SUMMARY AND CONCLUSION

Progress in the field of Science and Technology during past century has transformed conditions and quality of human life. Advanced agricultural practices like use of fertilizers, herbicides, insecticides, domestic as well as industrial wastes have caused serious environmental pollution. Industrialization has caused a decisive bad effect on the Earth climate, our natural resources, wild life, food and even the delicate ecosystem balance. Among various industries, leather tanning industry has emerged as a battle ground for current environmental debates. Leather industry is one of the highly polluting industries. The transformation of the raw hides into leather requires various mechanical and chemical treatments using substantial amounts of acids, alkalies, salts of chromium and sodium, dyes, etc. These effluents are usually discharged in drains, sewage, etc and finally reach the main water bodies. Use of contaminated water for irrigation affects the soil and ground water quality.

Tannery effluents are causing serious problems in Punjab. A number of the tannery units at Leather and Sports complex, Kapurthala Road, Jalandhar are discharging the heavy metal rich effluents directly to Kala Sanghian drain that leads to rivulet Chittibein and then to river Sutlej. The continuous use of effluent rich water for irrigation by the villagers on the bank of Kala Sanghian is causing increase in the heavy metal load in the soil and ultimately passing these to human through plants

Many physical, chemical and biological methods have been suggested for metal decontamination of soil but are very expensive, technologically demanding or less effective. Phytoremediation, a plant based remediation technology, use green plants and their associated microbiota for the in situ treatment of contaminated soil and ground water. Phytoremediation is an environment friendly, safe and cost effective approach. Plants show natural ability to absorb and accumulate heavy metals from the soil and water. Hyperaccumulator plants are generally recommended to be used for metal phytoremediation of heavy metals (Cr, Cu, Ni, Pb, Cd). Identification of candidates for removal of heavy metals by phytoremediation is still at its preliminary stage and a critical job. Already known hyperaccumulator can be used but are not expected to thrive well in all the locations and condition. Introduction of non native species for phytoremediation purpose may be risky option
as species may be invasive and affect the local biodiversity. So the locally adapted species/genotype can be used for heavy metal remediation.

Considering above facts, the present problem was taken up to evaluate the metal accumulation potentials of the denizen plant species inhabiting polluted areas. The study was aimed of bioprospecting of vegetation of the tannery affected soils to discover locally adapted species/genotypes with favourable properties of metal remediation.

**IN SITU ANALYSIS**

The present study was conducted to access the effect of heavy metal built up in soil due tannery effluents on the diversity of the wild plants mainly weeds of the region. Under the influence of natural selection the possibility of existence of genetically adapted genotypes of these weeds in this region cannot be ruled out. The present investigation was carried out at four fields having irrigation with tannery waste water (one each from village Chamiara, Budopunder, Kotli and Ibbam) and a field at village Vandala where tube well irrigation was the only mode of irrigation was selected as the control site. The main objective of the present study was to select the some naturalized weeds of the study area which could be tested and later utilized for removal of heavy metals from soil.

A total of 13 species of denizen plant species were initially chosen which are common in all the five locations. Out of these seven species showing luxuriance, good biomass and metal uptake, namely, *Amaranthus spinosus, Cannabis sativa, Cassia tora, Chenopodium album, Parthenium hysterophorous, Rumex dentatus* and *Solanum nigrum* were selected for further study. The comparison among the plants of different populations (study area and control area) of these seven species revealed that:

Morphologically the plants of a species collected from tannery effluent irrigated fields at four test sites and the control site were indistinct. Cytological analysis carried out on the plants of various species revealed that there is no variation in chromosome numbers of these species collected from four test sites and the control site. Some differences were observed in the pollen fertility. The plants of the control populations of these species had more pollen fertility than that of the plants from polluted area. Biochemical studies revealed that the plants inhabiting polluted soils show no toxic manifestations.
PHYTOREMEDIATION POTENTIAL

The potential of a plant to be useful for phytoremediation is influenced by the mobility and availability of heavy metal in the soil and uptake by the plants. Thus parameters like metal bioaccumulation, Tolerance index (TI), bio-concentration factor (BF) and translocation factor (TF) have been studied in the in vivo evaluation of phytoremediation potential covering all the seven species of weeds inhabiting in the selected polluted site (Chamiara fields) along Kala Sanghia drain. The phytoremediation potentials of the seven plant species, namely, *Amaranthus spinosus*, *Cannabis sativa*, *Cassia tora*, *Chenopodium album*, *Parthenium hysterophorus*, *Rumex dentatus* and *Solanum nigrum*, were tested by conducting in vivo pot experiments and hydroponics. Heavy metal salts were used as the source of metal and appropriate amount of the salt was added to the soil and water to make final concentrations of 25, 50 and 100 ppm of metal (Cr, Cu, Ni, Pb, Cd) in the medium. Un-amended soil in the pots and plain tap water served as the control for the pot experiments and the hydroponics, respectively.

The seedlings of all the species raised from seeds collected from the control site (village Vandala) could not survive in the heavy metal rich environment. The seedlings of these species raised from the seeds brought from polluted Kala Sanghia drain site (village Chamiara) not only survived on the metal in the medium but are able to tolerate high concentration of metals without showing toxic symptoms.

