

COMPARATIVE STUDY ON THE PHYSICO-
CHEMICAL CHARACTERISTICS OF SOME OF THE
SOILS OF DIFFERENT REGIONS OF
UTTARANCHAL

Thesis
Submitted to the
Kumaun University Nainital

By

RUCHI PANDEY

UNDER THE SUPERVISION OF

PROFESSOR (Mrs.) A. ADHIKARI

Department of Chemistry, D.S.B. Campus

Kumaun University, Nainital

(UTTARAKHAND)

2008

ACKNOWLEDGEMENTS

At this great moment of submission of my Ph.D. thesis first of all I shall express my indebtedness to my supervisor respected Prof. (Mrs.) Alka Adhikari for her valuable guidance, untiring supervision and continuous encouragement throughout the course of present work.

I would like to express my deep sense of gratitude and indebtedness to respected Professor C.S. Mathela ji, Head Department of Chemistry, D.S.B. Campus, Kumaun University, Nainital for his valuable suggestions and encouragement.

I am grateful to Prof. S.P.S. Mehta, Department of Chemistry, D.S.B. Campus, Kumaun University, Nainital, for all necessary help and cooperation. I am also grateful and obliged to all my teachers and staff members of D.S.B. Campus, Kumaun University, Nainital for their help, encouragement and blessings.

I wish to express my thanks to Dr. B.P. Gaur and Dr. H.S. Hasmi, Soil Testing Laboratory Rudrapur, U.S. Nagar (Uttarakhand) for all the necessary help and cooperation to me during my research work. I also thank S.K. Sexana ji, Soil Science Laboratory, G.B. Pant University of Agriculture and Technology, Pantnagar.

I am thankful to Mr. R.D. Bhatt (Advc.) Shri R.P. Sharma (Advc.), Mr. N.K. Bhatt (Advc.), Mr. K.S. Waldia, Mr. Anmol Agrawal, Mr. K.S. Bisht, Mr. Lalit Bisht and Vijay Chandra Tewari for their genuine help, cooperation and encouragement during the entire period of my research work.

Thanks are also due to the authorities of G.B. Pant Agriculture and Technology University, Pantnagar for extending library facilities to me during the course of my research work.

I am grateful to those eminent scholars, research workers, authors whose thoughts, ideas and writings have been useful to me for presenting this humble work. I am also grateful to all other persons for their help whose names I could not mention here due to lack of space.

No words can adequately express the affection and loving care of my mother respected Mrs. Indira Pandey ji and my father respected Sri Dinesh Chandra Pandey (Adv.) whose help, sacrifice and blessings have sustained me through this difficult and pains taking effort. I shall always keep in mind the contribution, affection and blessings of my parents throughout my life.

I would like to express deep sense of indebtedness to my brother Mr. Bharat Pandey, all my friends and wellwishers for their help, cooperation and encouragement during the course of my research work. I am also grateful to Mr. M.S. Rana ji for typing and formatting the manuscript so neatly and speedily.

Place: Nainital

Date: / /2008

(Ruchi Pandey)

CERTIFICATE

This is to certify that the thesis entitled ***COMPARATIVE STUDY ON THE PHYSICO-CHEMICAL CHARACTERISTICS OF SOME OF THE SOILS OF DIFFERENT REGIONS OF UTTARANCHAL*** submitted in full requirement for the **Degree of Doctor of Philosophy in Chemistry to the Kumaun University, Nainital**, is based on the original investigations carried out by ***Ruchi Pandey, M.Sc.***, under my supervision.

It is also certified that this thesis or its contents have not been submitted for the degree of any other University.

It is further certified that ***Ruchi Pandey*** has put in more than two hundred days of attendance in the department for her laboratory work.

Place: Nainital

Dated: / /2008

Prof. Alka Adhikari

Research Supervisor
Department of Chemistry
D.S.B. Campus, Kumaun University
Nainital – 263 002 (Uttarakhand)

Prof. C.S. Mathela

Head,
Department of Chemistry
D.S.B. Campus, Kumaun University
Nainital – 263 002 (Uttarakhand)

CONTENTS

S. No.	CHAPTER NO.	PARTICULARS	PAGE NO.
1.	I	INTRODUCTION	1 – 8
2.	II	A SHORT REVIEW OF LITERATURE	9 – 209
3.	III	A BRIEF DESCRIPTION OF THE STUDY AREA	210 – 214
4.	IV	MATERIALS AND METHODS	215 – 242
5.	V	OBSERVATION AND RESULTS	243 – 260
6.	VI	DISCUSSION	261 – 277
7.	VII	REFERENCES	278 – 310

CHAPTER - I

INTRODUCTION

1.1 INTRODUCTION

The earthy material in which the plants grow is known as **Soil**, which has been derived from the Latin word “**Solum**”. Soil is also defined as an independent body in nature with a unique morphology from the surface down to the parent material as expressed by the sample profiles (**Tan; 1995**).

Soil can also be defined as: “A dynamic natural body on the surface of earth, in which plants grow, composed of materials and organic materials and living forms.”

or

“The collection of natural bodies, occupying parts of the earth’s surface that support plants, and that have properties due to the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time” (**Negi ; 2000**).

Soils like a film envelop the surface of our planet. These are the “Youngest” or rather the most recent formations. The origin of soils, their position as the boundary between the lithosphere and the biosphere, and their peculiar structure and composition, which make them so different from other natural bodies, means that they must be treated as complicated biogeochemical system (**Victorova; 1986**).

Soils are created on land surfaces by weathering processes that include chemical, geological, hydrological, and on the planet earth, biological

phenomenas. The continual influence of percolating water and the biota produce a vertical stratification (a soil profile) of the concentration of elements and the chemical compounds in which they occur. The solid phase of soils is composed of two broad classifications of compounds: Inorganic (mineral) compounds and organic matter (**Helmke; 2000**).

The mechanical or granular composition (texture) of a soil is the number and size of its mechanical elements or particles after all the compounds holding them together have been destroyed (**Victorova; 1986**).

Soil is a dynamic system in which the soil solution is the medium of physical, chemical and biological processes in soil environments. Soil solution is in dynamic equilibrium with minerals, organic matter, microorganism, and soil atmosphere. Thus it is the bottle neck of transformations and transport of vital and detrimental molecules and ions in the ecosystems (**Huang; 2000**).

The study of soil is known as the soil science or pedology (pedos means earth) or edaphology (edaphos means soil). Soil may also be defined as the part of the earth crust in which humus is present (**Shukla and Chandel; 1991**).

Soils are divided by texture into the following groups in the American classification (**Victorova; 1986**).

(i) Clayey Soils

Very Clayey	{	Clay
		Silty Clay

Intermediate	{	Silty heavy loam Heavy loam Sandy Clay
 (ii) Loamy Soils		
Medium loamy	{	Sandy heavy loam loam
Slightly loamy		Sandy loam
 (iii) Silty Soils		
Silty Soil	{	Silty loam Silty Clay loam Silt
 (iv) Sandy Soils		
Sandy Soils	{	loamy Sand Sand

As per Soil Management Principle “Soil-Fertility Control is possible where soil testing is practiced” (Cook and Ellis; 1987).

Soil testing makes complete nutrient control a possibility, Fertilizer experiments are being patterned to determine economically optimum rates of nutrients application high yields with low production costs per unit are a must in modern farming.

Farmers of today are different in the failure is more certain and sooner unless they are obtaining reasonably high yields, improved drainage, many

improved Cultural practices, better varieties, and control of insects and disease have helped to set the stage for high yields. As a result, the demand on the soil has gradually increased. Soil testing lets farmers know how much and what kind of fertilizer they must apply to be sure of returns from their investments in other improved practices.

1.2 The proposed work is to be undertaken for the analyse of the soil for its physical state, its constituents and the nutrients, present in the soil. Different physico-chemical characteristics of the Khatima region of Uttarakhand State (formerly known as Uttaranchal since its inception in the year 2000) has be determined by using standard methods.

The entire study area has been divided into three major regions.

- 1. Hill Region**
- 2. Bhabar Region**
- 3. Tarai Region**

Each of these regions has been sub-divided into specific zones depending upon the land being used by the farmer of the region for agricultural purposes the zones have been divided as follows:

- 1. Hill Region**
 - (i) Bhimtal
 - (ii) Mehra Gaon
 - (iii) Khalkwira

(iv) Nauligarh

2. Bhabar Region

(i) Haldwani

(ii) Gajraula

(iii) Kathgodam

(iv) Kusumkhera

3. Tarai Region

(i) Khatima

(ii) Sitarganj

(iii) Rudrapur

(iv) Pantnagar

The samples were collected periodically from the selected sites at the same time say around 8.00 a.m. on the day of sampling. Soil samples have been collected at a depth of 15 cm at the site. Samples have been collected only from the open places. Sampling dates have been selected in such a way that these represent the major seasons of the year viz. autumn, winter, spring, dry summer, and wet summer. Separate sampling calendar has been made for each parameter to be studied.

Some of the physico-chemical characteristics like temperature, pH and conductivity have been determined at the spot using a portable soil analysis kit. Nitrogen has been determined by the Kjeldahl method, and other physico-

chemical properties, like organic carbon, phosphorous, potassium etc. have been determined by the standard methods.

The presence of metal ions like, Na^+ , Cu^{++} , Fe^{+++} etc. and their characterization has been done by using **Atomic Absorption Spectrophotometer (A.A.S.)**.

A comparison of the Physico-Chemical Characteristics of some of the soils of different regions of the Uttarakhand state has been undertaken by comparing the results of the present study with the studies done earlier in the other regions of the state.

The following procedure shall be undertaken for the present study.

1. Collection of the soil samples

Soil samples were collected randomly from a site using soil auger and carpenter screw auger, Khurpa Knife at the depth of 15-20 cm. All these samples will be mixed and the mixed sample has been divided into four parts by the paper quartering method.

2. Analysis of the soil

Analysis of the soil samples have been done under the following steps-

(A) *Physical properties*

- (a) Colour
- (b) Odour
- (c) Moisture
- (d) Temperature

(e) Bulk Density (B.D.)

(B) *Chemical properties*

(a) Soil pH

(b) Electrical Conductivity

(c) Cation exchange capacity

(C) *Nutrients*

(a) Organic Carbon/Organic matter

(b) Metal ions like Na^+ , Cu^{++} , Fe^{+++} etc. (by A.A.S.)

(c) Macronutrients (N.P.K.) etc.

(d) Micronutrients (Zn, Cu, Mn)

1.3 Objectives of Present Study

As suggested by **Fitts and Nelson** (1956), the objectives of the soil analysis should be:

- (i) To group soils into classes for the purpose of suggesting fertilizer and lime practices.
- (ii) To predict the probability of getting a profitable response to the application of plant nutrients.
- (iii) To help evaluate soil productivity.
- (iv) To determine specific soil conditions which may be important by addition of soil amendments or cultural practices.

The present works have been done in the study area as per objectives suggested by Fitts & Nelson (1956). The following objectives were also taken into consideration for the present work.

- (i) To study the types of the soil.
- (ii) To study the contents of available macronutrients in the soil.
- (iii) To study the contents of available micronutrients in the soil.
- (iv) To correlate the available soil macro- and micronutrients with properties of the soil.
- (v) To suggest the proper use of the suitable fertilizers for achieving the maximum yield regularly.
- (vi) To compare the results of the present study with earlier work.

With the above mentioned objectives, the analysis of the main soil types of the Hill region, Bhabar region and Tarai region of Kumaon was attempted under the following major investigations.

- (1) Physical examination of the soil types.
- (2) Chemical examination of the soil types.

Standard methods (as describe in chapter IV) were used for determing the various parameters and for the qualitative as well as quantitative estimation of the macro-and micronutrients in the soil types. Observation and results have been reported in Chapter-V, while a discussion has been given in Chapter VI. References have been given in Chapter VII.



CHAPTER - II

A SHORT REVIEW OF LITERATURE

2.0 A SHORT REVIEW OF LITERATURE

A short review of the literature on the Soil analysis has been attempted here, which gives an overview of the work done in this field during the last three decades.

2.1 ZOU XIAOMING *et al.*, (1992) reported “**A new method for estimating gross phosphorus mineralization and immobilization rates in soils**”. A new method to estimate P transformation rates in three forest soils and one grassland soil representing an Alfisol, an Ultisol, and Andisol, and a Mollisol. Three treatments were applied to each soil in order to separate the processes of mineral P solubilisation, organic P mineralization, and solution P immobilization. One set of soils was retained as control, a second set was irradiated with X-rays to stop microbial immobilization, and a third was irradiated and then autoclaved, also stop phosphates activity. All three sets of samples were then incubated with anion exchange resin bags under aerobic conditions. Differences in resin P among the three treatments were used to estimate gross P mineralization and immobilization rates. Autoclaving did not affect resin-extractable P in any of the soils. Radiation did not alter resin-extractable P in the forest soils but increased resin-extractable P in the grassland soil. This increase was corrected in the calculation of potential P transformation rates. Effects of radiation on phosphatase, activity varied with soils but was within 30% of the original values. Rates of P gross mineralization and immobilization ranged from 0.6 - 3.8 and 0 - 4.3 mg kg-soil⁻¹ d⁻¹, respectively, for the four soils. The net rates of solubilization of mineral P in the grassland soil were 7 – 10 times higher than the rates in forest soils. Mineralization of organic P contributed from 20-60% of total

available P in the acid forest soils compared with 6% in the grassland soil, suggesting that the P mineralization processes are more important in controlling P availability in these forest ecosystems.

2.2 Lesch S.M. et al. (1992) studied the “**Mapping Soil Salinity Using Calibrated Electromagnetic Measurements**”. A statistical modeling approach is presented that predicts spatial soil salinity patterns from aboveground electromagnetic induction (EM) readings. In this approach, EM readings are obtained from a field sampled on a uniform (centric systematic) grid. A small number of these sample sites are chosen for soil sampling, based on the observed EM field pattern. The salinity levels for these soil samples are determined and then the remaining non-sampled salinity values are predicted from the corresponding EM readings through a multiple linear regression equation. Experimental results suggest that this approach will work well in fields having low to moderate levels of soil textural variability. For example, 95% of the spatial variability in soil salinity within typical 16.2 ha (40-acre) cotton (*Gossypium hirsutum* L.) fields could be accounted for with only 36 soil samples, as opposed to the 200 to 300 soil samples typically required if no EM readings were available. This approach makes EM readings a more practical and cost-effective tool by substantially reducing the number of soil samples needed for accurate mapping of spatial salinity patterns at the field scale.

2.3 Batch L. B. (1992) studied the “**Soil water movement in response to Temperature Gradients: Experimental Measurements and Model Evaluation**”. Temperature gradients may have a significant effect on soil water movement under certain conditions, but inclusion of these effects adds complexity to the flow analysis. This study was conducted

to help clarify the significance of nonisothermal water flow, and to examine theoretical and numerical descriptions of the transport processes. At initial water contents of 0.00, 0.049, 0.099, 0.151, and 0.282 m³ m⁻³, isothermal and nonisothermal laboratory experiments were conducted to provide direct information on soil water movement in response to temperature gradients. These data were used to evaluate the numerical simulation model **SPLaSHWaTr2**, and to examine calculation of the thermal conductivity, $\lambda(\theta)$, the thermal vapour diffusivity, the thermal vapour diffusivity, $D_{TV}(\theta)$, and the temperature coefficient of the matric potential, C_ψ , based on modifications to a theory proposed by Philip and de Vries in 1957. A statistically significant effect of the temperature gradient was found at an initial water content of 0.151 m³ m⁻³, which corresponds to a pressure head of approximately -1.2 m of H₂O. No effect of the temperature gradient was found at an initial water content of 0.00, 0.049, 0.099, or 0.282 m³ m⁻³. Under isothermal conditions, the model provided simulated water-content profiles that were in good agreement with measured profiles. Under nonisothermal conditions, profiles simulated by the model were in poor agreement with the measured data, using the original values of $\lambda(\theta)$, $D_{TV}(\theta)$, and C_ψ . Sensitivity analysis showed that $\lambda(\theta)$ and $D_{TV}(\theta)$ had a negligible influence on nonisothermal water movement. On the other hand, C_ψ had a significant influence on nonisothermal water movement. Adjusting C_ψ from the original value of -0.0068 K⁻¹ to the value suggested by Philip and de Vries, -0.00209 K⁻¹, improved the agreement between simulated and measured water-content profiles, particularly at an initial water content of 0.282 m³ m⁻³. With the adjustment in C_ψ , the model simulations were in good agreement with the measured data, indicating that the Philip and de Vries theory

provides an adequate description of the nonisothermal transport processes.

2.4 Sheppard and Thibault (1992) studied the **“Desorption and Extraction of selected Heavy Metals from soils.”** The need for proper disposal of industrial wastes and for remediation methods for soils contaminated with heavy metals necessitates a better understanding of the processes involved in mobilizing, transporting, and retaining elements in surface soils. The objective of this study was to investigate the desorption in water and efficacy of several traditional extraction agents in removing Tc, Np, Mo, U, Cr, Pb, Cs, and Th. Selected slices were taken with depth in acidic sand (Dystrochrept) soil cores that were spiked for 4 yr. Similarly, Tc, Np, and U were desorbed and extracted from the clay subsoil of reed /sedge peat cores following a one-season migration study. Technetium and Mo behaved as anions, and the small amount of Tc retained was attributed to insoluble organic complexes and oxides in the sandy soil and carbonates in the clay subsoil. The retention of Mo was attributed to colloidal Fe(III) oxides and organic colloids or complexes. Neptunium sorption appears to be dependent on the variable charge of the soil, making organic matter and pH important factors. Uranium and Pb were associated with oxides. Cesium and Cr took part in inorganic reactions that fixed them rigorously to the soil solids or formed precipitates. The formed organic complexes. Results suggest that remediation techniques for soils contaminate with Tc, Mo, and Np could be quite successful using intense leaching with acidified water. Soils containing U, Pb, and Th may be partially reclaimed by manipulation of the organic matter or leaching with organic acids; however, soils contaminated with Cs and Cr would require extensive chemical treatment.

2.5 Meek *et al.* (1992) reported the “**Bulk Density of a sandy loam: Traffic, Tillage, and Irrigation – Methods Effects.**” Modern crop production creates a cycle between soil compaction caused by traffic and alleviation of this condition by tillage or natural processes such as freezing and thawing. The objective of this study was to evaluate important management practices as they relate to changes in bulk density of a tilled sandy loam soil. Practices evaluated were irrigation method, time between tillage and traffic, tire pressure and wheel load of applied traffic, and controlled traffic. Relationships among bulk density, penetration resistance, and infiltration rate were determined. Experiments were conducted in the San Joaquin Valley of California, on a sandy loam soil (Entisol) with an organic-matter content < 1%. After tillage, settling and trafficking of a soil resulted in rapid changes in its Bulk Density until a new equilibrium was reached. Tire pressure of 408 kPa and wheel weight of 2724 kg applied at moisture contents near field capacity resulted in a bulk density of 1.92 Mg m^{-3} , compared with a value of 1.67 for no traffic. The time interval between tillage and traffic did not affect final bulk density. Drip irrigation which did not saturate the soil, resulted in a bulk density of $\approx 0.1 \text{ Mg m}^{-3}$ lower than flood irrigation, which saturated the soil surface. Wheel traffic in the furrow resulted in only small changes in the bulk density within the row. When tillage did not occur between cropping seasons, traffic caused high bulk densities in the furrow but only small changes in the row. An increase in bulk density from 1.7 to 1.89 Mg m^{-3} decreased the infiltration rate by four times and increased resistance to penetration at the end of the season by three times. Knowledge of how management practices affect bulk density can aid growers in reducing recompaction following tillage.

2.6 Tietema *et al.* (1992) reported “**Abiotic factors regulating nitrogen transformations in the organic layer of acid forest soils: Moisture and pH**”. A linear relation between gravimetric moisture content and nitrification was found within the whole studied range of moisture conditions (10-290% ODW). Net nitrogen mineralization increased linearly with moisture content up to 140% ODW. At higher moisture contents, net mineralization was found to be independent of moisture. Relative nitrification was found to be a linear function of moisture content. The dependence of CO₂ production rates on moisture in the coniferous litter decreased from low to high moisture availability. Due to a nearly linear relationship between gravimetric moisture content and log-(water potential) within the investigated moisture range, the same type of relationships were found with this latter parameter as well. The relationship between nitrogen transformations and pH was studied by means of the addition of different amounts of HCl and NaOH during short incubation experiments (1 week). Nitrification was found to be a negative linear function of the H-ion concentration within the range of 0.04 (pH 4.40) and 0.36 (pH 3.45) mmol H-ion L⁻¹. At a higher H-ion concentration and thus at a lower pH than 3.45, no nitrate was produced any more. No relationship between net mineralization and pH was found.

2.7 Sjöström and Qvarfort (1992) studied the “**Long-Term, Changes of Soil Chemistry in Central Sweden.**” Analytical chemistry data for composite samples from the A₂, A₂/B, B, B/C, and C horizons were used. The exposed site has a higher exchangeable acidity in the four upper horizons and a lower base saturation in the A₂, A₂/B, and B/C horizons. The content of none extractable metal cations is markedly lower in the exposed site, and the amount of extractable metal cations is

larger. This is interpreted as the effect of more intense weathering due mostly to infiltrate acidic precipitation. The results reveal that long-term changes of the soil chemistry, including the estimation of metal fluxes, can be determined by this method.

2.8 Selassie *et al.* (1992) studied “Saline and Sodic-Saline Soil Reclamation: First Order Kinetic Model”. A column study was conducted involving the reclamation of saline and saline-sodic soils. The amount of water moving through the soils was measured as the pore volume of drainage. During saline soil reclamation, under saturated soil moisture flow, the electric conductivity (EC) of the effluent was defined by a multiple slope, apparent first order kinetic equation. The data were also described by the parabolic diffusion law equation.

For saline-sodic soil reclamation, under saturates soil moisture flow, both the decrease in the effluent EC and the sodium adsorption ratio (SAR), were described by a multiple slope, apparent first order kinetic equation. The saline-sodic, reclamation under unsaturated soil moisture flow was also successfully described by a multiple slope first order kinetic model. Reclamation under an unsaturated moisture regime used 36-40 percent less water than saturated moisture flow. The relation between the “true” and “practical” SAR using data from both saturated and unsaturated studied was. $SAR_{true} = 0.02 + 1.085 SAR; r^2 = 0.959$.

2.9 Kemp *et al.* (1992) reported “A Simple Model for Predicting Soil Temperatures in Desert Ecosystems”. The model is based on that of Parton (Parton, W.J., 1984. Soil Sci. 139: 93-101) and provides considerable temperature detail with a daily time step: maximum, minimum, and mean temperature at any depth; hourly temperature detail if desired. The error in predicted temperatures is about the same

as those in models that require soil temperature inputs from at least one depth. This model however, can be used for predicting soil temperature in arid sites for which there are no soil temperature data or for predicting soil temperatures under future climates or environmental conditions.

2.10 Basta and Tabatabai (1992) studied the “**Effect of Cropping Systems on Adsorption of Metals by Soils: II. Effect of pH.**” The effect of pH on adsorption of Cd, Cu, Ni, Pb, and Zn by soils under different cropping systems was investigated. Plots of metal adsorption vs. pH (unadjusted) were generated for 24 soils, 12 from each of two long-term cropping systems. Two soils, one from each site, were selected to study the metal adsorption over a range of adjusted pH values. Results showed that differences in metal adsorption were dependent on the initial heavy-metal concentration. At low concentration, all the added metals were adsorbed regardless of the solution pH. At high concentrations, however, metal adsorption by soils was strongly related to solution pH; metal adsorption increased with increasing solution pH. A decrease in solution pH with increasing initial metal concentration was observed for all soils and metals. In general, a decreased in solution pH for a given amount of metal added followed the sequence: $Cu = Pb > Cb = Ni = Zn$. Metal solubility diagrams showed that, in general, metal adsorption by soils could not be attributed to precipitation. Although some of the adsorption behaviour of these metals was consistent with that based on metal hydrolysis, other results showed that this mechanism could not explain metal adsorption. Metal distribution coefficients, K_d , decreased sharply with increasing initial metal concentration and followed the sequence: $Pb \geq Cu \gg Cd = Ni = Zn$. Also, K_d values were related to solution pH. At high solution part of the

Pb and Cu adsorption could be explained by adsorption of hydroxo-complexes from hydrolysis reactions of these metals. Plots of K_d vs. initial metal concentration suggested that Cd, Ni, and Zn adsorption could be attributed to ion-exchange reactions.

2.11 Grigal and Ohmann (1992) studied the “**Carbon Storage in Upland Forests of the Lake States**”. Carbon storage and dynamics are receiving increasing attention because of the hypothesized role of CO₂ in global climate change. This study was carried out to determine total C storage in Lake States, forests, including C in biomass, forest floor, and mineral soil. Over-story trees were measured and samples of both forest floor and mineral soil (to 1 m) were collected from plots in 169 forest stands across Minnesota, Wisconsin, and Michigan. Five forest types were represented: balsam fir, *Abies balsamea* (L.) Mill.; jack pine, *Pinus bankglana* Lamb.; red pine, *P. resinosa* Ait.; aspen, *Populus tremuloides* Michx.; and northern hardwoods dominated by sugar maple, *Acer saccharum* Marsh. There were no strong geographic trends in C storage in biomass, forest floor, or mineral soil across the study area. Storage differed significantly among forest types. Each major C pool was related to a different set of descriptors. Total C storage, the sum of all pools, was related to forest type, stand age, available water, actual evapotranspiration, and soil clay content, explaining about 65% of the variation. Use of soil and site descriptors did not completely account for the strong effects of forest type on C storage. Differences in the size of C pool, as related to time since disturbance and forest type indicate that C storage in forests of the Lake States can be influenced by forest management activities. Patterns of C storage in these moist temperate ecosystems are not as strongly influenced by climatic variables as in C storage in grasslands to the west.

- 2.12 Schnitzer and Kodama (1992)** reported the “**Interactions between Organic and Inorganic Components in Particle-Size Fraction Separated from Four Soils**”. Little information is available in the literature on the mechanism(s) of interaction of organic matter (OM) and inorganic crystalline and noncrystalline components in particle-size fractions. To obtain a better understanding of this subject, five particle-size fractions, ranging from coarse silts to fine clays, were separated from two soils from eastern Canada (Armadale and Bainsville) and from two prairie soils (Melfort and Regina). Each size fraction was characterized by chemical and mineralogical methods. Humic acids (HAs), Fulvic acids (FAs), and humins were found to accumulate in size fractions ranging from medium silts to coarse clays, while aliphatics were concentrated in fractions from medium silts to fine clays. Amino acids tended to be enriched in clay fractions of the two prairie soils, but accumulated in the silt fractions separated from the two soils from eastern Canada. Except for one soil, $\text{NH}_3\text{-N}$ accumulated in the fine silt and finer fractions, which were rich in expandable phyllosilicates. In general, amount of OM, aliphatics, and $\text{NH}_3\text{-N}$ tended to accumulate in fractions rich in noncrystalline inorganic. Noncrystalline inorganic separated from the two prairie soils were rich in Si, which appeared to contribute to the preferential accumulation of humin, HA, and neutral amino acids. On the other hand, noncrystalline components from the two soils from eastern Canada were rich in Al, which may have been associated with the accumulation of $\text{NH}_3\text{-N}$ and acidic amino acids in these soils. The pH-dependent charges of noncrystalline inorganics may also have contributed to the accumulation of OM.
- 2.13 Moore *et al.* (1992)** studied “**Controls on the Sorption of Dissolved Organic Carbon by Soils**.” Dissolved organic carbon (DOC)

isotherms were determined for 48 soil samples derived from Humaquepts, Inceptisols, and Spodosols using a DOC solution derived from a swamp peat (Hemist). Forty-six of the samples had DOC sorption adequately represented by the linear initial mass isotherm, with initial DOC concentrations up to 81 mg L^{-1} . Null-point DOC concentrations (DOC_{np}), where there is zero net DOC sorption, ranged from 6.7 to 85.4 mg L^{-1} , with an average regression coefficient of 0.45. Distribution coefficients (K_d) averaged $1.00 \times 10^{-2} \text{ m}^3 \text{ kg}^{-1}$, suggesting that DOC sorption by soils is of moderate strength compared with anions such as Cl^- , NO_3^- , PO_4^{3-} , and SO_4^{2-} .

DOC_{np} values were strongly related to contents of soil organic C (positive) and oxalate-extractable Al and dithionite-extractable Fe (both negative) using partial regression analysis ($R^2 = 0.41 - 0.61$, $P < 0.001$). A multiple regression with these three variables explained 70% of the variance in DOC_{np} . The sorption regression coefficient and reactive soil pool for DOC were also positively related to soil organic C content, with an average of 3.2% of the organic C in the soil being part of the DOC reactive pool.

2.14 Williams and Co-workers (1992) studied the “**Comparison of Methods to Estimate Soil Water Characteristics from Soil Texture, Bulk Density, and Limited Data.**” Regression equations based on soil texture and bulk density provided poorer estimates of soil water content, with large errors at some matric potentials, compared with other approaches examined. Regression model results were improved when one measured value of soil water content (-1500 kPa) was included as a variable in the equations, and greatly improved when two (-33 and -1500 kPa) measured values were included. A simple log-log interpolation/extrapolation approach, based on two measured values at -33 and -1500 kPa,

provided results similar to the regression model with two known values. The similar-media scaling approach, utilizing one measured value at -33 kPa, displayed results similar the log-log method, but the error was slightly higher. Estimates with the one-parameter model of Gregson, Hector and McGowan (GHM), based on one known value (-33kPa), was similar to the log-log interpolation/extrapolation when a required generalized slope-intercept relation was calculated for the soils in the study; and the error was slightly higher when using the generalized relationship found by GHM for their data. We conclude that the models which incorporated even one known value of soil water content-matric potential relationship were much better than those based on soil texture and bulk density alone. The simple log-log interpolation/extrapolation and the one-parameter GHM model provided the best estimates of soil water content. The scaling method estimates were only slightly worse than the GHM model estimates. The soil survey data often contain at least one value of the water characteristic. These point methods should, therefore, be methods of choice.

2.15 Walters *et al.* (1992) reported that the “**Effects of Soil Aeration, Legume Residue, and Soil Texture on Transformations of Macro- and Micronutrients in Soil**”. Soil Aeration is an important factor controlling microbial activity, nutrient availability, and plant root growth. We investigated the effect of hairy vetch (*vicia villosa*) addition to well aerated (60% water-filled pore space (WFPS) and poorly aerated (90% WFPS) soils of varying texture on transformations of C, N, P, K, Ca, Mg, S, Zn, Mn, Fe, and Cu for a 30-d period.

Of the total residue C recovered as CO₂-C, 84 and 68% evolved in 0 to 10 d and 11 and 19% from 10 to 20 d at 60 and 90% WFPS, respectively, suggesting rapid decomposition of vetch residue. Of the

total nutrients added to soil in vetch residue of the total nutrients added to soil in vetch residue, significant apparent mineralization of N, P, K, S, and Zn were observed after the initial 20 d of aerobic incubation. Rapidly decomposing residue enhanced anaerobiosis in poorly aerated soils resulting in chemical reduction and a severalfold increase DTPA extractable Mn, Fe, and Cu after 20d. After 30d, reoxidation of these nutrients resulted in decreased DTPA extractable concentrations. At 90% WFPS, coarse soil texture retarded residue composition, and texture had a controlling influence on the time required for reoxidation of reduced Fe, Mn, and Cu in the order of SIC > SiL > SL.

These results imply that incorporation of early decomposable residue may supply substantial amounts of nutrients to growing plants. Where soils remain wet for > 10d, residues may create intensive redacting conditions and a several fold increase in available Fe, Mn, Cu, and P. Conversely, DTPA extractable Fe, Mn, and Cu can very greatly within a few weeks depending on soil aeration status, residue management, time of sampling, and soil texture and may lead to erroneous indices of nutrient availability to plants.

2.16 Bauer and Black (1992) investigated “**Organic Carbon effects on Available Water capacity of three Soil Textural Groups**”. The objective of this study was to measure the effect of management-induced changes in soil organic carbon (OC) concentration on soil characteristics affecting the available water capacity. Four sites each of moderately coarse (sandy), medium, and moderately fine or fine (fine) soils were sampled in four increments to 0.457 m within each of two cropland management system (conventionally cultivated and stubble mulched) and each of two virgin grassland management systems (grazed virgin and relict virgin). Measurements of the water

concentration by weight (P_w) at field capacity (FC) and permanent wilting point (PWP) were made on disturbed soil samples. Bulk density decreased with increasing OC concentration. The magnitude of change was greatest in sandy and least in the medium textured soils. For all soils combined, a change in sand fraction accounted for about 75% of the change in P_w at both the FC and the PWP. The change in P_w was greater at FC than the PWP. A unit change in OC concentration in the sandy soils caused a greater change in P_w at FC than at the PWP, but in the medium and fine soils the change in P_w at FC essentially paralleled the change at the PWP. An increase in OC concentration did not change the available water capacity in the sandy group and decreased it in the medium and fine textural groups. Loss of soil productivity induced by erosion in the northern Great Plains is probably more closely associated with a decline in nutrients and biological activity than from a change in available water capacity.

2.17 Johanson and Farmer (1993) reported “**Batch versus Column method for determining distribution of organics between soil and Water Phases**”. Using a low infiltration rate of 2.7 cm day^{-1} essentially identical values were obtained by the two methods for the distribution of napropamide and lindane between the sorbed and solution phases in a Pachappa sandy loam. Values for K_{OC} of 421 and 1300 L kg^{-1} were measured for napropamide and lindane, respectively, at 20°C . Distribution coefficients decreased with increasing temperature. In the column experiments, similar values for the distribution coefficients were obtained regardless of whether the amounts of pesticide sorbed were determined by direct extraction of the soil or by the difference between quantities added to the columns and the quantities of solute in the effluent. Both linear and Freundlich isotherm models were used to

calculate distribution coefficients. The soil column breakthrough curves were reproducible in duplicate runs for both napropamide and lindane. When distribution coefficients were estimated using a chemical retardation factor from the column experiments, the coefficients were consistently larger than those determined by the batch equilibrium method.

2.18 Tamari *et al.* (1993) studied “**A Simple Method for Determining Soil Hydraulic Properties in the Laboratory**”. Three methods for the estimation of the hydraulic properties were used: the reference method, which requires the pressure head and water content profiles at several times, and the original and modified Wind methods, which require the average column water content at several times instead of the water content profile. Experimental results showed that the hydraulic properties obtained with the modified Wind method agreed well with those obtained with the reference method. Simulated data were used to compare the original and modified Wind methods, and to determine the effect of added noise on the determination of soil hydraulic properties. Using the numerical experiments, it was shown that the modified Wind method provided results slightly better than those of the original Wind method when the number of tensiometers was greater than three. When measurement errors were taken into account, estimation of the water retention curves using the modified Wind method was not very sensitive to experimental errors, but small uncertainties in tensiometric data influenced greatly the hydraulic conductivities determined in wet conditions.

2.19 Moshrefi (1993) studied “**A New method of Sampling Soil Suspension for particle size analysis**”. Grain size analysis is

performed in many soil science laboratories using the pipet method. However, it is still troublesome and time consuming to sample a suspension at a particular depth. In this paper a method is presented in which soil suspensions (clay and silt) were sampled faster and more easily with a syringe inserted horizontally into the suspension through septa. The new syringe method was compared with the pipet method. Both methods were equally accurate but the syringe method has the advantage of being easier to handle and more time efficient. This makes it especially suitable for series analysis.

2.20 Amrhein and Co-workers (1993) reported “**The Effects of Redox on Mo, U, B, V, and As Solubility in Evaporation Pond Soils**”. A laboratory incubation study was conducted to evaluate the effects of redox status on the solubility of trace elements in saline sediments and soils from the San Joaquin valley. The elements U and Mo were mobilized under oxidizing condition while Fe, Mn, Ni, V, and As were more soluble under reducing conditions. Reduction and precipitation of Mo, apparently as MoS₂, was observed from 1 to 10 days after flooding, but when reiterated the Mo resolubilized in less than 1 day. The reductive dissolution of Fe- and Mn-oxyhydroxides released adsorbed B, which resulted in an increased solution concentration of B. Low redox conditions in drain water ponds may reduce the solution concentrations of U, Mo, and Se, thereby reducing their chances of entering the food chain through algae uptake. However, low redox conditions favour the solubilization of As and V, which may pose an alternative threat to wildlife visiting the ponds.

2.21 QIU and ZHU (1993) was studied “**Rapid Analysis of Cation Exchange Properties in Acidic Soils**”. The conditions for the

spectrophotometric determination of exchange acidity with ethyl red in soil extracts were studied. Results are in reasonable agreement with those obtained by routine HCl titration after extraction with BaCl₂-triethanolamine. Exchangeable bases in the soil extract can be determined with atomic absorption spectroscopy or photometrically using chlorophosphonazo III xylidyl blue I, and flamophotometry. After removal of the extractant, cation exchange capacity can be determined.

2.22 Tariq and Durnford (1993) investigated the **“Soil Volumetric Shrinkage Measurements: A Simple method”**. Present methods of determining soil volume changes have many constraints. They require the use of hazardous chemicals, take a long time to complete, are not useful near the wet end of the moisture range, and have limited accuracy. A new method of soil volumetric shrinkage measurement using a balloon apparatus is presented. In this method, the soil bulk volume is determined by measuring the displacement of the soil specimen wrapped in water with the soil specimen wrapped in a flexible rubber membrane, an ordinary rubber balloon. The method is very simple and doesn't require use of any chemicals. Therefore, it is environmentally safer than other methods. The volumetric shrinkage measurements can be completed for the full moisture range in a short time. The proposed method compares very favourably with the results of the resin coating method.

2.23 Massman (1993) studied **“Periodic Temperature Variations in an inhomogenous Soil: A Comparison of Approximate and Exact Analytical Expression”**. Comparisons (of the first harmonic) between exact and two approximate analytical solutions to the one-dimensional

heat conduction equation for an inhomogeneous soil show that the approximate analytical solutions are potentially more useful for profiles of soil thermal properties that exhibit positive or zero concavity than for those that exhibit negative concavity. Comparisons between the two approximate analytical solutions also suggest that one solution provides a much easier method for estimating profiles of soil thermal properties from soil temperature profiles than does the other. A brief summary of tree analytical solutions to the one-dimensional heat conduction equation is also given. Furthermore, some of these extent analytical solutions are unique to the present study and employ relatively simple and easily implemented algorithms for their evaluation. For many applications involving periodic variations in soil temperature, these algorithms are likely to provide more realistic results than can be obtained more realistic results than can be obtained by assuming homogeneous soil properties with their associated “exponentially decaying” solution for soil temperatures. It is further suggested that the solutions presented in this work could be used to verify more complex numerical models of soil heat flow.

2.24 Campbell and Zentner (1993) studied the “**Soil Organic Matter as Influenced by Crop Rotations and Fertilization.**” We monitored soil organic matter in the 0- to 0.15- and 0.15- to 0.3- m depth of a 24-yr crop rotation experiment conducted on a medium-textured Aridic Haploboroll in southwestern Saskatchewan. Prior to the study, the land had been in hard red spring wheat (*Triticum aestivum* L.)-fallow rotation for = 50 yr. Only the 0- to 0.15-m segment showed significant treatment effects. Due to good weather and crop yields in the first 15 yr, soil organic matter had increased under well-fertilized annually cropped rotations, and it remained constant under fallow-containing rotations

and under continuous wheat receiving inadequate N fertilizer. Because of several dry years in the final 9 yr of the study, all rotations except a well-fertilized, fallow-winter cereal-wheat system lost organic matter. Changes in organic matter were directly related to the amount of crop residues produced by these systems and their ease of eroding. Soil organic matter was inversely related to apparent N deficit (i.e., N exposed in grain minus N applied as fertilizer). The fallow-flax (*Linum usitatissimum* L.)-wheat rotation receiving N and P fertilizer had the lowest soil organic matter, partly due to low production of crop residues by flax, partly to greater leaching of NO_3 , and partly due to some loss of flax residues blown from the plots. Soil organic matter in the well-fertilized fallow-winter cereal-wheat rotation remained constant because its shorter fallow period reduced soil erosion, and due to its more efficient use of N, as evidenced by minimal leached $\text{NO}_3\text{-N}$.

2.25 Mordelet et al. (1993), investigated the **“Effects of Tree clumps on soil characteristics in a humid savanna of West Africa (Lamto, Coted Ivoire).”** Soil texture and field capacity were not significantly different under tree clumps compared to open grassland. On the other hand, bulk density was lower under tree clumps, likely due to a greater soil fauna activity under the trees. The pH, available phosphorus, cation exchange capacity, total carbon and total nitrogen contents were higher under tree clumps due to greater organic matter input beneath canopies. Potential soil respiration and mineral nitrogen accumulation were also enhanced, indicating a higher potential microbial activity under tree clumps. Soil water content was slightly lower beneath canopies (from July to November only between 0 and 10 cm depth) when soil moisture was above field capacity. During the other months, no significant difference was measured.

- 2.26 Giesler and Lundstrom (1993)**, studied the “**Soil Solution Chemistry: Effects of Bulking Soil Samples**”. This study investigated whether bulking can affect the chemistry of soil solution extracted by the centrifuge drainage technique. The short-range variation within a 1-m-wide pit face was also investigated. Systematic differences were found between the chemistry of soil solutions taken from bulked and unbulked soil samples. The soil samples studied were taken on several occasions from the upper and lower part of a Bs horizon. Samples of soil solution extracted from replicate bulked soil samples contained significantly ($P \leq 0.05$) larger amounts of Si, Na, Mg, and K as well as significantly ($P \leq 0.05$) smaller amounts of Al and Fe than soil solution from unbulked samples. Bulking reduced the variation in all solutes measured, although a variation remained in replicates from the bulked sample. The variation between individual core samples taken just tens of centimetres apart can be considerable, although the magnitude of variation differs depending on the solute studied. The results suggest that unbulked soil samples may be preferable, especially when Al or Fe chemistry is studied and a centrifuge drainage technique is used.
- 2.27 ZHU and Alva (1993)** studied the “**Differential Adsorption of Trace Metals by Soils as Influenced by Exchangeable Cations and Ionic Strength**”. The objective of this study was to evaluate the relative effects of Ca, Mg, and K on the adsorption of Zn and Cu by several Florida soils under citrus production and to differentiate the specific cation effects vs. effects of ionic strength on adsorption of Zn and Cu. A batch-equilibration technique was employed to evaluate the adsorption of Cu and Zn (added at 10^{-4} M) in the presence of varying concentration of Ca or Mg (2.5-15 mmol) or K (5.0-30 mmol). Adsorption of both Cu

and Zn decreased with an increase in concentrations of either Ca or Mg. The inhibitory effects of added cations on the metal adsorption was much greater for Zn than for Cu. Addition of K slightly decreased the adsorption of Zn but had little effect on Cu. The inhibitory effects of Ca and Mg on the adsorption of Cu or Zn appear mainly due to competition for the exchange sites on soil colloids.

2.28 Chiang *et al.* (1993), studied “Hydraulic properties of Surface Seals in Georgia Soils.” Few studies have reported measured seal hydraulic conductivities in soils from the southeast USA. Seven Georgia soils packed in columns were subjected to simulated rainfall at an intensity of 50 mm h⁻¹. The sandy loam soils were easily disrupted by rainfall. The calculated seal hydraulic conductivities (K_c) dropped sharply in 10 min of rain and were less than 10% of the initial saturated hydraulic conductivity (K_i) after 45 min. The sandy loam soil with low aggregate stability and Fe content was especially prone to sealing in that K_c dropped to 4% of K_i after 10 min. The well-structured soil with a clay texture declined in K_c gradually with time, indicating a high resistance to rainfall energy. The sandiest soil showed intermediate resistance to raindrop impact, and K_c levelled off at a high value after 20 min due to the low clay content. The loamy soil with smectitic clay had the lowest K_i and showed little change in K_c with time. Relative seal hydraulic conductivity after 10 or 60 min of rain were good indices differentiating the relative resistance of these soils to surface sealing. A soil stability factor, used to characterize the decrease of K_c in an exponential decay equation, was significantly correlated with water-dispersible clay on a soil basis.

2.29 Raven and Hossner (1993) was investigated “**Phosphorus Desorption Quantity- Intensity Relationships in Soils.**” Phosphorus desorption quantity-intensity (Q/I) relationships reveal information about the P release properties of a soil. This research was carried out to evaluate the P desorption characteristics of a group of soils of diverse properties and to compare several empirical models to describe P desorption Q/I curves. Samples of five soils (Typic Calclustoll, Udic Pellustert, Vertic Albaqualf, and Aridic Calciustoll surface soils, and Psammentic Paleudult subsoil) were enriched with five P concentrations (0, 25, 50, 75, and 100 mg P kg⁻¹) and incubated for 31d. Subsamples of each treated soil sample were equilibrated with different amounts of HCO₃⁻-saturated anion-exchange resin. After 72 h the amount of P sorbed on the resin (Q) as well as the solution P concentration (I) were determined. Results from each sub-sample gave a point on the Q/I curve. The P release capacity of the soils used in this study was relatively low. In untreated samples, the solution P concentration when no P was desorbed (I_0), an intensity parameter, ranged between < 0.01 and 0.19 mg P L⁻¹, while the maximum desorbed soil P (Q_{max}), a quantity parameter, was in the range 4.7 to 21.1 mg P kg⁻¹. The corresponding P buffering power index, the slope of the Q/I curve at I_0 , ranged between 56 and 1703 L kg⁻¹. These Q/I parameters were not closely related to any evaluated soil property, with the possible exceptions of CaCO₃ content in calcareous soils and clay content. The P buffering power of a soil apparently depended on the availability of P sorption sites and their degree of depletion, and was not always directly related to the ability of a soil to release P. The P release activity of P-enriched soil depended on the desorbability of the applied P as well as the native labile soil P. Plots of P buffering power against intensity for a given soil were not affected by P enrichment. The Q/I curves could be

best described by a proposed desorption Q/I equation ($Q = aI^{0.1} + b\ln(I + 1) + c$) and the Barrow power function, but the proposed equation followed the theoretical expected trend. The proposed equation is therefore recommended to describe P desorption Q/I curves.

2.30 Yaan Cheng and Petty (1993) studied the “**Horizontal and Vertical Movements of Two Expansive Soils in Mississippi**”. Expansive soils create severe problems for road construction and maintenance, building foundations, and agricultural and industrial operations. Quantification of soil movement under natural field condition has received little attention and is not well understood. Horizontal and vertical movements were measured for 20 mo by surveying rods placed at various depths in field plots of Typic Chromuderts and Vertic Hapludalfs of the Mississippi Black land prairie. Vertical soil movement was a function of soil depth, soil water content, and rainfall. Greatest vertical soil movement occurred in the upper 50 cm of both soils, with a maximum of 27 mm in the Vertisol and 24 mm in the Alfisol. Soil swelling occurred in winter and shrinking occurred in late spring and summer. Horizontal soil movement was not related to soil depth, but was related to soil water content and rainfall. Maximum horizontal movement was 36 mm in the Vertisol and 20 mm in the Alfisol. Horizontal and vertical movements in expansive soils are reversible, dynamic processes under natural field conditions. Horizontal movement appears more dynamic than vertical movement, and in reflects short-term response to precipitation events followed by drier periods. Vertical movement reflects long-term precipitation-evapo-transpiration distribution and is probably related to movement along master slickensides.

2.31 Osaki (1993) studied the “**Carbon-nitrogen interaction model in field crop production**”. Two Carbon-nitrogen interaction models were developed, one, expressed as $DM = DM_o \exp(CN_I N)$, was for growth of *Gramineae* (rice, wheat, and maize) root crops (potato, sweet potato, and sugar beet), the other $DM = DM_o + CN_I N$ for *Leguminosae* (soybean, field bean, and aduki bean), where, DM is dry weight of plant at a given time, N is the amount of nitrogen accumulated in plant at a given time, DM_o is the initial amount of dry weight, and CN_I or CN_I , is the carbon-nitrogen index.

The CN_I value changed with the amount of nitrogen absorbed at the time of harvest (Nh), indicating that the relationship between the CN_I value and Nh fitted to a hyperbolic curve as follows:

$CN_I = 1/(a Nh + b)$, where, a and b are the coefficients of the equation.

In rice, coefficients a and b were estimated by the Gauss-Newton method.

2.32 GRANT (1993) investigated “**Simulation model of soil compaction and root growth**”. Soil compaction is understood to reduce root growth by increasing soil resistance to root elongation and by decreasing O_2 transport to root surfaces. Although mathematical models have been proposed for each of these processes, there remains a need for a more comprehensive model of root growth if the effects of soil compaction on carbon and nutrient cycling are to be represented in larger ecosystem simulation models. In the model presented here, root growth simulated in each horizontal layer of the soil profile is taken to be the lesser of that enabled by soil strength and that by carbon respiration. Soil strength is calculated from the bulk modulus of soil elasticity, estimated from bulk density, water content and organic matter content, and carbon respiration is estimated from the availability of O_2 , nutrients and

reduced carbon in the roots. This model represents an attempt to integrate the effects on root growth of soil physical characteristics, such as water content and bulk density, with those of soil chemical characteristics, such as nutrient and O₂ concentrations, and those of plant biological activity, such as the production of reduced carbon. The mathematical equations on which the model is based are presented, and the behaviour of the model is discussed. Further knowledge of how root branching is controlled will be needed for further model development. In the accompanying article, this model of root growth is tested against experimental data recorded in soil different soil bulk densities.

2.33 Whitehead and Raistrick (1993) studied **“The volatilization of ammonia from Cattle urine applied to soils are influenced by soil properties.”** The urine contained 12.0 g N dm⁻¹ and was applied to small columns of soil at a rate equivalent to 26.5 g N m⁻². The soils were from fields of both grassland and arable cultivation and varied widely in properties. Ammonia volatilization ranged from 6.8 to 41.3% of the total urinary N, with a mean value of 26.4%. The soil property most closely related to the extent of volatilization was cation exchange capacity (CEC), and this was so whether all 22 soils were considered together or whether the 14 grassland and 8 arable soils were considered separately. In general, the higher the CEC the less the amount of ammonia volatilized. However, for a given value of CEC, volatilization tended to be greater from grassland than from an arable soil. The pH of a soil/urine mixture measured after 24 hours was also quite closely correlated with the amount of ammonia volatilized, but the initial pH and titratable acidity of soil were poorly correlated with ammonia volatilization.

2.34 RON VAZ and co-workers (1993) studied the “Phosphorus fractions in soil solution: Influence of soil acidity and fertiliser additions.”

The influence of soil acidity and phosphorus fertilization on phosphorus fractions and dissolved organic carbon (DOC) in soil solution was quantified experimentally in an iron humus podzol. Soil solution was isolated by centrifugation from top- and sub-soil samples. Total dissolved phosphorus (TDP), dissolved reactive phosphorus (DRP), dissolved organic phosphorus (DOP) and DOC increased as soil pH and P status increased. DOP was the fraction present at the highest concentration (0.080 – 0.464 mg P L⁻¹) for the majority of samples. DOC and DOP concentrations which remained relatively constant down the soil profile were also highly correlated. Soluble organic P compounds may make a significant contribution to plant available soil P particularly for soils with low fertility levels. The relatively high DOP concentrations (Ca 0.227 mg P L⁻¹) found throughout the soil profile have important consequences with regards to P leaching and plant nutrition.

2.35 Zhu and Alva (1993) investigated “Trace metal and cation Transport in a Sandy Soil with various Amendments.”

This study was conducted to determine the effects of either gypsum, MgSO₄, or K₂SO₄ on transport of Cu, Zn, Ca, and Mg from a slightly alkaline sandy soil (top 15-cm layer) using leaching columns. Concentrations of the above elements were measured in seven leachate fractions, each representing 0.64 pore volumes. The concentrations of Cu and Zn in the leachate were greater in the K₂SO₄-amended than the unamended soil. Gypsum or MgSO₄ amendments significantly decreased the recovery of Cu and Zn in the leachate, compared with that from the unamended soil; however, transport of Mg was increased in the gypsum-amended soil;

however, transport of Mg was increased in the gypsum-amended soil as a result of cation exchange. The concentration of dissolved organic carbon (DOC) was highest in the K₂SO₄-amended soil followed by the unamended soil and the MgSO₄- and gypsum-amended soils. A positive correlation ($r^2 = 0.77$) was found between the concentrations of Cu or Zn in the leachate fractions and that of DOC. Since Cu and Zn form complexes with organic ligands in soil solution, a decrease in transport of trace metals.

- 2.36 Quisenberry *et al.* (1993)** studied “**A Soil Classification System for Describing Water and Chemical Transport.**” The system is based primarily on surface texture, clay mineralogy, and nature of soil structure. We now have developed this system for the more extensive soil series in South Carolina, and these soils have been grouped into eight different classes. While variability of some soil properties within a given class certainly exists, a class is distinct from each of the other seven classes in water and chemical transport characteristics. A classification system such as this can help to identify those soil properties that most affect transport processes and will help to provide the framework for development of mathematical transport models that incorporate these same soil properties.
- 2.37 CHOW and co-workers (1993)** investigated “**Modification of Subsoil Characteristics Resulting from Drainage Tile Installation.**” Modification of subsoil characteristics caused by drainage tile installation was examined on loamy glacial till soils in Nova Scotia and New Brunswick, Canada. The objectives were to evaluate the effects of different drain line installation techniques, trenchless vs. trenching, and system age on subsoil physical characteristics. The area of disturbance

caused by trenching (both machine and hand dug) tends to be uniformly 30-40 cm wide in the subsoil portion of the profile, whereas a zone of disturbance 7-17 cm wide was created by the trenchless plow. Although both methods result in bulk density of the disturbed subsoil being significantly lower than the undisturbed subsoil, disturbance caused by trenching exhibited lower bulk density than that of the trenchless plow. Percent reduction in bulk density did not significantly change over time periods of up to 30-40 years. Increase in macro porosity of disturbed subsoils correlated significantly with reduction in bulk density. With increase in macropores, saturated hydraulic conductivity of the disturbed subsoil was significantly higher than found originally, except in newly drained (1 and 2 years) fine-loamy till soils. Saturated hydraulic conductivity of disturbed subsoils resulting from trenching was significantly higher than that of the trenchless plow. Although not always statistically significant, organic carbon content of the disturbed subsoil was considerably higher than that of the undisturbed. The difference in organic carbon between the disturbed and the undisturbed subsoils decreased with increasing time. A significant correlation was found between the logarithm of the rate of organic carbon decomposition and average age of installation ($r^2 = 0.9$). This indicates that the shallow rooted crops being grown (corn and forages) did not, or could not, possibly because of low pH values, take advantage of the modified subsoil conditions created since little organic matter from decaying roots was added to the disturbed soil mass. As a result of subsoil modifications, surface soil moisture content immediately above the drain line was lower than the adjacent surface soil.

2.38 Kuiters and Mulder (1993) studied the “**Water Soluble Organic Matter in Forest Soils**”. Soil culture experiments were conducted to

examine the effect of water-soluble organic matter (WSOM), isolated from the A_h horizon of a forest soil on cation uptake by seedlings of *Agrostis capillaris* and *Silene dioica*. In contrast to the large effects on soil equilibria, cation uptake was only slightly affected by WSOM. Solubilized Al, Fe, Cu and Pb, were not found in higher amount neither in the root nor in the shoot of the test species. Significant effects were only found for Cd, Mg, Mn and Zn, where uptake was either enhanced or decreased by WSOM. An experiment with several standard low molecular weight organic acids affirmed the results obtained with WSOM and supported the hypothesis that cations are taken up predominantly in the free ionic form and not as organic complexes. Results are discussed in relations to the effects often found for fulvic and humic acids.

2.39 Lefroy *et al.* (1993) reported the “**Changes in soil organic matter with cropping as measured by organic carbon fractions and ^{13}C natural isotope abundance.**” In soil organic matter with cropping is a major factor affecting the sustainability of cropping systems. Changes in total C levels are relatively insensitive as a sustainability measure. Oxidation with different strength KMnO_4 has been shown to be a more sensitive indicator of change. The relative size of soil C fractions oxidised by 333 mM KMnO_4 delined with cropping, whilst the relative size of the unoxidised fraction increased. Changes in $\delta^{13}\text{C}$ ratio have been used to measure C turnover in systems which include C_3 and C_4 species.

2.40 Paige and Hillel (1993) reported the “**Comparison of three methods for Assessing Soil Hydraulic properties.**” The methods compared are: the Instantaneous Profile Method, the Guelph Permeameter, and

laboratory determination using intact soil cores. The saturated conductivity functions, as well as the moisture retention relationship when possible, were determined and the results compared with respect to their ranges of applicability and the respective limitations of each method. We found close agreement for the moisture retention relationships determined by the instantaneous determined by the instantaneous profile method and the soil cores for the ranges of pressures and moisture contents they have in common. In addition, there was also close agreement between the $K(\psi)$ relationship measured using the instantaneous profile method and that predicted using the van Genuchten and Mualem models. The field saturated conductivity results determined using the Guelph Permeameter were one to three orders of magnitude less than the saturated conductivity results determined from soil cores and those determined by the instantaneous profile method. The unsaturated $K(\psi)$ relationship using Gardner's definition of matric potential and the results from the Guelph permeameter predicted hydraulic conductivity values three to four orders of magnitude less than the other two methods at 200 cm of pressure.

- 2.41 Mc Laughlin and co-workers (1993)** studied the “**Use of cation/anion exchange membranes for multi-elements testing of acidic soils.**” They have developed a technique using cation/anion exchange resins which allows the simultaneous extraction from soil of Ca, Mg, K, Mn, Al and P. Ions are extracted by shaking soil with resin in distilled water. The resin is separated from the soil and ions are desorbed from the resin using an acid/salt solution. Concentrations of ions in solution are then determined by conventional means. Concentrations of ions extracted by the resin method were compared with concentrations determined by commonly-used analytical procedures. Except for Al, concentrations of

ions extracted by the resin procedures correlated well with conventional extraction and analytical procedures. The resin membrane method offers considerable speed and cost advantage over conventional methods.

2.42 Norfleet and co-workers (1993) reported the “**Soil Solution Composition Relative to Mineral Distribution in Blue Ridge Mountain soil**”. Soils with large quantities of gibbsite are normally associated with tropical climates and very intense weathering. The abundance of this mineral in the clay fractions of soils in the temperate climate of the Blue Ridge Mountains raised questions about the soil environment and possible mineral weathering trends. The composition of interstitial soil solutions of three highly weathered soils in the mountains of South Carolina was studied in order to explain contrasting distributions and prevalence of gibbsite and kaolinite. Extensive leaching caused by high amounts of rainfall was evidenced from the low solution ionic strengths and soluble *Si* content of these soils. The solubility data suggested gibbsite to be the most stable mineral in subsurface horizons serving as *Al* sinks (mineral precipitation), with kaolinite being more stable in surface horizons. These two minerals appeared to be in a dynamic equilibrium with hydroxy-interlayered vermiculite, which is controlled by kinetic gradients imposed by site characteristics rather than solution chemistry alone. While the solution composition is consistent with the mineralogical suite of these soils, the residence time of *Al* and especially *Si* appears to be the determining factor for secondary mineral formations, weathering transformations and distribution in the soil profile.

2.43 Raj Kumar and co-workers (1994) reported the “**Occurrence of Sodic Soils at Different Geomorphic Locations and Climate in the**

Satluj-Yammuna Divide.” Characteristics of sodic soils do not vary much with changes in geomorphology and climate of the study area. These observations do not support the earlier works advocating relief and climate as the major factor responsible for the formation of sodic soils. Occurrence of sodic conditions below a normal surface soil in pedons with lithological discontinuity points towards the parent material as a factor responsible for the formation of sodic soils in the study area. Source of salts in sodic soils of north-west India has been linked to various salts bearing geological formations of sub-Himalayas that have contributed to the alluvium or the parent material of these soils.

2.44 Jalota *et al.* (1994) studied the “Evaporate Parameter in Relation to Soil Texture and Atmospheric Evaporativity to Predict Evaporation from Bare Soil.” An equation describing effects of soil texture and evaporativity on evaporation parameter, to be used in square root of time relation for estimating cumulative evaporation (*CE*) from soil was developed. The estimated *CE* involving the evaporation parameter computed from the equation matched with the *CE* data observed by different workers for varying soil texture and evaporativity.

