Ex situ treatment of lead synthetic effluent to *Epipremnum aureum* macrophytes using Phytoremediation

M. Janani, M Dinesh Kumar, A. Sivalingam and M.Thirumarimurugan

***Abstract*— Lead is an environmental pollutant, toxic even at very low concentration. A bench scale experiment was conducted using Epipremnum aureum. Present study is to investigate the removal of lead from synthetic effluents. Synthetic effluent of various concentrations ranging from 10, 25, 50, 75 and 100 ppm were treated with Epipremnum aureum, at regular intervals 5, 10, 15, 20, 25 and 30 days samples were collected and analysed. Various parameters were estimated such as pH, Plant Relative Growth (PRG), Bioconcentration Factor (BF), Translocation Ability (TA), and Water Vaporization. Experimental results showed gradual decreases in pH from 7.66 to 4, Plant Relative Growth were increased in the range of 1.16, 0.60, 0.57, 0.31 and 0.09 grams for various concentrations 10, 25, 50, 75 and 100 ppm respectively. Accumulation of Heavy Metal in plant and water sample was analysed using Atomic Absorption Spectroscopy(AAS), less amount of heavy metal have been transformed from root to the various part of the plant system. The maximum amount of heavy metals uptakes were found in the root system.**

***Index Terms*—Atomic Absorption Spectroscopy, *Epipremnum aureum*, lead.**

I. INTRODUCTION

Contamination of the aquatic environment by the heavy metals is a serious environmental problem, which threatens aquatic eco system, agriculture and human health. Recent research groups have recognized that certain toxic metals may remains environment for a long period and can eventually bioaccumulate to higher levels that affect human being [1]. Heavy metals i.e., Cd, Pb and Ni etc., are necessary for plant growth, however they are passionately taken up and accumulated by plants up to certain levels [3]. Conventional metal removal and mobilization techniques include sedimentation, adsorption, reverse osmosis, ion exchange electrolysis etc., Most of the technologies are quite costly, energy intensive and metal specific. Considering the importance of soil, various techniques, such as excavation, solidification and bioremediation have been used to decrease the impact of contaminants on the soil environment [4]. Comparatively, operations based on biological processes are considered to be more efficient, less costly and the least invasive, related to the degradation of organic compounds in soil [5]. Aquatic macrophytes have enormous potential to accumulate heavy metal inside their body from the liquid environments. Therefore macrophytes have been used for heavy metal removal of contaminated water bodies. A plant is said to be a hyperaccumulator if it can concentrate the pollutants in a minimum percentage which varies according to the pollutant involved. This capacity for accumulation is due to the adaptative evolution of the plants to hostile environments through many generations [6].

Plant used in the present study is Epipremnum aureum available at every place. E. aureum is an evergreen plant growing to 20 m (66 ft) tall, with stems up to 4 cm (2 in) in diameter, climbing by means of aerial roots which adhere to surfaces as well as in water. The plant was used in aquariums, placed on top of the aquarium and allowed to grow roots in the water. This is beneficial to the plant and the aquarium as it absorbs many nitrates and uses for growth. E. aureum used is to treat lead contamination.

Manuscript received April 21, 2015.

M. Janani, Department of Chemical Engineering, Coimbatore Institute of Technology, Coimbatore, India, 7708902793.

M Dineshkumar, Department of Chemical Engineering, Coimbatore Institute of Technology, Coimbatore, India, 9597351722.

A. Sivalinngam, Department of Chemical Engineering, Coimbatore Institute of Technology, Coimbatore, India, 9865020076.

M. Thirumarimurugan, Department of Chemical Engineering, Coimbatore Institute of Technology, Coimbatore, India, 9943549700.

II. MATERIAL AND METHODS

A. *Collection of plant species*

The pilot-scale experiments were performed using E. aureum. Plants were collected from Coimbatore Institute of Technology, Coimbatore city. Plants were transported to laboratory during winter season.

B. *Preparation of effluent*

Lead synthetic effluent was prepared by dissolving 1.462 g of salt in one liter of distilled water. From the standard solution, effluent was diluted to various concentrations such as 10 ppm, 25 ppm, 50 ppm, 75 ppm and 100 ppm. A set of control were maintained throughout the experiment.

C. *Analysis*

At regular interval of time samples are collected and analyzed using Atomic Absorption Spectrometer.