Metal uptake in the plants under pot experiment showed variability depending on the species studied and the metal in question. Chromium accumulation in the roots ranged from 2.9 µg/g in *Parthenium hysterophorus* to 78.56 µg/g in *Cassia tora*. The metal accumulation varied between 1.9 µg/g in *Parthenium hysterophorus* to 79.22 µg/g in *Cassia tora* for leaves. Similarly the uptake of copper was found from 9.69µg/g in *Cassia tora* to 71.88µg/g in *Cannabis sativa* in roots and for leaves it was varying from 12.77µg/g (*Parthenium hysterophorus*) to 81.73µg/g (*Cassia tora*). Nickel and lead accumulation was maximum in the roots of *Amaranthus spinosus* and the leaves of *Cassia tora*. In case of Cd the metal accumulation for roots varied from 2.41 µg/g in *Cassia tora* to 74.67µg/g in *Chenopodium album* and 2.77 µg/g in *Cassia tora* to 84.57 µg/g in *Cannabis sativa* in leaves. The amount of arsenic accumulated by all the species from respective media was positively correlated with the metal added to the soil or media. In the hydroponic experimentation *Cannabis sativa* exhibited maximum accumulation of chromium,
copper and cadmium. *Amaranthus spinosus* and *Cassia tora* showed highest accumulation of Ni and Pb, respectively.

In this study Translocation factor (TF) was used to measure the effectiveness of plant for transfer of different heavy metals from soil to plants. TF was observed to be greater than one for Cr, Cu and Cd in the case of *Cassia tora*. The TF was highest for Ni and Pd in case *Amaranthus spinosus* and *Rumex dentatus*, respectively.

The bioaccumulation factor for Cr and Ni was highest in *Amaranthus spinosus*. Of the shoots of various weed species in the pot experiment was observed to be highest in However, for Pb and Cu the BF was highest in *Rumex dentatus* and *Solanum nigrum*, respectively. Overall *Cannabis sativa* showed good BF for heavy metals like Cd, Cu and Cr.

Since the phytoextraction of heavy metals depends on shoot biomass production, soil metal content, metal uptake and other factors, the phytoextraction capacity (PC) of the presently investigated seven species was evaluated *in vivo*. The *Cannabis sativa* had the highest phytoextraction capacity for Cr, Cu, Cd followed by *Amaranthus spinosus* for Ni and *Cassia tora* for Pb in metal exposure.

**Concluding remarks**

It can be concluded from the above study that all the species collected from Chamiara fields are adapted to grow in soil high in heavy metal content. The present study demonstrates the in enhanced metal accumulation in the tissues of these plants producing comparatively potential of genotypes of *Chenopodium album*, *Parthenium hysterophorus* and *Cannabis sativa* plants collected from Tannery affected Chamiara area in phytoremediation of heavy metal contaminated sites. Exposure to Cr, Cu, Ni, Pb and Cd metal individually resulted high biomass with no toxicity symptoms, indicates that these plants can tolerate high metal concentrations. Further, the data clearly establish that the *Chenopodium album* is the most suitable species for phytoremediation job and should be exploited for phytoextraction of heavy metals from soil in the tannery belt of Punjab.

Phytoextraction, a fairly new technology, is very dependent on the species of plant and soil factors, such as soil suitability for plant growth, depth of the contamination, of the plant root system, level of contamination, and urgency in cleaning up. A better understanding of the interactions taking place in the soil
especially in the rhizosphere will be important to the ultimate success of phytoextraction as a technique to clean up soils. In the last few years advances have been made in understanding the processes involved in phytoextraction of metals from contaminated soils, especially the processes concerned with uptake and hyperaccumulation of metals. However, there are many gaps in the knowledge of both soil chemistry and microbial and plant physiology that must be filled before phytoremediation can become a commercial technology. Some of the key areas and issues that need future attention are

- There is need to carry out biodiversity prospecting of the polluted areas with an aim to discover well acclimatized novel genotypes of the wild or cultivated plants that could clean up the polluted soils/environment.
- A complete understanding of plant metal tolerance will be essential to develop strategies to genetically enhance the metal accumulation ability of plants.
- Little is known about the genetics of metal hyperaccumulation. The identification of these genetic secrets may provide a tool in the hands of plant breeders and genetic engineers to possibly produce transgenic crops/plants with increased uptake of heavy metals.
- There is a need to optimize the agronomic practices to maximize the cleanup potential of remediative plants.
- Research is also needed to identify phytoremediating species capable of being rotated to sustain the rate of metal extraction.
- More information is also needed to optimize the time of harvest.
- An important factor that controls biomass production is plant density (number of plants/m²).
- Manipulating the plant rhizosphere is expected to produce a substantial impact on phytoextraction potential. It is important to further investigate the use of chemical amendments to induce metal bioavailability and enhance metal uptake by plants.

The future may reveal the introduction of new non-conventional metallo-crops that can decontaminate the environment. Till that time no food crop should be allowed to be grown in the area of Jalandhar-Kapurthala belt. The food crops be replaced by crops yielding wood, pulp, fuel, fiber, floriculture, etc. so that these heavy elements should not get easy entry in to the food chain.