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Research Article

BIO CONCENTRATION FACTOR (BCF) FOR HEAVY METALS DETECTION AND SELECTION OF HYPER-ACCUMULATOR PLANTS-CASE STUDY OF PUNE-INDIA AND TEHRAN -IRAN

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ABSTRACT
There is increasing contamination of soil due to pollution effect on water and air from activities like urbanization, industrialization, application of chemical fertilizer and pesticide. Polluted soils transfer of heavy metals to plants is the major pathway of human exposure to soil contamination. Bio Concentration Factor (BCF) of Cd, Zn, Pb, Cu, Ni and Cr from soils to vegetables were calculated in present paper. The BCF values for heavy metals for various crops varied greatly between plants species and selected stations from India and Iran. The result obtained in selecting particular floriculture crops such as *Aster amellus* L. and *Polianthes tuberose* L. are accumulator plants near Pune. It is possible to reduce the risk of human exposure to soils and heavy metal contamination. Vegetable that cultivated in Tehran such as *Coriandrum sativum* L., *Aniethum graveolens* L., *Petroselinum sativum* Hoffm, *Lepidium sativu* L., are harmful for human consumption.

***Keyword**: Heavy Metals, BCF, Hyper-Accumulator Plants*

INTRODUCTION
Heavy metals are harmful to humans, animals and tend to bio-accumulate in the food chain. Activities such as mining and smelting of metal ores, industrial emissions and applications of insecticides and fertilizers are contributed to elevated levels of heavy metals in the environment (Alloway, 1994).Heavy metals are easily accumulated in human vital organs and threaten human health. Vegetables are part of human diet to take up a lot of essential nutrients and certain trace elements in a short period. In this situation, safety of vegetables is very important (Liu *et al.*, 2005; Zhou *et al.*, 2005). Heavy metal pollution in soil is often mentioned by several countries. Scanty information is available on heavy metal transfer from soil to vegetable (Chen *et al.*, 1999; Wong *et al.*, 2002). Few studies reported that the bioavailability of soil metal to vegetable was controlled by soil properties, soil metal speciation, and plant species (Davies, 1992; Ehlken and Kirchner, 2002). In addition, foliar uptake of atmospheric heavy metal emissions has also been identified as an important pathway of heavy metal contamination in vegetable crops (Bassuk, 1986; Salim *et al.*, 1992).
Pune, India and Tehran in Iran are heavy populated and pollution effects are recorded by several workers. The concept of heavy metal pollution on crops and soils along highways were first recorded in both places. Agricultural soils and crops along highways are mostly affected by heavy metals like Pb, Cr, Cd, Cu, Fe, Zn, Ni and Mn. In this connection (Delbari *et al.*, 2011a and 2011b) reported heavy metal pollution in agriculture soils of Tehran. Delbari and Kulkarni 2012, 2013 recorded pollution effect on agricultural soils from Pune region. Vegetables pollution due to heavy metals in Teheran and seasonal variation of heavy metals in soils from Pune region were recorded (Delbari and Kulkarni, 2011, 2013.). The concept of Bio-concentration factor for selecting hyper-accumulator plants is reported for first time in this paper.
It is observed that plants contain large amounts of metals in their roots. Metal indicator plants accumulate metals in their above-ground tissues and its concentrations in the tissues of these plants generally reflect metal levels in the soil. Metal accumulators are usually referred to as hyper-accumulators that concentrate metals in their above-ground tissues to levels far exceeding those present in the soil as compare to other

plants. Effect of heavy metal pollution on crops and soils along high ways in India and Iran were carried out to know hyper accumulator plants in both the areas.

Area under Study

Tehran's air quality is impacted by the stationary and mobile sources as well as its location and topography. It is estimated that about 30% of Iran's industrial establishments, heavy metal deposition due to vehicular pollution are located around Tehran. Six stations were selected for crop and soil sample collection for analysis point of view (Ttable-1).

Table 1: The areas around Tehran were selected for data collection.

