ACCUMULATION OF HEAVY METALS IN DIFFERENT PLANTS ON APPLICATION OF WASTE WATER

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Abstract

Healthy seeds of *Zea mays* L., (maize), *Helianthus annuus* L., (sunflower), *Phaseolus lunatus* L., (lobia), *Lens esculenta* moenchL., (masoor), *Capsicum annum* L., (chili), *Leucaena leucocephala* L., (lucaena), *Thespesia populnea L.,* (thespisia), *Spinacia oleracea* L., (spinach), and *Abutilon m*ill L.,(abutilon) were collected and planted in pots with soil. Seeds were treated with seven different treatments including control. The study was carried out to find out the levels of six heavy metals including cadmium, cobalt, iron, manganese, lead and zinc in plants irrigated by waste water of Lyari and Malir rivers. The results indicated the presence of metals in plant tissues irrigated by industrial and sewerage waste water of Karachi. The ranges of different metals in plants grown control water and by waste water were 0 to 2.2ppm, 0 to 26.9ppm, 0 to 1289ppm, 0 to.198.45ppm, 0 to 22.9ppm and 0 to 124.9ppm for cadmium (Cd), cobalt (Co), iron (Fe), manganese (Mn), lead (Pb) and zinc (Zn) respectively. The highest levels of Cd and Co were detected in *Thespesia populnea* when treated with Lyari industrial water and Lyari mix water respectively whereas Fe and Mn were highest in *Phaseolus lunatus* and *Thespesia populnea* under treatment of Lyari mix water and Lyari industrial waste water respectively. The contents of lead and zinc were highest in *Capsicum annum* and *Zea mays* when grown using Lyari mix and Lyari industrial respectively.

Introduction

Food safety is considered as a major concern, public as well as governmental agencies particularly in the developed countries are very much anxious about accumulation of heavy metals in food chain. Wastewater is being used since longtime in agriculture (Asano and Levine 1996) and is becoming more important due to the scarcity of fresh water. Generation of waste water due to industrial effluent and domestic sewerage is a worldwide problem especially in thickly populated areas. Karachi is the most populated city of Pakistan and two main waste water streams Malir and Lyari rivers flow through the heart of the city. It was also observed that Malir River was highly lethal for all plants due to the presence of toxic pollutants in waste water released by the tanneries and refineries in that area. Lyari river waste water was less toxic and plants responded to growth. In view of the nature of pollution in the rivers the inhabitants of Karachi are likely to get affected due to the mixing of this water with drinking water and consumption in food.

Heavy metals, such as cadmium, copper, lead, chromium and mercury are important environmental pollutants, particularly in areas with high anthropogenic pressure. Their presence in the atmosphere, soil and water, even in traces can cause serious problems to all organisms. They accumulate in the food chain which is dangerous to human health. Heavy metals enter the human body mainly through two routes namely: inhalation and ingestion, ingestion being the main route of exposure to these elements in human population. Their intake by human populations through food chain has been reported in many countries. Chronic low-level intakes have damaging effects on human beings and other animals, since there is no good mechanism for their elimination. Metals such as lead, mercury, cadmium and copper are cumulative poisons. These cause environmental hazards and are reported to be exceptionally toxic (Ellen *et al*., 1990). Metal contamination may be widespread in urban areas due to past industrial activity and the use of fossil fuels (Sánchez-Camazano *et al*., 1994). Predicting exposure to potentially toxic metals from consumption of food crops is complicated because uptake of metals by plants depends on soil properties, plant physiologic factors and intensity of toxic water used.

The plants absorb toxic elements and this will undoubtedly deteriorate soil productivity and adversely effect crop production in the surrounding land (Islam *et al*., 2006). Industrial waste water specially containing toxic heavy metals are real problem because they are not degraded like organic matter and persist in the ecosystem accumulating in different forms of the food chain (Smejkalova *et al*., 2003). Heavy metal accumulation in soils is of concern in agricultural production due to the adverse effects on food quality (safety and marketability), crop growth (Ma *et al*., 1994; Fergusson, 1990) and environmental health (soil flora/fauna and terrestrial animals).

Purpose of present study was to check the level of heavy metal accumulation in some species. Further research is needed to find out the variations in metal uptake by other plant species, and the site-specific risk assessment guidelines to highlight and to minimize the potential health risks of ingesting vegetables containing high levels of heavy metals.

