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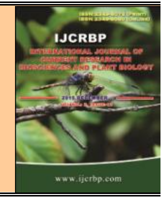

Original Research Article

Effect of Mixed Cropping Technique on the Phytoextraction Potential of Vegetables over Hyperaccumulators

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Abstract

Accumulation of heavy metals by plants may depend on plant species and soil properties. Long-term consumption of vegetables grown with sewage water near the railway tracks can lead to the early onset of Parkinson's disease, neuron degeneration, hearing and vision impairment, and gastro-intestinal infection. The sewage water contains industrial effluents, which enter the plants through the soil. The uptake of heavy metals in cereals and vegetables is likely to be higher and accumulation of these toxic metals in human body has created growing concern in the recent days. Mixed cropping technique in the present study was tried to seek for the possibility of growing sturdy field crops like *Helianthus annuus* and *Brassica juncea* along with garden vegetables like spinach and *Amaranthus viridis* to ensure decrease metal *uptake* by edible garden vegetable. The technique was proven to be unreliable as it rather triggered the efficiency of *Spinacea oleracea* and *Amarathus viridis* considerably rendering it unsuitable for mixed cropping as it would lead to unhealthy crop.

Keywords

Lead (Pb)

Mixed cropping

Phytoextraction

Vegetables

Introduction

All compartments of the biosphere are polluted by a variety of inorganic and organic pollutants as a result of anthropogenic activities and alter the normal biogeochemical cycling. A variety of biological resources have been employed widely both in developed and developing nations for cleanup of the metal polluted sites. These technologies have gained considerable momentum in the last one decade and currently in the process of commercialization (Salt et al., 1995; Vangronsveld and Cunningham, 1998; Prasad and De Oliveira Freitas, 1999; Alcantara et al., 2000; Glass, 2000; Raskin and Ensley, 2000; Watanabe, 1997; Prasad, 2004).

At sites where the contaminants are slightly higher than the industrial criterion (governmental regulations), the use of conventional technologies is not economically viable due to the cost involved. So far, irrespective of the technology being selected, the cost estimates for utilizing conventional remediation techniques have remained high (Glass, 2000). Also, in the case of most *ex situ* treatment technologies, and transport costs need to be factored in, to arrive at the final cost for remediating a contaminated site. Phytoremediation using hyperaccumulator plants has been studied extensively. *Helianthus annuus* and *Brassica juncea* have proven to be extremely effective in phytoextracting lead. The potentials of other edible plants like *Spinacea oleracea* and *Amaranthus viridis* are investigated in the present study.

The uptake of heavy metals in cereals and vegetables is likely to be higher and accumulation of these toxic metals in human body created growing concern in the recent days. Hence mixed cropping techniques is tried to evaluate the advantages of growing kitchen garden vegetables along with field crops.

Materials and methods

The present study investigated the comparative potentials of four hyperaccumulator species namely: Field crop: *Brassica juncea* and *Helianthus annuus*; Edible crop: *Spinacea oleracea* and *Amaranthus viridis*. The plants were grown on soils spiked with 5, 50 and 250 ppm of Lead.

The soil was spiked with 5ppm, 50 ppm and 250 ppm of lead stock solution. Approximately 5 g seeds were sown with equidistant spreading to avoid crowing and maintain equal plant density. Before sowing; seeds were selected each of approximate same size and color; they were washed with distilled water (except *Amaranthus viridis* as its too small) and then sown into the soil.

For mixed cropping two hyperaccumulators were grown in the same area. Plants were harvested after 45 days from the date of sowing. The plants were uprooted manually and preserved in plastic zip lock bags for further analysis at the laboratory.

Preparation of plants for digestion: The sampled plants were wash thoroughly with tap water and then with distilled water to remove any soil debris adhering to the roots or the plant. The plants were then cut into roots and shoots and dried in hot air oven at 70°C for 2 days.