No. St	Name of station around Tehran-Iran	Name of crops	Name of crops (opposite site)
1	Saidi high way (shahid beheshty complex)	*Lepidium sativum* L.	*Coriandrum sativum* L.
2	Saidi high way(shah Tareeh)	*Ocimum basilicum* L.	*Aniethum graveolens* L.
3	Tehran-Qom high way(Turouz abad)	*Spinacia oleracea* L	*Petroselinum sativum* Hoffm
4	Tehran-Qom high way (Jalil Abad)	*Aniethum graveolens* L.	*Ocimum basilicum* L.
5	Tehran-Varamin high way(near Amin Abad road)	*Petroselinum sativum* Hoffm	*Spinacia oleracea* L
6	Tehran -Varamin high way(Firooz Abad)	*Coriandrum sativum* L.	*Lepidium sativum* L.

Pune city is situated at a height of 560m above the mean sea level, near the confluence of Mula and Mutha rivers. During the last four decades, innumerable developmental projects in and around Pune has changed the atmosphere. It has created an adverse impact on the environment and increased the chances of grave health risk due to continual air, water and soil pollution. Several vehicles are coming into Pune city by all highways and transportation of goods from Pune to other long distances. This change is a major factor of vehicular pollution around Pune city. Six stations were selected for crop and soil sample collection for analysis point of view (Table-2).

Table 2: Area under study: The area around Pune was selected for data collection

No.St.	Name of station	Main crop	
1	Shivapur Toll collection centre- Pune to Bangalore	*Sorghum bicolor* (L.) Moench.	*Sorghum bicolor* (L.) Moench.
2	Bhugaon- Pune to Mangaon-Konkan	*Oryza sativa* L./(, *Pisum sativum L*	*Oryza sativa* L./ (, *Pisum sativum L*
3	Telegaon- Chakan- Connecting road to Bombay Pune old highway to Nasik Highway	*Allum cepa* L./*Ground nut*	Ground / *Zey mays* L.,)
4	Nasik- Pune highway, Near Hotel Vedant	*Aster amellus* L.	*Aster amellus* L.
5	Pune- Ahmednagar Highway- Harshraj Garden Dhaba	*Sorghum bicolor* (L.) Moench.	*Triticum astivum* L
6	Pune-Solhapur highway- Near village Yavat.	*Polianthes tuberosa* L.	*Polianthes tuberosa* L.

MATERIALS AND METHODS

Methodology for Data Collection and Analysis

Present research activity has been carried out on above locations and collected 72 soil samples and 72 crops samples (6 stations and every station 3 samples 5m, 10m, 15m and opposite site) in monsoon and winter were collected during 2010-2011 in India. In Iran 108 soil samples and 108 crops samples (6 stations and every station 3 samples 5m, 10m, 15m and opposite site) in spring, summer and winter were collected. The Schematic diagram of experimental sites shows in Figure1-2

Concentrations of heavy metals were detected in different sampling stations in three seasons in Iran and 2 seasons in India. The soils and crops were dried and the analyses of heavy metals were done by Atomic Absorption Spectrophotometer after acid digestion. Quality assurance was guaranteed through double determinations and use of blanks for correction of background and other sources of error. Digestion of samples for analysis with GFAA or ICP-MS, add 10 mL of 1:1 HN03, mix the slurry, and cover with a watch glass or vapour recovery device. The sample was heat up to 95°C ± 5°C and reflux for 10 to 15 minutes without boiling. The samples were allowed to cool and add 5 mL of concentrated HN03, replace the cover, and reflux for 30 minutes. Brown fumes were generated, indicating oxidation of the sample by HN03, repeated the step (addition of 5 mL of cone. HN03) over and over until no brown fumes are given off by the sample indicating the complete reaction with HNO3. Used a ribbed watch glass or vapor recovery system, allowed the solution to evaporate it approximately 5 mL without boiling for two hours. Maintained a covering solution over the bottom of the vessel at all times. Pb, Cr, Cd, Cu, Fe, Zn, Ni and Mn concentrations in some species of vegetables and floriculture based on their fresh weight (FW).

Bio Concentration Factor (BCF) of Cd, Zn, Pb, Cu, Ni and Cr from soils to vegetables were calculated by using formula as below:

BCF=Metal concentration in plants/ Metal concentration in soil

The BCF values for heavy metals for various crops varied greatly between plants species and station.