2.45 Jennifer Donaldson Knoepp and Swank (1994) studied “Long-Term Soil Chemistry changes in Aggrading Forest Ecosystem.” Assessing potential long-term forest productivity requires identification of the processes regulating chemical changes in forest soils. We resample the litter layer and upper two mineral soil horizons. A and AB/BA, in two aggrading southern Appalachian watersheds 20 yr after an earlier sampling. Soils from a mixed-hardwood watershed exhibited a small but significant decrease in soil pH. Extractable base cation content

declined substantially in both mineral horizons. Cation content did not change significantly in the AB/BA soil horizon. Nutrient budgets were constructed using these soil and litter data plus existing data on weathering rates, forest productivity, and hydrologic fluxes and associated chemistry. Decreases in soil base cations and soil pH are attributed to leaching and to the sequestration of nutrients in biomass.

- 2.46 Sen *et al.* (1994)** studied “**Occurrence and characteristics of some Kandi Soils in Manipur**”. Classical method for identification of clay cutan or argillic horizon in the field has been a matter of uncertainty till 1987 when ‘Kandi’ concept was introduced into the diagnostic criteria in Soil Taxonomy for low activity clay (LAC) soils. With this concept, morphology and soil characteristics of four representative pedons formed on sedimentary parent material in hilly terrain of Manipur were studied. All the four soils showed kandic properties and these were classified as Typic Kanhaplohumult and Typic Kanhapludult.
- 2.47 Bhattacharyya and co-workers (1994)** investigated “**Morphology and classification of Ultisols with Kandic Horizon in North Eastern Region**”. Four Ultisols from north-eastern region of India (Manipur and Meghalaya) for which no information is available have been classified according to Soil Taxonomy. The soils are acidic, of low base status and rich in organic matter in the surface horizons. CEC and ECEC of clay support the presence of kandic horizon in three pedons. The soils of Meghalaya appear to be more weathered than those of Manipur.
- 2.48 Soni *et al.* (1994)** investigated “**Effect of Sewage sludge Application on the Mineralization of Nitrogen in Soils.**” The present investigation was conducted to determine the effect of sludge levels on mineralization

potential (N_0) and rate constant (k) in four different soils. Cumulative N mineralized increased with increasing incubation period and sludge application. The magnitude of increase in N mineralized, however, was not the same with the successive additions of sludge. It was greatest for the first increment of sludge (0.5%) and subsequently narrowed down with the further application of sludge. Maximum amount (90 mg kg^{-1}) of mineralized N was obtained in Karnal soil (Typic Ustochrept) and lowest amounts (30 mg kg^{-1}) in Balsamand soil (Typic Ustipsamment) at 4 per cent sludge level. Both soil type and sludge levels significantly affected the mineralization of sludge organic N . The values for nitrogen mineralization potential (N_0) and rate constant (K) were greater in sludge treated soils as compared to untreated soils.

- 2.49 Milap Chand and Dhillon (1994)** reported the “**Evaluation of various Soil Test methods for available phosphorous in Reclaimed Sodic Soils of Punjab.**” Ten rapid soil testing procedures for available P were evaluated. In a greenhouse experiment, wheat grain yield correlated significantly with P extracted by citric acid, acetic acid, Bray-I, Bray-II, Egner and Olson’s reagents. Among all the extractants, Olsen’s P with four hour shaking had the highest correlation coefficient with wheat grain yield, relative yield, and total P uptake of wheat. The critical level of Olsen p with four hour shaking below which wheat will respond to P application was found to be 10 mg P kg^{-1} .
- 2.50 Bhattacharyya *et al.* (1994)** reported the “**Classification of Saline-Sodic Vertisols in the Coastal Plains of Gujarat**”. Morphological and analytical characteristics of two representative saline-sodic Vertisols in the humid/subhumid region of coastal plains of Gujarat have been described. An attempt has also been made to classify such soils bringing

the important soil characteristics viz. calcareousness, salinity and sodicity at higher category level in the light of recent modification suggested by the International Committee on Management of Vertisols as has been accepted in Soil Taxonomy.

- 2.51 Bharadwaj and Omanwar (1994)** studied **“Long Term Effects of Continuous Rotational Cropping and Fertilization on Crop Yields and Soil Properties-II. Effects on EC, pH, Organic Matter and Available Nutrients of Soil.”** Continuous cropping without fertilization leads to the depletion of organic matter, available N, P, K, Fe, Mn, Zn and Cu, whereas continuous fertilization had beneficial effect on organic matter and available N, P, and K of the soil. A build up of available P and K in control plots showed dynamism of these nutrients in soil. Depletions in DTPA extractable (available) Fe, Mn, Cu and Zn status of unfertilized as well as fertilized plots indicated these nutrients were utilized from soil to meet the requirements of crops.
- 2.52 Bharadwaj and co-workers (1994)** studied **“Long Term effects of continuous Rotational cropping and fertilization on crop yields and Soil properties-III changes in the fractions of N, P and K of the soil.”** Analysis of surface and subsurface soil samples collected from a long term fertilizer experiment indicated that continuous cropping without fertilization decreased the N, P and K fractions of soil to a considerable extent. Well fertilized plots showed an increase in the fractions of these nutrients in soil. The non-distillable acid soluble nitrogen fraction constituted the highest percentage of soil nitrogen. Ca-P and Fe-P forms were more important than Al-P in rice based cropping

system. The tendencies of shift from Ca-P to Fe-P and Al-P and from total K to plant available K were noticed.

2.53 Mathan *et al.* (1994) investigated “**Application of Fertility Capability Classification Concept in Major Soil Groups of Kamarajar District, Tamil Nadu.**” Twenty one soils, belonging to subgroups Typic Chromusterts, Typic Ustropepts, Udic Haplustalfs, Typic Haplustalfs, Vertic Haplustalfs and Tupic Ustorthents were grouped in 8 FCC (Fertility Capability Classification) units based on type, substrata type and conditions modifiers. The FCC units will serve as the basis for conducting fertility related experiments and extrapolation of such experimental results. The condition modifiers that decide the soil and fertilizer interactions in the study are ‘d’ (dry condition), ‘b’ (basic reaction), ‘v’ (vertic characters), ‘m’ (magnesium deficiency), ‘n’ (natric), ‘k’ (potassium deficiency), ‘i’ (Fe-P fixatin) and ‘e’ (low CEC).

2.54 Ladislau Martin Neto et al. (1994) investigated the “**Effects of Cultivation on ESR Spectra of Organic Matter from Soil Size Fractions of a Mollisol**”. Organic matter from different soil size fractions (<2 μm ; 20-50 μm ; 50-150 μm , and > 150 μm) was obtained, using a combination of physical separation and light chemical treatment, in an Argentine Mollisol. Quantification of semiquinone free radicals was done using electron spin resonance spectroscopy, taking into account the organic carbon content of each sample. Values obtained for fractions less than 50 μm in size were significantly higher than values for fractions greater than 50 μm . Comparison of this data with C/N ratios suggests that there is an association between fractions where more humified organic matter occurs and a higher level of semiquinone

is detected. A 2 to 20 μ m size fraction was identified as that with the highest humification degree and one, which undergoes only minor changes as a result of agricultural practices. Alterations associated with soil compaction, principally in an A₁₂ horizon in an area cultivated for 80 years, were accompanied by a reduction in the level of semiquinone free radicals compared with a native grassland area.

- 2.55 Chandrasekharan and co-workers (1994)** was “**Studies on Salinity and Water Content of Soils – Geoelectrical Approach.**” Field investigations carried out using the earth resistivity meter for studying variations of salinity and water contents of soils in the vadoze zone of Delhi soils are presented. Variations in the salinity levels have been interpreted through bulk soil electrical conductivity (EC_a measured by the resistivity meter), electrical conductivity of soil saturation extract (EC_e) and other soil-water parameters. EC_a values were also used to estimate the soil water contents in a soil profile. The spatial variation of EC_a indicates an exponential relation with the corresponding EC_e values and EC_a values in a soil profile has curvilinear correlation with soil water contents. With prior calibration, the resistivity meter can be used to estimate the soil profile water contents as well as to study the variation of soil salinity over a larger area. The method is non-destructive, rapid and gives reproducible results.
- 2.56 Lebron *et al.* (1994)** studied “**Stability of a Calcareous Saline-Sodic During Reclamation.**” General guidelines to reclaim saline or sodic soils do not adequately consider variables such as pH and the presence of organic matter that are known to affect soil stability. Poor structural stability of sodic, saline-sodic, and high-pH soils adversely influences crop yields; promotes piping, tunneling, and slope erosion; and can

accelerate the failure of water conveyance systems. We evaluated six soil tests, used to measure physico-chemical properties, for their suitability to evaluate the structural stability of a calcareous, saline-sodic soil under reclamation. The stability tests were wilting point, plastic limit, coefficient of linear extensibility (COLERod), water content at 0.03 MPa, liquid limit, and dispersion index. The range of electrical conductivity (EC) studied was 0.5 to 20 dS m⁻¹, sodium adsorption ratio (SAR) 0 to 400 (mmol L⁻¹)^{0.5}, and pH 8.4 to 10.5. The results obtained indicate that the amount of water necessary for a soil to flow under standard conditions for the liquid limit test decreased an average of 25% when the EC decreased from 40 to 2 dS m⁻¹. The liquid limit and EC showed a linear correlation ($R^2 = 0.785$); therefore, the liquid limit was considered to be an appropriate index to evaluate the physical properties of a soil under a leaching process.

2.57 “Simulation of Cation Exchange Involving Hydrogen Ion in Soil”

investigated by **Kun-Huang Houg (1994)**. A computer program for simulating cation exchange in soil was developed and used for simulating the determination of exchangeable acidity with 1 M KCl and of hydrolytic acidity with 1M NaOAc. The acidification process resulting from extraction of an initially base-saturated soil with a dilute solution of an acid having various dissociation constant may also be simulated. From the calculated pH-base saturation relationships for assumed K-H exchange coefficient (K_{K-H}) varying from 1×10^1 to 1×10^{-6} , it is noted that for K_{K-H} values of 1×10^{-n} , the inflection point of the pH-base saturation curve is at the pH value of n. Thus, the permanent charge sites of mineral soils appeared to have a K_{K-H} value of 1×10^{-1} and greater, while for the pH-dependent charge sites the K_{K-H} values are smaller than 1×10^{-2} . The acidity extracted by 1 M KCl

solution corresponded to the H^+ on the permanent charge sites, with K_{K-H} values of 1×10^{-2} and greater, but it may also include some portions of H^+ bound on exchange sites with K_{K-H} values smaller than 1×10^{-2} . Exchangeable H^+ from sites with K_{K-H} smaller than 1×10^{-5} were practically not displaced by 1 M KCl solution. The use of 1 M NaOAc instead of KCl could quantitatively displace the H^+ held on the sites with K_{Na-H} values $> 1 \times 10^{-3}$ by a single extraction, while those of 1×10^{-6} and greater may be displaced by repeated extractions. Calculations with K_{Na-H} values of 1×10^{-7} did not converge, but available soil data indicate that the pH-dependent sites of soils have K_{Na-H} values in the order of 1×10^{-7} . Use of dilute acid solution in place of KCl or NaOAc solution simulates the acidification process of acid precipitations.

2.58 Preston and co-workers (1994) investigated the “Using ^{13}C CPMAS NMR to assess effects of cultivation on the organic matter of particle size fractions in a grassland soil.” They examined particle size fractions from the surface horizons of a native untilled grassland site and an adjacent field cultivated for 65 years in the Peace River region of British Columbia, Canada. While cultivation resulted in the loss of approximately 50% of the C and N in the soil, there was little change in the distribution of particle sizes, in their C/N ratio, and in the fraction of C found as carbohydrate. Changes in the nature of the organic C were generally small, but obvious difference was seen in the ^{13}C CPMAS NMR spectra of two of the size fractions. Compared with the native grassland, the sand fraction from the cultivated field had a lower proportion of 0-alkyl C and a loss of resolution. The clay fraction from the cultivated field had lower 0-alkyl and higher alkyl C than its grassland counterpart. Subtraction of linear combination of spectra of

the whole soil from the two sites showed a 10% increase with cultivation in the proportion of humified to decomposable organic C. All of these trends are consistent with a greater degree of decomposition in the cultivated site. The changes are small and do not suggest a serious degradation in the quality of the soil organic matter, compared with the large change in quantity. We also examined factors that might affect the quality and quantitative reliability of the ^{13}C CPMAS NMR spectra. Dithionite treatment was not very effective in improving resolution or fraction of observable C for these samples. The latter was in the range of 10-30%, largely a result of the association of organic matter with paramagnetic iron. For this reason, comparison of relative areas must be interpreted with caution and confined to samples with reasonably similar contents of C and iron.

2.59 Kohut and Dudas (1994) reported that the ‘**Characteristics of Clay Minerals in Saline Alkaline Soils in Alberta Canada.**’ A survey of the the clay mineralogy of surface horizons of 39 salt-affected soils in Alberta, Canada, showed that many samples had unusual x-ray diffraction characteristics in that essentially no basal reflections for smectite minerals were recorded. Four sites were subsequently selected for detailed mineralogical characterization. Extremely diffuse smectite diffraction of surface soils and appear to be the result of interaction with organic matter. After traditional pretreatments to remove organic matter and carbonates, the clay mineralogy of salt-affected soils was found to be similar to nonsaline soils. Slight changes were sometimes noted in the diffraction maxima of the smectite minerals, possibly indicating lower crystallinity and layer charge. Tetrahedrally substituted smectites were not identified, while variable amounts of high charge smectite or

vermiculite were detected in most samples. Despite very high ionic strengths and pH values as high as 10, little or no degradation of clay minerals appears to be occurring in these soils. Analysis of immiscibly displaced pore water indicated that the soil solutions were supersaturated with respect to common phyllosilicates. Relatively low amount of fine clay, however, indicate that neoformation of clay minerals is unlikely.

2.60 Xing and Dudas (1994) reported that the “**Characterization of Clay minerals in white clay soils, people’s republic of China.**” A widely distributed white clay soils are major agricultural soils in China. While some of the chemical, physical, and morphological properties have been documented for these soils, there is little information available on their clay mineralogy. The purpose of this study was to conduct a detailed characterization of the clay mineralogy of white clay soils. Representative pedons were sampled by horizon and used in the detailed mineralogical study of these soils. Clay separates were analyzed by x-ray diffraction methods. Layer charge of 2:1 expandable phyllosilicates was determined by the n-alkylammonium ion exchange technique. Elemental composition of clay separates was determined by inductively coupled plasma atomic emission spectrometry. Vermiculite and smectites, which have not been recognized before, were identified in these soils. Other phyllosilicates were mica, kaolinite, and chloritic intergrades. Vermiculite had a uniform charge distribution of $0.82 \text{ mol}_c/\text{O}_{10}(\text{OH})_2$. Layer charge of smectites ranged from 0.36 to 0.47 $\text{mol}_c[\text{O}_{10}(\text{OH})_2]^{-1}$ with a mean of $0.41 \text{ mol}_c[\text{O}_{10}(\text{OH})_2]^{-1}$. Content of vermiculite in clay fractions ranged from 150 to 230 g kg^{-1} , mica from 180 to 250 g kg^{-1} , and kaolinite from 310 to 370 g kg^{-1} . The high contents of kaolinite and mica in A and E horizons may be caused by

aerosolic dust input and lessivage. Chloritic intergrades are thought to form from progressive filling of interlayer space of expanding phyllosilicates during pedogenesis. Smectites may have been derived from pedogenic weathering of vermiculite in these soils. Systematic documentation on clay mineralogy of white clay soils provides fundamental information for agricultural use and management of these soils.

2.61 Schmidhalter and co-worker (1994) studied “**Adsorption of Thiamin (Vitamin B₁) on Soils and Clays**”. Recent research suggests that thiamin applied to soils or coated onto seeds may stimulate plant growth. The behavior of thiamin in soils has not been investigated. Therefore, studies were carried out to determine how thiamin hydrochloride (3-[(4-amino-2-methyl-pyrimidinyl)methyl]-5-(2-hydroxyethyl-4-methylthiazolium chloride hydrochloride) is adsorbed by 17 soils and three clays. The dominant mechanism in binding of thiamin is thought to be cation exchange with clay minerals and organic matter. In soils with low to medium organic matter content, thiamin adsorption occurred primarily on clay minerals and depended particularly on the amount and composition of the clay. Adsorption is species dependent (pK_{a1} [negative logarithm of the first dissociation constant] = 4.85) and takes place principally in the acidic pH range, probably with position 1' of the pyrimidine ring. Adsorption equilibrium is attained in < 30 min. Adsorption in all soil, and in kaolinite and illite clays, could be described by a one-surface Langmuir isotherm at initial concentrations ranging from 16.3 to 995 $\mu\text{mol L}^{-1}$. Adsorption by smectite in the same range was log-linearly related to the equilibrium concentration range from 16.3 to 9890 $\mu\text{mol L}^{-1}$ showed that a two-surface Langmuir

equation more adequately described adsorption in hydroxy-interlayered vermicultitic and chloritic-illitic soils, whereas a one-surface Langmuir equation was found to be adequate in mixed layer-smectitic soils. Only in the case of smectite clays is thiamin allowed to lie in a monolayer configuration paralld to the basal plane.

2.62 Soil Organic Matter Testing and Labile Carbon Identification by Carbonaceous Resin Capsules” studied by **Johns and Skogley (1994)**. The objectives of this study were to apply carbonaceous resin capsules for measurement of soil organic C (SOC) and for identification of soluble SOC constituents. Seven carbonaceous resins, selective for nonpolar organic adsorbates, were evaluated. The resins were tightly packed as spherical capsules and placed in saturated soil pastes of 19 Montana Soils. Resin capsules were desorbed with NaOH, CH₃OH, CHCl₃, and C₆H₁₄. Capsules extracted with the organic solvents were used in identification by nuclear magnetic resonance and infrared spectroscopy. Ultrafiltration and atomic absorption spectrophotometry of trace metals were also used. All resin capsules sorbed measurable levels of soil labile C (LC). All the resin types provided statistically significant prediction of SOC. The Ambersorb 564 resin showed the highest prediction, with a linear relationship between capsule-extracted LC (NaOH) and SOC of $r^2 = 0.009$ ($P < 0.0001$). Prediction results from these soils suggested a linear relationship between soluble SOC and solid-phase SOC, describable as constant partitioning. Labile C was composed of mostly aliphatics and some aromatics. Carbohydrates, OH, COOH groups, and metal-organic complexes were present. Most of the LC was composed of low molecular weight humics (< 1000 daltons). The ability of LC to be desorbed by the more nonpolar solvents indicated an amphipathic character for some LC constituents.

The resin capsule methodology showed good testing potential for these SOC investigations.

2.63 Veldkamp and Weitz (1994) reported the “**Uncertainly Analysis of $\delta^{13}\text{C}$ Method in Soil Organic Matter Studied.**” They have performed an uncertainty analysis on the calculations in the $\delta^{13}\text{C}$ method to evaluate the influence of uncertainty in the input data on the results of the caluclations. Based on field measurements, we estimated the frequency distribution of the input data required for the $\delta^{13}\text{C}$ method (soil organic carbon, bulk density and $\delta^{13}\text{C}$). From these frequency distributions, 200 randomly chosen data combinations were sampeled, taking into account their mutual correlations (Monte Carlo sampling). The data combinations were used to calculate the soil organic C pools in the forest and pasture and the C loss isnce forest clearing. The uncertainly in output was described using frequency distributions. Uncertainty in the output was high, especially for net C loss (ranging between -79.3 and $+63.5 \text{ Mg ha}^{-1}$). An estimation of the C pools within $\pm 10\%$ of the estimated mean at the 90% confidence level required 5 measurements in the forest and 7 in the pasture. Heteroeneity in $\delta^{13}\text{C}$ values of soil organic matter was the main reason for the higher sample number requirement in the pasture, compared to the forest. To estimate the C loss with the same precision requires 170 measurements in forest and pasture.

2.64. Shihe Xu and Boyd (1994) reported the “**Cation Exchange Chemistry of Hexadecyltrimethylammonium in a Subsoil Containing Vermiculite.**” Both static and kinetic studied were conducted to probe the inorganic-HDTMA exchange processes in a subsoil containing vermiculite and to

determined the chemical stability of the resultant HDTMA-soil complexes. The HDTMA generally had much higher affinity for the clay surface than inorganic cations native to soil and thus HDTMA saturation of soil resulted in a low residual HDTMA concentration in solution ($\approx 10^{-6}$ to 10^{-5} M). Conditions leading to flocculation of soil clays (e.g., high ionic strength or divalent exchangeable cations) resulted in inorganic cation entrapment in the interlayers of clays and decreased cation selectivity coefficients of inorganic-HDTMA exchange. Under these conditions a portion of HDTMA was adsorbed via nonpolar interactions (hydrophobic bonding) resulting in a higher residual concentration of HDTMA in solution ($\approx 10^{-4}$ M) and a greater tendency for HDTMA desorption. The change in electrophoretic mobility of soil clays and turbidity of soil suspensions as HDTMA loading increased suggested that HDTMA, if adsorbed via cation exchange mechanism, caused clay aggregation and tended to distribute on the internal sites of the aggregates, leaving inorganic cations on external surfaces. The kinetic study revealed that inorganic-HDTMA exchange was fast on external surfaces but slow on internal sites of Al-hydroxy-interlayered vermiculites or flocculated vermiculites where the inorganic cation entrapment had been found. We concluded that the most stable HDTMA-soil complexes form at HDTMA loading of 0.6 to 0.7 cation-exchange capacity for nonsodic soils.

2.65 Diwakar and Singh (1994) studied the “**Characterization of Soils of Diara Land Occuring in Gangetic Plains of Bihar.**” The soils of *Diara* land occuring in alluvial fans and flood plains are young and stratified with AC profiles. They are characterized by light colour, sand to sandy loam texture, single grain to massive structure, slightly alkaline

reaction, low CEC and high base saturation. They are found to be highly siliceous and low in iron and aluminium oxides. The variation in CaO and K₂O contents is attributed to the nature of parent materials. These soils have very faint and poor pedogenic manifestations as seen in their morphology. These soils have been classified as Typic Ustifluvents.

2.66 Barber and Diaz (1994) reported the “**Maintenance of Yields and Soil Fertility in Nonmechanized Cropping Systems, Bolivia.**” Twelve cropping systems were investigated in a factorial design, with three summer-winter crop sequences: rice-peanut (*Arachis hypogaea* L.), corn (*Zea mays* L.)-bean (*Phaseolus vulgaris* L.) later substituted by cowpea [*Vigna unguiculata* (L.) Walp.], and rice-fallow (control); two weed control treatments: minimal and optimal; and two fertilizer treatments; with and without 60 kg N ha⁻¹ and 17.5 or 35 kg P ha⁻¹. Crop sequences significantly increased exchangeable acidity; the rice sequence significantly reduced exchangeable Ca, and cornbean/cowpea and rice-peanut significantly reduced exchangeable Mg. Fertilization significantly increased soil P but decreased Ca. Foliar analysis revealed N, Mg, and Zn deficiencies in all cropping systems. Rice yields, unlike corn were significantly increased, by optimal weeding. Corn yields were dominated by fertilization increased by optimal weeding. Corn yields were dominated by fertilization, whereas rice yields were mainly influenced by fertilization in the first and fourth years and by weeds in the intervening years. Without fertilizer rice-fallow was not sustainable, and only corn-bean/cowpea was sustainable for 3 yr. With fertilization, rice-fallow plus optimal weed control and corn-bean/cowpea with minimal or optimal weeding were sustainable for 3 yr. Additional fertilization and future liming would be necessary for more prolonged sustainability.

2.67 Sanchez-Maranon *et al.* (1995) studied the “**Spectroradiometric and Visual Color Measurements of Disturbed and Undisturbed Soil Samples.**” To standardize the process, and to compare the accuracy of the spectroradiometric measurement with the results of visual determinations, we measured color in natural soil aggregates and in ground-homogenized samples and represented the results in the CIE 1976 ($L^*a^*b^*$) color space. Variability in colors in a given aggregate was evaluated with the parameter $\langle \Delta E^*_{ab} \rangle$ and was, on average, 10-fold greater than for ground samples. Grinding and homogenization of soil materials resulted in significant change in color (18.3 CIELAB units in average), 89% of this color difference being attributable to an increase in lightness. Visual measurements of color with standard soil color charts showed an interobserver variability very similar for disturbed and undisturbed samples. However, color differences between the instrumental measurements of soil samples and the average visual judgements were 4.41 and 10.19 CIELAB units for disturbed and undisturbed samples, respectively, with the greatest errors in the estimation of the L^* coordinates in both cases.

2.68 Anthony and co-worker (1995) investigated the “**Chamber Measurement of Soil-Atmosphere Gas Exchange: Linear Vs Diffusion-Based Flux Models.**” They compared linear regression with a diffusion-based for N_2O flux estimation using non-steady-state chamber gas concentrations from a long-term study of N cycling in a managed grass pasture on sandy soil in southern Texas. Of 2224 chamber deployments, 449 met criteria established for using the diffusion-based model, which yielded flux estimates that averaged 54% larger than linear regression ($n = 3$). Although they represented only

about 20% of all chamber deployments, this group included most of the data with greatest influence on the magnitude and dynamics of total N_2O exchange at our site; e.g., of the 263 flueses $> 10 \text{ g N ha}^{-1} \text{ d}^{-1}$, 192 (or 73%) were included. Apparently, application of a linear model to nonlinear chamber concentration data represents a potentially serious source of measurement bias that may influence not only summary statistics for the experiment, but also larger scale budgets based partially or wholly on those data.

2.69 Polubesova and co-workers (1995) studied the “**Surface Charge Characteristics of Podzolized Soil.**” Recently developed method for the accurate measurement of surface charge components and the points of zero charge in soils containing both permanent- and variable-charge constituents were applied to a Haplorthod that is typical of podzolized soils in North America, Scandinavia, and Russia. Independently measured values of the density of structural surface charge, net proton charge, and net adsorbed ion charge were obtained for soil samples from the E2 and Bhs horizons suspended in LiCl or Li_2SO_4 solution of ionic strength 1 or 10 mmol kg^{-1} . Data taken across the pH range 2 to 6 tested successfully for conformity to the law of surface charge balance. Relationships between the point of zero net proton charge and the point of zero net charge were consistent with the fact that, at any pH, increasing ionic strength favoured an increase in the net adsorbed ion charge, whereas changing from Cl^- to SO_4^{2-} favored a decrease in the net adsorbed ion charge. The methodology and charge balance analysis are applicable to any podzolized soil.

2.70 Backes and co-workers (1995) studied the “**Kinetics of Cadmium and Cobalt Desorption from Iron and Manganese Oxides.**” Oxides of Fe and Mn in soils are capable of sorbing large amounts of trace metal ions and can therefore be important in controlling trace metal concentrations in soil solution, and hence trace metal bioavailability in soils. There is, however, relatively little information on the rates of desorption of trace metals from oxide materials or on the factors affecting desorption rates. The objective of this was to examine the kinetics of desorption of trace metals from oxide materials or on the factors affecting desorption rates. The objective of this study was to examine the kinetics of desorption of Cd and Co from two Fe oxides, goethite and ferrihydrite, and from two Mn oxides, hausmannite and cryptomelane. The concentrations of Cd and Co specifically sorbed by the oxides at pH 6.0 were greater for the Mn oxides than for the Fe oxides. The metals were also much less readily desorbed from the Mn than the Fe oxides and, in general, Cd was more readily desorbed than Co from all four oxides. Increasing the initial sorption period from 1 to 15 wk substantially decreased the proportion of sorbed Cd or Co subsequently desorbed from goethite, with a similar but much smaller effect also observed with the Mn oxides. Desorption kinetics for both Cd and Co were found to be described well by assuming either the occurrence of two simultaneous first-order desorption reactions, or by a continuous distribution of reaction sites, distributed lognormally with respect to desorption first-order rate constant. With increasing initial sorption period, the parameters obtained from fitting either type of kinetic equation to the experimental data could be interpreted as indicating a movement of metal ions to sites with slower desorption reactions.

- 2.71 CHAVAN *et al.* (1995)** investigated the “**Effect of Forest Tree Species on Properties of Lateritic Soil.**” The Forest tree species in the ten-year-old plantations at forestry block of Central Experiment Station, Wakawali did not change the physical properties of the soil under the canopy, but the effect on the chemical properties of the soil were conspicuous. The organic carbon, available nitrogen, phosphorus and potassium increased very markedly in the surface layer. The CEC and exchangeable cations were also found to increase due to the decomposition of organic matter added through leaf litter. Calcium was the dominant among the cations. In general, the soils under the forest cover showed higher nutrient status.
- 2.72 John and Abraham (1995)** studied the “**Microbial Immobilization and Mineralization of Nutrients during Different Seasons of the Year.**” Representative soil samples were collected from the experimental plots before, immediately after and 21 days after the application of treatments. A portion of the soil samples collected after 21 days of incubation under field condition was subjected to chloroform fumigation, reinoculation, and incubation. All the above soil samples were analysed and hence quantified the extent of immobilization by soil microflora and subsequent release through mineralization. The immobilization and mineralization of organic carbon was maximum during rainy season in the glucose treated plots registering a net assimilation of 18.0 to 23.9% and net mineralization of 14.6 to 17.3% respectively of the total organic carbon content of the soil. Nitrogen also followed the same trend with net immobilization and mineralization of 214.6 kg N ha⁻¹ and 26.2 to 34.0 kg N ha⁻¹, respectively on the fertilizer treated plots during rainy season. The immobilization and mineralization of available phosphorus was highest during summer season with values

ranging from 4.0 to 16.5 kg P ha⁻¹ and 3.0 to 12.5 kg P ha⁻¹, respectively in the fertilizer treated plots. In the case of exchangeable potassium, the net immobilization and mineralization was maximum, during rainy season in the fertilizer treated plots, which comes to nearly 14 to 84 and 10.5 to 44 kg K ha⁻¹, respectively. The rates of mineralization of calcium and magnesium followed a random trend about 2 to 15%, 2 to 12% and 5 to 28% and 3 to 15% of the total exchangeable Ca and Mg are immobilized and mineralized, respectively.

2.73 Sahu and Bala (1995) studied the “Characterization and Classification of soils on valley plains of middle Andaman Island.”

Five pedons of valley plains of middle Andaman Islands were characterized and classified. Three pedons situated in valley flat plains had mottles, loam to sandy clay texture with slow permeability and were moderately acidic to neutral. Two pedons just adjacent to the valley plains on slightly sloping land and in brackish water marshes were sandy loam to loam in texture with moderate permeability and strongly to mildly acidic. In all these soils organic carbon content was generally high in the surface (0.37 – 0.06 g kg⁻¹) and gradually decreased with a depth. Exchange acidity was mostly due to exchangeable H⁺. The CEC varied from 23.0 to 8.4 cmol (p⁺) kg⁻¹ and Ca²⁺ dominated the exchange complex. Soils of valley plains were classified as Fluventic Entropepts, Aquic Entropepts and Aeric Tropepts. The other two soils were classified as Typic Udifluvents.

2.74 Maji and Bandyopadhyay (1995) studied the “Characterization and Classification of Coastal Soils of various pH Groups in Sundarbans, West Bengal.” Thirty-four pedons of coastal soils representing an area

os 15,000 ha of Sundarbans, West Bengal were categorized on the basis of pH variations. Forty per cent of the study area falls in pH range 4-6: 40 per cent in pH range 6-7.5 and the rest 20 per cent in pH range > 7.5. A representative pedon under each pH category was characterized for morphological, physical and chemical properties and classified as per Soil Taxonomy.

2.75 Ulf Skjellberg (1995) investigated the “**Solution/Soil Ratio and release of Cations and Acidity from Spodosol Horizons.**” The influence of the s/s ratio on pH, exchangeable acidity, and cations were studied in soil suspensions of Spodosol O, E, and Bs horizon soil samples in distilled water, 0.01 M CaCl₂, 1.0 M KCl, and 0.5 M CuCl₂. An enhanced s/s ratio resulted in a release of H ions from O and E horizon soil samples in agreement with a weak acid equilibrium, whereas the Bs horizon samples showed a higher buffer intensity of pH. A simultaneous release of organic acids and Al and the fact that samples from the spodic horizons were close to the point of zero charge indicate a more complicated pH buffering mechanism in these horizons. The amount of Al ions released from O and E horizon samples in 1.0 M KCl (Al_e) were simply diluted when the s/s ratio was increased. Therefore, Al_e is suggested to be a quite finite subpool of totally bound Al (Al_t; extracted in 0.5 M CuCl₂). A solution of 0.5 M CuCl₂ extracted all exchangeable K⁺, Na⁺, Mg⁺, Mn²⁺, Fe³⁺, and Al³⁺ in O horizon samples, independent of s/s ratio, whereas the release of Ca²⁺ was slightly enhanced with increased s/s ratio, whereas the release of Ca²⁺ was slightly enhanced with increased s/s ratio. Hydrogen ions exchangeable in 1.0 M KCl (H_e, centimoles of charge per kilogram) increased by 17 to 22% in O and E horizons and by 32 to 33% in Bs horizons when the s/s ratio increased

from 100 to 150. Consequently, estimated H_e and CEC_e pertaining to different samples can only be accurately compared if they are obtained at the same s/s ratio or corrected for differences in the s/s ratio by specific functions for different soil horizons.

2.76 Ben-dor and Banin (1995) studied “Near Infrared analysis as a rapid method to simultaneously evaluate several soil properties.”

The near infrared analysis (NIRA) approach was studied to examine its capability for predicting spectral feature soil properties from the reflectance curves in the near infrared (NIR) region (1-2.5 μm) of arid and semiarid soils. High-resolution diffuse reflectance spectra (3113 spectral points) in the NIR region were recorded for 91 soil samples from Israel. Six soil properties (clay content, specific surface area, cation-exchange capacity, hygroscopic moisture, carbonate content, and organic matter content) were measured by routine methods employed in soil laboratories. An empirical model to predict each property from its spectral signature was developed by adapting the NIRA technique. Several data manipulations were used to obtain optimum performance. The optimum performance of all properties was found to be between 25 and 63 spectral points. Strong support for the NIRA capability was provided by its ability to examine most of the spectral assignments. A slight bias was observed for the prediction of both organic matter and hygroscopic moisture, suggesting that more attention in the prediction of these constituents is required. It was concluded that NIRA is a promising method for rapid and nonrestrictive analysis of soil materials, and further study of the synergism between NIRA and soil materials is recommended.

2.77 Jener L. Moraes *et al.* (1995) investigated the “**Soil Carbon Stocks of the Brazilian Amazon Basin.**” They determined Stocks of C and N for soil under undisturbed vegetation across the Brazilian Amazon Basin based on 1162 soil profiles of the RADAMBRASIL survey and a digitized Brazilian soil survey map. Mean basin soil C density was 10.3 kg C m^{-2} . Forty-seven petagrams C and 4.4 Pg N were contained in the top 1 m of soil. Forty-five percent of total basin soil C (21 Pg C) and 41% of total soil N (1.8 Pg N) were contained in the top 20 cm across a $\approx 5000000 \text{ km}^2$ area. Mean C/N ratio for the basin to a depth of 1 m was 10.7. Because these data represent sites with forest vegetation in the absence of significant disturbances, they represent a valuable baseline for evaluating the effects of land-use change on soil C stocks in the Amazon Basin.

2.78 Curtin and Smillie (1995) studied the “**Effects of incubation and pH on soil solution and exchangeable cation ratios.**” The objectives of this study were to evaluate the effects of liming on the exchange relationships of the major cations (Ca, Mg, K, and Na) and to determine the causes of incubation-induced changes in their solution concentrations. For periods of up to 1 yr, soil solution was extracted from soils treated in the laboratory with CaCO_3 and incubated at approximately field capacity. Solution samples were also obtained from field-limed soils (lime applied 17 yr previously) after 1 and 10 wk of incubation in field-moist condition. The concentrations of cations in solution increased substantially during incubation. These increases were balanced by NO_3^- , indicating that the changes in cation solubility were microbially mediated. In contrast to cation concentrations, cation ratios (i.e., Mg/Ca, Na adsorption ratio, K adsorption ratio) were little affected

by incubation. These ratios were directly related to the composition of the exchange phase and were strongly influenced by liming. Protons generated by mineralization of organic N during incubation displaced exchangeable Ca, Mg, K, and Na in ratios that maintained the equilibrium between solution and exchangeable phases. The results suggest that a reasonable approximation of soil solution cation can be obtained from exchangeable cation data.

2.79 Jeffrey S. Kern (1995) reported the “**Evaluation of soil water Retention model based on basic soil physical properties.**” The objective of this study was to evaluate some soil water retention models to identify minimum input data requirements. Six models that function with various combinations of particle-size distribution bulk density (P_b) and organic matter data were tested using data for nearly 6000 pedons. The Rawls model, which requires particle-size distribution and organic matter data, had the lowest overall absolute value of the mean error (ME) with 0.020, 0.001, and 0.007 $\text{m}^3 \text{H}_2\text{O m}^{-3}$ soil for matric soil water pressures of -10, -33, and -1500 kPa, respectively. The Saxton model, which requires particle-size distribution data, had small MEs (0.018 and 0.007 $\text{m}^3 \text{H}_2\text{O m}^{-3}$ soil) for -10 and -1500 kPa matric soil water pressures, and a moderately small ME (0.017 $\text{m}^3 \text{H}_2\text{O m}^{-3}$ soil) at -33 kPa. The Vereecken model, which requires ρ_b particle-size distribution, and organic matter data, had small MEs (0.016 and 0.009 $\text{m}^3 \text{H}_2\text{O m}^{-3}$ soil) at matric soil water pressure of -10 and -33 kPa, with a larger ME (0.020 $\text{m}^3 \text{H}_2\text{O m}^{-3}$ soil) at -1500 kPa. The remaining three models had relatively large MEs for at least two of the three soil water pressures. For estimating water-holding capacity only, the Saxton model is

adequate. The Rawls model is recommended for characterizing the relationships of water content to matric soil water pressure.

2.80 Homann and co-workers (1995) investigated “**Soil Organic Carbon in a Mountainous, Forested Region: Relation to Site Characteristics.**” Soil Organic C Content (SOC, kilograms C per square meter) and its relation to site characteristics are important in evaluating current regional, continental, and global soil C stores and projecting future changes. Data were compiled for 499 pedons in the largely forested, mountainous western Oregon region. The SOC of mineral soil ranged from 0.9 to 24 kg C m⁻² (mean = 6.5) for 0- to 20-cm depth and 2.3 to 88 kg cm⁻² (mean = 15.8) for 0- to 100-cm depth. Variability in each of the three terms that determine SOC – C concentration, bulk density, and rock volume – contributed substantially to SOC variation. Regression analysis of 134 forest pedons indicated that combinations of site characteristics explained up to 50% of the SOC variability. The SOC increased with annual temperature, annual precipitation, actual evapotranspiration, clay, and available water-holding capacity and decreased with slope. Relations for western Oregon differed qualitatively and quantitatively from those for other regions and contrasted with the decrease in SOC associated with increased temperature in Great Plains grasslands. Of the variability not explained by regression analysis, one-half may be due to the combined uncertainty associated with measurements of C concentrations, bulk density, and rock volume; natural within-site variability; and site-characteristic measurements. Other unexplained variability is probably due to potentially important but poorly documented site characteristics, such as recent vegetation composition, geomorphic disturbance regime, and fire history.

- 2.81 Mahendran and Mathan (1995)** investigated “**Relative Importance of Component Soil Properties on Saturated Hydraulic Conductivity in Soil.**” Saturated Hydraulic Conductivity (K_s) was measured on undisturbed soil cores collected from 72 horizons of 21 profiles comprising six soil Sbugroups, viz., Typic Chromusterts, Typic Ustropept, Udic Haplustalf, Typic Haplustalf, Vertic Haplustalf and Typic Ustortherents. Relationships were established with effective porosity (ϕ_e), percentage of aggregate stability (AS), disperiosn coefficient of silt and clay ϕ_e , (DCSC) exchangeable sodium percentage (ESP), clay and organic carbon (OC). Path coefficient analysis confirmed that the direct influence on the K_s was strongest through ϕ , DCSC, AS and ESP. Though clay and OC influenced K_s , their role was minimal as a direct factor. The major influence of clay and organic carbon was indirect through AS and ϕ_e .
- 2.82 Igwe and co-worker (1995)** studied “**Physical Properties of Soils of SouthEastern Nigeria and the Role of Some Aggregating Agents in Their Stability.**” The Topsoils were generally sandy loam to sandy clay loam, with the clay content increasing with depth. Topsoil bulk densities were high, varying between 1.34 and 1.55 Mg m⁻³. Subsoil bulk densities were also high, with values reaching as high as 1.56 to 1.92 Mg m⁻³ in some horizons. The correlation between bulk density and organic matter (OM) was low, but the trend showed an increase in bulk density with derease in OM content. The values of liquid and plastic limits were low to modereate. The low correlations between plastic limit (PL) and the aggregate stability indices indicate that PL is not a good predictor of the structural stability of these soils. The influence of OM on the aggregate stability indices was more

pronounced within than between the soil profiles, implying that the role of OM as an aggregating agent is soil-dependent. The lowest clay content was obtained with water as the dispersant. Removal of OM and carbonates from the soil samples did not produce clay different in amount from that produced when sodium hexametaphosphate alone was used. This shows that OM and carbonates play minor roles as clay aggregating agents in these soils, probably because of their low concentrations. Removal of Fe_2O_3 and Al_2O_3 with sodium dithionite-citrate-bicarbonate (DCB) solution produced the highest concentrations of clay in all soils. This shows that Fe and Al oxides play the most important clay-aggregating roles in these soils. Therefore, for more reliable and reproducible soil particle size analysis, pretreatment for removal of these sesquioxides is needed.

The correlations between the soil erodibility factor (K) and the aggregate stability indices were generally low ($r < 0.35$), implying that these aggregate stability indices are not reliable for assessing the erodibility of these soils.

2.83 Rasiah and Biederbeck (1995) studied “Fractal Dimension of Soil Aggregates: Influence of Bulk Density, Fitting Procedure, and Oily Waste Sludge in Corporation.” Researchers have used scale-invariant bulk density, ρ , to estimate values of fractal dimension, D , for soil aggregate fragmentation. Justification for this assumption has not been fully explored. The objectives of this study were to compare values of D obtained using (i) scale-invariant and scale-variant ρ and (ii) linear (defined D_1) and nonlinear (defined D_n) fitting procedures, and also (iii) to evaluate the influence of oily waste sludge incorporation on D . Aggregate ρ and mass-size distribution for a Meota loamy sand treated with different rates of an oily waste sludge were determined in the

laboratory. Bulk density of soil aggregates, average size ranging from 0.21 to 9.55 mm, ranged from 1.15 to 1.37 Mg m⁻³ ($R^2 = 0.91$). Fifty-four values of D were obtained using the scale-variant or scale-invariant ρ for D_1 or D_{nl} . Values of D_1 ranged from 2.23 to 3.83, and those of D_{nl} for 2.07 to 3.15. The values of D obtained using the scale-variant ρ were always smaller than those obtained using the scale-invariant ρ . A switch from linear to nonlinear fitting resulted in significantly smaller values of D ($D_1 \geq D_{nl}$). Oily waste sludge incorporation resulted in marked reductions in D_1 ($R^2 = 0.88$) or D_{nl} ($R^2 = 0.88$). The results show the values of D obtained using nonlinear fitting and scale-variant ρ are accurate and smaller than those obtained using nonlinear or linear fitting or scale-invariant ρ or a combination of the latter three.

2.84 Santini and co-workers (1995) studied “**Evaluation of a Laboratory Inverse Method For Determining Unsaturated Hydraulic Properties of a Soil Under Different Tillage Practices.**” The laboratory inverse method simultaneously determined relationships of water retention, $\theta(h)$, and hydraulic conductivity, $k(\theta)$, from an evaporation experiment using a parameter estimation technique. This method was developed with the aim of reducing experimental efforts without significantly lowering accuracy in parameter estimates. A Crank-Nicolson type finite-difference solution of Richards’ equation was coupled with a nonlinear optimization problem to estimate unknown parameters in the closed-form analytical relations employed in this study for describing soil hydraulic properties.

Comparisons with laboratory-measured saturated hydraulic conductivity and soil water retention data obtained for a group of soil cores by a sand-kaolin box apparatus demonstrate the applicability and

accuracy of the proposed inverse method. Overall, the results of hydraulic-property characterization for the soil at the experimental farm reveal no significant differences among tillage treatments. In addition, as a general rule, a progressive annulment of tillage effects on structure and hydraulic properties of soil is observed with time.

- 2.85 Room Singh (1995)** investigated “**Role of Soil Texture and Plant Age in Leaf-Water Potential Measured at Different Crop Stages of Wheat in Mollisols of Tarai.**” Measurement of the leaf water potential (LWP) of wheat grown on six soil series of Pantnagar tarai was done at different crop stages, soil water condition and day time, in order to examine its variation and its relationship with these factors. Soils comprising three textural groups recorded different crop yields as well as LWP. There was a considerable seasonal variation in the LWP (- 0.25 to -2.13 MPa), decreasing with plant age. The morning LWP before irrigation was well correlated with that measured after respective irrigation. Morning and mid-day time LWP were positively correlated with each other before irrigation. Grain yields highly significant relationship with the morning time LWP, particularly, at later crop stages.
- 2.86 Saha, Das and Mukherjee (1995)** reported the “**Effect of Decomposition of Organic Matter on the Activities of Microorganism and Availability of Nitrogen, Phosphorus and Sulphur in Soil.**” Study Organic Matter namely, berseem straw, bagasse and rice straw, Cassia sophera, Cestrum diurnum and Ipomoea cornea, augmented significantly aerobic non-symbiotic nitrogen fixing bacteria, phosphate solubilizing and sulphur oxidizing microorganisms as well as their activities, viz. nitrogen fixing,

phosphate solubilizing and thiosulphate oxidizing capacities of the soil. Typic Fluvaquent resulting in greater availability of N, P and S in soil solution. Among the organic matters, berseem straw was superior to others in this respect, excepting Ipomoea cornea, which released maximum amount of available S in soil. Rice straw, on the other hand, exhibited on immobilization of ammoniacal nitrogen in soil.

- 2.87 Kumar, Rao and Singh (1995)** studied “**Forms of Acidity in Some Acid Inceptisols under Different Land Use in Manipur.**” The electrostatically bonded (EB)-H⁺ and EB-Al³⁺ acidities constituted 39.3 and 60.7 per cent of exchangeable acidity while pH dependent and exchange acidities comprised 92.2 and 7.8 per cent of total acidity, respectively. Various forms of acidities are significantly related to pH, organic carbon, exchangeable and extractable Al³⁺ and exchangeable Ca²⁺ and Mg²⁺. Land use pattern also affect the various forms of acidities considerably. Shifting cultivation increased all forms of acidities whereas the terrace cultivation brought them to the lowest magnitude.
- 2.88 Bala et al. (1995)** studied “**Effect of Ionic Strength on Phosphate Adsorption by Soils.**” Effect of ionic strength and cation species of the supporting electrolyte on adsorption of phosphate by selected benchmark soils of Pubjab was studied at 25⁰C. Phosphate adsorption increased with increase in ionic strength. At a particular molarity, phosphate adsorption was higher in the presence of CaCl₂ as compared with NaCl. The adsorption data conformed to Langmuir and Freundlich adsorption equations. Adsorption maxima and Freundlich constant K increased with increase in ionic strength.

- 2.89 AVASTHE and AVASTHE (1995)** reported a “**Altitudinal distribution of Micronutrients in the soil of Sikkim.**” Cultivated soils of five different altitude zones of Sikkim, viz. sub-alpine (> 2700 m), temperate (2000 – 2700 m), mid-hill temperate (1500 – 2000 m), subtropical (500 – 1500 m) and tropical (300 – 500 m) zone were selected for the study. The total Zn, Cu, Mn, Fe, B and Mo content of the surface soils varied widely. About 94 and 85 per cent of the soils could be rated as deficient in available boron and molybdenum, respectively. Total micronutrients and DTPA extractable Cu and Mn and hot-water extractable B had a significant negative correlation with altitude whereas DTP – Zn and Fe were positively correlated.
- 2.90 PARDEEP KUMAR, SHARMA AND SHARMA (1995)** reported the “**Distribution of N, P and K in Soan River Valley Soils of Lower Shiwaliks.**” The relationship of soil properties with forms of N, P and K indicated positive influence of pH and total N and organic carbon and silt on available N. The total P bore significantly positive relationship with pH, organic carbon, cation exchange capacity, silt and clay. The organic carbon and clay contents had positive influence on water soluble P as well. Total K was positively correlated with organic carbon. CEC and silt water soluble K with sand and silt.
- 2.91 HOSUR and DASOG (1995)** studied the “**Effect of Tree Species on Soil Properties.**” This paper reports the influence of tree plantations (*Tectona grandis*, *Dalbergia sissoo* and *Acacia catechu*) on properties of red loam soil (Inceptisol) of Dharwad. Plantation of trees decreased bulk density and pH whereas soil aggregation, organic matter and exchangeable calcium of the soils increased. The nutrient status of the soils was very little changed by tree plantations. The nutrient return

through litter fall followed the order $Ca > K > N$ in *D. sissoo* and *A. catechu* and $Ca \rightarrow N > K$ in teak.

2.92 Tiwari, Tiwari and Mishra (1995) reported “**Soil Test Methods and Critical Limits of Potassium in Soil and Plants for Wheat Grown in Typic Ustochrepts.**” Multilocation field experiments were also conducted on cultivators’ fields to verify the differences in responses to added K in relation to soil test values and the critical limits of K in soil established through field and greenhouse experiments. The extraction capacities of the fourteen extractants were different, being highest for boiling HNO_3 and lowest for 0.01M $CaCl_2$. The quantities of K desorbed by boiling 1M HNO_3 showed highest degree of correlation with 0.5N acetic acid and lowest with 0.13M HCl. In view of the fact that responses to added K in soils of varying 1M $NH_4 OAc$ (pH 7.0) status were modified by the 1M HNO_3 soluble K content of soils, the critical limits of K were established taking into consideration both exchangeable and non-exchangeable K status of the soils. Under greenhouse condition responses to K were significant only up to soils testing medium-high in both exchangeable and non-exchangeable K. Responses to K under field conditions were significant on soils testing medium in respect of both exchangeable and non-exchangeable K. Apparently, the critical limit recorded under field conditions is slightly lower than of greenhouse conditions. Critical concentration of K in 6-week-old plants of wheat was 2.7 per cent.

2.93 Singh *et al.* (1995) described the “**Genesis and Taxonomy of Black Soils from Basalt and Basaltic Alluvium in Rajasthan.**” Six typical pedons representing black soils, two (P1 & P2) developed from basalts and the other four (P3 to P6) developed from basaltic alluvium in

Rajasthan were selected for this purpose. Soil colour, was found to be the function of free iron oxide to clay ratio while vertic properties were found to be governed by free iron to total iron ratio. The irregular distribution of organic carbon and regular depthwise function CaCO_3 indicate differential pedoturbation with respect to these constituents. Fe_2O_3 and MgO content of the soils from basalts were more than the soils from basaltic alluvium while SiO_2 , Al_2O_3 and K_2O content showed a reverse trend. The weathering indices, like lower $\text{Al}_2\text{O}_3/\text{Fe}_2\text{O}_3$, CEC, $\text{SiO}_2/\text{R}_2\text{O}_3$ and $\text{K}_2\text{O}/\text{Na}_2\text{O}$ molar ratios in clays and CEC of clay/clay ratios, reflected advanced stage of weathering in basaltic soils compared with compared with their basaltic alluvial counterpart. CEC/clay ratio was found to decrease with the increase in Fe_2O_3 content of clays. Taxonomically these soils were classified under Chromic Haplusterts and Typic Haplusterts subgroups of Vertisol soil order.

2.94 Francois Courchesene and co-workers (1995) studied the “**Effect of Air-Drying on the Measurement of Soil pH in Acidic Forest Soil of Quebec, Canada.**” Nine podzoli soil profiles ($n = 67$ horizons) were sampled in southern Quebec to evaluate the effects of drying on soil pH measurements in H_2O (pH_W) and in 0.01M CaCl_2 (pH_{CA}) and to identify the existence of relationships between pH changes on drying and soil properties. The precision of pH measurements (global precision of ± 0.035 pH unit) varied, with the poorest precision value (0.10) being recorded for pH_W in field-moist samples of organic horizons (O). For any soil horizon group (O, E, B, C), the pH change attributable to drying was always larger in H_2O (up to 0.50 pH unit or $130 \mu\text{mol H}^+\text{L}^{-1}$) than in CaCl_2 (up to 0.25 pH unit or $520 \mu\text{mol H}^+\text{L}^{-1}$). When expressed in terms of H^+ concentration, the trend is inverted because pH_{CA} values

are often one pH unit more acidic than pH_w values for the same horizon. Drying generally resulted in soil acidification for all horizon types although both acidification and alkalization could occur in a given profile. We found positive and significant relationships between pH changes attributable to drying expressed as $|\Delta H^+|$ and organic C and exchangeable Al for both electrolytes. The relationships were stronger when soil materials were grouped on a profile basis (average r value = 0.78 and 0.62 for organic C and exchangeable Al, respectively) than when grouped by horizon type (average r value = 0.39 and 0.49 for organic C and exchangeable Al, respectively). The DOC concentrations in both electrolytes and for any given horizon were always higher in dry than in moist soil samples. Absolute changes in DOC concentrations were correlated to the absolute magnitude of pH changes upon drying ($0.67 < r < 0.96$; $\alpha \leq 0.05$). However, the relationships between the magnitude of DOC changes, and the polarity of pH changes upon drying (ΔH^+) varied with the electrolyte used. In H₂O, the decrease in soil pH is mostly associated with the acidifying effect of an increase in organic matter solubility after drying. In CaCl₂, it is suggested that the potential reduction of Al availability after soil drying and the flocculation of organic substances by Ca²⁺ ions could contribute to the increase in pH. Characterizing the suite of organic substances present in individual horizons could also prove very helpful in elucidating the response of soil pH to drying.

2.95 Michael A. and co-workers (1995) studied the “**Factors Affecting the Surface Tension of Soil Solution and Solutions of Humic Acids.**” Humic and fulvic Acids and other naturally derived and fatty acids are important constituents of soil solutions and surface waters and groundwater. The presence of both hydrophilic polar or ionic functional groups and

hydrophobic structural units on these natural organic compounds can be expected to promote accumulation at the air-water interface, which would thereby influence the solution surface tension. This study evaluated the influence of organic C concentration, pH, and temperature on the surface tension of soil solutions extracted from forest soil solutions of International Humic Substances Society (IHSS) reference humic acids. The surface tensions of the soil solutions were substantially lower than those of IHSS humic acids at equivalent organic C concentrations and solution conditions. Differences were also observed in the temperature dependence of surface tension for the solutions. All solutions exhibited a strong dependence of surface tension on solution pH. Characterization of the soil solutions and humic acid solutions by fluorescence and absorption spectroscopy and titration analysis confirmed that the soil solutions varied markedly from humic acid solutions. The soil solutions bore substantially higher acidity and yielded qualitatively different fluorescence spectra when compared with the humic acid solutions equivalent conditions.

2.96 Rao and co-worker (1996) studied the “**Predication of Cation Exchange Capacity from Clay and Organic Carbon of Some Smectite and Kaolinite-Rich Soils.**” Predicting cation exchange capacity (CEC) from the contents of clay and organic carbon, soils were grouped into classes on the basis of their clay and organic carbon contents. In each class, multiple regression equations were worked out between organic carbon and clay and CEC. Using average CEC, percentage of organic carbon and clay and partial regression coefficients of the latter parameters, the relative contribution of clay and organic to CEC was estimated. The CEC can be predicted with reasonable accuracy from the content of organic carbon and clay of the two groups

of soils. Contribution of clay was more to CEC in the smectitic soils, whereas organic carbon contributed more in the kaolinitic soils. Irrespective of soils, the contribution of clay or organic carbon to CEC increased with their contents.

2.97 Singh and Kumar (1996) reported the “Nitrogen mineralization of legume Residues in soils in relation to their chemical Composition.”

The N mineralization of seven legumes (45-day old) in Hisar sandy loam (Typic Camborthid) and Karnal loam (typic Ustochrept) soils were studied under constant temperature (35⁰C) and water (-0.03 MPa) conditions. Patterns of N mineralization in both the soils from different legumes were almost similar and followed the first order kinetics. The nitrogen mineralization potential (N_0) of legumes differed significantly and ranged from 59.8 mg kg⁻¹ for clusterbean to 96.9 mg kg⁻¹ for green gram. The rate of N mineralization (k) was highest for green gram (0.199 week⁻¹) and lowest for clusterbean (0.149 week⁻¹). The K values were significantly affected by lignin to N ratio, lignin plus polyphenol to N ratio and C:N ratio of legumes. The net amounts of N mineralized at the end of 56 days of incubation was lowest from clusterbean amounting to 53 and 55 mg kg⁻¹ and highest from green gram amounting to 96 and 99 mg kg⁻¹ in Hisar and Karnal soils, respectively. The order of N mineralization (%) from different legumes was same in both the soils and followed the sequence: green gram > black gram > soybean > cowpea > sesbrania > sunnhemp > clusterbean. The percentage of N mineralized was positively correlated with total N content and negatively with C:N ratio, lignin to N ratio, polyphenol to N ratio. However, the best chemical index of N mineralization was found

to be lignin + polyphenol to N ratio which accounted for 84 per cent of the variation in the percentage of legume N mineralized.

- 2.98 Walia and Rao (1996)** reported the “**Genesis, Characteristics and Taxonomic Classification of Some Red Soils Bundelkhand Region of Uttar Pradesh.**” The soils are deep very deep, excessively to well drained, reddish brown to red, mildly acidic, low to medium in CEC, medium to high in organic carbon with wide textural variations depending upon parent material and physiography. The soils show high molar ratios and variations of $\text{SiO}_2/\text{R}_2\text{O}_3$ are due to parent material. The depthwise distribution of SiO_2 indicates the stabilization of silica content under mildly acidic pedochemical environment. Flat-topped hill and monadnock exhibit the development of Bt horizon while soils of other landforms show B_w horizon. The soils are classified under the orders of Inceptisols and Alfisols.
- 2.99 Patil et al. (1996)** studied “**Effects of the Fly Ash on Soil Crust Strength and Crop Yield.**” Field Experiments were conducted on Typic Haplustalf soils to study the utility of fly ash as soil amendment in reducing the soil crust strength the soil crust strength. Application of Fly ash @ 20 q ha^{-1} reduced the crust strength from 2.38 kg cm^{-2} to 0.98 kg cm^{-2} . This has resulted in higher yields of sunflower (7.6 q ha^{-1}) and groundnut (31.9 q ha^{-1}) when compared to control. Application of other amendments, namely, FYM, sand and paddy husk either alone or in combination with fly ash reduced the unconfined crust strength of soil significantly. The effect was in the order of paddy husk > fly ash > FYM > sand = control in two years.

2.100 Ellerbrek *et al.* (2005) reported a “**Composition of Organic Matter Fraction for Explaining Wettability of Three Forest Soils**”. Soil organic matter (SOM) as a solid or as a film at mineral surfaces affects wetting properties in unsaturated soil. Soil organic matter mostly consists of heterogeneous mixture of components with hydrophilic and hydrophobic functional groups. This paper analyzes relations of SOM to soil wettability by considering functional group compositions of different soluble fractions. Forest soil samples from two loamy and Cambisol profiles (locations Chorin and Steigerwald) and from a Podzol (Waldstein) were used to obtain water [SOM(W)] and sodium pyrophosphate [SOM(PY)] soluble SOM fractions. The hydrophobic (A) and hydrophilic (B) functional groups of bulk soil SOM and of the soluble fractions were evaluated using transmission Fourier-transform infrared (FT-IR) spectroscopy. Advancing liquid-solid contact angles (CA) were determined by using the capillary rise method. For soil organic carbon (SOC) contents $< 10 \text{ g kg}^{-1}$, wettability increased with SOC content while it decreased for SOC contents $> 10 \text{ g kg}^{-1}$. Although hydrophilic groups in FT-IR spectra of SOM(W), SOM(PY), and bulk soil dominated (i.e., A/B ratios between 0.08 and 0.5), soil wettability was reduced (i.e. CA between 88 and 52°). Soil specific relations between CA and A/B ratios could be obtained after introducing relatively soil type independent factors, G. As exponential functions of the SOC/clay relation, the G-factors imitate the effectiveness of functional groups with respect to wettability. The results suggest that in addition to SOC content, the SOM composition may improve explanation of soil wettability if the spatial orientation of SOM functional groups at the SOM-mineral surface in the presence of sorption sites and polyvalent cations is considered.

