6. SUMMARY AND CONCLUSIONS

The environment we live in has broadly four components- atmosphere, hydrosphere, lithosphere and biosphere, where the other components interact with living being has a number of different kinds of ecosystem. Each ecosystem has a food web comprising numerous food chains. The modified agro-ecosystem, which meets the food demand of the large population, is now under the serious threat of heavy metal contamination of soil. Use of sewage, sludge and industrial effluents on these agricultural lands is continuously rising. These effluents pollute the soil with a considerable amount of heavy metals. A substantial build up of Zn, Cu and Ni in the agricultural lands of Khurja- Bulandshahr area is under study for the metal pollution by sewage effluents. Recycling of wastes in agriculture, especially sewage and sludge effluents have also led to the accumulation of heavy metals in the soil.

Contaminated soils and waters pose a major environmental and human health problem through bio-magnification along the food chain, which can be decontaminated by the emerging technology of phytoremediation. This cost-effective plant based approach to remediation takes advantage of the remarkable ability of plants to concentrate elements and compounds from the environment and to metabolize various molecules in their tissues.

The present investigation on "Remediation of heavy metal contaminated soil using different amendment and different *species of Brassica*" was studied to find out possible hyper accumulators of Zn, Cu and Ni in order to decontaminate soil.

In our investigation, a pot culture experiment was conducted at the department of chemistry, N.R.E.C. Post –Graduate College, Khurja, U.P., The incubation experiment aimed to study the changes occurring in DTPA and diacid extractable fraction of heavy metals (Zn, Cu and Ni) in soil at 6 and 12 months intervals. Pot culture experiments involve growing of different *Brassica species viz. B.juncea, B. campestris, B. carinata, B. napus and B. nigra* in heavy metals treated soil. The influence of the amendments, namely FYM, lime, single super phosphate (SSP) and combination of FYM+$CaCO_3$ was also studied with the aim to compare the five crops in relation to the accumulation of Zn, Cu and Ni in influence of amendments on the uptake of heavy metals by these crops.

To study the comparable accumulation pattern of heavy metals by these five *Brassica species* at the time of flowering, heavy metal content in shoot of the plant was determined.

The results obtained from the present study can be summarized as follows:

1. Chemical immobilization of metals in soil is found to be a logical and rotional remediation process for metal contaminated soil. Application of lime, phosphate or

organic matter residues to the contaminated sites is a common method for immobilization of metals in soil.

2. Liming increases the pH, which is an important factor affecting the bioavailability of heavy metals. Along with this, calcium carbonate could be converted to sparingly soluble metal carbonates through the exchange of reaction with the respective metal ions.

3. Organic matter is reported to be an important factor controlling the phytoavailability of metals in contaminated soils. Phosphates are also useful to reduce the soluble and plant available fractions of metals in soil by precipitation of corresponding metal phosphates.

4. Single extraction of solid phase metals in soil using selective chemical extractants such as strong chelating agent has been used to indicate the bioavailability of heavy metals in soil. Chelating agent like DTPA is used as the common extractant to determine the bioavailability of metals in soils. Bioavailability of metals in soil is controlled by several chemical reaction like adsorption, desorption and precipitation. These reaction govern the chemical equilibrium of metal ions in solid and solution phases in soil.

5. The present investigation has been carried out to assess the effectiveness of different amendments *viz.* FYM, phosphate and lime in reducing the phytoavailable Zn, Cu and Ni in metal contaminated soil.

6. It has also been studied to evaluate the suitable of selective chemical extractants to predict the plant ability of these metals in the effect of the amendments on metal adsorption in soil. .

7. The results obtained in our present investigation following conclusion can be drown-

- Chelating agents like DTPA predicted the availability of Zn, Cu and Ni in the plants significantly in amended soils.
- Diacid was unsuccessful in extracting measurable amount of metals from the soils treated with lime.
- Liming of soil has significantly decreased Ni concentration in *Brassica species.*
- Phosphates were found to be effective in reducing the Cu content in *Brassica species.*

8. From present study it can also be provided that among the different species taken for the current study *Brassica carinata* produced highest shoot biomass followed by *Brassica napus, Brassica nigra, Brassica juneca* and *Brassica campestris.* Hence for shoot biomass production following order is observed

Brassica carinata > *Brassica napus* > *Brassica nigra* > *Brassica juneca* > *Brassica campestris.*

9. The important step in phytoremediation is the induction of heavy metal accumulation in plants.

10. The present study indicated that the different *species o*f *Brassica* showed the following trend with respect to uptake of Zn when grown in contaminated soil

    Brassica carinata > *Brassica napus* > *Brassica nigra* > *Brassica campestris* > *Brassica juneca.*

11. An increase in content and accumulation of Zn in shoots were observed at the time of flowering, *Brassica campestris* showed higher rate of accumulation of Zn in shoots and lower concentration of *Brassica nigra.*

12. The different *species of Brassica* showed the following order with respect to uptake of Cu by shoots from contaminated soil,

    Brassica nigra > *Brassica juneca* > *Brassica carinata* > *Brassica napus* > *Brassica campestris.*

13. An increase in content and accumulation of Cu in shoots were observed at the time of flowering, *Brassica juneca* showed higher rate of accumulation of Cu in shoot.

14. With respect to uptake of Ni by five *Brassica species* following order was observed,

    Brassica carinata > *Brassica napus* > *Brassica nigra* > *Brassica campestris* > *Brassica juneca.*

15. An increase in content and accumulation of Ni in shoots were observed at the time of flowering, *Brassica carinata* showed higher rate of accumulation of Ni in shoots.