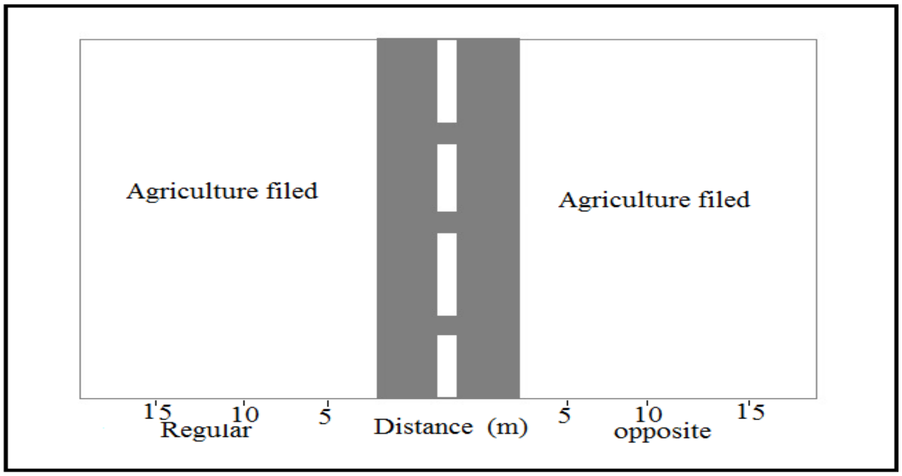

Figure 1: Schematic diagram of the experimental site Pune, India

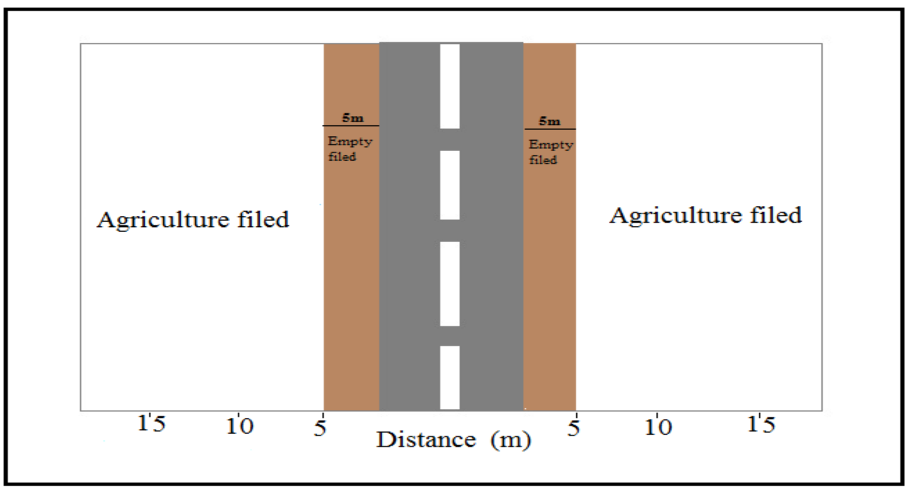

Figure 2: Schematic diagram of the experimental site Tehran, Iran

RESULTS

Heavy metals accumulation in agricultural soils is of increasing concern due to the food safety issues and potential health risks as well as its detrimental effects on soil ecosystems (McLaughlin *et al.,* 1999). It also poses potential barriers for international trading of foodstuffs. Regulatory frameworks and guidelines for heavy metals in the environment and foodstuffs have been developed in many countries around the world, such as Australia and New Zealand (McLaughlin *et al.*, 2000). Sources of heavy metals in soils mainly include natural occurrence derived from parent materials and human activities (anthropogenic sources). Anthropogenic inputs are associated with industrialization and agricultural activities such as atmospheric deposition, waste disposal, waste incineration, urban effluent, vehicle exhausts, fertilizer application and long-term application of sewage sludge in agricultural land (Hlavay *et al.*, 2001; Koch and Rotard, 2001; McLaughlin and Singh, 1999; McLaughlin and Hamon, 2000).
Soil-to-plant transfer of heavy metals is the major pathway of soil contamination. Health risk due to soil contamination with single heavy metal has been widely studied. For example, lifetime exposure to low level soil contamination with cadmium (Cd) has shown to cause renal dysfunction in residents living near the contamination sites in Japan (Ryan *et al.*, 1982) and China (Cao *et al.*, 2002; Nordberg *et al.*, 1997). However, in the reality, multiple contaminants often co-exist in the environment and health risk estimated on the basis of single contaminant may not be sufficient to predict the risk for mixed contaminants.
