Original Research Article

Phytoremediation of Heavy Metals from Water of Yamuna River by *Tagetes patula, Bassica scoparia, Portulaca grandiflora*

Abstract

Heavy metal contamination is a worldwide problem, causing many serious diseases and the levels of contamination varied from place to place. Heavy metals like cadmium (Cd), mercury (Hg), zinc (Zn), chromium (Cr), and lead (Pb) etc are very injurious even at low concentration and are present in Yamuna river water. Phytoremediation has great potential as an efficient cleanup technology for contaminated soils, groundwater, and wastewater. It is a cheap and very efficient technique for metal removal. A study had been carried out to detect the efficiency of phytoremediation technique for removal of heavy toxic metals from water of yamuna river. This study also focused on the phytoremediation capacity of all of three selected plants: *Tagetes patula, Bassica scoparia,* and *Portulaca grandiflora.* Bioaccumulation of heavy metals in various parts of plants has also been checked.

Keywords : Yamuna river, *Tagetes patula, Bassica scoparia, Portulaca grandiflora,* Heavy metals, Phytoremediation.

1. INTRODUCTION

Yamuna river originates from yamunotri glaciers of Himalayas. It is the largest tributary of river Ganga. It is around 1370 kilometers in length. It flow across the states of Haryana, Delhi, Uttar Pradesh. It merges into Ganga river in Allahabad. Big cities like Mathura, Agra, Delhi lie on

Yamuna river bank. It is classified into five segments like Delhi segment, Upper segment, Himalayan segment, Eutriphicated segment, Diluted segment depend on the basis of ecological and hydrological conditions. The quality of water river water in Himalayan segment is very good and also meets all the standards within this segment. Yamuna river water is trapped by Wazirabad barrage for the purpose of domestic supply of water in delhi. The Okhla barrage of Delhi receive water of seventeen drain sewage, Najafgarh drain. It is the most polluted segment of river Yamuna. Today it has become the most polluted and dirtiest river of the country and was once described as the lifeline of Delhi city.

It has been given the grade "E" by the Central Pollution Control Board (CPCB), which means it is only good for recreation and industrial cooling. No underwater life found in this segment of river. The domestic discharges from Delhi, Faridabad, Noida, Ghaziabad, Mathura, Agra, Haryana, has rendered the river unfit for any use.

Even taking a dip into river water can cause various health and skin regarding issues. One of the major contaminants present in river water is toxic heavy metals. Presence of toxic heavy metals is an issue of major concern because of bio-accumulative nature of metals. These metals have geological origin, but entering in the river water can be by erosion, weathering and anthropogenic activities of human beings like agricultural runoff, industrial processing, sewage disposal etc. Environmental related exposure of theses heavy metals are like lead paint, house hold dust, silver foil in food, surface soil, batteries, peeling paints, sewage wastes, plumbing system etc. use of fertilizers and pesticides is also a great source of heavy metals like Cd, As. Some of these metals are essential for human beings but in very low concentration such as Ca, Cu, Fe, Cr, Mg, K, Zn, Ni, Mn, Co and Na are essential for normal growth of plants and living organisms. Cd, Ag, Al, Pb are some non essential metals and are very toxic.

High uptake and slow elimination of Heavy metals cause harm to the aquatic life. As the heavy metals get settled down in the sediment and uptake by the plants or aquatic organisms, drink by the animal and this will ultimately harm the life of organisms. Humans by many ways are highly exposed to heavy metals as they are also the part of food chain. Table 1 shows the permissible

limit of heavy metals (Ad, Zn, Cr, Pb, Hg) prescribed by WHO.

Table 1: Maximum permissible value of heavy metals by WHO

Metals	**Water (L/kg^{-1})**	**Sediment (µg/kg$^{-1)}$**
Cadmium	0.003	6
Zinc	3	123
Chromium	0.05	25
Lead	0.01	----
Mercury	1.3	0.3

High uptake of lead causes changes in the gill, kidney and liver of fish **(Mohamed and Gad, 2005)**. Intestine and gills are the major site of metal accumulation in fishes. It causes variation in the lipids of aquatic organisms. Lead cause swelling in the gills and jaws of fishes. Nausea, anemia and vomiting etc problems are the side effects of lead exposure in humans.

Zinc accumulate in the gills of fish, this indicate a depressive effect in tissue respiration cause hypoxia or death of the fish. Zinc also cause decrease in total white blood cells. Zinc causes change in heart physiology and also cause toxic changes in ventilatory System. Headache, fever, vomiting, chest tightness, aches, chills, metallic taste in mouth And cough are the side effects of acute exposure to zinc. Chronic exposure causes problems like cancer, kidney and lungs failure.

Cadmium mostly accumulates in gills, intestine and stomach of fishes. It cause changes in enzymatic activities in marine animals and also changes in oxygen consumption. High concentration of cadmium also affects the osmotic-regulation activity in fishes. Cadmium also causes reduction in red blood cells in the fishes. Exposure to heavy metals causes various serious diseases in human beings. Cadmium exposure cause lung inflammation and lungs cancer as cigarette smoking is the largest source of cadmium In humans. Osteomalacia and proteinuria are the kind of problems occur in humans due to cadmium.

Chromium cause acute and chronic effects on fishes. High chromium Uptake causes changes in

metallo-enzymatic activity. Chromium gets accumulate in the gills of aquatic biota. High chromium concentration cause altered blood chemistry, osmoregulatory changes, behavioral modifications and in severe conditions hypoxia. Acute renal failure, hemolysis and gastrointestinal hamorrhage are the problems occur in humans at acute exposure to chromium. At chronic exposure to Chromium lungs cancer and pulmonary fibrosis diseases will take place.

Mercury is highly toxic to aquatic animals. It shows variable effects on Oxygen consumption, osmoregulation, and enzyme activity of marine life. It also shows several effects on blood circulation system and cause reduction in RBC count. Diarrhea, fever and vomiting are the side effects of acute mercury exposure. Nausea, nephrotic syndrome, pink disease, stomatitis, neurotic disorders and tremor diseases are the side effects of cadmium at chronic exposure as mercury is highly toxic.

Various techniques are available for remediation of contaminants. Which are chemical, physical and biological methods. Chemical method involves the use of several harsh chemicals like leaching of metals by chelating agents and chemical wash. Physical methods are very expensive and cause labor demand. That's why researchers have developed highly efficient ,cost effective, eco friendly remediation techniques, in which organic waste are biologically degraded to an innocuous state.

Removal of heavy metals with the help of microorganisms is very efficient method but it is confined to water system only. Some other remediation methods are bio augmentation, land farming, bio leaching, rhizofiltration, biostimulation, composting, bioreactor, and phytoremediation. Phytoremediation is a technique that uses plants for degradation of toxic contaminants present in environment. It involves the use of living organisms especially plants and microorganisms to eliminate the effects of contaminants present in air, water, soil.