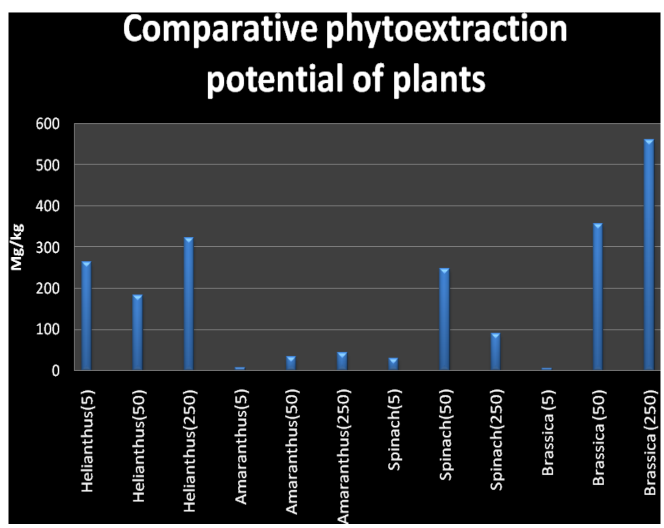
Preparation of plant extracts

Dried material was ground using mortar and pestle. About 0.5 g of dried plant powder was taken in borosilicate beaker. Some glass beads were added to avoid spurting during acid digestion. 30 ml of nitric acid was added to the beaker. The sample was digested on hot plate at 80 degrees for 2 h. It was ensured that the acid level would remain at least 5ml in the beaker during digestion to prevent charring of the contents. After cooling, the final digest was diluted to about 100 ml with deionized, distilled water.

The digestate was filtered through a vacuum filtration apparatus and the final volume was adjusted to 100 ml with deionized, distilled water. Filtrate collected in 100 ml using standard flask. Finally the volume was made using ultra pure distilled water. The extract were tested for lead using ICP:AES

Fig. 1: Mixed cropping practiced in pot beds using four plants.

Fig. 2: Phytoextraction potentials of plants without mixed cropping.



Results and discussion

This was tried to seek for the possibility of growing sturdy field crops like *Helianthus annuus* and *Brassica juncea* along with garden vegetables like spinach and *Amaranthus viridis* to ensure decrease metal uptake by edible garden vegetable. Overall bioaccumulation decreased in case of *Helianthus annuus* and *Brassica juncea* with exception for *Brassica juncea* at 250 ppm lead concentration and mixed cropping with *Spinacea oleracea.* In case of *Amaranthus viridis,* its bioaccumulation factor increased with both the hyperaccumulators.

Fig. 3: Comparative graphical representation of mixed cropping of hyper accumulators with *Helianthus annuus, Brassica juncea, Spinacea oleracea* and *Amaranthus viridis.*

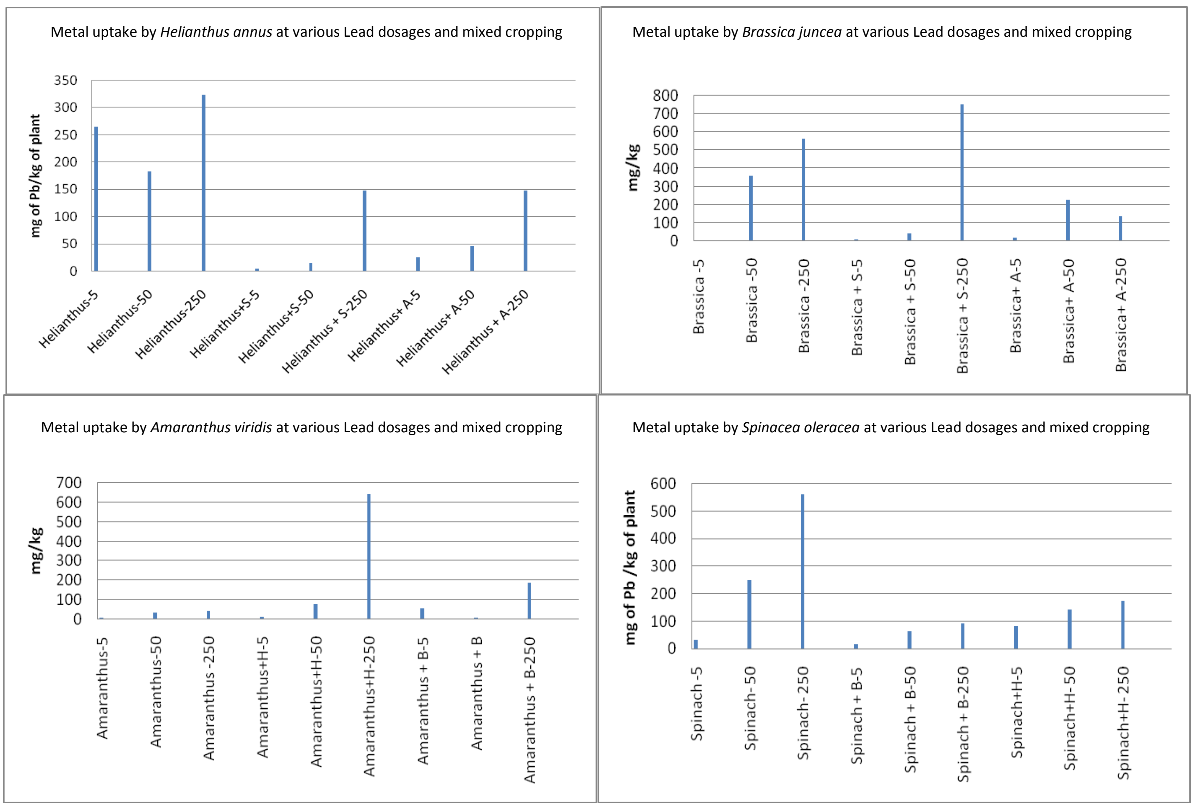
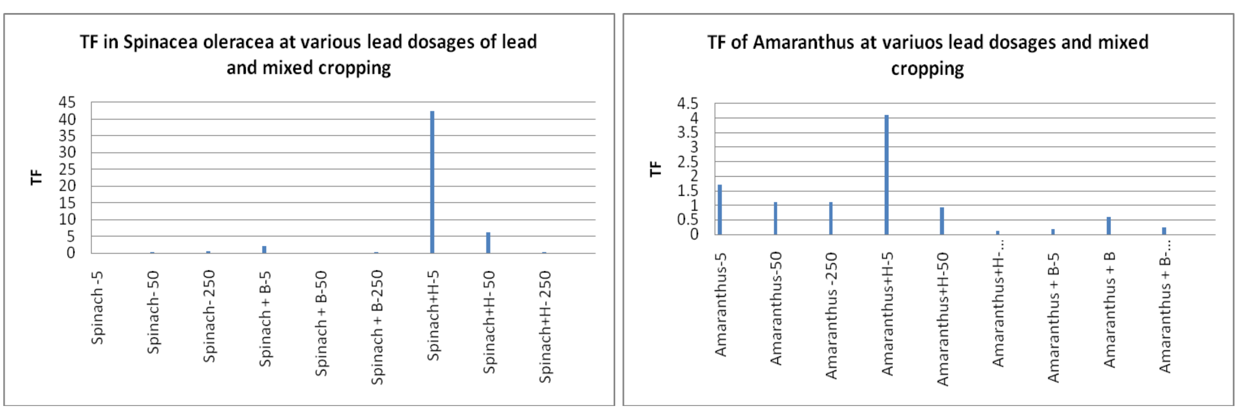