Contamination of vegetables with heavy metals may be due to irrigation with contaminated water, the addition of fertilizers and metal-based pesticides, industrial emissions, transportation, the harvesting process, storage and/or at the point of sale. Plants contain both essential and toxic metals over a wide range of concentrations. (Khairiah *et al.*, 2004; Chojnacka *et al.*, 2005). The potential toxicity and persistent nature of heavy metals and the frequent consumption of vegetables and fruits. It is necessary to analyze these crops items to ensure the levels of these contaminants meet agreed international requirements (Radwan and Salama, 2006). The Ni, Cr, Pb, Cu and Zn transport from soil to crops was evaluated using BCF. The ratio >1 means, higher accumulation of metals in plant parts (Bahemukaand Mubofu 1996)The results are present in Figure 3 - 7.

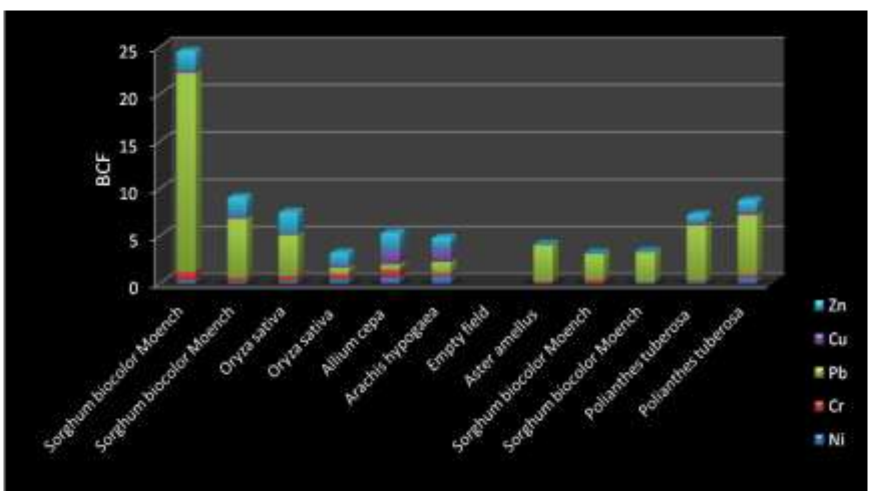

Figure 3: Bio Concentration Factor of soil to crops in monsoon season Pune-India

The BCF values for Ni varied from 0.06 (*Aster amellus* L.) to 0.71(*Arachis hypogaea*L.) values for Pb were much higher than those for Ni, varying from 0.6 (*Allium cepa*) to 21.00 (*Sorghum bicolor* Moench.). Values for Cr varied from 0.05 (*Sorghum bicolor* Moench) to 0.93 (*Sorghum bicolor* Moench.).. Values for Zn were generally slightly lower than those for Pb and varied from 0.02(*Aster amellus* L.) to 2.27(*Oryza sativa* L.). Values for Cu were within the similar range of variation as those for Zn. According to the BCF values, conclusion may be drawn that *Sorghum bicolor* Moench.**,** *Oryza sativa* L., *Arachis hypogaea* L. , *Aster amellus* L., *Polianthes tuberose* L., are Pb-accumulator.

