Summary
SUMMARY

In modern economies, various activities including agriculture, industry and transportation, produce a large amount of wastes and new types of pollutants. Soil, air and water have traditionally been used as sites for the disposal of all these wastes. The most common kinds of wastes can be classified into four groups such as: (a) agricultural, (b) industrial, (c) municipal, and (d) nuclear. Agricultural wastes include a wide range of organic materials (often containing pesticides), animal wastes and timber by-products. Many of these, such as plant residues and livestock manure, are very beneficial if they are returned to soil. However, improper handling and disposal may cause pollution.

Numerous organic and inorganic chemicals are being used as fertilizers, pesticides and plant growth regulators for the healthy crop production. During the last decade, man has utilized sewage sludge as a source of fertilizer. Although sludge may be important as a renewable resource a concern has been generated over the possibility of toxic substances (e.g. Cd, Cr, Co, Pb and Ni) entering the food chain or moving into ground water systems.

The application of sludge, fertilizer and certain other pesticidal formulations, while beneficial in several ways, has aroused concern from the standpoint of their accumulation in soils with possible toxic effects on the soil microorganisms as well as pollution of soil and water. However, the use of pesticides in crop disease control has vastly increased in India. One of the serious deficiencies in the successful and wide-spread use of pesticides has a non developed application of proper doses in the different types of clay mineral containing soil.

The effectiveness and mobility of pollutants such as heavy metals, pesticides and surfactants in soil depends upon a large number of factors such as climatic factors, texture, moisture level, alkalinity, salinity, pH and clay mineral composition of the soil.
The information regarding the fate of pollutants (heavy metals, pesticides and surfactants) in altering the soil chemical properties, nutrient status of soil and their availability to plants and their movement, persistence in soil under Indian climatic conditions are important from practical as well as theoretical point of view. Therefore, it is important that the role of all such pollutants be investigated so that their undesirable side effects can be detected and minimized.

In view of this it was considered worthwhile to investigate the, "Interaction and mobility of pollutants with crops and soils of Aligarh district". The work reported in this thesis has been illustrated in the form of seven chapters as follows:

1. Mobility of chromium(VI) and molybdenum(VI) through soil static phase by thin layer chromatography
2. Mobility of zinc(II) and cadmium(II) on soil layers developed with surfactant mediated mobile phase systems
3. Effect of some anions on the mobility of amino acids in soils by thin layer chromatography
4. The effects of cadmium and zinc interactions on the accumulation and tissue distribution of cadmium and zinc in tomato (*Lycopersicum esculentum*)
5. Study of the effect of molybdenum on growth and nutrients concentration of tomato (*Lycopersicum esculentum*) and black gram (*Phaseolus mungo*) plants
6. Effect of heavy metals (cadmium & nickel) on the seed germination, growth and metals uptake by chilli (*Capsicum frutescens*) and sunflower (*Heliantus annuus*) plants
7. Influence of dimethoate on some available nutrients of fertilized soil, seed germination, growth and nutrients uptake by wheat (*Triticum aestivum*)

A concise account of the results achieved on the basis of the plan mentioned above is summarized in the following chapters:
CHAPTER 1
Mobility of Chromium(VI) and Molybdenum(VI) Through Soil Static Phase by Thin Layer Chromatography

Adsorption of chromium(VI) and molybdenum(VI) was examined through six types of soil beds using soil thin layer chromatography. The effects of decomposition of soil organic matter by 30% H$_2$O$_2$, cation saturation (K$^+$, Mg$^{2+}$, Ca$^{2+}$ and NH$_4^+$), size of the soil particles, soil pH, sewage sludge, sample pH and surfactants (cationic, nonionic and anionic) were investigated. On the basis of differential migration, optimum conditions for the separation of Cr(VI) from Cr(III) and from Mo(VI) on soil thin layer plates were identified. The mobility (or R$_f$ value) of Cr(VI) and Mo(VI) through all soils follows the order: Cr(VI) > Mo(VI) > Cr(III). A statistical analysis of the results (p ≤ 0.05 and 0.01 level) revealed, a significant positive correlation between R$_f$ values of Cr(VI) and Mg content of soil (r = 0.930) or the base saturation (r = 0.831) as well as between R$_f$ value of Mo(VI) and Mg content of soil (r = 0.872), sum of bases (r = 0.847) or the base saturation (r = 0.925). Conversely, a significant negative correlation between R$_f$ values of Cr(VI) and soil organic matter (r = -0.916) or cation exchange capacity of soil (r = -0.851) was observed. Similarly, significant negative correlation between R$_f$ values of Mo(VI) and clay content (r = -0.928) or cation exchange capacity (r = -0.852) of soil also exists. The R$_f$ values of Cr(VI) and Mo(VI) were found to depend upon the soil parameters such as soil organic matter, clay content of soil, cation exchange capacity of soil, cation saturation, size of soil particles, soil pH, sewage sludge content as well as the sample pH and the nature of surfactant (cationic, anionic or nonionic) in the mobile phase. The obtained results have been explained on the basis of adsorption behavior of Cr(III), Cr(VI) and Mo(VI) on soil colloids.