Phytoextraction of heavy metals by the hyperaccumulator plants from both soil and water is also a key area of search. This study was also focused on the phytoremediation capacity of all of three selected plants *Tagetes patula, Bassica scoparia, Portulaca grandiflora.*

1.2 OBJECTIVES

i. Determination of heavy metal content in Yamuna river water sample
ii. Removal of contaminants from river water sample with the help of Hyper - accumulator plants
iii. Evaluation of Bio-accumulation capacity of all of three selected plants

2. Material and Methods

2.1 Solution: Water sample from Yamuna river was collected and preserved in a can at freezing temperature.

2.2 **Plants used:-** Three different plants (*Tagetes patula, Bassica scoparia, Portulaca grandiflora*) were used for the study. The seeds of the plants were collected from local nursery at Delhi-NCR. The plants classifications have been listed in table 2.

Table 2:

	Tagetes patula	***Bassica scoparia***	***Portulaca grandiflora***
Kingdom	Plantae	Plantae	Plantae
Order	Asterales	Caryophyllales	Caryophyllales
Family	Asteraceae	Amaeanthaceae	Portulacaceae
Genus	Tagetes	Bassia	Portulaca
Species	*T.patula*	*B.scoparia*	*P.grandiflora*

T.patula grown and harvested annually and flowers are yellow and red in colour, reaching 0.3 m to 0.5 m in size.the plant size vary from 0.1 to 2.2 m tall. They have fibrous roots.In India it grows from October to April. Plants common name is called “Marygold” . the leaves of plant include oil glands and the oils are pungent. It can grow in any sort of soil. T.patula is widely cultivated in India it also have various use in medicines.

The main reason for selecting this plant for phytoremediation is its ability of resist adverse

condition like pests, salinity, drought etc. *T.patula* is good for phytoextraction of heavy metals like arsenic, Mercury etc.

It is a small but fast growing annual plant as it grown 30 cm tall. the leaves of the plant are thick and fleshy , upto 2.5 cm long arranged in a cluster like structure. the flowers are 2.5- 3 cm diameter with five petals . colour of flowers varied from red, pink, white, orange and yellow. In India it is called **"9 o clock"** flower because it blooms at 9am. it generally require no attention as it get spread very easily by itself. This plant can easily grow in Adverse conditions like pesticides, high heavy metal concentration, chemicals etc. This plant consumption known to reduce the risk of cancer and heart diseases (thangavel . et . al ., 1999) .

It is a large annual herb. The plant is helpful in controlling soil erosion. This plant is suggested as a agent for phytoremediation technique because it is hyperaccumulator of Cadmium, zinc, mercury, chromium. It is an evergreen foliage plant. The seeds of the plant help in regulation of hypertension and obesity etc.

2.3 Procedure

2.3.1 Water Collection: Water sample was collected from Yamuna river enrooted Delhi-Agra via Haryana, near near Palwal district, as shown in picture below.

2.3.2 Model set up:

i. Six plastic boxes were taken.
ii. Two box for each plant.
iii. For setting up the model, one plastic box was placed on other.
iv. Small holes were induces in the centre of each plastic box for the passage of plant roots as shown by the pictures below in figure a, b, c, d, e.
v. After germination of seeds in soil, small plants was transplanted From the soil to the upper plastic box which was already filled with garden soil.
vi. Roots of the plants were allowed to reach the lower plastic box Already filled with

151 contaminated water sample of Yamuna river through induced wholes.

152
153 **Figure a: Set up for plant**
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156 **Figure b: Set up of different plants**
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Figure c: Set up for *P.grandiflora*

Figure d: Picture of *B.scoparia*

Figure e: Picture of *T.patula*

2.3.3 Growth period:

i. Plants were allowed to grow in that setup for eight weeks.

ii. During these eight weeks, generally called “Growth period”, Proper attention to the plants was given just to make sure. That none of the plant will die.

iii. Fertilizers such as cow dung was mixed to the soil.

iv. Plants were placed beneath a tree, because much, Sunlight exposure can cause browning of plants.

2.3.4 Change in size parameters: Growth in the length of the plants was measured After completion of fourth and eighth week by a centimeter scale.

2.3.5 Lab work: After 8 weeks, all of the three plants were harvested and the water Samples initial untreated and final treated, from all the three plants Were taken and stored in three different plastic bottles with proper Labeling.

2.3.6 Acid Digestion: Acid digestion a method for dissolving samples into a solution. It is done by adding considerable amount of acids and heathing, Until the matrix get completely decompose and release metals.

a. For acid digestion of water samples, the water samples were Autoclaved and added in the glass beakers.

As nitric acid can never used alone, so it was combined with sulfuric acid.

To the water samples, first added 5ml of concentrated HNO_3 and 10ml of concentrated H_2SO_4, boil on a hot plate at 90^o temperature for evaporation, until dense fumes of dense SO_3 appears.

After clearing of the solution, no brownish fume appear, then Distilled water was added to make solution dilute and heated.

Then solution was centrifuged at 3000 rpm for 25 min and pellet was discarded, supernatant was taken and stored in test tubes with proper labeling.

b. For acid digestion of plant tissues

Plants were first wiped with 0.01N HCl followed by rinsing with distilled water ,then the plants were separated into different parts viz. roots,stems, leaves. And let them dry in oven for 15 min or less. All the parts were grind into grinder and 2g of sample were Taken in the glass beaker after weighing For digestion, HNO_3 And $HCLO_4$ acids was used To the sample first 5ml of HNO_3 added and heated on a Hot plate at temperature 100^o for 30 to35 min, then 2.5ml Of $HCLO_4$ added to the mixture and boiled. white fumes Appeared, later 5ml of dilute water added to mixture and again boiled until the fumes were totally released.

Detection of present heavy metals in all the samples was done by AAS technique.

3. **Results and Discuusion:** Final growth in the length of plants is given in the table below

206 and also shown in the picture given below.

207 **Table 4: Change in length (cm) of the Plants**

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Plants	Zero day	After four weeks	After eight weeks
T.patula	5 cm	9.5 cm	19 cm
B.scoparia	6 cm	8.5 cm	11.5 cm
P.grandiflora	3.5 cm	7 cm	13 cm

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210 The amount of heavy metals present in water sample and in plant tissue sample were analyzed by
211 a technique called “Atomic absorption spectrometry”. The amount of heavy metals such as Cd,
212 Hg, Zn, Cr, Pb in initial untreated water sample and also in final treated Water samples are given
213 in table below.

