SUMMARY

With the advent of industrialization and urbanization, a wide range of pollutants have been released into the environment. Heavy metals are one such pollutant which cannot be degraded and remain in the environment for thousands of years. They have received a lot of attention because of its toxicity to plants, animals and other living organisms. Many investigators have reviewed the toxic effects of heavy metals on microbial growth (numbers and biomass) and their activity. Microorganisms also mediate several ecologically relevant processes such as mineralization of native soil organic matter or decomposition of fresh inputs of dead and decaying plant litter. These processes assume paramount importance as they aid in the cycling of C, N, P, S and several other elements. Decomposition of plant litter involves the transfer of carbon and nutrients from organic substrates to soil. The process of decomposition has large scale impacts on biogeochemical cycling of inorganic nutrients and metals.

Negative effects on microbial mediated processes such as litter decomposition have been reported in severely contaminated forest soils. It has been postulated that three probable reasons may be responsible for the decline in the rate of decomposition in the presence of heavy metals.

1. the elevated levels of metals either in the environment or in the litter
2. metal complexes of litter constituents may be resistant to microbial degradation than metal free litter
3. inhibition of the activity of enzymes responsible for a large part of mineralization of the litter

The purpose of the present study was to determine the effects of heavy metals on the growth and activity of microorganisms associated with the decomposing litter in soil. The response of the microbial populations was investigated with respect to the presence of single metal. Microbial growth was monitored by determining the biomass of the entire population of microorganisms and microbial activity by measuring the activity of enzymes synthesized by the microbes in association with the decaying litter. The activity
of dehydrogenase enzyme was included as it reflects the overall metabolic activity of microorganisms of the decomposing litter. The activity of acid and alkaline phosphatase enzyme provides an indirect assessment of the effect on nutrient (phosphorous) mineralizing ability of microbes in the presence of heavy metal stress.

Young plants of *Typha angustata* and *Vallisneria spiralis* from different wetland habitats near Delhi were sampled and grown in tanks in the garden of the Department of School of Environmental Sciences (SES), JNU. Young seedlings of *Typha angustata* from Sultanpur National Park, Gurgaon and *Vallisneria spiralis* plants were collected from Karna Lake in Karnal district, Haryana. These plants were then grown separately in tanks within the garden of SES.

They were subjected to three different treatments

1. control treatment in which no metal was added to the soil
2. Nickel treatment in which nickel metal was added at a concentration of 300mg/kg of soil
3. Copper treatment in which copper metal was added to the soil at a concentration of 300mg/kg of soil

After harvests these plants were dried in an oven at 60°C for 48-72 hrs. The leaves of *T. angustata* were separated from the stem bearing the inflorescence and similarly the roots were separated from the rhizomes. In case of *Vallisneria spiralis* the entire plant was used for decomposition. Sub samples of the different parts of *T. angustifolia* plant (roots, rhizomes, leaves and stem) and entire plants of *V. spiralis* were analyzed in triplicates for copper and nickel. From this data the metal (copper and nickel), which has been significantly taken up by plants was considered for this study. The litter bags were prepared by filling in a known weight of the dried plant material and appropriately numbered with a plastic tag. The weight of litter in each litter bag was noted against each plastic tag number.

There were three treatments for the roots of *T. angustata* (a) uncontaminated root litter in uncontaminated soil – a control set; (b) uncontaminated root litter in nickel
The litter bags containing *V. spiralis* were placed for decomposition as below

- Uncontaminated plant litter decomposing in uncontaminated soil
- Nickel contaminated plant litter decomposing in uncontaminated soil
- Uncontaminated plant litter in Nickel contaminated soil
- Nickel contaminated plant litter in Nickel contaminated soil

Litterbags were placed in soils on 13th December, 2005 and the experiment continued till 9th March, 2006.

On each sampling day the litter bags along with soils were collected and brought to laboratory in an ice chest. Soils were air dried and stored in zip lock bags for subsequent analysis. Triplicate samples of fresh litter from the litter bag were taken for microbial enzyme and microbial biomass analysis and their corresponding weight was noted. In order to calculate the ash free dry weight a sub sample of fresh litter was taken, dried in oven at 105°C for 24 hrs, dry weight taken and then it was combusted to ash at 550°C for 3hrs and its final weight was noted. The analysis for the three enzymes was conducted within a day and extracts of potassium sulphate salt were also analyzed for microbial carbon and ninhydrin reactive nitrogen immediately by the end of 3 days after harvests.