III. PARAMETERS TO BE ANALYSED

A. *pH*

pH is an important property for aquatic plants. Various concentrations of pH were measured at the regular interval 5, 10, 15 and 20 days pH is measured.

B. *Plant Relative growth (PRG)*

PRG of control and treated plants was measured for every five days till 30 days. PRG was calculated using Eq. 1, to evaluate the effect of heavy metals concentration on *E.aureum* [7].

$$PPG = \frac{FFW}{IFW} \qquad (1)$$

Where, PRG-Plant Relative Growth (dimensionless)
FFW- Final Fresh Weight of *E. aureum* (g)
IFW- Initial Fresh Weight of *E. aureum* (g)

C. Bioconcentration Factor (BCF)

The BCF provides an index of the ability of the plant to accumulate the metal with respect to the metal concentration in the substrate. The BCF is calculated using Eq. 2, larger ratio implies better phytoaccumulation capability.

$$BCF = \frac{P}{E} \qquad (2)$$

Where BCF- Bioconcentration Factor (dimensionless)
P- Trace amount of heavy metal in plant tissue (mg/kg)
E-Trace amount of heavy metal in water (mg/kg)

D. Metal Accumulation

Metal accumulation of plant and synthetic effluents were measured using Atomic Absorption Spectrometer. Digestion of samples was performed by acid digestion method, in which plant biomass were incinerated at the temperature of 400°C and ashes were digested using nitric acid (1:1 ratio) and then filtered, tested with Atomic Absorption Spectrometer[8].

E. Translocation ability (TA)

The translocation ability was calculated for root and leaf samples at different concentration of 10, 25, 50, 75 and 100ppm at regular interval of 5 days till 20 days. It was calculated by dividing the concentration of a trace element accumulated in the root tissues by that accumulated in shoot tissues [9]. TA was calculated using Eq. 3,

$$TA = \frac{\sum R}{\sum L} \qquad (3)$$

Where R- Trace amount of heavy metal in plant root (mg/kg)
L- Trace amount of heavy metal in leaves (mg/kg)

F. Water vaporization

Each concentration has various vaporization rates. Diffusion of water to the atmosphere was changes for each concentration.

IV. Result and Discussion

A. pH

pH for E. aureum for lead is given below Fig. 1.

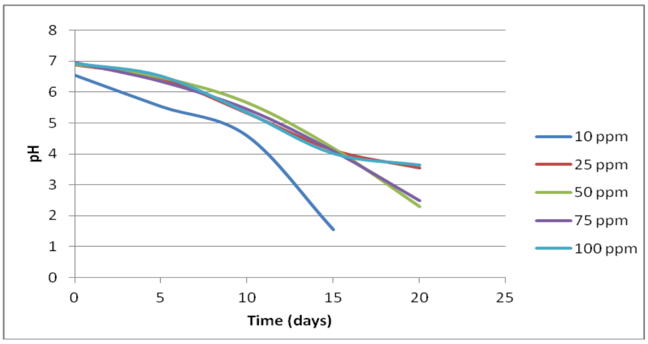

Fig. 1. Effect of pH without using HCl and NaOH

The initial solution pH was adjusted to 6.9 in water using HCl or NaOH. The extent of adsorption was rather low at low pH values. However, in the equilibrium solid phase, lead ion concentrations increased with increasing pH because of increasingly negative charges on the surfaces of the roots at high pH values. It was observed that the pH effect variations were due to the saturation of binding sites on root systems which affect the pH in water samples with water E. aureum plants by releasing H^+ in water samples. pH after using NaOH or HCl is shown in Fig. 2