214

215 **Table 5: Presence of heavy metals (mg/L) in water sample**

Metals	Initial water sample	*Tagetes Patula*	*Portulaca GrandiFlora*	*Bassia Scoparia*
Cd	0.715	0.489	0.315	0
Cr	0.513	0.269	0.418	0.379
Zn	0.948	0.533	0.697	0.705
Hg	1.079	0.782	0.969	0.783
Pb	1.098	0.055	0.079	0.069

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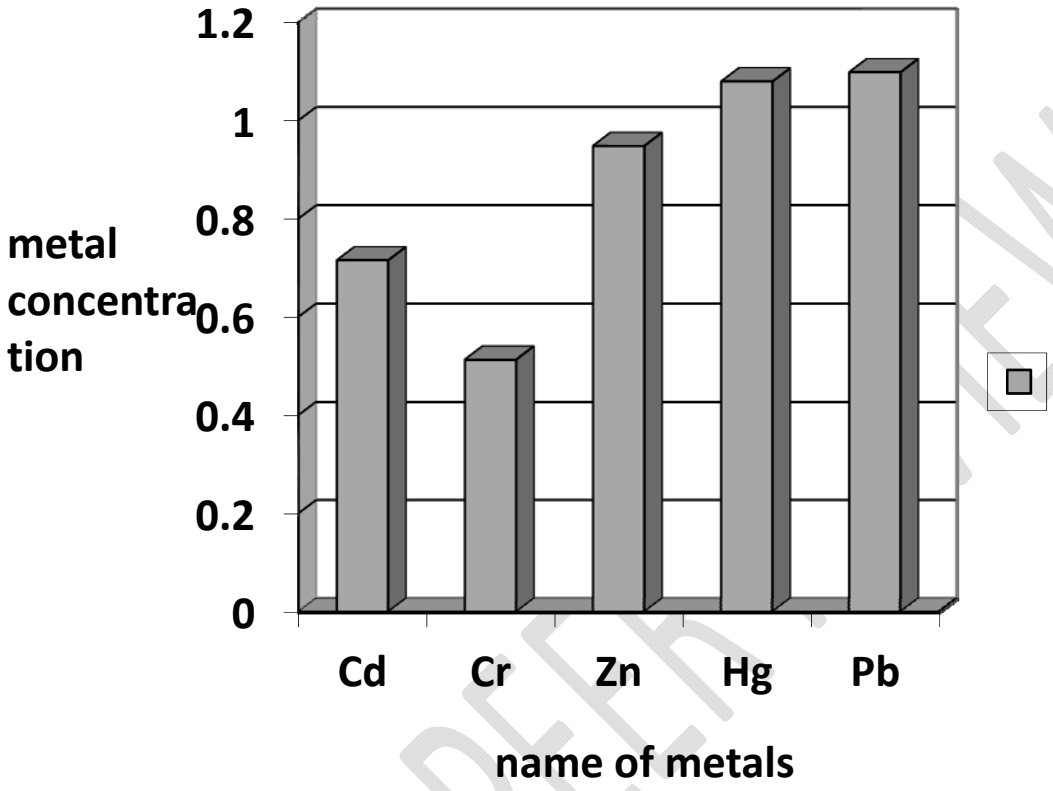
217

218 According to the results, Cadmium was undetectable in the water sample of *B.scoparia* and

T.patula absorbed greater amount of cd as comparison to *T.patula*. Chromium concentration found very less in the treated water sample by *T.patula* and highest in *P.grandiflora*. zinc level highest in *P.grandiflora* and lowest in *T.patula*. hg concentration found highest in *P.grandiflora* and there is approximately no difference in the results of *T.patula* and *B.scoparia*. pb concentration has been found in this decreasing order *P.grandiflora*> *B.scoparia* > *T.patula*. so according to this result *T.patula* is good for treatment of chromium, zinc, mercury, lead from waste water . *B.scoparia* is good for the removal of mercury most as comparson to other heavy metals from waste water and *P.grandiflora* is proved to be a good remediation agent for cadmium etc mostly as comparison to other heavy metals from contaminated water.

Graph3. 1: Graphically representation of concentration of heavy metals in untreated initial water sample



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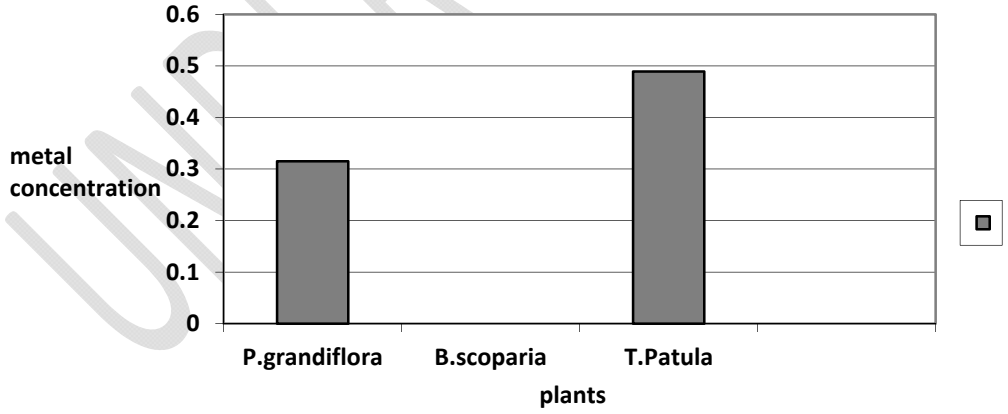
232 **Graph 3.2: Cadmium concentration left in treated water sample after eight weeks**