CHAPTER 2
Mobility of Zinc (II) and Cadmium (II) on Soil Layers Developed with Surfactant Mediated Mobile Phase Systems

The sorption studies of Zn(II) and Cd(II) ions (in term of hR$_f$ value) on different planar soil static phases have been performed with the aid of thin layer
chromatography. The effects of decomposition of soil organic matter, cations saturation, soil pH and sewage sludge on the \( hR_f \) values (or sorption) of Zn(II) and Cd(II) were investigated. Among these parameters, soil pH was most important factor affecting the sorption of Zn(II) and Cd(II) ions onto the soil layers. Aqueous solutions of cationic (cetyltrimethylammonium bromide, CTAB), nonionic (t-octylphenoxycetoxaethoxy ethanol, Triton-100) and anionic (sodium dodecyl sulphate, SDS) surfactants at different concentrations (below, near and above their critical micelle concentration levels i.e. CMC value) were tested as mobile phase to examine their influence on sorption efficiency of zinc(II) and cadmium(II) on soil stationary phases. Furthermore, the combined effect of surfactant solutions and fertilizers (NH4Cl, NaCl, KCl, MgCl2 and CaCl2) on the sorption pattern of Zn(II) and Cd(II) was also investigated. Fertilizers such as KCl and CaCl2 in SDS remain insoluble whereas MgCl2 (1.0M) in SDS was highly viscous and causes difficulty during development of soil TLC plates. Addition of Cl' fertilizer into aqueous surfactant mobile phase led to increase in the \( hR_f \) value (or decrease in magnitude of sorption) of Zn(II) and Cd(II) ions on soil layers. Amongst mobile phase systems examined, 1.0M MgCl2 in aqueous CTAB (concentration above CMC value) was capable to bring about differential migration (or sorption) between Zn(II) and Cd(II) ions leading to their sharp separation from their mixture. Cadmium(II) was found to migrate faster through soil layer as compared to the mobility of Zinc(II). Thus, Zn(II) is strongly retained by soil its surface and Cd(II) is allowed to pass through this static layer of soil.

CHAPTER 3
Effect of Some Anions on the Mobility of Amino Acids in Soils by Thin Layer Chromatography

The mobility rate of some cyclic and aliphatic amino acids in terms of \( R_f \) values by using soil thin layer chromatography shows the following order: glutamic acid > histidine > valine > leucine > serine > alanine. After conducting the studies to determine the effect of some anions, viz. MoO4^2-, B4O7^2-, C2O4^2-, CO3^2-, HCO3-, and H2PO4- on the mobility of those amino acids, the mobility of the amino acids was
found to increase with the increasing concentration of these anions up to a certain
limit and thereafter the mobility rate declined except in case of glutamic acid which
shows a fall in its movement throughout the entire range of their application in all
cases. The results have been explained on the basis of a reaction mechanism
involved in the interaction of these anionic species with soil colloids any amino
acids in soil solution.

CHAPTER 4
The Effects of Cadmium and Zinc Interactions on the Accumulation and Tissue
Distribution of Cadmium and Zinc in Tomato (Lycopersicum esculentum)