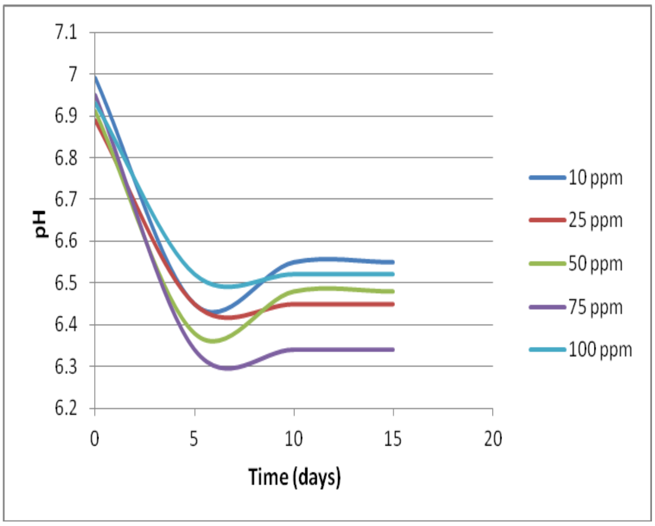

Fig. 2. Effect of pH with using HCl and NaOH

B. Plant Relative growth (PRG)

PRG of *E. aureum* plant is given below

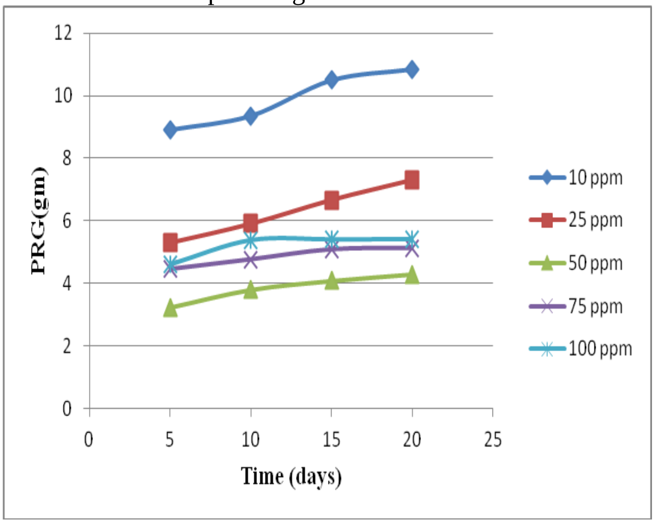

Fig. 3, PRG of *E. aureum*

Lower concentration has higher growth rate and vice versa. Even though higher concentration 100ppm doesnot affect the growth but in very slow rate, which shows that such concentration also treated.

C. Bioconcentration Factor (BCF)

The bioconcentration factor (BCF) was calculated as the ratio of the trace element concentration in the plant tissues at harvest to the concentration of the element in the external environment. The pattern of the bioconcentration factor of water is given below TABLE. 1

TABLE.1. Effect of BCF

Samples	Trace metals in plant (g)	Trace metals in water(g)	BCF
sample1(10 ppm)	5.05	4.95	1.020202
sample2(25 ppm)	9.44	15.56	0.606684
sample 3(50 ppm)	22.9	27.1	0.845018
sample 4(75 ppm)	31.54	43.46	0.725725
sample5(100 ppm)	42.14	57.86	0.72831

Higher Bioconcentration Factor gives by 50 ppm, often it shows that gradual increase from lower concentration to higher. A larger ratio implies better phytoaccumulation capability

D. Metal Accumulation

It was measured using Atomic Absorption Spectrometer fallowed by the acid digestion. Metal accumulation analysis taken separately, for leaves and for root. Total accumulations given by summing up all the trace metals present in separate parts of the plant. For 10ppm concentration total accumulation was 5.05mg which has 2.57mg at root and 2.48mg at leaves which has metal accumulation ability, for 100 ppm total metal accumulations 42.14mg which has 25.44mg at root and 16.66mg at leaves. Higher concentrations have higher accumulation of metal .

E. Translocation Ability (TA)

The quantities of trace elements accumulated in the root exceeded those in the leaf is given in below TABLE.2,
TABLE.2. Effect of TA

Samples		Trace Metals (mg) in various interval				TA
		5(d)	10(d)	15(d)	20(d)	∑L/∑R
Sample 1(10 ppm)	leaf	1.97	0.46	0.13	0.01	0.964981
	root	2.02	0.24	0.19	0.03	
Sample 2(25 ppm)	leaf	2.6	1.2	0.36	0.08	1.226415
	root	4.67	0.37	0.1	0.06	
Sample 3(50 ppm)	leaf	7.33	2.23	0.12	0.1	1.341513
	root	8.34	3.67	0.75	0.36	
Sample 4(75 ppm)	leaf	10.46	3.04	0.33	0.08	1.267434
	root	12.38	4.33	0.89	0.03	
Sample5(100ppm	leaf	12.02	2.34	1.9	0.4	1.529412
	root	13.49	6.45	3.34	2.2	

F. Water Vaporization

A simple measurement of vaporization of water molecules from container with plant, regular interval of day the reduction of water is measure is given below TABLE. 3.