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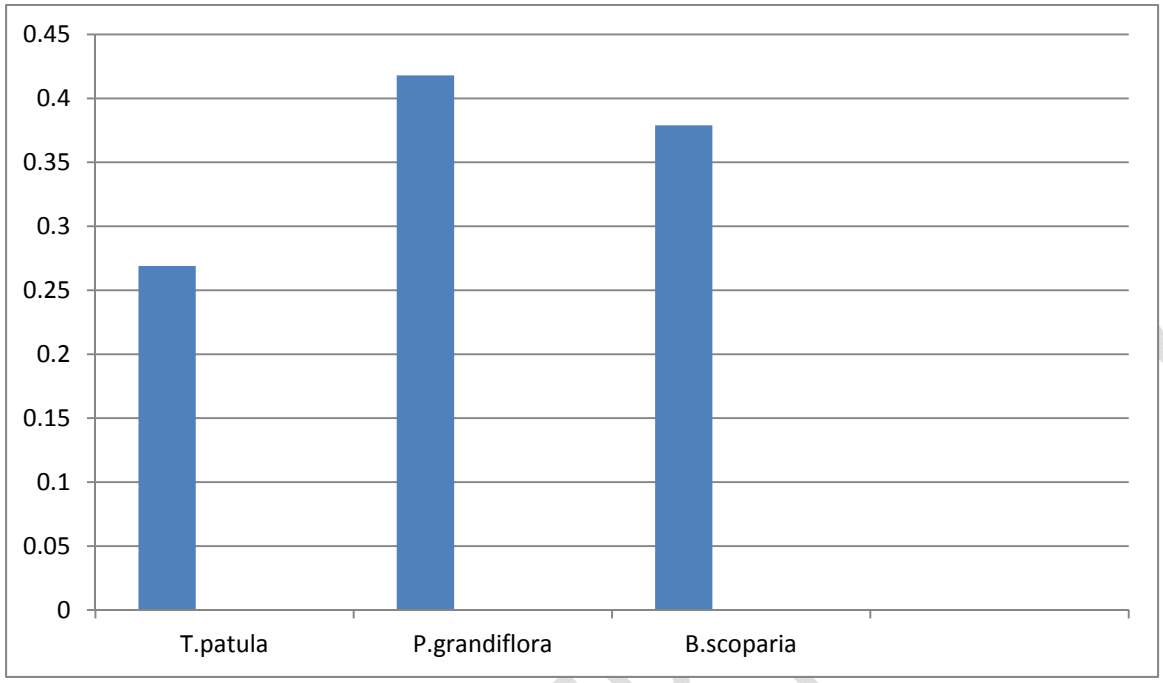
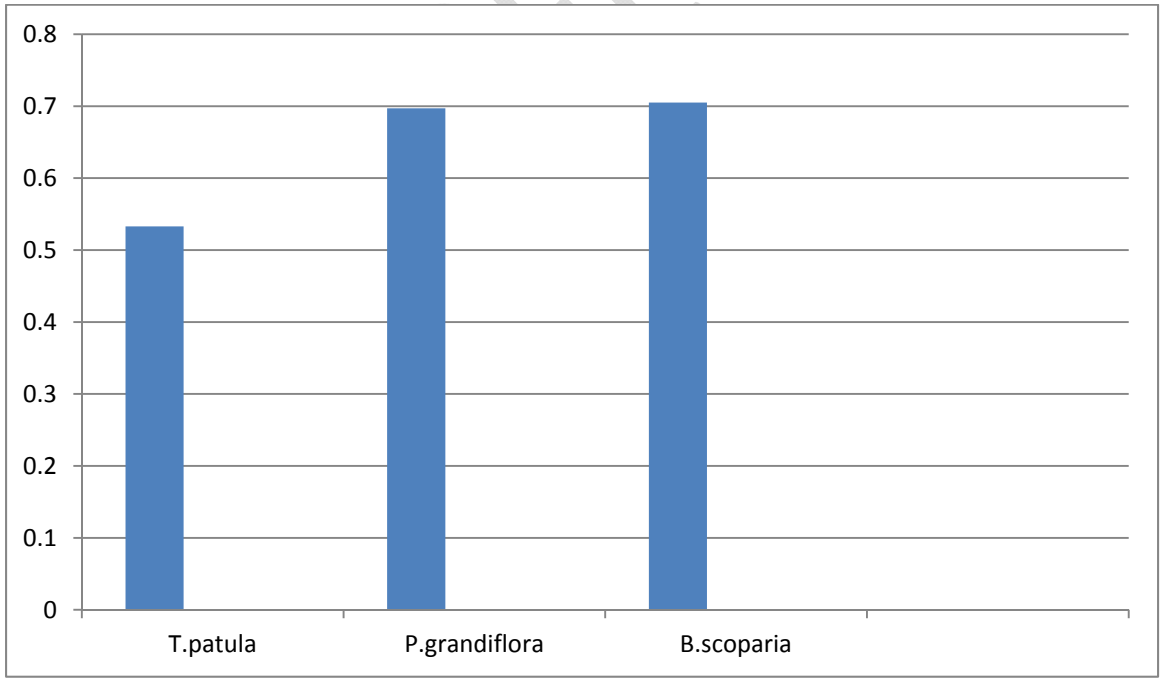
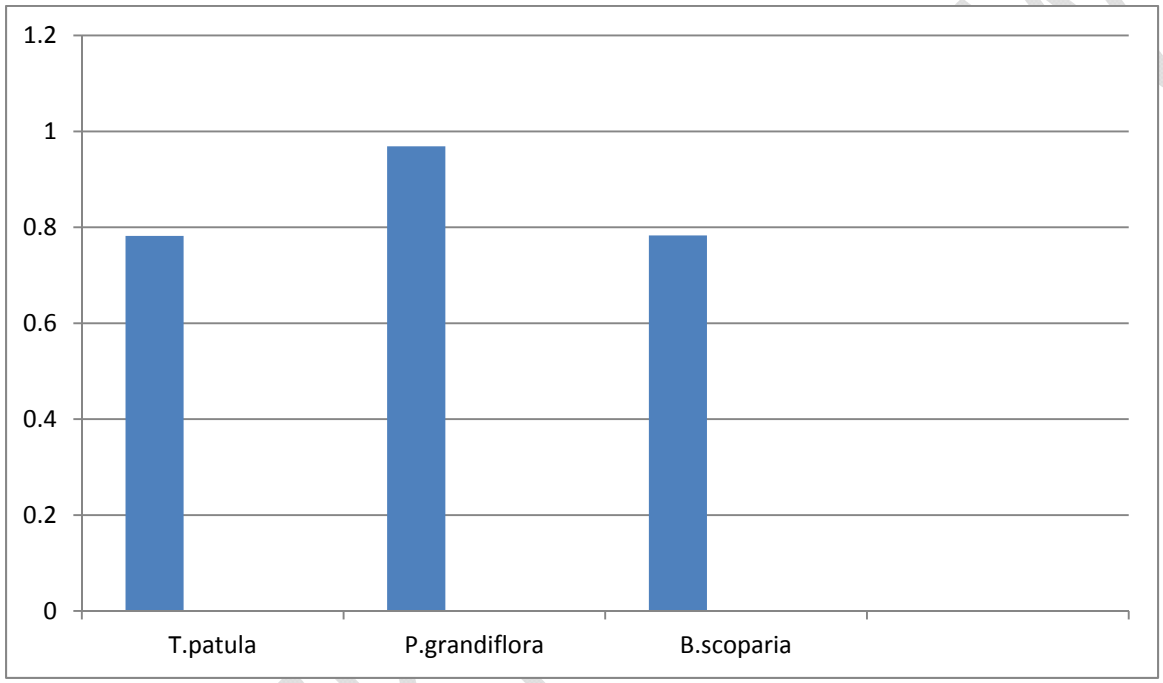


