DETERMINATION OF LEAD FROM PLANTS GROWN IN HYDROPONIC CONDITIONS

[1]Vaishali Nirmalkar*, [2]Jayashree Thakre, [3]Raana Ansari, [4]Asfiya Shaikh

[1]Assistant Professor, Department of Botany, [2]Assistant Professor, Department of Chemistry
[3, 4] Department of Botany, G. M. Momin Women's College, Bhiwandi, Maharashtra, India

Abstract : Increasing urbanization, industrialization and over population is one of the leading causes of environmental degradation and pollution. Heavy metals (HMs) such as Pb, Zn, Cd, As etc. are one of the most toxic pollutants which show hazardous effects on all living creatures. Lead is one such pollutant which disrupts the food chain and is lethal even at low concentrations. The aim of phytoremediation research is to identify metal-tolerant plants that are capable of uptake and efficient translocation of HMs to harvestable above-ground organs. The main objective of this study was to assess the metal tolerance of *Eleusine coracana* (Ragi) and *Pennisetum glaucum* (Bajra) after exposure to lead (Pb) solutions. Plants were grown hydroponically using coconut coir and were exposed to different concentrations of Pb (300 ppm, 400 ppm, 500 ppm, 700 ppm and 1000 ppm). Various physio-biochemical parameters were studied. Determination of heavy metal in the residual water from coir and from plant samples was done using the spectrophotometer. The concentration of Pb in *Eleusine coracana* was found to be much higher compared to *Pennisetum glaucum*. The results of this research showed that Ragi and Bajra of the family Poaceae are hyper accumulator plants that can concentrate heavy metals in their different parts, thus they can be used for remediation of polluted area. This report shows the ability of these plants to accumulate Pb. The benefit of this technology is the potential for low cost remediation.

***IndexTerms* - Lead, *Eleusine coracana, Pennisetum glaucum*, phytoremediation**

INTRODUCTION

Heavy metal contamination refers to the excessive deposition of toxic heavy metals in the water caused by human activities. Heavy metals in the water include some significant metals of biological toxicity, such as mercury, cadmium, lead, chromium, arsenic etc. Stresses are increasing drastically today because of pollution, declining availability of quality water and land degradation (Krishania and Agarwal, 2013). Heavy metals are hazardous to the environment and living organisms and they can be enriched through the food chain. Once the water suffers from heavy metal concentration, it is difficult to be remediated (Chauhan and Yadav, 2015; Han et al, 2002; Jean-Philippe et al, 2012; Sayyed and Sayadi, 2011; Raju et al, 2013; Prajapati and Meravi, 2014; Zojaji et al, 2014). Traditional methods of remediation are very difficult and not feasible. There is great need to promote effective water treatment technologies that attempts to remove the metals from the water. Phytoremediation are the alternatives found. Phytoremediation is a general term for the use of plants to remove, degrade or stabilize the complex environmental contaminants. The majority of phytoextraction research has focused on finding the ideal metal-accumulating plant and the means by which metals can be liberated from the water for root uptake (Patel et al, 2015).

The present study involves use of plants like pearl millet and finger millet for phytoremediation of lead. Phytoremediation involves: 1) solubilization of metals in growing medium and their transfer to the root surface, 2) uptake into the roots, 3) translocation to the shoots (Luo et al, 2006; Lestan et al, 2008, Lo et al, 2011). However, there is no clear evidence how chelated metal is taken up and distributed in plants (Lestan et al, 2008; Glinska et al, 2014).

Hydroponics

In hydroponics, plants are grown without soil so they get essential nutrients for growth from the nutrients solution added to water. There is an absence of soil for growing so there must be some way of supporting the plants and allowing the bare root system for exposure to the nutrient solution. The growing medium is used for support and to add in moisture and nutrient retention. The advantages of hydroponics are no soil is needed, water stays in the system and thus can be reused, nutrition levels can be controlled and thus the system remains stable and of lower costs.

Coconut coir as growing medium

When grown without soil, many options are there for growing medium. But one growth medium which is becoming quite popular to use as soil less substrate and is widely available in indoor gardening shops all over is Coconut coir. Coconut coir is a light weight, soil less growth medium from the fibres found between a ripe coconut's shells and other surface. As it is a material that occurs in nature, it is completely renewable and is therefore considered an excellent choice for environmental sustainability.

