ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Phyto-remediation of urban lakes in and around Chennai

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ABSTRACT

Phyto-remediation is an environmental friendly technique which uses plants to improve the condition of the contaminated ecology by absorbing the contaminants. In this research, we have used Water Hyacinth to remediate the waters of Ambattur, Retteri and Korattur. The removal of Lead (Pb), Copper (Cu), Cadmium (Cd) and Iron (Fe) is examined through a model system. These heavy metals were chosen due to their repercussions under high concentration. Batch treatment method is adopted and assessed for 4 weeks. The parameters are tested using Atomic absorption spectroscopy equipment and the results are compared. The results obtained show that water hyacinth is efficient enough in removing almost 95% of harmful heavy metals from urban lake sample.

Key words: Green techniques, Phyto-remediation, Water, Plants, Urban lakes, Pollution

INTRODUCTION

Water is one of the most important constituents needed by living organisms for their day-to-day survival. Even though water is present abundantly on the earth, only 2.5% of it is available to us as freshwater. One of the most important sources of freshwater is lakes which are getting highly contaminated due to increasing urbanization, rapid industrialization and intensification of pesticides in agricultural activities using pesticides. The pollutants are commonly removed through chemical precipitation, reverse osmosis and solvent extraction. These techniques have disadvantages such as incomplete metal removal, high reagent and energy requirements, generation of toxic sludge or other waste products that again require further treatment if required necessary. The search for alternate and innovative treatment techniques has focused attention on the use of biological materials for heavy metal removal. Such a treatment method is Phyto- remediation. It is the use of plants and trees to clean up contaminated soil and water. Plants can break down, or degrade organic pollutants or stabilize metal contaminants by acting as filters or traps. Qin Lu (2009) evaluated the efficiency of phyto-remediation in removing Nitrogen, Phosphorus and other heavy metals from storm water in detention ponds. The plants used were water lettuce and common salvinia. Turbidity, total solids and nutrient concentration were reduced by a large percentage. Hari Priya Naidu et.al (2011) has concluded in her study that the level of contamination absorbed by the plant depends upon its absorption capacity. It can be limited due to the depth of the roots, solubility and concentration of the contaminants.

A comparative analysis was done by Moushumi Hazra et.al (2011) in which water samples from hospitals, domestic, steel, mining areas were collected and analyzed. The aquatic plants which were taken for the study were disease and drought resistant. It should also be chemical, insect and stress tolerant. The plants used for the study are generally responsible for the removal of nutrients such as COD, N, P, hydrocarbons and heavy metals. Sanniyasi Elumalai et.al (2011) studied the phyto- remediation of trace elements in natural and constructed wetlands. He made use of three species of water hyacinth in the selected three study areas. He proved that the species E-crassipes was a potential and promising species of water hyacinth which accumulated calcium, magnesium and chlorine.

Jaikumar.M (2012) created a wetland model and used water hyacinth as the main phyto-remediator for cleaning Velachery Lake in south Chennai. Siti Zubaidah Abu Kasim et.al (2013) considered three study areas which were highly polluted in Malaysia and applied phyto-remediation using water lily, water lettuce and common hydrilla. They created a model wetland and monitored the sample for 14 days. The aim of this project is to study the pollution of surface water resources and to reduce the contaminants present in the water sample from selected study areas. Water hyacinth is chosen as the main phyto-remediator for this experiment. Batch treatment method is opted and the results are compared.

MATERIALS AND METHODS

Study area: Three study areas were selected based on the level of contamination and their importance. They are Ambattur, Korattur and Retteri lakes which are shown in Fig. 1. Due to the growing industrialization in Ambattur area, there is a rising level of contamination in the lake which affected the local ground water table. This had a sequential effect on Korattur and Retteri respectively. The samples were collected from the respective areas whose location details are shown in Table.1.