2.101 Scheidegger and Sparks (1996) studied “**A Critical Assessment of Sorption-Desorption Mechanisms at the Soil Mineral/Water Interface.**” Sorption is one of the most important chemical processes in soil. It affects the fate and mobility of nutrients and contaminants in soils and waters greatly. This paper critically reviews the mechanisms of sorption/desorption phenomena at the mineral/water interface. A brief discussion of macroscopic, equilibrium approaches for describing sorption processes is provided. However, emphasis will be placed on the importance of understanding the rates of sorption/desorption processes and coupling of kinetic investigations with in-situ atomic/molecular resolution surface techniques. The use of X-ray absorption fine structure (XAFS) spectroscopy and scanning force microscopy (SFM) will be emphasized.

2.102 Lawrence *et al.* (1996) studied a “**Chemical Evaluation of Soil-Solution in Acid Forest Soils.**” A new technique was developed to compare soil-solution chemistry among red spruce stands in New York, Vermont, New Hampshire, and Maine. Soil solutions were expelled by positive air pressure from soil that had been placed in a sealed cylinder. Before the air pressure was applied, a solution chemically similar to throughfall was added to the soil to bring it to approximate field capacity. After the solution sample was expelled, the soil was removed from the cylinder and chemically analyzed. The method was tested with homogenized Oa and Bs horizon soils collected from a red spruce stand in the Adirondack Mountains of New York, a red spruce stand in east-central Vermont, and a mixed hardwood stand in the Catskill Mountains of New York. Reproducibility, effects of varying the reaction time between adding throughfall and expelling soil solution (5-65 minutes)

and effects of varying the chemical composition of added throughfall, were evaluated. In general, results showed that (i) the method was reproducible (coefficients of variation were generally < 15%), (ii) variations in the length of reaction time did not affect expelled solution concentrations, and (iii) adding and expelling solution did not cause detectable changes in soil exchange chemistry. Concentrations of expelled solutions varied with the concentrations of added throughfall; the lower the CEC, the more sensitive expelled solution concentrations were to the chemical concentrations of added throughfall. Addition of a tracer (NaBr) showed that the expelled solution was a mixture of added solution and solution that pre-existed in the soil. Comparisons of expelled solution concentrations with concentrations of soil solutions collected by zero-tension and tension lysimetry indicated that expelled solution concentrations were higher than those obtained with either type of lysimeter, although there was less difference with tension lysimeters than zero-tension lysimeters. The method used for collection of soil solution should be taken into consideration whenever soil solution data are being interpreted.

2.103 Nelson *et al.* (1996) studied “The Effects of Soil Physical Properties and Irrigation Method on Denitrification.” Acetylene-inhibition techniques were used to monitor the effects of soil physical properties, such as bulk density and crusting, on field denitrification losses under flood and sprinkle irrigation. In one flood irrigation treatment, polyacrylamide (PAM) was incorporated at the rate of 650 kg ha⁻¹ into a clay loam soil to enhance soil aggregate stability. In additional flood and sprinkle irrigation treatments, PAM was not applied. All treatments were irrigated on a weekly basis with 5 cm of water. Bulk density, soil moisture, and soil crusting were 1.2, 1.5, and 19.2 times higher,

respectively, under flood irrigation than under sprinkle irrigation, and infiltration rates were 4.7 times lower under flood irrigation. Soil physical properties of flood-irrigated soils treated with PAM were similar to sprinkle-irrigated soils. Penetrometers measurements of the surface of PAM-treated and sprinkle treated soils were not significantly different and bulk density differences were less than 6%. The poor physical properties and wetter conditions of the flood-irrigated plots produced a fourfold increase in total cumulative nitrate losses by denitrification compared with sprinkle-irrigated plots. In field experiments, the highest denitrification rates were from flood-irrigated soils, without PAM, initiated within 24 h after irrigation. Rates decreased rapidly beyond that time, whereas PAM-treated soils evolved high amounts of N₂O throughout both field and laboratory experiments. The continuously elevated denitrification activity in PAM-treated soils is believed to be caused more by increased anaerobic microsite activity within PAM-stabilized aggregates than by irrigation method.

2.104 Auxtero *et al.* (1996) reported the “Properties and Related Management Implications of Major Soils in Bukidnon, Philippines.” The mineralogy of the various soil horizons has been determined using X-ray diffraction (XRD), scanning electron microscopy SEM, and transmission electron microscopy (TEM).

The soils in the steepland and upland areas are classified as Typic Hapludalfs and Lithic Dystropepts. The floodplain is occupied by Typic Tropaquepts. The pH of the Ap horizons is moderately acid in Typic Hapludalfs and Typic Dystropepts and strongly acid in Typic Tropaquepts. The apparent cation exchange capacity is very high in

these soils, characterized by low contents of organic carbon and total nitrogen, a very low available phosphorus and low base status.

XRD analysis showed that gibbsite, quartz, halloysite and hydroxy interlayered 2:1 minerals are present in the clay fraction of all soils. TEM showed goethite as acicular crystals extending into pores like needles and lepidocrocite as highly elongated flakes found abundant in the sub-soils of Typic Tropaquepts.

Typic Hapludalfs are deep, well-drained soils suitable for upland cultivation. Use of light implements would help minimize soil compaction during land preparation, and contour plowing would alleviate soil erosion hazards on these soils. The coarse-textured Lithic Dystropepts, which have a coherent underlying hard rock material at 50 cm of the mineral surface, would require proper drainage. A clayey texture and a massive structure with redoximorphic conditions pose aeration problems in the Typic Tropaquepts. These soils could best be utilized for lowland rice cultivation.

2.105 Nayak and co-workers (1996) studied the “**Nature of Soil Acidity in Some Soils of Manipur.**” All types of soil acidity are relatively high in the hill soils than in the alluvial soils due to variations in physicochemical properties of the soils. High amount of ammonium acetate (pH 4.8) extractable Al indicates the presence of appreciable quantity of soluble $\text{Al}(\text{OH})_3$ and hydroxyl Al polymers in soils. The major controlling soil factor on exchange acidity is exchangeable Al^{3+} and pH-dependent acidity is influenced by organic matter, non-exchangeable Al and free iron oxides. The exchangeable Al^{3+} and per cent aluminium saturation increases with decreasing soil pH and it tends

to be zero at pH 5.6. The management of such acid soils includes liming to neutralize exchangeable Al^{3+} to the tolerance level of crops.

2.106 Elahi *et al.* (1996) investigated the “**Characteristics of Some Soils Developed on Madhupur Clay in Bangladesh.**” Four soil profiles representing two typical soil series of Madhupur clay in Bangladesh were studied for some of their morphological, physical and chemical properties. Formation of these soils appeared to be controlled by the composition and age of the parent materials, influenced by climate and relief. All the soils have developed on reddish brown clay of uniform nature called Madhupur clay. Movement of clay from the summit to the bottom of the valley indicates that there has been considerable dispersions of clay on wetting by rain water and movement of clay down the slope along with runoff water. Soil reaction is acidic, the organic matter and nitrogen content are low, and also base saturation is low. Highly soluble sodium and potassium have leached out of the catena. Calcium and magnesium are the dominant cations in the profiles, which increase with increasing depth. The soils have been classified as Inceptisols.

2.107 Sharma *et al.* (1996) investigated a “**Characterization and classification of soils in a Topsequence over basaltic Terrain.**” The soils at elevated topography were shallow to moderately shallow, clayey to loamy skeletal and yellowish brown, while at lower topography were deep to very deep, fine to fine loamy and grayish. The influence of topography was marked on properties like pH, $CaCO_3$, clay content, vertic properties, CEC and exchangeable cations up to pedon 4, thereafter; they were subdued by local ephemerals. The soils were

classified taxonomically in Lithic/Typic Ustorthents, Typic Haplusterts and Typic Ustifluents sub-groups and land use plans for the soils associated with each landform are proposed for their better management.

- 2.108 Kumar and co-workers (1996)** reported “**Estimating Penetration Resistance from Soil Physical Properties.**” Stepwise regression analysis showed that among one-variable models, only soil depth explained significantly the variation in cone index. The two-variable model, soil water content and depth explained 59 per cent variability. Inclusion of sand and bulk density in the model increased the coefficient of determination of 61 per cent. With square terms of depth, sand and bulk density, the model explained 80 per cent of variability in cone index and most of the points scattered around 1:1 line. Partial correlation coefficient of depth and soil water content with cone index had almost same magnitude followed by that of sand and bulk density.
- 2.109 Piccolo and co-workers (1996)** investigated the “ **^{15}N natural abundance in forest and pasture soils of the Brazilian Amazon Basin.**” Six sites in the state of Rondônia, two sites in Pará and one in Amazonas were studied. All sites except one were chronosequences and contained native forest and one or more pastures ranging from 2 to 27 years old. Forest soil $\delta^{15}\text{N}$ values with depth of 1 m ranged 8‰ to 23‰ and were higher than values typically found in temperate forests. A general pattern of increasing $\delta^{15}\text{N}$ values with depth near the soil surface was broadly similar to patterns in other forests but a decrease in $\delta^{15}\text{N}$ values in many forest profiles between 20 and 40 cm suggests that illuviation of ^{15}N -depleted nitrate may influence total soil $\delta^{15}\text{N}$ values in

deeper soil where total N concentrations are low. In four chronosequences in Rondônia, the $\delta^{15}\text{N}$ values of surface soil from pasture were lower than in the original forest and $\delta^{15}\text{N}$ values were increasingly depleted in older pastures. Inputs of atmospheric N by dinitrogen fixation could be an important N source in these pastures. Other pastures in Amazonas and Pará and Rondônia showed no consistent change from forest values. The extent of fractionation that leads to ^{15}N enrichment of soils was broadly similar over a wide range of soil textures and indicated that similar processes control N fractionation and loss under tropical forest over a broad geographic region. Forest $\delta^{15}\text{N}$ profiles were consistent with conceptual models that explain enrichment of soil $\delta^{15}\text{N}$ values by selective loss of ^{14}N during nitrification and denitrification.

2.110 Lovell and Jarvis (1996) investigated the “**Effect of urine on soil microbial biomass methanogenesis, nitrification and denitrification in grassland soils.**” Urine was added under controlled conditions to intact turfs taken from long-term permanent pasture on clay loam and sandy loam soils in South West England. Methane exchanges were small ($< \pm 0.03 \mu\text{g CH}_4 \text{ m}^{-2} \text{ min}^{-1}$) and overall absorption equalled or exceeded emission in both soils. On the clay loam, wetting with water or urine increased soil microbial biomass C and N contents by about 20% but there was no specific effect of urine. Urine, however, caused an increase in soil respiration of $>50\%$ and the average increase was greater for cow’s urine ($30.8 \text{ mg CO}_2 \text{ m}^{-2} \text{ min}^{-1}$) than for an artificial urine ($20.1 \text{ mg CO}_2 \text{ m}^{-2} \text{ min}^{-1}$). Emissions of nitric and nitrous oxides following urine application were substantial (on average $0.36 \mu\text{g NO-N}$ and $29 \mu\text{g N}_2\text{O-N m}^{-2} \text{ min}^{-1}$) but short lived (< 40 days). This high levels of ammonium found in the urine treated soils ($> 200 \text{ mg NH}_4^+ \text{-N m}^{-2} \text{ kg}^{-1}$) were

strified to nitrate over a period of 42 days. Qualitative changes in the soil microbial biomass were evidently not related to biomass size.

2.111 Tang and Thomson (1996) reported the “**Effects of solution pH and bicarbonate on the growth and nodulation of a range of grain legume species.**” Species differed greatly in response to solution pH. For both N-fertilized and N₂-fixing plants, shoot growth of *L. culinaris* was very sensitive to low pH (pH < 7), whereas shoot growth of *Lupinus angustifolius* L. and *Lupinus albus* L. was sensitive to higher pH (pH ≥ 6). Other species had a broader optimal pH range for growth when supplied with N, but were generally sensitive to low pH (pH < 7 for *C. arietinum* and *Vicia sativa* L., pH < 6 for *P. sativum*, *Vicia faba* L., *Lathyrus sativus* L. and *Lathyrus cicera* L., and pH < 5 for *Vicia benghalensis* L. and *Vicia narbonensis* L.) when reliant on N₂-fixation. For these other species, symbiotic N₂-fixation appeared to be more sensitive than host plant growth to low pH. This finding was supported by lower nodule numbers and mass, and lower N concentrations in shoots of sensitive species at low pH relative to higher pH. For *L. culinaris*, nodule numbers and mass were relatively unaffected by pH 5-8, N concentrations in shoots were high at low pH and plants developed symptoms relating to H⁺ toxicity at pH as high as 7. These results indicate that host plant growth of *L. culinaris* is more sensitive to low pH than the *Rhizobium* symbiosis. For *L. albus* and *L. angustifolius*, both host plant growth and symbiotic N₂-fixation appeared to be equally sensitive to pH ≥ 6. *Lupinus pilosus* Murr. was more tolerant of high pH than the other *Lupinus* species. At pH 4, two genotypes of *C. arietinum* had better early nodulation than other species. *Vicia ervilia* L. nodulated poorly at all levels of solution pH, indicating that the commercial Group

E inoculum (*Rhizobium leguminosurum* bv. *Viceae* SU303) may not be effective for this species in solution culture.

Addition of bicarbonate decreased shoot growth, nodulation and N concentrations in shoots of most species. Early nodulation (nodule number) of *Lathyrus ochrus*(L.) DC was not affected by the bicarbonate treatment.

2.112 Tsuyoshi Myazaki (1996) reported the “**Bulk Density Dependence of Air Entry Suctions and Saturated Hydraulic Conductivities of Soils.**” The bulk density of a soil changes with natural and artificial processes in a field. The larger the bulk density ρ_b of the soil, the larger the air entry suction h_e and the smaller the hydraulic conductivity K_s . Although both the Kozeny-Carman equation, based on Poiseuille’s law, and Campbell’s method, based on a similar media concept (SMC) by Miller and Miller are able to predict bulk density dependencies of hydraulic conductivities theoretically, the applicabilities and limitations of them have been vague. This paper proposes a non-similar media concept (NSMC) model, composed of a characteristic length for the solid phase S and for the porephase d , and a shape factor τ of the solid phase, to predict h_e and K_s values of a given soil as functions of its ρ_b . By comparing the NSMC model with the Campbell method and the Kozeny-Carman equation, it was clarified experimentally that the NSMC model is applicable to aggregated soils in the predictions of h_e (ρ_b) and K_s (ρ_b) as well as to dispersed soils. The shape factor τ was close to 1 when the soil was dispersed and sandy, whereas it was close to ρ_b/ρ_s , ρ_s being the density of soil particles, when the soil was aggregated.

2.113 KAUSHAL *et al.* (1996) investigated the “**Soil Water Retention Characteristics of Some Soils under Forests in Temperate Zone of the Himalayas.**” Some soil profiles developed under temperate zone of Himalayan forest ecosystem, representing Typic Hapludolls and Typic Udorthents were studied for their water retention characteristics in relation to different soil properties. Available soil water was very low and varied with a narrow range. Organic carbon and CEC as well as water retention at various suction values were comparatively higher at lower altitude and on northern aspect. Available water was significantly and positively influenced by clay, silt, CEC and organic carbon, while negatively by sand and bulk density. Most (40-50%) of the available water retained was released up to 200 kPa matric suction.

2.114 Hudson and co-worker (1996) studied “**Unsaturated Hydraulic Properties from Upward Flow into Soil Cores.**” This study developed a transient upward infiltration procedure for estimating soil hydraulic properties. The procedure involves pumping a carefully controlled water flux into the bottom of an initially dry soil core. As the unsaturated core slowly absorbs water, soil water potentials are measured with tensiometers, and, optionally, soil water contents are measured with time domain reflectometry. No porous plates are required for this unsaturated flow procedure because a flux boundary is used. Applied fluxes of approximately 0.76 cm d^{-1} for 60 h to 7.6 cm diam. by 7.6 cm high cores increased the water content from an initial dry state (approximately -7500 kPa) to almost saturation. A Levenberg-Marquardt inverse parameter estimation procedure was combined with a onedimensional numerical model of the experimental flow system to estimate the soil hydraulic properties from the collected water potential

data using five different methods. Parameters in the van Genuchten water retention relationship and van Genuchten-Mualem or the Campbell hydraulic conductivity relationships were simultaneously estimated. The optional water content data was combined with the water potential data to provide initial estimates of water retention parameters. The best method (lowest RMSE) that estimated all parameters in the water retention relationship [$\phi_m(\phi)$] and the hydraulic conductivity relationship [$K(\theta)$] produced similar hydraulic property relationships for four identically packed cores of a loamy fine sand.

2.115 Dulohery and co-workers (1996) studied “**Assessing Forest Soil Disturbance through Biogenic Gas Fluxes.**” This study’s objective was to determine if the gaseous products of aerobic and anaerobic soil biological activity could reveal harvest-damage effects, even after applying costly mitigation treatments. Fluxes of CO₂, CH₄, and N₂O across the soil surface were measured in Ultisols of a Coastal Plain pine flat damaged during timber harvest, then mitigated by bedding and fertilization (100 kg ha⁻¹ N, P, and K). Gas fluxes were measured with large static chambers (0.5 by 1.0 m sampling area) to compensate for high microsite variability and the presence of coarse debris on the forest floor. Carbon dioxide evolution was a robust and consistent indicator of residual damage, declining an average of 34% in planting beds on damaged vs, undamaged soils. For example, in a late summer reading, efflux of CO₂-C from beds installed over former skid trails was 143 mg m⁻² h⁻¹ vs. 258 mg m⁻² h⁻¹ from undamaged beds and 231 mg m⁻² h⁻¹ from undisturbed forest floor. Methane and N₂O fluxes were ephemeral and, thus, generally unreliable as indicators of harvest damage – though bedding produced scattered high peaks in both. Carbon dioxide was also the only gas flux that responded significantly to fertilization, with an

average 26% increase up to 4 mo after fertilization. These results suggest that suppression of gross soil biological activity by harvest damage was not restored by intensive mitigation in the next rotation's establishment phase.

2.116 Neal A. Scott *et al.* (1996) reported a “**Soil Textual Control on Decomposition and Soil Organic Matter Dynamics.**” They examined the direct and indirect effects of soil texture on litter decomposition and soil organic matter mineralization during 91-d laboratory incubations. Treatments included texture (73, 55, and 40% sand), soil water pressure (-0.012, -0.033, and -0.30 MPa), and nutrient availability (with or without additional N and P). Wheat litter (*Triticum aestivum* L.) was placed on the surface or incorporated into the soil. Soil texture had no effect on litter decomposition ($P \geq 0.23$). Litter decomposition was fastest for the - 0.012 MPa treatment across all soil types ($P < 0.01$), and the difference between water pressure treatments was greatest in the loam (40% sand) soil. The effects of texture and soil water pressure could be combined into one variable (percentage water-filled pore space), which accounted for more of the variability in litter decomposition and native soil C mineralization than either texture or soil water pressure alone. Surface-applied litter decomposed significantly faster than incorporated litter, but the effect was not consistent across different soils ($P = 0.04$). Litter addition stimulated the mineralization of native soil C, the greatest effect occurring when litter was incorporated into the fine-textured soil.

2.117 Rafael Angulo- Jaramillo *et al.* (1996) studied and “**Measurement of Hydraulic Properties and Mobile Water Content of a Field Soil.**” The hydraulic conductivity and the sorptivity were obtained using a new

approach that considers the transient three-dimensional infiltration from a disk. The measurement of the mobile water content was performed by adding KCl tracer after P rewetting the soil with water. Results show an important nonlinearity in both conductivity and sorptivity of the soil with applied pressure heads. The mobile water content ratio changes with the applied water pressure, and it was found to be a function of the effective mean pore size, λ_m . results show a transition from a capillary-dominated to a gravity-dominated flow. The soil water flow changes to a macroporosity flow when the water pressure head increases from -100 to 0 mm, resulting in an abrupt increase in the mobile water content ratio from 0.11 to 0.37.

2.118 Wang and Wang (1996) reported a “**Rapid Estimation of Cation Exchange Capacities of Soils and Clays with Methylene Blue Exchange.**” Four Methods to determine the cation-exchange capacities (CEC) of soils and clays were evaluated: (i) conventional $\text{NH}_4\text{-Na}$ exchange, (ii) methylene blue (MB) capacity with MB acid, (iii) CEC of tetrasodium pyrophosphate (TSPP), and (iv) MB- water filter paper spot test titration methods. Eighteen surface soils (0-15 cm) from farm fields in Taiwan and four reference clays obtained from the Source Clay Repository (Clay Minerals Society, Columbia, MO) were used in this work. Under appropriate conditions of concentration, equilibration period, and flocculation of MB solutions, MB absorption can be used to determine the CEC of soils and clays. Regression analyses gave R^2 values 0.91, 0.99, and 0.74 for MB-acid, MB-TSPP, and MB-water titration methods, respectively, vs. $\text{NH}_4\text{-Na}$ exchange. The CEC values of MB-TSPP titration showed a good linear correlation with values from the $\text{NH}_4\text{-Na}$ exchange method. Thus, the method of MB-TSPP

filer paper-test titration is recommended for rapid CEC determination in field test of soils.

2.119 Matschonat and Vogt (1996) studied a “**Equilibrium solution composition and exchange properties of disturbed and undisturbed soil samples from an acid forest soil.**” They investigated exchange properties and soil solution composition of disturbed and undisturbed samples of an acid forest soil lacking visible structure. Cation concentrations in the soil solution resulting from two extraction procedures and two analytical methods were compared. The effective cation exchange capacity (CEC_e) of the undisturbed samples represented 56-69% of the bulk soil CEC_e . Base saturation of undisturbed samples equalled that of disturbed samples for EA, Bhs, and Bsh horizons, and was higher for the Bw horizon. Contradicting the results of other authors, soil pore solution obtained by percolating soil cores under conditions of low water tension offered more favourable conditions for plant roots when compared to the equilibrium soil solution of the bulk soil sample in all except the Bsh horizon. Ca^{2+}/Al^{3+} molar ratios were higher and fractions of $H^+ + Al^{3+}$ on total cationic charge were lower in the soil pore solution. These results were obtained employing soil: solution ratios of about 1:0.5 during the extraction of soil pore solution, and by determination of free cations. Other authors used a water extraction with soil: solution ratios up to 1:2 and took total metal for ion concentrations. The combination of the latter extraction and analytical method in our study, too, led to unfavourable Ca^{2+}/Al^{3+} ratio and high fractions of $H^+ + Al^{3+}$.

2.120 Sawhney *et al.* (1996) studied “**Magnitude of Soil Variability in Morphological and Other Properties across Different Landscapes in**

the Siwalik Hills of Punjab.” Five different landscape elements (shoulder, toeslope, backslope, footslope and rivulet) in the Siwalik Hills in semi-arid tract of Punjab have been encountered. A statistical analysis of horizon thickness determinations showed a consistently wide range of variability within the different landscape positions as indicated by high standard deviations and coefficient of variations. The soils developed on toeslopes showed thicker horizons whereas shoulder slope showed thinner horizons with minimum solum thickness. A statistical calculation showed highest variation amongst clay and silt, organic matter and calcium carbonate but there was no difference in pH and EC.

2.121 Skyllberg (1996) studied **“Small Scale pH buffering in organic horizons of two boreal coniferous forest stands.”** Factors behind the small-scale variation of pH were examined in O horizons (humus layers) developed two stands of *Picea abies* (L.) Karst. (Site F and K) by combining data on the composition of the cation exchange complex with data from titrations of corresponding H⁺-saturated samples. Cations extractable in 0.5 M CuCl₂ ($S = \text{cmol}_c \text{ Kg}^{-1} [2\text{Ca} + 2\text{Mg} + 2\text{Mn} + \text{K} + \text{Na}]$), aluminium extractable in 1.0 M KCl ($\text{Al}_e = \text{cmol}_c \text{ kg}^{-1} [3\text{Al}]$) and in 0.5 M CuCl₂ ($\text{Al}_{\text{org}} = \text{cmol}_c \text{ kg}^{-1} [3\text{Al}]$), as well as pH measured in 0.01 M CaCl₂ (pH_{Ca}) were analysed in one-cm-layers of 13 O horizon cores at each site. Composite samples representing each of the one-cm-layers at each site, as well as samples with two different levels of Al saturation at Site K, were H⁺-saturated and titrated with NaOH to chosen end points of $\text{pH}_{\text{Ca}} = 4.0$ and 5.5 in a 0.01 M CaCl₂ ionic medium. The Acid Neutralisation Capacity (ANC) was estimated as the amount of base needed to increase pH_{Ca} of the composite H⁺-saturated samples of the mean pH_{Ca} of the corresponding natural samples. The

ANC was found to be similar in magnitude or higher than the amount of sites binding $S + Al_e$, which suggests that 1.0 M KCl exchangeable Al ions are nonacidic in acid O horizons. The relative contribution from i) the capacity of acidic functional groups, ii) their acid strength and iii) their degree of neutralisation to differences in pH_{Ca} between sites, among cm-layers and between samples with different levels of Al saturation were estimated from titration curves adjusted to hold two out of three factors (i, ii and iii) to be constant. The degree of neutralisation explained most of the differences in pH_{Ca} between the two sites, as well as between samples with different levels of Al saturation at site K. The pH_{Ca} decreased by depth at site F was, however, partly explained by an increasing acid strength.

2.122 Baruah and Aylmore (1996) studied “**Thermodynamic Evaluation of Cation Exchange Equilibria in Binary and Ternary Systems on a Sandy Clay Loam Soil.**” Cation exchange equilibria involving cation pairs, $Ca^{2+}-Na^+$, $Mg^{2+}-Na^+$ and $Ca^{2+}-Mg^{2+}$, in varying cationic ratios at two electrolyte concentrations (10 and 100 m equiv. L^{-1}) were studied on a sandy clay loam soil from Narrogin, Western Australia. In heterovalent systems, there existed a preferential adsorption for divalent cations (Ca^{2+} and/or Mg^{2+}) *vis-a-vis* monovalent cation (Na^+), regardless of solution concentration. This is evident from the position and shape of the Na^+ isotherms as well as from the sign and magnitude of free energy change ($\Delta Gr'$) of exchange reactions. In homovalent systems, the position of the Mg^{2+} isotherm indicated a preferential adsorption of Ca^{2+} . The smaller values of Gapon selectivity coefficient (K_G) at different degrees of Na^+ saturation also confirm the selectivity for divalent cations, irrespective of solution concentration. The surface activity coefficients (f_j), calculated for both heterovalent binary and

ternary systems further confirm weaker Na-binding on the soil exchange over a range of ESP values. The disproportionately higher value of f_{Na} corresponding to lower Na^+ saturation is discussed in the light of the 'tactoid model'. The preferential adsorption of Ca^{2+} and Mg^{2+} *vis-a-vis*, Na^+ for the soil exchange sites was greater, when they competed separately with Na^+ , than when all three cations competed together. At comparable fraction on the soil exchanger ($N_{Ca} = N_{Mg} = 0.17$ or 0.33), the values of f_{Mg} were larger than those of f_{Ca} . This infers a competitive edge to Ca^{2+} over Mg^{2+} for the soil exchange sites. This is most evident at low proportions of these cations on the soil exchanger. The predictive equations developed in this study conform to the recognized exchange properties for all three cations. It is concluded that, in general, the behaviour of the ternary exchange system can be predicted with a reasonable accuracy from data for the relevant binary systems.

2.123 Mondal *et al.* (1997) studied the “Spectroscopic, Thermal and Electron Microscopic Investigations on Clay-Humus Complexes.”

From IR spectroscopy and TG analysis, no significant involvement of the OH groups of the clay minerals in complexation with HA (humic acids) could be detected. Furthermore, there is no detectable interaction of the free radicals of HA with Fe^{3+}/Mn^{2+} in the clay minerals, as seen by ESR measurements. TEM showed sheet-like forms of free HA in kaolinite-HA complexes and surface deposits in illite-HA complexes. Montmorillonite-HA complexes showed extensive coating by HA as well as a reduction in the size of the clay particles as a consequence of the braking up of clay platelets by HA.

2.124 Menzies and Gillman (1997) studied a “Chemical Characterization of Soils of a Tropical Humid Forest Zone: A Methodology.” A

Methodology based on combination of routinely performed analyses and investigation of fundamental charge and anion sorption properties was used to characterize the soils of the humid forest zone of Cameroon. In general, the soils have about 2 cmol kg⁻¹ permanent negative charges, with about 1 cmol kg⁻¹ from variable-charge sources at current soil pH values. Furthermore, they are impoverished with respect of Ca, Mg, and K, while Al frequently dominates the exchange complex. Thus, the ability of these soils to retain base cations is more limited than is suggested by the cation-exchange capacity (CEC). Therefore we propose the concept of a degradation index (DI) defined as: $DI = 100 (CEC_{5.5} - \text{sum of basic cations})/CEC_{5.5}$, where $CEC_{5.5}$ is the CEC measured at pH 5.5. This index encompasses degradation a soil may have experienced from natural or man-made cause. Extractable PO₄ concentrations are considered very low and the soils have a moderate to high capacity to fix added PO₄. Surface Soil SO₄ concentrations are considered marginal to deficient for plant growth, though adequate reserves of SO₄ are held in the subsoil by SO₄ sorption. The approach used demonstrated that the five morphologically different soil profile classes identified in the zone have similar chemical characteristics. Thus, the results of experimentation conducted on one of the soil profile classes will be applicable throughout the zone. Furthermore, the approach has provided a means of identifying comparable soil types in other parts of the world and will guide technology transfer. The analytical methods used in this study are relatively simple and require no specialized equipment, and are therefore within the capabilities of many laboratories in the developing world.

2.125 Tamgadde (1997) investigated “**Soil of Gadchiroli District of Maharashtra.**” Twenty soil series in Gadchiroli district of Maharashtra have been identified and mapped while conducting the reconnaissance soil survey. The geology of the area consists of granite, granite-gneiss and shale. The landform sequence in the area comprises of plateau, escarpment, pediment, valley bottom and flood plain. They are classified (Soil Taxonomy) and mapped into 56 soil series associations. The soils are mostly cultivated to paddy, minor millets and patches are under dry deciduous mixed forest vegetation. Based on the soil properties, soil taxonomy, present land use and climatic make up, the soils have been interpreted for sustainable land uses. The productivity potential ratings as low, medium and high are suggested.

2.126 Tamgadde (1997) investigated “**Soils and Their Production Potential of Bhandara District Maharashtra State.**” Seventeen soil series in Bhandara District of Maharashtra were identified, and classified according to Soil Taxonomy while conducting the reconnaissance soil survey of the area. The geology of the area was complex consisting of granite gneiss, laterite, shale, feldspathic quartzitic schist, alluvium. The landform sequence was plateau, escarpment, ridge, ridge slope, valley bottom, upper piedmont, lower piedmont and flood plain. The soils were classified as Lithic Ustorthents, Typic Ustorthents, Lithic Ustochrepts, Typic Ustochrepts, Vertic Ustochrepts, Udic Ustochrepts, Fluventic Ustochrepts, Udic Haplustalfs, Typic Haplustalfs, Typic Haplusterts, Chromic Haplusterts and Udic Haplusterts. The soils were mapped into 35 soil associations. Based on the properties, climate, and experience gained in the area, the land use and productivity potential of these soils were suggested, Burkhabodi, Khamtalao, Kochi, Deori,

Seoni, Lakhandur, Sonogaon soils had low productivity potential; Karati, Jamnapur, Paraswada, Sawarbandh, Kumbhali, Korambi – medium productivity potentials and Sakoli, Dholsar, Arjuni soils had high productivity potentials.

2.127 Sen *et al.* (1997) studied “**Chemical and Electrochemical Characterization of Some Acid Soils of Assam.**” Measurement of CEC by three different methods was compared; the CEC by sum of cations and NH_4OAC method gave much higher values than effective CEC. Total potential acidity constituted 34 to 88 per cent of the total exchange capacity (extractable acidity + cations). Acidity due to variable charge (pH dependent) contributed 86 to 95 per cent of total acidity while exchange acidity contributed 5 to 14 per cent only. The variable charge characteristics were positively related with free oxides ($r = 0.66$) and clay content ($r = 0.74$) of the soils. The zero point charge (ZPC) varied from 2.4 to 3.2 while surface potential varied between -82.6 and -206.5 mV. In all the soils, the permanent charge was negative, indicating thereby that the soils though leached are not extremely weathered. The clay minerals in association with free sesquioxides and organic matter contributed towards the development of variable charge.

2.128 Dey and Jain (1997) studied “**Mineralization and Nitrification in Soil Amended with Urea and Enriched Green manures in Submerged Soil System.**” Mineralization pattern of three green manures, viz. *dhaincha*, cowpea and *guar* were evaluated along with the effect of their enrichment and compared with that of urea in a submerged soil system. Inorganic N in soil was found to decrease after 42 days after transplanting (DAT) rice. Mineralization of urea amended

soil was on par with enriched *guar*. Cumulative mineralization from green manures followed the order: *guar* > *dhaincha* > cowpea. Rate of mineralization attained peak after 35 DAT. Relationship between net ammonification and mineralization was found to be significant. Cumulative mineralization from greenmanures was positively correlated with total N, whereas negative correlation existed with lignin content and C/N ratio. Lignin was found to be the best predictor of mineralization, which can explain 80 per cent of total variations.

2.129 Luisella Celi (1997) investigated the “**ANALYSIS OF CARBOXYL GROUPS IN SOIL HUMIC ACIDS BY A WET CHEMICAL METHOD, FOURIER-TRANSFORM INFRARED SPECTROPHOTOMETRY, AND SOLUTION-STATE CARBON-13 NUCLEAR MAGNETIC RESONANCE. A COMPARATIVE STUDY.**” Carboxyls are important functional groups that affect polarity and reactivity in humic acids (HAs). Carboxyls were analysed in eight soil HAs by three methods based on widely differing principles: (i) wet chemical analysis, (ii) Fourier-Transform Infrared spectrophotometry (FT-IR), and (iii) liquid-state ^{13}C Nuclear Magnetic Resonance (^{13}C NMR). The objective was to uncover the suitability of each of these methods for the analysis of COOH groups in HAs and the extent to which the three methods agreed with each other in quantitative measurements of COOH groups in HAs. In regard to reaction mechanisms, the chemical Ca-acetate method is based on ion-exchange of H of COOH for Ca of Ca-acetate. From FT-IR spectra of HAs, COOH groups were determined by totalling absorbances at $1720\text{-}1710\text{ cm}^{-1}$ (COOH) and $1620\text{-}1600\text{ cm}^{-1}$ (COO⁻), whereas from ^{13}C NMR spectra of HAs, COOH groups were computed by integration of 175-185 ppm area. Good correlations were found between the three methods although the COOH values computed by ^{13}C

NMR were higher, as a result of the inclusion of small amounts of esters, amides, and lactones than those obtained by the other two methods. Thus, depending on the equipment and facilities available, soil scientists have a choice of methods that can be used for determining COOH groups in HAs.

- 2.130 Sahu and Mishra (1997)** studied a “**Morphology, Characteristics and Classification of Soils of an Irrigated River Flood Plain in the Eastern Coastal Region.**” Four pedons of an irrigated river flood plain under Salandi irrigated command of eastern coastal region were characterized and classified. Gradual increase of clay and development of structure down the depth indicated presence of cambic horizon. Fluctuation of water table and alternate wet and dry condition in an irrigated regime have given rise to formation of Fe, Mn concretions and lime nodules in the subsurface horizons. Soils were imperfectly drained, neutral to alkaline and the pH values increased down the depth. A significant positive correlation was obtained between clays and CEC ($r = 0.92^{**}$). Soils were of medium fertility.
- 2.131 Walia and Rao (1997)** studied a “**Characteristics and Classification of Some Soils of Trans-Yamuna Plain.**” Characteristics and elemental compositions of soils of four pedons representing four landforms of Banda plain in Bundelkhand region of Uttar Pradesh were studied. Khraund soils on piedmont plain are well drained, reddish brown, clay loam, slightly acidic, low in organic carbon, moderately eroded and classified as Fluventic Ustochrept. Bharatkup pedon on recent dissected flood plain is somewhat excessively drained, light yellowish brown, sandy clay loam, highly calcareous with lime *kankars*, severely eroded

soils and classified as Typic Ustochrept. Badausa pedon on slightly undulating flood plain has moderately well drained, dark greyish brown, clay soils with deep cracks and weak slickensides and classified as Udic Haplustert. Considerable reduction of CEC and weak are probably the expression of partial chloritization of smectitic clays. Anuwan soils on level flood plains are imperfectly drained, greyish brown to olive brown, silty clay, rich in organic carbon, showing surface cracks and redoximorphic features, hence, put under Vertic Epiaquepts. The soils are, in general, siliceous; the variations in SiO₂ and total base content are mostly associated with nature, source and composition of alluvium.

2.132 Singh and Mishra (1997) investigated **“Irrigability and Productivity Classification of Some Typical Soils of Sedentary and Alluvial Origins.”** The soils differed in irrigability classes and the differences are related to various soil limitations. Both, land and soil irrigability classes, show alignment with each other in their broader perspective. Pedons 1, 4, 5 and 6 fall under good productivity class whereas pedon 2 has average and pedon 3 poor productivity. The potential productivity class is excellent for pedons 4, 5 and 6 whereas good for pedons 1 and 2 but poor for pedon 3. The coefficient of productivity follows the order: Pedon 6 > Pedon 2 > Pedon 1 > Pedon 5 > Pedon 4 > Pedon 3. These findings enable database to execute the reliable decision for effective land use planning and help to resolve the contrast on land surface significantly for maximizing production.

2.133 Sarma *et al.* (1997) studied a **“Physical Characterization of Soils in Two Command Areas of Assam.”** Physical properties of two soils (Alfisols and Inceptisols) from two different command areas (Shallow

Tubewell Command, Alfisols; Deep Tubewell Command, Inceptisols) in the rain shadow belt under Central Brahmaputra Valley Zone (CBVZ) of Assam were studied. The bulk density in Alfisols was higher than Inceptisols and it increased with depth, in both the soils. Soils of STW command registered very low hydraulic conductivity (K_s) values while it was moderate to moderately rapid in DTW command. The surface layer soil of both the command areas contained higher percentage of aggregates less than 0.25 mm. The soils of STW command contained higher water content at all the suction ranges as compared to DTW command. The clay content was the single most dominant factor influencing the physical attributes of soils and it was significantly and positively correlated with bulk density, macro-aggregates, mean weight diameter (MWD), field capacity and permanent wilting point.

2.134 Madhumita Das and co-workers (1997) studied a “**Effect of Major Land Uses on Soil Characteristics of Alfisols in Meghalaya.**” Horticulture land use pattern ameliorated acid Alfisol by reducing Al-toxicity followed by dairy farming, while organic matter build-up was highest by the dairy farming (1.63%) followed by agroforestry (1.6%). Dairy farming was superior to other systems including pasture and helped in building up of P, Ca, Mg, K, Zn, Cu and B in the soil profile. Among all, maize-based cropping was inferior, in correcting soil acidity problems and enhancing nutrients in soils. Dairy farming or horticulture could be adopted as alternative to shifting cultivation *jhuming* on sloping land under mid to low altitude (980-200 m) situation in Meghalaya.

2.135 Burle and co-workers (1997) investigated an “**Effect of cropping systems on soil chemical characteristics with emphasis on soil acidification.**” The soil under intensive cultivation and low addition of crop residues is exposed to erosion and reduction of organic matter. Increases in soil organic matter, cation exchange capacity (CEC) and nutrient availability may occur in no-till systems with legumes and with large additions of organic residues. Nevertheless, some legumes may increase soil acidification through the carbon and nitrogen cycles. An experiment was carried out over 10 years, with 10 cropping systems on a Dark Red Podzolic soil (Paleudult) to evaluate the effect of no-till cropping systems on soil chemical characteristics. Legume cropping systems resulted in the greatest soil organic C gain and the highest ECEC to a depth of 17.5 cm. The increase was greatest at 0 – 2.5 cm layer. Clover systems resulted in the highest soil acidification at 2.5 – 7.5 and 7.5 – 17.5 cm depths. The rate of soil pH decrease at 2.5 – 7.5 cm depth under clover + *Spergula/maize* system was 0.1 unit year⁻¹. Differences in soil acidification affected soil ECEC. Soil exchangeable cation data indicate that nitrate leaching increased soil acidification. Maize yields were greatest in legume systems due to increased N supply.

2.136 Jain et al. (1997) studied the “**Carbon to Organic Matter Ratios for Soils in Rocky Mountain Coniferous Forests.**” Vegetation type, soils, climate, and conversion ratios influence estimates of terrestrial C. Our objectives were to (i) determine carbon to organic matter (C/OM) ratio for brown cubical rotten wood, litter, surface humus, soil wood, and mineral soils; (ii) evaluate the validity of using 0.58 and 0.50 ratios for estimating C in mineral and organic soil components, respectively; and

(iii) determine if C/OM relationships were applicable across broad geographic areas. The study sites were located from the southern to northern Rocky Mountains. They differed in vegetation, soil parent material, and climate. The C/OM regression slopes we developed for organic components were quite consistent and relatively constant across vegetation types ranging from 0.43 to 0.51 and were similar to the 0.50 traditional ratio. The C/OM regression slopes for mineral soils ranged from 0.16 to 0.48 depending on vegetation type. These slopes were lower than the 0.58 ratio often applied. The reliability of simple ratios when used in estimating C as a function of organic matter is often overestimated. Error and bias can be introduced into C estimates when using simple ratios. This study refined C/OM regressions for mineral soils and provided regressions for organic soil components. Information developed in this study can be applied to improve regional and global C assessments.

2.137 Khan and co-workers (1997) reported a “Fertility Status and Productivity Potential of Some Benchmark Soils of Bangladesh.”

Five soil profiles representing five major soil series from the floodplains of Bangladesh have been studied to evaluate their fertility status. The nutrient contents of these soils have been reported. With respect to nutrient status, the soils are classed as fertile with reasonably high production potentiality, which is renewed every year because of siltation during the monsoon season.

2.138 Ananthanarayana and Ravi Kumar (1997) studied the “Characterization of Soil Acidity and Lime Requirement of Soils in the Agroclimatic Zones of Hassan District of Karnataka.” In Hassan, 16 per cent of the total

cultivated are is acidic. Majority of the soils under study were sandy loam with low cation exchange capacity. The nature of acidity in these soils is pH-dependent. Extent of calcium saturation ranged from 5.3 to 26.4 per cent and aluminium saturation ranged from 11.6 to 39.4 per cent. Lime additions based on exchangeable calcium method correlated with soil physicochemical properties.

2.139 Kornecki *et al.* (1997) studied the “DETERMINATION OF CATIONIC AND ANIONIC SURFACTANT CONCENTRATIONS IN SOIL.”

Research within this field often requires determination of anionic and cationic surfactant concentrations in soil. This paper details a study through which simple and effective extraction procedures were established for use in conjunction with two different surfactant chemical analysis methods. Surfactant extraction is accomplished in two steps. First, a sodium chloride solution is used to reduce electrostatic soil/surfactant attractions and precipitation, and second, acetone is added to minimize hydrophobic adsorption. The extractant solution was diluted, followed by colorimetric chemical analysis using a spectrophotometer. The extraction effectiveness of these procedures was found to be near 100% for both cationic and anionic surfactants.

2.140 Yi-Ju Chien *et al.* (1997) studied “GEOSTATISTICAL ANALYSIS OF SOIL PROPERTIES OF MID-WEST TAIWAN SOILS.”

In this kriging and cokriging methods were applied to estimate the spatial distribution of soil properties from available large-scale survey data of Taiwan. The data were derived from soils in a 10-km² area divided into 250 m X 250 m node intervals. The soil properties examined included the extractable P, Ca, Mg, and Fe contents, the sum of exchangeable

bases (SEB), % sand, % silt, and % clay. The sum of exchangeable bases and particle-size distribution were regarded as the primary and auxiliary variables, respectively, in the cokriging procedure. The ratio of nugget to total variation was about 57 to 80%, indicating that the spatial correlation of the tested soil properties at the large scale was moderately (cross-) dependent. The estimated spatial distributions of the soil properties by kriging, under the decreasing sampling densities, all correlated significantly ($P < 0.1\%$) with those obtained from original data. Furthermore, with the over-sampled particle-size distribution, the overall estimation of SEC quality by cokriging was superior to that by kriging. The results suggested that by Kriging and cokriging the existing sampling density could be decreased under the large-scale sampling interval by nearly half and that sufficient spatial information about the soil properties could still be retained. The information obtained could be used to improve the long-term sampling design of soil surveys in Taiwan. It also may be useful for identifying the appropriate sampling densities for these for these scales of soil surveys.

2.141 J.N. Shaw *et al.* (1997) studied a “**MORPHOLOGIC AND HYDRAULIC PROPERTIES OF SOILS WITH WATER RESTRICTIVE HORIZONS IN THE GEORGIA COASTAL PLAIN.**” Objectives included characterizing the morphological and hydraulic properties of major horizons in soils with plinthite, determining the extent of preferential flow, and relating flow/transport parameters derived from breakthrough curve analyses to morphological properties. These soils have developed from Miocene aged sediments and are classified in fine-loamy, siliceous, thermic families of Plinthaquic, Aquic, Arenic Plinthic, Plinthic, and Typic kandiodults. Morphological evidence indicates that BC horizons are restrictive to vertical

percolation of drainage water. Methylend blue by staining, K_{sat} and breakthrough curves (analyzed by two regin/MIM using CXTFIT) were measured on 15-cm-diameter undisturbed cores to determine the effects of argillic horizons, argillic horizons with plinthite, and subjacent BC horizons on hydraulic properties of the soils. K_{sat} for seven sampled pedons averaged 1.6×10^{-2} , 1.1×10^{-2} , and $3.8 \times 10^{-3} \text{ mm s}^{-1}$ for B_t , B_{tv} , and BC horizons, respectively. Dye staining and model output (MIM) indicates a greater degree of preferential flow with depth and subsequent less mobile area contributing to water flow. Analyses of the flowpaths indicate water is translocated in regions with relatively higher porosity that also contain a higher proportion of coarser pores. Micrographs indicate that flowpaths are associated with bio-pores and areas of better aggregation in the B_t horizons and structural voids in the BC horizons. BC horizons in these soils are less permeable because of increased clay content, differences in pore characteristics, and less cross-sectional area contributing to flow.

2.142 Hans-Roff Schulten and Schnitzer (1997) investigated a “**Chemical Model Structures for Soil Organic Matter and Soils.**” A hypothesis for the three-dimensional structure of soil organic matter (SOM) and whole soil, based on an improved humic acid (HA) model that resulted from comprehensive investigations combining geochemical, colloid-chemical, electron-microscopical, IR, ^{13}C -NMR, and X-ray spectroscopic as well as agricultural and ecological data with analytical pyrolysis, is proposed. Direct, temperature-programmed pyrolysis in the ion-source of the mass spectrometer combined with soft ionization in very high electric fields (Py-FIMS) and Curie-point pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) were the main thermal analytical methods employed. Molecular modeling and geometry

optimization of SOM complexes and soil particles was performed using molecular mechanics and dynamics calculations in order to optimize the structural geometry and to determine low energy conformations. Atomic and molecular space requirements, voids, inter- and intramolecular hydrogen bonds and water and metal cation interactions were evaluated. First investigations of quantitative structure-activity relationship (QSAR) properties were made to correlate molecular structures with soil properties such as mass, surface area, volume, partial charges (electronegativity), polarizability, refractivity, hydrophobicity, and hydration energy. Important characteristics of SOM such as surface activity, cation exchange capacity, binding and trapping of biological and anthropogenic substances, soil stabilization, and nutrient supply can be illustrated by these models.

2.143 Asadu, Diels, and Vanlauwa (1997) reported “**A COMPARISON OF THE CONTRIBUTIONS OF CLAY, SILT AND ORGANIC MATTER TO THE EFFECTIVE CEC OF SOILS OF SUBSAHARAN AFRICA.**” The contributions of clay, silt, and organic matter (OM) to the effective cation exchange capacity (ECEC) of soils in subSaharan Africa were examined using data from more than 2131 soil samples collected from Cote d’Ivoire, Nigeria, Tanzania, and Uganda. The data were partitioned into highland humid (HLH), lowland humid (LLH), subhumid (SH), nonhumid (NH), low altitude (LA), mid altitude (MA), 0-20-cm depth (D_1), and 20-40-cm depth (D_2) following preliminary analysis.

The soils of each zone are generally low in ECEC and OM and low to medium in clay and silt contents, and all exhibited wide variations both within and across the zones. In most of the zones, ECEC

correlated significantly with all three variables. In the NH zone, however, clay exhibited a nonsignificant correlation with ECEC, and silt showed similar characteristics with ECEC in the SH zone. The absolute CEC of clay was highest in the HLH zone, where it made a relative contribution (RC) of 67% to the ECEC. The highest RC of silt (37%) was obtained in the NH zone, where the CEC of silt was also highest. Generally, the RC of OM was either as high as or higher than the combined contributions of clay and silt of ECEC, except in the SH and LA zones. For the entire subregion, OM alone could account for about 60% of the mean ECEC of the soil. This demonstrates the overall importance of OM in maintaining the nutrient reserve in tropical areas. The overall variations in ECEC attributable to the three variable could range from 56% in the SH zone to 95% in the LLH zone.

2.144 Khan *et al.* (1997) studied a “**Total and DTPA-Extractable Fe, Mn, Cu and Zn Contents in Some Soils of Bangladesh.**” Thirty soil samples representing different parent materials of Bangladesh were studied for the distribution of total and DTPA-extractable zinc, copper, manganese and iron in the surface horizons. Total content of micronutrients in these soils was moderate to high and their content decreased from the younger to the older soils. But the total quantity of the above nutrients showed little variation in soils developed on similar parent materials. On the basis of DTPA-extractable micronutrients, zinc deficiency was widespread (13 out of 30 soils) in these soils, whereas the quantities of iron, manganese and copper were adequate. The DTPA-extractable zinc, copper, manganese and iron showed high correlations with their total amounts, indicating a genetic relationship of these soils with zinc, copper, manganese and iron.

- 2.145 Sharma and co-worker (1997)** studied a “**Characterization, Classification and Landscape Relationships of Inceptisols in North-West India.**” Morphological, physical, chemical and mineralogical characteristics of Inceptisols occurring on five dominant landscape positions *viz.* footslopes, toeslopes, interdunal areas, alluvial plain and microdepressions in the Punjab state in north-west India have been studied. In udic region the soils developed on footslopes are non-calcareous and those on toeslopes are calcareous. These soils are classified as Dystric Eutrochrepts and Typic Eutrochrepts. In ustic moisture region (less hot zone) the soils of Siwaliks are calcareous and are classified as Fluventic Ustochrepts. In piedmont plain soils are classified as Typic Ustochrepts. In the ustic region (more hot zone), the soils developed in interdunal areas show weakly developed cambic horizon and are classified as Typic Ustochrepts. The soils developed on alluvial plains have variable calcium carbonate content and relatively well developed cambic horizon. These soils are classified as Typic Ustochrepts. Some of the soils developed on slightly lower topographic positions are alkaline in nature ($ESP > 40\%$) and are classified as Natric Ustochrepts. Fine textured soils developed on alluvial plains in the old flood-plain areas show the development of strong angular blocky structure with pressure faces and slickensides. These are classified as Vertic Ustochrepts. All the soils have mixed mineralogy and hyperthermic temperature regime. The morphological, physical and chemical properties and land use limitations of these soils as discussed.
- 2.146 Patil, Veeramallappa and Hebbara (1997)** studied “**Sulphate Retention as Influenced by pH and Soil Constituents in Some Major Soil Groups of Karnataka.**” Sulphate retention studied with

two pairs of Vertisols (pH-independent) and three pairs of Alfisols (pH-dependent) were carried out at the Agricultural Research Station, Gangavati. The soils had a range of properties in respect of pH, organic matter and free iron oxides. Adsorption of sulphate by Vertisols remained largely independent equilibrium pH and solution concentration and was purely desorption. The negative values of distribution coefficient (K_d) and Freundlich's 'k' as a measure of adsorbability and 'n' as a measure of energies of adsorption indicated that soils carried predominantly pH-independent charges. Alfisols representing variable charges recorded desorption (Ranebennur) at lower equilibrium concentration and higher pH value of the solution. All the soils, both surface and subsurface recorded a net loss in adsorption due to removal of organic matter and free iron oxides. Further, a decrease in adsorption was indicated by ' K_d ' and Freundlich's 'k' and 'n' values apart from marginal reduction in PZC.

2.147 Randhawa and Singh (1997) reported a “**Distribution of Manganese Fractions in Alluvium-Derived Soils in Different Agro-climatic Zones of Punjab.**” In the soils from the four major agro-climatic regions of Punjab, viz., undulating, central, western and flood-plain regions, total and DTPA-extractable Mn in these soils ranged from 200 to 550 and 2.6 to 9.9 mg kg⁻¹ soil with average values of 373 and 5.1 mg kg⁻¹ soil, respectively. A sequential fractionation showed that Mn-exchangeable, weakly adsorbed, moderately adsorbed, strongly adsorbed, associated with organic matter, occluded and bound by carbonates/acid soluble minerals were in very low proportion while most of the total Mn (35.3 to 84.9%) was in the residual fraction. The chemical pools of Mn were positively correlated with major soil properties.

2.148 Beyer *et al.* (1997) studied a **“Soil organic matter of suggested horizons in relic ornithogenic soils of coastal continental Antarctica (Casey Station, Wilkes land) in comparison with that of Spodic Soil horizons in Germany.”** The SOM investigations were carried out by means of wet chemical SOM analyses and carbon-13 and nitrogen-15 nuclear magnetic resonance (NMR) spectroscopy. The purpose is to compare these data with those obtained from spodic horizons formed under temperate climate conditions. This comparison should provide the first information concerning the possibility of podzolization in Antarctica. In contrast to the spodic horizons in Germany, the SOM of the antarctic soils is characterized by a high percentage of amino derivatives from proteins, polysaccharides, urates, and chitin, resulting in a mean C-to-N ratio of 10 and a high content of carboxyl carbon units, which probably derived from amino and other organic acids. The ¹⁵N-NMR spectrum of penguin guano suggests the presence of uric acid (2, 6, 8-trioxypurine). Our data suggest that migration of organic acids, not-humified carbohydrates, and N-containing moieties from the topsoil moving into the spodic horizons of the ornithogenic soils affect the podzolization process. In the SOM of the German Podzols, N-compounds and not-humified carbohydrates were of minor importance the SOM translocation processes.

2.149 Jiří Šimunek, Martinus and Genuchten (1997) studied **“ESTIMATING UNSATURATED SOIL HYDRAULIC PROPERTIES FROM MULTIPLE TENSION DISC INFILTRATION DATA.”** In this paper they analyze the possibility of using cumulative infiltration rates obtained at several consecutive tensions for the purpose of estimating soil hydraulic parameters. We also investigate whether

additional, easily obtainable information improves identifiability of the unknown parameters. The study is carried out using numerically generated data. The uniqueness problem was analyzed by studying the behavior of response surfaces in the optimized parameter planes. Our parameter estimation procedure combines the Levenberg-Marquardt nonlinear parameter optimization method with a quasi three-dimensional numerical model, HYDRUS-2D, which solves the variable-saturated flow equation. We found that the combination of multiple tension cumulative infiltration data with measured values of the initial and final water contents yielded unique solutions of the inverse problem for the unknown parameters.

2.150 Malik *et al.* (1997) studied “**A Simple field method to determine soil dispersiveness.**” Dispersion experiments for different soils were carried out in a distance-marked test tube (1.2 cm i.d., and 16 cm length) using 1.5g of oven dry soil and 15mL of water. The falling distance of the dispersion front (z) was observed as a function of time (t). The linear relationship between z and t for all soils verified the applicability of Stokes’s law in the initial distance ($z \leq 8$ cm). Dispersiveness was defined as the inverse of the falling velocity of the dispersion front in water, V_w . The latter was related quantitatively to penetration coefficient λ_w ($\lambda_w = 0.513 V_w^{0.338}$) and hydraulic conductivity, K_s ($K_s = 0.001 V_w^{0.582}$). The designed dispersiveness method is simple and practical; preparation of sample, handling of instruments, and measurements of z and t are easy and convenient and require less technological input. Reproducibility is very high ($CV < 10\%$), and the method is highly sensitive because its range of variation in falling velocity over different soils is two orders higher than that of penetration coefficient. The

method is intended for field use. Under field situations, volume (1 cm^3) may be substituted for weight (1.5 g oven dry) of soil, which keeps the variation within the experimental errors.

Falling velocity (V) and penetration coefficient (λ) increased in a 0.1N CaCl_2 solution compared with distilled water in all soils except sand. Effect of the height of suspension on dispersiveness was found to be positive, whereas the diameter of the sedimentation cylinder had no significant effect.

2.151 T. Olesen *et al.* (1997) investigated a “Modeling diffusion and Reaction in Soils: V. Nitrogen Transformations in Organic Manure-Amended Soil.” Measurements of nitrogen transformation with high temporal and spatial resolution are needed to better understand and predict nitrogen losses from manure-amended soil. Centimeter-scale measurements of nitrogen transport and transformations were carried out in a soil-manure model system corresponding to direct injection of liquid manure into soil. Influence of manure type (cattle or pig manure), initial soil-water, and soil-nitrate content were investigated. The manure type was the dominating factor with respect to both the initial redistribution of water and solutes and the subsequent nitrogen transformation processes. The liquid transport from the pig manure into the soil was rapid and extensive compared with the cattle manure. In both systems, the initial water transport created a low-nitrate zone at the manure-soil interface, possibly limiting denitrification that was found to be insignificant. Nitrification was inhibited initially in the cattle manure systems with high NH_4^+ and DOC concentrations. A small N immobilization during the first 2 days of incubation, followed by a net mineralization, was seen in all experiments. An Inverse Diffusion-

Reaction Model (IDRAM) was used to calculate spatial and temporal variations in net nitrate production rates after the initial water transport had ceased. Good agreement was found between IDRM-calculated net nitrate production rates and measured nitrification rates. The net nitrate production rates were higher in the pig manure than in the cattle manure systems in the first 8 to 10 days, but they then decreased rapidly as a result of NH_4^+ limitation in the pig manure system. Unlike the frequently used mass balance considerations, the IDRAM includes the effects of diffusion and, therefore, seems promising for high resolution analyses of solute transformation processes.

2.152 Andrew P. Low and co-worker (1997) studied a **“Effects of soil osmotic Potential on, Nitrification, ammonification, N-Assimilation, and Nitrous oxide production.”** They used a ^{15}N isotopic dilution method to evaluate the effects of Ψ_s on gross rates of nitrification, ammonification, NH_4^+ assimilation, and NO_3^- assimilation, and net rates of nitrous oxide production in a Penoyer sandy loam at field capacity. To avoid creating specific ion toxicities that normally do not occur in this soil, we used a chemical equilibrium model to predict how solute concentrations in the soil solution change during evapo-concentration; then we used solutions containing these mixtures of solutes to create individual Ψ_s treatments. A nitrification potential assay was also performed to determine the effect of Ψ_s on nitrification rates at high substrate concentrations. In soil slurries with elevated NH_4^+ concentration (1110 μm), nitrification rates declined exponentially with reduced Ψ_s (increased salt concentration); however, in soil samples incubated at field capacity without added NH_4^+ (9.7 μm , or 2 mg N Kg^{-1}), the gross nitrification rate was

independent of Ψ_s . The differential response between slurries and soil at field capacity was attributed to differences in NH_4^+ concentrations, and indicated that the effects of Ψ_s were secondary to NH_4^+ concentrations in controlling nitrification rates. Nitrification rates in slurries declined more when a single salt (K_2SO_4) was used than when the mixture of salts that more closely approximated the solute composition predicted to occur in the field was used to lower Ψ_s . This suggests that nitrifying bacteria are capable of adapting to specific ion toxicities. Gross rates of ammonification declined exponentially with decreased Ψ_s between 0 and -500 kPa but were independent of Ψ_s at potentials of -500 to -1750 kPa. Rates of microbial assimilation of NO_3^- exceeded NH_4^+ assimilation by a factor of 4, indicating that under NH_4^+ limited conditions substantial NO_3^- assimilation can occur. Microbial assimilation of both NH_4^+ and NO_3^- declined exponentially with decreased Ψ_s , and were insignificant at < -1500 kPa Ψ_s . Because NO_3^- assimilation declined more rapidly than gross nitrification, net nitrification rates actually increased with declining Ψ_s . Rates of nitrous oxide (N_2O) production were also inversely correlated with Ψ_s . Our results indicate that in previous studies, measurement of net rates, use of inappropriate salts, and addition of substrate may have resulted in over estimation of the adverse effects of low Ψ_s on rates of N-transformations.

