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International Letters of Chemistry, Physics and Astronomy

11(3) (2014) 214-222 ISSN 2299-3843

Photochemical studies of *Eichhornia crassipes* (Water Hyacinth)

Amrita Ratan, V. N. Verma*

Department of Chemistry, Faculty of Natural Sciences, University of Guyana, Turkeyen Campus, Georgetown, Guyana, South America

*E-mail address: professorverma@ymail.com

ABSTRACT

Eichhornia crassipes is a floating macrophyte. It is capable of assimilating large quantities of toxic metals, some of which are essential for plant growth. Water Hyacinth grows rapidly in water with a high level of nutrients like nitrogen and phosphorous. The plants have been shown to absorb trace elements such as Silver (Ag), Lead (Pb), Cadmium (Cd) and Copper (Cu) reported by Lu et al [1]. The purpose of this study is to determine the distribution of heavy metals in different parts of the Water Hyacinth . Such a detail study has been taken for the first time. It is expected that the metal distribution within the plant species would be a representation of the concentration and distribution of the water in which it is found. Plants have the ability to accumulate non-essential and essential trace elements and this ability could be harnessed to remove pollutant metals from the environment. Aluminum, cadmium, calcium, copper, iron, lead, magnesium and zinc have been found in different amounts in roots, stems , leaves and flowers.

***Keywords*:** Water Hyacinth; *Eichhornia crassipes*; AAS; Elements; Metals

1. INTRODUCTION

The industrial revolution releases large quantities of toxic metals into the water ways and soil through the depositing of waste water into natural water ways. In addition, the road ways and vehicles became contributing factors of toxic metals. Iron, Copper, and Lead are three of the most common heavy metals released from road travel, accounting for at least 90 % of the total metals in road runoff. The release of these heavy metals in large quantities from factories, dump sites, automobile repair shops to name a few may, damage or alter both natural and man-made ecosystems reported by Lui and Krustrachu [1].

Metals are natural components of the Earth's crust which cannot be degraded or destroyed easily. They enter our bodies through food, drinking water and air. Toxic metals are dangerous in that they tend to bio-accumulate that is they increase in concentration over a period of time in a biological organism whether plant or animal. Excessive accumulation in animal and plant tissues can lead to death of these organisms due to high toxicity, as well as severely affecting humans who consume them and may even result in fatalities. They may suppress the immune system, leading to increased susceptibility to disease while some may be carcinogenic reported by Mason [2].

A variety of methods are applied to remove toxic metal ions from waste water, mostly chemical methods including chemical oxidation and some electrochemical applications *Eichhornia crassipes* is a floating macrophyte whose appetite for nutrients and explosive growth rate has been put to use in cleaning up municipal and agriculture wastewater (Lu, et al. [1]). It is a fast growing, free-floating aquatic weed. It is capable of assimilating large quantities of toxic metals, some of which are essential for plant growth. The uptake of these elements is often increased when plants are cultured in wastewater containing high levels of macronutrients. It has clusters of violet and yellow flowers, surrounded by dark green bulb like leaves which act as a float. Water hyacinth grows very rapidly in water with a high level of nutrients like nitrogen and phosphorous.

Fig. 1. Water Hyacinth plant with leaves and flowers.

The purpose of this study is to determine the distribution of heavy metals throughout the various parts of the Water Hyacinth (*Eichhornia crassipes)* such study has been taken for the first time. It is expected that the metal distribution within the plant species would be a representation of the concentration and distribution of the water in which it is found The study will also offer a better understanding of the facts about toxic metal pollution from Industrial and Municipal discharge so that more appropriate actions can be taken to reduce such emissions, and in doing so, reduce the risks associated with these metals. Plants have the ability to accumulate non-essential elements and essential trace elements of Cu, Zn, Fe and Se, and this ability could be harnessed to remove pollutant metals from the environment [1].

Some of the more prominent heavy metals that constitute wastewater are Lead (Pb), Zinc (Zn), Iron (Fe), Copper (Cu), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Aluminum (Al), Nickel (Ni), Mercury (Hg) and Manganese (Mn). These metals are non-biodegradable and tend to bio-accumulate in the body tissues of living things. Heavy metals as trace elements are needed by the body but in large quantities, they lead to poisoning [3].