Plants growing in polluted environment can accumulate heavy metals at high concentrations causing serious risk to human health when consumed. Moreover, heavy metals are dangerous because they tend to accumulate in plants and animals thereby causing deleterious effects, concentrate in the food chain or attack specific organs in the body (Sensor, 2005; Pillai et al, 2014). Lead is a soft metal of bluish grey color. It is malleable but not highly ductile (Soni et al, 2012).

Ragi (*Eleusine coracana*) is an African genus and one of the important millets of the world (Poonia et al, 2012). Ragi (Finger millet) is an annual cereal crop widely grown in arid and semi arid areas of Africa and Asia. The grain is a good source of protein, carbohydrate but contains less amount of fat (Anjaneyulu et al, 2011). Also digests easily from infancy through old age, and its nutrients are highly absorbed. Ragi has a high amount of calcium 0.38%, fibre 18%, phenolic compounds 0.3%-3% and sulphur containing amino acids 17, 19, 21. Ragi also has some good number of essential amino acids like Valine, Methionine, Isoleucine, Threonine and Tryptophan (Patil and Sawant, 2012).

Bajra (*Pennisetum glaucum*) is an annual crop which is widely grown for its grains for consumption by human beings, also for grazing, hay, cover crop and wildlife. Bajra (Pearl millet) is a bunch grass growing 4-8 ft tall, on smooth ½-1 inch diameter stems, with upright side shoots (tillers). The inflorescence (4-20 in) is a terminal spike, seeds are cylindrical, typically white, or yellow, leaf blades are long and pointed (Hannaway and Larson, 2004). Pearl millet has a high potential for accumulating toxic levels of nitrate (Strickland et al., 2007). It has crude protein (CP) level of 12-14% (Lee et al., 2012) with relatively low fiber and lignin concentration.

RESEARCH METHODOLOGY

Plant material and treatment

To initiate the experiment under controlled condition, seeds of finger millet, pearl millet and coconut coir were brought from local market of Bhiwandi. Coconut coir was partially grounded in mixer grinder. Seeds of both the plants were soaked overnight for further processing.

Hydroponic condition

Coconut coir was placed in plastic containers as a source of growing medium and was wet with the macro and micro nutrients solution generally required by plants. Seeds were surface sterilized with 0.1% mercuric chloride solution for 15 mins. with frequent shaking and then were thoroughly washed with distilled water then treated with anti-fungal agent Streptomycin for 15 mins. Lead solutions of different concentrations i.e. 300 ppm, 400 ppm, 500 ppm, 700 ppm and 1000 ppm were used. Seeds were sown in every system containing the coconut coir, nutrients solution and different lead solutions whereas the control system was devoid of lead solution. Care was taken that the system remains wet and the roots do not dry up.

Plant harvest and analysis

Plants samples were gently removed from the hydroponic system after 7-8 days of growth. Length of shoots and roots were measured. Fresh weight of samples was taken. The coconut coir after removal of plants was transferred on a muslin cloth which was then tightly shrieked and twisted so that all the liquid get filtered into the container. Then volume was measured.

Acid Digestion

The plant samples were dried using hot air oven at 120°C for 24 H and dry weight was measured. The samples were then completely dissolved in 15ml concentrated nitric acid and heated for 30 minutes until yellow liquid appeared. The solutions were allowed to cool for 10 mins. To the oxidized solutions 10ml of 30% hydrogen peroxide was added. The digested solution was heated until the effervescence diminished (McComb et al, 2012). The solution was filtered and transferred to a 50ml volumetric flask where the final volume was adjusted to 50 ml with distilled water (Zeng-YeiHseu, 2004; McComb et al, 2012).

Analysis of lead content

The solution containing lead (1 ml) was reacted with 1ml of dithizone in chloroform which resulted in a colorful solution. Lead content of each sample was quantified using UV- Vis Spectrophotometer UV-1800 (Shimadzu, Japan). A standard curve was established. Lead contents were calculated in mg/ml using the absorbance readings of the digestates (McComb et al, 2012).

RESULTS AND DISCUSSION

This research work has been undertaken to study the accumulation of lead in plants or in other words the uptake of Pb by plants. The plants used were *Eleusine coracana* (Ragi) and *Pennisetum glaucum* (Bajra).This study also makes a comparative study of Ragi and Bajra to find out whether bioaccumulation varies with type of plants.