2.153 A. Rahman Barzegar and co-workers (1997) studied “Organic Matter, Sodicty, and Clay Type: Influence on Soil Aggregation.”

This study was to examine the role of organic matter in aggregation and clay dispersion in soils with different levels of sodicty. Prepared soils with 15% clay (smectitic or illitic) and natural soil aggregates (from a smectitic clay soil [Pellustert] with 25 g kg⁻¹ organic Carbon C and a

pair of illitic loams [Rhodoxeralfs] with 15 and 29 g kg⁻¹ organic C) were equilibrated with solutions having sodium adsorption ratios (SAR) of 0, 5, 15 and 30. Pea (*Pisum sativum* L.) straw was added at 50 g kg⁻¹ to the prepared soils, which were then incubated. Changes in aggregation during incubation were similar irrespective of clay type. After 7 d incubation with no added straw at SAR 0 and 30, the amounts of spontaneously dispersible clay were 5.9 and 23.7 g kg⁻¹ soil, and mechanically dispersible clay was 11.9 and 23.3 g kg⁻¹ soil. Macroaggregation (> 250 μm) was 125 and 41 g kg⁻¹ soil at SAR 0 and 30. After 67 incubation with pea straw, spontaneously dispersible clay contents were 2.1 and 5.4 g kg⁻¹, mechanically dispersible clay contents were 9.0 and 17.7 g kg⁻¹ soil, and macroaggregation was 533 and 416 g kg⁻¹ soil at SAR 0 and 30. The effects of sodicity and organic matter on structural stability of the natural soil aggregates were similar to those in the prepared soils, but macroaggregation was less, and the smectitic clay soil was more sensitive to sodicity than the illitic loams. This work showed that organic matter has at least at great a role in aggregation in sodic soils as in non-sodic soils.

2.154 Jennifer D. Knoepp and Wayn T. Swank (1997) reported a “**Forest Management Effects on Surface Soil Carbon and Nitrogen.**” Changes in surface soil C and N can result from forest management practices and may provide an index of impacts on long-term site productivity. Soil C and N were measured over time for five watersheds in the southern Appalachians: two aggrading hardwood forests, one south- and one north-facing, undisturbed since the 1920s; a white pine (*Pinus strobus* L.) plantation planted in 1956; and two regenerating hardwood forests, a whole-tree harvest in 1980, and a commercial sawlog harvest in 1977.

soils on harvested watersheds were sampled before and for ≈ 15 yr after harvest. Surface soil C concentration on the undisturbed watersheds varied significantly among sample years. Concentrations fluctuated on the south-facing and decreased on the north-facing watershed. The pattern for total N was similar. Total N decreased significantly on the north-facing but was stable on the south-facing watershed. In the white pine plantation, C increased while N concentrations decreased during the 20-yr period. Soil C and N concentrations generally declined the first year following whole-tree harvest. Fourteen years after cutting, C remained stable, while N was greater compared with reference watershed soils. The commercial sawlog harvest resulted in large increases in surface soil C and N concentrations immediately after cutting. Carbon levels remained elevated 17 yr following cutting. Our data suggest that the forest management practices examined do not result in long-term decreases in soil C and N.

2.155 Francois Courchesne and George R. Gobran (1997) studied a “**Mineralogical Variations of Bulk and Rhizosphere Soil from a Norway Spruce Stand.**” The mineralogy of clay-sized particles of both fractions was determined by x-ray diffraction (XRD) and normalized with respect to quartz (I/I_{QZ}). Amorphous solid phases were estimated by extracting Fe and Al with acid-ammonium oxalate (Al_0 , Fe_0). Mineral abundance (I/I_{QZ}) near roots differed consistently from that in the bulk soil. The rhizosphere contained significantly lower amounts of amphiboles and expandable phyllosilicates ($\alpha = 0.10$) relative to the bulk soil. This trend was paralleled by a systematic increase in Al_0 and Fe_0 ($\alpha = 0.10$) at the root-soil interface. Lower amounts of plagioclase were also seen in the rhizosphere samples from five of the six horizons,

but the difference from the bulk soil was not significant when all horizons were integrated in the comparison. No rhizosphere effect was detected for K-feldspars. This study provides converging results that emphasize the pedogenic significance of the rhizosphere zone and the role of roots as dynamic weathering agents.

2.156 Nanda, Mishra and Bhatta (1997) studied “**Soil Classification and Soil and land Suitability for Irrigation in Kuanria Irrigation Project.**” In the culturable command area (CCA) of 200 ha in the head reach of left main canal of Kuanria irrigation project, Dasapalla, in the district of Nayaragh, Orissa, four soil series, viz. Sariganda 1 loam (Udic Ustochrept), Sariganda 2 clay loam (Udic Ustochrept), Neliguda sandy loam (Typic Haplustalf) and Patharpunja loamy sand (Aquic Ustifluent) were identified. Based on fifteen characteristics pertaining to soil, topography and drainage conditions under subhumid climate the above soils were classified into four soil and land irrigability subclasses. Shallow water table, imperfect drainage, low available water capacity and milk alkalinity are some of the limiting factors for sustainable use of irrigation water.

2.157 Lalita M. Arya and co-worker (1998) studied a “**FIELD MEASUREMENT OF THE SATURATED HYDRAULIC CONDUCTIVITY OF A MACROPOROUS SOIL WITH UNSTABLE SUBSOIL STRUCTURE.**” A field method for measuring saturated hydraulic conductivity, K_s , was developed to characterize water flow in highly-weathered soils of Sitiung, Indonesia. Soil of this area is known to absorb large volumes of rain-water rapidly. However, K_s data obtained on soil cores do not corroborate field-observed rapid infiltration rates. In the field method,

constant rate irrigation was applied to a field plot, delineated to a depth of 120 cm, and bordered on the surface to contain a depth of ponded water. The rate of irrigation was sufficient to maintain the ponding depth at a constant level as well as cause water to overflow from the ponded surface. The difference between the steady-state irrigation and overflow rates was considered to be the instantaneous flux and was assumed applicable to all depths. Simultaneous tensiometric measurements of pressure head as a function of depth provided the hydraulic gradients needed for calculation of K_s using Darcy's law. Hydraulic gradients deviated considerably from unity, and soil saturation did not exceed 92% of porosity. Laboratory-measured K_s values for the stable structured topsoil agreed well with the field data. However, those for the subsoil were 2 to 3 orders of magnitude lower than the field-measured values. The susceptibility of the subsoil to compaction during core extraction and slaking when in contact with free water appeared to be responsible for the highly reduced rates of flow in the laboratory samples. The subsoils pore structure was preserved only as long as it was overlain by the stable structured topsoil. Results suggest that measurements of water flow on small soil cores may, in some cases, be of questionable value. The field method provided accurate in situ data on plot-size areas. The field plot method used in this study causes minimal disturbance of the soil while the effects of sample confinement and overburden are represented fully in the measurements.

2.158 Bhaskar and Nagaraju (1998) reported a “**Characterization of Some Salt-Affected Soil occurring in the Chitravathi River Basin of Andhra Pradesh.**” The pedological characteristics of some salt-affected soils occurring in piedmont slopes and in basin floors of

sedimentary rock formations in Chitravati river basin in Andhra Pradesh were studied. The soils of piedmont slopes have brown to light gray matrix with subangular to angular blocky aggregates in B horizon whereas soils of basin floors have grayish brown to very dark gray matrix with angular to prismatic structure. The textural change in soils of piedmont slopes shows high degree of variability in vertical distribution of sand and silt contents and yielded high sand/ silt ratio. The high degree of sodicity in these soils is due to presence of sodium carbonate and bicarbonate and resulted in high pH conditions. The soils on piedmont slopes are classified as Vertic Ustopepts and Fluventic Ustopepts and soils on basin floors as Sodic Haplusterts.

2.159 Galbraith and Bryant (1998) studied “**A FUNCTIONAL ANALYSIS OF SOIL TAXONOMY IN RELATION TO EXPERT SYSTEM TECHNIQUES.**” They studied the functional logic and query processes employed by *Soil Taxonomy* to identify soil individuals and compared the methods with those used in other natural object classification systems. Numerical and classical identification methods and program features found in recent computer programs were evaluated for use with *Soil Taxonomy*. The keys in *Soils Taxonomy* are purely phenetic in nature and single-access in approach. In the absence of rule- and value confidence-weighting factors, the rules must be encoded without sequence modification to preserve the decision logic. Decisions in *Soil Taxonomy* query a large, often incomplete, and sometimes faulty data set, requiring error-checking of data and the addition of expert rules to the encoded decisions to prevent indecision. *Soil Taxonomy* check within the soil individual for the presence or absence of spatial and nonspatial differentiae, specific property values, or other qualifications. *Soil Taxonomy* is suitable as the subject of an

object-oriented expert system and planning has begun on development of an automated prototype for the Histosol, Andisol, Spodosol, and Oxisol soil orders. Expert system features coupled with additional models and algorithms can be used to improve the use and user-friendliness of *Soil Taxonomy*.

2.160 Banerjee *et al.* (1998) studied an “**Estimation of Soil Salinity at IARI Farm by Inductive Electro-Magnetic Technique.**” The main advantages of this technique are: rapidity and non-requirement of sample and sample preparation. IEM investigations were carried out at the farm of IARI, New Delhi. Results indicated that the bulk soil electrical conductivity (EC_a) values, computed from IEM survey data, were compared with those measured by the conventional method [EC (1:2 soil: water ratio)] to understand the feasibility of IEM-meter for estimating bulk soil EC values. No effects of soil moisture content, clay content and soil temperature on EC_a were observed. Predictive equations for estimation of bulk soil EC (termed as EC_{pr}) values were subsequently developed and verified from independent observations. The predictive equations were found to be quite different from those reported by Rhoades and others. Finally, the spatial and temporal variations of EC_{pr} were studied to have the present status of soil salinity at the IARI farm.

2.161 Dipak Sarkar & Abhijit Haldar (1998) studied “**A Comparison of Different Methods for pH Determination in Soils of West Bengal.**” Soil pH was determined in water 0.01M $CaCl_2$ and 0.1 M KCl at 1:2, 1:2:5 and 1:5 soil: solution ratio and were found to be correlated over a wide range. The regression equations obtained in fairly large number soils of West Bengal under certain rigid laboratory conditions were

similar to those obtained in comparative studies from Britain (Davies 1971). The regression equation obtained for 0.01M CaCl₂ versus water medium was found to be $\text{pH}_{\text{Ca}} = 1.05 \text{ pH}_{\text{w}} - 0.77$ and is valid strictly for non-saline, net negatively charged soils. In general, the release of H⁺ [cmol (p⁺) kg⁻¹] ions was linearly related to increased dilution ratio. Moreover soil/solution-shaking time in excess of few hours is undesirable as there was fluctuation in pH with time, as stability was not attained. Reversal in trend of pH-dilution curve was noted at lower soil solution-dilution ratio if sufficient reaction time was allowed.

2.162 Jogendra Kumar and Room Singh (1998) studied “**Phosphorus Adsorption and Release Characteristics of Some Soils in Tarai and Bhabar Regions of Uttar Pradesh.**” A plot culture study was conducted phosphorus adsorption and release characteristics of two soil each from *tarai* (Mollosils) and *bhabar* (Entisols) regions of Uttar Pradesh. Langmuir constants of P sorption capacity (b) and P affinity (k) ranged from 110.2 to 142.2 mg kg⁻¹ and 0.43 to 1.31 L mg⁻¹, *respectively. The cumulative release of P had high level positive relationship with the supply parameter ($r = 0.968^{***}$), irrespective of the level of P. *Tarai* soils with slightly lower pH, clay content and CEC than the *Bhabar* soils, did not differ appreciably in respect of adsorption, desorption and supply parameter of P, owing to their similar mineralogical make-up.

2.163 Bhattacharyya et al. (1998) investigated “**Soil Formation as Influenced by Geomorphic Processes in the Brahmaputra Flood Plains of Assam.**” Different geomorphic feature were identified on the Brahmaputra flood plains. These features such as *levees*, *back swamps*,

meander scroll and *oxbow lakes* were formed through the depositional processes of lateral and vertical accretion. Three representative soil series formed on different geomorphic features are described with respect to their morphological, physical and chemical properties and classified taxonomically. Due to continuous shifting of course of the Brahmaputra river and its tributaries, genetic development in any of the soil is not conspicuous. Observations also indicated that in the Brahmaputra valley, the geomorphic processes of erosion and accretion are more active than pedogenic processes of soil formation.

2.164 Singh and co-workers (1998) studied a “**Genesis of Some Soils of Goa.**” Five pedons widely occurring in Goa were studied for their and classification. Clay/Fe₂O₃ ratio, degree of hydration and organic carbon content alone or in combination contributed significantly towards the expression of soil colour. Higher Al₂O₃/Fe₂O₃ at the surface and lower in the subsurface provided confirmatory evidence of clay translocation. Clay/Fe₂O₃ registered similar trend of distribution as indicated by clay up to the Argillic horizon suggesting their combined movement pH potential was governed by relative amount of Fe₂O₃ and SiO₂. The soils from ferruginous quartzite were richest in sesquioxide content followed by the soils from phyllites and schistose rocks. The silica content established the reverse trend of distribution as shown by sesquioxide. These were classified in Ultic Haplustalfs, Ultic Rhodustalfs and Oxic Dystropepts subgroups.

2.165 Sidhu and co-workers (1998) studied “**Elemental and Mineralogical Composition of Coarse Fractions of Some Soils of Aravallies-Yamuna River Transect in North-West India.**” In general, all the

elements (except SiO_2) increased with decrease in particle size fraction. The soils are relatively rich in alkali and alkaline earth elements indicating moderate degree of weathering of their source minerals. The soils developed on hills and upper piedmont plains are originated from garnetiferous mica-schist rich parent materials of Aravallies. The soils on active flood plain originated from the alluvium of Yamuna are rich in amphiboles and pyroxene. The soils on lower piedmont plain and on old flood plain were of intermixed parent materials of two distinct physiographic setting.

2.166 Singh *et al.* (1998) studied “**Mineralogy of Some Important Soils of Sona Basin.**” In the old alluvial soils representing Dulhingaon, Agiaon, Kapsandi and Suhiya series (Psammentic/ Udic Haplustalfs and Typic Haplusterts) which have developed on alluvium derived from the rocks like granite-gneiss, basalt, quartzite, etc., the clay minerals seem to be geogenic and pedogenic. The dominance of kaolinite in upland soils of Dulhingaon series may be due to their acidic and well drained environment, while illite in the soils of Agiaon series is due to high K content. Mica and hydrous mica are found to be derived from feldspars. A portion of kaolinite seems to be inherited from the parent material. Some of orthoclase feldspars appear to have weathered to kaolinite. The formation of smectite appears to be under basic environment, impeded drainage and water logging.

2.167 Kumaraswamy and Co-workers (1998) reported a “**Cumulative Effects of Continuous Cropping and Manuring of Sugarcane on Organic Matter and NPK Status of the Soil.**” Continuous cropping with different manure-fertilizer schedules for 29 years had no marked

change on EC and pH of the soil. Organic C content had increased markedly, particularly in the surface layer soil in the treatments that received pressmud for every crop of sugarcane. There was no appreciable build up of N and K in the soil inspite of application of these nutrients to each crop over the years. There was a significant build up of P in the soil in treatments receiving, P every years. Available P status was appreciably higher in treatments receiving pressmud than in treatments without pressmud.

2.168 Santhy *et al.* (1998) studied a “**Long Term Fertilizer Experiments- Status of N, P and K Fractions in Soil.**” A study was taken up in the existing Long Term Fertilizer Experiment in Tamil Nadu Agricultural University, Coimbatore, conducted since 1972 to know the status and content of various macronutrient fractions and their effects on crop yield, uptake and nutrient availability in the soil. Exchangeable $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ were significantly increased by incremental additions of N. Inclusion of FYM along with inorganic fertilizers, had a positive effect on the build up of all the organic N fractions. There was a build up in total-P content and it was maximum with 150 per cent NPK applications. N-alone application drastically reduced the concentration of available P. The Ca-P constituted the dominant inorganic P form. Available K revealed a negative balance due to continuous with a decrease of 22 per cent from the initial level. Lattice K constituted a dominant fraction of K and water soluble K proved to be the deciding factor in predicting yield variations.

2.169 Walia and co-workers (1998) reported a “**Profile Distribution of Various Forms of Nitrogen and C/N Ratio in Some Landforms of**

Bundelkhand Region of Uttar Pradesh.” Total N was positively correlated with organic carbon content of soils of different landforms but did not follow consistent pattern of distribution within the profile in majority of the soils due to leaching of N and fluvial characteristics. Mineral N (NH_4^+ , NO_3^-) accounted for 0.6 to 4.2 per cent of total N, which was dominated by $\text{NH}_4\text{-N}$ and its distribution in the profile varied with profile characteristics and age of landform. Some soils have nearly same available N content despite large variations in organic carbon and total N, which may be attributed to variation in other factors in soils such as C/N ratio of organic matter, texture, mineralogy and bulk density which probably brought about similar N mineralization rates. In alluvial landforms the pattern is not clear but Vertisols containing smectitic clays showed lowest per cent of available N of its total N in comparison to soils of other landforms. The C/N ratio of surface soils varied from 8 to 13.5 and decreased from hills to plains.

2.170 Clough *et al.* (1998) studied a “**Fate of ^{15}N labelled urine on four soil types.**” A field lysimeter experiment was conducted over a 406 day to determine the effect of different soil types on the fate of synthetic urinary nitrogen (N). Soil types included a sandy loam, silty loam, silty loam, clay and peat. Synthetic urine was applied at $1000 \text{ kg N ha}^{-1}$, during a winter season, to intact soil cores in lysimeters. Leaching losses, nitrous oxide (N_2O) emissions, and plant uptake of N were monitored, with soil ^{15}N content determined upon destructive sampling of the lysimeters. Plant uptake of urine-N ranged from 21.6 to 31.4%. Soil type influenced timing and form of inorganic-N leaching. Macropore flow occurred in the structured silt and clay soils resulting in the leaching of urea. Ammonium ($\text{NH}_4^+\text{-N}$), nitrite ($\text{NO}_2^-\text{-N}$) and nitrate

(NO₃⁻-N) all occurred in the leachates with maximum concentrations, varying with soil type and ranging from 2.3-31.4 μg NH₄⁺-N mL⁻¹, 2.4-35.6 μg NO₂⁻-N mL⁻¹, and 62-102 μg NO₃⁻-N mL⁻¹, respectively. Leachates from the peat and clay soils contained high concentrations of NO₂⁻-N. Gaseous losses of N₂O were low (< 2% of N applied) over a 112 day measurement period. An associated experiment showed the ratio of N₂-N: N₂O-N ranged from 6.2 to 33.2. Unrecovered ¹⁵N was presumed to have been lost predominantly as gaseous N₂. It is postulated that the high levels of NO₂⁻-N could have contributed to chemodenitrification mechanisms in the peat soil.

2.171 Laboski (1998) studied a “**Soil strength and water content influences on corn root distribution in a sandy soil.**” Since root distribution influences crop water and nutrient absorption, it is essential to identify factors limiting root growth. The objective of this study was to determine the factor(s) limiting corn-rooting depth on an irrigated fine sand soil. Bulk density, saturated hydraulic conductivity, and soil water retention were measured on undisturbed soil cores. Corn root distribution assessed at tasseling over a 3-yr period showed an average of 94% of total root length within the upper 0.60 m of soil with 85% in the upper 0.30 m of soil. Mechanical impedance was estimated with a cone penetrometer on two dates with differing water contents. Cone penetrometer measurements greater than 3 MPa indicated mechanical impedance in soil layer extending from 0.15 to 0.35 m deep. Penetration resistance decreased as soil water content increased. However, soil water contents greater than field capacity was required to decrease penetration resistance below the 3 MPa thresholds. Such water saturated conditions only occurred for short periods immediately after

precipitation or irrigation events, thus roots usually encountered restrictive soil strengths. The soils layer from 0.15 to 0.60 m had high bulk density, 1.57 Mg m^{-3} . This compacted soil layer, with slower saturated hydraulic conductivities (121 to 138 mm hr^{-1}), held more water than the soil above or below it and reduced water movement through the soil profile. Crop water use occurred to a depth of approximately 0.75 m . In conclusion, a compacted soil layer confined roots almost entirely to the top 0.60 m of soil because it had high soil strength and bulk density. The compacted layer, in turn, retained more water for crop use.

2.172 Pareek and co-worker (1998) studied an “**Adsorption /Desorption Behaviour of Selenium in Alluvial Soils of Punjab.**” Laboratory studies were conducted to investigate the adsorption/ desorption behaviour in alluvial soils of seleniferous and non-seleniferous regions of Punjab. Adsorption of Se by different soils from the equilibrium solutions containing 1 to $100 \mu\text{g mL}^{-1}$ could be described by Langmuir and Freundlich equations for the entire range of concentration used in the study. Adsorption maximum was highest for Barwa soil ($460.8 \mu\text{g g}^{-1}$) from seleniferous region, whereas, binding energy was more for Gurdaspur soil (0.207 mL g^{-1}) from non-seleniferous region. Significant positive relationship existed between adsorption maximum and cation exchange capacity ($r = 0.930^*$) as well as clay ($r = 0.986^{**}$) content of soils. The amount of Se desorbed in KCl (water-soluble) was relatively higher than desorbed in KH_2PO_4 (exchangeable) in all the soils except Gurdaspur soil. On an average, water-soluble and exchangeable Se together constituted 78.7 to 95.6 per cent of total adsorbed Se on all the soils.

2.173 Wander, Bidart and Aref (1998) reported a “**Tillage Impacts on Depth Distribution of Total and Particulate Organic Matter in Three Illinois Soils**”. The benefits of no-tillage (NT) practices to soil matter (SOM) were inconsistent in fine-textured, poorly drained soils. Tillage impacts on SOM were investigated in central Illinois, assuming particulate organic matter (POM) would accumulate where SOM aggraded. Soils were collected in 1994 and 1995 from a trial established in 1985 at Perry and Monmouth (somewhat poorly drained Aquic Argiudoll silt loam), and DeKalb (a poorly drained Typic Haplaquoll silty clay loam). In general, NT practices increased SOM-C and POM-C contents 25 and 70% compared with conventional till (CT) at the soil surface (0-5 cm). This was at the expense of C at depth (5-17.5 cm), which decreased by 4 and 18%, respectively. Tillage effects varied among sites. No-till increased SOM C and POM C more than 30 and 100%, respectively, in the top 5 cm of the two silt loams. In the silty clay loam, NT reduced SOM C 14% in the 5- to 17.5-cm depth and POM C more than 20% in the 5- to 30-cm depth. Bulk density was greater under NT than CT at the DeKalb (0-17.5 cm) and Monmouth sites (0-5 cm). No-till only increased C and N sequestration, assessed on an equivalent mass basis, at Monmouth. Accumulation of POM in the surface depth of the NT silt loams may have improved soil quality in those erosion-prone soils. Reduced POM contents in the NT silt clay loam reflect SOM degradation. The high clay and organic matter content and low bulk density of the DeKalb soil may have contributed to the atypical effect of NT practices on SOM at that site.

2.174 Shang and Tiessen (1998) studied “**Organic Matter Stabilization in Two Semiarid Tropical Soils: Size, Density and Magnetic Separations.**” Soil organic matter (SOM) in many tropical soils is less

stable than that of temperate soils, in part due to faster decomposition processes in the tropics, but possibly also due to different mechanisms of organomineral stabilization. We studied the mineral associations of SOM in the surface horizons of two semiarid tropical soils (an Oxisol and an Alfisol) using particle-size, density, and magnetic separations. The inorganic phases of fractionated materials were examined using chemical extraction and x-ray diffraction. Organic matter associated with the sand fraction accounted for 21 to 30% of soil C, mostly as coarse, floating material. This coarse material was more abundant in the Alfisol. One-half the organic C of both soils was associated with the silt-sized fraction, which contained a substantial portion of micro-aggregates resistant to sonication. Carbon in silt-sized aggregates was mainly stabilized by association with poorly crystalline oxides and by aggregation with crystalline oxides and clays. The C as light matter ($<1.8 \text{ g cm}^{-3}$) liberated from silt-size micro aggregates by successive sonication treatments accounted for $\approx 23\%$ of total soil C for both soils. The SOM in the $< 1.8 \text{ g cm}^{-3}$ fraction seemed younger and less decomposed than the organic materials in the temperate soil fractions with similar density and equivalent sizes. In clays, C was concentrated in fractions of intermediate magnetic susceptibility, whereas both the highly magnetic fraction of predominantly well-crystallized Fe and the nonmagnetic fraction were C poor. The study points to the important role of particle size and crystallinity of Fe oxides and micro aggregation between oxides, organic matter, and other minerals in stabilizing tropical soil organic matter.

2.175 *McCarty et al. (1998)* studied “**Short-term Changes in Soil Carbon and Nitrogen Pools during Tillage Management Transition.**” It is well established that distribution of organic C and N within a soil

profile is substantially influenced by long-term conversion of soil from plow-tillage management, but little is known about the short-term changes in the character of soil organic matter during transition between these two soil management systems. To characterize the changes in composition of organic C and N pools in soil during tillage transition, we measured total N, organic C, active N, biomass N, and biomass C at depth intervals of 0 to 2.5, 2.5 to 5, 5 to 12.5, and 12.5 to 20 cm within the profile of soil during the first 3 yr in the transition from plow tillage to no tillage. The results obtained showed that transformation of a soil profile from that typical of plow tillage management to one characteristic of no tillage occurred rapidly within a 3-yr period of transition. In this time period, stratification of organic matter in the profile progressed significantly toward that which occurs after 20 yr of no-tillage treatment. For example, substantial increases in total N (30%), organic C (38%), biomass N (87%), and biomass C (33%) were detected in the top layer of no-tillage soil along with corresponding decreases of 6%, 7%, 35%, and 15% of those respective components in the bottom layer. With transition, the biomass C, biomass N, and active N pools increased more rapidly in the upper soil profile than did the total pools of C and N. Although the characteristic profile of no-tillage soil developed quickly during tillage transition, evidence was equivocal for any significant increase in organic matter content within the first 3-yr after conversion to no-tillage management.

2.176 Drury *et al.* (1998) studied a “**Long-Term Effects of Fertilization and Rotation on Denitrification and Soil Carbon.**” This laboratory study explored the effect of long-term (35 yr) fertilization and crop rotation on soil organic C and denitrification capacity at different depths of a Brookston clay loam soil (fine-loamy, mixed, mesic Typic Argiaquoll).

We related denitrification capacity to soil biochemical (CO₂ production, organic C, microbial biomass C, soluble organic C) and soil structural properties. Denitrification capacity was determined as the increase in N₂O that occurred when NO₃⁻-amended soils were incubated anaerobically in the presence of acetylene. Treatments included fertilized and nonfertilized plots of continuous corn (*Zea mays* L.), continuous bluegrass (*Poa pratensis* L.), and rotation corn (corn-oat [*Avena sativa* L.]-alfalfa [*Medicago sativa* L.]-alfalfa). Soils from an adjacent mixed deciduous woodlot were also sampled. Soils from the woodlot had higher denitrification capacities than the continuous or rotation corn treatments. Among the agricultural treatments, the soil under bluegrass had the greatest denitrification capacity followed by the soil under corn rotation, with the continuous corn having the lowest capacity. Long-term fertilization resulted in 35% higher denitrification capacity and 65% higher CO₂ production than nonfertilized soils. Denitrification capacity across all depths in the agricultural soils was correlated with CO₂ production ($r^2 = 0.76$), microbial biomass C ($r^2 = 0.60$), and organic C ($r^2 = 0.54$); however, the relationship between denitrification capacity and soil structure was not as strong ($r^2 = 0.28$).

2.177 Page-Dumroese *et al.* (1999) studied a “**Comparison of Methods for Determining Bulk Densities of Rocky Forest Soils.**” Measurement of forest soil bulk density is often hampered by coarse fragments. In this study, five methods to determine total and fine bulk density and coarse-fragment content of a rocky forest soil in western Montana were evaluated. Two methods of core sampling (small and large diameter cylinders), two methods of soil excavation and volume determination (water and polyurethane foam), and a nuclear source moisture gauge

were tested at two depths (0-10 cm and 10-20 cm) on a soil with a 35% slope and 45% rock content. In the surface 10 cm, total and fine soil bulk density values were greatest from the nuclear gauge. The two excavation techniques gave similar results. Volumetric rock-fragment content calculations using the small diameter cylinder were significantly lower than those using the other methods. At the 10- to 20-cm depth, all methods except the large diameter cylinder gave comparable results for total soil bulk density. The small diameter core method gave the highest estimate of fine bulk density at this depth.

2.178 Johannisson and co-worker (1999) studied “Retention of Nitrogen by a Nitrogen-Loaded Scotch Pine Forest.” The studied N retention in a Scotch pine (*Pinus sylvestris* L.) forest that had received two decades of annual additions of N as NH_4NO_3 at four rates ($\text{N}_0\text{-N}_3$, equivalent to 0, 36, 72 and 108 kg N $\text{ha}^{-1} \text{yr}^{-1}$), with and without supplementary additions of P and K. The highest N treatment (N_3) was suspended three years before this study. Leaching of inorganic N was measured beneath lysimeters with and without living tree roots inside them, and the fate of ^{15}N injected into the more layer was traced by sampling understory vegetation, soil to 20-cm depth, and leachates. Leaching of inorganic N increased with increasing N dose and was dominated by NO_3^- on plots to which N had been added. In the suspended N_3 treatment, leaching of N was lower than in the N_2 treatment. The presence of tree roots greatly reduced leaching of N. The occurrence of labelled NO_3^- under lysimeters to which labelled NH_4^+ had been added showed that nitrification was important in treatment N_2 , but not in N_1 , suggesting that additions of $> 30 \text{ kg N ha}^{-1} \text{yr}^{-1}$ are needed to induce larger net nitrification at this site. Our data showed (i) that trees

were an important sink for N, (ii) that additions of P and K had a marginal positive effect on N retention, and (iii) that leaching from previously N-loaded forest rapidly decreased when the N load was removed.

2.179 Kodesová *et al.* (1999) studied the **“ESTIMATION OF SOIL HYDRAULIC PROPERTIES WITH THE CONE PERMEAMETER: FIELD STUDIES.”** The cone permeameter was designed to inject water into the soil under known pressure. The cumulative inflow volume and pressure heads measured with tensiometer rings at two locations above the water source are recorded in time. The observed data sets are analyzed using an inverse modeling method to predict the soil hydraulic properties. The device was field tested for the first time in two types of sandy soil. Tests were always conducted with two sequentially applied pressure heads of different magnitudes for different experimental runs. After the water source was shut off, tensiometer measurements were continued to monitor the redistribution of water in the soil. To study the impact of one on two steps of applied pressure head on estimates of wetting soil hydraulic properties, we carried out numerical inversions for data from the injection (wetting) part of experiment, first with only one supply pressure head and then with two supply pressure heads. For selected tests we analyzed data from the entire experiment to investigate hysteresis of the soil hydraulic properties. The resulting soil hydraulic properties correspond well with those obtained with standard techniques.

2.180 Baoshan Xing and Zhengqi Chen (1999) studied **“SPECTROSCOPIC EVIDENCE FOR CONDENSED DOMAINS IN SOIL ORGANIC**

MATTER.” This paper was to provide some spectroscopic evidence of condensed domains in SOM. Six humic acids (HA) extracted from different depths of a single soil profile were analyzed using X-ray diffraction (XRD) and solid-state ^{13}C nuclear magnetic resonance (NMR) with cross-polarization (CP) and magic angle spinning (MAS) techniques. The XRD results showed a strong peak at 0.35 nm for the condensed aromatic structure of the HA from mineral horizons and a dominant peak at 0.43 nm for less tightly packed side chains of the HA from surface organic horizons. The ^{13}C CP/MAS NMR results indicated further that HA becomes more aromatic from surface organic to mineral horizons. This increase of aromatic structure in HA was confirmed by the increase of nonprotonated carbon signals at 130 ppm using a dipolar-dephasing technique and by the increase of atomic C/H and C/O ratios. These spectroscopic and elemental data corroborate further the dual-mode model for the sorption of HOC in SOM.

2.181 Robert D. Hall (1999) studied “**A COMPARISON OF SURFACE SOILS AND BURIED SOILS: FACTORS OF SOIL DEVELOPMENT.**” There are at least as many soils (really types of soil) in the Sangamon Soil (used here in a stratigraphic sense) as there are in the complex of surface soils on today’s landscape. The Sangamon Soil soils formed in parent material similar to the parent material of the surface soils, and the variation in soil drainage was probably similar too. In buried soils, soil drainage is inferred from color and from interpretations of the positions of the buried soils on the paleolandscape. The sedimentological properties of the parent materials aid greatly in the interpretation of paleolandscapes.

By placing all soils in four drainage classes and comparing soil characteristics within and between classes, and by paying attention to parent material variations and the possibly different times of development of soils, differences in soil drainage and parent material seem to be more important in explaining differences in soil characteristics within the buried soils than within the surface soils. The buried soils have characteristics that indicate more extensive pedogenesis than the surface soils. This difference is believed to be a reflection of the duration of pedogenesis, with the buried soils having a longer formation period by a factor of about 4.5.

2.182 J.M. Arocena and P. Sanborn (1999) studied a “**Mineralogy and genesis of selected soils and their implications for forest management in central and northeastern British Columbia.**” The sampled of nine pedons developed on till (Bobtail, Lucille Mountain, Skulow Lake, Log Lake, Topley, and Kiskatinaw), glaciofluvial (Bowron), and glaciolacustrine (Aleza Lake 1, 2) deposits. The Skulow Lake pedon is distinctive in the occurrence of talc, while the Lucille Mountain pedon has the only clay fraction in which kaolinite is absent. Other pedons on till contain mica, kaolinite, chlorite, smectite, and vermiculite. The Bowron pedon has mica, kaolinite, and chlorite, while the Aleza lake pedons have mica, kaolinite, chlorite, and 2:1 expanding minerals. In pedons with low amount of 2:1 expanding clays in the C horizon, mica and chlorite appear to degrade into 2:1 expanding clays, while in pedons with C horizons containing 2:1 expanding clays, mica and chlorite seem stable and the formation of hydroxyl-interlayered clays in the predominant process. Podzolization and lessivage are major pedogenic processes, while redoximorphic processes are observed in

some pedons with illuvial Bt horizons. Significant soil compaction hazards are presented by the medium and fine soil surface texture. Although clay-rich Bt horizons may benefit soil nutrient regimes, conservation of nutrient-rich forest floors is important, given the low S contents in mineral soils. High contents of feldspars in these soils provide a large reserve of nutrients such as Ca and K.

2.183 Pennock *et al.* (1999) studied “**Effects of soil redistribution on Soil properties in a cultivated Solonetzic-Chernozemic landscape of southwestern Saskatchewan.**” Their research site in southwestern Saskatchewan a clear landscape-scale pattern of soil distribution occurred. Regosolic and thin Chernozemic soils were associated with the long, gentle (2-5%) slopes and solonetzic – Influenced soil were associated with higher catchment area foot slope and depressional positions. High rates of soil loss occurred throughout the landscape- overall a net soil loss of 31 Mg ha yr⁻¹ was calculated using ¹³⁷Cs redistribution techniques. No net depositional sites were observed in the 45 sampling points in the landscape, suggesting that the site was dominated by wind erosion. The high rates of loss were consistent with very low levels of soil organic carbon storage (37 to 46 Mg ha⁻¹ to 45 cm) at all slope positions in the landscape and with the occurrence of sub-soil features in the plough layer. The Solonetzic-influenced soils occupy 38% of the site and have high sodium adsorption ratios (from 18 to 38 in the B horizon) and high soil resistance values as determined with a penetrometer. For the Solonetz and Solodized Solonetz soils these growth-limiting properties occur immediately below the 10-cm plough layer and many constitute a largely irreversible decrease in their productive capacity.

- 2.184 Sun and co-worker (1999)** investigated “**The effect of soil electrical conductivity on moisture determination using time-domain reflectometry in sandy soil.**” A series of laboratory experiments was conducted, in order to systematically explore the effect of soil electrical conductivity on soil moisture determination using **time domain reflectometry (TDR)**. A Moisture Point MP-917 soil moisture instrument (E.S.I. Environmental Sensors Inc., Victoria, BC, Canada) was used to measure propagation time (time delay) of a step function along a probe imbedded in fine sand with different moisture and salinity. The volumetric soil water content was independently determined using a balance. With the help of the diode-switching technique, MP-917 could detect the reflection from the end of the probe as the electrical conductivity of saturated soil extract (EC_e) increased to 15.29 dS m^{-1} . However, the relationship between volumetric soil water content and propagation time expressed as T/T_{air} (the ratio of propagation time in soil to that in air over the same distance) deviated from a linear relationship as the conductivity exceeded 3.72 dS m^{-1} . At the same water content, the time delay in a saline soil was longer than that in a non-saline soil. This leads to an over-estimation of volumetric soil water content when the linear calibration was applied. A logarithmic relationship between volumetric soil water content and T/T_{air} has been developed and this relation includes soil electrical conductivity as a parameter. With this new calibration, it is possible to precisely determine the volumetric water content of highly saline soil using TDR.
- 2.185 Amponsah et al. (1999)** investigated “**Soil sampling size estimates for soils under teak (*Tectona grandis* Linn. F) plantations and natural forests in Ashanti Region, Ghana.**” Site selected for this study were in

the moist semideciduous forest zone and had nearly identical physiographic characteristic. A simple random sampling procedure was used to obtain soil samples at each site. In each of three natural forest stands and three teak plantation, 16 soil pits were examined and soil samples from the 0- to 20-cm (major rooting depth) and 20- to 40-cm depths were analysed for selected chemical and physical properties. In the 0- to 20-cm depth, coefficients of variation varied from 8% (pH) to 72% (available P), and in the 20- to 40-cm depth from 16% (pH) to 116% (available P) under teak plantations. Similarly, in the 0- to 20-cm depth coefficients of variation varied from 11% (pH) to 40% (exchangeable K) and in the 20- to 40-cm depth from 10% (bulk density) to 86% (available P) under natural forests. Under both cover types, more samples were required to estimate means at $\pm 10\%$ allowable error with a confidence level of 95% for chemical properties than for physical properties.

2.186 Rodney Bennett *et al.* (1999) studied a “Salinity and sodicity of irrigated Solonetzic and Chernozemic soils in east-central Alberta.”

Two of the study sites consisted mainly of soils classified as Solodized Solonetz, with at least 70% in the Solonetzic order. Two chernozemic sites were almost exclusively Chernozemic soils. A significant increase in soil salinity occurred in the A horizon at one solonetzic site and at both chernozemic sites and in the B horizon of one chernozemic sites. Mean **electrical conductivity** (EC_e) in these horizons for all irrigation treatments was less than or equal to 1dS m^{-1} . Soil sodicity also increased significantly in the A horizon at one solonetzic site, and in the A and B horizons of both chernozemic sites. The mean **sodium adsorption ratio** (**SAR**) of the A horizon at this solonetzic site was 2.9, 4.8, 4.4 and 5.0 for the control, low, medium and high irrigation treatments,

respectively. The SAR in the A horizon at the chernozemic sites was less than 2.6 for all the irrigation treatments. Increases in soil salinity and sodicity were attributed to the chemistry and amount of irrigation water used at each site. Salinization and sodification in addition to the changes associated with the quality and quantity of irrigation water were not evident at any of the sites. The two-cut yield of alfalfa from the solonetzic sites in the third year of growth was about 25% less than from the chernozemic sites and was below the acceptable yield range for irrigated alfalfa in southern Alberta. Our results confirm existing land classification standards in Alberta that exclude solonetzic landscapes from irrigation development where more than about 30% of the soils have an SAR value greater than 12 in any soil horizon within 1 m of the surface.

2.187 Elberling and Jakobsen (1999) studied a “**Soil solution pH measurements using in-line chambers with tension lysimeters.**” The in-line method was designed to eliminate atmospheric contact with soil solutions prior to pH measurements. The time-dependent pH error was quantified based on laboratory experiments with soil solution under controlled temperatures and CO₂ partial pressures. Equilibrium speciation modelling was used to predict pH values observed in the field and in the laboratory and the model was found to reproduce the observations well. We conclude that traditional pH measurements on extracted soil solutions in the pH range from 5 to 7 are not appropriate for detailed pH measurements due to errors associated with CO₂ degassing. In-line measurements provide more accurate measurement necessary for detailed studies on soil acidification dynamics.

2.188 Oorts and co-worker (2004) studied “**A New Method for the Simultaneous Measurement of pH-Dependent Cation Exchange Capacity and pH Buffering Capacity.**” The pH dependent cation exchange capacity (CEC) and pH buffering capacity (pH BC) are two crucial properties in soil fertility management of variable charge soils. However, they are rarely measured, since most of the existing methods are cumbersome and time-consuming. We propose a new method, based on the silver-thiourea (AgTU) method, for the simultaneous measurement of pH dependent CEC and the pH BC. In general, this method consists of first increasing the pH of the soil to about pH 7 and then gradually acidifying the soil by titrating with HNO₃, while measuring pH and CEC after each equilibration. This way, both CEC at different pH values and the pH BC are measured on the same sample, without the multiple washing steps needed in other procedures. Various aspects of the proposed method were tested and the results obtained were compared with the ion adsorption method. The modified AgTU method obtains field relevant results and is suitable for the routine analysis of large numbers of samples.

2.189 Ghose and Kothandaraman (1999) determined a “**COMPARISON OF METHODS FOR DETERMINATION OF ORGANIC PHOSPHORUS IN SOILS OF TAMIL NADU.**” Organic phosphorus content of soils was estimated by three different methods viz., alkali extraction (Mehta *et al.*, 1954); resin acetyl acetone method (Hong and Yammne, 1980) and ignition method (Saunders and Williams, 1955). The extractability power of different methods as judged by ‘t’ test indicated the superiority of alkali extraction compared to other two aforesaid methods irrespective of variation in organic-C status. The extraction use efficiency of alkali method was comparable to resin acetyl acetone

method and superior to ignition method under acidic pH range, while it was found to be the best in neutral and alkaline soil samples.

2.190 Hussain, Olson and Ebelhar (1999) was determined “**Long-Term Tillage Effects on Soil Chemical Properties and Organic Matter Fraction.**” Change in frequency and intensity of tillage practices alters the soil properties, distribution of nutrients, and soil organic matter in the soil profile. We hypothesized that 8 yr of no-till (NT), chisel plow (CP), and moldboard plow (MP) treatments would affect chemical properties and organic matter of eroded soil. The corn (*Zea mays* L.)-soybean [*Glycine max* (L.) Merr.] rotation study was established in tall fescue (*Festuca arundinacea* L.) sod on a previously eroded, moderately well-drained, Grantsburg (Fine-silty, mixed, mesic Oxyaquic Fragiudalf) soil in southern Illinois. In the eight year, soil pH, exchangeable Ca, and Bray P-1 were greater in NT than in CP and MP in the 0- to 5-cm soil depth. In the 0- to 5-cm soil depth, exchangeable K and Mg were greater with the CP than with the NT and MP. In the 5- to 15-cm soil depth, exchangeable Ca and Mg were greater in the MP and CP than in NT, due to mixing. Soil pH and P were greater for CP than MP and NT in the 5- to 15-cm layer. Exchangeable K in the 5- to 15-cm soil depth was greater in the MP than CP and NT. In the 0- to 5-cm soil depth, NT, CP, and MP had 38, 35, and 31% of their total C as particulate organic matter (POM), respectively. After 8 yr, CP and MP had less total organic C than NT in the 0- to 5-cm depth. In the 0- to 5-cm soil depth, CP and MP had less POM C than NT. The greater reduction of organic C in the POM fraction than in whole soil showed that POM was the most tillage-sensitive fraction of organic matter. After 8 yr of study, the water-stable aggregates in the 0- to 5-cm soil depth of MP and CP was reduced compared with NT. The effects of

tillage treatment and associated soil erosion either resulted in different findings from tillage treatments on uneroded soil or affected the trend and magnitude of the soil property differences between treatments. For the 10-yr period prior to the establishment of the tillage experiment the site was managed as hayland. At the end of 8 yr, the NT maintained or improved nutrient retention and aggregate stability in the 0- to 5- cm layer compared with MP and CP.

2.191 Puri, Jaipurkar and Bajpai (1999) studied a “**INFLUENCE OF SOIL FERTILITY STATUS AND APPLICATION OF PRIMARY NUTRIENTS (NPK) ON CHEMICAL COMPOSITION AND OIL CONTENT OF MUSTARD (*Brassica Juncea* Linn.), GROWN IN VERTISOLS**”. Significant influence of varying degree of soil fertility status on nutrient concentration (N and P) and oil content in seed was noted. Relative mean concentrations of major nutrients (%) were in the following order: N(2.1) > K(0.76) > P(0.62) > Ca (0.566) > Mg(0.225) > S(0.218). The removal of major nutrients was significantly affected by fertilization. The N and P contents in seed, total removal of nutrients (N, P, K), seed yield and oil content were significantly affected by level of fertilisation (N, P, K). The highest seed yield (16.8 kg ha⁻¹) and oil content (39.72%) were noted in the treatment 100:40: 20 kg N, P, K ha⁻¹. Significant negative correlation coefficient of oil content with protein content ($r = -0.2663^*$), with yield ($r = 0.4292$), seed S content ($r = 0.3242^*$) and seed Mg content ($r = 0.2732^*$) were obtained.

2.192 J. Ingwersen *et al.* (1999) studied a “**Barometric Process Separation: New Method for Quantifying Nitrification, Denitrification, and Nitrous Oxide Sources in Soils.**” A method (Barometric Process,

BaPS) was developed for the quantification of gross nitrification rates and denitrification rates in oxic soil using intact soil cores incubated in an isothermal gas tight system. Gross nitrifications rates and denitrification rates are derived from measurements of changes (i) in air pressure within the closed system, which are primarily the result of the activities of nitrification (pressure decrease), denitrification (pressure increase), and respiration (pressure neutral), and (ii) of O₂ and CO₂ concentrations in the system. Besides these biological processes, the contribution of physicochemical dissolution of produced CO₂ in soil water to the pressure changes observed is to be considered. The method allows collection of additional information about the contribution of nitrification and denitrification to N₂O emission from soil, provided simultaneous measurements of N₂O emission are performed. Furthermore, BaPs can be used to quantify the percentage of N₂O lost from nitrification. The advantage of BaPS is that disturbance of the soil system is minimized compared with other methods such as the use of gaseous inhibitors (e.g. acetylene) or application of ¹⁵N compounds to the soil. We present the theoretical considerations of BaPS, results for nitrification rates, denitrification rates, and identification of soil N₂O sources in a well-aerated coniferous forest soil using BaPS. The suitability of BaPS as a method for determination of gross nitrification is demonstrated by validation experiments using the ¹⁵N-pool dilution technique.

2.193 C. Wayne Honeycutt (1999) studied a “**Nitrogen Mineralization from Soil Organic Matter and Crop Residues: Field Validation of Laboratory Predictions.**” This study was conducted to assess the utility of microplot cylinders with mixed-bed exchange resins for

monitoring field N mineralization, to compare laboratory predictions with field measurements of N mineralization, and to determine the impact of using ground (≤ 1 mm) crop residues in the laboratory to predict N mineralization of unground (≤ 25 mm) residues in the field. Nitrogen mineralization from soil organic matter and hairy vetch (*Vicia villosa* Roth) residues was followed in the laboratory at 15, 20, and 25 °C with 0, 2150, 4300, and 6450 kg vetch ha⁻¹ equivalent loading rates of ≤ 1 mm particle-size residue. Ground and unground residues were added to microplot cylinders at loading rates equivalent to 0, 4028, and 5010 kg vetch ha⁻¹ and installed in potato (*Solanum tuberosum* L. Norwis) crop rows in two growing seasons. Nitrogen mineralization from soil organic matter under field conditions was overestimated by laboratory predictions; however, field measurements of N mineralization from both ground and unground vetch residues were closely predicted by a complementary laboratory study. These data indicate vetch residue N mineralization under these modified field conditions (i.e., microplot cylinders) can be predicted from laboratory studies that use ground residues, constant temperatures, and variable residue quantities. This finding may advance our ability to model and account for residue N mineralization when developing N management recommendations.

2.194 Roger E. Smith (1999) investigated a “**TECHNICAL NOTE: RAPID MEASUREMENT OF SOIL SORPTIVITY.**” A simple and fast method is described for measuring surface soil sorptivity, *S*. Rather than measure the progress of infiltration flux for a long initial period, the cumulative infiltration is measured in the early stage in which the gravity effect is negligible. The theory behind the method is sound and

simple, and measurements may be taken in only a few minutes using a small single ring. It is applicable to find S for both ponded and flux surface boundary conditions.

2.195 Schwarz *et al.* (1999) investigated a “**Heavy Metal Release from Soils in Batch pH_{stat} Experiments.**” In Slovakia H^+ input soils is increasing because alkaline dust emissions have been reduced since 1990. Our objectives were to examine (i) the metal release in H^+ buffer reactions of Slovak soils and (ii) the impact of the proton buffering on heavy metal partitioning. We used 10 soils (pH 7.4 – 3.6) in a batch pH_{stat} experiment. Released ions were adsorbed to an ion-exchange resin, while pH was kept constant. After reaction times of 10 min, 30 min, 1, 2, 4, 24, 48, and 96 h, soil and ion-exchange resin were separated and ions were extracted from the resin. After 0, 4, and 96 h, we determined metal concentration in seven fractions. On average, the total release after 96 h (in percentage of the total concentration) decreased in the order: Cd (74) > Pb (59) > Cu (29) > Zn (22) > Ni (17) > Cr (3.1), while the initial release rate into solution decreased in the order: Cd > Zn > Ni > Cu > Pb > Cr. After 48h, only the Cr release rate was lower than that of Cd. Particularly in less acid soils, Pb, Cu, Zn and Cd released by the dissolution of oxides were adsorbed onto the soil matrix, explaining the slower decrease of the Pb and Cu release rates. The percentages of weakly bound heavy metals decreased more markedly during the titration than those of metals bound to Fe oxides. Increased H^+ inputs into Slovak soils will cause enhanced metal release into soil solution.

2.196 Poudel and West (1999) investigated a “**Soil Development and Fertility Characteristics of a Volcanic Slope in Mindanao, the**

Philippines.” Thirteen pedons representing the mountains, the upper footslopes, the lower footslopes, and the alluvial terraces of a volcanic slope in Mindanao, the Philippines were studied to understand relationships between the degree of soil development and fertility characteristics. Soils in the upper and the lower footslopes were Oxisols as were soils in the alluvial terraces, while those in the mountains were Ultisols and Inceptisols. Presence of “amorphous components”, such as allophone and imogolite, in all the pedons studied was indicated by a > 9.4 soil pH in NaF. Halloysite, gibbsite, goethite, hematite, and cristoballite were more common minerals in the clay fraction. Surface layers of all the pedons were slightly acidic and pH increased by depth. Phosphate sorption maxima ranged from 6944 to 14208 $\mu\text{g P g}^{-1}$, and it was closely associated with oxalate-extractable Al (Al_0) and clay content. Inceptisols had higher phosphate sorption maxima than Oxisols. Soil samples representing the mountains showed the lowest level of both the available K and the potential buffering capacity for K (PBC^{K}), while the upper footslopes had the highest level of available K. The PBC^{K} values were lower for Inceptisols than for Oxisols, and they were found to be positively correlated with soil pH. There was a large difference between the cation-exchange capacity (CEC) and the effective cation-exchange capacity (ECEC), an indication of a large pH-dependent charge. Mountain soils showed lower base saturation than soils representing the upper footslopes, the lower footslopes, and the alluvial terraces.

2.197 Mahiev *et al.* (1999) studied a “**Statistical Analysis of Published Carbon-13 CPMAS NMR Spectra of Soil Organic Matter.**” They have collected solid-state ^{13}C nuclear magnetic resonance (NMR) data from the published literature (76 papers) and from our own results on

311 whole soils, physical fractions (25 clay-, 43 silt-, and 52 sand-size fractions) and chemical extracts (208 humic and 66 fulvic acids). Our purpose was to see whether a comprehensive analysis of data on >300 soils that ranged in organic C content from 0.42 to 53.9% would show any universal influence of management practice on the chemical composition of soil organic matter (SOM). The relative abundance of functional groups was calculated for the following chemical shift regions: 0-50 ppm (alkyls), 50-110 ppm (O-alkyls), 110-160 ppm (aromatics), and 160-200 ppm (carbonyls). There was a remarkable similarity between all soils with respect to the distribution of different forms of C despite the wide range of land use (arable, grassland, uncultivated, forest), climate (from tropical rainforest to tundra), cropping practice, fertilizer or manure application, and the different spectrometer characteristics and experimental conditions used. Functional groups in whole soils were always in the same abundance order despite the generally wide proportion range: O-alkyls (a mean of 45% of the spectrum, increasing with C content), followed by alkyls (mean 25%), aromatics (mean 20%), and finally carbonyls (mean 10%, decreasing with soil C content). Humic and fulvic acids contained much smaller proportions of O-alkyls than whole soils (means of 26%). Clay-size fractions were the most different from whole soils, being more aliphatic (+8%). Sand-size fractions generally gave very similar results to whole soils.

2.198 Page-Dumroese *et al.* (1999) reported a “**Comparison of Methods for Determining Bulk Densities of Rocky Forest Soils.**” In this study, five methods to determine total and fine bulk density and coarse-fragment content of a rocky forest soil in western Montana were evaluated. Two methods of core sampling (small and large diameter

cylinders), two methods of soil excavation and volume determination (water and polyurethane foam), and a nuclear source moisture gauge were tested at two depths (0-10 cm and 10-20 cm) on a soil with a 35% slope and 45% rock content. In the surface 10 cm, total and fine soil bulk density values were greatest from the nuclear gauge. The two excavation techniques gave similar results. Volumetric rock-fragment content calculations using the small diameter cylinder were significantly lower than those using the other methods. At the 10- to 20-cm depth, all methods except the large diameter cylinder gave comparable results for total soil bulk density. The small diameter core method gave the highest estimate of fine bulk density at this depth. All methods are easy to use. Soil excavation using the polyurethane foam for volume determinations is the simplest method and has low standard errors.

2.199 Bouma, Droogers and Peters (1999) were “Defining the ‘Ideal’ Soil Structure in Surface Soil of a Typic Fluvaquent in the Natherlands.” This paper explores a proactive approach in which measurement of basic soil characteristics on a series of standardized structure samples and exploratory simulation modeling are used to define an “ideal” structure, using plant growth and nutrient-use efficiency as indicators. Management practices to realize such an “ideal” structure remain to be designed by others. Quantitative indicators for the “ideal” structure in the 0- to 30-cm surface soil of a loamy, mixed, mesic Typic Fluvaquent (a prime agricultural soil in the Netherlands) were based on simulated yields and associated nitrate leaching. Simulations considered water supply capacity, occurrence of bypass flow and internal catchment, loeaching of nitrates as a function of fertilization scenarios, accessibility of water to roots, and trafficability in spring. Exploratory simulations, using a validated model

for a period of 30 yr to express temporal variability for a complete soil profile with varying topsoil structures, showed a structure consisting of 0.5-cm aggregates and a bulk density of 1.6 g cm^{-3} to be “ideal” for the agricultural land use being considered.

2.200 Seybold *et al.* (1999) was studied “**Soil Resilience a fundamental component of Soil Quality.**” The concept of soil resilience in combination with resistance is presented as an important component of soil quality, a key element of sustainability. Factors that affect soil resilience and resistance are soil type and vegetation, climate, land use, scale, and disturbance regime. Maintenance of recovery mechanisms after a disturbance is critical for system recovery. Three approaches for assessing soil resilience are presented: (i) directly measuring recovery after a disturbance, (ii) quantifying the integrity of recovery mechanisms after a disturbance, and (iii) measuring properties that serve as indicators of those recovery mechanisms. Research is needed in the development of indicators or quantitative measures of the ability of soils to recover from specific disturbances.

2.201 Carlos Manoel Pedro Vaz *et al.* (1999) studied a “**SOIL PARTICLE SIZE FRACTIONS DETERMINED GAMMA-RAY ATTENUATION.**” A new procedure is presented to determine the soil particle size more quickly than the original procedure of gamma-ray attenuation. Instead of measuring a complete PSD curve, the cumulated percentage of particles in only two positions of the sedimentation container are measured for specific sedimentation times related to the limits of sand/silt ($50 \mu\text{m}$) and silt/clay ($2 \mu\text{m}$). Because this new procedure allows the particle size fractions of 10 soil sample to be determined in

approximately 1 hour, as many as 80 samples can be analyzed in 1 day. Triplicate soil samples of different textures were each analyzed with the new gamma procedure and the pipette method. Although the average standard deviation of all particle size fractions for the gamma procedure was greater (1.6%) than that for the pipette method (0.7%), the new procedure appears to be an acceptable method for analyzing soil texture. The larger deviations are due mainly to the statistical behaviour of gamma ray emission. The new gamma method yielded an acceptable linear correlation with the pipette method ($r^2 = 0.976$) for all particle size fractions.

We propose that the new procedure should be used routinely for particle size analysis. Its advantages are associated with automation of the analysis, decreasing time and work for handling samples (sieving, collecting, weighing, drying, measuring temperature) and minimum influence of the operator expertise.

2.201 Yasushi Mori et al. (1999) studied “DISCRIMINATING THE INFLUENCE OF SOIL TEXTURE AND MANAGEMENT-INDUCED CHANGES IN MACROPORE FLOW USING SOFT X-RAYS.” Soft X-rays radiography, a non-destructive technique, was employed to examine macropore flow characteristics in soils of different management: paddy, upland field, and forest. A constant-head saturated hydraulic conductivity experiment was conducted using the soft X-ray apparatus. A contrast medium, CH_2I_2 , was applied as a tracer to obtain contrast images of macropore flow. The visualization efficiency has been increased by the low-energy system that enables high-contrast images to be obtained as a result of a wider range of mass attenuation coefficients. CH_2I_2 has a larger attenuation coefficient than bulk soil and has a kinematic viscosity similar to water. It was introduced dropwise to

allow movement with the water flow. Macropore flow was captured using a soft X-ray TV camera, whereas flow paths were photographed on X-ray films. Light duralumin, was used for the sample holder instead of the conventionally used stainless steel in order not to cancel the efficiency induced by the contrast medium. We found that the highest resolution obtained was 42.3 μm . This corresponded well to the calculated value of 30 μm at an energy level of 60 to 70 keV. The resultant images showed that only about 30% of potentially available macropores conducted water flow. Macropore flow paths were affected by land management: straight isolated cylindrical paths in paddy field soils; a network of tortuous isolated cylindrical paths in paddy field soils; a network of tortuous paths in upland field soils; and round cloudy interaggregate paths in forest soils. Macropore flow velocity was estimated from CH_2I_2 movement. Because the flow area was restricted to a small number of macropores, the Reynolds number of flow ranged from 51.6 to 88.6. The flow was in a transition region from laminar to turbulent flow. Under actual conditions of macropore flow, the assumption of laminar flow was not realized. Both structural and dynamic analyses of macropore flow explained the flow characteristics successfully.

2.203 Guoshu Yuan and Baoshan Xing (1999) investigated a “**Site-Energy distribution analysis of organic Chemical sorption by Soil Organic Matter.**” Sorption of several hydrophobic organic compounds by selected soils, and their humic substance fractions as well, was examined using batch equilibration methods. The results could not be explained by the well known partitioning mechanism alone, but were consistent with the dual mode sorption model for soil organic matter

(SOM) in which both solid-phase dissolution and hole-filling mechanisms take place. The heterogeneous nature of the natural sorbents was demonstrated by site-energy distributions derived from the common Freundlich model. The site-energy distribution analysis is useful for examining and understanding the energetic characteristics of a sorbent. This analysis lends further support for the dual-mode model of sorption of SOM.

2.204 Roger S. Swift (1996) studied a “MACROMOLECULAR PROPERTIES OF SOIL HUMIC SUBSTANCES: FACT, FICTION, AND OPINION.”

This is followed by an analysis of the strengths and weaknesses of size-exclusion chromatography (SEC) techniques that is central to the studies under consideration. Emphasis is placed on the importance of overcoming interferences, attributable largely to charge and sorption effects, in order to achieve meaningful applications of SEC. An overview is given of the results obtained by SEC and ultracentrifugation studies of a carefully fractionated collection of humic acid samples. The development of the proposal of the flexible, random-coil model of the macromolecular conformation of HS in solution based on this work is described. This is followed by a review of the evidence put forward in support of the ‘self-associating aggregate’ hypothesis of molecular structure, and emphasis is placed on areas of concern that question the validity of this model. Aspects of the work that require investigation and verification are identified, and proposals are made for the further studies required.