The mechanism by which the plants absorb the metals is a simple, yet interesting one. The heavy metal ions all have positive charges and the roots of plants are negatively charged, this difference in charges causes an attraction between the ions and the roots, and thus the ions are absorbed into the plant. Ghosh et al. [4] acknowledged that fast growth rates and high plant density (biomass) account for significantly higher rates of phytoaccumulation of the heavy metals. Heavy metals are basically elements that have a relatively high density and are toxic even at very low concentration. They are found both from natural and man-made sources all around us. They tend to increase in concentration with time despite the low concentrations which they may have been expelled into the environment from their source of origin [5].

2. EXPERIMENTAL

2. 1. Methodology

Samples of similar sizes were collected and rinsed with DI distilled water and then stored in plastic containers that were pre-rinsed with conc. Nitric acid. These samples were collected from both upstream and downstream

Prior to collection of samples from areas of interest a few saplings were placed in tanks containing deionized water. These were to be used as blanks. The stems were cut a few inches away from the root prior to being placed in a tank of water. They were given essential nutrients which included Nitrogen, Phosphorous and Potassium to ensure growth and placed in a cool area where they had access to sunlight and were subsequently monitored from a period of three weeks.

Samples and blanks were washed with another portion of Deionized-distilled water and then separated into leaves, roots, shoots and flowers. They were separately dried at 105 C until a constant weight was recorded. This was done to remove all moisture. They were then ground into a fine powder by use of a pestle and mortar.

0.5 grams of ground sample was weighed in a 100 milliliter beaker to which 3 milliliters of 75 % nitric acid and 1 milliliter of 35 % hydrochloric acid were added. The mixture was then heated at 70 degrees until a light colour was noted. The sample was then filtered into a 50 milliliter standard flask and the 100 milliliter beaker washed with two portions of 5 milliliter deionized-distilled water.

The mixture was allowed to cool to room temperature and made to mark with deionized-distilled water. The mixture was then mixed thoroughly by inverting and a metal scan conducted by use of an Atomic Absorption Spectrophotometer. Flame atomic absorption is a very common, simple and reliable technique for detecting metals in environmental samples. The technique is based on the fact that ground state metals absorb light at specific wavelengths. Metal ions in a solution are converted to atomic state by means of a flame. Light of the appropriate wavelength is supplied and the amount of light absorbed can be measured against a standard curve.

The liquid sample was aspirated, aerosolized, and mixed with combustible gases, such as acetylene and air or acetylene and nitrous oxide. The mixture is ignited in a flame whose temperature ranges from 2100 to 2800 °C. During combustion, atoms of the element of interest in the sample are reduced to free, unexcited ground state atoms, which absorb light at characteristic wavelengths.

Table 1. Average of moisture contents in different parts of Water Hyacinth.

METAL	PLANT PART	ALUMINIUM	CADMIUM	CALCIUM	COPPER	IRON	LEAD	MAGNSIUM	ZINC
Location A (ppm)	Root	**8.23**	**8.15**	**5.21**	**8.43**	**197.15**	**89.95**	**9.35**	**0.09**
	Shoot	**2.38**	**3.36**	**2.18**	**6.43**	**2.22**	**9.80**	**1.74**	**0.06**
	Leaf	**0.48**	**1.34**	**1.24**	**7.81**	**1.56**	**9.82**	**1.69**	**0.00**
	Flower	**0.04**	**0.00**	**0.11**	**2.59**	**0.37**	**3.44**	**0.56**	**0.00**
Location B (ppm)	Root	**8.09**	**8.94**	**3.65**	**9.34**	**310.03**	**54.02**	**10.08**	**0.06**
	Shoot	**3.31**	**4.53**	**1.86**	**8.01**	**0.86**	**8.06**	**3.72**	**0.05**
	Leaf	**1.13**	**1.08**	**0.85**	**7.89**	**0.69**	**9.83**	**1.83**	**0.00**
	Flower	**0.00**	**0.04**	**0.00**	**1.87**	**0.00**	**4.16**	**0.51**	**0.00**
Location C (ppm)	Root	**9.57**	**10.02**	**6.18**	**10.52**	**426.32**	**78.21**	**10.17**	**0.64**
	Shoot	**2.41**	**3.25**	**2.36**	**6.74**	**4.25**	**8.64**	**3.42**	**0.08**
	Leaf	**1.06**	**1.36**	**1.64**	**7.92**	**1.48**	**7.23**	**1.05**	**0.02**
	Flower	**0.00**	**0.08**	**0.32**	**1.96**	**0.34**	**4.62**	**0.56**	**0.00**

Standards of several dilutions were made ranging from 0.5 ppm to 100 ppm. These standards were used to plot a calibration curve automatically. The samples were then checked against the calibration curve to determine the concentration of metals present.