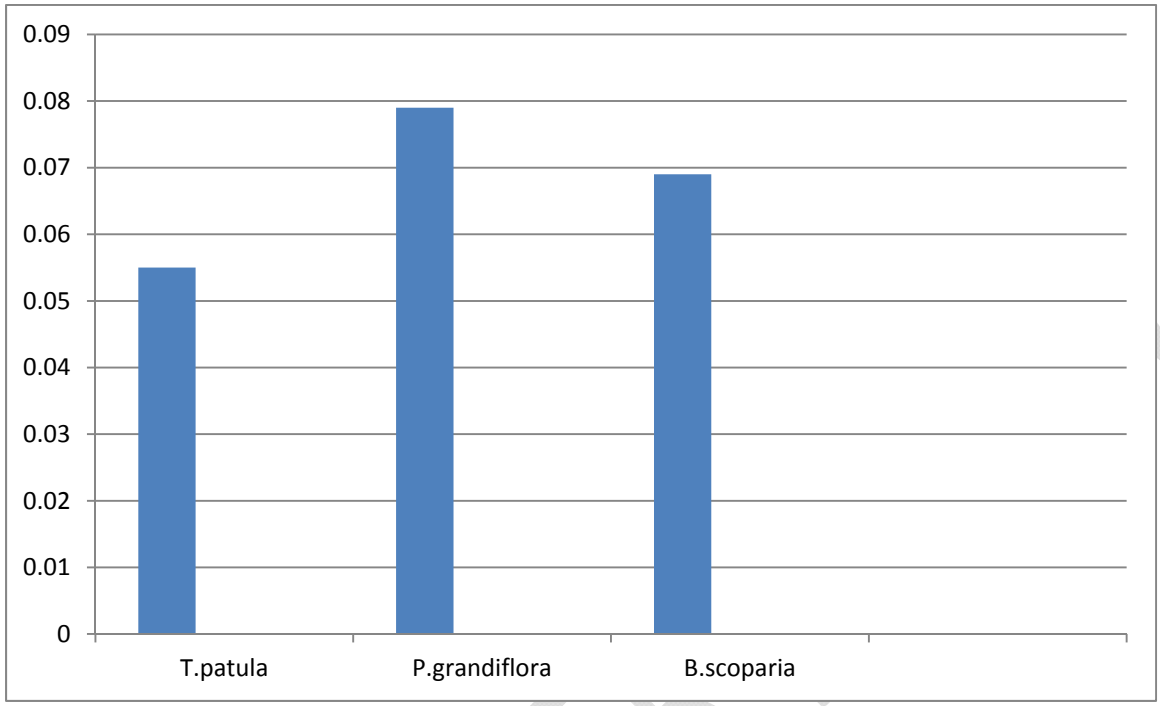
Graph 3.3: Chromium concentration left in water samples after eight weeks



Graph 3.4 :Zinc concentration left in water sample after eight weeks



Graph3. 5: Mercury concentration left in water after eight weeks



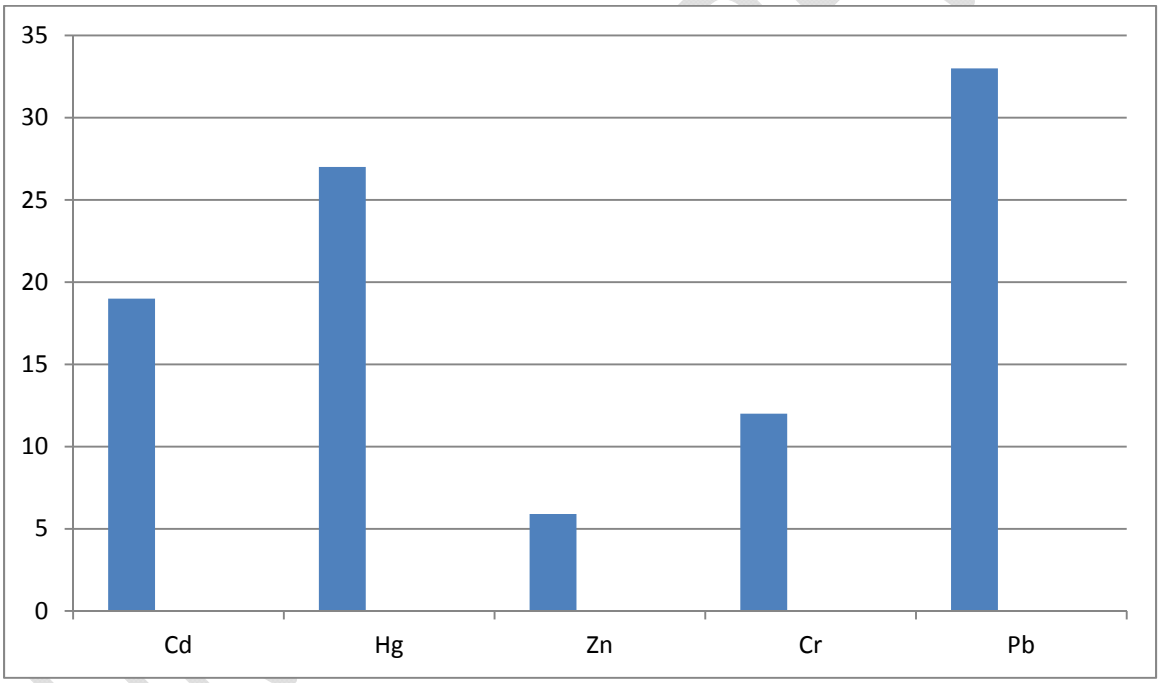
Graph3. 6: lead concentration left in water sample after eight weeks

Bioaccumulation of heavy metals by plants: Plants also have the ability to accumulate the Abeen checked with the help of AAS technique, after the acid digestion process of samples. The results of AAs are given in table below.

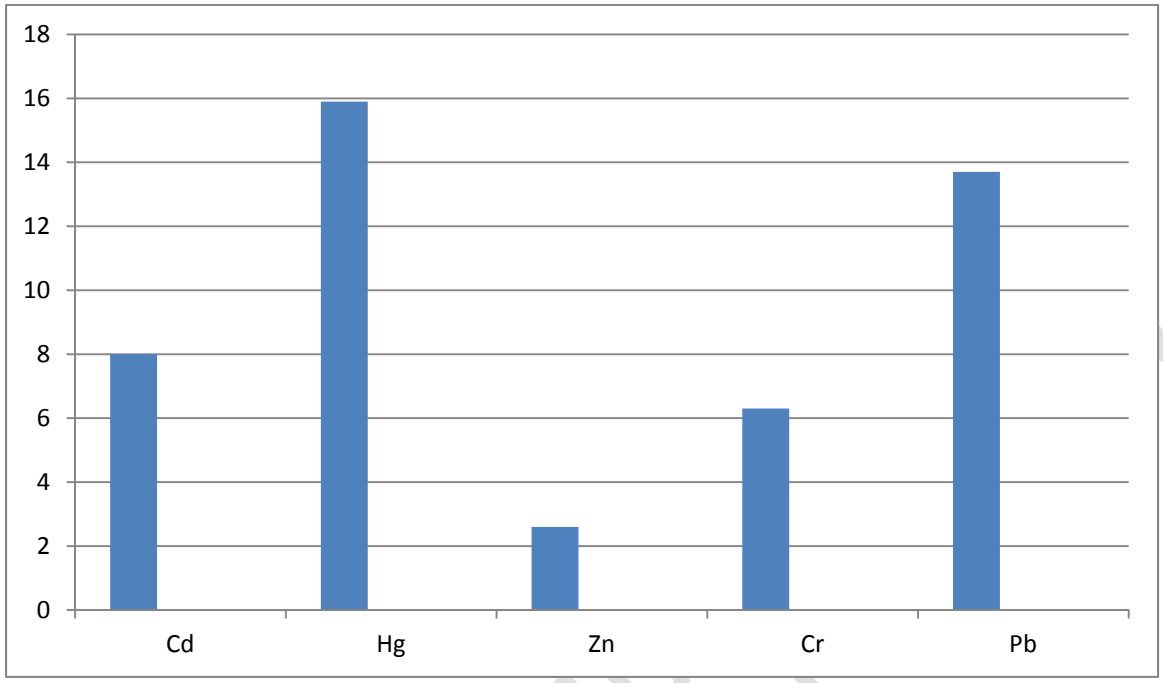
Table 6: Presence of heavy metals in the Roots (mg/kg^{-1}) of plants