2.205 Leinweber *et al.* (1999) reported a “NEW EVIDENCE FOR THE MOLECULAR COMPOSITION OF SOIL ORGANIC MATTER IN

VERTISOLS.” The distribution of soil organic matter (SOM) in particle-size fractions and the molecular composition of SOM were investigated for five FAO/UNESCO reference Vertisols. Throughout the soil profiles, more than 80% of SOM was associated with clay-size fractions. The remaining proportions were distributed in silt (mean: 155) and sand (mean < 1%). The uniform depth distribution of organic carbon (C_{org}) and total nitrogen (N_t) in size fractions distinguished the Vertisols from other major soil groups. The composition of SOM in the surface horizons was studied by solid-state ^{13}C nuclear magnetic resonance (^{13}C -NMR) spectroscopy, analytical pyrolysis, and wet chemical analyses of organic N forms. The ^{13}C -NMR spectra showed low signal-to-noise ratios and indicated the predominance of alkyl C in four of the samples. In contrast to the general low extractability of SOM in Vertisols, unexpectedly large proportion of C and N (61-95%) could be pyrolyzed and analyzed by field-ionization mass spectrometry (Py-FIMS) and Curie-point gas chromatography/mass spectrometry (Py-GC/MS). Signals of nitrogen-containing compounds were pronounced in the FI mass spectra, and carbohydrates also contributed significantly to the total ion intensity (TII). Quantitative evaluation showed that the large proportions of heterocyclic N-containing compounds and peptides (up to 20% of TII) distinguished these Vertisols from Regosols, Cambisols, Podzols, Chernozems, and Histosols, which were analyzed by Py-FIMS. Derivatives of pyrrole and pyridine as well as aromatic nitriles were observed in the GC/mass spectra of all samples. Hydrolysis and fractionation of organic N forms yielded large proportions of hydrolyzable N (84-98% of total N) and NH_3 -N (32-53% of total N), adding further evidence to the importance of N-containing molecules in Vertisols. These results suggest that recent concepts regarding the molecular composition of SOM in Vertisols should be revised because

they overemphasize long-chain aliphatics and neglect aromatic and aliphatic N-containing molecules, which were unequivocally identified by analytical pyrolysis.

2.206 Rochelte *et al.* (1999) was studied “**Separating Soil Respiration into Plant and Soil Components Using Analyses of the Natural Abundance of Carbon-13.**” In this study, we (i) used measurements of the ^{13}C value of soil CO_2 to separate total soil respiration (R_t) into subcomponents R_{rh} and R_s in a maize (*Zea mays* L.) field under undisturbed conditions and (ii) compared these R_{rh} estimates with values obtained using the root-exclusion approach. The maximum contribution of R_{rh} to total respiration was 45%, observed in August. Estimates of R_{rh} increased from zero 30 d after planting to $2 \text{ g CO}_2\text{-C m}^{-2} \text{ d}^{-1}$ 70d after planting, remained relatively constant at that level in August, and then decreased until the end of the growing season. The total C losses as R_{rh} were 17% of the crop net assimilation. Estimates of R_s gradually declined from $3.3 \text{ g CO}_2\text{-C m}^{-2} \text{ d}^{-1}$ in late June to $1.4 \text{ g CO}_2\text{-C m}^{-2} \text{ d}^{-1}$ at the end of the season. Losses of soil C represented $\approx 6\%$ of total soil C. Variable values of $\delta^{13}\text{C}$ of the soil CO_2 in the control plot after Day 250 made the technique less reliable late in the season. However, several observations indicated that the approach has potential to provide quantitative estimates of R_{rh} and R_s . First, the seasonal pattern of the R_{rh} estimates coincides with that of the plant growth and physiological activity. Second, the cumulated R_{rh} across the growing season agreed well with published data obtained using ^{14}C labelling techniques. Third, in the maize plot, variation in the estimated R_s was closely correlated with changes in soil temperature with Q_{10} of 1.99 ($r^2 = 0.87$). Finally, the estimates of R_{rh} obtained using the isotopic

approach agreed well with those obtained using the root exclusion technique.

2.207 Rafael Celis and William C. Koskinen (1999) was reported a **“Characterization of Pesticide Desorption form Soil by the Isotopic Exchange Technique.”** Isotopic exchange method to characterize the irreversibility of the sorption-desorption process of the insecticide imidacloprid-urea(1-[6-chloro-3-pyridinyl)-methyl]-N-alt2imidazolidinimine) and its degradation product imidacloprid urea (1-[(6-chloro-3-pyridinyl)methyl]-2-imidazolidinone) on a silty clay loam (SiCL) soil, and that of the metabolite imidacloprid –guanidine (1-[6-Chloro-3-Pyridinyl)methyl]-4,5-dihydro-1H-imidazol-2-amine) on a loamy sand (LS) soil. The exchange between ^{12}C -pesticide molecules and ^{14}C -labeled pesticide molecules in soil suspensions preequilibrated for 24 h was monitored and indicated that a fraction of the sorbed chemicals was resistant to desorption. A two-compartment model was applied to describe the experimental sorption data points of the sorption isotherms as the sum of a reversible component and a nondesorbable, irreversible component. The quantitative estimation of the irreversible and reversible components of sorption experimentally derived from isotopic exchange experiments, indicated degree of irreversibility (percentage irreversibly bound) in the order: imidacloprid-SiCL soil (6-32%) < imidacloprid urea-SiCL soil (15-23%) < imidacloprid guanidine-LS soil (32-51%), with greater irreversibility at lower pesticide concentration. Increasing the preequilibration time and decreasing pH in the imidacloprid-SiCL soil system resulted in increased sorption irreversibility. The irreversible component of sorption determined by the isotopic exchange technique also allowed accurate prediction of the

sorption-desorption hysteretic behavior during successive desorption cycles for all three soil-pesticide systems studied. The isotopic exchange technique appears to be a suitable method to quantitatively characterize pesticide desorption from soil, allowing-prediction of hysteresis during sorption-desorption experiments.

2.207 Mahapatra and co-workers was reported a **“Assessment of degradation status of Jammu and Kashmir Soils for their Amelioration.”**

The study reveals that soil degradation problems are mainly due to water erosion, wind erosion and partly due to flooding and water logging. About 31 per cent area of the state is under various forms of degradation and about 57 per cent is unfit for agriculture due to rock outcrops, ice caps and glaciers. The rest of the area (about 12 per cent) constitutes arable lands, stable under natural conditions and through human interventions. The ameliorative measures to arrest further degradation of soils have been suggested.

2.209 Chefetz *et al.* (2000) was determined the **“Characterization of Organic Matter in Soils by Thermochemolysis Using Tetramethyl-ammonium Hydroxide (TMAH)”**.

Tetramethylammonium hydroxide (TMAH) thermochemolysisgas chromatography/mass spectrometry (GC/MS) was employed to study the chemical structure of soil organic matter sampled from a soil plot in which corn (*Zea mays* L) was farmed continuously for 15 yr. The chromatograms exhibited peaks related to compounds derived from lignin, fatty acid methyl ester (FAMES), non-lignin aromatic structures, and heterocyclic N compounds. The dominant lignin-derived peaks in the TMAH thermochemolysis-GC/MS chromatograms were mainly derivatives of *p*-hydroxyphenyl and guaiacyl structures, suggesting a non-woody (grass)

lignin type. With depth, the ratio of syringyl to guaiacyl compounds (S/G) decreased, suggesting a preferential degradation of the syringyl units by microorganisms. Fatty acid methyl esters of varying C-chain length (C₇ to C₂₇) were identified in the soil chromatograms. Both TMAH-GC/MS and ¹³C-NMR (nuclear magnetic resonance) data suggested a relative increase of long chain fatty acids with soil depth (or degree of humification), suggesting a refractory nature for these compounds. The heterocyclin N compounds yielded from the TMAH thermochemolysis were mainly pyrroles, pyridines, and pyrroles. In addition, low levels of methylated amino acids (phenylalanine, leucine, and valine) were detected. The presence of the amino acids in the bottom layer of the soil suggests a preservation mechanism. The change identified in the chemical components provide clues as to the nature of the humification processes in the soil profile and also yield information on the nature of the sources of soil organic matter.

2.210 Zhao, Gray and Toth (2000) studied **“Influence of Soil Texture on Snowmelt infiltration into Frozen Soils.”** Field data collected on frozen, unsaturated agricultural soils of the Canadian Prairies during snow ablation demonstrate: (a) poor association between the amounts of infiltration of meltwater released by the seasonal snowcover and soil texture, and (b) small differences in cumulative amounts among soils of widely different textures. A physics-based numerical simulation of heat and mass transfers with phase changes in frozen soils is used to study the mechanics of the infiltration process in representative clay, silty clay loam, silt loam and sandy loam soils. The results of the simulations show that the differences among cumulative snowmelt infiltration into clay, silty clay loam and silt loam soils after 24h of continuous infiltration are small. Infiltration into a lighter-textured sandy loam after

24 h was on average 23% higher than in the other three soils with most of the increase occurring in the first 5 h of the simulation.

2.211 Tamgadge and co-worker (2000) investigated “**Assessment of Soil Degradation Status in Madhya Pradesh.**” The soil degradation status in Madhya Pradesh was assessed for its kind, degree, extent and serverity and mapped into 55 soil degradation units. It is found that 59.1 per cent of the total geographical area (TGA) is degraded by various factors and processes. The soil degradation in the state is mainly due to water erosion, specifically loss of topsoil (W_t) and terrain deformation (W_d), which amounts to 55.66 per cent. Besides, water erosion in association or complexed with chemical/salinity/waterlogging and flooding have been also found to be responsible for the process. The degradation is largely intensive as 44.6 and 11.6 per cent of the area of the state falls under high and very high severity classes, respectively.

2.212 X.Y. Dai and co-workers (2000) studied “**Characterization of Soil Organic Matter Fractions of Tundra Soils in Arctic Alaska by Carbon-13 Nuclear Magnetic Resonance Spectroscopy.**” Soil organic matter (SOM) was extracted with 0.1 M NaOH resulting in an extractable fraction (EF) and a nonextractable fraction (humins). The SOM of the EF was separated into six fractions: humic acid (HA), fulvic acid (FA), low-molecular-weight acids (LMA), low-molecular-weight neutrals (LMN), hydrophobic neutrals (HON) and hydrophilic neutrals (HIN). Liquid-state and solid-state ^{13}C nuclear magnetic resonance (NMR) were applied to characterize the EF and the humins as well as the whole soils, respectively. The distribution of C species was calculated on the basis of relative integrated peak area. The liquid-state

^{13}C NMR spectra of the extractable organic fraction demonstrated that O-alkyl C was concentrated in the low-molecular weight fraction such as LMN and LMA, while the aromatic unsaturated C was predominantly in the HA and FA. The solid-state ^{13}C MNR of the whole soils showed that the Site 2 soil (Oe and O/A horizons) contained more O-alkyl C and less alkyl C content than the Site 1 (Oal and Oa2) and 3 (Cf horizon) soils; the Site 3 Cf horizon exhibited spectra similar to those of the Site 1 soil, supporting the theory that organic matter in the Cf horizon could originate in the Oa horizon and was translocated by cryoturbation. Spectra of the humin, which make up 53 to 76% of total C, exhibited trends similar to those of the whole soils. Humin appeared to possess greater alkyl C and less O-alkyl C content than whole soil; aromatic, carboxyl carbonyl C contents seemed the same. Although cross-polarization, magic angle spinning (CPMAS) ^{13}C NMR spectra intensities are nonquantitative, the spectral differences between humin and HAs and FAs indicated significant differences in their composition. The humin contained much higher alkyl C and lower aromatic-unsaturated as well as carboxyl-carbonyl C than the HA and FA. The results suggested that the humin fraction was different chemically from the HA and FA. It consisted of a large proportion of paraffinic carbons that may derive from algal or microbial sources.

2.213 Singh *et al.* (2001) studied “**Estimating Soil Hydraulic Properties Using Field Drippers.**” A field dripper method is proposed to estimate the soil hydraulic properties based on unsaturated hydraulic conductivity function of Gardner (1958). In this method, water is applied at a constant rate to a point on relatively level and dry soil using field drippers, which create a ponded zone. For low dripper discharges a hemispherical saturated soil geometry is most common. The area of

saturated zone increases with time and approaches a constant circular area quickly. Steady state solution of two-dimensional soil water flows in homogenous and isotropic soil is developed and applied for estimating unsaturated hydraulic conductivity function, which is of great importance in drip design. Other hydraulic parameter ' α ' (an empirical constant, which is relative measure of capillary and gravity) can also be determined based on assumed relationship. It is a reliable, quick and practicable field method. A comparison of hydraulic parameters (K_s and α) measured and estimated by other methods for three soils show good agreement with field dripper method. In sandy loam soil, the proposed dripper method gives 10.5, 2.7 and 1.8 per cent higher V_s values over inverse auger hole, cylinder infiltrometer and cavity methods, respectively. In silty clay loam soil K_s values obtained by cylinder infiltrometer and inverse auger hole methods are 12.1 and 55.8 per cent lower than field dripper method. In loam soil, the values of K_s obtained by dripper and cavity method have close agreement. The values of ' α ' estimated by field dripper method was within the range of values obtained by other workers, but was higher than the values obtained from different laboratory methods, i.e. Diffusivity method, steady state method and data generated by empirical equations.

2.214 Dipak Sarkar *et al.* (2002) reported the “Characteristics and Classification of Soils of Loktak Catchment Area of Manipur for Sustainable Land Use Planning.” Typical pedons representing major landforms of Loktak catchment area of Manipur *viz.* very steep high hill slope, steep high hill slope, steep medium hill slope, moderately steep medium hill slope, moderately sloping food hill slope and very gently sloping plain, developed from shale and occurring at different

elevations under varying landuse were studied for their morphological and chemical characteristics and classified. Soils were deep, moderate to slightly acidic (pH 4.6 – 5.4) in the surface, rich in organic carbon, low to medium in exchange capacities with higher clay and low base status in the subsurface horizon. Soils were high in available nitrogen, medium to high in available potassium and low in available phosphorus. Available iron and manganese were high, Cu and Zn were low particularly in subsurface horizon. The BaCl₂-TEA acidity was several times more than KCl acidity. Translocation of clay and iron oxide was prominent. High soil acidity associated with aluminium toxicity and gravelly substratum were the main limitations in these soils. Soils were classified as Humic Dystrudepts, Humic Hapludults, Typic Haplohumults, Typic Palehumults and Aquic Haplohumults. On the basis of the major soil constraints, suitable landuse plan has been suggested.

2.215 Desharnais and Lewis (2002) studied a “**Electrochemical Water Splitting at Bipolar Interfaces of Ion Exchange Membranes and Soils.**” This phenomenon, termed *accelerated water splitting*, is well known in industry where BPMs are designed for electro synthesis of acids and bases. In this work, it is hypothesized that (i) accelerated water splitting can also take place at the bipolar interface between ion exchange membranes (IEMs) and the ion exchange surfaces of soils, and (ii) electro osmosis plays a key role. If the IEM has an electrostatic charge opposite in sign to the predominant charge on the soil colloidal particles, the interface is, in effect, bipolar. If an external electric field is then applied, conditions can give rise to accelerated water splitting. Laboratory experiments performed on various mixtures of Ottawa sand,

bentonite, talc, and anion exchange resin indicate that accelerated water splitting occurs when the free pore solution in the low permeable soil moves away from the bipolar interfaces due to electroosmosis, thus causing an unsaturated zone at these interfaces. Accelerated water splitting then initiates at these interfaces since there are not enough counter ions in contact with the IEMs to maintain an ionin current. Very little cation exchange capacity (CEC), anion exchange capacity (AEC), or clay is needed for water splitting to occur at a bipolar IEM and soil interface.

2.216 Amelung *et al.* (2002) studied **“ORGANIC CARBON AT SOIL PARTICLE SURFACES – EVIDENCE FROM X-RAY PHOTO-ELECTRON SPECTROSCOPY AND SURFACE ABRASION.”** The XPS was applied to micro-aggregates of the A horizon of a Typic Haplustoll (< 20- μm equivalent diameter, > 53- μm maximum real diameter) and to the fine-earth fraction (< 2 mm) of the Bs horizon of a Typic Haplorthod. Carbon and N, as well as Si (both samples), Ca (Haplustoll), and Al (Haplorthod) were detected. Removing the particle surface layer (< 50 nm) by bombarding with Ar^+ resulted in a strong reduction of the signals of C and N, while those attributed to inorganic components increased relatively. Consequently, in both soils, organic matter was concentrated at the surface of soil aggregates. We conclude that Ar^+ sputtering followed by XPS analysis is a useful tool in identifying the accumulation of elements at the surface of soil particles.

2.217 Picone and co-worker (2002) reported **“A Rapid Method to Estimate Potentially Mineralizable Nitrogen in Soil.”** An experiment was conducted to determine the effects of reaction time, soil/reagent, and

soil/water ratios on the gas pressure generated by the method. Based on this experiment, 5g of soil, 5 mL of deionized water, 0.3 g $\text{Ca}(\text{ClO})_2$, and a reaction time of 25 min were selected as optimum conditions. The method was evaluated with 60 Cecil (fine, kaolinitic, thermic Typic Kanhapludults) sandy loam samples ranging in organic C from 4 to 16 g C kg^{-1} . Nitrogen mineralized in 24 d and soil microbial biomass C (SMBC) were measured and related to the $\text{Ca}(\text{ClO})_2$ method and to two other rapid method, the flush of CO_2 during 3 d following rewetting of a dry soil, and the $\text{NH}_4\text{-N}$ extractable with hot 2 M KCl. The $\text{Ca}(\text{ClO})_2$ method (mmol kg^{-1}) was strongly correlated with net N mineralized in 24 d ($r = 0.77$) and with microbial biomass C ($r = 0.90$). The method was also correlated with the flush of CO_2 during 3 d following rewetting of dried soil ($r = 0.85$) and with the $\text{NH}_4\text{-N}$ extractable with hot 2 M KCl ($r = 0.86$). These results indicate that the $\text{Ca}(\text{ClO})_2$ method may be useful to make rapid estimates of mineralizable N and microbial biomass C in soil. Additional work is needed to investigate the nature of the compounds oxidized by the method.

2.218 Teotia, Ghosh and Srivastava (2002) studied “A New Anion Exchange Resin Method for Sulphate-Sulphur Extraction in Mollisols of Nainital.” A new method for S-extraction was tried using strong basic anion exchange resin (Amberlite IRA-400) on seventeen Mollisol soil samples. A four-hour shaking, keeping 1: 1 soil: resin ratio was found optimum. Of all the methods compared the resin method had the highest S-extractability from soil. The values ranged from 4.4 to 30.3 mg kg^{-1} for Morgan’s reagent, 4.4 to 28.1 for $\text{NH}_4\text{OAc-HOAc}$, 1.9 to 21.3 for 0.15% CaCl_2 , 3.1 to 28.1 for Olsen’s reagent, and 3.1 to 22.5 mg kg^{-1} for MCP (500 mg P L^{-1}), with mean values of 13.7, 12.3, 10.6, 13.6 and 10.3 mg S kg^{-1} , respectively. Two procedures based on anion

exchange resin method yielded much higher values, ranging from 48.8 to 65.5 and 50.5 to 70.4 mg S kg⁻¹ without and with H₂O₂ treatment, with mean values of 57.5 and 59.1 mg S kg⁻¹ respectively. Resin extractable-S was highly correlated with the S content extracted by all other extractants under study.

2.219 Chefetz *et al.* (2002) reported the “Structural Components of Humic Acids as Determined by Chemical Modifications and Carbon-13 NMR, Pyrolysis-, and Thermochemolysis-Gas Chromatography/Mass Spectrometry.” The chemical structure of humic acids (HAs) extracted from a grassland surface soil and peat were studied using bleaching (NaClO₂ oxidation) and acid hydrolysis (6 M HCl) in combination with advanced analytical techniques: solid-state ¹³C nuclear magnetic resonance (NMR), pyrolysis-gas chromatography/mass spectrometry (GC/MS), and tetramethylammonium hydroxide (TMAH) thermochemolysis-GC/MS. The purpose of the chemical treatments was to remove known structural fragments from the HA to study the building blocks and components of the macromolecule. Bleaching the peat HA resulted in an attack on the lignin structures leading to a significant reduction in the C-substituted and O-substituted aromatic C peaks (128 and 150 ppm) in the ¹³C NMR spectrum. However, the bleached soil HA still contained residual aromatic C, suggesting that part of its aromaticity had originated from aromatic structures resistant to bleaching, possibly black C (charcoal). The pyrolysates of the bleached HAs contained mainly alkanes and alkenes (C₈ to C₂₉), whereas TMAH thermochemolysis yielded a homologous series of long-chain fatty acid methyl esters (FAMs) (C₈ to C₃₂) and dicarboxylic acid dimethyl esters (DAMES). The data are comparable

with those obtained from pyrolysis and thermochemolysis of plant cuticular materials, and therefore suggest that cuticular residues are an integral part of the HA macromolecule. The acid hydrolysis treatment removed esters, amides, carbohydrates, and some of the N-containing compounds from the HAs. This study demonstrates the effectiveness of bleaching and hydrolysis treatments together with advanced analytical techniques for characterization of aliphatic, lignin-derived (LG) and nonhydrolyzable N-containing structures associated with the HA macromolecule.

2.220 Joosse and McBride (2002) studied the “**Assessing physical quality of plastic soils of differing mineralogy and pre-stress history using mechanical parameters I. Saturated compression tests.**” This study was conducted to determine: (i) if existing pedotransfer function developed for southwestern Ontario soils could be used outside this physiographic region, and (ii) if key mechanical parameters were sensitive to a range of land use conditions that are likely to influence soil structural quality. Soil profiles were sampled in natural (forested or grassland), agricultural and pipeline workspace areas (land use variable) located in south-western Ontario, eastern Ontario, Alberta and Texas (mineralogy variable). Slurry consolidation and uniaxial compression tests were conducted on remoulded and structurally intact samples, the resulting void ratio-log stress [$e(\log \sigma')$] data were fitted to linear or nonlinear model equations, respectively, and several key mechanical parameters were derived. The effective stresses at the liquid and plastic limits could not be adequately estimated for soils with smectitic mineralogy using existing pedotransfer functions because of the absence of a significant relationship with organic carbon content. The difference

between void ratio intercepts for remoulded and structurally intact soils ($e^*_{1kPa} - e_0$) was found to be a suitable indicator of physical soil quality because of the convergence of remoulded and structured compression lines in $e(\log\sigma')$ co-ordinates. Severely over consolidated soils were identified when the ($e^*_{1kPa} - e_0$) variable exceeded 0.40.

2.221 Martin and co-worker (2002) studied “Determination of soil organic Carbon and nitrogen at the field level using near-infrared spectroscopy.” This study explored the use of near-infrared spectroscope (NIRS) for the rapid analysis of organic C (C_{org}) and organic N (N_{org}) in the A horizon of soil within a single field. Soil was sampled throughout a field in Manitoba, Canada to capture soil variability associated with topography. The soil samples were oven-dried and treated with acid to remove carbonates, after which C and N were determined by dry combustion. In this study, portions of the dried soil samples not treated with acid were scanned with a near-infrared scanning spectrophotometer between 1100 and 2500 nm. Correlating the spectral and the chemical analytical data using multiple linear regression or principal component analysis/partial least squares regression gave useful correlations of C_{org} . Over the range of 0-40 $mg\ g^{-1} C_{org}$, NIR-predicted values explained 75-78% of the variance in the chemical results. Results were improved to 80% for calibrations developed for the 0-20 $mg\ g^{-1}$ organic C range. Useful results were not obtained for N_{org} although the literature shows that total N in soil is predictable using NIRS. It is likely that the acid treatment altered the composition of the samples in an inconsistent manner such that the chemically analyzed samples and those scanned by NIRS were different from each other in N_{org} concentration or composition. Extrapolation of

these C_{org} results to the landscape scale implies that NIRS has potential to be a suitable method for mapping C for the purpose of monitoring C sequestration.

2.222 Seena *et al.* (2002) studied the “Cation Exchange in Laterite Soils – A Critical Assessment Based on Net Ionic Equilibrium (NIE).”

An extensive study of exchange properties of surface and subsurface soil samples of the main campus of Kerala Agricultural University, Vellanikkara, covering a total of 914 samples was conducted. The 0.1 M $BaCl_2$ extractable exchangeable ions, CEC and the relative factor(s) in terms of ionic ratios of monovalent (K^+ and Na^+) ions to the divalent and/or trivalent ions, computed based on ratio law were subjected to regression analysis in an attempt to predict the contents of the exchangeable ions. In the case of exchangeable K and Na, the ratios $[K/(Ca+Mg+Mn+Fe)^{1/2}+(Al)^{1/3}]$ and $[Na/(Ca+Mg+Mn+Fe)^{1/2}+(Al)^{1/3}]$, respectively, could predict 60 to 70 per cent of the variation in the content of these ions in the exchange fraction, while CEC could explain only 12.4 to 14.7 per cent and percent base saturation (PBS) only 10% of the variability.

2.223 Faz Cano *et al.* (2002) studied the “ ^{13}C CP/MAS-NMR spectra of organic matter as influenced by vegetation, climate and soil characteristics in soils from Murcia, Spain.”

The objective of this work was to establish the distribution of functional groups in organic-C from these soils using ^{13}C CP/MAS-NMR spectroscopy and to investigate the influence of vegetation, climatic conditions, soil parameters, parent material, and soil order on these functional groups. No statistically significant variability in the distribution of organic-C

groups was found as a result of the influence of either soil order or parent material. The content of O-alkyl-C in the soil under the Rhamno-Quercetum plant community was higher (95% probability) than in the soils under the Paronychio-Sideritidetum plant community. Soils located in the mesomediterranean climatic zone displayed a higher content of O-alkyl-C and a lower content of aromatic-C compared to the soils located in the thermomediterranean zone. These differences were statistically significant at 95% of probability. Vegetation and climatic conditions appear to play a major role in the OM decomposition processes in this region. Statistically significant and positive correlations were found between alkyl-C and both **cation exchange capacity (CEC)** and clay content indicating the recalcitrant nature of these organic compounds.

2.224 Pankhurst and co-workers (2002) reported that “**Microbiological and chemical properties of soil associated with macropores at different depths in a red-duplex soil in NSW Australia.**” Some agricultural soils in South Eastern Australia with duplex profiles have subsoils with high bulk density, which may limit root penetration, water uptake and crop yield. In these soils, a large proportion (up to 80%) of plant roots may be preferentially located within the macropores or in the soil within 1-10 mm of the macropores, a zone defined as the macropore sheath (MPS). The chemical and microbiological properties of MPS soil manually dissected from a 1-3 mm wide region surrounding the macropores was compared with that of adjacent bulk soil (> 10 mm from macropores) at 4 soil depths (0-20 cm, 20-40 cm, 40-60 cm and 60-80 cm). Compared to the bulk soil, the MPS soil had higher organic C, total N, bicarbonate-extractable P, Ca⁺, Cu, Fe and Mn and supported higher populations of bacteria, fungi, actinomycetes,

Pseudomonas spp., *Bacillus spp.*, cellulolytic bacteria, cellulolytic fungi, nitrifying bacteria and the root pathogen *Pythium*. In addition, analysis of carbon substrate utilization patterns showed the microbial community associated with the MPS soil to have higher metabolic activity and greater functional diversity than the microbial community associated with the bulk soil at all soil depths. Phospholipid fatty acids associated with bacteria and fungi were also shown to be present in higher relative amount in the MPS soil compared to the bulk soil. Whilst populations of microbial functional group in the MPS and the bulk soil declined with increasing soil depth, the differentiation between the two soils in microbiological properties occurred at all soil depths. Soil aggregates (0.5 mm diameter) associated with plant roots located within macropores were found to support a microbial community that was quantitatively and functionally different to that in the MPS soil and the bulk soil at all soil depths.

2.225 J. Six and co-workers (2002) reported “**Stabilization mechanisms of soil organic matter: Implications for C-saturation of soils.**” Method of quantification and characteristics of three SOM pools defined as protected are discussed. Soil organic matter can be: (i) Physically stabilized, or protected from decomposition, through microaggregation, or (2) intimate association with silt and clay particles, and (3) can be biochemically stabilized through the formation of recalcitrant SOM compounds. In addition to behaviour of each SOM pool, we discuss implications of changes in land management on processes by which SOM compounds undergo protection and release. The characteristics and responses to changes in land use or land management are described for the light fraction (LF) and particulate organic matter (POM). We defined the LF and POM not occluded within microaggregates (53-250

μm sized aggregates as unprotected. Our conclusions are illustrated in a new conceptual SOM model that differs from most SOM models in that the model state variables are measurable SOM pools. We suggest that physiochemical characteristics inherent to soils define the maximum protective capacity of these pools, which limits increases in SOM (i.e. C sequestration) with increased organic residue inputs.

2.226 Bekele *et al.* (2003) studied “**COMPARATIVE EVALUATION OF SPATIAL PREDICTION METHODS IN A FIELD EXPERIMENT FOR MAPPING SOIL POTASSIUM.**” For the predication of soil potassium (K), we evaluated the performance of the inverse distance weight of powers 1, 2, and 3, ordinary kriging, cokriging, multiple linear regressions assuming independent error, and multiple linear regression with auto correlated error structure. Two forms of ordinary kriging were evaluated: kriging the residuals from tend surface regression (geographic location only as predictors) and Kriging the residuals from a regression of K on geographic location and other soil property predictors (soil pH and apparent electrical conductivity, ECa). The autocorrelated error model as implemented in the Statistical Analysis System (SAS) mixed linear model was employed to adjust for autocorrelated error structure in the regression models used for prediction. For cokriging, either soil ECa or soil pH was used as a secondary soil property to predict K. The root mean square error (RMSE) and mean error (ME) calculated from an independent validation data set ($n = 68$) were used as comparison criteria. The best result was obtained with the methods that incorporated geographic locations, other soil property predictors, and the correlated error structure. This investigation demonstrated the flexibility of the

regression-based autocorrelated error model for spatial prediction compared with other methods.

2.227 M. Camps Arbestain *et al.* (2003) studied “RHIZOSPHERE CHEMISTRY IN ACID FOREST SOILS THAT DIFFER IN THEIR DEGREE OF AL-SATURATION OF ORGANIC MATTER.” The objective of this research was to study the rhizosphere of tree species of acid forest soils derived from amphibolite (AMP) and granite (GR) rocks, so that the influence of the type of pedogenesis (generated by these materials) on its chemistry could be established. Umbric A₁ horizons were sampled in three AMP soils (Lithic Hapludands, Andic Dystrudept), under orak, pine, and eucalyptus stands, and in three nearby GR soils (Typic Dystrudepts) under identical stands. The A₁ GR horizons had a lower pH (4.2 vs 4.6), and greater aqueous soluble Al (0.40 vs 0.60 mmol kg⁻¹) and NH₄Cl-extractable Al contents (6.8 vs 2.6 cmol_c kg⁻¹) than the A₁ AMP horizons. Mean values of sodium pyrophosphate extractable-Al (Al_p) and ammonium oxalate extractable-Al (Al_o) in the A₁ AMP horizons were 12.0 and 16.2 g kg⁻¹, respectively, and the molar ration between Al_p and sodium pyrophosphate extractable-C (C_p) ranged between 0.1 and 0.2. Mean values of Al_p, Al_o, and Al_p/C_p in the A₁ GR horizons were significantly (P < 0.05) smaller (5.2 g kg⁻¹, 5.3 g kg⁻¹, and 0.06, respectively). In the A₁ GR horizons, we observed a lower pH (significant at P < 0.05) in the rhizosphere than in the bulk soils, a pattern, which was not observed in the A₁ AMP horizons. The balance of nutritive cations and anions between rhizosphere and bulk soils did not explain the patterns of pH change. Based on the relationships found among organic acids, soil pH, and Al_p/C_p, we propose that, in the Al GR horizons, where organic

matter is Al-undersaturated, the increased organic acidity produced in the rhizosphere cannot be completely buffered by Al alkalinity, whereas in the AMP soils, where mineral amorphous Al coexists with Al-humus complexes, organic compounds become stabilized with reactive Al surface, maintaining organic acidity at low levels, even in the rhizosphere (whenever the stabilization capacity of these surfaces is not exceeded). Our results imply that both variations in organic matter content and the degree of metal saturation of the organic matter need to be considered when investigating the causes behind changes in soil pH in the rhizosphere of acid forest soils.

2.228 Maruyama *et al.* (2003) was reported **“Direct observation of soil water movement through soil macropores using soft x-rays and stereography.”** Water movement in soil was observed directly and recorded on videotape using soft X-ray technology with a liquid contrast agent and on continuous photos. The movement of soil water occurred in an Andosol sample, and quantitative analyses were carried out by image processing. The results shown here are:

- (1) The fluids flowing in tubular macro pores connected with each other. The flow showed spatial motion in which the tubular pores were sometimes swollen. Soil water moved into macropores like a volcanic explosion and also moved, worm-like, according to the shape of the tubular pores. Soil water movement occurred only in some tubular pores. In most cases, soil water was not detected in the pores.
- (2) The spatial structures of macropores shown in three-dimensional graphics were drawn from stereo-radiographs, based on the observation of the spatial contribution of soil pore structures and the calculation of their actual length and tortuosity.

- (3) Applying Darcy's law, various permeabilities (K_2 , K_3 , K_4) of the soil were calculated using the diameters of the dominant macropores and actual velocities. The permeability was compared with the permeability (K_1) tested independently by the constant head method. Differences among K_1 , K_2 , K_3 and K_4 were not significant.
- (4) The validity of Darcy's law was tested using the constant head tank at different heads and samples. Results show that the validity of Darcy's law was not confirmed.
- (5) The Reynolds was calculated using the actual diameter of the tubular pores and velocities of the agent measured by the stereograph obtained by the video. The flow seemed to be transitional between laminar and turbulent.

2.229 Schmalz Britta and co-worker (2003) was "ANALYSIS OF UNSATURATED WATER FLOW IN A LARGE SAND TANK."

This study was initiated to acquire experimental data about the water flow characteristics of sandy soils to serve as a base for numerical analysis. Specific objectives were to clarify the effects of (i) the invoked procedure for estimating the soil hydraulic parameters and (ii) using increasingly refined spatial definitions of the hydraulic properties on simulated two-dimensional water content and flow velocity distributions.

Water flow in and drainage from a large sand tank (approximately $5 \times 3 \text{ m}^2$ at the base, $6 \times 5.6 \text{ m}^2$ at the top) was investigated using soil hydrologic and geophysical methods. Numerical analyses of variably saturated flow along a two-dimensional cross-section were carried out in attempts to describe the heterogeneous flow fields using the Richards equation-based HYDRUS-2D code. The unsaturated soil hydraulic

properties were describes using van Genuchten-Mualem type expressions. Information from both in situ and laboratory measurements was employed to obtain parameter estimates.

The observed variability in discharge rate with time was reproduced best when an average water retention curve was used and the saturated water content was set equal to the porosity, whereas cumulative outflow was predicted best when all van Genuchten hydraulic parameters were fitted to the retention data.

2.230 Turner *et al.* (2003) studied a “**Phosphorus-31 Nuclear Magnetic Resonance Spectral Assignments of Phosphorus Compounds in Soil NaOH-EDTA Extracts.**” They report solution ^{31}P NMR chemical shifts of model P compounds, including inorganic phosphates, orthophosphate monoesters and diesters, phosphonates, and organic polyphosphates, determined in a standardized soil P extractant (0.25 M NaOH and 0.05 M EDTA). Signals from nucleic acids (DNA – 0.37 ppm, RNA 0.54 ppm) and phospholipids (phosphatidyl choline 0.78 ppm, phosphatidyl serine 1.57 ppm, phosphatidyl ethanolamine 1.75 ppm) could be differentiated in the orthophosphate diester region, and were identified in a sample of cultured soil bacteria. Inorganic and organic polyphosphate could be differentiated by the presence of a signal at -9 ppm from the α phosphate of organic polyphosphates. Some orthophosphate diesters, notably RNA and phosphatidylcholine, degraded rapidly to orthophosphate monoesters in NaOH-EDTA although DNA, other phospholipids, and orthophosphate monoesters were more stable. Changes in probe temperature had a marked influence on signal intensities and the relative magnitude of signals from orthophosphate monoesters and inorganic orthophosphate, and we

suggest that solution ^{31}P NMR spectroscopy of soil extracts he performed at 20 $^{\circ}\text{C}$.

2.231 Nannipieri and co-worker (2003) studied “Microbial Diversity and Soil functions.” A better understanding of the relations between microbial diversity and soil functions requires not only the use of more accurate assays for taxonomically and functionally characterizing DNA and RNA extracted from soil, but also high-resolution techniques with which to detect inactive and active microbial cells in the soil matrix.

Soil seems to be characterized by a redundancy of functions; for example, no relationship has been shown to exist between microbial diversity and decomposition of organic matter. Generally, a reduction in any group of species has little effect on overall processes in soil because other microorganisms can take on its function.

The determination of the composition of microbial communities in soil is not necessary for a better quantification of nutrient transformations. The holistic approach, based on the division of the systems in pools and the measurement of fluxes linking these pools, is the most efficient. The determination of microbial C, N, P and S contents by fumigation techniques has allowed a better quantification of nutrient dynamics in soil. However, further advances require determining new pools, such as active microbial biomass, also with molecular techniques. Recently investigators have separated ^{13}C - and ^{12}C -DNA, both extracted from soil treated with a ^{13}C source, by density-gradient centrifugation. This technique should allow us to calculate the active microbial C pool by multiplying the ratio between labelled and total DNA by the microbial biomass C content of soil.

2.232 Ludwig and Kölbl (2003) studied a “**MODELING CATION EXCHANGE IN AN UNDISTURBED SUBSOIL AT DIFFERENT FLUX RATES.**” Undisturbed samples of a Luvisol subsoil that differed in their hydraulic conductivities (k_1 : 4 to 6 cm d^{-1} ; k_2 : 20 to 21 cm d^{-1} ; k_3 : 42 to 59 cm d^{-1}) were leached under saturated conditions with 4, 20, 102, and 205 mM BaCl_2 at a hydraulic gradient of 6.5, and the Darcy velocities were q_1 (270 to 360 mm d^{-1}), q_2 (1280 to 1360 mm d^{-1}) and q_3 (2730 to 3830 mm d^{-1}). Objectives were to investigate how different flux rates affect the amount of desorbed cations in an undisturbed soil when percolated with BaCl_2 solutions of different concentrations and whether ion concentrations in the percolates can be predicted. The model PHREEQC was used for the calculation of one-dimensional transport, inorganic complexation, and multiple cation exchange, and the program UCODE was used for the parameter optimization. The best prediction performance of ion concentration and the sum of cations desorbed at q_1 (73% satisfactory or good predictions) was obtained when the parameters were 0.6 cm (dispersivity λ), 0.74 (fraction of mobile water f_θ), $3.4 \times 10^{-5} \text{ s}^{-1}$ (mass transfer coefficient α), and 0.91 (proportion of cation exchange capacity in contact with the mobile water $f_{\text{CEC-m}}$). At q_2 , the optimum performance (71% satisfactory or good predictions) was achieved with $\alpha = 6.2 \times 10^{-4} \text{ s}^{-1}$ and $f_{\text{CEC-m}} = 5.8$. At q_3 , the optimum parameters were $\alpha = 6.8 \times 10^{-4} \text{ s}^{-1}$ and $f_{\text{CEC-m}} = 0.38$, which resulted in 58% satisfactory or good predictions. This study suggests that α increases with increasing pore water velocity and that $f_{\text{CEC-m}}$ decreases with increasing hydraulic conductivity.

2.233 Harris (2003) studied of the “**Measurement of the soil microbial community for estimating the success of restoration.**” Recent

research has shown quantitatively how by measuring the soil microbial community we can assess degradation and the effects of management designed to reverse it. The size, composition and activity of the soil microbial community convincingly distinguish between systems, and between the impacts of management strategies upon them. Measurements of these characteristics of the microbial community provide invaluable information for restoring degraded land and are ready for routine use. Specifically, profiles of phospholipids fatty acid contents, and substrate induced respiratory responses to different carbon substrates, will yield significant data upon which management decisions may be based.

2.234 Van Hees *et al.* (2003) studied a **“Impact of ectomycorrhizas on the concentration and biodegradation of simple organic acids in a forest soil.”** They have investigated one set of factors, namely the impact of ectomycorrhizal (*Paxillus involutus*) and non-mycorrhizal *Picea abies* seedlings and humic acid on the concentration and dynamics of organic acids in soil solution. We did so over 10 months in laboratory columns containing soil from the E horizon of a sandy forest soil. Several organic acids were identified in the solution extracted from the root zone including oxalic, citric, malonic, succinic, acetic, formic and lactic acids at concentrations ranging from < 0.1 to $2.3 \mu\text{M}$. Both plants and ectomycorrhizas had significant effects on the concentration of organic acids in soil solution. In contrast, omitting P from the irrigation water appeared to have little effect on the concentrations. The microbial mineralization kinetics of oxalate conformed well to a single Michaelis-Menten equation. Further, the soil with the mycorrhizas had a significantly faster mineralization of oxalic acid over a wide concentration range than did the soil without ectomycorrhizas and

without plants. We conclude that the oxalate flux through the soil with both trees and mycorrhizas is much faster than is evident from measurements of solution concentration at steady state. Humic acid had little effect on the organic acids or dynamics in the soil solution. Oxalic acid concentrations in the soil solution were correlated with hyphal length, rate of microbial mineralization, soil respiration, and shoot to root weight ratio. We conclude that both mycorrhizas and plants have a large impact on organic acid cycling in forest soils.

2.235 Kinraide (2003) was studied a “**Toxicity factors in acidic forest soils: attempts to evaluate separately the toxic effects of excessive Al^{3+} and H^+ and insufficient Ca^{2+} and Mg^{2+} upon root elongation.**” Activities of ions in the soil solutions and at the surfaces of root-cell plasma membranes were computed with electrostatic models. Activities of Al^{3+} in solutions ($\{\text{Al}^{3+}\}$) peaked at pH 4.1, and Al^{3+} activities at the surface of the plasma membrane ($\{\text{Al}^{3+}\}_0$) achieved a broad maximum between pH 4.1 and 4.8; thus, Al^{3+} intoxication is likely to be more severe in soils at pH 4.1 than in more acidic ones. Intoxication (assessed by root elongation) correlated somewhat ambiguously with ion activities, but Al^{3+} - and H^+ -induced depletion of Ca^{2+} and Mg^{2+} , or both, from the cell surface appears to play a role in toxicity. By contrast, experiments in solution culture, where intercorrelation among $\{\text{Al}^{3+}\}$, $\{\text{H}^+\}$, and $\{\text{Ca}^{2+}\}$ could be avoided, clearly demonstrated the following extrinsic and intrinsic effects.

1. The ions Al^{3+} and H^+ are intrinsic toxicants.
2. They are also extrinsic toxicants because of electrostatic displacement of Ca^{2+} from the surface of the plasma membrane.

3. They are extrinsic ameliorants because each electro statically displaces the other from the surface of the plasma membrane.
4. The ion Ca^{2+} is an extrinsic ameliorant because of the electronstatic displacement of Al^{3+} and H^+ from the surface of the plasma membrane.
5. It is an intrinsic ameliorant of intrinsic H^+ toxicity, but not intrinsic Al^{3+} toxicity.
6. It meets an intrinsic requirement.
7. The ion Mg^{2+} resembles Ca^{2+} in item 4 but not items 5 and 6 in short-term cultures.

In acidic soils, resembles Ca^{2+} may prevent H^+ from becoming an intrinsic toxic (item 3) and may induce an insufficiency of Ca^{2+} and Mg^{2+} (item 2). These findings have implications for the mechanisms by which woodland plants tolerate very acidic soils.

2.236 Smernik and Oades (2003) studied a “**Spin accounting and RESTORE –two new methods to improve quantitation in solid-state ^{13}C NMR analysis of soil organic matter.**” They have developed two new techniques to overcome these problems. The first, spin accounting, enables accurate gauging of how quantitative a spectrum is likely to be. The result is expressed as the percentage of potential NMR signal that can be accounted for (Cobs). Spin accounting improves on the established spin counting technique by correcting for rapid $T_{1\rho\text{H}}$ relaxation and inefficient cross-polarization. Spin accounting identifies three components: one that is well represented in CP spectra, one that is under-represented in CP spectra due to rapid $T_{1\rho\text{H}}$ relaxation and one that is under-represented in CP spectra due to inefficient cross-polarization. Spin accounting identifies three components: one that is

well represented in CP spectra, one that is under-represented in CP spectra due to rapid $T_{1\rho H}$ relaxation, and one that is under-represented in CP spectra due to inefficient cross-polarization. For a range of eight deashed soils, Cobs was in the range 83-106%, indicating that virtually all potential signal could be accounted for after correcting for rapid $T_{1\rho H}$ relaxation and inefficient cross-polarization. The second new technique, RESTORE (REstoration of Spectra via T_{CH} and T One Rho ($T_{1\rho H}$) Editng), generates subspectra for the essentially a corrected CP spectrum. The RESTORE subspectra is essentially a corelated CP spectrum. The RESTORE spectra of all eight soils more closely resembled the corresponding, and presumably quantitative, Bloch decay spectra than did the CP spectra. RESTORE identifies the types of structures underestimated by CP, and the cause of their underestimation.

2.237 Mbila *et al.* (2003) studied a “**MORPHOLOGICAL AND CHEMICAL PROPERTIES OF SELECTED SLUDGE-AMENDED NIGERIAN SOILS.**” This study was conducted to investiage the morphological and chemical properties os sludge-amended soils after about 37 years of sludge application. Two soils on a 5-ha sewage farm and a soil at a nearby, unamended site were selected for the study. Soil at all three sites would have been mapped and classified in the same soil series before application of seqage sludge. The unamended soil was a fine-loamy, kaolinitic, isohyperthermic Rhodic Kandiusult. Compared with the unamended soil, the sludge-amended soils had better aggregation in the surface horizon, greater total soil C and N, and higher levels of exchangeable bases. After 37 years of seqage sludge amendment, a higher base saturation percentage in the subsurface horizons of one sludgeamended soil led to its classification as an Alfisol instead of an Ultisol.

2.238 Gerin *et al.* (2003) studied a “**Surface analysis of soil material by X-rays photoelectron spectroscopy.**” The surfaces was systematically enriched in carbon, sometimes up to 1000 times, indicating that the soil particle surfaces are coated with organic substances, even in horizons where the bulk organic content is less than 0.1 g kg^{-1} . The distribution of carbon in the various oxidation states was $0.569 \pm 0.008 \text{ C}^{[0]}$, $0.275 \pm 0.004 \text{ C}^{[+1]}$, $0.089 \pm 0.003 \text{ C}^{[+2]}$ and $0.066 \pm 0.002 \text{ C}^{[+3]}$ for most horizons (mean \pm standard error, 69 data). Only Andosol surface horizons systematically had surface organic matter in a more oxidized state. After correcting the results for the presence of organic coatings, we found that Si was generally depleted and Al enriched at the surface of soil particles, while Fe was either depleted or enriched depending and Al enriched at the surface of soil particles, while Fe was either depleted or enriched depending on the sample considered. However, the coating of the coarser soil particles by the finer ones and their differential composition explained this observation and limits the interest XPS for characterizing the surface enrichment of inorganic elements in crude soil samples. These limitations should be considered when interpreting XPS results in future work. Nevertheless, XPS can analyse the adsorbed organic matter and its functional composition of carbon without the need for any chemical or physical extraction that might alter the structure and composition of the organic molecules.

2.239 Cosenza, Guerin and Tabbagh (2003) reported a “**Relationship between thermal conductivity and water content of soils using numerical modelling.**” Using a numerical modelling approach, we have shown that the microscopic arrangement of water influences the relation between λ and θ . Simulated values for n ranging form 0.4 to 0.6, λs

ranging from 2 to 5 W m⁻¹ K⁻¹ and θ from 0.1 to 0.4 can be fitted by a simple linear formula that takes into account n , λ_s and θ . The results given by this formula and by the quadratic parallel (QP) model widely used in physical property studies are in satisfactory agreement with published data both for saturated rocks and for unsaturated soils. Consequently, the linear formula and the QP model can be used as practical and efficient tools to investigate the effects of water content and porosity on the thermal conductivity of the soil and hence to optimize the design of thermal *in situ* techniques for monitoring water content.

2.261 Garnier *et al.* (2003) reported the “**Modelling carbon and nitrogen dynamics in a bare soil with and without straw incorporation.**” They tested carbon and nitrogen dynamics by measuring C mineralization rates, the rates of gross immobilization and mineralization of N (using ¹⁵N tracing), and inorganic pools of N in the soil profile during 1 year in a bare soil with or without addition of wheat straw. Most of the model parameters were determined in independent experiments. We estimated the biological parameters from incubation experiments in the laboratory. The simulated results were in good agreement with experimental data, particularly for gross N rates. Hypotheses concerning the pathway of microbial assimilation and the dependence of decomposition on the size of the biomass were tested. The simulated net N immobilization due to addition to straw (8000 kg dry matter ha⁻¹) reached a maximum of 64 kg N ha⁻¹ after 2 months, whereas the observed value was 66 kg N ha⁻¹. The model indicated that after 13 months the incorporation of straw had reduced the net amount of nitrogen mineralized by 13% and the amount of leached nitrate by 27%. The sensitivity analysis to the depth of straw

incorporation indicated that the deeper was the incorporation the less was the leaching and the mineralization of nitrogen.

2.262 Pachepsky and Rawls (2003) reported a “**Soil structure and pedotransfer functions.**” Two case studies are presented. Data from the US National Pedon Characterization database are used to estimate soil water retention from categorical field-determined structural and textural classes. Regression-tree estimates have the same accuracy as those from textural class as determined in the laboratory. Grade of structure appears to be a strong predictor of water retention at – 33 kPa and – 1500 kPa. Data from the UNSODA database are used to compare field and laboratory soil water retention. The field-measured retention is significantly less than that measured in the laboratory for soils with a sand content of less than 50%. This could be explained by Rieu and Sposito’s theory of scaling of soil structure. Our results suggest a close relationship between structure observed at the soil horizon scale and structure at finer scales affecting water retention of soil clods. Finally we indicate research needs, including (i) quantitative characterization of the field soil structure, (ii) an across-scale modelling of soil structure of use fine-scale data for coarse-scale PTFs, (iii) the need to understand the effects of soil structure on the performance of various method available to measure soil hydraulic properties, and (iv) further studies of ways of use soil-landscape relationships to estimate variations of soil hydraulic properties across large areas of land.

2.263 Kaiser and Guggenberger (2003) studied a “**Mineral surfaces and soil organic matter.**” Sorption of organic matter reduced the SSA, depending on the amount sorbed and type of mineral. The reduction in

SSA decreased at large organic matter loadings. The SSA of the mineral soils was positively related to the content of Fe oxyhydroxides and negatively related to the content of organic C. The strong reduction in SSA at small loadings was due primarily to the decrease in the micropores to which N_2 was accessible. This suggests preferential sorption of organic matter at reactive sites in or at the mouths of micropores during the initial sorption and attachment to less reactive sites at increasing loadings. The exponential decrease of the heat of gas adsorption with the surface loading points also to a filling or clogging of micropores at early stages of organic matter accumulation. Desorption induced a small recovery of the total SSA but not of the micropore surface area.

Destruction of organic matter increased the SSA of all soil samples. The SSA of the uncovered mineral matrix related strongly to the amounts of Fe oxyhydroxides and the clay. Normalized the C removed, the increase in SSA was small in topsoils and illuvial horizons of Podzols rich in C and large for the subsoils containing little C. This suggests that micropores preferentially associate with organic matter, especially at small loadings. The coverage of the surface of the soil mineral matrix as calculated from the SSA before and after destruction of organic matter was correlated only with depth, and the relation appeared to be linear.

2.264 Poulsen *et al.* (2003) studied “Estimating saturated hydraulic conductivity and air permeability from Soil. Physical Properties Using State Analysis.” In this study, three modeling approaches were used to identify the dependence of saturated hydraulic conductivity (K_s) and air permeability at -100 cm H_2O soil water potential (k_{a100}) on soil physical properties in undisturbed soil: (i) Multiple regression, (ii)

ARIMA (autoregressive integrated moving average) modeling, and (iii) State-space modeling. In addition to actual soil property values, ARIMA and state-space models account for effects of spatial correlation in soil properties. Measured data along two 70-m-long transects at a 20-year old constructed field were used. Multiple regression and ARIMA models yielded similar prediction accuracy, whereas state-space models generally gave significantly higher accuracy. State-space modeling suggested K_s at a given location could be predicted using nearby values of K_s , K_{a100} and air-filled porosity at -100 cm H_2O soil-water potential (ϵ_{100}). Similarly, k_{a100} could be predicted from nearby values of K_{a100} and ϵ_{100} . Including soil total porosity in the state-space modeling did not improve prediction accuracy. Thus, macro-porosity (ϵ_{100}) was the key porosity parameter for predicting both K_s and K_{a100} in undisturbed soil.

2.265 Nissen *et al.* (2003) studied a “TIME DOMAIN REFLECTOMETRY DEVELOPMENTS IN SOIL SCIENCE: I. UNBALANCED TWO-ROD PROBE SPATIAL SENSITIVITY AND SAMPLING VOLUME.” In this study, a two-rod probe without a balun (unbalanced) was exposed to a rising air-water interface, creating a sharp dielectric permittivity boundary within the sample volume of the probe. The probes were horizontal, but they were located within a vertical plane, i.e., one rod was placed above the other. A shorting diode technique was used to improve the location of the end reflection on the TDR trances. Two experiments were carried out differing only in the connection of the coaxial cable to the probe rods. In one experiment, the conductor was connected to the lower rod and the shield was connected to the upper rod. In the second experiment these connections were reversed. Using a numerical model, the relative dielectric permittivity (K) responses of two-rod balanced and unbalanced TDR probes were predicted as

a function of the fluid interface height. The measured and modeled responses of the unbalanced two-rod probe matched perfectly, and there was no observed increase in the spatial sensitivity of the probe adjacent to either rod. Furthermore, the modelled probe responses as well as the sample areas for the balanced and unbalanced probe configurations were identical. Based on these results, we suggest that baluns be omitted from two-rod TDR probe designs.

- 2.266 Nissen, Ferré, and Moldrup (2003)** studied a **“TIME DOMAIN REFLECTOMETRY DEVELOPMENT IN SOIL SCIENCE: IL COAXIAL FLOW CELL FOR MEASURING EFFLUENT ELECTRICAL CONDUCTIVITY.”** To determine the presence of heterogeneous solute transport effectively, there is a need for a device to monitor the EC boundary conditions. In this study, a simple and easy-to-make coaxial flow cell is designed and tested for this purpose. The flow cell is made primarily of cheap, prefabricated, and readily available components, and the construction requires only a hacksaw and some welding skills. The idea is to make the effluent from a solute transport experiment pass through the coaxial flow cell, thereby obtaining a measure of the effluent EC. In addition to providing detailed information on the solute transport through the entire sample of porous medium, it will also detect, for example, bypass flow. A solute transport experiment was carried out in PVC pipe packed with coarse silica and under saturated conditions to calibrate the flow cell and to demonstrate its potential use. Step input breakthrough and breakdown functions were created using tap water and KCl solution. Highly detailed measurements of EC in the effluent were obtained, from which solute transport parameters can easily be inferred.

- 2.267 John J. Kelly (2003)** studied a **“MOLECULAR TECHNIQUES FOR THE ANALYSIS OF SOIL MICROBIAL PROCESSES:**

FUNCTIONAL GENE ANALYSIS AND THE UTILITY OF DNA MICROARRAYS.” Recent research has revealed the tremendous diversity of microorganisms responsible for catalyzing a variety of soil processes. Such functional redundancy within soil microbial communities may have significant impacts on process rates and ecosystem stability. Therefore, the analysis of functional diversity and its dynamics in the environment is essential for understanding the biogeochemistry in soil systems. Until recently, methodological limitation hindered investigation of the relationship between microbial diversity and soil processes. Over the last decade, innovative molecular approaches to the study of natural microbial communities and the functional genes responsible for biogeochemical processes have given us new insight into this relationship. One new approach, DNA microarray analysis, promises to be especially useful for the analysis of these functional genes.

2.268 Fiedler and Kalbitz (2003) studied a “CONCENTRATIONS AND PROPERTIES OF DISSOLVED ORGANIC MATTER IN FOREST SOILS AS AFFECTED BY THE REDOX REGIME.” They estimated the influence of redox conditions on DOM dynamics in the field, sampling soil solutions at different depths of three soils (Humic and Histic Gleysol, Chromic Cambisol) along a soil catena in the cool-humid Black Forest (Germany) over a period of 2 years. We measured dissolved organic carbon (DOC) and determined the specific absorbance at 280 nm and two humification indices derived from fluorescence spectra to describe the aromaticity and complexity of DOM. Redox potential (Eh) was monitored continuously *in situ*. In the forest floor, DOC concentrations ranged independent of soil organic matter content and redox regime between 40 and 60 mg C L⁻¹. DOC concentrations in all

soils decreased with depth, accompanied by a decrease in DOM aromaticity and complexity. In the mineral subsoil, DOC concentrations, aromaticity, and DOM complexity were smallest in the aerobic soil (Chromic Cambisol; Eh > 500 mV) and largest in the most anaerobic soil (Histic Gleysol; Eh < 100 mV). Large DOM retention in the aerobic soil could be related to high contents of Fe oxides, highlighting their importance for DOM adsorption. Despite significantly reduced DOM retention under anaerobic conditions, it remains relatively large because the main (DOM) adsorbents changed from Fe oxides under oxic conditions to clay minerals, which were about 100 times more abundant under anaerobic conditions than Fe oxides. We found indications that biodegradation of DOM contributes more to DOM retention under anaerobic conditions, and we conclude that large DOM fluxes from anaerobic forest soils are the result of limited DOM adsorption in the subsoil rather than large DOM release from the topsoil.

2.269 Chaplot *et al.* (2003) studied a “**SOIL SPATIAL DISTRIBUTION IN THE ARMORICAN MASSIF, WESTERN FRANCE: EFFECT OF SOIL-FORMING FACTORS.**” This study aimed to quantify the relationship between soil spatial distribution and the soil-forming factors of geology, topography, climate, and tectonic regime in order to predict soil spatial distribution over a wide region (30,000 km²). The Armorican Massif (western France), a complex basement of Proterozoic and Paleozoic rocks affected by recent tectonic activity and characterized by variations in topography and climate, was chosen as the study site. Detailed soil maps (1:25, 000) were used to describe soil spatial distribution along transects. An ANOVA performed on 314 transects showed a high correlation between the occurrence of soils with particular features (namely redoximorphic, leached, glossic, and albic)

and geological substrate, uplift ratio, mean slope gradient, and net rainfall. No such correlation was found with fluvic soils. These soil-forming factors seem to act through saporlite quality and erosion processes, which in turn control the development of soil features. A quantification of the relationship between soil features and soil-forming factors was performed by regression analysis in order to allow further prediction of the soil spatial distribution over the entire Armorican Massif. These results revealed and quantified the hitherto unrecognized role of tectonism on soil distribution and its relative importance in respect to other soil-forming factors.

2.2610 Arriaga and Lowery (2003) was a “**SOIL PHYSICAL PROPERTIES AND CROP PRODUCTIVITY OF AN ERODED SOIL AMENDED WITH CATTLE MANURE.**” A study was established to determine the effects of soil erosion and long-term manure applications on selected soil physical properties and corn (*Zea mays* L.) production. After 10 years of annual manure applications, soil core samples were collected in 7.6-cm increments at three depths, 0 to 7.6, 15 to 22.6, and 30 to 37.6 cm, to determine soil bulk density (ρ_b), hydraulic conductivity of saturated soil (K_s), and water retention. Bulk density and K_s increased slightly with erosion level. Water retention did not change in the surface 7.6 cm, but it did decrease with increasing erosion level at deeper depths. Long-term application of manure decreased ρ_b by 10%, whereas K_s was doubled in the top 7.6 cm of soil. Manure increased soil-water retention capacity and decreased differences in water retention between erosion levels, especially at low suctions (0 to 20 kPa). Soil carbon content correlated well with water retention and ρ_b . Corn grain yields in 1997, 1998, and 1999 were 15, 6, and 14% less, respectively, in the

severe than in the slight erosion phase. Long-term manure additions increased corn grain yields by 19% in 1998 and by 25% in 1999. Increased yield from manure additions was likely related to an enhancement in water retention. Results from this study show that long-term manure application is a possible management alternative for restoring the physical properties and crop productivity of eroded soil.