Pot experiment was conducted to investigate the effects of cadmium and zinc
interactions on the accumulation and tissue distribution of cadmium and zinc in
tomato (Lycopersicum esculentum) plant. The results obtained in this study reveal
that the application of Cd, Zn and their interaction did not improve plant growth as
compared to control. The levels of concentrations of Cd and Zn in shoots, roots and
leaves were determined. The highest concentration of Cd was 135 mg kg\(^{-1}\) d.w. in
the leaves 57 mg kg\(^{-1}\) d.w. in the shoots, and 210 mg kg\(^{-1}\) d.w. in the roots; Zn
concentration ranged from 186.0 to 776 mg kg\(^{-1}\) d.w. in leaves, 126.7 to 700 mg kg\(^{-1}\)
d.w. in shoots, and 320 to 2015 mg kg\(^{-1}\) d.w. in roots of tomato plant. The
inhibitory effects of soil Zn on Cd accumulation in all organs of tomato plant
occurred only at toxic levels, but the reduction in Cd accumulation did not improve
plant growth (no gain of dry shoot and root biomass), suggesting that Zn
concentration became the dominant factor affecting plant growth. An examination
of Cd and Zn interactions and their transfer to soil-plant system indicate their
synergistic effect. Increasing Cd and Zn concentrations in soil results in an increase
in the accumulation of Cd or Zn in the plant tissues.

CHAPTER 5
Study of the Effect of Molybdenum on Growth and Nutrients Concentration of
Tomato (Lycopersicum esculentum) and Black Gram (Phaseolus mungo) Plants

A polyhouse experiment was conducted to evaluate the effect of Mo as sodium
molybdate on growth and nutrients concentration of tomato (Lycopersicum
esculentum) and black gram (Phaseolus mungo) plants. The beneficial effects on growth were noticed at lower doses of Mo up to 0.10 and 0.20 ppm in case of tomato and black gram plant respectively, thereafter a phytotoxic behavior was observed. The results of plants analysis showed an increase in the concentration of nutrients viz: K, Ca, Mg and Cu up to 0.10 ppm in case of tomato plant, thereafter they tend to decline on increasing doses of Mo. The concentration of Mn and Fe increases and that of Zn decreases throughout the entire concentration (0.05 to 0.80 ppm) of Mo application. There was no effect of degree of Mo concentration in the uptake of Na by tomato plant. However in case of black gram plant the concentration of K, Ca, Mg, Cu, Zn, Mn and Fe increases up to 0.20 ppm, after they tend to decline on increasing doses of Mo. The Na content was found to increase with the increasing concentration of Mo over the entire range (0.05 to 0.80 ppm). The results have been explained on the basis of chemical nature of organic ligands present in plant xylem sap contents to form complexes, translocation through plant sap and nodulation in leguminous plant.

CHAPTER 6
Effect of Heavy Metals (Cadmium & Nickel) on the Seed Germination, Growth and Metals Uptake by Chilli (Capsicum frutescens) and Sunflower (Helianthus annuus) Plants

Pot experiments were conducted to evaluate the phytotoxic behavior of Cd$^{2+}$ and Ni$^{2+}$ on the seed germination, growth, and metals utilization by chilli (Capsicum frutescens) and sunflower (Helianthus annuus) plants. The results show the toxicity order being, Cd$^{2+}$ > Ni$^{2+}$. The Cd$^{2+}$ on chilli plant was found to be phytotoxic in the entire range of 75 to 600 ppm of its application with respect to control. However, in the case of Ni on sunflower plant showed a beneficial effect as its lower concentration from 75 to 150 ppm and thereafter became phytotoxic at higher concentration up to 600 ppm of its entire range studied. The sequence of the plants growth and metals utilization revealed the symptoms of beneficial and phytotoxic behavior of these heavy metals in soil environment. The results have been
explained on the basis of changes in bioactivity and chemical behavior of Cd$^{2+}$ and Ni$^{2+}$ ions in soil environment.

CHAPTER 7
Influence of Dimethoate on Some Available Nutrients of Fertilized Soil, Seed Germination, Growth and Nutrients Uptake by Wheat (*Triticum aestivum*)

The effect of dimethoate (O, O-dimethyl S-methylcarbamoylmethyl phosphorodithioate) on available nutrients of fertilized soil, seed germination, growth and nutrients uptake by wheat were examined and LSD at 5% calculated. The presence of dimethoate in the fertilized soil affects the availability of nutrients, seed germination, growth and nutrients uptake by wheat.

The available nutrients in fertilized soil and their uptake by wheat were found to increase significantly at lower doses and smaller duration of application of dimethoate. Likewise, the availability of P and their uptake also increases significantly upto 5.0 ppm and for 30 days of dimethoate application. An irregular pattern was noticed for the availability of Mg at different doses and days of dimethoate application in fertilized soil.

The beneficial effect on seed germination and growth was observed upto 5.0 ppm and 10.0 ppm of dimethoate respectively, thereafter a phytotoxic behaviour was noticed. The results have been explained on the basis of soil microbial activity, solubilization effect and chemical doses and duration.