Metals	*Tagetes Patula*	*Portulaca Grandiflora*	*Bassia Scoparia*
Cd	19	22	8
Cr	12	7.9	6.3
Zn	5.9	4	2.6
Hg	27	25.2	15.9
Pb	33	38	13.7

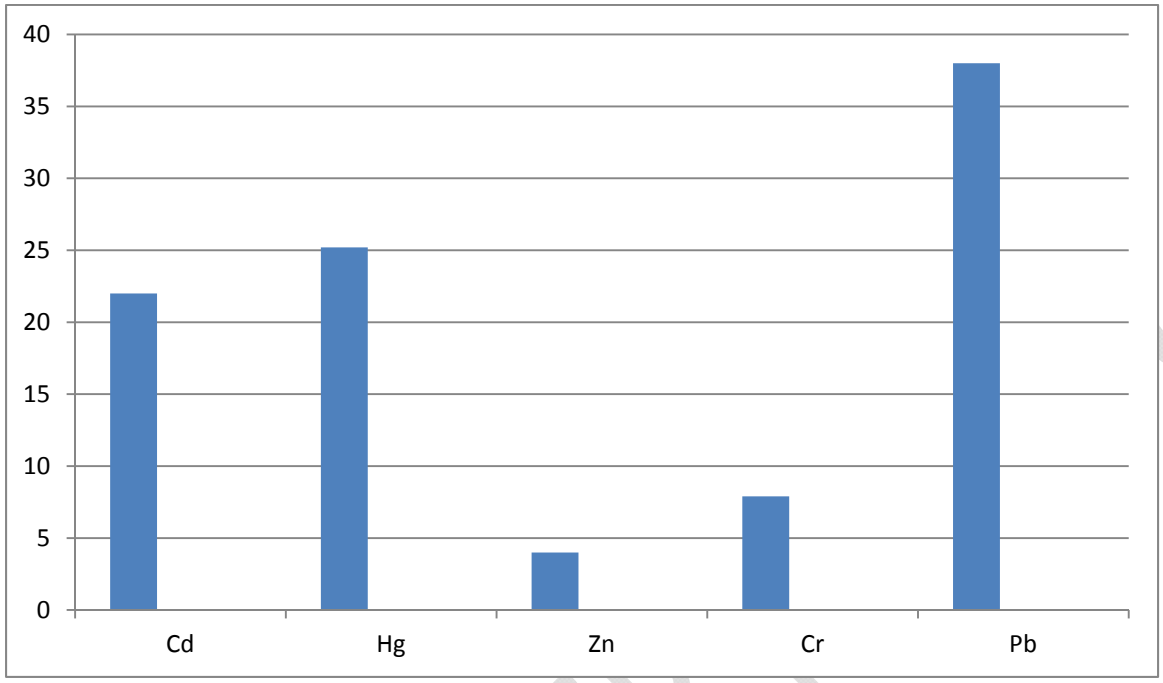
According to the above result, accumulation of zinc, mercury and chromium was highest in the roots of *T.patula*. Lead and cadmium accumulation was highest in the roots of *P.grandiflora*.