2.250 Franklin *et al.* (2003) was studied the **“ELEMENTAL CONCENTRATIONS IN SOILS OF SOUTH CAROLINA.”** They determined the concentrations of 25 elements in soils typical of the Southeast Atlantic Coastal Plain, Piedmont, and Blue Ridge at 50 sites in South Carolina. Our purpose was to gather baseline data on the elemental content of soils for use in dealing with land application of wastes and other environmental issues involving metal content in soils. Concentrations of more than one-half of the elements were higher in the Blue Ridge and Piedmont soils than in those in the Carolina Sandhills, Upper Coastal Plain, or Lower Coastal Plain. Concentrations of Al, Ba, Be, Cd, Co, Cr, Fe, K, Li, Mn, Na, Ni, Rb, S, Sb, Sc, V, and Zn were correlated positively with clay content. Selenium and were correlated negatively with clay content. Several of these elements (Al, Ba, Fe, K, Mn, Ni, S, Se, V, and Zn) were correlated positively with soil pH, but correlation coefficients were generally less than for correlations with clay content. Land use, according to cropping history, was not a significant factor affecting elemental concentrations. Sites that had been cropped to cotton or pastures for long periods of time had slightly higher concentrations of As and Cu, respectively, but differences were of little consequence. Soil Ni concentrations were higher at forest sites compared with all other sites, which may have been due to more effective biogeochemical recycling at forest sites resulting in higher soil retention. We found no

evidence that soil at the 0-15-cm depth was enriched with any elements. Concentrations within the 0-15-cm depth were no different than those within the 15-30-cm depth, indicating that any enrichment that may have occurred because of anthropogenic activities had become distributed throughout the 30-cm depth as a result of tillage and natural processes. The maximum value and geometric mean of Cd concentrations were considerably greater than values reported in two other surveys of U.S. soils. Some sites in all of the land resource and land use categories had concentrations of As and Cd that translated into soil loads exceeding 30% of the cumulative pollutant load limits cited in the USEPA 503 regulations.

2.251 Norfleet *et al.* (2003) studied “**SOIL QUALITY AND ITS RELATIONSHIP TO PEDOLOGY.**” In this regard, soil quality can be considered part of the science of pedology. Significant differences in selected near-surface soil properties and subsequent interpretations as influenced by land use are illustrative of the need to collect data reflecting use-dependent or dynamic soil properties. Inherent or use-invariant properties dictate the limits to which dynamic properties range. As pedologists begin to explore these relationships, a dynamic soil properties database should be developed as a companion to the database of use-invariant properties used currently for classification, mapping, and interpretation.

2.252 Shukla and co-worker (2003) was studied the “**LAND USE AND MANAGEMENT IMPACTS ON STRUCTURE AND INFILTRATION CHARACTERISTICS OF SOILS IN THE NORTH APPALACHIAN REGION OF OHIO.**” The five treatments were no-till without manure (NTWM), no-till with manure (NTM), no-till corn (*Zea mays*)-soybean

(*Glycine max*) rotation (NTCSR), conventional tillage (CT), and meadow (M). Treatments significantly influenced water infiltration characteristics, soil bulk density (ρ_b), aggregation, and mean weight diameter (MWD). The maximum cumulative infiltration after 3 h (I) of 109.3 ± 29.0 cm (average of 9 measurements at 3 landscape positions) was measured for the NTM treatment and the lowest 27.7 ± 21.0 cm (average of 3 measurements at shoulder slope or S) for the CT treatment. The infiltration rate at 5 min (i_5), steady state infiltration rate after 3 h (i_c) and field capacity water content 24 h after the infiltration (FC) were higher in NTM (1.5 cm min^{-1} , 0.4 cm min^{-1} , and 0.35 g g^{-1} , respectively) than other treatments. The least values of i_5 , i_c and FC (0.4 cm min^{-1} , 0.18 cm min^{-1} , and 0.22 g g^{-1} , respectively) were observed for the CT treatment. Saturated hydraulic conductivity (K_s) measured on soil cores was the highest for the NTM (0.29 cm min^{-1}) for 0 to 10 cm and NTCSR (0.24 cm min^{-1}) for 10 to 20 cm depth. The ρ_b (1.52 g cm^{-3} for 0 to 10 cm and 1.62 g m^{-3} for 10 to 20 cm depth) was the lowest and water stable aggregates (WSA) were the highest (WSA of 89% and 63%) for both depths for the NTM treatment. The ρ_b was much higher for the CT (1.75 g cm^{-3} for 0 to 10 cm depth) and NTWM (1.77 g cm^{-3} for 10 to 20 cm depth) than NTM, NTCSR and M treatments for either depth. The landscape positions did not have a significant influence on soil physical and water transmission properties nor on total biomass. The manuring treatment improved soil aggregation and water transmission properties.

2.253 Liu and Chen (2004) was studied the “**SOIL CHARACTERISTICS AND CLAY MINERALOGY OF TWO SUBALPINE FOREST SPODOSOLS WITH CLAY ACCUMULATION IN TAIWAN.**” The objectives of this were to investigate the soil characteristics, weathering

patterns of clay mineralogy, and genesis of the two Spodosols with clay accumulation in the Chunta Mountain region of central Taiwan. We have also proposed modification of the description of Spodosols in *Soil Taxonomy*. Soil characteristics, clay distribution, low soil pH, and very low base saturation percentage caused by strongly leaching processes indicate that podzolization and clay illuviations are the pedogenic processes in the study area. The subsurface horizons of the two Spodosols meet the chemical criteria of the spodic horizon defined in Soil Taxonomy, which suggest that translocation of spodic materials has occurred. The value of organic carbon and Fep/Feo or Alp/Alo ratio reaches a profile maximum in the spodic horizon, which suggests that the spodic horizon was formed predominantly by the illuviation of organo-metallic complexes. Soluble organic matter leached with the soil solutions along the soil pores from the upper horizons to the spodic horizon. The spodic horizon is characterized by many black and other dark pellets of organic matter. The clay mineralogy of the A and albic horizons is dominated by illite, vermiculite and vermiculite-illite interstratified minerals (VI), but the Bhs horizons contain mainly vermiculite and hydroxy-interlayer vermiculite (HIV). The clay mineralogy of the eluvial horizons differs somewhat from that in the illuvial horizons as a result of moderate weathering. The weathering sequence of clay minerals in these two loamy Spodosols is: illite → vermiculite (or VI) → HIV. According to the USDA Soil Taxonomy, the two pedons with clay accumulation can be classified as a Typic Haplohumod and a Typic Haplorthod.

2.254 A. Thangasamy and co-worker (2004) studied “Clay Mineralogy of Soils in the Sivagiri Micro-watershed of Chittoor District, Andhra Pradesh.” The clay film invariably exhibited the characteristic peaks of

smectite, kaolinite and mica. Semi-quantitative estimates of clay fractions based on relative areas under corresponding peaks indicated that the pedons 1, 2, 3, 5, 6, 7, and 8 are dominated by smectite followed by kaolinite and mica whereas pedons 4 and 9 are dominated by kaolinite followed by considerable amounts of smectite and mica. Feldspar and quartz are present in traces. However, use and management of these soils for agricultural production require an understanding of their clay mineralogy.

2.255 A.K. Guber, Pachepsky and Levkovsky (2004) studied a “MASS-SIZE SCALING IN SOIL AGGREGATES AS AFFECTED BY AGGREGATE WATER CONTENT AND SOIL COMPACTION.”

Information about soil structure can also be derived from examining the aggregate mass or density of aggregate size. There have been several reports indicating that the density-size relationships in air-dry aggregates follow predictions of a model assuming aggregates to be mass fractals. It was demonstrated recently that such model is applicable to wet aggregates if parameters of this model are assumed to be linear functions of gravimetric water contents. The objective of this study was to evaluate sensitivity of fractal parameters to soil compaction caused by wheel traffic. Irrigated and non-irrigated plots were laid out at silty clay Greyzem under fallow, and treatments of one tractor pass and three tractor passes were applied. The volume of individual aggregates for four depths in the plow layer was measured by kerosene method at air-dry water content, at two intermediate water contents between saturation and air-dry, and at saturation. The mass fractal model fitted data in a satisfactory manner within the range of water contents from air-dry to saturation with a R^2 of 0.99. Both the slope and the intercept of the dependence of fractal dimension and reference aggregate mass on water

content were more sensitive to compaction than to soil bulk density and aggregate size distributions. Parameters of fractal scaling showed promise for diagnosing compaction in studied soil.

2.256 Krishnan and co-worker (2004) was studied **“Land, Soil and Land Use of Lakshadweep Coral Island.”** Ten soil series identified on the basis of soil morphological, physical and chemical properties were spatially delineated. The soils are generally deep, excessively drained, alkaline in reaction and poor in water holding capacity. Coarse fragments, shallow rooting depth and poor drainage conditions were observed in limited areas. The soils, in general, are deficient in plant nutrient element viz. K, Me, Mn, and Zn. In absence of viable sources of irrigation water, rainfed coconut plantation inter-cropped with vegetable and fruit crops seems to be the only land use option. Alternate uses of problem areas are suggested.

2.257 Hassan and co-workers (2004) was the **“DEPENDENCE OF THE DEGREE OF LINEAR POLARIZATION IN SCATTERED VISIBLE LIGHT ON SOIL TEXTURAL FRACTIONS.”** Determination of soil textures in the laboratory using traditional methods is labor and time intensive. A quick and relatively easy method was developed to achieve this purpose using light polarization. Preliminary measurements based on Stokes polarimetry were made to examine the feasibility of estimating soil texture by measuring the degree of linear polarization (P) in light scattered by surface layer (0-30 cm) samples. Samples were collected at 18 locations along a transect from Alexandria to Sidi Barrani on the north-western coast of Egypt. These samples represent a broad range of soil types and textures. The results from this study show that the soil textural fractions (% sand, % silt, and % clay) were linearly related to P

in the scattered visible light. For a given particle size fraction, the relationship was especially strong for a preferred wavelength. The best-fitted regression lines ($R^2 > 0.99$) were % sand = $66.53 - 64.10 P$ for 470 nm, % silt = $10.35 + 40.65 P$ for 420 nm, and % clay = $4.92 + 44.44 P$ for 410 nm. These findings indicate that there is potential for development of a laboratory procedure to rapidly determine the texture of soil samples.

2.258 Dolui and Maity (2004) was studied the “**Nature of Soil Acidity in Relation to Different Forms of Iron and Aluminium of Some Alfisols of West Bangal.**” Acid soils of West Bangal, belonging to the order Alfisols, were studied to characterize the nature of acidity in relation to different forms of iron and aluminium. The mean contents of iron and aluminium, extracted by various extracting reagents, were found to be in the following descending order: Dithionite > oxalate > pyrophosphate > KCl > ammonium acetate. The electrostatically bonded EB- H^+ and EB- Al^{3+} acidities constituted 32 and 68%, respectively of exchangeable acidity while EB- H^+ , EB- Al^{3+} , exchangeable and pH-dependent acidities comprises 7, 15, 22 and 78%, respectively of total potential acidity. Correlation between different forms of acidity and Fe and Al in soils suggested that the effects of different forms of Al was more dominant, which directly participate in the formation of different forms of acidity.

2.259 Zeng-Yie Hseu and co-workers (2004) studied the “**TRANSITIONAL SOIL CHARACTERISTICS OF ULTISOLS AND SPODOSOLS IN THE FOREST OF TAIWAN.**” Soil analysis, including field description, physical and chemical analyses, and micro morphological studies, was used to study the soils. The soil colors are

close to 7.5YR 5/6 in all subsurface horizons with different degrees of spodic material accumulation. Various clay coatings and pellet-like aggregates were found in all subsurface horizons, which satisfied the morphological and chemical criteria for a spodic horizon (Bhs) as defined in *Soil Taxonomy*. The illuvial clay coatings have relatively weak birefringence but are masked by organo-metallic complexes. Spodosols were found locally to have a thick organic layer, which may intensify the podzolization process. We hypothesized that Fe and Al were chelated by organic matter in the surface portion of the pedon to form organo-metallic complexes. The translocation of clay occurred before the illuviation of organo-metallic complexes in the subsurface horizons during soil development. The slow accumulation of organo-metallic complexes in the Bhs horizons within the 50 cm depth is attributed to fine texture and less porosity. The soils derived from two pedogenic process to show the transitional status between Ultisols and Spodosols that the argillic horizon is overlain by the spodic horizon.

2.260 Patel et al. (2004) reported the “**Heavy Metal Content of Different Effluents and their Relative Availability in Soils Irrigated with Effluent Waters around Major Industrial Cities of Gujarat.**” The soil, plant, effluents and well-water samples collected were analysed for the relevant parameters. The COD value of effluents from Ankleshwar site was extremely high, while the BOD values were within the safe limit in all the cases. The effluents from Ankleshwar site were the most polluted with respect to different elements viz. Fe, Cu, Mn, Cd, Ni, Co and Cr. The dissolved oxygen was observed only in well-water and not in effluents. The results of relative availability of trace and heavy metals indicated that Cu, Pb, Zn and Cd were the most available elements in different soils. However, the soils continuously irrigated with effluents

showed the highest Cu availability and Mn, Cu, Cd and Ni moderately available, while Fe and Cr indicated low availability.

2.261 Sharma *et al.* (2004) studied the “**Characterization of Cultivated Soils of Neogal Watershed in North-West Himalayas and their Suitability for Major Crops.**” Six typical pedons representing cultivated soils of Neogal watershed in North-West Himalayas occurring on river terraces and hill slopes viz. Baun, Talinu, Phata, Gopalpur, Bhattu and Mahadev were studied for their morphological characteristics and physico-chemical properties and suitability for locally preferred crops. The soils are acidic in reaction, non-calcareous, coarse to fine loamy in particle size class, mixed in mineralogy and medium and medium to very deep and have thermic soil temperature and udic soil moisture regimes. The soil texture, pH (1:2.5), organic carbon, CEC, base saturation, water retention at 33 and 1500 kPa ranged from loamy sand to clay loam, 5.2 to 6.2, 3.2 to 9.5 g kg⁻¹, 4.9 to 14.3 cmol (p⁺) kg⁻¹, 46 to 77%, 4.2 to 31.2% and 2.6 to 16.8%, respectively. Taxonomically, the soils on moderately sloping hill slopes and gently sloping streams side (Baun and Phata) belong to Typic Udorthents and Typic Udipsamments and those on gently to moderately sloping river terraces.

2.262 Madumita Das (2004) was studied “**Alliance among Hydro-physical and Physico-chemical Properties of Soil.**” Estimation of water retention characteristics, penetrability, weighted mean diffusivity and cation exchange capacity (CEC) of soil is difficult though imperative to characterize any soil and study the soil water relation. Therefore, with the measured values of clay, organic and humus carbon, pore space,

coarse sand, soil volume expansion, pH, saturated hydraulic conductivity and absolute specific gravity of twelve different soils, linear, quadratic and logarithmic regressions were evaluated separately in different relevant combinations for determining the above properties. Validation of relations reveals that linear and quadratic regressions with known values of clay, organic carbon and pore space/ soil volume expansion determine the wilting point successfully, while quadratic relation was only found suitable to determine the field capacity of soil. Quadratic equation developed from clay and pore space per cent with organic/ humus carbon can be used to determine available water capacity and penetrability of soil. However, the CEC of soil, derived from all regression functions developed on clay content, organic carbon, and soil volume expansion / pH, was found in good agreement with the actual value. The study thus provides some easy alternatives to be utilized appropriately with the actual value. The study thus provides some easy alternatives to be utilized appropriately for precise evaluation of important hydro-physical and physico-chemical soil properties.

2.263 Lama, Mallick and Sanyal (2004) studies of “**Solute Transport and Retention in Some Soils of West Bengal.**” Solute transport involving passage of aqueous electrolytes, namely KCl, K_2SO_4 and $MgCl_2$ in vertical columns of soils from four locations, namely Baruipur, Gayeshpur, Kalimpong and Matimahal at two different compactions levels has been studied. The experimental data were analysed to obtain the hydraulic conductivity, solute accumulation and breakthrough curves for the aqueous electrolytes in the given soils. The hydraulic conductivity of the aqueous electrolytes through the soils decreased with the increase in compaction. Baruipur soil having high clay and organic

matter contents gave distinctly lower values of hydraulic conductivity for K_2SO_4 than those for KCl. The values of solute accumulation parameter 'r' for Baruipur and Gayeshpur soils were greater than those for other soils for each solute over the entire permeation period. This may be due to the presence of smectitic and illitic clay minerals having high specific surface area. The value of 'r' in all the soils was greater for the passage of aqueous potassium salts as compared to aqueous $MgCl_2$. This may have arisen from the presence in these soils of considerable amounts of illitic minerals having a high degree of specificity for retaining K^+ ions. The sigmoid shape of the breakthrough curves (BTCs) for the electrolytes indicated hydrodynamic dispersion. The shifting of the BTCs to the left of the inflexion point suggested the preferential flow of solute in the large pores. The shift was minimum for the Matimahal soil having lowest clay and organic matter contents. On the other hand, the shifting was greater for Kalimpong soil than for Baruipur soil despite the fact that the former had lower clay and organic matter contents, possibly due to greater size of aggregates in the former.

2.264 Dianqing Lu and co-worker (2004) studied the “**EFFECT OF CHANGING BULK DENSITY DURING WATER DESORPTION MEASUREMENT OF SOIL HYDRAULIC PROPERTIES.**” The objective of this study was to investigate bulk density changes during water desorption measurement and the effects of these changes on soil hydraulic properties. Soil water characteristic curves were measured by a pressure plate technique for five soils with textures ranging from silt loam to clay loam. Bulk densities of the soils were determined at all equilibrium pressure values during the water desorption measurements. Measured water characteristic curves for the soils were described by the

Brooks and Corey model. Measured water characteristic curves with changing bulk density were compared with those derived from using four characteristic bulk densities – assigned, packing, averaged, and optimal – for five soils. Results showed that there were measurable changes in bulk density during the pressure plates tests for the four characteristic bulk densities, the differences between fitted Brooks and Corey soil water characteristics curves and those derived from measured bulk density data at each pressure were the smallest for the optimal bulk density. The optimal bulk densities were associated with a pressure of about 0.7m. For each soil, estimated hydraulic conductivities and water diffusivities were smaller for the larger characteristic bulk density values.

2.265 Bhattacharya and co-worker (2004) studied the “**Effect of Long-term Manuring on Soil Organic Carbon, Bulk Density and Water Retention Characteristics under Soyabean-Wheat Cropping Sequence in North-Western Himalayas.**” The dynamics of soil characteristics was studied in an on going long term fertility experiment *since kharif* 1973 at Hawalbagh, Uttaranchal with 6 treatments (viz. NP, NK, NPK, N+FYM, NPK+FYM and Control) comprised of recommended levels of N, P, K and FYM @ 10 Mg ha⁻¹. The manure and fertilizers were given in soybean crop every year and wheat crop was grown on residual fertility. Depthwise (0-15, 15-30 and 30-45 cm) soil samples and undisturbed soil cores from all the treatments were studied for oxidizable and non-oxidizable organic carbon (OC), bulk density (BD), soil-water retention and available water capacity. Both oxidizable and non-oxidizable soil OC contents of the soil were higher in FYM treated plots at the first two depths (1.31 and 10.44 g C kg⁻¹ in

0-15 cm; 1.87 and 8.44 g C kg⁻¹ in 15-30 cm, respectively for NPK+FYM treatment) and were significantly higher than all other treatments. The BD was minimum in NPK+FYM treatment in all the depths (1.24, 1.24 and 1.25 Mg m⁻², respectively) and it had a negative correlation with OC content. It has also been found that decrease in BD per unit increase in non-oxidisable OC content over initial soil was more than decrease in BD per unit increase in oxidizable OC content. Water retention on volumetric basis decreases with increasing depth and suction within a particular treatment, the highest water retention was found in FYM combined treatments. Available water capacity was maximum in N+FYM and NPK+FYM treatments and showed a decreasing trend with depth. The N+FYM treatment has a net gain of 2.85 cm (per 45 cm soil layer) of available water over control in 29 years while NPK+FYM treatment has the gain of 3.45 cm.

2.266 Jena and co-worker (2004) studied the “**Transport of Nitrogen Contained in Urea Super Granules Placed in Flooded Rice Soils.**” A field experiment was conducted during 1995 to study the transport of N species originating from 1g urea super granules (USG) point-placed in the rice root zone at 0.025 and 0.05 m soil depth. Velocity of urea-N at 0.20 m soil depth was higher than that of NH₄⁺-N. The velocity of water was lower than urea-N and NH₄⁺-N. Nitrogen in the form of urea N and NH₄⁺-N to the extent of 20-55% of applied USG-N was detected in soil solution collected at 0.20 m soil depth. Downward movement of NH₄⁺-N was higher than upward diffusion from the point of placement of USG. No NO₃⁻-N was detected in the soil solution. Manual placement of USG at 0.05 m soil depth increased both grain and straw yield significantly over surface application of prilled urea at same N dose. On the other

hand, grain yield due to mechanical application of USG was at par with that of yield due to the application of USG manually. Mechanical placement of USG at 0.05 m soil depth in flooded rice soil will be cost-effective and economical without much reduction in yield.

2.267 Brye and West (2005) studied “**GRASSLAND MANAGEMENT EFFECTS ON SOIL SURFACE PROPERTIES IN THE OZARK HIGHLANDS.**” The objective of this study was to characterize the effects of prairie conversion to agricultural grasslands on soil properties in the Ozark Highlands of northwest Arkansas. Three native prairie sites were identified with adjacent grazed or hayed grasslands on silt-loam soils. Four prairie-agricultural grassland comparisons were made for this study, with each comparison occurring on the same soil-mapping unit. Conversion of native prairie to grazing and hay harvesting created significantly ($P < 0.05$) higher bulk density, soil pH, and extractable P, Mg, and Mn within the top 10 cm. There was a significantly ($P < 0.2$) larger difference in electrical conductivity, extractable K, Na, and Fe, but a significantly smaller difference in total N and C and organic matter concentration, in the top 10 cm between prairie-grazed and prairie-ungrazed land use combinations. Overall, soil surface properties of agricultural grasslands in the Ozark Highlands were similar to those of native on disturbed prairie, indicating that either negligible responses occurred following conversion, parameters recovered to original equilibrium levels, or the magnitudes of agricultural inputs following conversion were too low to change equilibrium levels substantially.

2.268 Olness and Archer (2005) studied the “**EFFECT OF ORGANIC CARBON ON AVAILABLE WATER IN SOIL.**” A model of water-holding characteristics of soil is needed to develop a systematic method

for determining the value of organic C in soil. In the United States, available water-holding capacity (AWC) in soil is that water retained in soil between field capacity and the permanent wilting point; these limits are approximated by that water retained between two energy limits: -1500 matrix potential (hygroscopic and micropore water) and about -33 k Pa matrix potential (capillary rise). The General Energy Model for Limited Systems (GEMLS) was used to describe the effects of clay, silt, and organic C content and silt content. The data from each subset were plotted as a function of soil clay content. Because of an apparent matrix transition effect, two complementary GEMLS functions were used to describe the -33 kPa and -1500 kPa water content as a function of soil clay, silt, and organic C content. The model used six parameters (two function coefficients, two energy coefficients, and two critical clay contents), and required an initial manual fit of the models to the data subsets (about 100 ± 20 observations). Criteria for acceptance were uniform and homogenous distribution of the model residuals, absence of a detectable trend in the residual distribution, zero error sum, and maximal R^2 . The primary energy coefficients were correlated with silt content. After the initial manual fit, the data were subjected to analysis using the SAS PROC MODEL procedure and a variable energy coefficient. Subsequent analyses indicated a complex relationship between the energy coefficients and the soil organic C content. A 1% increase in soil organic carbon causes a 2 to > 5% increase in soil AWC depending on the soil texture.

2.269 Solomon *et al.* (2005) studied a “Carbon K-Edge NEXAFS and FTIR-ATR Spectroscopic Investigation of Organic Carbon Speciation in Soils.” They used C (1s) near-edge x-ray absorption fine

structure (NEXAFS) and synchrotron-based Fourier transform infrared-attenuated total reflectance (FTIR-ATR) spectroscopy to speciate C and investigate the influence of land use on the composition of SOM in the humic substances extracted from clay and silt fractions. Soil samples were collected from natural forest, tea and Cupressus plantations and cultivated fields in Ethiopia. Carbon K-edge spectra revealed multiple C (1s) electron transitions in the fine structure of C NEXAFS region (284-290 eV) indicating the presence of aromatic-C, phenolic-C, aliphatic-C, carboxylic-C, and O-alkyl-C in the humic substances. It also exhibited good selectivity, where specific energy regions correspond to C in discrete functional groups. However, regions of slight overlap between 1s-3p/ σ^* transition of aliphatic-C and 1s- π^* transition of carboxylic-C may not be excluded. Fourier transform infrared-attenuated total reflectance spectroscopy showed larger proportions of aromatic-C (25.5%, 21.9%) and asymmetric and symmetric aliphatic-C (19.7%, 15.2%) groups in the silt than in clay, respectively. However, smaller proportion of polysaccharides (19.3%, 11.5%) was obtained from the silt compared with clay. The proportions of phenols (20.7%, 20.4%), aliphatic deformation of CH₂ or CH₃ (13.1%, 14.5%), and carboxylic (9.8%, 8.3%) groups were of similar magnitude in both fractions. The proportion of polysaccharides decreased in the order: natural forests > plantations > cultivated fields, while recalcitrant aromatic-C increased in the order: natural forest < plantation < cultivation.

2.270 Brouder, Hofmann and Morris (2005) were reported the “**Mapping Soil pH: Accuracy of Common Soil Sampling strategies and Estimation Techniques**”. Our objective was to compare the accuracy of spatially continuous pH and lime requirement (LR) maps derived from

commercially used approaches to sampling and LR prediction at unsampled locations. We evaluated point (P) sampling on 0.1-, 0.4-, and 1.0-ha grids and area composite (AC) sampling by 1-ha grids, soil type (ST), and whole field (WF). Inverse distance (ID) weighting and ordinary kriging were applied to water pH and LR data from 11 fields. Modeling of semivariance identified range parameters of ≤ 100 m. For intensive P sampling (0.1- or 0.4-ha grids), kriging was occasionally more accurate than ID weighting but mean absolute error (MAE) differences were small (≤ 0.01 pH units and ≤ 0.13 Mg lime ha^{-1}), suggesting little practical consequence to prediction method selection. One-hectare point data were too sparse to produce variograms and applying ID weighting to these data found only small advantages over WF compositing. Lime use was either unaltered or minimally reduced (10%) by 1-ha P as compared with WF compositing. When compared with WF composites, map prediction efficiencies (PEs) based on mean square error (MSE) analysis ranged from 7 to 51, -13 to 40 and -6 to 54% for ST compositing, 1- and 0.4-ha P sampling, respectively. These results suggest ST compositing remains viable and cost-effective for pH management, especially where ancillary information exists to verify distinct soil series boundaries.

2.271 Sorensen and Dalsgaard (2005) studied “**Determination of Clay and Other Soil Properties by Near Infrared Spectroscopy.**” The feasibility of using near infrared (NIR) spectroscopy for rapid non-destructive prediction of clay and other soil properties was investigated. Soil from all regions of Denmark was used to develop universal NIR spectroscopic calibrations. Samples were packed in a rectangular sample cell with a surface area of 60 cm^2 and the cell was moved during measurements using a transport module. Reflectance was

measured in the 400- to 2500-nm range and instrument calibration was performed by partial least square (PLS) regression. The accuracy and robustness of NIR equations for determination of clay was dependent on the calibrated concentration range, the spectral regions used for calibrations and the spectral pre-treatment procedure. The optimal narrow range calibration for clay (1-26% clay) gave predication errors of 1.7 to 1.9% while the prediction error for the optimal broad range calibration (3-74% clay) was estimated as 3.4%. The estimated true accuracy was 1.5 to 1.7% (1-26% clay). By comparison, the reproducibility standard deviation of the reference method was 1.3%. For C, silt and sand, the prediction erros were 0.42, 4.6, and 5.5% respectively. The ratios between analyte variation range standard deviation and prdidtion error were 3.1 (1-26% clay), 4.7 (3-74% clay), 2.4 (C), 2.0 (silt), and 2.4 (sand). The results demonstrate that NIR spectroscopy is a potential technique for rapid and cost-effective determination of clay in a soil. The technique may also be useful in prediction of other particle-size fractions. The investigated technique was less suitable for determination of total C in Danish soil samples.

2.272 C.E. Allen (2005) was studied a **“Physical and Chemical Characteristics of Soils Forming on Boulder Tops, Kärkevagge, Swedan.”** However, these studies have overlooked soils that are forming on the uppermost surface of the boulders that give Kärkevagge its name, “Valley of the Boulders.” The physical and chemical characteristics of the soils forming on boulder tops are therefore examined herein. Soil samples were collected from 20 large boulder tops and analysed according to standard procedures. The boulder-top soils were weakly developed, < 27-cm deep, coarse-textured, weak-structured, and well-drained. There was minimal horizonation. Physical

characteristics of the boulder-top soils are comparable with the alpine soils in the region. Soil reactions were very acidic, with low base saturation and low cation exchange capacity (CEC). Chemical characteristics are similar to soils in the rest of the watershed, whereby extractable $\text{Ca} > \text{Mg} > \text{K} > \text{Na}$ in the soils, albeit the values are substantially lower overall in the boulder-top soils than for the rest of the Kärkevagge. Although the boulder top soils were weakly developed, there was incipient pedogenesis as exemplified by the presence of pedogenic Fe. The boulder-top soils were classified as loamy-skeletal, micaceous, acid Lithic Cryothents. Results illustrated that, like the rest of Kärkevagge, chemical weathering is an important contributing process in boulder-top soil formation, and that the boulder-tops provided a unique opportunity to evaluate incipient pedogenesis in an arctic-alpine setting.



CHAPTER – III

A BRIEF DESCRIPTION OF THE STUDY AREA

3.1 DESCRIPTION OF THE STUDY AREA

The study area selected for the present work is situated in the **Kumaon region** of the **Uttarakhand state** (formerly known as **Uttaranchal state**) of **India**. The total area of Uttarakhand state is 53,484 sq. km. **Tibet, China and Nepal** countries touch the boundaries of Uttarakhand state. In **India, Himanchal Pradesh, Haryana and Uttar Pradesh** are the three main neighbouring states of Uttarakhand state. There are thirteen districts in this state. Based on the situation of these districts, the approach by road and convenience in administrative implementations the Uttarakhand state has been divided into two regions/divisions namely **Kumaon and Garhwal divisions**. **Kumaon region is situated between 28°43'24" to 31°27'5" North latitude and 77°34'27" to 81°02'22" East longitude**. The location of the Uttarakhand state has been shown in Fig. 3.1.

The entire study area has been divided into various sites depending upon the criteria given below:

- (i) The site represents the agricultural fields/areas of a specified portion of the land used or likely to be used by the farmers.
- (ii) The sites are separate and different from each other in terms of distance as well as Physical/Chemical properties of the soils as evidenced by the preliminary examinations.

The three major regions selected for the present study have been described as follows:

(1) Hill Region

Four sites were selected from Hill region. Fig. 3 represents the sites, which describe the location of the study area:

- (i) **Site No.1: Bhimtal:** This site is close to Bhimtal and situated on the Bhowali road. The land is mostly covered by green grass.
- (ii) **Site No. 2: Maharagaon:** This site is about 5 km far from Bhimtal on the Bhimtal-Bhowali road. The land is mainly used for agriculture. Fertilizers are used according to the requirements of crops.
- (iii) **Site No. 3: Khalkwira:** This site is situated in the east of Bhowali town and is about 2 km far from Bhowali. There are orchards of plums (a famous fruit of Uttarakhand) around this site.
- (iv) **Site No. 4: Nauligarh:** This site is about 3 km far from Bhowali on the Bhimtal-Bhowali road on the western side.

(2) **Bhabar Region**

Four sites were selected from Bhabar region. Fig. 3 represents the sites, which describe the location of the study area:

- (i) **Site N0. 5: Haldwani:** This site is close to Haldwani proper near Dhanmill on Haldwani-Rampur road. It is mainly used for agricultural purposes as it is connected by canals for irrigation purposes.
- (ii) **Site No. 6: Gajraula:** This site is about 9 km. from Haldwani on the Haldwani-Kaladhungi road. It is also used basically for agricultural purposes.
- (iii) **Site No. 7: Kathgodam:** This site is near Kathgodam railway station on Kathgodam-Nainital road. The main soil of this site is directly or

indirectly affected by the falling leaves as it provides “humus” to the land.

(iv) **Site No. 8: Kusumkhera:** This site is about 3 km far from Haldwani on the South-west direction. The land is mainly used for agricultural purposes.

(3) **Tarai Region**

The study areas of the Tarai-region has been selected from Khatima, Sitarganj, Rudrapur and Pantnagar cities/towns of the Udham Singh Nagar district of Uttarakhand state. Five sites from Khatima area and two sites each from the Sitarganj, Rudrapur and Pant Nagar areas were selected for the present work.

Fig. 4 to Fig. 6 represents the location of the sites of the study area in this region.

(A) **Khatima:** The study area of Khatima was divided into five sites for the present study.

(i) **Khatima (Banusa) (Site -1 \Rightarrow S₁)**

This site is situated at about 9 km away in the western part of Khatima Block. The site is about 2-3 km along the main road. This site is one of the main agricultural areas of Khatima region.

(ii) **Khatima (Jhankat) (Site -2 \Rightarrow S₂)**

The site is about 8 km away from Khatima Tehsil on the western part of Khatima. It is a barren land and its adjoining land is mainly used for agricultural purposes.

(iii) Khatima (Amaun) (Site -3 \Rightarrow S₃)

The site is about 2 km far from Khatima Tehsil along Tanakpur road in the northern direction of Khatima. The study area is lying barren since a long period.

(iv) Khatima (Chakerpur) (Site -4 \Rightarrow S₄)

The site is about 7 km far from Khatima Tehsil in the northern direction. The population density is very low in this area. As it is surrounded by the forest, it is rich in “humus”.

(iv) Khatima (City) (Site -5 \Rightarrow S₅)

The site is close to the Khatima Tehsil and the adjoining playground of the area. Therefore this site is also lying barren since a long period. This site may have the larger impact of the urban population, animals and other ecological factors.

(B) Sitarganj: The Sitarganj area was divided into two sites for present work. The two sites of this area are as follows:

(i) Sitarganj - 1 (Site -6 \Rightarrow S₆)

This site is present on Sitarganj by pass road. It is an agricultural land on which mainly seasonal crops are grown.

(ii) Sitarganj - 2 (Site -7 \Rightarrow S₇)

This site is close to Sitarganj town. It is an agricultural land and people dump their garbage on the land near this site.

(C) **Rudrapur:** Two sites were selected from Rudrapur.

(i) **Rudrapur -1 (Site -8 \Rightarrow S₈)**

This site is about 3.5 km before Rudrapur on Rudrapur-Haldwani road. The land is mainly used for agricultural purposes. The soil of this land is affected by ecological factors.

(ii) **Rudrapur -2 (Site -9 \Rightarrow S₉)**

The site is about 1 km far from Rudrapur Bus-stand.

(D) **Pantnagar:** Two sites were selected from the Pantnagar area for this study

(i) **Pantnagar-1 (Site -10 \Rightarrow S₁₀)**

This site is about 3 km from Pantnagar on Haldi-Rudrapur road. This site is agricultural land on which some guava trees are also grown. This site is surrounded by mango and guava trees.

(ii) **Pantnagar-2 (Site -11 \Rightarrow S₁₁)**

This site is about 6 km far from Pantnagar on Rudrapur road. This site is near the main road.



CHAPTER – IV

MATERIALS AND
METHODS

4.1 CHEMICAL AND REAGENTS

The following chemicals and reagents were used in the present work:

S.No.	Name of the Chemicals/Reagents	Specifications
1.	Acetic Acid (glacial)	AR Grade
2.	Boric Acid	AR Grade
3.	Calcium Carbonate	AR Grade
4.	Copper Sulphate	AR Grade
5.	Diphenyl Amine	AR Grade
6.	Bromo-Cresol-Green	AR Grade
7.	Hydrochloric Acid (Con.)	AR Grade
8.	Sulphuric Acid	AR Grade
9.	Ortho Phosphoric Acid	AR Grade
10.	Sodium Hydroxide	AR Grade
11.	Sodium Acetate	AR Grade
12.	Sodium Fluoride	AR Grade
13.	Sodium Chloride	AR Grade
14.	Sodium Bicarbonate	AR Grade
15.	Ammonium Hydroxide	AR Grade
16.	Ammonium Fluoride	AR Grade
17.	Ammonium Molybdate	AR Grade
18.	Potassium Dichromate	AR Grade
19.	Potassium Sulphate	AR Grade
20.	Potassium Chloride	AR Grade
21.	Ferrous Ammonium Sulphate	AR Grade
22.	Zinc Sulphate	AR Grade
23.	Manganese Sulphate	AR Grade

24.	Methyl Red (Indicator)	AR Grade
25.	Activated Charcoal (Darco G-60)	AR Grade
26.	Methanol	AR Grade
27.	Ammonium Acetate	AR Grade
28.	Selenium Metal	AR Grade
29.	Ethyl Alcohol (95%) Rectified	AR Grade
30.	Stannous Chloride	AR Grade
31.	Nitric Acid	BDH
32.	Phenolphthalein	BDH

4.2 APPARATUS/ EQUIPMENTS USED

The following apparatus/equipments were used in the present study:

S.No.	Name of the Equipments/Apparatus	Specifications
1.	Digital pH meter (Microprocessor based)	Systronics μ pH-362
2.	Magnetic Stirrer	Tempo
3.	Auto titrator	Systronics-351
4.	Conductivity meter (Digital Microprocessor based)	Systronics-306
5.	Centrifuge with Centrifuge tube	Remi 4C
6.	Shaker Electrical	Toshiba
7.	Water bath	Sonar
8.	Flame Photometer with (Na, K, and Ca) filters	Systronics Mediflame
9.	Hot air oven (small)	RTSE
10.	Atomic Absorption spectrophotometer	Cameto 201
11.	Grinding mortar	Toshiba
12.	Micro Kjeldahl apparatus	Toshiba

13.	Digestion block (with auto cut device)	Toshiba
14.	U.V.-VIS 119 (computer based)	Systronics 119
15.	Triple Distillation Assembly	NPL
16.	Separating funnel	Pyrex Glass
17.	Electrical balance (Single Pan)	Verbal 200 Super
18.	Pestal Mortar	Toshiba Fishr type
19.	Volumetric flask	Pyrex Glass

4.3 PREPARATION OF THE REAGENTS

1. Ammonium acetate solution (1.0N) CH_3OONH_4

154.0g Ammonium acetate was dissolved in 1.8L of distilled water in 2L volumetric flask. The pH was adjusted approximately at 7.0 with dilute ammonium hydroxide or acetic acid which ever was required and final volume was made up to 2L. This was stored in Pyrex bottle. 1.0N Ammonium acetate solution was also prepared by the following method:

57 mL glacial acetic acid and 59 mL of conc. ammonium hydroxide were taken in a 1L volumetric flask. 900 mL of distilled water were added to dilute it. pH was adjusted at 7.0 by adding more NH_4OH or CH_3COOH as per requirement and final volume was made to 1L by distilled water. This solution was stored in a polypropylene bottle.

2. Ammonium Molybdate Solution $[(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}\cdot 4\text{H}_2\text{O}]$

40.0g of ammonium molybdate $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}\cdot 4\text{H}_2\text{O}$ were dissolved in 1 L of distilled water to prepare this solution.

3. L-Ascorbic Acid Solution

52.8g of L-ascorbic acid ($C_6H_8O_6$) were dissolved in 1000 mL of distilled water.

4. Sodium Acetate Solution (1.0N) CH_3COONa

136.0g of sodium acetateTrihydrate was dissolved [$CH_3COONa.3H_2O$] in distilled water and diluted to 1L in a volumetric flask. The pH of this solution was 8.2 – 8.3 approximately in a 2L volumetric flask.

5. Mixed Indicator

1.0 g of Bromo-cresol-green and 0.2 g of methyl red were dissolved in 100 mL of 95% Ethanol. The pH was adjusted at 4.2 (drak green) with NaOH.

6. Standard Calcium Carbonate ($CaCO_3$) solution (0.01N)

0.5g of pure Calcium Carbonate was dissolved in 10 mL of approximately 3NHCl and the solution was diluted to 1L.

7. 0.5N Sodium Bicarbonate ($NaHCO_3$) or Olsen's Extraction Solution

84.0g of $NaHCO_3$ were dissolved in 2L of distilled water, which was mixed up throughly, and the pH was adjusted with dilute HCl or NaOH at 8.5 as per requirement.

8. Potassium Dichromate (1.0 N) ($K_2Cr_2O_7$)

Oven dry 49.04 g of $K_2Cr_2O_7$ were dissolved in distilled water. Final volume was made up to 1L using distilled water.

9. Ferrous Ammonium Sulphate (0.5N)

196.0 g of ferrous ammonium sulphate were dissolved in 800 mL of distilled water. 20 mL of Conc. H_2SO_4 were added to this solution and final volume was made to 1 litre.

10. 4% Boric acid solution

20.0 g of Boric acid crystals were dissolved in 400 mL of distilled water and the volume was made up to 500 ml in a volumetric flask.

11. Diphenyl Amine Indicator

0.5 g of Diphenyl Amine was dissolved in the mixture of 20 mL of water and 100 mL of Conc. H_2SO_4 .

12. Digestion Mixture

200.0g of K_2SO_4 , 20.0 g of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ and 2.0 g of Selenium metal were mixed thoroughly but very carefully because Selenium (Se) is very toxic in nature.

13. Standard Stock P-Solution

0.439 g oven dry Potassium dihydrogen orthophosphate (KH_2PO_4) were dissolved in 500 mL of distilled water. 25 mL of 7N H_2SO_4 were added and the volume was made up to 1L with distilled water, which gives 100 ppm standard stock solution of P ($100 \mu\text{g L}^{-1}$). Out of the above solution 1 mL, 2 mL, and 5 mL volumetric flask separately and the volume was made up to 100 mL in

each case. These were the working standards of P of 1, 2 and 5 ppm respectively.

14. Murphy-Riley Colour Developing Solution

It was formed by mixing of 250.0 mL of 2.5 M H_2SO_4 , 75 mL of Ammonium Molybdate solution, 50 mL of L-ascorbic acid solution, 25 mL of antimony potassium tartrate solution and finally 100 mL of distilled water. All above solution mixed over a magnetic stirrer in 500 mL of volumetric flask.

15. Bary and Kurtz Extracting Solution

11.1 g of NH_4F were dissolved in 100 mL of distilled water. 1L of distilled water, containing 20 mL of conc. HCl , was added in the above solution and finally it was diluted up to 10 L. This solution was stored for a long time in a polyethylene bottle.

16. Antimony Potassium Tartrate Solution

2.908 g of Antimony Potassium Tartrate [$\text{K}(\text{SbO})\text{C}_{44}\text{O}_{6.1/2}\text{H}_2\text{O}$] were dissolved in 1000 mL of distilled water to prepare this solution.

17. Standard KCl Solution

1.908g oven dry KCl were dissolved in distilled water and volume was made up to 1L, which gave 100 ppm stock solution. 100 mL of this solution was taken in a 1 L volumetric flask and volume was made up to 1L with a 1.0 N ammonium acetate solution which gave 100 ppm working standards were made from the above solution after pipetting out 0.5, 10, 20 mL of the stock solution

in 100 mL volumetric flasks diluted with 1.0 N ammonium acetate solution in each case.

18. Standard NaCl Solution

5.845g of oven dry NaCl were dissolved in 1.0N ammonium acetate and the final volume was made upto 1L in a 1L volumetric flask. It was 100 milli equivalents/L solution of Sodium Chloride (NaCl). Working standards of this solution were prepared by taking 1, 2.5 and 5 mL of the above solution in 100 mL volumetric flasks and final volume was made up to 100 mL by further addition of 1.0N ammonium acetate solution in each case.

19. Extracting Solution for Micronutrients

0.005M DTPA, 0.01 M $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ and 0.1 M TEA (Triethanolamine) adjusted to pH 7.3. Dissolved 1.967g DTPA and 13.3 mL TEA in deionized or glass distilled water. Add 1.47g $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ or glass distilled water taken in one liter volumetric flask and add the DTPA TEA mixture to it and make final volume to about 900 mL adjust pH to 7.3 using 1N.HCl. To make the final volume to one liter and mixed thoroughly.

20. Stock Standard Solution of Microelements

The Standard Solution of different micronutrient cation are prepared preferably by using their foil or wire (AR Grade). Dissolve 0.1g of the foil in dilute HCl (1+1) and make the volume to one liter with deionized water to obtain 100 $\mu\text{g}/\text{mL}$ (i.e. mg/L or ppm) solution of every micronutrient cation.

Alternatively, analytical grade salts can be used to prepare Stock Standard Solution of different micronutrients. The quantity of the salt to be

dissolved its chemical formula, and concentration of receptive stock solution in given below.

S. No.	Element	Atomic Wt.	Salt to be used	Con. of Stock	Quantity (g) to be dissolved in 1L of Solution
1.	Zn	65.38	ZnSO ₄ .7H ₂ O	100	0.4398
2.	Fe	55.85	FeSO ₄ .7H ₂ O or FeSO ₄ (NH ₄) ₂ .6H ₂ O	100	0.4946
3.	Cu	63.54	CuSO ₄ .5H ₂ O	100	0.3928
4.	Mn	54.94	MnSO ₄ .H ₂ O	100	0.3076

The amount of salt as given above was dissolved in a small volume of water followed by shaking after adding about 5 mL of 1.5 sulphuric acids. The contents were then diluted to one liter with deionized or glass distilled water.

Working Standard Solutions

- (i) **Zinc (Zn):** Transfer 10 mL of Stock Standard solution of 100 mL volumetric flask and dilute up to the mark with DTPA extracting solution to have a Stock Solution of (10 µg Zn/mL) to a series of 100 ml volumetric flasks and each diluted each to the mark with DTPA extracting solution. This will give Standard Solution having zinc concentration 0, 0.1, 0.2, 0.4, 0.6 and 0.8 (µg/mL) (ppm).
- (ii) **Iron (Fe):** Transfer 0, 1, 2, 4, 6 and 8 mL of Stock Solution (100 µg Fe ml or 100 ppm Fe) were transfer to a series to 100 mL volumetric flasks and diluted each to the make with DTPA extracting solution. This will give standard solution having iron concentration of 0, 1, 2, 4, 6, and 8 µg/mL (ppm).

- (iii) **Copper (Cu):** Transfer 0, 1, 2, 4, 6 and 8 mL of Stock Solution containing 100 μg Cu/mL (100 mL Cu) were transferred to a 100 mL volumetric flask and each was diluted to the mark with DTPA extracting solution. It gave Standard Solution having Cu concentration 0, 1, 2, 4, 6 and 8 μg /mL (ppm).
- (iv) **Manganese (Mn):** Transfer 0, 1, 2, 4, 6 and 8 mL of Stock Solution containing (100 μg /mL or 100 ppm Mn) were transferred to a series of 100 mL volumetric flask and each was diluted to the mark with DTPA extracting solutions. The standard solution thus prepared have the Mn concentration 0, 1, 2, 4, 6 and 8 μg /mL (ppm).

21. Preparation of Standard Solution of NaOH

A standard solution of NaOH of desired concentration cannot be prepared by direct weighing. An Indirect method, using a primary standard is adopted for prepared a standard solution of NaOH of desired concentration.

Primary Standard

The solutions of a substance, which can be prepared accurately by direct weighing, are known as “*Primary Standards*”. Substances which hydrolyse or ionise in water are not suitable for making a “*Primary Standard*” in water by direct weighing Oxalic acid is generally used to make a “*Primary Standard*” of desired concentrations using water as a solvent.

eg. **Preparation of 1.0N NaOH solution**

- (I) An Oxalic acid “Primary Standard” of a suitable concentration is prepared in 100 mL is prepared in measuring flask by direct weighing

using distilled or conductivity water, e.g. in the present case N/10 Oxalic acid solution would serve the purpose. For making N/10 Oxalic acid (250 mL) 1.575 g of Oxalic acid were dissolved in a 250 mL measuring flask using distilled water.

(II) NaOH solution approximately twice of the desired concentration is made by direct quick weighing, using a glazed paper or watch glass.

e.g. If the 2.0N NaOH solution (250 mL) is required, 4N NaOH solution is prepared in a 250 mL measuring flask by direct weighing i.e. using the relation:

$$W = \frac{ENV}{1000} = \frac{40 \times 2 \times 250}{1000} = 20 \text{ g}$$

20g of NaOH pellets are dissolved by approximately quick weighing, using a glazed paper or a watch glass; rider was not used for approximate weighing. If NaOH is not weighed quickly it will absorb water from atmosphere, as NaOH is hygroscopic.

(III) This NaOH solution of tritrated N/10 Oxalic acid primary standard taking 1 to 5 mL of Oxalic acid solution as per suitability phenolphthalein was used as the indicator suppose the normality of this NaOH solution is found 3.98 N (It is ensured that this concentration is roughly two times or more than the desired concentration of NaOH to be prepared.

(IV) This required volume of this NaOH (3.98N) is calculated to prepare 2N NaOH (250 mL) as follows:

$$N_1 V_1 = N_2 V_2$$

$$3.98 \times V_1 = 2.0 \times 250$$

$$V_1 = \frac{2.0 \times 250}{3.98} = 125.62 \text{ mL} = 125.6 \text{ mL (say)}$$

- (V) 125.6 mL of 3.98N NaOH which was prepared via step (iii) are taken in a 250 mL measuring flask and the volume is made upto the mark by gradual addition of distilled/conductivity water. These contents are mixed thoroughly. This solution should be 2.0N NaOH (250 mL). This NaOH solution so obtained is standardized by titrating 5 mL of this solution against N/10 oxalic acid using phenolphthalein as indicator. If the NaOH solution is exactly 2.0N, the desired solution is ready. If the normality of the NaOH solution after standardization differs from 2.0N, whatever is the normality of this NaOH solution should only be taken to be correct e.g., if it is 2.01N or 1.98N, the NaOH solution is 2.01N or 1.98 N as the case may be.

Note: Standard solutions of NaOH of different concentrations and the Standard solution of KOH can also be prepared by the same procedure.

22. Preparation of a Standard Solution of HCl e.g. Preparation of 1.0N HCl (250 mL):

- (i) A standard solution of NaOH of desired concentration (say 2.0N) is prepared as described above.
- (ii) 1 mL of the Stock Solution of HCl is titrated against the Standard Solution of NaOH, using phenolphthalein as indicator. Suppose the normality of the Stock Solution of HCl is N_1 . The required volume of this HCl to be calculated to prepare 250 mL of 1.0N HCl as follows:

Since,

$$N_1V_1 = N_2V_2$$

$$N_1V_1 = 1.0 \times 250$$

$$V_1 = \frac{1.0 \times 250}{N_1} = Y \text{ mL (Suppose.)}$$

Y mL of the stock solution of normality N_1 are taken in a 250 mL measuring flask and the volume is made upto mark using distilled /conductivity water. This should be required 1.0 N HCl. This HCl solution is standardized using a standard solution of NaOH. The exact normality of this HCl solution will be the correct normality of the HCl solution.

Note: Standard solution of different concentrations of HCl and the Standard Solution of desired Concentration of H_2SO_4 , HNO_3 etc. can also be prepared by the above procedure.

4.4 SOIL SAMPLING

According to **Cline (1945)**, the accurate description of the soil properties is possible only if the following conditions are fulfilled:

- (i) The gross sample accurately represents the whole soil from which it was taken.
- (ii) The sub samples analysed represent the gross sample accurately.
- (iii) No changes occur in the gross and sub samples prior to analysis.
- (iv) The analysis determines a true value of the soil characteristic under investigation.

In view of the above the representative soil in the study area was therefore selected vide the following three phases:

1. Selection of the sites.
2. Selection of the representative soil.

3. Collection of the soil samples.

1. Selection of the sites

In soil analysis of any region region selection of the sites is the most important part of the study.

2. Selection of the representative soil

The validity of the soil as a true representative as whole depends upon the following criteria (**Tan; 1995**):

(a) The degree of the homogeneity of the sampling volume

The less homogeneous the sampling volume, the greater will be the sampling error.

(b) Method of sampling

Samples can be collected from a pit with or without exposing the soil profile or they may be drawn from road banks. They can be taken with a auger. Samples obtained from soil profile may be better representatives than auger samples.

(c) The Number of sampling units contributing to the gross samples

The use of several sampling units instead of only one sampling unit may yield a gross sample providing a closer approximation of the soil. Several small sampling units, each drawn from a homogeneous part of the pedon yield a better representation of the whole soil than does a single large sample.

(iii) Collection of the soil samples

The soil samples were collected by the compositing method. Compositing is the mixing of sample units to form a single sample, which is used for Chemical Analysis (**Tan; 1995**). This method offers the advantage of increased accuracy through the use of large numbers of sampling units per sample. In compositing, the fundamental assumption is that analysis of the composited sample yields a valid estimate of the mean, which would be obtained by averaging the result of analysis from each of the sampling units contributing to the composite. (**Cline; 1944**) indicated that this assumption is valid only if:

1. **The sampling volume represents a homogenous population.**
2. **Equal amount of each sampling unit contribute to the sub-sample analysed.**
3. **No changes should have taken place in the composite and sub-samples prior to analysis that would affect the analytical results, and**
4. **An unbiased estimate of the mean is the only objective.**

The common procedure in compositing is to take a number of individual sampling units (slices or cores) (**Tan; 1945**). The number of sampling units to make one composite sample ranges from 4 to 16. As a general rule, the total area represented by one composite sample should not exceed **1 ha (100 m x 100 m)**, unless the field under investigation is reasonably homogenous in characteristics or the field can be treated as a single unit in terms of treatments and cropping sequences.

4.4.1 Mechanics of Sampling

The soil samples were collected randomly from the selected sites using soil auger, Carpenter scraw auger, Khurpa and knife. The sample was collected by cutting a **V shaped slice** to the proper depth of about 15-20 cm. The centre of the sample was then cut, lifted with the help of a knife and was collected in a plastic bag to carry to the laboratory.

4.4.2 Time of Sampling

The samples were collected periodically from the selected sites at the same time say around 8.00 a.m. on a selected day. Sampling dates were selected in such a way that these represent the major seasons of the year viz., autumn, winter, spring, dry summer and wet summer. Separate sampling calendar was made for each parameter to be studied.

4.4.3 Size of the Sample

The size of the sample can be distinguished (**Tan; 1995**) as follows:

- (i) The size /quantity of samples
- (ii) The number of the samples

The size of the sample or the size of the sampling unit to be drawn depends upon three factors:

- (a) Coarseness of the material
- (b) Objectives of the analysis
- (c) The desired accuracy

About 500 mL approximate volume (Half kg) of or particular soil sample was collected every time.

4.4.4 Sample Preparation

After the collection of the gross samples, precaution was taken to avoid further chemical reactions. The soil samples were dried for 24 to 48 h in shade and were changed into powder. After this samples were preserved in plastic bags. Each soil sample prepared as above was analysed in the laboratory as early as possible to avoid adsorption of NH_3 , SO_2 , SO_3 gases in the laboratory.

4.4.5 Grinding and Sieving

Large soil aggregates were crushed by hand into smaller one and were further reduced by grinding **Grinding Mortar (Toshiba)**. Grinding provides a maximum surface area for physical and chemical reactions and reduces the heterogeneity.

Grinding was followed by sieving for which 0.5, 2.0 mm sieve was used.

4.4.6 Reduction of the sample size

The sample size was reduced by the **Paper Quartering Method**. The soil samples were mixed uniformly. The soil samples were spread over a sheet of paper, which was divided into four equal parts. 2 and 3 parts were collected and mixed thoroughly while 1 and 4 parts were discarded. This process was repeated several times, till approximately $\frac{1}{2}$ kg of the soil remains and right size of the sample was obtained.

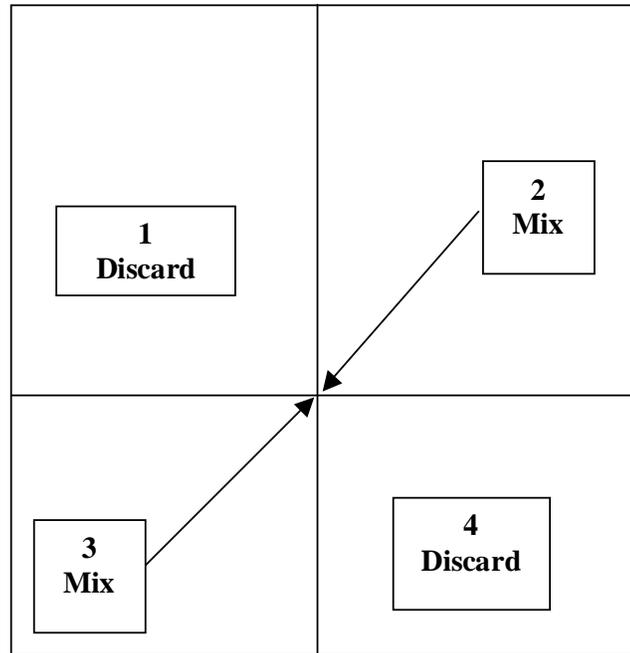


Fig. 1. Reducing sample size by “Quartering Method”

4.5 SOIL ANALYSIS

Analysis of the soil was carried out under the following two major categories:

- (a) Physical examination**
- (b) Chemical examination**

4.5.1 Physical Examination

Physical examination of the soil sample was done for the following:

(i) Soil Colour

Soil has colour perhaps is the most obvious characteristic of soil at the first sight. It was used in is differentiating soils of a site from another site. Soil colour was noted for each sample as it was observed by naked eye at the site.

(ii) Soil temperature

Solar radiation is the principle source of heat and losses are due to radiation and convection. The main source of the soil temperature is solar radiation. The soil temperature is also affected by decomposition of dead organic matter and forest cover. Soil temperature also depends upon the atmospheric air, temperature and moisture content of the soil.

Soil temperature was determined for a given sample immediately after it was collected, with the help of a simple thermometer.

(iii) Soil Water

About 5 to 10 g of the soil sample was placed in a pre-weighed stoppered 100 mL conical flask. The sample was weighed immediately nearest to 0.1 mg. The flask containing the soil sample was then kept in an oven at 105 °C to 110°C for 24 hrs for drying. The flask was then allowed to cool in a desiccator. The flask was weighed again nearest to 0.1 mg. The amount of water lost which is the water content of the sample, was calculated as follows:

Water Lost = Mass of the Moist Soil- Mass of the Soil dried in the oven

Suppose,

The mass of the flask = W_1g

The mass of flask + Soil before drying = W_2g

The mass of flask + Soil after drying = W_3g

The mass of the soil before drying = $(W_2 - W_1)g = Xg$ (suppose)

The mass of the soil after drying = $(W_3 - W_1)g = Yg$ (suppose)

Amount of H_2O lost = $(X - Y) g = Zg$ (suppose)

$$\text{Dry mass percentage of } H_2O = \frac{Z \times 100}{Y} \%$$

and,

$$\text{Wet mass percentage of } H_2O = \frac{Z \times 100}{X} \%$$

The dry mass percentage is used in soil science and soil chemistry, while wet mass percentage is used in the botanical sciences and finds, its practical application in agriculture, horticulture and nurseries (**Tan; 1995**).

(iv) Soil Texture

S. No.	Experience	Type	Texture Class
1.	Very gritty, does not form balls, does not strain finger	Very light	Sand
2.	Very gritty, forms ball but very easily broken stain finger slightly.	Light	Loamy Sand
3.	Moderately gritty, forms fairly firm ball which is easily broken, definitely stains finger	-	Sandy Loam
4.	Moderately sticky, slightly gritty feel forms moderately hard ball when dry, stains, ribbons out on squeezing but the ribbon breaks easily	Heavy	Clay Loam
5.	Same as above but very smooth, shows flucking on ribbon surface, similar to still loam	Heavy	Silt Clay Loam
6.	Very sticky feel, forms ball which when dry can not be crushed by fingers, stains heavily, squeezes out at right moisture in to long (2-5 cm) ribbon	Very heavy	Clay
7.	Neither very gritty nor very smooth, forms firm ball but does not ribbon, stains finger appreciably	Medium	Loam
8.	Smooth or sticky, butterly feel, forms firm ball, stains and has a slight tendency to ribbon with flasky surface	-	Silt Loam

(v) Bulk Density (BD)

Soil Bulk density (BD) is defined as the oven dry weight of soil per unit of its Bulk volume. The bulk volume comprises volume of soil solids and of pore spaces. The density is expressed in the unit of gm/cm³ or mg/m³.