The data were collected and analyzed. However due to limitations in the amount of AAS lamps available, the experiment was performed only for 8 metals, 2 of which were essential (Calcium, Magnesium) and 6 being heavy metals (Aluminum, Cadmium, Copper, Iron, Lead, Zinc). When the samples upstream and downstream were checked against the blank showed the blank having traces of Calcium, Aluminum, Cadmium and Copper. The blank also have surprisingly high concentrations of Iron, Lead and Magnesium.

The Water Hyacinth taken from all three sites was found to have an average of moisture content as shown in Table 1.

The concentration of the metal accumulated in the plant overall is a representative of the metal present in the wastewater and directly what metals are being disposed of in the water from its source. Iron and Lead are the two most common heavy metals from rusting parts of vehicles.

Table 2. Concentrations in different parts of the samples collected from different locations.

	PLANT PART			
	ROOT	SHOOT	LEAF	FLOWER
AVERAGE (%) MOISTURE	81	92	93	90

Table 3. Average Metal content in the Water Hyacinth (values in ppm).

Metal	**Root**	**Shoot**	**Leaf**	**Flower**	**Water**
Aluminum	17.26	5.4	1.78	0.027	5.98
Cadmium	16.3	7.42	1.78	0.73	4.23
Calcium	10.03	4.27	2.46	0.29	3.65
Copper	18.86	14.12	15.75	4.28	15.23
Iron	311.17	4.89	2.49	0.47	84.25
Lead	74.06	17.92	17.67	8.15	29.16
Magnesium	19.73	5.92	3.05	1.09	7.52
Zinc	0.53	0.13	0.00	0.00	0.237

3. RESULTS AND DISCUSSIONS

The accumulative pattern observed in the water hyacinth could have easily been the cause of an increase in biomass. The Stems of the water hyacinth are long and slender and as such provide an area where metal dilution into cells would be encouraged. Dilution in this sense suggest that the stem has more than enough cells to store the metal accumulated there and as such a small concentration is available to be translocated to the leaves and subsequently flowers. As a result some the metal concentration decreased upwards the anatomy of the plant. The solubility factor would also have contributed to this pattern. If the metal was in a form where it was insoluble and as such would have been bio-unavailable to the plant a less concentration would have been able to make its way up the plant. This is clearly illustrated from the values inserted in the line representing Lead on the Figure 2.

