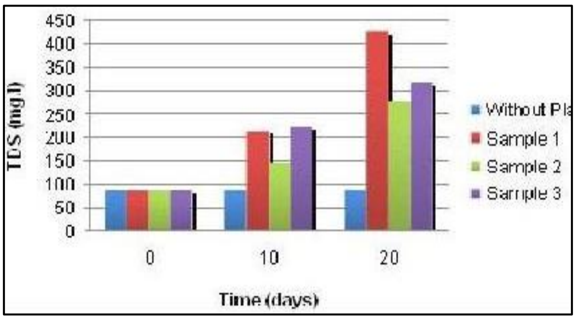

Fig. 11: Results of TDS

Results of experiments carried out in jars with copper.

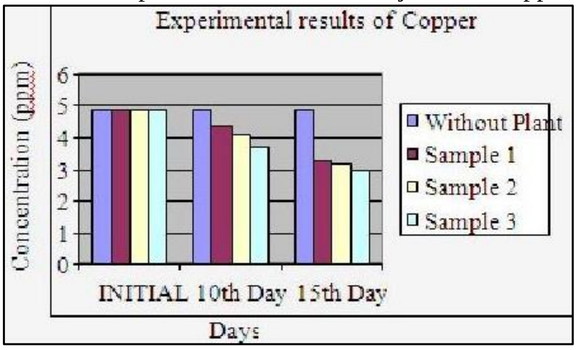

Fig. 12: Results of Copper in Jars

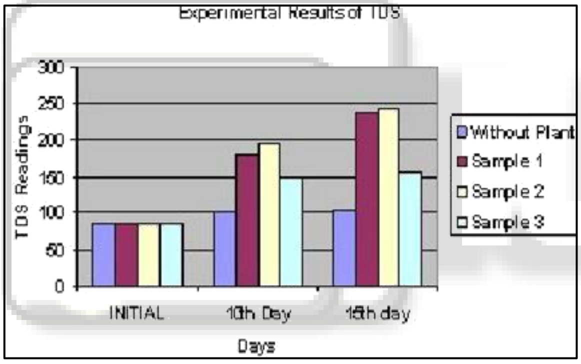

Fig. 13: Results of TDS

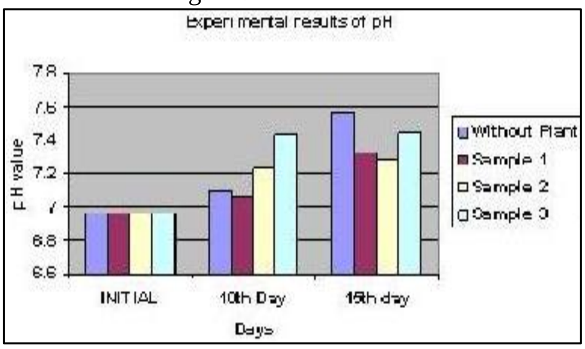

Fig. 14: Results of pH

B. Discussions

Results are carried out in the tank showed, the plant have the capability to absorb heavy metals Cr and Cu from the wastewater. The TDS value increased on placing the plants in the tank. It will be increases due to the presence of clay or other fine particles, which was present in plant roots. On day to day passed, it showed that the TDS value considerably decreased by accumulation process of water hyacinth. There was decrement in BOD also. The jars with plants showed a considerable reduction in Cr and Cu concentrations. For jar without plant, the decrease of Cr and Cu concentrations was found to be very less. Thus we could that loss due to evaporation and settlement was very less. There was no much change for pH. The value of TDS was found increasing. This may be attributed to the decay of the single plant growing in the jar with high Cr concentrations contributing to TDS content. The pH value was found to be between 6 and 8. The further collected result indicated that water hyacinth could use as an effective means for the removal of heavy metals from wastewater. Efficiency of heavy metal removal id more, if the used collectively as done in the RCC tank.

VI. CONCLUSIONS

The effectiveness of waste water treatment was defined in terms of variations in pH, BOD, TDS and heavy metals before and after treatment. It is seen, as the removal of pollutants from the water was very high if plant were collectively grown. After experimental thesis it concludes that about 65% removals of heavy metals could be achieved by water hyacinth. The plant has also got the capacity to convert the accumulated biomass into biogas. As the angle of cost can say that treatment was cost effective since cost of installation and maintenance was very low. This system could be provided alone or together with other systems used for treating wastewater. At last, the present investigation demonstrated the feasibility of adopting a “sustainable and eco-friendly” approach to sewage wastewater treatment using aquatic plant eichhornia. Since it was only a laboratory scale base – line study, further investigations should be carried out in future on a large scale particularly focusing on phyto-remediation and resource utilization.

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