The remaining litter in the litter bag was washed and rinsed in double distilled water and then dried in oven at 50°C for 24-48 hrs. Dried litter samples were later weighed on a digital balance ±0.001g and then ground to fine size. They were stored in zip lock bags until further analysis. The dry litter was analyzed for nitrogen,
phosphorous, soluble carbohydrates, potassium, sodium, calcium and magnesium ions and lastly lignin and cellulose content. The air dry soil was analyzed for organic carbon, nitrogen and phosphorous. The metal content in litter and DTPA available metal in soil was also determined.

**Major findings of this study include:**

There was no effect of nickel or copper contamination on the decomposition rate of roots or leaves of *Typha angustata*. The decomposition rate was lower in ucl-Nis treatment than in other treatments for *Vallisneria spiralis* plant decomposition experiment. There was consequently no effect on microbial biomass or dehydrogenase activity during the decomposition of roots and leaves of *T. angustata*. In case of ucl-Nis treatment of *V. spiralis* plant the dehydrogenase activity was significantly lower than in other treatments.

The results illustrate that the microorganisms during the decomposition of roots and leaves of *T. angustata* are adapted to the presence of 3.51 μg/g DTPA available nickel and 23.08 μg/g copper in soil. In case of *V. spiralis* plant the microbes are adapted to 25.73 μg/g nickel in soil. No effect on dehydrogenase activity reflects any effect on their metabolism. However the negative effect of nickel contamination recorded on the activity of acid phosphatase during the decomposition of roots of *T. angustata* indicate that phosphate utilizing ability of the microbes is impeded by nickel.

On the contrary, a higher production of phosphatase enzymes during *V. spiralis* decomposition in nickel containing treatments can be explained by the need of the microbes to utilize more phosphate than their counterparts in control treatment. Since nickel uptake is energy dependent requiring glucose as well as phosphate it becomes imperative for the microbes in nickel contaminated soils to metabolize more organic substrates for glucose and phosphate than those residing in control treatment. It has been further observed that microbial response differs between the present experiments in response to differences in the availability of nickel in soil and chemical composition of the different plant materials.
The microbial biomass C: N ratio was determined to assess in a crude way the differences in microbial community in the different treatments. Biomass specific dehydrogenase activity was calculated from microbial biomass and dehydrogenase activity in order to determine the extent of metabolic activity of the associated microbial population during decomposition. A higher microbial biomass C: N ratio was observed in nickel treatments of roots and *V. spiralis* plant.

Lignin decomposition was also higher in Nil-Nis and Nil-ucs treatments during the decomposition of *V. spiralis* plant and in Nil-Nis treatment of roots. Greater loss of lignin was attributed to the differences in microbial community as evident from the observed higher microbial biomass C: N ratio. Increase in the rate of cellulose decomposition in ucl-Nis and ucl-Cus treatments of leaves as well as ucl-Nis treatment of roots of *T. angustata* was attributed to the greater mineralization ability of the microbes in these treatments.

The nickel contaminated roots of *T. angustata* (94μg/g) and entire plants of *Vallisneria spiralis* (166μg/g) contained about 29 times and 7.7 times higher nickel than their uncontaminated counterparts. The nickel concentration in these plants is much higher than the critical threshold. Considerable loss was registered in the first few days of decomposition in the different nickel treatments, yet sufficient amount of nickel was still retained in the roots (44% remaining) and *V. spiralis* plant (9-25% remaining) at the end of 352 days and 86 days of decomposition respectively.

There is considerable increase of nickel recorded on the uncontaminated leaves (34μg/g) and roots (35μg/g) of *Typha angustata* and *Vallisneria spiralis* plants (320μg/g) during decomposition in the corresponding nickel and copper contaminated soil in this study. There was, however, no correlation between the changes in metal content of the decomposing litter and changes in DTPA extractable metal in the surrounding soil.

A consistent increase in dehydrogenase activity was observed in all the treatment for the three experiments. Microbial biomass increased throughout the experiment for *V.
spiralis plant while such a consistent increase was not observed for the other two experiments. The microbial activity was much higher on the decomposing Vallisneria spiralis plant litter when compared with the microbial activity assessed during the decomposition of Typha angustata

With respect to the nutrient changes during the decomposition net increase in nitrogen and phosphorous was observed initially in the different treatments. Net increase of calcium was also noted during the decomposition of roots and V. spiralis plant. The pattern of nutrient mobility in the different experiments

Roots: K< Na< P< Ca< N
Leaves: K< Na< Ca< P< N
V.spiralis plant: K< Na< N< P< Ca

There was no effect of nickel on nutrient changes during the decomposition except for sodium which was lost relatively faster from nickel contaminated plant material than uncontaminated plant. There were small but significant effects observed of nickel on the loss of nitrogen, sodium and potassium from the decomposing V. spiralis plant in the different treatments of this study.

In conformation with the findings of the previous studies, this study observes that the roots decompose slowly than the leaves and V. spiralis plant decomposes faster than T. angustata plant.