Materials and Methods

Nine species of plants i.e. *Zea mays, Helianthus annuus, Abutilon mill, Phaseolus lunatus, Lens esculenta moench, Capsicum annum*, S*pinacia olerace, Leucaena leucocephala and Thespesia populnea* were tested by seven types of waste water including control or tap water. The wastes were Lyari (mix, industrial, sewerage) and Malir (mix, industrial, sewerage) and control water. 200 gallons of each kind of water was collected from various locations along Lyari and Malir rivers. Ten seeds of each species were planted in pots filled with 80% soil and 20% organic matter. Five replications were used for each treatment. Seeds were planted 2 inches deep in the soil. These were watered every alternate day by waste waters. Only three prominent healthy plants were selected and left for further growth in the pot. The rest were removed by plugging them.

The plants were then crushed into fine particles by means of grinder. Approximately 2 to 3 grams of each sample was selected and put in crucible for further investigation. The samples were heated up to temperature 500ºC in a furnace and maintained for an hour and digested in Aqua regia. Digested samples were filtered and solutions were stored in bottles to analyze by atomic absorption spectrophotometer (PG 990).

Results and Discussion

The plants only grew in control or Lyari waste water and there was no response in case of Malir water. It was due to the toxicity of water. The permissible levels of Cd, Pb, Zn, Fe and Mn are 0.2ppm, 0.3ppm and 50ppm, 1000ppm and 1000ppm respectively as per EU standards and UK guidelines (Muchuweti *et al* 2006; EC 2001). The mean concentration for cobalt for plant is 0.48 ppm (Bowen, 1966).

On the basis of table 1, cadmium contents were below the detection limits in almost all the plants. In case of thespesia (*Thespesia populnea L.,*) in Lyari industrial, the value of cadmium was 2.2ppm as the highest value recorded. It was above the permissible limit.

The content of cobalt in sunflower (*Helianthus annuus L*.,) when treated with control water was 0.93ppm as minimum value while maximum value was 26.9ppm in thespesia (*Thespesia populnea L.,*) under treatment of Lyari industrial water.

Minimum iron concentration was detected as 9.5ppm when sunflower (*Helianthus annuu*) was treated with Lyari sewerage. The maximum value recorded was 1289ppm in lobia (*Phaseolus lunatus* L.,) (Lyari mix). This was above (1000ppm) permissible value.

The range of manganese was from 2.4ppm in case of thespesia (*Thespesia populnea* L.,) in neutral water to 198.45ppm in thespesia (Thespesia populnea L.,) when treated with Lyari industrial water. The lower and upper limits in Lyari mix were 0.05ppm of Cd in abutilon (Abutilon mill L.) and 1289ppm (Fe) in lobia (Phaseolus lunatus L.,) respectively. In case of Lyari sewerage the range was 0.08ppm of Cd in Spinacia oleracea L.(spinach) to 305.5ppm of Fe in lobia (Phaseolus lunatus L.,). In case of Lyari industrial it was 0.08ppm (Cd) in abutilon (*Abutilon m*ill L.) and 709.5ppm (Fe) for spinach (*Spinacia oleracea*).

Out of 36, seventeen trials showed some lead contents. The range was from 0.4ppm in lucaena (*Leucaena leucocephala Lam*) (Lyari sewerage) to 22.9ppm thespesia (*Thespesia populnea L.,*) when treated with Lyari mix. It was 76.33 times the allowed limit.

The lower limit of zinc 0.2ppm was found in abutilon (*Abutilon m*ill L.,) in treatment with neutral while upper limit was 124.9ppm in case of maize (*Zea mays*) when treated with Lyari industrial water.

Lead is a toxic element that can be harmful to plants, because they usually show ability to accumulate large amounts of lead without visible changes in their appearance or yield. In many plants, Pb accumulation can exceed several hundred times the threshold of maximum level permissible for human (Wierzbicka, 1995). According to our study the maximum lead content was 22.9ppm. This value was 76.3 times the allowed limit. The introduction of Pb into the food chain may affect human health, and thus, studies concerning Pb accumulation in vegetables have increasing importance (Coutate, 1992).Long *et al*., (2003) showed that zinc uptake and accumulation by shoots and roots varied with Zn levels in growth media and vegetable types. Knowledge of Zn toxicity in humans is minimal. An acute oral Zn dose may provoke include: tachycardia, vascular shock, dyspeptic nausea, vomiting, diarrhea and damage of hepatic parenchyma. Although maximum Zn tolerance for human health has been established for edible parts of crops (20 mg/kg) (Chinese Department of Preventive Medicine, 1995), Maximum zinc content recorded in our study was 124.9ppm which is more than 50ppm as per EU standard. It is concluded that the Lyari river waste water was less toxic than Malir water as far as germination of seeds in soil were concerned. Species which were highly tolerant to the toxic chemical and their growth not effected by waste water are still environmentally not suitable, if they accumulate heavy metals. Therefore before making any suggestions regarding polluted water to be used for irrigation, chemical analysis for heavy metals are highly recommended for soil, water and plants.