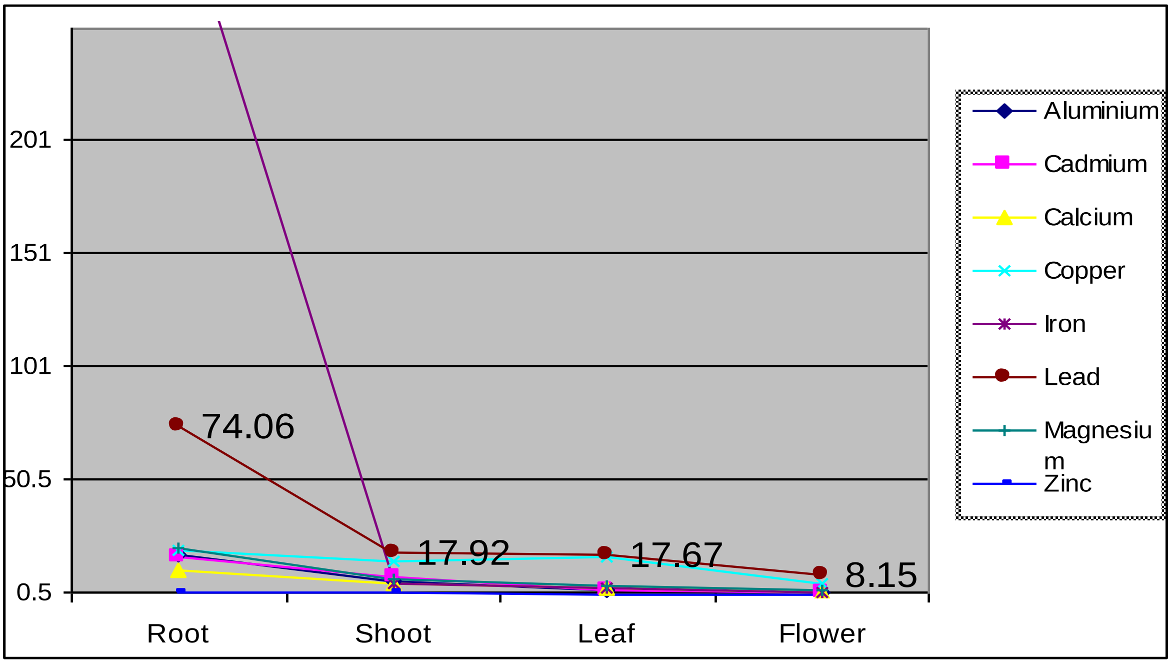

Fig. 2. Accumulative of metal pattern in the Water Hyacinth.

In comparing the total metal concentration in the waste water and the total plant a vast difference was noted. The metals had an accumulative ratio of 3:1 with respect to plant and waste water.

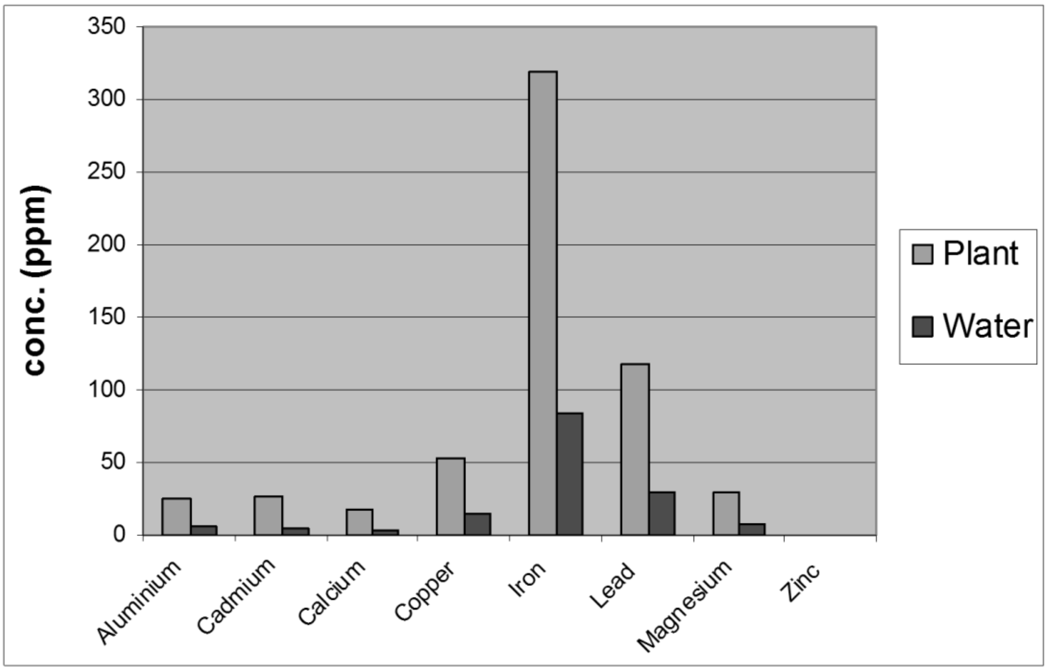

Fig. 3. Accumulative potential of the Water Hyacinth compared to the waste water.