The shoot length of Ragi in response to various concentrations of lead is shown in Fig.1.Shoot length of untreated plant was 2.12 cm. With 300 ppm and 400 ppm the length of shoot was 2.80 cm and 2.91cm respectively. At 400 ppm lead concentration the length of shoot was highest. For each exposure to lead concentration i.e., 500 ppm, 700 ppm and 1000 ppm the shoot length declined. The shoot length increased with the increasing concentration of Pb but after 400ppm it decreased. It suggests that the plant is not able to withstand the higher concentration of Pb. The shoot length of Bajra in response to various concentrations of lead is shown in Fig.2. The shoot length of Bajra in control condition (without Pb) was 2.17 cm. The length of shoot gradually increased upto 700 ppm. For each lead exposure concentration (300ppm, 400ppm, 500ppm) there was no significant differences in the length of shoot. However at 700ppm exposure to lead, the length of the shoot apparently increased (7.38 cm). The length significantly reduced with 1000 ppm where it was found to be 2.5 cm. As in Ragi, here also as the concentration of Pb increased the shoot length increased. But it was found to be maximum at 700 ppm concentration. Gradually at 1000 ppm the plant may not be able to withstand the higher concentration of Pb.

Fig. 3 shows the length of root of Ragi in response to various concentrations of lead. Root length of untreated plant was 1cm. With exposure to different lead concentration 300ppm, 400ppm, 500ppm and 700ppm, there were no significance difference in the length of root. With 400ppm the length of root was much shortest, it was 0.6cm. The root length of Bajra in response to various concentrations of lead is shown in Fig. 4. Root length of untreated plant was 0.88 cm. The length of roots gradually increased upto 500 ppm. For each lead exposure concentration 300 ppm, 400 ppm, 500 ppm there were no significant differences in the length of root. However, there was an apparent difference in the root length with 700 ppm (3.52 cm). The length of the root significantly reduced with 1000 ppm. This suggests that at 700 ppm the root length is maximum and also the shoot length is found to be maximum. Thus Bajra plant grows best at 700 ppm concentration of Pb (Fig. 4).

In Ragi, the highest metal concentration was observed in 700 ppm (208.72 mg/gm dwt). The lowest concentration was observed in control plant which was grown without lead (110.45 mg/gm dwt). At 1000 ppm the plant was not able to uptake the metal (Fig. 5). The residual water after the plants were harvested from the coir, also shows the accumulation of left over metal concentration. From the data collected, it can be analyzed that the residual metal was found to be highest in 500 ppm with 0.10 mg/ml. (Fig.6). Thus in Ragi it could be suggested that as at 700 ppm the highest accumulation of Pb might have increased the stress in plant which restricted its growth which is clear from the shoot length at 700 ppm.

In Bajra, the highest metal concentration was observed in 500 ppm (68.47 mg/gm dwt). The lowest concentration was observed at 700 ppm with 10.07 mg/gm dry weight (Fig.7). The residual water after the plants were harvested from the coir, also shows the accumulation of metal concentration. From the data collected, it can be analyzed that the residual metal concentration was low at 500 ppm and lowest at 700 ppm with 0.02mg /ml (Fig.8). Thus in Bajra it could be suggested that as at 500 ppm the highest accumulation of Pb might have increased the stress in plant which restricted its growth which is clear from the shoot length at 500 ppm.

The concentration of Pb in Ragi was much higher compared to Bajra thus Ragi shows the better ability to accumulate the metal. The concentration of metal in the residual water from which Bajra plant was harvested was much higher than the residual water from which Ragi plant was harvested. So it can be interpreted that Ragi can be good option for the phytoremediation of lead from the environment. The Ragi plant is almost three times much efficient to Bajra plant in accumulating lead. Thus it has the potential to be a suitable phytoextraction plant. Lead is a toxic element that can be harmful to plants which usually shows ability to accumulate large amounts of lead without visible changes in appearance. The introduction of lead in food chain may affect human health. Heavy metal deposition is associated with a wide range of sources. To avoid the entrance of metals in food chain Municipal or industrial waste should not be drained into rivers or farmlands without prior treatment (Pillai et al, 2014). The concentrations of heavy metals in plants were inversely proportional to those in residual water. These results will serve as a pilot study for further investigation of plant species in bioindication of environmental pollution, also for phytoextraction. It also becomes necessary to check the soil quality while growing these plants as they are found to be the good Pb accumulators.