Graph 3.7: Heavy metal concentration in roots of *T.patula*



Graph 3.8: Heavy metal concentration in roots of *B.scoparia*

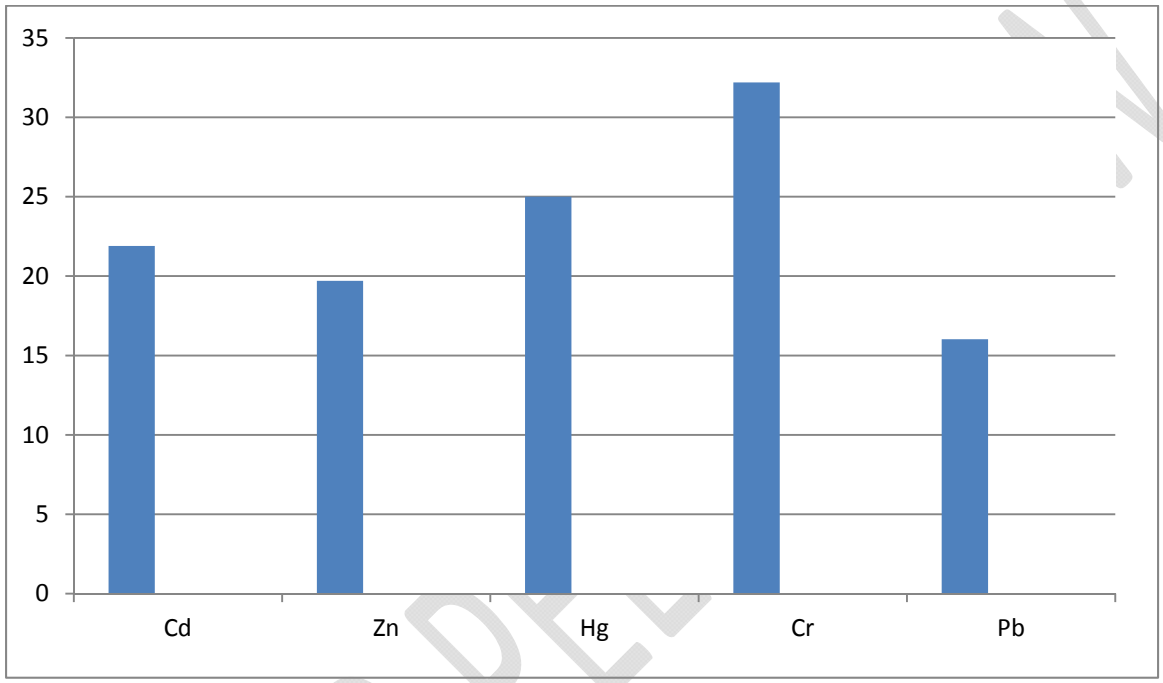


Graph 3.9: Heavy metal concentration in roots of *P.grandiflora*

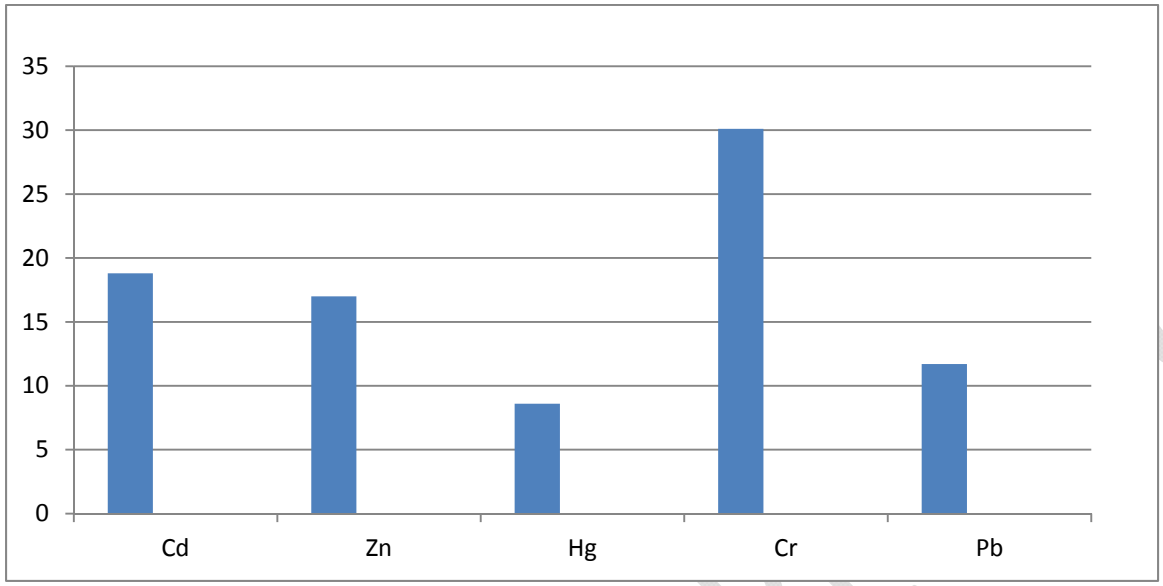
Table 7: Presence of heavy metals in the Stems (mg/kg^{-1}) of plants

Metals	***Tagetes Patula***	***Portulaca Grandiflora***	***Bassia Scoparia***
Cd	21.9	18.8	6.9
Cr	32.2	30.1	4
Zn	19.7	17	3.1
Hg	25	8.6	21
Pb	16.02	11.7	7

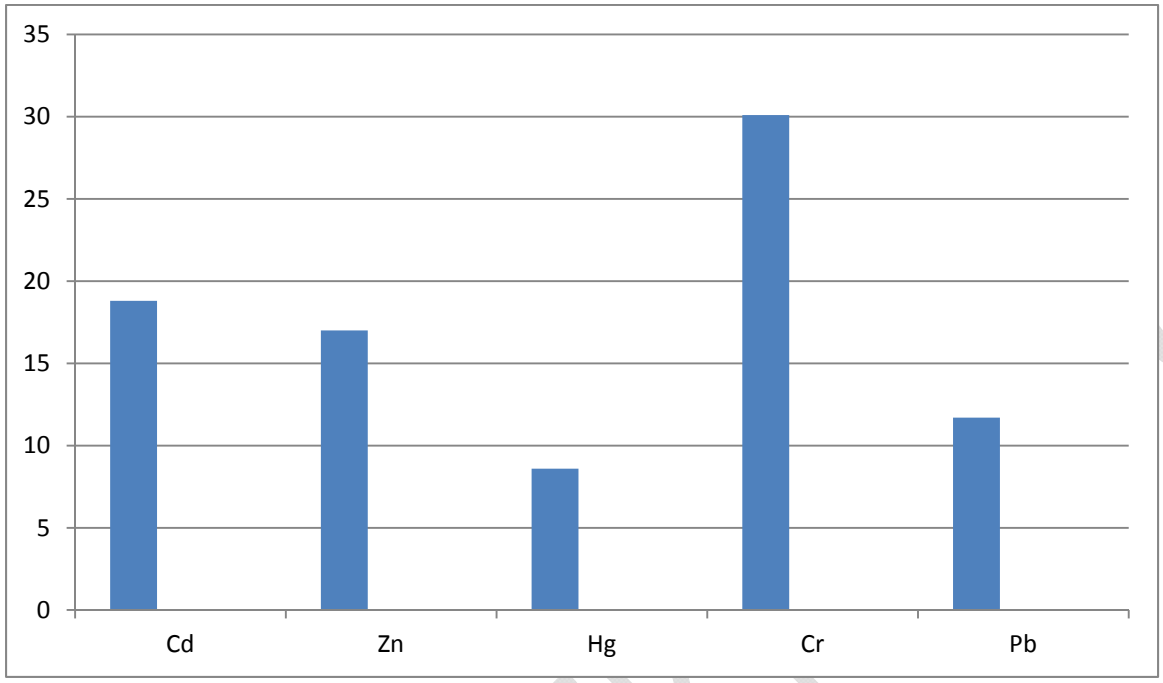
According to the result given in above table, stems of *T.patula* has the highest efficiency for accumulating all the above heavy metals, even *P.grandiflora* and *T.patula* shows approximately same results for accumulation of heavy metals in their stems.