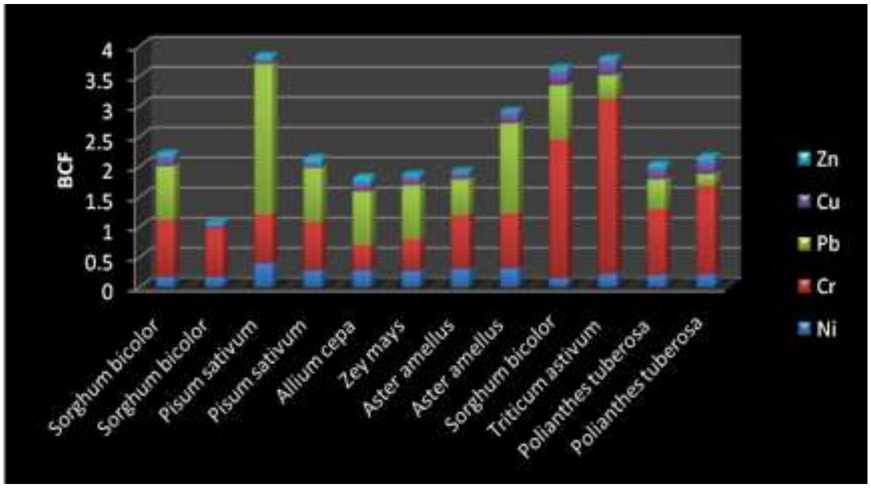

Figure 4: Bio Concentration Factor of soil to crops in winter season Pune-India

The BCF values for Ni varied from 0.15(*Sorghum bicolor* Moench.) to 0.4 (*Pisum sativum* L.) values for Pb were much higher than those for Ni, varying from 0.0 (Sorghum *bicolor* Moench.) to 2.50 (*Pisum sativum* L.). Values for Cr varied from 0.41(*Allium cepa* L.) to 2.90 (*Triticum astivum* L.).Values for Zn were generally slightly lower than those of Pb and varied from 0.05(*Aster amellus* L.) to 0.13 (*Allium cepa L.*). Values for Cu were within the similar range of variation as those for Zn. According to the BCF values conclusion may drawn that *Pisum sativum L., Aster amellus L.,* are Pb-accumulator and *Polianthes tuberose* L., *Sorghum bicolor* Moench and *Triticumastivum* L. are Cr –accumulator .

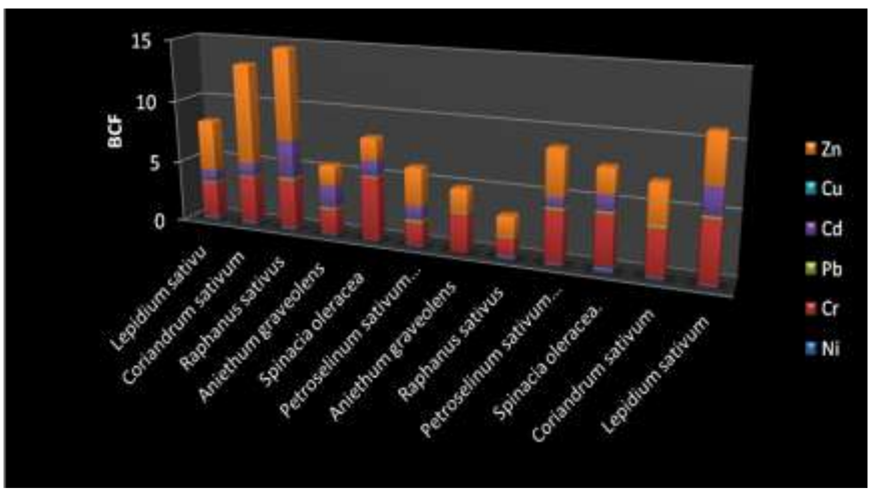

Figure 5: Bio Concentration Factor of soil to crops in spring season Tehran-Iran

The BCF values for Ni varied from 0.07 (*Spinacia oleracea* L.) to 0.35(*Spinacia oleracea* L.) values for Pb were varying from 0.12 (*Coriandrum sativum* L.) to 0.23 (*Spinacia oleracea L.*) Values for Cr varied from 1.41(*Raphanus sativus* L.) to 5.00 (*Spinacia oleracea* L.). Values for Zn were varied from 1.5(*Raphanus sativus* L.) to 0.13 (*Coriandrum sativum* L.). According to the BCF values present in crops, concludes that *Raphanus sativus* L., Spinacia *oleracea* L., *Lepidium sativum* L., *Coriandrum sativum*L ,*Aniethum graveole* Land *Petroselinum sativum* Hoffm are Cr and Zn-accumulator. *Lepidium sativum* L., *Coriandrum sativum* L., *Raphanus sativus* L., *Aniethum graveole* L., *Spinacia oleracea* L., *Petroselinum sativum* Hoffm are Cd accumulator.