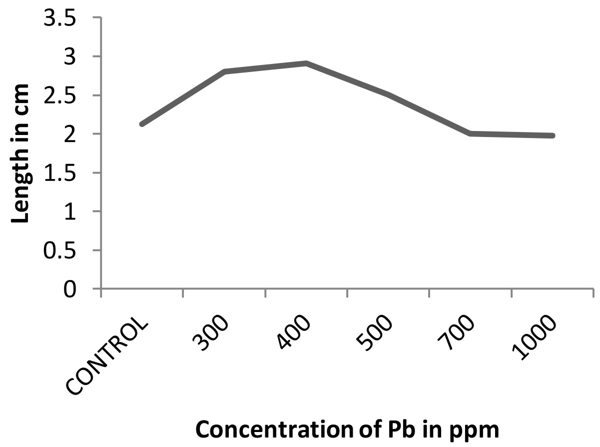

Fig.1:Length of shoot of *Eleusine coracana*

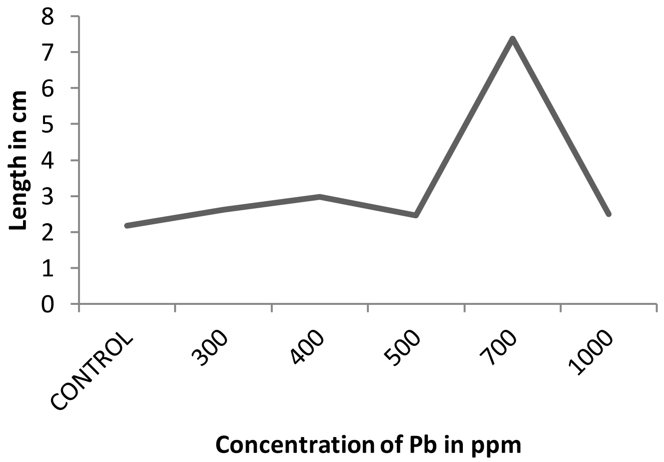

Fig.2: Length of shoot of *Pennisetum glaucum*

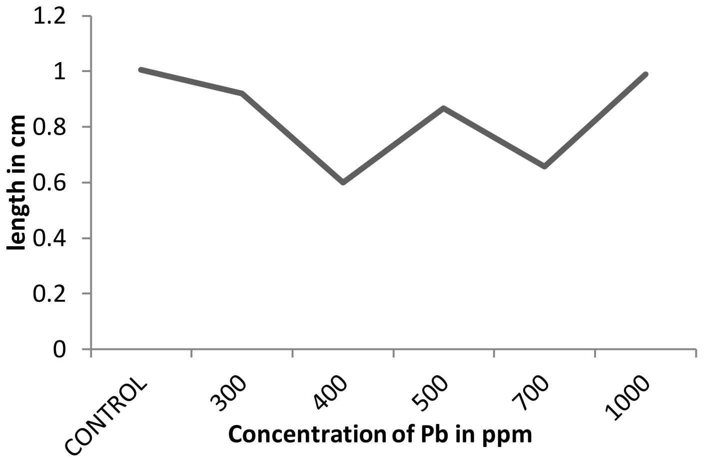

Fig.3: Length of root of *Eleusine coracana*

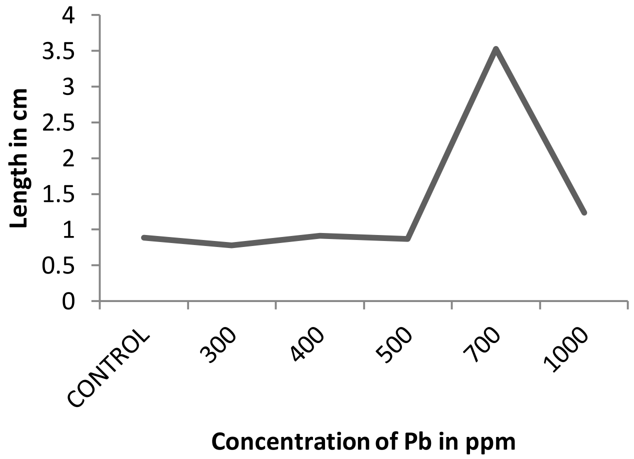

Fig.4: Length of root of *Pennisetum glaucum*

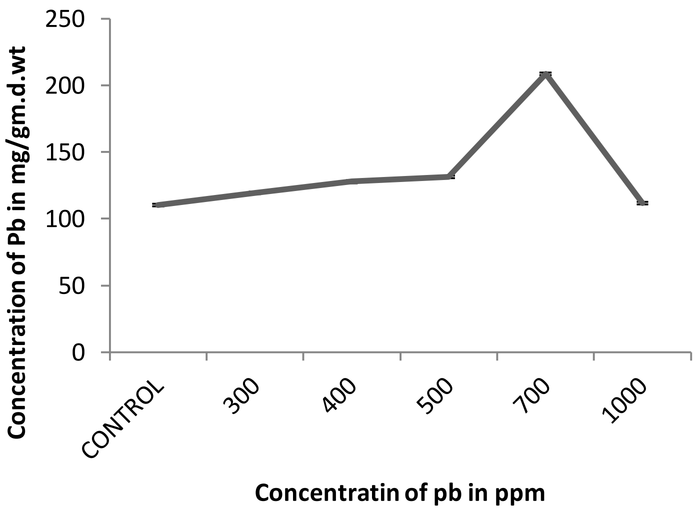