TABLE.3. Effect of Water Vaporizations

Samples	Day 1(l)	Day 5(l)	Day 10(l)	Day 15(l)	Day 20(l)
Sample 1(10 ppm)	1	0.8	0.64	0.56	0.47
Sample 2(25 ppm)	1	0.9	0.75	0.62	0.33
Sample 3(50 ppm)	1	0.92	0.78	0.64	0.55
Sample 4(75 ppm)	1	0.94	0.8	0.69	0.61
Sample5(100 ppm)	1	0.96	0.88	0.71	0.68

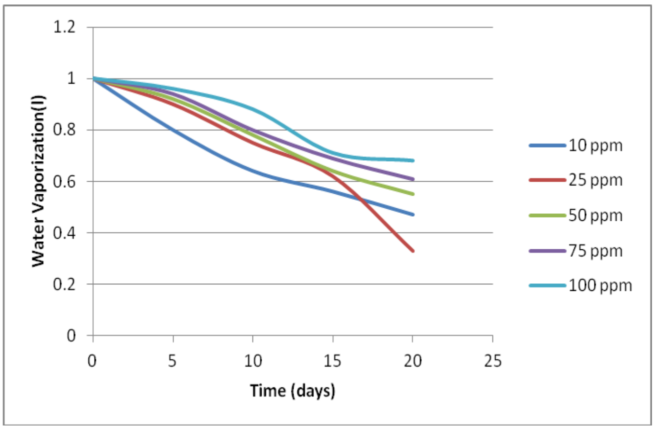

Fig. 4. Effect of Water Vaporization

V. CONCLUSION

From all above analysis show that pH should maintain in the range of 6.5. Relative Growth was increases at lower concentration 10ppm and very low at higher concentration 100 ppm. Bioconcentration Factor was gradually decreases with increases in concentration from 1.020 to 0.7. Translocation Ability is less for low concentration and high for higher concentration 3.09 at 100 ppm. Trace metals are found in more in root at higher concentration 100ppm at initial stage (5th day). Water vaporization is more for lower concentration. It is optimal to use E. aureum plant for treating lead effluent not more that 100ppm.

APPENDIX

Preparation of effluent
Weight of lead salt/ weight of lead= 331.2/207.2=1.6 g/l

BCF =5.05/4.95=1.020202

TA=(1.97+0.46+0.13+0.01)/(2.02+0.24+0.19+0.03)= 0.964981

ACKNOWLEDGMENT

The authors are very grateful to Coimbatore Institute of Technology, Coimbatore for sponsoring this study through the TEQIP-PHASE II is gratefully acknowledged.

REFERENCES

[1] kuldeep Bauddh, Neetu Dwivedi, S.C. Barman and D.P. Singh "Accumulation of metals in selected macrophytes grown in mixture of drain water and tannery effluent and their Phytoremediation potential" JEB, 33, pp 923-927 (2012).

[2] Sasmaz. A. E, Obek and Hazar.H "The accumulation of heavy metals in *Typha latifolia L* in a stream carrying effluent" Ecol, Eng. 33, pp 278-284 (2008).

[3] Saim Mukhtar, Haq Nawaz Bhatti, Muhammad Khalid, M. Anwar Ul Haq and Sher Muhammad Shahzad "Potential of sunflower (*Helithus annuus l*.) for Phytoremediation of Nickle(Ni) and Lead(Pb) contaminated water" pak. J. Bot., 42(6): pp 4017- 4026 (2010).

[4] C. N. Mulligan, R. N. Yong and B. F. Gibbs, "Remediation technology for metal contaminated soil and groundwater: an evaluation" Engineering Geology, vol. 60, pp 193-207 (2001).

[5] S. C. Wilson and K. C. Jones "Bioremediation of soil contaminated with polynuclear aromatic hydrocarbons (PAHs): a review", Environmental Pollution, vol. 81, pp 229-249,(1993).

[6] Anju Meshram and Nidhi Srivastava "Molecular and physiological role of *Epipremnum aureum"* International Journal of Green Pharmacy, pp. 73-6.(2014)

[7] Gakwavu. R.J, Sekomo. B.C and Nhapi, I "Zinc And Chromium Removal Mechanisms From Industrial Wastewater By Water Hyacinth, *Eichhornia Crassipes (Mart.) Solms"* Applied Ecology And Environmental Research 10(4): pp. 493-502. (2012).