Soil was filled in a pre-weighed 100 mL graduated cylinder and the soil was made compact by tapping the bottom of the cylinder about 10 times with the help of palm. Soil was added further by following the tapping process till a

tapped soil-volume of 100 mL was obtained the cylinder containing the soil was kept in an oven for 24h and was weighed after cooling in a dissector.

Calculation:

$$\text{Bulk density} = \frac{\text{Oven dry mass of soil}}{100} \text{ mg/ m}^3$$

4.5.2 Chemical Examination

The chemical examination of the soil samples of all the sites was done for the following:

(i) pH of the Soil

The acidity, neutrality or alkalinity of a soil is measured in terms of hydrogen ion concentration of the Soil-Water system. Hydrogen ions are important for plant growth.

20g air-dry soil and 40 mL distilled water were shaken on a rotary shaker (**Toshiba**) for 10 to 15 minutes. This gave the 1:2 soil water suspensions. **The Microprocessor based pH meter (Systronics, μ pH 362)** was calibrated using buffer solutions pH = 4 and pH = 7.9. The pH of the soil samples was then determined the above digital pH-meter.

(ii) Electrical Conductivity

Electrical Conductivity is important in order to determine the concentration of soluble salts present in the soil suspension.

20 g of air-dry soil and 40 mL of distilled water were shaken on a rotary skaker (**Toshiba**) for 10 to 15 minutes. After this solution was filtered through Whatman filter paper No. 1 and a clear solution was obtained. The **Electrical**

Conductivity of the clear solution thus obtained was then determined using a **Microprocessor based digital Conductivity Meter (Systronics – 306)**.

(iii) Cation Exchange Capacity (CEC)

The capacity of negatively charged clay and organic matter to adsorb cations by simple physical, attractive force is called the Cation Exchange Capacity (CEC) of a soil. Which is quantitative measure of all Cation adsorbed on the surface of the soil colloids. Cation exchange capacity of the soil sample determined in N-ammonium acetate ($\text{CH}_3\text{COONH}_4$) extract.

The soil sample was washed 4-5 times by ethanol ($\text{C}_2\text{H}_5\text{OH}$, 95%). Finally the sample was treated with 1.0 N ammonium acetate solution (4 times; 25 mL each time). Every time it was centrifuged and supernatant liquid was decanted in a 100 mL volumetric flask. This way the sodium ions came in volumetric flask, replaced by ammonium ions. This liquid thus obtained was thus diluted up to 100 mL and sodium concentration was determined by flame photometer after necessary setting.

Calculation:

CEC in milli equivalents per 100 g

$$= \frac{\text{Sodium concentration in milli equivalents per L} \times 10}{\text{Mass of soil sample in g}}$$

(iv) Organic Carbon and Organic Matter

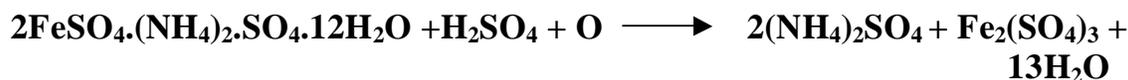
The organic matter content of soil is estimated from the organic carbon, determined by using **Titrimetric determination (Walkely and Black, 1934)**

method. The method is also known as “**Wet-digestion method**” involves a rapid titration procedure for the estimation of organic Carbon content of soil. Carbon in on $K_2Cr_2O_7$ followed by back titration, against a standard solution of ferrous ammonium sulphate.

Reations Oxidation of Carbon



Titration Procedure



1g soil was taken in a 500 mL conical flask. 10 mL of 1N $K_2Cr_2O_7$ solution was mixed and shaken. Then, added 20 mL of con. H_2SO_4 and swirl the flask 2 or 3 minute, allow the flask to cool for 30 minutes. Poured 200 mL of distilled water, 10 mL of H_3PO_4 (85%) or 0.5 gm of NaF and 1 mL (10 drops approximately) of diphenyl amine indictor were than added and swirled to mix well. The souldion was titrated with 0.5N **Ferrous Ammonium Sulphate** solution on **Auto-Titrator (Systronics-351)** till the colour changed from blue violet to green. A blank solution made as described above (without soil sample) was titrated and the same process was repeated for all the soil samples.

Calculation:

$$\% \text{ C of organic} = \frac{(B-T) \times 0.10 \times 0.003 \times 100}{B \times \text{mass of the soil sample}}$$

Where,

B = Titre value for the blank solution.

T = Titre value with the solution containing the soil sample

% of organic Matter = % Organic Carbon x 1.724

(v) Available Phosphorus

Two most commonly used methods are known for determination of available Phosphorus in soil.

(a) Bray and Kurtz method for acidic soil (Bray and Kurtz, 1945)

5.0 g of air dry soil was taken in a beaker and 50 mL of Bray extracting solution (1: 10 soil to solution ratio) were added to it. The beaker was placed in rotatory shaker for 5 – 10 minutes. Then the solution was filtered through Whatman filter No. 42. The filtrate should be clear.

5 mL aliquot of the extract was taken in 25 mL volumetric flask 7.5 mL of 0.8 N Boric acid were added to it to avoid fluoride interference. To the above solution 20 mL of distilled water and 4 mL of **Murphy-Riley (1962)** colour producing solution were added.

A blank and all soil samples were prepared by the above procedure. The readings were taken on an **UV-VIS spectrophotometer (Computerized Systronics – 119)**.

Calculation:

$$\text{Bray's P (Kg/ha)} = \frac{\text{A x Volume of the extradent in mL x 2.24}}{\text{Volume of the aliquot in mL x mass of the soil in g}}$$

Where,

A = Conc. of P as read from the standard curve.

(b) Olsen’s Method

Neutral and alkaline soil is treated by this method. 2.5 g of air dry soil sample and 50 mL Olsen solution (0.5 M NaHCO₃, pH 8.5) in a beaker of 100 mL. This is 1: 20 soil is solution ratio. Add a pinch of Darco-G-60 charcoal. The beaker was placed in a rotatory shaker for 30 minutes. All samples and blank were run simultaneously. All the extracts were filtered through Whatman filter paper No. 42. A clear filter was thus obtained.

10 mL aliquot of the extract were pipetted out in a 50 mL volumetric flask, 10 mL of distilled water were added in this aliquot where in one drop of P-nitrophenol indicator was also added. The contents were then acidified up to pH = 0.5 by adding 2.5 M H₂SO₄ drop wise till the colour disappears. 8 mL of the **Murphy-Riley (1962)** solution were added to the above solution and final volume was made up to 50 mL by adding distilled water. A blue colour was obtained. The optical density of this blue colour was determined on an **UV-VIS spectrophotometer (Systronics – 119 computerized)** at 660 nm.

Calculation:

$$\text{Available P (Kg/ha)} = \frac{\text{A x Volume of the extractant in mL}}{\text{Volume of the aliquot in mL x mass of the soil in g}}$$

(vi) Exchangeable Potassium

The exchangeable potassium is usually determined in normal neutral ammonium acetate (CH₃COONH₄) extract of soil.

5.0 g air dry soil was taken in a centrifuge tube and add to it 25 mL of neutral normal N CH₃COONa. Shake the contents of the conical flask on a

electric shaker for 5 minute and filter. Feed the filtrate into the atomizer of the Flame photometer, 100 of which has been set with 40 ppm K-solution and note the reading. Locate this reading on the standard curve, which will give the K-concentration in the extract. From this concentration measurement, the amount of K in the sample was calculated.

Calculation:

$$\text{Exchangeable Potassium (Kg/ha)} = \frac{A \times 100 \times 2.24}{5}$$

Where,

A = Concentration (ppm) as read from the standard curve.

The same procedure used for the estimation of K was also used for the estimation of Na and Ca using proper filters of Na and Ca.

(vii) Micronutrients Available Metallic Ions (Zn, Cu, Fe, Mn)

Lindsay and Norvell (1978) gave the method commonly used for determining the available micronutrients in soil sample which consists of use of **DTPA (Diethylene triamine penta acetic acid)** as an extractant which has been widely accepted for the simultaneous extraction of micronutrient cations viz. Zinc (**Zn**), Copper (**Cu**), Iron (**Fe**), Manganese (**Mn**) in neutral and alkaline soils. The extract is determined on an **Atomic Absorption spectrophotometer (AAS)**. DTPA as a chelating agent combine with free metal ions in the solution to form soluble complexes. Stability constant for the simultaneous complexing of Zn, Cu, Mn and Fe shows DTPA as a most suitable extractant. Excessive dissolution of CaCO₃, which may release occluded micronutrients that are not available for plant particularly in calcareous soils, misleads the results. To avoid this, the extractant is buffered in a lightly alkaline pH range and included soluble Ca⁺².

Triethanolamine (TEA) is used as buffer because it burns cleanly during atomization. At the selected pH of 7.3, three fourth of TEA is protonated (HTEA).

Which exchange with Ca^{+2} and some Mg^{+2} from the soil exchange sites. This increases the concentration of Calcium ions (Ca^{+2}) by two to three fold and help in suppressing the dissolution of CaCO_3 in calcareous soils. The DTPA has a capacity to complex each of the micronutrients cations as 10 times of its atomic weight. The capacity ranges from 550-650 mg kg^{-1} depending on the micronutrient cation.

Weight 10 g of soil sample and add 20 mL of the extractant DTPA solution added to it. The flask was shake continuously for 2 hours preferably on a horizontal shaker, and filter through Whatman filter paper No. 42. The filtrate was then analysed for Zn, Cu, Fe and Mn with an atomic absorption spectrophotometer. One blank solution also analysed as followed above method.

Calculation:

The amount of the given micronutrient is then calculated as below.

Wt. of soil taken = 10 g.

Volume of DTPA extractant added = 20 mL

Dilution = $20/10 = 2$ times

Absorbance shown by the AAS = T

Concentration of the heavy metal as read from the standard curve against T = C
 $\mu\text{g/mL}$

Content of the micronutrient Cation in the Soil sample = $C \times 2 \text{ mg/Kg}$ or ppm

(viii) Available Sulphur

Sulphur was estimated turbidimetrically using a spectrophotometer at 340 nm. In this method, Calcium Chloride dehydrate ($\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$) 0.15% solution which was prepared by dissolving 1.5 g of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ in about 700 mL distilled water and the volume was made up to 1L by adding distilled water, was used as one of the reagents.

5.0 g dry soils were passed through a 10 mesh sieve in a 500 mL conical flask and add 50 mL of 0.15% $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ solution. Shake for 30 minutes and filter through Whatman filter paper No. 42 filter paper. 10 mL of the above extract were taken in a 150 mL conical flask and 20 mL of water were added to it so that the total volume of the solution was 30 mL. 2.5 mL of stabilizing solution and 0.2g of BaCl_2 crystals were added to the above solution. The contents were shaken for 1 to 3 minutes. The turbidity was measured on a spectrophotometer at 340-nm. Standard plots were drawn between S concentration in standard solution and spectrophotometer readings. The concentration of S in the extracts was determined using the standard plots.

Calculation:

$$\text{SO}_4\text{-S (Mg/Kg)} = \frac{\text{S in extract (Mg/L)} \times \text{Volume of extract (mL)}}{\text{Volume of extract (mL)} \times \text{Oven dry soil (g)}}$$

(ix) Total Nitrogen (by Kjeldahl Method)

Nitrogen (N) is one of the major nutrients required for the nutrients of plants. The total amount of N present in soil nearly 95 – 99% is in the organic form and 1 – 5% in the inorganic forms a ammonion and nitrates. The “**Kjeldahl Method**” of conversion of N into $[(\text{NH}_4)_2\text{SO}_4]$.

500 mg (80 mesh) oven dry soil samples were taken in the digestion tube, 5 ml conc. H_2SO_4 and 1 – 2 g catalyst were added into the tube. The

digestion tube was then placed in digestion unit (Digestion unit with fume hood-Toshiba) or block and heated to boiling until green. Heating time was very long and temperature at that time was very high. After complete digestion, the digestion tubes were allowed to cool for 5 – 10 minutes outside the block and then 20 mL of distilled water was used to dilute the contents. Finally the volume was made up 50 mL.

Distillation and Titration

Distillation was done in the Kjeldahl apparatus (**Micro Kjeldahl apparatus – Borosil**). 10 mL digest (aliquot) were placed in steam chamber of Kjeldahl apparatus with 10 mL of 2N NaOH. A 50 mL conical flask containing 10 mL of H_3BO_3 , a few drops of mixed indicator, which was placed under the condenser, steam of the distillation apparatus. The liberated $NH_4^+ -N$, liberated by distillation of the digest with 2N NaOH was absorbed in unstabilization H_3BO_3 in the form of ammonium borate. The contents were titrated against standard 0.01 N HCl by **Auto-Titrator (Systronics – 351)**.

Calculation:

$$\text{Total Nitrogen \%} = \frac{(T-B) \times \text{Molarity of Standard HCl} \times 1.401}{\text{Mass of Soil Sample (g)}}$$

Where,

T = Volume of Standard HCl for titration of the soil sample.

B = Volume of Standard HCl for titration of the blank solution.

The blank solution mentioned here was prepared as described without the soil sample.

CHAPTER – V

OBSERVATION AND
RESULTS

5.1 The present work was initially undertaken for the analysis of the soil types of Hill region and Bhabar region due to the easy approach to the sites. Another reason to start the work in these regions was that there is comparatively lesser impact of human and animal activities. The results have been reported in **Table 5.1**.

A survey of the recent literature and the work done in the recent past **Chhabra (1993), Kaur (1995), Raghvansh (2002), Shiveshwer Pratap Singh (2002), and Trilochan (2004)** reveals that the Hill region as well as the Bhabar region of Uttarakhand state have been studied recently, with special reference to the Physical and Chemical analysis of the soil-types of these regions.

A comparison of the results of the present study Table 5.1 with the work done earlier indicates that the results of the present study are in agreement with the earlier studies upto a large extent. **No remarkable difference between the present study and the earlier studies was found. It was therefore not necessary to further extend the present work for the analysis of the soil types in the Hill region as well as in the Bhabar region of Uttarakhand state.**

The analysis of the soil types in the present study was therefore undertaken for the Tarai region of Uttarkhand state, with the objective to obtain the relevent and desired information regarding soil types of the Tarai region. The results obtained in the present study will not only be of theoritical importance but will also be of genuine use to all the farmers as well as the Scientists/ Research Scholars interested in this field.

Table 5.1: Physico-Chemical properties of the soils of the Hill and Bhabar regions.

Site Name/ Physical and Chemical properties ⇨ (Average values) ⇩	Year: 2006							
	Bhimtal	Mahara Gaon	Khalkwira	Nauligarh	Haldwani	Gajraula	Kathgodam	Kusum-Khera
	Site No. 1	Site No. 2	Site No. 3	Site No. 4	Site No. 5	Site No. 6	Site No. 7	Site No.8
1. Soil Colour	Black	Brown Black	Brown	Light Brown	Brown	Dark Black	Dark Brown	Grey
2. Soil water	30.1	25.2	22.1	20.2	40.9	60.0	40.9	38.2
3. Soil Temperature	16	18	15	14	18	25	16	17
4. Bulk Density	1.70	1.60	1.25	1.20	1.3	1.3	1.4	1.6
5. Soil Texture	loam	Silty loam	loam	loam	Silty clay	Silty loam	Silty loam	Silty loam
6. pH	6.62	6.96	6.74	6.81	6.68	6.70	6.88	6.00
7. E.C. (ds/m)	0.275	0.538	0.605	0.39	0.21	0.18	0.15	0.17
8. C.E.C. (milleq/100 g)	18.2	16.1	14.0	15.0	13.0	8.20	12.6	14.26
9. % of O.C.	1.26	1.42	0.91	1.09	0.46	0.18	0.50	0.41
10. % of O.M.	2.18	2.45	1.57	1.88	0.796	0.311	0.259	0.710
11. P (Kg/ha)	65	70	65	72	51	60	65	62
12. K (Kg/ha)	0.22	0.29	0.30	0.25	0.15	0.24	0.17	0.18
13. Na (ppm)	0.18	0.22	0.24	0.20	0.14	0.16	0.11	0.21
14. Zn (ppm)	2.45	1.35	1.54	2.11	1.61	1.71	0.97	1.61
15. Cu (ppm)	3.42	2.05	2.95	3.52	2.37	3.43	1.94	1.25
16. Fe (ppm)	38.7	26.7	31.83	26.57	110.84	187.1	103.46	101.2
17. Mn (ppm).	31.48	18.34	32.05	27.00	33.83	67.17	41.38	51.2

5.2 The observation and the results of present work carried out on the main soil – types of the Tarai region for all the sites as described in Chapter 3 of Kumaon (Uttarakhand) are reported in **Table 5.2.1 to 5.2.15**.

5.2.1. Soil Colour

The soil colour was noted as it was observed. The observations have been reported in Table 5.2

Table 5.2.1. Colour of the soil of the Tarai region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	Soil Colour
1.	Khatima (Banusa)	S ₁	Blackish yellow
2.	Khatima (Jhanket)	S ₂	Light yellow
3.	Khatima (Amaun)	S ₃	Yellow
4.	Khatima (Chakerpur)	S ₄	Dark Brown
5.	Khatima (City)	S ₅	Brown Red
6.	Sitarganj-1	S ₆	Brownish
7.	Sitarganj-2	S ₇	Brownish
8.	Rudrapur-1	S ₈	Dark greyish Brown
9.	Rudrapur-2	S ₉	Blackish
10.	Pantnagar-1	S ₁₀	Dark greyish Brown
11.	Pantnagar-2	S ₁₁	Dark grey

5.2.2. Soil Water

Soil water was determined by the methodology described in Chapter-IV for each of the samples of selected sites and the results have been reported in Table 5.2.2.

Table 5.2.2. Soil water (Dry mass percentage of H₂O) of the Tarai region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	Dry mass percentage of H ₂ O											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	7.7	13.12	8.69	7.75	11.11	21.95	13.63	11.11	8.69	11.60	10.13	9.64
2.	Khatima (Jhanket)	S ₂	10.13	13.12	8.69	4.60	8.69	16.27	19.04	4.16	13.63	12.10	11.60	9.64
3.	Khatima (Amaun)	S ₃	5.04	10.13	9.64	4.16	6.38	13.63	11.11	13.63	16.27	16.27	12.61	6.83
4.	Khatima (Chakerpur)	S ₄	4.16	6.38	5.93	3.30	6.38	16.27	21.95	19.04	16.27	18.48	13.12	8.69
5.	Khatima (City)	S ₅	7.29	5.93	6.38	2.06	11.11	21.95	13.63	13.63	13.63	16.82	15.20	12.60
6.	Sitarganj-1	S ₆	7.75	11.11	9.17	8.69	11.11	16.27	11.11	11.11	11.11	16.82	8.69	9.64
7.	Sitarganj-2	S ₇	8.06	7.75	7.75	3.73	6.38	19.00	14.67	13.63	13.63	10.13	9.64	8.69
8.	Rudrapur-1	S ₈	5.88	8.22	5.48	5.48	8.69	21.95	16.27	19.04	11.11	9.64	10.13	5.93
9.	Rudrapur-2	S ₉	6.83	5.04	9.17	1.62	8.69	16.27	16.27	13.63	12.00	13.63	11.00	11.60
10.	Pantnagar-1	S ₁₀	9.17	13.63	13.63	7.75	11.11	19.04	16.27	13.63	13.63	17.37	17.00	12.61
11.	Pantnagar-2	S ₁₁	7.29	8.69	8.22	4.60	8.69	19.04	16.27	11.11	11.11	10.13	11.21	9.64

5.2.3. Soil Temperature

The Soil Temperature was recorded for each of the selected sites for all the months of the calendar year 2006 i.e., from January 2006 to December 2006. The results have been given in Table 5.2.3.

Table 5.2.3. Temperature of the Soil of Tarai region Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	Temperature (^o C)											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	12	19	20	24	33	28	29	28	33	32	26	23
2.	Khatima (Jhanket)	S ₂	13	18	19	28	34	26	28	29	30	34	29	24
3.	Khatima (Amaun)	S ₃	14	18	18	26	29	27	31	31	32	31	27	23
4.	Khatima (Chakerpur)	S ₄	14	17	19	28	32	28	29	30	32	31	25	21
5.	Khatima (City)	S ₅	11	17	19	24	30	28	31	30	31	33	27	23
6.	Sitarganj-1	S ₆	10	16	18	29	35	27	30	31	31	32	25	25
7.	Sitarganj-2	S ₇	10	16.5	19	28	29	27.5	30	30	30	30	26	25
8.	Rudrapur-1	S ₈	10	16	18	29	37	32	30	34	31	32	25	22
9.	Rudrapur-2	S ₉	15	18	20	26	42	38	30	28	33	27	25	21
10.	Pantnagar-1	S ₁₀	12	19	19	25	31	28	28	28	29	26	25	23
11.	Pantnagar-2	S ₁₁	13	16	18	25	33	27	28	29	31	28	23	20

5.2.4. Bulk Density

Bulk densities of the soil samples was determined as described in chapter-IV and the results have been given in Table 5.2.4.

Table 5.2.4. Bulk densities of the soils of Tarai region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	Bulk Density (mg m^{-2})											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	1.20	1.10	1.20	0.83	1.10	1.20	1.18	1.25	1.24	1.19	1.22	1.28
2.	Khatima (Jhanket)	S ₂	1.18	1.18	1.18	1.18	1.05	1.15	1.22	1.25	1.25	1.28	1.28	1.20
3.	Khatima (Amaun)	S ₃	1.24	1.23	1.22	1.22	1.20	1.25	1.19	1.45	1.33	1.29	1.26	1.20
4.	Khatima (Chakerpur)	S ₄	1.26	1.20	1.20	1.20	1.10	1.25	1.41	1.25	1.23	1.24	1.18	1.18
5.	Khatima (City)	S ₅	1.32	1.30	1.22	1.22	1.25	1.30	1.22	1.20	1.29	1.27	1.30	1.34
6.	Sitarganj-1	S ₆	1.24	1.22	1.15	1.15	1.52	1.20	1.20	1.23	1.27	1.18	1.22	1.18
7.	Sitarganj-2	S ₇	1.30	1.20	1.18	1.19	1.20	1.20	1.18	1.19	1.27	1.26	1.24	1.24
8.	Rudrapur-1	S ₈	1.20	1.20	1.23	1.24	1.10	1.20	1.37	1.25	1.23	1.25	1.20	1.26
9.	Rudrapur-2	S ₉	1.26	1.23	1.20	1.22	1.05	1.25	1.32	1.25	1.16	1.20	1.20	1.20
10.	Pantnagar-1	S ₁₀	1.26	1.25	1.25	1.31	1.37	1.38	1.40	1.41	1.44	1.33	1.25	1.20
11.	Pantnagar-2	S ₁₁	1.22	1.18	1.15	1.18	1.10	1.25	1.12	1.15	1.29	1.27	1.25	1.20

5.2.5. Soil Texture

Soil texture was determined as described in chapter IV and the results have been given in Table 5.2.5.

Table 5.2.5. Texture of the soils of Tarai region of Uttarakhand.

Year : 2006

S. No.	Site Name	Site No.	Soil Texture
1.	Khatima (Banusa)	S ₁	Sandy loam
2.	Khatima (Jhanket)	S ₂	Silty clay loam
3.	Khatima (Amaun)	S ₃	Silty clay loam
4.	Khatima (Chakerpur)	S ₄	Silty loam
5.	Khatima (City)	S ₅	Silty clay loam
6.	Sitarganj-1	S ₆	Silty clay loam
7.	Sitarganj-2	S ₇	Silty clay loam
8.	Rudrapur-1	S ₈	Silty clay loam
9.	Rudrapur-2	S ₉	Silty clay loam
10.	Pantnagar-1	S ₁₀	Loam
11.	Pantnagar-2	S ₁₁	Silty clay loam

5.2.6. pH of the Soil

pH of the soil samples was determined by the microprocessor based pH meter (Model: Sytronics μ -pH-362). The pH of the soils of each of the sites selected have been given in Table 5.2.6.

Table 5.2.6. pH of the soils of Taria region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	pH											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	6.9	7.1	7.0	7.1	7.0	7.6	7.8	7.5	7.2	7.3	7.5	7.4
2.	Khatima (Jhanket)	S ₂	6.6	6.8	6.8	6.8	6.9	7.0	7.6	7.5	7.0	7.1	7.1	7.2
3.	Khatima (Amaun)	S ₃	6.9	7.2	7.0	6.9	7.3	7.4	7.5	7.5	7.4	7.6	7.6	7.5
4.	Khatima (Chakerpur)	S ₄	6.7	7.0	6.8	6.8	7.0	7.5	7.5	7.5	7.4	7.5	7.4	7.2
5.	Khatima (City)	S ₅	7.1	7.0	7.4	7.5	7.4	7.5	7.5	7.3	7.2	7.2	7.4	7.4
6.	Sitarganj-1	S ₆	7.1	7.2	7.1	7.1	7.2	7.2	7.5	7.5	7.3	7.9	7.4	7.4
7.	Sitarganj-2	S ₇	7.0	7.2	7.1	7.0	7.1	7.2	7.5	7.2	7.0	6.9	7.1	7.1
8.	Rudrapur-1	S ₈	7.0	7.1	6.9	6.8	6.9	7.5	7.7	6.9	7.0	7.1	7.2	7.3
9.	Rudrapur-2	S ₉	6.6	6.9	7.3	7.4	7.5	7.4	7.5	7.4	7.5	7.5	7.4	7.2
10.	Pantnagar-1	S ₁₀	7.0	7.2	7.5	7.6	7.1	7.2	7.4	7.6	7.5	7.3	7.5	7.4
11.	Pantnagar-2	S ₁₁	7.3	6.9	6.9	7.1	7.0	7.9	7.4	7.5	7.6	7.8	7.1	7.3

5.2.7. Electrical Conductivity C.E.C. of the Soil

The Electrical Conductivity of the soil types determined by the digital conductivity meter (Model: Systronics-306) results have been reported in Table 5.2.7.

Table 5.2.7. Electrical Conductivity of the soils of Taria region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	Electrical Conductivity (ds/m)											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	0.44	0.41	0.46	0.47	0.43	0.44	0.45	0.45	0.40	0.41	0.39	0.40
2.	Khatima (Jhanket)	S ₂	0.30	0.32	0.30	0.30	0.35	0.35	0.36	0.30	0.29	0.35	0.29	0.28
3.	Khatima (Amaun)	S ₃	0.33	0.34	0.35	0.37	0.36	0.39	0.37	0.36	0.36	0.35	0.32	0.38
4.	Khatima (Chakerpur)	S ₄	0.29	0.32	0.39	0.33	0.36	0.35	0.35	0.34	0.30	0.30	0.28	0.29
5.	Khatima (City)	S ₅	0.39	0.44	0.43	0.42	0.39	0.40	0.40	0.42	0.39	0.38	0.37	0.40
6.	Sitarganj-1	S ₆	0.36	0.33	0.34	0.34	0.35	0.34	0.34	0.33	0.36	0.32	0.30	0.33
7.	Sitarganj-2	S ₇	0.29	0.27	0.30	0.32	0.31	0.32	0.33	0.30	0.26	0.27	0.28	0.30
8.	Rudrapur-1	S ₈	0.46	0.52	0.53	0.51	0.49	0.48	0.58	0.62	0.62	0.59	0.60	0.45
9.	Rudrapur-2	S ₉	0.41	0.42	0.47	0.39	0.38	0.40	0.42	0.50	0.52	0.39	0.38	0.46
10.	Pantnagar-1	S ₁₀	0.41	0.35	0.36	0.39	0.38	0.35	0.35	0.36	0.40	0.41	0.40	0.42
11.	Pantnagar-2	S ₁₁	0.33	0.34	0.35	0.37	0.36	0.39	0.37	0.36	0.36	0.35	0.32	0.38

5.2.8. Cation Exchange Capacity of the Soil

The CEC of the soil types determined by the method described in chapter-IV have been reported in Table 5.2.8.

Table 5.2.8: CEC of the Soils of Tarai region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	CEC (milli. equiv./100 g)
1.	Khatima (Banusa)	S ₁	11.2
2.	Khatima (Jhanket)	S ₂	12.6
3.	Khatima (Amaun)	S ₃	13.9
4.	Khatima (Chakerpur)	S ₄	16.8
5.	Khatima (City)	S ₅	14.7
6.	Sitarganj-1	S ₆	16.1
7.	Sitarganj-2	S ₇	15.2
8.	Rudrapur-1	S ₈	15.56
9.	Rudrapur-2	S ₉	15.50
10.	Pantnagar-1	S ₁₀	16.10
11.	Pantnagar-2	S ₁₁	13.40

5.2.9. (a) Organic Carbon and Organic Matter in the Soil.

The Organic Carbon was determined by the method by the method as described in Chapter-IV. The results have been given in Table 5.2.9 (a). Organic matter of the soils of all the sites have been reported in Table 5.2.9 (b).

Table 5.2.9. Organic Carbon in the soils of Tarai region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	% of Organic Carbon											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	0.56	0.59	0.61	0.60	0.60	0.59	0.55	0.58	0.55	0.58	0.56	0.62
2.	Khatima (Jhanket)	S ₂	0.26	0.28	0.30	0.31	0.30	0.23	0.21	0.23	0.24	0.24	0.25	0.26
3.	Khatima (Amaun)	S ₃	0.24	0.25	0.25	0.27	0.26	0.28	0.27	0.30	0.29	0.30	0.28	0.28
4.	Khatima (Chakerpur)	S ₄	0.61	0.60	0.60	0.63	0.60	0.62	0.61	0.61	0.62	0.64	0.69	0.63
5.	Khatima (City)	S ₅	0.28	0.28	0.27	0.30	0.25	0.25	0.21	0.24	0.23	0.25	0.24	0.23
6.	Sitarganj-1	S ₆	0.53	0.61	0.59	0.67	0.66	0.70	0.57	0.69	0.58	0.70	0.70	0.57
7.	Sitarganj-2	S ₇	0.60	0.62	0.63	0.65	0.69	0.63	0.60	0.61	0.61	0.67	0.68	0.60
8.	Rudrapur-1	S ₈	0.63	0.69	0.70	0.77	0.80	0.88	0.82	0.77	0.85	0.76	0.69	0.67
9.	Rudrapur-2	S ₉	0.76	0.77	0.83	0.80	0.79	0.88	0.88	0.78	0.83	0.79	0.90	0.80
10.	Pantnagar-1	S ₁₀	0.85	1.00	0.98	0.90	0.93	0.90	1.00	0.86	0.89	0.98	0.91	0.86
11.	Pantnagar-2	S ₁₁	0.79	0.80	0.89	0.88	0.94	0.87	0.77	0.90	1.04	0.89	0.98	0.82

Table 5.2.9. (b): Organic Matter in the Soils of Tarai region region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	% of Organic Matter											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	0.97	1.02	1.05	1.04	1.04	1.02	0.95	1.00	0.95	1.00	0.97	1.07
2.	Khatima (Jhanket)	S ₂	0.45	0.48	0.52	0.54	0.52	0.40	0.36	0.40	0.42	0.42	0.43	0.45
3.	Khatima (Amaun)	S ₃	0.42	0.43	0.43	0.47	0.45	0.48	0.47	0.52	0.56	0.52	0.48	0.48
4.	Khatima (Chakerpur)	S ₄	1.05	1.03	1.03	1.09	1.03	1.05	1.09	1.05	1.07	1.10	1.19	1.09
5.	Khatima (City)	S ₅	0.48	0.48	0.47	0.52	0.43	0.43	0.36	0.42	0.40	0.43	0.42	0.40
6.	Sitarganj-1	S ₆	0.92	1.05	1.02	1.16	1.14	1.21	1.00	1.19	1.00	1.21	1.22	1.00
7.	Sitarganj-2	S ₇	1.03	1.07	1.09	1.12	1.19	1.09	1.03	1.05	1.05	1.16	1.17	1.03
8.	Rudrapur-1	S ₈	1.09	1.19	1.21	1.33	1.38	1.52	1.42	1.33	1.47	1.31	1.19	1.16
9.	Rudrapur-2	S ₉	1.31	1.33	1.43	1.38	1.36	1.52	1.52	1.35	1.43	1.36	1.55	1.38
10.	Pantnagar-1	S ₁₀	1.47	1.73	1.69	1.55	1.61	1.55	1.73	1.48	1.54	1.69	1.57	1.48
11.	Pantnagar-2	S ₁₁	1.36	1.38	1.54	1.52	1.62	1.50	1.33	1.55	1.80	1.54	1.69	1.42

5.2.10. Phosphorus (P) in the Soil

Phosphorus in the soils of the study area was determined by both the Method i.e. by the Bray and Kurtz method as well as well as by the Olsen's Method, as described in Chapter-IV. Phosphorus (P) in the soils have been given in Table 5.2.10.

Table 5.2.10. Phosphorus in the soils of the Tarai region of Uttarakhand

Year: 2006

S. No.	Site Name	Site No.	Phosphorus (P) (in Kg/ha)											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	72.00	72.50	70.70	40.50	69.10	76.50	77.00	71.90	71.10	75.50	77.5	77.5
2.	Khatima (Jhanket)	S ₂	31.50	30.00	32.10	28.00	27.50	27.00	27.00	26.00	31.50	35.50	30.0	26.52
3.	Khatima (Amaun)	S ₃	18.00	16.50	16.00	11.52	15.50	16.25	9.00	9.50	13.50	19.50	15.00	16.00
4.	Khatima (Chakerpur)	S ₄	11.60	11.10	14.30	9.60	10.10	14.56	9.00	9.50	10.50	9.00	12.76	11.20
5.	Khatima (City)	S ₅	5.50	6.15	7.18	4.50	4.50	4.72	9.00	6.25	8.15	6.50	5.91	9.71
6.	Sitarganj-1	S ₆	69.70	66.20	69.40	60.00	62.70	71.00	80.01	68.10	71.60	62.10	60.50	68.00
7.	Sitarganj-2	S ₇	54.00	56.20	59.60	69.10	66.27	70.00	56.20	68.20	64.10	66.21	70.00	69.20
8.	Rudrapur-1	S ₈	62.10	60.10	69.40	66.40	60.00	65.00	68.00	70.61	66.20	71.68	63.10	70.00
9.	Rudrapur-2	S ₉	66.00	64.02	64.06	55.80	66.20	61.10	62.50	60.00	67.00	70.00	66.60	69.20
10.	Pantnagar-1	S ₁₀	78.00	80.00	88.20	89.60	100.08	92.60	98.90	89.00	95.20	101.20	99.20	96.40
11.	Pantnagar-2	S ₁₁	72.00	68.00	65.60	69.00	71.20	66.21	76.01	77.20	79.40	76.00	74.40	77.50

5.2.11. Potassium (K) in the Soil

Potassium (K) in the study area was determined by the method as described in Chapter-IV. The results have been in Table 5.2.11.

Table 5.2.11. Potassium (K) in the soils of Taria region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	Potassium (K) (in Kg/ha)											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	298	302	302	300	298	297	297	295	296	297	300	298
2.	Khatima (Jhanket)	S ₂	150	157	155	155	156	155	150	156.5	147	154	145	155
3.	Khatima (Amaun)	S ₃	36	70	71	66	70	77	72	80	99	99	98	90
4.	Khatima (Chakerpur)	S ₄	385	387	377	397	385	387	390	385	360	390	366	386
5.	Khatima (City)	S ₅	36	50	84	77	70	88	77	79	83	90	91	93
6.	Sitarganj-1	S ₆	230	300	224	301.5	230	225	225	238.5	235	240	237	236
7.	Sitarganj-2	S ₇	302	300	301	297	298	299	300	295	297	300	303	302
8.	Rudrapur-1	S ₈	450	444	445	450	440	445	450	443	454	450	454	450
9.	Rudrapur-2	S ₉	157.5	170	165	144	160	157	150	155.5	157	135	144	150
10.	Pantnagar-1	S ₁₀	298	302	302	300	298	297	297	295	296	297	300	298
11.	Pantnagar-2	S ₁₁	307	300	301	297	298	299	300	295	297	300	303	302

5.2.12. Available or Exchangeable Sodium (Na) in the Soil

Available or Exchangeable Sodium (Na) in the Soils of the Study area was determined by the methods as described in Chapter-IV. The results have been given in Table 5.2.12.

Table 5.2.12. Available Sodium (Na) in the soils of the Khatima region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	Available Sodium (Na) (in ppm)											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	28	30	25	26	27	26	28	27	26	26	25	25
2.	Khatima (Jhanket)	S ₂	25	25	30	24	25	23	25	27	24	24	27	28
3.	Khatima (Amaun)	S ₃	25	27	31	28	27	26	30	29	27	28	27	25
4.	Khatima (Chakerpur)	S ₄	25	26	26	27	27	26	28	29	26	27	25	27
5.	Khatima (City)	S ₅	25	27	26	24	26	23	25	23	24	24	22	22
6.	Sitarganj-1	S ₆	20	23	21	19	20	20	21	22	19	24	20	21
7.	Sitarganj-2	S ₇	22	22	21	19	22	24	22	23	20	23	20	21
8.	Rudrapur-1	S ₈	21	24	22	21	26	25	24	21	22	18	27	18
9.	Rudrapur-2	S ₉	23	24	25	23	24	27	26	23	24	25	28	19
10.	Pantnagar-1	S ₁₀	25	29	22	27	21	24	22	20	21	18	24	16
11.	Pantnagar-2	S ₁₁	21	24	23	22	22	23	24	22	18	24	19	24

5.2.13. Available Sulphur (S) in the soil

Sulphur (S) was determined turbiditrimetrically using a spectrophotometer at 340 nm. The results have been reported in Table 5.2.13.

Table 5.2.13. Available Sulphur (S) in the soils of Tarai region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	Available Sulphur (S) (in ppm)											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	20.29	23.00	25.00	24.00	23.00	20.00	23.00	24.00	24.00	22.00	25.10	22.00
2.	Khatima (Jhanket)	S ₂	25.48	27.00	29.00	26.00	23.00	24.00	25.00	26.00	26.00	28.00	28.00	29.10
3.	Khatima (Amaun)	S ₃	29.29	29.00	30.00	34.20	30.00	32.00	25.00	29.00	32.00	39.00	34.00	35.00
4.	Khatima (Chakerpur)	S ₄	10.14	9.85	10.01	10.00	9.15	10.60	9.35	9.30	9.90	9.37	9.50	9.28
5.	Khatima (City)	S ₅	10.13	9.50	7.10	9.21	11.30	12.10	9.10	10.00	9.27	12.5	9.00	9.00
6.	Sitarganj-1	S ₆	11.00	12.10	9.06	10.31	8.00	12.00	10.70	8.00	11.10	11.00	12.00	12.00
7.	Sitarganj-2	S ₇	11.01	12.00	10.08	9.00	14.00	12.00	9.00	10.78	10.08	13.00	14.00	12.10
8.	Rudrapur-1	S ₈	12.08	15.07	15.00	17.00	18.00	13.00	18.00	17.00	14.01	15.10	13.01	12.10
9.	Rudrapur-2	S ₉	12.00	14.00	13.00	15.04	15.00	15.00	17.00	18.00	10.00	16.02	14.00	9.10
10.	Pantnagar-1	S ₁₀	12.01	18.00	14.00	17.00	18.00	17.00	15.00	16.01	15.02	13.00	12.01	14.05
11.	Pantnagar-2	S ₁₁	13.01	14.05	15.01	15.01	14.01	16.01	15.01	17.05	9.37	9.50	14.07	9.28

5.2.14. Total Nitrogen (N) in the Soil

Total Nitrogen (N) percentage in the soils was calculated by the Kjeldahl's method as described in chapter-IV. The results have been reported in Table 5.2.14.

Table 5.2.14. Total Nitrogen percentage in the Soils of Tarai region of Uttarakhand.

Year: 2006

S. No.	Site Name	Site No.	Percentage of Nitrogen (N)											
			Months											
			Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Khatima (Banusa)	S ₁	0.098	0.095	0.090	0.084	0.082	0.081	0.092	0.084	0.091	0.090	0.098	0.082
2.	Khatima (Jhanket)	S ₂	0.112	0.124	0.145	0.168	0.144	0.151	0.168	0.109	0.115	0.112	0.142	0.151
3.	Khatima (Amaun)	S ₃	0.084	0.052	0.080	0.084	0.072	0.056	0.084	0.061	0.420	0.056	0.062	0.072
4.	Khatima (Chakerpur)	S ₄	0.071	0.082	0.081	0.109	0.098	0.084	0.084	0.122	0.091	0.066	0.056	0.060
5.	Khatima (City)	S ₅	0.112	0.122	0.131	0.112	0.111	0.102	0.112	0.103	0.091	0.102	0.109	0.098
6.	Sitarganj-1	S ₆	0.168	0.125	0.135	0.184	0.144	0.144	0.084	0.109	1.220	0.102	0.144	0.142
7.	Sitarganj-2	S ₇	0.155	0.132	0.132	0.181	0.082	0.092	0.084	0.091	0.098	0.101	0.152	0.140
8.	Rudrapur-1	S ₈	0.082	0.120	0.123	0.152	0.144	0.122	0.066	0.095	0.111	0.131	0.156	0.006
9.	Rudrapur-2	S ₉	0.114	0.125	0.106	0.122	0.135	0.056	0.094	0.084	0.121	0.131	0.122	0.066
10.	Pantnagar-1	S ₁₀	0.140	0.122	0.110	0.114	0.115	0.126	0.120	0.061	0.041	0.098	0.142	0.125
11.	Pantnagar-2	S ₁₁	0.122	0.136	0.144	0.099	0.017	0.056	0.112	0.084	0.056	0.098	0.125	0.110

5.2.15. Micronutrients

Micronutrients in the soils of the study area were determined by the methods as described in Chapter-IV using Atomic Absorption Spectrophotometer (A.A.S.) method. The results have been reported in Table 5.2.15.

Table 5.2.15. Metallic ions (Zn, Mn, Fe and Cu) in the soils of the Tarai region of Uttarakhand.

	Year: 2006										
Metals/Site No.	S₁	S₂	S₃	S₄	S₅	S₆	S₇	S₈	S₉	S₁₀	S₁₁
Zinc (in ppm)	1.0	2.5	0.76	1.38	0.27	1.45	1.07	1.34	0.73	0.82	0.79
Manganese (in ppm)	4.0	10.0	1.19	1.65	4.02	3.00	4.00	4.02	2.38	2.78	3.02
Ferrous (in ppm)	4.0	10.0	5.45	5.15	14.79	8.83	10.03	14.79	13.86	12.02	17.02
Copper (in ppm)	2.0	5.0	1.67	1.01	0.49	0.65	0.56	1.16	1.67	0.62	0.53



CHAPTER – VI

DISCUSSION

6.1 Soil is defined as an independent body with a unique morphology from the surface down to the parent material as expressed by the sample profiles (**Tan; 1995**).

Soil Can also be defined as the collection of natural bodies occupying parts of the earth’s surface that support plant and that have properties due to the integrated effect of climate and living matter acting upon parent material as conditioned by relief over period of time (**Negi; 2000**).

The study of soil is also known as the soil science or pedology (pedos means earth or edaphology edaphos means soil). Soil may also be defined as the part of the earth crust in which humus is present (**Shukla and Chandal; 1991**).

Soils are devided by texture into the following groups in the American classification (**Victorova; 1986**).

(i) Clayed Soils

- | | | |
|--------------|---|--|
| Very Clayed | { | Clay
Silty Clay |
| Intermediate | { | Silty heavy loam
Heavy loam
Sandy Clay |

(ii) Loamy Soils

- | | | |
|----------------|---|--------------------------|
| Medium loamy | { | Sandy heavy loam
loam |
| Slightly loamy | | Sandy loam |

(iii) Silty Soils

- | | |
|---|--|
| { | Silty loam
Silty clay loam
Silty |
|---|--|

6.2 RELATIONSHIP OF THE NUTRIENTS WITH SOILS OF THE TARAI REGION OF UTTARAKHAND STATE (INDIA)

Calculating the average of a particular characteristic or nutrient content for a calendar year, the relationship between the nutrients and the soils of the region has been reported in **Tables 6.2.1 to 6.2.13**.

Table 6.2.1: Variation of soil water (Dry mass percentage of H₂O) in different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average Dry Mass percentage of H ₂ O
1.	Khatima (Banusa)	S ₁	11.26
2.	Khatima (Jhanket)	S ₂	10.97
3.	Khatima (Amaun)	S ₃	10.47
4.	Khatima (Chakerpur)	S ₄	11.66
5.	Khatima (City)	S ₅	11.68
6.	Sitarganj-1	S ₆	11.04
7.	Sitarganj-2	S ₇	10.25
8.	Rudrapur-1	S ₈	10.65
9.	Rudrapur-2	S ₉	10.47
10.	Pantnagar-1	S ₁₀	13.73
11.	Pantnagar-2	S ₁₁	10.50

Table 6.2.2: Variation of Soil Temperature in different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average Temperature (in °C)
1.	Khatima (Banusa)	S ₁	25.58
2.	Khatima (Jhanket)	S ₂	26.00
3.	Khatima (Amaun)	S ₃	25.58
4.	Khatima (Chakerpur)	S ₄	25.50
5.	Khatima (City)	S ₅	25.33
6.	Sitarganj-1	S ₆	25.75
7.	Sitarganj-2	S ₇	25.08
8.	Rudrapur-1	S ₈	26.33
9.	Rudrapur-2	S ₉	26.91
10.	Pantnagar-1	S ₁₀	24.40
11.	Pantnagar-2	S ₁₁	24.25

Table 6.2.3: Variation of Bulk Density of the Soil in different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average Bulk Density (mg/m³)
1.	Khatima (Banusa)	S ₁	1.16
2.	Khatima (Jhanket)	S ₂	1.20
3.	Khatima (Amaun)	S ₃	1.25
4.	Khatima (Chakerpur)	S ₄	1.22
5.	Khatima (City)	S ₅	1.26
6.	Sitarganj-1	S ₆	1.23
7.	Sitarganj-2	S ₇	1.22
8.	Rudrapur-1	S ₈	1.22
9.	Rudrapur-2	S ₉	1.21
10.	Pantnagar-1	S ₁₀	1.32
11.	Pantnagar-2	S ₁₁	1.19

Table 6.2.4: Variation of pH of the Soil Temperature in different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average pH
1.	Khatima (Banusa)	S ₁	7.20
2.	Khatima (Jhanket)	S ₂	7.03
3.	Khatima (Amaun)	S ₃	7.31
4.	Khatima (Chakerpur)	S ₄	7.19
5.	Khatima (City)	S ₅	7.32
6.	Sitarganj-1	S ₆	7.32
7.	Sitarganj-2	S ₇	7.11
8.	Rudrapur-1	S ₈	7.11
9.	Rudrapur-2	S ₉	7.30
10.	Pantnagar-1	S ₁₀	7.35
11.	Pantnagar-2	S ₁₁	7.31

Table 6.2.5: Variation of Electrical Conductivity (EC) in the soils of different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average Electrical Conductivity (EC) (ds/m)
1.	Khatima (Banusa)	S ₁	0.429
2.	Khatima (Jhanket)	S ₂	0.315
3.	Khatima (Amaun)	S ₃	0.356
4.	Khatima (Chakerpur)	S ₄	0.325
5.	Khatima (City)	S ₅	0.402
6.	Sitarganj-1	S ₆	0.336
7.	Sitarganj-2	S ₇	0.295
8.	Rudrapur-1	S ₈	0.537
9.	Rudrapur-2	S ₉	0.428
10.	Pantnagar-1	S ₁₀	0.381
11.	Pantnagar-2	S ₁₁	0.356

Table 6.2.6: Variation of Organic Carbon in the soils of different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average % of Organic Carbon
1.	Khatima (Banusa)	S ₁	0.528
2.	Khatima (Jhanket)	S ₂	0.259
3.	Khatima (Amaun)	S ₃	0.272
4.	Khatima (Chakerpur)	S ₄	0.621
5.	Khatima (City)	S ₅	0.252
6.	Sitarganj-1	S ₆	0.630
7.	Sitarganj-2	S ₇	0.632
8.	Rudrapur-1	S ₈	0.752
9.	Rudrapur-2	S ₉	0.817
10.	Pantnagar-1	S ₁₀	0.921
11.	Pantnagar-2	S ₁₁	0.880

Table 6.2.7: Variation of Organic Matter in the Soils of different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average % of Organic Matter
1.	Khatima (Banusa)	S ₁	1.006
2.	Khatima (Jhanket)	S ₂	0.449
3.	Khatima (Amaun)	S ₃	0.474
4.	Khatima (Chakerpur)	S ₄	1.070
5.	Khatima (City)	S ₅	0.436
6.	Sitarganj-1	S ₆	1.093
7.	Sitarganj-2	S ₇	1.090
8.	Rudrapur-1	S ₈	1.300
9.	Rudrapur-2	S ₉	1.410
10.	Pantnagar-1	S ₁₀	1.590
11.	Pantnagar-2	S ₁₁	1.520

Table 6.2.8: Variation of Phosphorus (P) in the Soils of different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average Phosphorus (P) (Kg/ha)
1.	Khatima (Banusa)	S ₁	70.98
2.	Khatima (Jhanket)	S ₂	29.38
3.	Khatima (Amaun)	S ₃	14.68
4.	Khatima (Chakerpur)	S ₄	11.10
5.	Khatima (City)	S ₅	6.50
6.	Sitarganj-1	S ₆	67.44
7.	Sitarganj-2	S ₇	64.08
8.	Rudrapur-1	S ₈	66.04
9.	Rudrapur-2	S ₉	64.37
10.	Pantnagar-1	S ₁₀	92.36
11.	Pantnagar-2	S ₁₁	72.71

Table 6.2.9: Variation of Potassium (K) in the Soils of different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average Potassium (K) (Kg/ha)
1.	Khatima (Banusa)	S ₁	298.33
2.	Khatima (Jhanket)	S ₂	152.98
3.	Khatima (Amaun)	S ₃	77.33
4.	Khatima (Chakerpur)	S ₄	382.91
5.	Khatima (City)	S ₅	76.50
6.	Sitarganj-1	S ₆	243.50
7.	Sitarganj-2	S ₇	299.50
8.	Rudrapur-1	S ₈	447.91
9.	Rudrapur-2	S ₉	153.75
10.	Pantnagar-1	S ₁₀	298.33
11.	Pantnagar-2	S ₁₁	299.91

Table 6.2.10: Variation of Available Sodium (Na) in the Soils of different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average Available Sodium (Na) (in ppm)
1.	Khatima (Banusa)	S ₁	26.58
2.	Khatima (Jhanket)	S ₂	25.58
3.	Khatima (Amaun)	S ₃	27.50
4.	Khatima (Chakerpur)	S ₄	26.58
5.	Khatima (City)	S ₅	24.25
6.	Sitarganj-1	S ₆	20.83
7.	Sitarganj-2	S ₇	21.58
8.	Rudrapur-1	S ₈	22.41
9.	Rudrapur-2	S ₉	24.25
10.	Pantnagar-1	S ₁₀	22.41
11.	Pantnagar-2	S ₁₁	22.16

Table 6.2.11: Variation Available Sulphur (S) in the Soils of different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average Available Sulphur (S) (in ppm)
1.	Khatima (Banusa)	S ₁	22.95
2.	Khatima (Jhanket)	S ₂	26.38
3.	Khatima (Amaun)	S ₃	31.54
4.	Khatima (Chakerpur)	S ₄	9.70
5.	Khatima (City)	S ₅	9.85
6.	Sitarganj-1	S ₆	10.60
7.	Sitarganj-2	S ₇	11.42
8.	Rudrapur-1	S ₈	14.94
9.	Rudrapur-2	S ₉	14.01
10.	Pantnagar-1	S ₁₀	15.09
11.	Pantnagar-2	S ₁₁	13.44

Table 6.2.12: Variation of Total Nitrogen (N) in the Soils of different sites of the Tarai Region of Uttarakhand state (India).

Year: 2006

S. No.	Site Name	Site No.	Average % of Nitrogen
1.	Khatima (Banusa)	S ₁	0.088
2.	Khatima (Jhanket)	S ₂	0.136
3.	Khatima (Amaun)	S ₃	0.098
4.	Khatima (Chakerpur)	S ₄	0.083
5.	Khatima (City)	S ₅	0.108
6.	Sitarganj-1	S ₆	0.225
7.	Sitarganj-2	S ₇	0.120
8.	Rudrapur-1	S ₈	0.109
9.	Rudrapur-2	S ₉	0.106
10.	Pantnagar-1	S ₁₀	0.109
11.	Pantnagar-2	S ₁₁	0.096

Table 6.2.13. Variation of Micronutrients in the Soils of different sites of the Tarai region of Uttarakhand state (India).

Year: 2006

Metals/Site No.	S₁	S₂	S₃	S₄	S₅	S₆	S₇	S₈	S₉	S₁₀	S₁₁
Zinc (in ppm)	1.0	2.50	0.76	1.38	0.27	1.45	1.07	1.34	0.73	0.82	0.79
Manganese (in ppm)	4.0	10.0	1.19	1.65	4.02	3.00	4.00	4.02	2.38	2.78	3.02
Ferrous (in ppm)	4.0	10.0	5.45	5.15	14.79	8.83	10.03	14.79	13.86	12.02	17.02
Copper (in ppm)	2.0	5.00	1.67	1.01	0.49	0.65	0.56	1.16	1.67	0.62	0.53

A detailed study of the present work done on the soil types of the Tarai region of Uttarakhand state (India) indicates that except in a few sites the soils are almost sufficient in **Fe, Mn, Cu, Na, S** and **P**.

The entire Tarai region is very poor in the concentration of nitrogen and nitrogen containing compounds. Organic Matter Content is also remarkably low in this region.

Potassium (K) popularly known as Potash in the Fertilizer Industry has a considerably high value in almost all the soil types of Taria region, Uttarakhand state (India).

A comparison of the present work, which was concentrated on the soil types of the Tarai region of Uttarakhand state (India) with the earlier studies Chhabra (1993), Kaur (1995), Raghvansh (2002), Shiveshwer Pratap Singh (2002), Pande (2002), and Trilochan (2004) done on the soil types of Hill and the Bhabar region of this state was done with the objective to establish a relationship between the soil types of these regions for the use of the farmers of this region. Attempt was also made so that the present study could be a small academic contribution in this field.

A perusal of the present study and earlier studies (Chhabra (1993), Kaur (1995), Raghvansh (2002), Shiveshwer Pratap Singh (2002), Pande (2002) and Trilochan (2004)) indicates that the soil types of the Tarai region are almost the same in the chemical properties with the soil types of the Hill and Bhabar of Uttarakhand state (India). But except a few sites the physical properties including the appearance of the soil types of all these three regions namely Hill region, Bhabar region and Tarai region are different. The probable reason of the similarities between the chemical properties is perhaps because in the Bhabar and Tarai regions almost all the soils have come from the hills due to land slides, rains and with the rivers/streams which flow from hill tops, down to the plains. The difference

in the physical properties as well as in the appearance is probably due to the remarkable temperatue and climatic differences in these regions.

The present work would definitely be useful not only for the farmers of this reagon but would also be of academic interest. Attempts have been made to undertake the detailed study of all the objectives mentioned in 1.2 earlier. But no study can be said to be sufficient and complete unless the study is worth use of everyone concerned. It is therefore proper to say that whatever be the shortcomings of this study, a detailed study in this field would further be carried out to make the study more useful and more fruitful.



CHAPTER – VII

REFERENCES

REFERENCES

1. Zonn, S.V.:(1986), *Tropical and Subtropical Soil Science*, Mir Publishers, Moscow.
2. Sachan R.S.; Ram N and Upadhyay R.M.; (1986), *Prayogik Mride Parikshan ewam Urvarak Prabandh Publications Directrate*, G.B. Pant, University of Agriculture and Technology, Pantnagar.
3. Cook Raj L. and Ellis Boyd. G.; (1987), *Soil Management, A World View of Conservation and Production*, John Willey and Sons, New York.
4. Shukla, R.S. and Chandel, P.S.:(1991), *Plant Ecology and Soil Science*, S. Chand and Co. Ltd., New Delhi, VII edition.
5. Zou Xiaoming; Binkley Dan; and Doxtader Kenneth G.; (1992). “*A new method for estimating gross phosphorus mineralization and immobilization rates in soils*”, *Plant and Soil*, **147**, 243-250.
6. Lesch S.M.; Rhodes J.D.; Lund L.J. and Corwin D.L; (1992). “*Mapping Soil Salinity Using Calibrated Electromagnetic Measurements*”, *Soil Sci. Soc. Am. J.*, **56**, 540-548.
7. Batch L. B. ;(1992), “*Soil water movement in response to Temperature Gradients: Experimental Measurements and Model Evaluation*”, *Soil Sci. Soc. Am. J.*, **56**, 37-46.
8. Sheppard Marsha I; Thibault Denis H.; (1992). “*Desorption and Extraction of selected Heavy Metals from soils*”, *Soil Sci. Soc. Am. J.*, **56**, 415-423.
9. Meek B.D.; Rechel E.R.; Carter L.M. and Detar W.R.; (1992). “*Bulk Density of a sandy loam: Traffic, Tillage, and Irrigation – Methods Effects*”, *Soil Sci. Soc. Am. J.*, **56**, 562-565.

10. Tietema A.; Warmerdam B.; Lenting E. and Riemer L.; (1992), “*Abiotic factors regulating nitrogen transformations in the organic layer of acid forest soils: Moisture and pH*”, *Plant and Soil*, **147**, 69-78.
11. Sjöström Jan and Qvarfort Ulf ;(1992), “*Long-Term, Changes of Soil Chemistry in Central Sweden*”, *Soil Science*, **154(6)**, 450-457.
12. Selassie T.G.; Jurinak J.J; and Dudley L.M; (1992), “*Saline and Sodic-Saline Soil Reclamation: First Order Kinetic Model*”, *Soil Science*, **154(1)**, 1.
13. Kemp Paul R.; Cornelius Joe M. and Reynolds James F. ;(1992), “*A Simple Model for Predicting Soil Temperatures in Desert Ecosystems*”, *Soil Science*, **153(4)**, 280.
14. Basta N.T. and Tabatabai M.A. ;(1992), “*Effect of Cropping Systems on Adsorption of Metals by Soils: II. Effect of pH*”, *Soil Science*, **153(3)**, 195.
15. Grigal D.F.; and Ohmann L.F.; (1992), “*Carbon Storage in Upland Forests of the Lake States*”, *Soil Sci. Soc. Am. J.*, **56**, 935-943.
16. Schnitzer M.; and Kodama H.; (1992), “*Interactions between Organic and Inorganic Components in Particle-Size Fraction Separated from Four Soils*”, *Soil Sci. Soc. Am. J.*, 1099-1105.
17. Moore T.R.; Souza W. DE and Kopriunjak J-F; (1992), “*Controls on the Sorption of Dissolved Organic Carbon by Soils*”, *Soil Sc.*, **154(8)**, 120.
18. Williams R.D.; Ahuja L.R. and Naney J.W; (1992), “*Comparison of Methods to Estimate Soil Water Characteristics from Soil Texture, Bulk Density, and Limited Data*”, *Soil Science*, **153(1)**, 172-183.
19. Walters D.T.; Aulakh M.S.; Doran J.W; (1992), “*Effects of Soil Aeration, Legume Residue, and Soil Texture on Transformations of Macro- and Micronutrients in Soil*”, *Soil Science*, **153(2)**, 100-107.