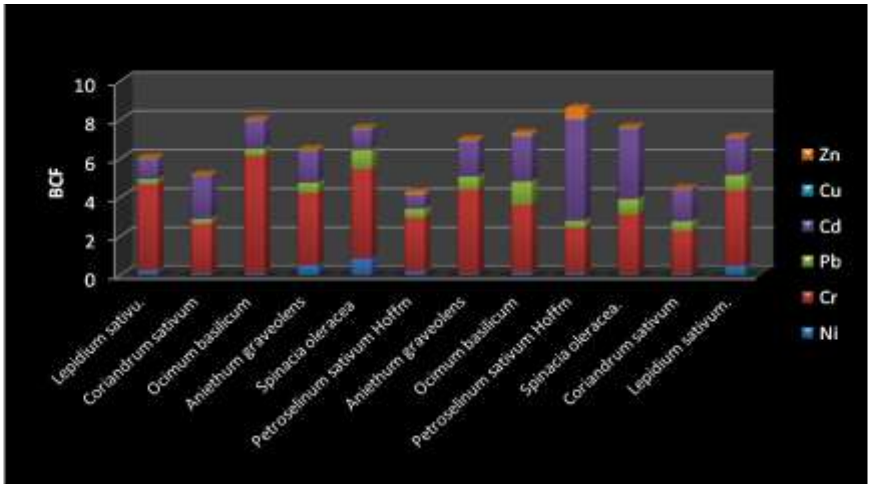

Figure6: Bio Concentration Factor of soil to crops in summer season Tehran-Iran

The BCF values for Ni varied from 0.05 (*Spinacia oleracea* L.) to 0.85 (*Spinacia oleracea.* L) Values for Pb were varying from 0. 28 (*Coriandrum sativum* L.) to 1.22 (*Ocimum basilicum* L.). Values for Cr varied from 2. 18 (*Coriandrum sativum* L.) to 6.04 (*Ocimum basilicum* L.). According to the BCF values conclusion may be drawn that all the collected vegetables are Cr and Cd –accumulator. *Lepidium sativum* L., *Ocimum basilicum* L., *and Spinacia oleracea* L., are Pb- accumulator.