TABLE I
COORDINATES OF SELECTED STUDY AREAS

Lake	Sample 1	Sample 2
Ambattur	Avapakkam housing board (13.105139, 80.143093)	Gandhi Nagar (13.11118626, 80.1432681)
Korattur	Madananluppam (13.128041, 80.187363)	Vallalar street (13.133543, 80.191435)
Retteri	Kathiravadu (13.146819, 80.205819)	Retteri Junction (13.13117, 80.213333)

Fig.1.Location of selected study areas

Fig.2.Ambattur

Fig.3.Korattur

Fig.4.Retteri

Sampling method: The samples were collected from two different places in each site. Two five litre sterilized and clean bottles were used and labelled to identify respective samples. The samples were taken from stagnant waters near the banks which were accessible as shown in Fig.2, Fig.3 and Fig.4. Water Hyacinth plant was also collected from the respective sites. The plants were half submerged in the water. The roots were washed clean, stored in the special containers and carefully transported back. The samples were stored at 4˚C in refrigerator in a controlled manner.

Initial testing: The samples were immediately tested to find the initial parameters like pH, total dissolved solids and turbidity in the laboratory using high resolution digital instrument. The heavy metals were tested using Atomic absorption spectroscopy (AAS) which are tabulated in Table II. Physical examination of the samples were also analyzed and explained as follows,

1) Ambattur Lake: This was the most turbid sample, but odour was less and the color was white.

2) Korattur Lake: This had less turbidity with no odour. Color was normal.

3) Retteri Lake: It had medium turbidity with high stench and the color was brownish.

Experimental setup: Batch treatment method was adopted in which the two samples taken from each lake was mixed and kept in a container with the plant as shown in Fig. 5. Five litre of the sample was used initially for each plant. Favorable conditions for the plant growth were created and the growth was monitored.

TABLE II
INITIAL PARAMETERS OF THE SAMPLES

Parameters	Ambattur	Korattur	Retteri
pH	7.05	8.23	8.6
TDS (ppm)	666	732	864

Fig. 5. Setup of plants by batch method

Parameter study: Periodic monitoring was done to find out the effect of Water hyacinth on the heavy metals contained in the sample. The samples were analyzed every week for 28 days. Lab tests were done for pH and TDS.

Metals remained in the water sample was measured. Heavy metal analyses were performed on an Atomic Absorption Spectrophotometer. Operational conditions were adjusted to yield optimal determination.

RESULTS AND DISCUSSIONS

The results are depicted diagrammatically using bar charts which were prepared separately for each metal with time element (weeks) in x axis and percentage removal in y axis. The comparison is done between the three study areas for each metal. The level of copper, lead and cadmium has decreased greatly to 95% as shown in Fig.6, Fig.7 and Fig.8 and the level of iron has gone down up to 75% in all three study areas as shown in Fig.9. Lead has been almost completely removed in Ambattur and Retteri lake samples. The highest removal (>95%) of the heavy metals was observed after 28 days from the commencement of the experiment. It is known that plants need small amount of cadmium for stimulating plant growth but provided in excess may prove to be lethal. Iron is one of the most important micro nutrients needed by the plant for the formation of chlorophyll. Copper is yet another nutrient needed by the plant for the production of proteins. It also plays an important role in the process of reproduction. Lead absorbed by plants does not get stored in fruits or vegetables. It is mainly accumulated in the leaves. However the risk of lead poisoning still prevails. Most of the risk arises when the concentration of the lead is above 300ppm. The strong stench of the water has disappeared and the color is more stable.

Table.3.Final parameters of the sample

Parameters	Ambattur	Korattur	Retteri
pH	9.21	9.22	9.2
TDS (ppm)	168	160	174

CONCLUSIONS

Phyto- remediation is a green technique which is more cost effective since it uses locally available plants and easy to maintain. It doesn't need any high initial costs. Plants being natural remediators do not induce any side effects like toxins, chlorine and sludge waste to the water body. It doesn't need any external energy resource like electricity or fuel. The removal of the contaminants does not affect the urban eco-system as the process is biological in nature. Moreover there is a chance of extracting the metals absorbed by the plants and can be reused.

However the treatment is limited due to the surface area and the depth of roots. Long period is needed for observation of results and it requires proper biomass rate, hence long time commitment is necessary. The plants cultivated for the treatment can also provide aesthetical improvement by proper landscaping and the areas can be used for recreational purposes.

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