[8] B.Y. Zhang, J.S. Zheng and and R.G. Sharp "Phytoremediation in Engineered Wetlands: Mechanisms and Applications" International Society for Environmental Information Sciences, pp. 1315–1325, (2010).

[9] Kumudhaveni Babu, Vijaya Bharathi Rajkishore, Jayshree Narayanan and Thirumal Margesan " Analysis of heavy metals and inorganic element content in *Stereospermum colais* leaves" International Current Pharmaceutical Journal, February 2013, 2(3), pp. 63-66, (2013).

M. Janani pursuing M.Tech Chemical Engineering at Coimbatore Institute of Technology, Coimbatore. She completed B.Tech degree in Chemical Engineering at Adhiyamaan College of engineering, hosur. Her B.Tech project was simulation of continuous stirred tank bioreactor using matlab. She has attended three national conferences and one international conference. She won third prize in paper presentation at national conference about purification of water using various techniques and second prize about production of alcohol from food waste in poster presentation at national conference. She organized two symposiums and seven national conferences. Currently she is doing project on synthetic effluent treatment using Phytoremediation. She has published a paper in international journal of Applied Engineering Research. She was a member in ISTE (Indian Society for Technical Education) chapter IIChE (Indian Institute of chemical engineers, student member) and IE (Institute of Engineers).

M Dineshkumar Ph.D Research Scholar under the guidance of Dr.A.Sivalingam. He completed his M.Tech Chemical Engineering in Coimbatore Institute of Technology, Coimbatore from 2012-2014. He completed B.Tech Chemical Engineering in Erode Sengunthar Engineering College, Erode from 2008-2012. He has done his M.Tech project on removal of heavy metals using three phase fluidization. He presented his B.Tech project in CHEMCON 2013 a four day National Conference at Mumbai. It is about the heavy metal removal by adsorption method. He has published his M.Tech project in International Journal of Engineering Research and Technology (IJERT) with an impact factor of 1.76. In 2014 he has joined Ph.D (Technology) in Anna University, Chennai.

Dr.A. Sivalinngam is working in the Department of Chemical Engineering since August 1984. Presently he is Associate Professor and his areas of interest are Mass Transfer Operations, Multiphase Flow and Waste Water Treatment. He is currently working in the area of Three Phase Fluidization. He was working as Plant Engineer in Private Industry in Bangalore prior to his teaching career. He has published 62 articles in Conferences/Seminar/Referred Journals. He has guided both Undergraduate and Postgraduate students in their project work. He is now guiding Ph. D Research scholars in their research. His activities associated with the Institute are Students' Union Staff Advisor since2011. He has organized one day workshop/seminar/ National and International conferences. He served as Controller of Examinations in - Charge from 1st June 2001 to 3rd August 2001. He served as Deputy Controller of Examinations from 23-05-1996 to 30-09-2001. He was a member in Board of Studies of Anna University Coimbatore, Board of Studies of Coimbatore Institute of Technology, Coimbatore, Result Passing Board, Anna University Coimbatore and Examiner in various Universities.

. **Dr.M.Thirumarimurugan** obtained both his Bachelors and Masters Degree in Chemical Engineering from Bharathiar University in the years 1995 and 1997 respectively. After his B.Tech, he served as Lecturer in Erode Institute of Chemical Technology (EICT) in 1995. Later, he joined Coimbatore Institute of Technology (CIT) as Lecturer in Chemical Engineering Department in the same year. He was promoted as Senior, Selection Grade and at present working as Associate Professor and Head of the Department Chemical Engineering. His main area of research is in Modeling, Simulation and Performance Analysis of Heat Exchangers. He has published around 35 articles both in International and National Journals like Bioresource Technology, International Journal of ChemTech Research, International Journal of Chemical and Environmental Engineering and American Journal of Applied Sciences. He has presented about 120 papers in various International and National Conference in India and Abroad. Recently, he has won Best Paper Award in Energy and Environment in National Conference (NCRES2011), Anna University of Technology Tiruchirappalli, India. In the Past 10 years, he has handled projects from different funding bodies like AICTE (net worth Rs 24, 46,000) and TNSCST (net worth Rs 15,000) under various schemes like MODROBS, RPS and R & D. He has guided many PG, UG students and currently guiding 12 PhD research scholars. He has organized 3 short term courses funded by ISTE-AICTE. In addition to this, he is a Life member in Indian Institute of Chemical Engineers (IIChE), Member in Indian society for Technical Education (ISTE).