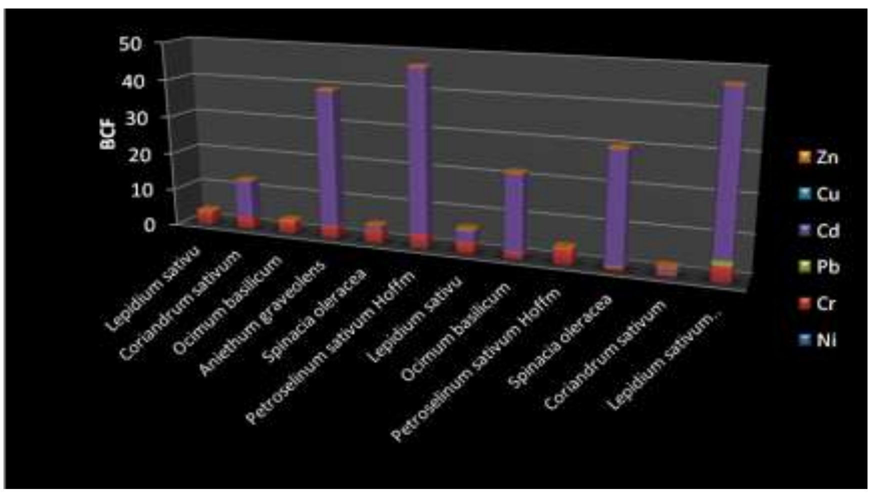

Figure 7: Bio Concentration Factor of soil to crops in fall season Tehran-Iran

The BCF values for Ni varied from 0.02 (*Lepidium sativum* L.) to 0.20 (*Lepidium sativum* L.) While values for Pb were varying from 0.05 (*Lepidium sativu*m L.) to 1.43 (*Lepidium sativu* L.), values for Cr varied from 0.78 (*Spinacia oleracea. L*) to 3.84 (*Lepidium sativum* L.). Values for Cr varied from 0.00 to 43.00 (*Petroselinum sativum* Hoffm). According to the BCF values, it concludes that *Lepidium sativum*..L,*Coriandrum sativum*L. ,*Ocimum basilicum*L.,*Spinacia oleracea* L., *Aniethum graveolens* L.*and Petroselinum sativum* Hoffm *a*re Cr -accumulator *Lepidium sativum*.L is Pb- accumulator. Finally *Coriandrum sativum*L.,*Aniethum graveolens*L.,*Petroselinum sativum* Hoffm, *Lepidium sativum*..L *and Spinacia oleracea.* L., are highly Cd-accumulator.

DISCUSSION

Heavy metal depositions are associated with a wide range of sources such as small scale industries (including battery production, metal products, metal smelting and Cable coating industries); brick kilns;

vehicular emissions; re-suspended road dust and diesel generator sets. These can all be important contributors to the contamination found in vegetables. Additional potential sources of heavy metals in field locations in urban and near urban areas include irrigation with contaminated water by industrial effluent leading to contaminated soils and vegetables.

Data showed that genotypic differences intolerance and co tolerance to heavy metals are well known in some species and ecotypes of natural vegetation. Leafy vegetables have been shown to accumulate relatively high concentrations of heavy metals in compare to fruit vegetables.

BCF values in monsoon season were concluded that *Sorghum bicolor* Moench**,** *Oryza sativa* L., *Arachis hypogaea* L., *Aster amellus* L., *Polianthes tuberose* L., are Pb-accumulator. Winter season *Pisum sativum* L., *Aster amellus* L. ,are Pb-accumulator and *Polianthes tuberose L*., *Sorghum bicolor* Moench and *Triticumastivum* L. are Cr –accumulator. Most of the plants covered in India are fodder, grain and flowering plants and they may be used as hyper-accumulator.

Tehran had BCF values in spring season are *Raphanus sativus* L., *Spinacia oleracea* L., *Lepidium sativum* L., *Coriandrum sativum* L., *Aniethum graveolens* L. and *Petroselinum sativum* Hoffm are Cr and Zn-accumulator. *Lepidium sativum* L., *Coriandrum sativum* L., *Raphanus sativus* L., *Aniethum graveolens L*., *Spinacia oleracea* L., *Petroselinum sativum* Hoffm are Cd-accumulator. Summer season values of vegetables are Cr and Cd –accumulator. *Lepidium sativum* L., *Ocimum basilicum* L,. *and Spinacia oleracea* L. are Pb- accumulator. In fall season plants like *Lepidium sativum* L. , *Coriandrum sativum* L. ,*Ocimum basilicum* L., *Spinacia oleracea* L., *Aniethum graveolens* L. and *Petroselinum sativum* Hoffmare Cr –accumulator, *Lepidium sativum*..L is Pb- accumulator. Finally *Coriandrum sativum*L., *Aniethum graveolens* L., *Petroselinum sativum* Hoffm, *Lepidium sativum* .L *and Spinacia oleracea* L., are highly Cd-accumulator.

Data clearly showed that by selecting particular floriculture crops such as *Aster amellus* L. and *Polianthes tuberose* L. are accumulator plants near Pune. It is possible to reduce the risk of human exposure to soil metal contaminations. Vegetable that cultivated in Tehran such as *Coriandrum sativum* L., *Aniethum graveolens* L., *Petroselinum sativum* Hoffm, *Lepidium sativum* L., are harmful for human consumption. It is recommended that these types of plants should not be cultivated in farms and fields irrigated with urban and industrial waste water or water contaminated with heavy metals.

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