Fig. 4: Graphical representation of translocation factor of the plants in mixed cropping.



TF of *Amaranthus viridis* had reduced when mixed cropped with *Brassica juncea* .Low translocation factor indicates that the plant is not able to transfer the metal to above ground edible leafy part of the plant. In case of *Spinacea oleracea* there was an overall decline in its metal uptake ability with hyperaccumulators Also overall reduction in Bioaccumulation factor of *Spinacea oleracea* with hyper accumulators suggested that the technique could be practiced in metal contaminated fields used for growing spinach. TF, BCF and BAC values >1 had been used to evaluate the potential of plant species for phytoextraction and phytostabilization (Malik et al., 2010; Moaffat, 1995). High translocation of these metals from root to shoot indicated that the plants have vital characteristics to be used in phyto-extraction of these metals as indicated by Ghosh and Singh (2005) and La´zaro et al. (2006). Plant species with slow plant growth, shallow root system and small biomass production are not generally preferred for phytoremediation. It is easy for plants species with TF>1 to translocation metals from roots to shoots than those which restrict metals in their roots.

Plant species with high TF values were considered suitable for phytoextraction generally requires translocation of heavy metals in easily harvestable plant parts i.e. shoots (Malik et al., 2010). According to Ghosh and Singh (2005) phyto-extraction is a process to remove the contamination from soil without destroying soil structureand fertility (Cui et al., 2007).

Conclusion

The technique is proven to be non beneficial as it increased the Bioaccumulation concentration of *Amaranthus viridis* considerably rendering it unsuitable for mixed cropping as it would lead to unhealthy crop. But it's noteworthy to see that the translocation factor of *Amaranthus viridis* decreased when mixed cropping with *Brassica juncea* hence could be grown together with *Brassica juncea*. Mixed cropping had a positive synergistic effect on the metal uptake activity *Amaranthus viridis* and negative effect on *Spinacea oleracea*. BAC of *Spinacea oleracea* reduced considerably when mixed cropped with hyperaccumulators hence could be grown together with them. An exceptionally high TF value with *Helianthus annuus* indicates that failure of this technique. With more extensive research on mixed cropping it could be possible to save our kitchen garden vegetables from uptake of more metal uptake and rendering safe for consumption.

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