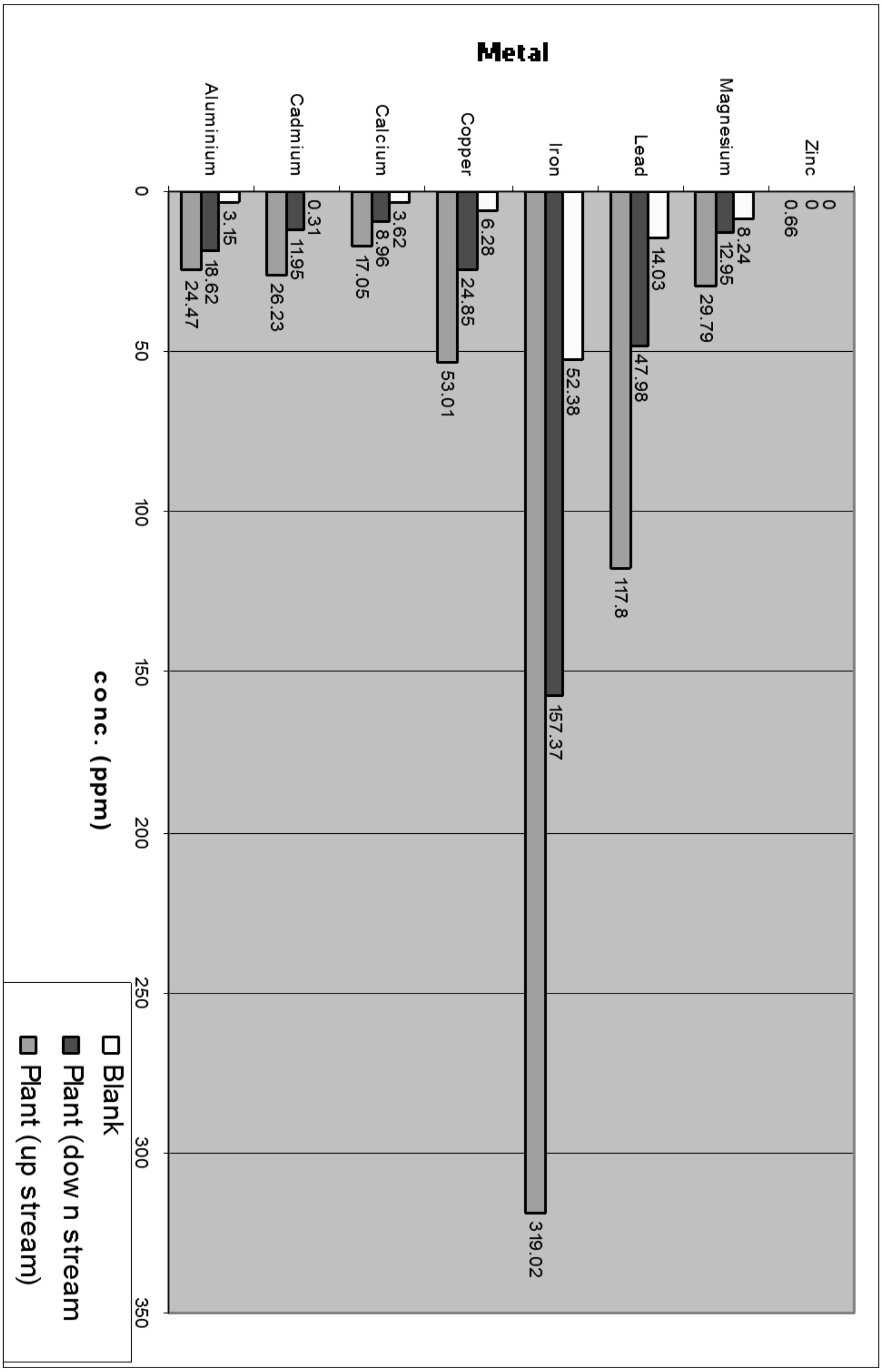

Fig. 4. Distribution of metals in the Water Hyacinth upstream and downstream and blank.

The variation in metal concentration upstream and downstream further strengthens the belief that the Water Hyacinth has accumulative potentials since it unequivocally represents a reduction in the metal concentration as the water flows through a few rows of free-floating plants. When these concentrations were compared to that of the blank it was found that the blank had surprisingly high concentrations of iron and lead.

The significance of the values obtained from the concentration scan can be determined from looking at the standard deviations calculated:

Table 4. Mean accumulative concentrations of the varying metals in the Water Hyacinth.

METAL	PLANT	
	MEAN*	STANDARD DEVIATION*
Aluminum (ppm)	6.12	7.76
Cadmium(ppm)	6.56	7.12
Calcium (ppm)	4.26	4.18
Copper (ppm)	13.25	6.29
Iron (ppm)	79.75	154.29
Lead (ppm)	29.45	30.08
Magnesium(ppm)	7.44	8.43
Zinc (ppm)	0.15	0.25

Since the standard deviations do not differ greatly from the mean the values obtained are relatively good representations of the population.

4. CONCLUSION

The Water hyacinth has the ability to absorb and accumulate almost three times the concentration of metals from surrounding contaminated water. These findings are of interest in relation to the treating of aquatic systems for the removal of heavy metal content as well as essential metals. Further it serves as a direct reflection of the metal composition of the water body in which it is found.

ACKNOWLEDGEMENT

The authors are grateful to Demerara Distillers Ltd to provide us the necessary facilities to run the samples on the Atomic Absorption Spectrophotometer .The samples were prepared in our Chemistry Lab.

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(Received 09 March 2014; accepted 14 March 2014)