Fig.5: Absorbance of lead by *Eleusine coracana*

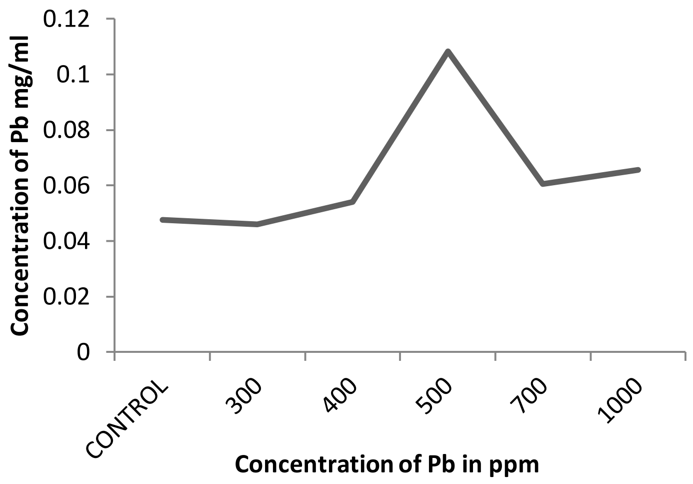

Fig.6: Absorbance of lead in residual water of *Eleusine coracana* grown medium

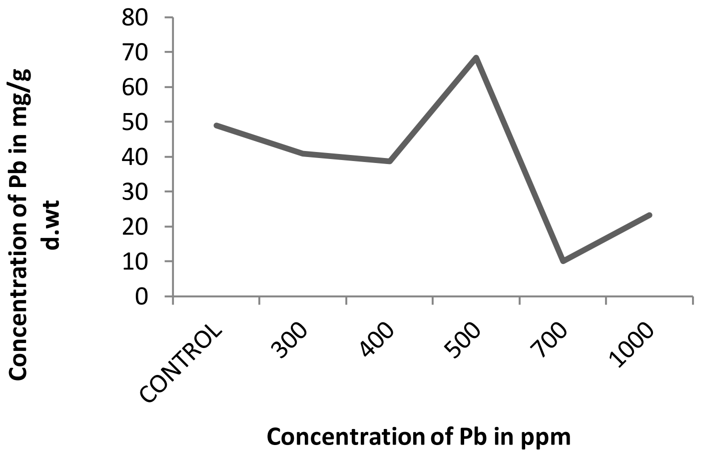

Fig.7: Absorbance of lead by *Pennisetum glaucum*

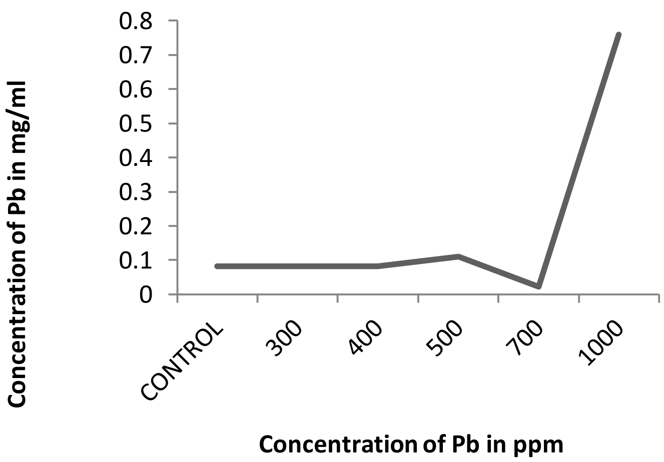

Fig. 8:Absorbance of lead in residual water of *Pennisetum glaucum grown medium*

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