Table1. Concentration of Heavy Metals in Various Plants in ppm

S. No	Name of Plant	Cd	Co	Fe	Mn	Pb	Zn
1	Zea mays L., maize(N)	bdl	bdl	bdl	bdl	bdl	bdl
2	Zea mays L., maize(LS)	M	6.34	52.99	14.7	6.5	9.2
3	Zea mays L., maize(LM)	M	10.35	190	26.62	7.2	26.87
4	Zea mays L., maize)(LI)	M	11.65	350.58	43.35	15.3	124.9
5	Helianthus annuus L., sunflower(N)	bdl	bdl	bdl	bdl	bdl	bdl
6	Helianthus annuus L., sunflower(LS)	bdl	0.93	9.5	4.66	bdl	bdl
7	Helianthus annuusL., sunflower(LM)	M	7.45	145.42	66.62	0.96	12.5
8	Helianthus annuus L., sunflower(LI)	M	M	M	M	M	M
9	Abuliton mill L., abolition (N)	bdl	1.67	21.07	2.44	bdl	0.2
10	Abuliton mill L., abolition (LS)	bdl	2.88	30.37	11.56	bdl	6
11	Abuliton mill L., abolition (LM)	0.05	6.8	63.76	20.4	0.47	11.18
12	Abuliton mill L., abolition (LI)	0.08	11.82	444.22	61.17	14.95	24.12
13	Phaseolus lunatus L., lobia (N)	bdl	bdl	bdl	bdl	bdl	bdl
14	Phaseolus lunatus L., lobia (LS)	bdl	12.72	305.5	46.52	9.17	22.17
15	Phaseolus lunatus L., lobia (LM)	bdl	14.18	1289	75.12	9.56	45.15
16	Phaseolus lunatus L., lobia LI)	M	M	M	M	M	M
17	Lens esculenta moench L., masoor (N)	bdl	bdl	bdl	bdl	bdl	bdl
18	Lens esculenta moench L., masoor (LS)	M	M	M	M	M	M
19	Lens esculenta moenchL., masoor (LM)	M	M	M	M	M	M
20	Lens esculenta moench L., masoor (LI)	M	M	M	M	M	M
21	Capsicum annum L., chilies (N)	bdl	bdl	bdl	bdl	bdl	bdl
22	Capsicum annum L., chilies (LS)	bdl	0.96	90.72	12.2	bdl	18.14
23	Capsicum annum L., chilies (LM)	bdl	24.56	261.07	154.4	21.55	82.2
24	Capsicum annum L.. chilies) (LI)	M	M	M	M	M	M
25	Spinacia oleracea L., spinach (N)	bdl	1.86	30.16	8.51	bdl	3.25
26	Spinacia oleracea L., spinach(LS)	0.08	2.42	136.93	15.1	1.47	3.25
27	Spinacia oleracea L., spinach(LM)	0.27	4.44	372.72	81.05	6.85	29.52
28	Spinacia oleracea L., spinach (LI)	0.33	10.95	709.5	89.15	10.65	46.32
29	Leuceana leucocephalaL., leucinia (N)	bdl	bdl	bdl	bdl	bdl	bdl
30	Leuceana leucocephala L., leucinia (LS)	bdl	9.75	56.4	26.6	0.4	bdl
31	Leuceana leucocephala L.,leucinia (LM)	bdl	13.69	130.1	61.17	3.2	13.35
32	Leuceana leucocephala L., leucinia (LI)	M	M	M	M	M	M
33	Thespesia populnea L.,thespesia(N)	bdl	4.02	78.22	2.4	bdl	7.82
34	Thespesia populnea L.,thespesia (LS)	bdl	5.3	237.47	20.4	5.58	20.40
35	Thespesia populnea L.,thespesia(LM)	1.1	23.25	278.22	30.5	21.3	58.7
36	Thespesia populnea L.,thespesia (LI)	2.2	26.9	699.8	198.45	22.9	68.4

Cd=0.2ppm, Co=0.4ppm, Fe=1000ppm, Mn=1000ppm, Pb=0.3ppm, Zn=50ppm,
Note: bdl= Below detection limit (<0.1ppm), M= Mortality

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