Graph 3.10: Heavy metal concentration in Stems of *T.patula*



Graph 3.11: Heavy metal concentration in Stems of *B.scoparia*

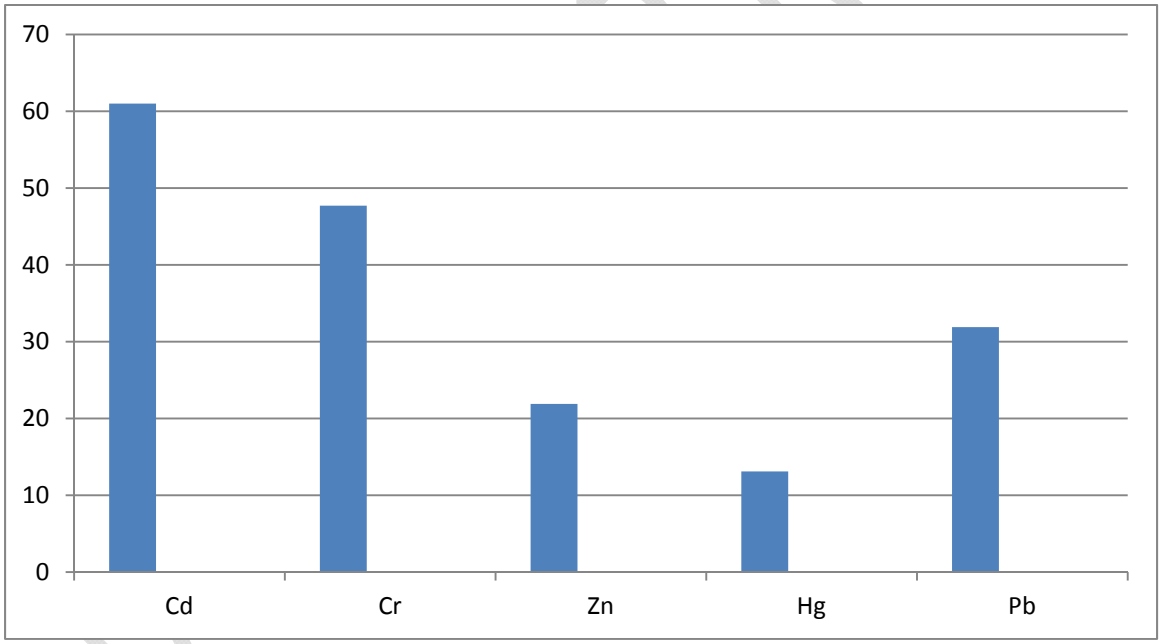


Graph 3.12: Heavy metal concentration in Stems of *P.grandiflora*

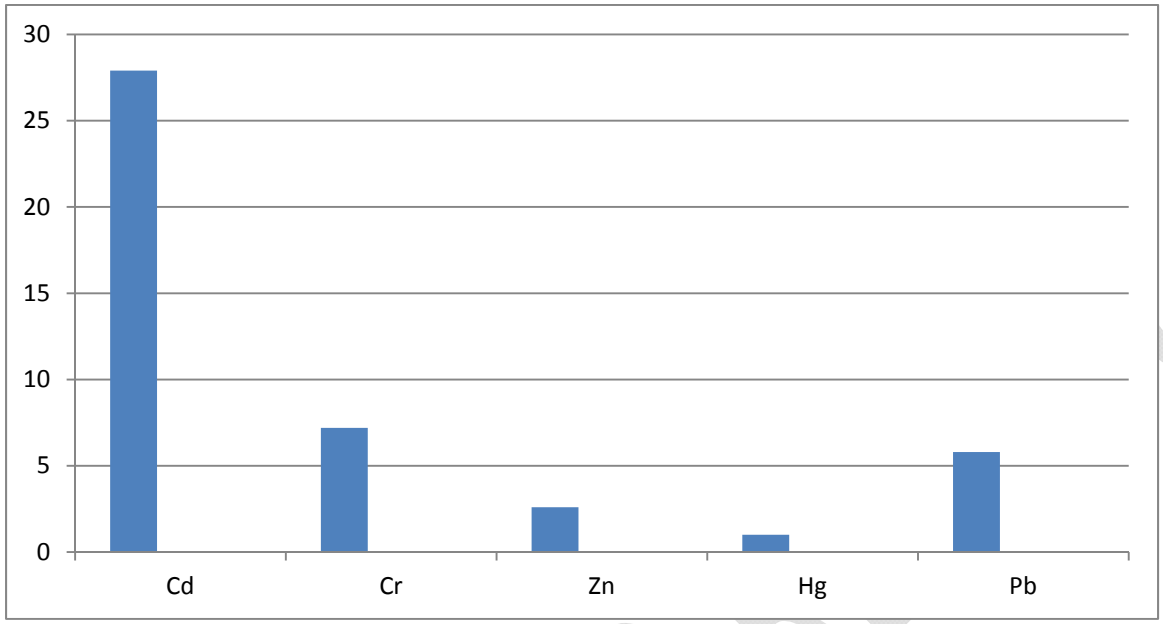
Table 8: Presence of heavy metals in the Leaves (mg/kg^{-1}) of plants

Metals	*Tagetes Patula*	*Portulaca Grandiflora*	*Bassia Scoparia*
Cd	61	36.1	27.9
Cr	47.7	20.8	7.2
Zn	21.9	2.3	2.6
Hg	13.11	4.6	1
Pb	31.9	4.6	5.8

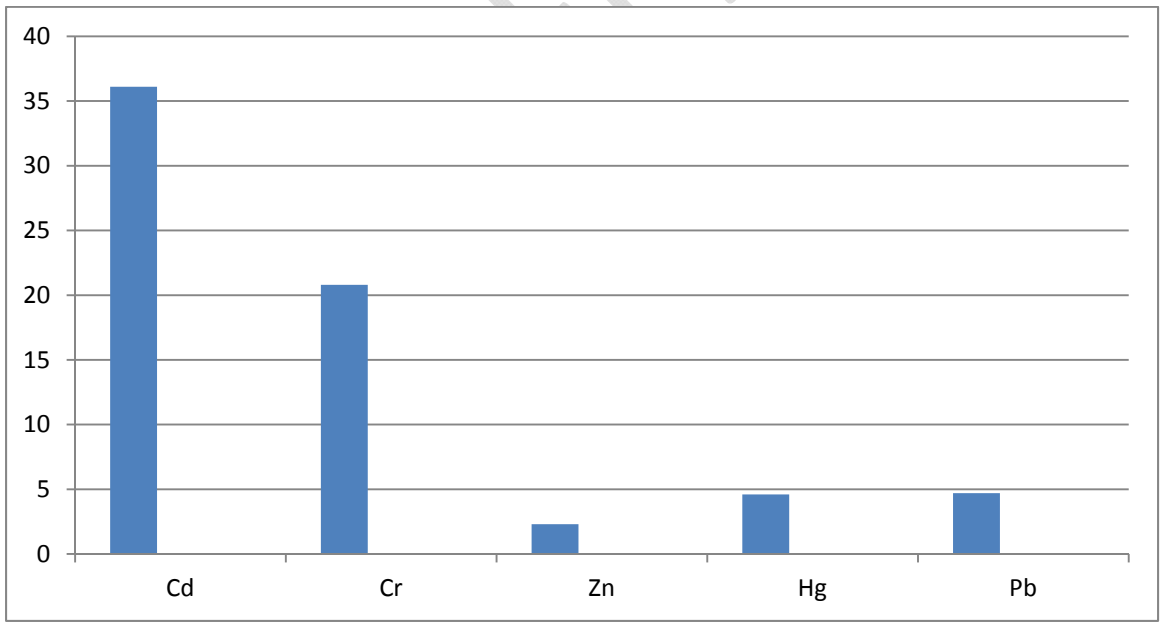
According to the above table, *T.patula* accumulated highest amount of heavy metals in its leaves and *P.grandiflora* and *B.scoparia* accumulated a great amount of cadmium in their leaves. *P.grandiflora* has also accumulated a significant level of chromium in its leaves.



Graph 3.13: Heavy metal concentration in Leaves of *T.patula*



Graph 3.14: Heavy metal concentration in Leaves of *B.scoparia*



Graph 3.15: Heavy metal concentration in Leaves of *P.grandiflora*

4. **Conclusion:** Phytoremediation is an effective, cheap or low maintenance technique for removal of heavy metals from environment. Out of all the three plants, T.patula shows a better growth in size and also shows the highest bio accumulating capacity for heavy metals. it can be concluded from the above study that the water quality of Yamuna river is good before entering national capital delhi. The main disastrous impact is from najafhgarh drains. From the above experiment it can be said that phytoremediation , phytoextraction technique can be used for making Yamuna river pollution free but we have to stop mixing untreated sewage water in Yamuna river.this project is a little attempt towards the big problem of Yamuna river pollution.

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