20. Bauer Armand and Black A.L; (1992), "*Organic Carbon effects on Available Water capacity of three Soil Textural Groups*", Soil Sci. Soc. Am. J., **56**, 248-254.
21. Johanson J.A.; Farmer W.J; (1993), "*Batch versus Column method for determining distribution of organics between soil and Water phases*", Soil Sci., **155(2)**, 92-99.
22. Tamari S.; Bruckler L.; Halbertsma J.; and Chadoeuf J.; (1993), "*A Simple Method for Determining Soil Hydraulic Properties in the Laboratory*", Soil Sci. Soc. Am. J., **57**, 642-651.
23. Moshrefi N. ;(1993), "*A New method of Sampling Soil Suspension for particle size analysis*", Soil Sci., **155 (4)**, 245-248.
24. Amrhein C.; Mosher P.A. and Brown A.D; (1993), "*The Effects of Redox on Mo, U, B, V, AND As Solubility in Evaporation Pond Soils*", Soil Sci., **155(4)**, 249.
25. XING-CHU QIU; YING-QUAN ZHU; (1993), "*Rapid Analysis of Cation Exchange Properties in Acidic Soils*", Soil Sci., **155(4)**, 301.
26. REHMAN ATA-UR; DURNFORD DEANNA S; (1993), "*Soil Volumetric Shrinkage Measurements: A Simple method*", Soil Sci., **155(5)**, 325-330.
27. Massman W.J; (1993), "*Periodic Temperature Variations in an inhomogenous Soil: A Comparison of Approximate and Exact Analytical Expression*", Soil Sci., **155(5)**, 331.
28. Campbell C.A.; and Zentner R.P.; (1993), "*Soil Organic Matter as Influenced by Crop Rotations and Fertilization*", Soil Sci. Soc. Am. J., **57**, 1034-1040.
29. Mordelet P.; Abbadie L. and Menaut J.C; (1993), "*Effects of tree clumps on soil characteristics in a humid savanna of West Africa (Lamto, Coted' Ivoire)*", Plant and Soil, **153**, 103-111.

30. Giesler R.; Lundstrom U; (1993), "*Soil Solution Chemistry: Effects of Bulking Soil Samples*", Soil Sci. Soc. Am. J., **57**, 1283-1288.
31. ZHU B.; ALVA A.K.; (1993), "*Differential Adsorption of Trace Metals by Soils as Influenced by Exchangeable Cations and Ionic Strength*", Soil Sci., **155(1)**, 61-66.
32. Chiang S.C.; Radcliffe D.E.; Miller W.P; (1993), "*Hydraulic properties of Surface Seals in Georgia Soils*", Soil Sci. Soc. Am. J., **57**, 1418-1426.
33. Raven K.P.; Hossner L.R.; (1993), "*Phosphorus Desorption Quantity-Intensity Relationships in Soils*", Soil Sci. Soc. Am. J., **57**, 1501-1508.
34. Yaan Cheng, Pettry D.E; (1993), "*Horizontal and Vertical Movements of Two Expansive Soils in Mississippi*", Soil Sci. Soc. Am. J., **57**, 1542-1547.
35. Chhabra Gulshan; (1993), *Available Micronutrient Cations as related to the Properties of Hill, Tarai and Alluvial Soils From Gola-Kosi interbasin*, Ph.D. Thesis, G.B. Pant University of Agriculture and Technology Pantnagar.
36. Osaki M.; (1993), "*Carbon-nitrogen interaction model in field crop production*", Plant and Soil, **155/156**, 203-206.
37. Grant R.F.; (1993), "*Simulation model of soil compaction and root growth*", Plant and Soil, **150**, 1-4.
38. Whitehead D.C.; Raistrick N. ;(1993), "*The volatilization of ammonia from Cattle urine applied to soils are influenced by soil properties*", Plant and Soil, **148**, 43-51.
39. Vaz M.D. Ron; Edwards A.C.; Shand C.A. and Cresser M.S.; (1993), "*Phosphorus fractions in soil solution: Influence of soil acidity and fertiliser additions*", Plant and Soil, **148**, 175-183.

40. Zhu B.; Alva A.K.; (1993), "*Trace metal and cation Transport in a Sandy Soil with various Amendments*", Soil Sci. Soc. Am. J., **57**, 723-727.
41. Quisenberry V.L.; Smith B.R.; Phillips R.E.; Scott H.D.; Nortcliffe S. (1993), "*A Soil Classification System for Describing Water and Chemical Transport*", Soil Sci., **156(5)**, 306-315.
42. Chow T.L.; Rees H.W.; Webb K.T. and Langille D.R. (1993), "*Modification of Subsoil Characteristics Resulting from Drainage Tile Installation*", Soil Sci., **156(5)**, 346.
43. Kuiters A.T.; Mulder W. ;(1993), "*Water Soluble Organic Matter in Forest Soils*", Plant and Soil, **152**, 225-235.
44. Lefroy Rod D.; Blair Graeme J.; and Strong Wayne M.; (1993), "*Changes in soil organic matter with cropping as measured by organic carbon fractions and ¹³C natural isotope abundance*", Plant and Soil, **155/156**, 399-402.
45. Paige G.B.; Hillel D.; (1993), "*Comparison of three methods for Assessing Soil Hydraulic properties*", Soil Sci., **155(3)**, 175.
46. Mc Laughlin M.J.; Lancaster P.A.; Sale P.W.G.; Uren N.C. and Peverill K.I. ;(1993), "*Use of cation/anion exchange membranes for multi-elements testing of acidic soils*", **155/156**, 223-226.
47. Norfleet M.L.; Karathanasis A.D.; and Smith B.R. ;(1993), "*Soil Solution Composition Relative to Mineral Distribution in Blue Ridge Mountain soil*", Soil Sci. Soc. Am. J., **57**, 1375-1380.
48. Kumar Raj; Ahuja R.L.; Singh N.T.; and Ghabru S.K.; (1994), "*Occurrence of Sodic Soils at Different Geomorphic Locations and Climate in the Satluj-Yammuna Divide*", J. Indian Soc. Soil Sci., **42(1)**, 114-119.

49. Jalota S.K.; (1994), "*Evaporation Parameter in Relation to Soil Texture and Atmospheric Evaporativity to Predict Evaporation from Bare Soil*", J. Indian Soc. Soil Sci., **42(2)**, 178-181.
50. Knoepp Jennifer Donaldson; Swank Wayne T. ;(1994), "*Long-Term Soil Chemistry changes in Aggrading Forest Ecosystem*", Soil Sci. Soc. Am. J., **58**, 325-331.
51. Sen T.K.; Chamuah G.S.; and Sehgal J.L.; (1994), "*Occurrence and characteristics of some Kandi Soils in Manipur*", J. Indian Soc. Soil Sci., **42(2)**, 297-300.
52. Bhattacharyya T.; Sen T.K.; Singh R.S.; Nayak D.C.; and Sehgal J.L. (1994), "*Morphology and classification of Ultisols with Kandic Horizon in North Eastern Region*", J. Indian Soc. Soil Sci., **42(2)**, 301-306.
53. Soni M.L.; Singh J.P. and Kumar Vinod ;(1994), "*Effect of Sewage sludge Application on the Mineralization of Nitrogen in Soils*", J. Indian Soc. Soil Sci., **42(1)**, 17-21.
54. Chand Milap; Dhillon N.S.; (1994), "*Evaluation of various Soil Test methods for available phosphorous in Reclaimed Sodic Soils of Punjab*", J. Indian Soc. Soil Sci., **42(2)**, 278-281.
55. Bhattacharya T.; Srivastava R.; Sharma J.P.; Sehgal J.L.; (1994), "*Classification of Saline-Sodic Vertisols in the Coastal Plains of Gujarat*", J. Indian Soc. Soil Sci., **42(2)**, 306-309.
56. Bharadwaj Venkatesh and Omanwar P.K.; (1994), "*Long Term Effects of Continuous Rotational Cropping and Fertilization on Crop Yields and Soil Properties-II. Effects on EC, pH, Organic Matter and Available Nutrients of Soil*", J. Indian Soc. Soil Sci., **42(3)**, 387-392.
57. Bharadwaj Venkatesh; Bansal S.K.; Maheshwari S.C. and Omanwar P.K.; (1944), "*Long Term effects of continuous Rotational cropping and fertilization on crop yields and Soil properties-III changes in the*

- fractions of N, P and K of the soil*”, J. Indian Soc. Soil Sci., **42(3)**: J. Indian Soc. Soil Sci., **42(3)**, 392-397.
58. Mathan K.K.; Natarajan S.; and Mahendran P.P.; (1994), “*Application of Fertility Capability Classification Concept in Major Soil Groups of Kamarajar District, Tamil Nadu*”, J. Indian Soc. Soil Sci., **42(3)**, 416-420.
59. Neto Ladislau Martin; Andriulo Anrian Enrique and Traghetta Dinis Gomes; (1994), “*Effects of Cultivation on ESR Spectra of Organic Matter from Soil Size Fractions of a Mollisol*”, Soil Science, **157(6)**, 365.
60. Chandrasekharan H.; Yadav B.R.; Tomar S.P.S. and Sharma P.B.S.; (1994), “*Studies on Salinity and Water Content of Soils – Geoelectrical Approach*”, J. Indian Soc. Soil Sci., **42(3)**, 430-436.
61. Lebron I.; Suarez D.L.; and Alberto F.; (1994), “*Stability of a Calcareous Saline-Sodic During Reclamation*”, Soil Sci. Soc. Am. J., **58**, 1753-1762.
62. Kun-Huang Houng ;(1994), “*Simulation of Cation Exchange Involving Hydrogen Ion in Soil*”, Soil Sci. Soc. Am. J., **58**, 1086-1094.
63. Preston C.M.; Newman R.H. and Rother P.; (1994), “*Using ¹³C CPMAS NMR to assess effects of cultivation on the organic matter of particle size fractions in a grassland soil*”, Soil Sci., 157(1), 26-35.
64. Kohut Connie K.; Dudas M.J.; (1994), “*Characteristics of Clay Minerals in Saline Alkaline Soils in Alberta Canada*”, Soil Sci. Soc. Am. J., **58**, 1260-1269.
65. Xing B.; Dudas M.J. ;(1994), “*Characterization of Clay minerals in white clay soils, people’s republic of China*”, Soil Sci. Soc. Am. J., **58**, 1253-1259.

66. Schmidhalter U.; Kahr G.; Evequoz M.; Studer C. and Oertli J.J. ;(1994), “*Adsorption of Thiamin (Vitamin B₁) on Soils and Clays*”, Soil Sci. Soc. Am. J., **58**, 1829-1837.
67. Johns Mitchell M.; Skogley Earl O.; (1994), “*Soil Organic Matter Testing and Labile Carbon Identification by Carbonaceous Resin Capsules*”, Soil Sci. Soc. Am. J., **58**, 751-758.
68. Veldkamp E.; Weitz A.M.; (1994), “*Uncertainly Analysis of $\delta^{13}C$ Method in Soil Organic Matter Studied*”, Soil Bio. Biochem. **26(2)**, 153-160.
69. Xu Shihe; and Stephen Boyd A.; (1994), “*Cation Exchange Chemistry of Hexa-decyltrimethylammonium in a Subsoil Containing Vermiculite*”, Soil Sci. Soc. Am. J., **58**, 1382-1391.
70. Diwakar D.P.S.; Singh R.N. ;(1994), “*Characterization of Soils of Diara Land Occuring in Gangetic Plains of Bihar*”, J. Indian Soc. Soil Sci., **42(3)**, 420-425.
71. Barber R.G.; Diaz O.; (1994), “*Maintenance of Yields and Soil Fertility in Nonmechanized Cropping Systems, Bolivia*”, Soil Sci. Soc. Am. J., **58**, 858-866.
72. Sanchez-Maranon M.; Delgado G.; Delgado R.; Perez M.M. and Melgosa M.; (1995), “*Spectroradiometric and Visual Color Measurements of Disturbed and Undisturbed Soil Samples*”, Soil Sci., **160(1)**, 291.
73. Anthony W.H.; Hutchinson G.L. and Livingston G.P.; (1995), “*Chamber Measurement of Soil-Atmosphere Gas Exchange: Linear Vs Diffusion-Based Flux Models*”, Soil Sci. Soc. Am. J., **59**, 1308-1310.
74. Polubesova Tamara A.; Chorover Jon and Sposito Garrison ;(1995), “*Surface Charge Characteristics of Podzolized Soil*”, Soil Sci. Soc. Am. J., **59**, 772-777.

75. Backes Clare A.; Mcaren Ronald G.; Rate Andrew W. and Swift Roger S.; (1995), "*Kinetics of Cadmium and Cobalt Desorption from Iron and Manganese Oxides*", Soil Sci. Soc. Am. J., **59**, 778-785.
76. CHAVAN K.N.; KENJALE R.Y. and CHAVAN A.S.; (1995), "*Effect of Forest Tree Species on Properties of Lateritic Soil*", J. Indian Soc. Soil Sci., **43(1)**, 43-46.
77. John K. Susan; Abraham Alice ;(1995), "*Microbial Immobilization and Mineralization of Nutrients during Different Seasons of the Year*", J. Indian Soc. Soil Sci., **43(1)**, 47-52.
78. Sahu G.C.; Bala Nirmalya; (1995), "*Characterization and Classification of soils on valley plains of middle Andaman Island*", J. Indian Soc. Soil Sci., **43(1)**, 99-103.
79. Maji B.; Bandyopadhyay B.K. ;(1995), "*Characterization and Classification of Coastal Soils of various pH Groups in Sundarbans, West Bengal*", J. Indian Soc. Soil Sci., **43(1)**, 103-107.
80. Skyllberg Ulf ;(1995), "*Solution/Soil Ratio and release of Cations and Acidity from Spodosol Horizons*", Soil Sci. Soc. Am. J., **59**, 786-795.
81. Ben-dor E.; Banin A.; (1995), "*Near Infrared analysis as a rapid method to simultaneously evaluate several soil properties*", Soil Sci. Soc. Am. J., **59**, 364-372.
82. Moraes Jener L.; Cerri Carlos C.; Melillo Jerry M.; Kicklighter David; Neill Christopher; Skole David L. and Steudler Paul A. ;(1995), "*Soil Carbon Stocks of the Brazilian Amazon Basin*", Soil Sci. Soc. Am. J., **59**, 244-247.
83. Curtin D.; Smillie G.W.; (1995), "*Effects of incubation and pH on soil solution and exchangeable cation ratios*", Soil Sci. Soc. Am. J., **59**, 1006-1011.
84. Jeffrey S. Kern ;(1995), "*Evaluation of Soil Water Retention Model Based on Basic Soil Physical Properties*", Soil Sci. Soc. Am. J., **59**, 1134-1141.

85. Homann P.S.; Sollines P.; Chappell H.N. and Stangenbrger A.G. ;(1995), “*Soil Organic Carbon in a Mountainous, Forested Region: Relation to Site Characteristics*”, Soil Sci. Soc. Am. J., **59**, 1468-1475.
86. Mahendran P.P.; Mathan K.K.; (1995), “*Relative Importance of Component Soil Properties on Saturated Hydraulic Conductivity in Soil*”, J. Indian Soc. Soil Sci., **43(2)**, 149-151.
87. Igwe C.A.; Akamigbo F.O.R. and Mbagwu J.S.C. ;(1995), “*Physical Properties of Soils of South-Eastern Nigeria and the Role of Some Aggregating Agents in Their Stability*”, Soil Science, **160(6)**, 431.
88. Rasiah V.; Biederbeck V.O.; (1995), “*Fractal Dimension of Soil Aggregates: Influence of Bulk Density, Fitting Procedure, and Oily Waste Sludge in Corporation*”, Soil Science, **160(1)**, 250.
89. Santini A.; Romano N.; Ciollars G. and Comegna V.; (1995), “*Evaluation of a Laboratory Inverse Method For Determining Unsaturated Hydraulic Properties of a Soil Under Different Tillage Practices*”, Soil Science, **160(5)**: 340.
90. Singh Room; (1995), “*Role of Soil Texture and Plant Age in Leaf-Water Potential Measured at Different Crop Stages of Wheat in Mollisols of Tarai*”, J. Indian Soc. Soil Sci., **43(3)**, 327-330.
91. Saha N.; Das A.C. and Mukherjee D.; (1995), “*Effect of Decomposition of Organic Matter on the Activities of Microorganism and Availability of Nitrogen, Phosphorus and Sulphur in Soil*”, J. Indian Soc. Soil Sci., **43(2)**, 210-215.
92. Kumar Kailash; Rao K.V.P. and Singh L.J.:(1995), “*Forms of Acidity in Some Acid Inceptisols under Different Land Use in Manipur*”, J. Indian Soc. Soil Sci., **43(3)**, 338-342.
93. Bala Parveen; Bhardwaj S.S.; Sidhu P.S. and Singh Bachan ;(1995), “*Effect of Ionic Strength on Phosphate Adsorption by Soils*”, J. Indian Soc. Soil Sci., **43(3)**, 342-346.

94. Avasthe Yashoda and Avasthe R.K. ;(1995), “*Altitudinal distribution of Micronutrients in the soil of Sikkim*”, J. Indian Soc. Soil Sci., **43(3)**, 374-377.
95. Kumar Pardeep; Sharma S.P.and Sharma P.D.; (1995), “*Distrubution of N, P and K in Soan River Valley Soils of Lower Shiwaliks*”, J. Indian Soc. Soil Sci., **43(3)**, 360-364.
96. Hosur G.C.; Dasog G.S.; (1995), “*Effect of Tree Speices on Soil Properties*”, J. Indian Soc. Soil Sci., **43(2)**, 256-259.
97. Tiwari Ashok; Tiwari K.N. and Mishra S.G.; (1995), “*Soil Test Methods and Critical Limits of Potassium in Soil and Plants for Wheat Grown in Typic Ustochrepts*”, J. Indian Soc. Soil Sci., **43(3)**, 408-413.
98. Singh S.K.; Das K.; Shyampura R.L.; Giri J.D.; Singh R.S. and Sehgal J.L. ;(1995), “*Genesis and Taxonomy of Black Soils from Basalt and Basaltic Alluvium in Rajasthan*”, J. Indian Soc. Soil Sci., **43(3)**, 430-436.
99. Courchesene Francois; Savoie Sylvain and Dufresne Alain ;(1995), “*Effect of Air-Drying on the Measurement of Soil pH in Acidic Forest Soil of Quebec, Canada*”, Soil Science, **160(1)**, 56.
100. Anderson Michael A.; Hung Albert Y.C; Mills David and Scott Maricia S. (1995). “*Factors Affecting the Surface Tension of Soil Solution and Solutions of Humic Acids*”, Soil Science, **160(2)**, 111.
101. Tan, Kim H.; (1995), *Soil Sampling, Preparation and Analysis*, Marcel Dekker, Inc. New York.
102. Rao A. Subba; Rao Ch. Srinivash and Pal S.K.; (1996), “*Predication of Cation Exchange Capacity from Clay and Organic Carbon of Some Smectite and Kaolinite-Rich Soils*”, J. Indian Soc. Soil Sci., **44(2)**, 214-219.

103. Singh J.P.; Kumar Vinod ;(1996), “*Nitrogen mineralization of legume Residues in soils in relation to their chemical Composition*”, J. Indian Soc. Soil Sci., **44(2)**, 219-223.
104. Walia and Rao Y.S.; (1996), “*Genesis, Characteristics and Taxonomic Classification of Some Red Soils Bundelkhand Region of Uttar Pradesh*”, J. Indian Soc. Soil Sci., **44(3)**, 476-481.
105. Patil C.V.; Math K.K.; Math K.K.; Bulbule A.V.; Prakash S.S and Yeledhalli N.A.; (1996), “*Effects of the Fly Ash on Soil Crust Strength and Crop Yield*”, J. Maharashtra Agric. Univ.,**21 (1)**, 9-11.
106. Ellerbek R.H.; Gerke H.H.; Bachmann J. and Goebel M.O.; (2005), “*Composition of Organic Matter Fraction for Explaining Wettability of Three Forest Soils*”, Soil Sci. Soc. Am. J., **69**, 57-66.
107. Scheidegger A.M. and Sparks D.L.; (1996), “*A Critical Assessment of Sorption-Desorption Mechanisms at the Soil Mineral/Water Interface*”, Soil Science, **161(12)**, 813.
108. Lawrence Gregory B. and David Mark B.; (1996), “*Chemical Evaluation of Soil Solution in Acid Forest Soils*”, Soil Science, **161(5)**, 298.
109. Nelson Shad D.; Terry Richard E. ;(1996), “*The Effects of Soil Physical Properties and Irrigation Method on Denitrification*”, Soil Science, **161(4)**, 242.
110. Auxtero E.; Ranst E. Van and Sakagami K.; (1996), “*Properties and Related Management Implications of Major Soils in Bukidnon, Philippines*”, Soil Science, **161(1)**, 46.
111. Nayak D.C.; Sen T.K.; Chamuah G.S. and Sehgal J.L. ;(1996), “*Nature of Soil Acidity in Some Soils of Manipur*”, J. Indian Soc. Soil Sci., **44(2)**, 209-214.

112. Elahi S.F.; Hossain M.F. and Kamal A.S.M.M; (1996), “*Characteristics of Some Soils Developed on Madhupur Clay in Bangladesh*”, J. Indian Soc. Soil Sci., **44(3)**, 482-488.
113. Sharma S.S.; Totawat K.L. and Shyampura R.L.; (1996), “*Characterization and classification of soils in a Top sequence over basaltic Terrain*”, J. Indian Soc. Soil Sci., **44(3)**, 470-475.
114. Kumar Kuldip; Gajri P.R. and Arora V.K. (1996). “*Estimating Penetration Resistance from Soil Physical Properties*”, J. Indian Soc. Soil Sci., **44(3)**, 375-377.
115. Piccolo Marisa C.; Neill Christopher; Melillo Jerry M.; Carri Carlos C. and Steudler Paul A.; (1996), “*¹⁵N natural abundance in forest and pasture soils of the Brazilian Amazon Basin*”, Plant and Soil, **182**, 249-258.
116. Lovell R.D. and Jarvis S.C. ;(1996), “*Effect of urine on soil microbial biomass methanogenesis, nitrification and denitrification in grassland soils*”, Plant and Soil, **186**, 265-273.
117. Tang C. and Thomson B.D. ;(1996), “*Effects of solution pH and bicarbonate on the growth and nodulation of a range of grain legume species*”, Plant and Soil, **186**, 321-330.
118. Miyazaki Tsuyoshi ;(1996), “*Bulk Density Dependence of Air Entry Suctions and Saturated Hydraulic Conductivities of Soils*”, Soil Science, **161(8)**, 484.
119. Kaushal R.; Bhandari A.R.; Tripathi D. and Sharma J.C. ;(1996), “*Soil Water Retention Characteristics of Some Soils under Forests in Temperate Zone of the Himalayas*”, J. Indian Soc. Soil Sci., **44(1)**: 9-12.
120. Hudson D.B.; Wierenga P.J. and Hills R.G. (1996), “*Unsaturated Hydraulic Properties from Upward Flow into Soil Cores*”, Soil Science Soc. Am. J., **60**, 388-396.

121. Dulohery C.J.; Morris Lawrence A. and Lowrance Richard ;(1996), *“Assessing Forest Soil Disturbance through Biogenic Gas Fluxes”*, Soil Sci. Soc. Am. J., **60**, 291-298.
122. Scott Neal A.; Cole C. Vernon; Elliott Edward T. and Huffman Steve A.; (1996), *“Soil Textual Control on Decomposition and Soil Organic Matter Dynamics”*, Soil Sci. Soc. Am. J., **60**, 1102-1109.
123. Jaramillo Rafael Angulo; Gaudet Jean-Paul; Thony Jean-Louis and Vauclin Michel; (1996), *“Measurement of Hydraulic Properties and Mobile Water Content of a Field Soil”*, Soil Sci. Soc. Am. J., **60**, 710-715.
124. Wang M.K.; Wang S.L. and Wang W.M.; (1996), *“Rapid Estimation of Cation Exchange Capacities of Soils and Clays with Methylene Blue Exchange”*, Soil Sci. Soc. Am. J., **60**, 138-141.
125. Matschonat G.and Vogt R.; (1996), *“Equilibrium solution composition and exchange properties of disturbed and undisturbed soil samples from an acid forest soil”*, Pant and Soil, **183**, 171-179.
126. Sawhney J.S.; Deka B.; Sharma B.D. and Sidhu P.S.; (1996), *“Magnitude of Soil Variability in Morphological and Other Properties Across Different Landscapes in the Siwalik Hills of Punjab”*, J. Indian Soc. Soil Sci., **44(3)**, 465-469.
127. Skyllberg U.; (1996), *“Small Scale pH buffering in organic horizons of two boreal coniferous forest stands.”* Plant and Soil, **179**, 99-107.
128. Baruah T.C.; Aylmore L.A.G. ;(1996), *“Thermodynamic Evaluation of Cation Exchange Equilibria in Binary and Ternary Systems on a Sandy Clay Loam Soil”*, J. Indian Soc. Soil Sci., **44(1)**, 16-21.
129. Mondal Ajijul Haque; Nayak Dulal C.; Varadachari Chandrika and Ghosh Kunal ;(1997), *“Spectroscopic, Thermal and Electron Microscopic Investigations on Clay-Humus Complexes”*, J. Indian Soc. Soil Sci., **45(2)**, 239-245.

130. Menzies N.W.; Gillman G.P. ;(1997), “*Chemical Characterization of Soils of a Tropical Humid Forest Zone: A Methodology*”, Soil Sci. Soc. Am. J., **61**, 1355-1363.
131. Tamgadge D.B ;:(1997), “*Soil of Gadchiroli District of Maharashtra*”, J. Maharashtra Argic. Univ., **22(1)**, 1-4.
132. Tamgadge D.B.; (1997), “*Soils and Their Production Potential of Bhandara District Maharashtra State*”, J. Maharashtra Argic. Univ., **22(1)**, 5-9.
133. Sen T.K.; Nayak D.C.; Dubey P.N.; Chamuah G.S. and Sehgal J. ;(1997), “*Chemical and Electrochemical Characterization of Some Acid Soils of Assam*”, J. Indian Soc. Soil Sci., **45(2)**, 245-249.
134. Dey P.; Jain J.M.; (1997), “*Mineralization and Nitrification in Soil Amended with Urea and Enriched Green manures in Submerged Soil System*”, J. Indian Soc. Soil Sci., **45(2)**, 249-255.
135. Celi Luisella; Schnitzer Morris; Negre Michele; (1997), “*Analysis of Carboxyl Groups in Soil Humic Acids by a Wet Chemical Method, Fourier-Transform Infrared Spectrophotometry, and Solution-State Carbon-13 Nuclear Magnetic Resonance: A Comparative Study*”, Soil Science, **162(3)**, 189-197.
136. Sahu G.C.; Mishra K.N. ;(1997), “*Morphology, Characteristics and Classification of Soils of an Irrigated River Flood Plain in the Eastern Coastal Region*”, J. Indian Soc. Soil Sci., **45(1)**, 152-156.
137. Walia C.S.; and Rao Y.S.; (1997), “*Characteristics and Classification of Some Soils of Trans-Yamuna Plain*”, J. India Soc. Soil Sci., 45(1), 156-162.
138. Singh V.N.; Mishra B.B. ;(1997), “*Irrigability and Productivity Classification of Some Typical Soils of Sedentary and Alluvial Origins*”, J. Indian Soc. Soil Sci., **45(4)**, 805-809.

139. Sarma P.K.; Bordoloi P.K.; Baruah T.C.; Das K.N. and Borah N. ;(1997), “*Physical Characterization of Soils in Two Command Areas of Assam*”, J. Indian Soc. Soil Sci., **45(4)**, 709-712.
140. Das Madhumita; Singh B.P. and Khan S.K; (1997), “*Effect of Major Land Uses on Soil Characteristics of Alfisols in Meghalaya*”, J. Indian Soc. Soil Sci., **45(3)**, 547-553.
141. Burle M.L.; Mielniczuk J. and Focchi S.; (1977), “*Effect of cropping systems on soil chemical characteristics with emphasis on soil acidification*”, Plant and Soil, **190**, 309-316.
142. Jain Theresa B.; Graham Russell T. and Adams David L.; (1997), “*Carbon to Organic Matter Ratios for Soils in Rocky Mountain Coniferous Forests*”, Soil Sci. Soc. Am. J., **61**, 1190-1195.
143. Khan Z.H.; Mazumdar A.R.; Hussain M.S. and Saheed S.M. ;(1997), “*Fertility Status and Productivity Potential of Some Benchmark Soils of Bangladesh*”, J. Indian Soc. Soil Sci., **45(1)**, 89-95.
144. Ananthanarayana R.; Ravi Kumar S.M.; (1997), “*Characterization of Soil Acidity and Lime Requirement of Soils in the Agroclimatic Zones of Hassan District of Karnataka*”, J. Indian Soc. Soil Sci., **45(3)**, 442-445.
145. Kornecki Ted S.; Allred Barry and Brown Glenn O.; (1997), “*DETERMINATION OF CATIONIC AND ANIONIC SURFACTANT CONCENTRATIONS IN SOIL*”, Soil Science, **162(6)**, 439.
146. Chien Yi-Ju; Lee Dar-Yuan; Guo Horng-Yuh and Hounng Kun-Huang ;(1997), “*GEOSTATISTICAL ANALYSIS OF SOIL PROPERTIES OF MID-WEST TAIWAN SOILS*”, Soil Science, **162(4)**, 291.
147. Shaw J.N.; West L.T.; Truman C.C. and Radcliffe D.E. ;(1997), “*MORPHOLOGIC AND HYDRAULIC PROPERTIES OF SOILS WITH WATER RESTRICTIVE HORIZONS IN THE GEORGIA COASTAL PLAIN*”, Soil Science, **162(12)**, 875.

148. Schulten Hans-Roff; and Schnitzer Morris; (1997), "*Chemical Model Structures for Soil Organic Matter and Soils*", Soil Science, **162(2)**, 115.
149. Asadu C.L.A.; Diels J. and Vanlauwa B.; (1997), "*A COMPARISON OF THE CONTRIBUTIONS OF CLAY, SILT AND ORGANIC MATTER TO THE EFFECTIVE CEC OF SOILS OF SUBSAHARAN AFRICA*", Soil Science, **162(11)**, 785.
150. Khan Z.H.; Mazumder A.R.; Hussain M.S. and Mohiuddin A.S.M.; (1997), "*Total and DTPA-Extractable Fe, Mn, Cu and Zn Contents in Some Soils of Bangladesh*", J. Indian Soc. Soil Sci., **45(3)**, 485-489.
151. Sharma B.D.; Sidhu P.S.; Kumar Raj and Sawhney J.S.; (1997), "*Inceptisols in North-West India*", J. Indian Soc. Soil Sci., **45(1)**, 167-174.
152. Patil S.G.; Veeramallappa P. and Hebbara M. ;(1997), "*Suplhate Retantion as Influenced by pH and Soil Constituents in Some Major Soil Groups of Karnataka*", J. Indian Soc. Soil Sci., **45(1)**, 48-53.
153. Randhawa H.S.;and Singh S.P.; (1997), "*Distribution of Manganese Fractions in Alluvium-Derived Soils in Different Agro-climatic Zones of Punjab*", J. Indian Soc. Soil Sci., **45(1)**, 53-57.
154. Beyer Lothar; Knicker Heike; Blume Hans-Peter; Bolter Manfred; Vogt Birgit and Schneider Dieter ;(1997), "*Soil organic matter of suggest Spodic horizons in relic arnithogenic soils of coastal continental Antarctica (Casey Station, Wilkes land) In comparision with that of Spodic Soil horizons in Germany*", Soil Science, **162(7)**, 518.
155. Šimunek Jiří; Genuchten Martinus Th. van ;(1997), "*ESTIMATING UNSATURATED SOIL HYDRAULIC PROPERTIES FORM MULTIPLE TENSION DISC INFILTROMETER DATA*", Soil Science, **162(6)**, 383.

156. Malik R.S.; Grewal K.S.; Jhorar B.S. and Oswal M.C.; (1997), "A Simple field method to determine soil dispersiveness", *Soil Science*, **162(4)**, 283.
157. Olesen T.; Griffiths B.S.; Henriksen K.; Moldrup P. and WheaHey R.; (1997), "Modeling diffusion and Reaction in Soils: V. Nitrogen Transformations in Organic Manure-Amended Soil", *Soil Science*, **162(3)**, 157.
158. Low Andrew P.; Stark John M. and Dudley Lynn M. ;(1997), "Effects of Soil Osmotic Potential on, Nitrification, ammonification, N-Assimilation, and Nitrous oxide production", *Soil Science*, **162(1)**, 16.
159. Barzegar Rahman A.; Nelson Paul N.; Oades J. Malcolm and Rengasamy Pichu ;(1997), "Organic Matter, Sodicity, and Clay Type: Influence on Soil Aggregation", *Soil Sci. Soc. Am. J.*, **61**, 1131-1137.
160. Knoepp Jennifer D.; Swank Wayne T.; (1997), "Forest Management Effects on Surface Soil Carbon and Nitrogen", *Soil Sci. Soc. Am. J.*, **61**, 928-935.
161. Courchesne Francois; and Gobran George R.; (1997), "Minerlogical Variations of Bulk and Rhizosphere Soil form a Norway Spruce Stand", *Soil Sci. Soc. Am. J.*, **61**, 1245-1249.
162. Nanda S.S.K.; Mishra B.K. and Bhatta A.K.; (1997), "Soil Classification and Soil and land Suitability for Irrigation in Kuanria Irrigation Project", *J. Indian Soc. Soil Sci.*, **45(2)**, 333-338.
163. Arya Lalita M.; dierolf Thomas S.; Sofyan Agus.; Widjaja-Adhi I.P.G. and Genuchten M.Th. van ;(1998), "FIELD MEASUREMENT OF THE SATURATED HYDRAULIC CONDUCTIVITY OF A MACROPOROUS SOIL WITH UNSTABLE SUBSOIL STRACT-URE", *Soil Science*, **163(11)**, 841-851.

164. Bhaskar B.P.; Nagaraju M.S.S. ;(1998), “*Characterization of Some Salt-Affected Soil Occurring in the Chitravathi River Basin of Andhra Pradesh*”, J. Indian Soc. Soil Sci., **46(3)**, 416-421.
165. Galbraith John M.; Bryant Ray B.; (1998), “*A FUNCTIONAL ANALYSIS OF SOIL TAXONOMY IN RELATION TO EXPERT SYSTEM TECHNIQUES*”, Soil Science, **163(9)**, 739-746.
166. Banerjee Saon; Das D.K.; Yadav B.R.; Navindu Gupta; Chandrasekharan H.; Ganjoo A.K. and Singh Ranjit ;(1998), “*Estimation of Soil Salinity at IARI Farm by Inductive Electro-Magnetic Technique*”, J. Indian Soc. Soil Sci., **46(1)**, 110-115.
167. Sarkar Dipak; Haldar Abhijit; (1998), “*A Comparison of Different Methods for pH Determination in Soils of West Bengal*”, J. Indian Soc. Soil Sci., **46(2)**, 180-183.
168. Kumar Jogendra; and Singh Room; (1998), “*Phosphorus Adsorption and Release Characteristics of Some Soils in **Tarai** and **Bhabar** Regions of Uttar Pradesh*”, J. Indian Soc. Soil Sci., **46(1)**, 14-18.
169. Bhattacharyya T.; Dubey P.N.; Das T.K.; Baruah U.; Gangopadhyay S.K. and Kumar Dilip; (1998), “*Soil Formation as Influenced by Geomorphic Processes in the Brahmaputra Flood Plains of Assam*”, J. Indian Soc. Soil Sci., **46(4)**, 647-651.
170. Singh S.K.; Shyampura R.L.; Singh R.S.; Harindranath C.S. and Venugopal K.R.; (1998), “*Genesis of Some Soils of Goa*”, J. Indian Soc. Soil Sci., **46(4)**, 651-656.
171. Sidhu G.S.; Manjaiah K.M. and Gosh S.K. (1998), “*Elemental and Mineralogical Composition of Coarse Fractions of Some Soils of Aravallies-Yamuna River Transect in North-West India*”, J. Indian Soc. Soil Sci., **46(1)**, 668-674.

172. Singh R.N.; Diwakar D.P.S. and Singh R.N.P.; (1998), "*Mineralogy of Some Important Soils of Sona Basin*", J. Indian Soc. Soil Sci., **46(1)**, 124-127.
173. Kumaraswamy K., Venu Reddy R. and Babu K. ;(1998), "*Cumulative Effects of Continuous Cropping and Manuring of Sugarcane on Organic Matter and NPK Status of the Soil*", J. Indian Soc. Soil Sci., **46(1)**, 47-49.
174. Santhy P.; Sankar S. Jayasree; Muthuvel P. and Selvi D. ;(1998), "*Long Term Fertilizer Experiments- Status of N, P and K Fractions in Soil*", J. Indian Soc. Soil Sci., **46(3)**, 395-398.
175. Walia C.S.; Ahmed Nayan; Uppal K.S. and Rao Y.S.; (1998), "*Profile Distribution of Various Forms of Nitrogen and C/N Ratio in Some Landforms of Bundelkhand Region of Uttar Pradesh*", J. Indian Soc. Soil Sci., **46(2)**, 193-198.
176. Clough T.J.; Ledgard S.F.; Sprosen M.S. and Kear M.J. ;(1998), "*Fate of ¹⁵N labelled urine on four soil types*", Plant and Soil, **199**, 195-203.
177. Laboski C.A.M.; Dowdy R.H.; Allmaras R.R. and Lamb J.A ; (1998), "*Soil strength and water content influences on corn root distribution in a sandy soil*", Plant and Soil, **203**, 239-247.
178. Pareek N.; Dhillon K.S. and Dhillon S.K.; (1998), "*Adsorption /Desorption Behaviour of Selenium in Alluvial Soils of Punjab*", J. Indian Soc. Soil Sci., **46(3)**, 363-367.
179. Wander M.M.; Bidart M.G. and Aref S.; (1998), "*Tillage Impacts on Depth Distribution of Total and Particulate Organic Matter in Three Illinois Soils*", Soil Sci. Soc. Am. J., **62**, 1704-1711.
180. Shang C.; Tiessen H. ;(1998), "*Organic Matter Stabilization in Two Semiarid Tropical Soils: Size, Density and Magnetic Separations*", Soil Sci. Soc. Am. J., **62**, 1247-1257.

181. McCarty G.W.; Lyssenko N.N. and Starr J.L.; (1998), “*Short-term Changes in Soil Carbon and Nitrogen Pools during Tillage Management Transition*”, Soil Sci. Soc. Am. J., **62**, 1564-1571.
182. Drury C.F.; Oloya T.O.; Mckenney D.J.; gregorich E.G.; Tan C.S. and Vanluyk C.L. ;(1998), “*Long-Term Effects of Fertilization and Rotation on Denitrification and Soil Carbon*”, Soil Sci. Soc. Am. J., **62**, 1572-1579.
183. Dumroese D.S. Page; Jurgensen M.F.; Brown R.E. and Mroz G.D. (1999), “*Comparison of Methods for Determining Bulk Densities of Rocky Forest Soils*”, Soil Sci. Soc. Am. J., **63**, 379-383.
184. Johannisson C.; Myrold D.D. and Hogberg P.:(1999), “*Retention of Nitrogen by a Nitrogen-Loaded Scotch Pine Forest*”, Soil Sci. Soc. Am. J., **63**, 383-389.
185. Kodesová Radka; Ordway Sondra E.; Gribb Molly M. and Simunek Jiri; (1999), “*ESTIMATION OF SOIL HYDRAULIC PROPERTIES WITH THE CONE PERMEAMETER: FIELD STUDIES*”, Soil Science, **164(8)**, 527.
186. Xingh Baoshan and Chen Zhengqi ;(1999), “*PECTROSCOPIC EVIDENCE FOR CONDENSED DOMAINS IN SOIL ORGANIC MATTER*”, Soil Science, **164(1)**, 40-46.
187. Hall Robert D. ;(1999), “*A COMPARISON OF SURFACE SOILS AND BURIED SOILS: FACTORS OF SOIL DEVELOPMENT*”, Soil Science, **164(4)**, 264-287.
188. Arocena J.M.; Sanborn P. ;(1999), “*Mineralogy and genesis of selected soils and their implications for forest management in central and northeastern British Columbia*”, Canadian J. Soil Sci., **79**, 571.
189. Pennock D.J.; McCann B.L.; Jong E. de and Lemmen D.S.; (1999), “*Effects of soil redistribution on Soil properties in a cultivated Solonchic-Chernozemic landscape of southwestern Saskatchewan*”, Canadian J. Soil Sci., **79**, 593.

190. Sun Z.J.; Young G.D.; Mc Farlane R.A. and Chambers B.M.; (1999) “*The effect of soil electrical conductivity on moisture determination using time-domain reflectometry in sandy soil*”, Canadian J. Soil Sci., **80**, 13-22.
191. Amponsah G.I.; Meyer W.L. and Murchison H.G. ;(1999), “*Soil sampling size estimates for soils under teak (Tectona grandis Linn. F) Plantations and natural forests in Ashanti Region, Ghana*”, Canadian J. Soil Sci., **80**, 327-336.
192. Bennett D. Rodney; Hecker Frank J.; Entz Toby and Greenlee Graeme M. ;(1999), *Salinity and sodicity of irrigated Solonchic and Chernozemic soils in east-central Alberta*”, Canadian J. Soil Sci., **80**, 117-125.
193. Elberling Bo; Jakobsen Bjarne H. ;(1999), “*Soil solution pH measurements using in-line chambers with tension lysimeters*”, Canadian J. Soil Sci., **80**, 283-288.
194. Oorts K.; Valauwe B.; Pleysier J. and Merckx R.:(2004), “*A New Method for the Simultaneous Measurement of pH-Dependent Cation Exchange Capacity and pH Buffering Capacity*”, Soil Sci. Soc. Am. J., **68**, 1578-1585.
195. Ghose T.J.; Kothandaraman G.V. ;(1999), “*COMPARISON OF METHODS FOR DETERMINATION OF ORGANIC PHOSPHORUS IN SOILS OF TAMIL NADU*”, J. Soil and Crops, **9(2)**, 155.
196. Hussain J.; Olson K.R. and Ebelhar S.A. ;(1999), *Long-Term Tillage (ffects on Soil Chemical Properties and Organic Matter Fraction*”, Soil Sci. Soc. Am. J., **63**, 1335-1344.
197. Puri G.; Jaipurkar S.A. and Bajpai R.K.:(1999), “*INFLUENCE OF SOIL FERTILITY STATUS AND APPLICATION OF PRIMARY NUTRIENTS (NPK) ON CHEMICAL COMPOSITION AND OIL CONTENT OF*

- MUSTARD (Brassica Juncea Linn.), GROWN IN VERTISOLS*", J. Soils and Crops, **9(2)**, 164-167.
198. Ingwersen J.; K. Btterbach-Bahl; Gasche R.; Richter O. and Papen H. ;(1999), "*Barometric Process Separation: New Method for Quantifying Nitrification, Denitrification, and Nitrous Oxide Sources in Soils*", Soil Sci. Soci. Am. J., **63**, 117-128.
199. Honeycutt C.Wayne ;(1999), Nitrogen Mineralization from *Soil Organic Matter and Crop Residues: Field Validation of Laboratory Predictions*", Soil Sci. Soci. Am. J., **63**, 134-141.
200. Uttaranchal Men Chey (Tea in Uttaranchal); (1999), *A manual Published by Uttarakhand Tea Development Project*, Consul Printers, Nainital.
201. Smith Roger E. ;(1999), "*TECHNICAL NOTE: RAPID MEASUREMENT OF SOIL SORPTIVITY*", Soil Sci. Soci. Am. J., **63**, 55-57.
202. Schwarz Andreas; Wilcke Wolfgang; Styk Jan and Zech Wolfgang;(1999), "*Heavy Metal Release from Soils in Batch pH_{stat} Experiments*", Soil Sci. Soci. Am. J., **63**, 290-296.
203. Poudel D.D.; West L.T.; (1999), "*Soil Development and Fertility Characteristics of a Volcanic Slope in Mindanao, the Philippines*", Soil Sci. Soci. Am. J., **63**, 1258-1273.
204. Mahieu N.; Powlson D.S. and Randall E.W.; (1999), "*Statistical Analysis of Published Carbon-13 CPMAS NMR Spectra of Soil Organic Matter*", Soil Sci. Soci. Am. J., **63**, 307-319.
205. Page-Dumroese D.S.; Jurgensen M.F.; Browen R.E. and Mroz G.D.; (1999), "*Comparison of Methods for Determining Bulk Densities of Rocky Forest Soils*", Soil Sci. Soci. Am. J., **63**, 379-383.

206. Bouma J.; Droogers P. and Peters P.; (1999), “*Defining the ‘Ideal’ Soil Structure in Surface Soil of a Typic Fluvaquent in the Natherland*”, Soil Sci. Soci. Am. J., **63**, 343-348.
207. Seybold C.A.; Herrick J.E. and Brejda J.J.; (1999), “*Soil Resilience a fundamental component of Soil Quality*”, Soil Science, **164(4)**, 224.
208. Vaz Pedro Carlos Manoel; Naime Joao de Mendonca and Macedo Alvaro ;(1999), “*SOIL PARTICLE SIZE FRACTIONS DETERMINED GAMMA-RAY ATTENUATION*”, Soil Sci., **164(6)**, 403.
209. Mori Yasushi; Lwama Kenji; Maruyama Toshisuke and Mitsuno Toru ;(1999), “*DISCRIMINATING THE INFLUENCE OF SOIL TEXTURE AND MANAGEMENT-INDUCED CHANGES IN MACROPORE FLOW USING SOFT X-RAYS*”, Soil Sci., **164(7)**, 467.
210. Yuan Guoshu; Xing Baoshan (1999). “*Site-Energy distribution analysis of organic Chemical sorption by Soil Organic Matter*”, Soil Sci., **167(7)**, 503.
211. Swift Roger S.; (1996), “*MACROMOLECULAR PROPERTIES OF SOIL HUMIC SUBSTANCES: FACT, FICTION, AND OPINION*”, Soil Sci., **164(11)**, 790.
212. Leinweber Peter; Schulten Hans-Rolf and Jancke H ; (1999), “*NEW EVIDENCE FOR THE MOLECULAR COMPOSITION OF SOIL ORGANIC MATTER IN VERTISOLS*”, Soil Science, **164(11)**, 857.
213. Rochete P.; Flanagan L.B. and Gregorich E.G. ;(1999), “*Separating Soil Respiration into Plant and Soil Components Using Analyses of the Natural Abundance of Carbon-13*”, Soil Sci. Soci. Am. J., **63**, 1207-1213.
214. Celis Rafael; Koskinen William C.; (1999), “*Characterization of Pesticide Desorption form Soil by the Isotopic Exchange Technique*”; Soil Sci. Soci. Am. J., **63**, 1659-1666.

215. Mahapatra S.K.; Rana K.P.C.; Sidhu G.S. and Walia C.S.; (2000), “*Assessment of degradation status of Jammu and Kashmir Soils for their Amelioration*”, J. Indian Soc. Soil Science, **48(3)**, 577-581.
216. Chefetz Benny; Chen Yona; Edward C. and Hatcher Patrick G. ;(2000), “*Characterization of Organic Matter in Soils by Thermochemolysis Using Tetramethyl-ammonium Hydroxide (TMAH)*”, Soil Sci. Soc. Am. J., **64**, 583-589.
217. Zhao Litong; Gray D.M. and Toth B.; (2000), “*Influence of Soil Texture on Snowmelt infiltration into Frozen Soils*”, Canadian J. Soil Sci., **82**, 75-83.
218. Tamgadge D.B.; Raja P.; Gaikaward S.T.; Sehgal J.L.; Gajbhiyl K.S. and Singh S.R.; (2000), “*Assessment of Soil Degradation Status in Madhya Pradesh*”, J. Ind. Soc. Soil Sci., **48(3)**, 581-586.
219. Dai X.Y.; Ping C.L.; Candler R.; Haumaier L. and Zech W.; (2000), “*Characterization of Soil Organic Mttter Fractions of Tundra Soils in Arctic Alaska Carbon-13 Nuclear Magnetic Resonance Spectroscopy*”, Soil Sci. Soc. Am. J., **65**, 87-93.
220. Helmko, Philip A. (2000) and Summer Malcolm E. (2000). Edited, *Handbook of Soil Science*, CRC Press London, B-3.
221. Huang, P.M. (2000). Summer Malcolm E; Edited, *Handbook of Soil Science*, CRC Press, London, B-1.
222. Singh H.C.; Shyam Radhey and Lal Chhedi; (2001), “*Estimating Soil Hydraulic Properties Using Field Drippers*”, J. Indian Soc. Soil Science, **49(3)**, 393-399.
223. Sarkar Dipak; Baruah U.; Gangopadhyay S.K.; Sahoo A.K. and Velayutham M.; (2002), “*Characteristics and Classification of Soils of Loktak Catchment Area of Manipur for Sustainable Land Use Planning*”, J. Indian Soc. Soil Sci., **50(2)**, 196-204.

224. Desharnais Brain M.; Lewis Barbara Ann. G.; (2002), “*Electrochemical Water Splitting at Bipolar Interfaces of Ion Exchange Membranes and Soils*”, Soil Sci. Soc. Am. J., **66**, 1518-1525.
225. Amelung Wulf; Kaiser Klaus; Kammerer Gerd and Sauer Gustav; (2002), “*ORGANIC CARBON AT SOIL PARTICLE SURFACES – EVIDENCE FROM X-RAY PHOTO-ELECTRON SPECTROSCOPY AND SURFACE ABRASION*”, Soil Sci. Soc. Am. J., **66**, 1526-1530.
226. Dr. Negi, S.S.; (2002), *Forest Soil*, Internation Book Distribution, Dehradun.
227. Hand Book of Soil Testing Kit, Biocraft and Scientific Industries, Agra.
228. Pande Promod Kumar; (2002), Studies on the Physico-Chemical Characteristics and Nutrient Dynamics of Some Soil in the Ramnagar Region of U.P., Ph.D. Thesis Kumaon University, Nainital.
229. Shiveshwar Pratap Singh ;(2002), *Distribution of Micronutrient Cations in Some Soils of Kumaon Region of Uttaranchal*, Ph.D. Thesis, G.B. Pant University of Agriculture and Technology, Pantnagar.
230. Raghvvanish Prabhat; (2002), *Potassium Distribution and Agricultural Evaluation of Some Bhabar Soil of Uttaranchal*, Ph.D. Thesis, G.B. Pant University of Agriculture and Technology, Pantnagar.
231. Picone L.I.; Cabrera M.L. and Franzluebbbers A.J.; (2002), “*A Rapid Method to Estimate Potentially Mineralizable Nitrogen in Soil*”, Soil Sci. Soc. Am. J., **66**, 1843-1847.
232. Teotia U.S.; Ghosh D. and Srivastava P.C.; (2002), “*A New Anion Exchange Resin Method for Sulphate-Sulphur Extraction in Mollisols of Nainital*”, J. Indian Soc. Soil Sci., **50(1)**, 19-22.
233. Chefetz Benny; Salloum Myrna J.; Deshmukh Ashish P and Hatcher Patrick G.; (2002), “*Structural Components of Humic Acids as Determined by Chemical Modifications and Carbon-13 NMR, Pyrolysis-, and*

- Thermochmolysis-Gas Chromatography/Mass Spectrometry*”, Soil Sci. Soc. Am. J., **66**, 1159-1171.
234. Joosse P.J.; McBride R.A;. (2002), “*Assessing physical quality of plastic soils of differing mineralogy and pre-stress history using mechanical parameters. I. Saturated compression tests*”, Canadian J. Soil Sci., **83**, 45-63.
235. Martin P.D.; Malley D.F.; Manning G. and Fuller L.; (2002), “*Determination of soil organic Carbon and nitrogen at the filed level using near-infrared spectroscopy*”, Canadian J. Soil Sci., **82**, 413-422.
236. Seena E.; Suresh Kumar P.; Sajnanath K. and Saifudden N.; (2002), “*Cation Exchange in Laterite Soils – A Critical Assessment Based on Net Ionic Equilibrium (NIE)*”, J. Indian Soc. Soil Sci., **50(3)**, 236-241.
237. Cano A. Faz; Mermut A.R.; Ortiz; Benke M.B. and Chatson B.; (2002), “*¹³C CP/MAS-NMR spectra of organic matter as influenced by vegetation, climate and soil characteristics in soils from Murcia, Spain*”, Canadian J. Soil Sci., **82**, 403-411.
238. Pankhurst C.E.; Pierret A.; Hawke B.G. and Kirby J.M ;(2002), “*Microbiological and chemical properties of soil associated with macropores at different depths in a red-duplex soil in NSW Australia*”, Palnt and Soil, **238**, 11-20.
239. Six J.; Conant R.T.; Paul E.A. and Paustian K. ;(2002), “*Stabilization mechanisms of soil organic matter: Implications for C-saturation of soils*”, Plant and Soil, **241**, 155-176.
240. Bekele A.; Downer R.G.; Wolcott M.C.; Hudnall W.H. and Moore S.H.:(2003), “*COMPARATIVE EVALUATION OF SPATIAL PREDICTION METHODS IN A FIELD EXPERIMENT FOR MAPPING SOIL POTASSIUM*”, Soil Science, **168(1)**, 15-28.
241. Arbestain M. Camps; Barreal M.E.; Mourenza C.; Aluarez E.; Kidd P. and Macias F.:(2003), “*RHIZOSPHERE CHEMISTRY IN ACID FOREST SOILS*

- THAT DIFFER IN THEIR DEGREE OF AL-SATURATION OF ORGANIC MATTER*”, Soil Science, **164(4)**, 267-279.
242. Maruyama Toshisuke; Tada Akio; Iwama Kenji and Horino Haruliko ;(2003) “*Direct observation of soil water movement through soil macropores using soft x-rays and stereographing*”, Soil Science, **168(2)**, 119-127.
243. Schmalz Britta; Lennartz Bernd and Martinus Th. van Genuchten ;(2003), “*ANALYSIS OF UNSATURATED WATER FLOW IN A LARGE SAND TANK*”, Soil Science, 168(1), 3-14.
244. Turner Benjamin L.; Mahiev Nathaliu and Leo M. Condron ;(2003), “*Phosphorus-31 Nuclear Magnetic Resonance Spectral Assignments of Phosphorus Compounds in Soil NaOH-EDTA Extracts*”, Soil Sci. Soc. Am. J., **67**, 497-510.
245. Nannipieri P.; Ascher J.; Ceccherini M.T.; Landi L.; Pietramellara G. and Renella G.; (2003), “*Microbial Diversity and Soil functions*”, European J. Soil Sci., **54**, 655-670.
246. Ludwig B.; Kölbl A.; (2003), “*MODELING CATION EXCHANGE IN AN UNDISTURBED SUBSOIL AT DIFFERENT FLUX RATES*”, Soil Science, **168(4)**, 253-265.
247. Harris J.A.; (2003), “*Measurement of the soil microbial community for estimating the success of restoration*”, European J. Soil Sci., **54**, 801-808.
248. Van Hees P.A.W.; Godbold D.L.; Jentschke G. and Jones D.L.; (2003), “*Impact of ectomycorrhizas on the concentration and biodegradation of simple organic acids in a forest soil*”, European J. Soil Sci., **54**, 697-706.
249. Kinraide T.B.; (2003), “*Toxicity factors in acidic forest soils: attempts to evaluate separately the toxic effects of excessive Al^{3+} and H^+ and insufficient Ca^{2+} and Mg^{2+} upon root elongation*”, European J. Soil Sci., **54**, 323-333.

250. Smernik R.J.; Oades J.M.; (2003), “*Spin accounting and RESTORE – two new methods to improve quantitation in solid-state ¹³C NMR analysis of soil organic matter*”, European J. Soil Sci., **54**, 103-116.
251. Monday O. Mbila; Michael L. Thompson; Mbagwu Joe and Devid A. Laird; (2003), “*MORPHOLOGICAL AND CHEMICAL PROPERTIES OF SELECTED SLUDGE-AMENDED NIGERIAN SOILS*”, Soil Science, **168(9)**, 660.
252. Gerin P.A.; Genet M.J.; Herbillon A.J. and Deluau B.;(2003), “*Surface analysis of soil material by X-rays photoelectron spectroscopy*”, European J. Soil Sci., **54**, 589-603.
253. Cosenza P.; Guerin R. and Tabbagh A. ;(2003), “*Relationship between thermal conductivity and water content of soils using numerical modelling*”, European J. Soil Sci., **54**, 581-587.
254. Garnier P.; Neel C.; Aita C.; Recous S.; Lafolie F. and Mary B. ;(2003), “*Modelling carbon and nitrogen dynamics in a bare soil with and without straw incorporation*”, European J. Soil Sci., **54**, 555-568.
255. Pachepsky Y.A.; Rawls W.L. (2003). “*Soil structure and pedotransfer functions*”, European J. Soil Sci., **54**, 443-451.
256. Kaiser K.; Guggenberger G.;(2003), “*Mineral surfaces and soil organic matter*”, European J. Soil Sci., **54**, 219-236.
257. Poulsen Tjalfe G.; Moldrup Per; Wendroth Ole and Nielsen Donald R. (2003). “*Estimating saturated hydraulic conductivity and air permeability from Soil. Physical Properties Using State Space Analysis*”, Soil Science, 168(5), 311.
258. Hernik H. Nissen; Paul A. Ferré, and Per Moldrup ;(2003), “*TIME DOMAIN REFLECTOMETRY DEVELOPMENTS IN SOIL SCIENCE: I. UNBALANCED TWO-ROD PROBE SPATIAL SENSITIVITY AND SAMPLING VOLUME*”, Soil Science, **168(2)**, 77-83.

259. Hernik H. Nissen; Paul A. Ferré, and Per Moldrup ;(2003), “*TIME DOMAIN REFLECTOMETRY DEVELOPMENT IN SOIL SCIENCE: II. COAXIAL FLOW CELL FOR MEASURING EFFLUENT ELECTRICAL CONDUCTIVITY*”, Soil Science, **168(2)**, 84.
260. John J. Kelly ;(2003), “*MOLECULAR TECHNIQUES FOR THE ANALYSIS OF SOIL MICROBIAL PROCESSES: FUNCTIONAL GENE ANALYSIS AND THE UTILITY OF DNA MICROARRAYS*”, **168(9)**, 597-605.
261. Fiedler S.; Kalbitz K. ;(2003), “*CONCENTRATIONS AND PROPERTIES OF DISSOLVED ORGANIC MATTER IN FOREST SOILS AS AFFECTED BY THE REDOX REGIME*”, Soil Science, **168(11)**, 793.
262. Chaplot Vincent; Vlietlanoe Brigitle Van; Walter Christian; Curmi Pierre and Cooper Miguel ;(2003), “*SOIL SPATIAL DISTRIBUTION IN THE ARMORICAN MASSIF, WESTERN FRANCE: EFFECT OF SOIL-FORMING FACTORS*”, Soil Science, **168(12)**, 856.
263. Francisco J. Arriaga; Lowery Birl ;(2003), “*SOIL PHYSICAL PROPERTIES AND CROP PRODUCTIVITY OF AN ERODED SOIL AMENDED WITH CATTLE MANURE*”, Soil Science, **168(12)**, 888.
264. Franklin R.E.; Duis L.; Smith B.R.; Brown R. and Toler J.E.; (2003), “*ELEMENTAL CONCENTRATIONS IN SOILS OF SOUTH CAROLINA*”, Soil Science, **168(4)**, 280.
265. Norfleet M.L.; Ditzler C.A.; Puckett W.E.; Grossman R.B. and Shaw J.N; (2003), “*SOIL QUALITY AND ITS RELATIONSHIP TO PEDOLOGY*”, Soil Science, **168(3)**, 149-155.
266. Shukla M.K.; Lal R.; Owens L.B. and Unkefer P;(2003), “*LAND USE AND MANAGEMENT IMPACTS ON STRUCTURE AND INFILTRATION CHARACTERISTICS OF SOILS IN THE NORTH APPALACHIAN REGION OF OHIO*”, Soil Science, **168(3)**, 167-176.

267. Liu Jen-Chyi and Chen Zueng-Sang; (2004), “*SOIL CHARACTERISTICS AND CLAY MINERALOGY OF TWO SUBALPINE FOREST SPODOSOLS WITH CLAY ACCUMULATION IN TAIWAN*”, Soil Science, **169(1)**, 66.
268. Thangasamy A.; Naidu M.V.S. and Ramavatharam N; (2004), “*Clay Mineralogy of Soils in the Sivagiri Micro-watershed of Chittoor District, Andhra Pradesh*”, J. Indian Soc. Soil Sci., **52(4)**, 454-461.
269. Guber A.K., Pachepsky Y.A. and Levkovsky E; (2004), “*MASS-SIZE SCALING IN SOIL AGGREGATES AS AFFECTED BY AGGREGATE WATER CONTENT AND SOIL COMPACTION*”, Soil Sci., **169(1)**, 1.
270. Krishnan P.; Nair K.M.; Naidu L.G.K.; Srinivas S.; Koyal Arti; Nasre R.A.; Ramesh M. and Gajbhiye K.S; (2004), “*Land, Soil and Land Use of Lakshadweep Coral Island*”, J. Indian Soc. Soil Sci., **52(3)**, 226-231.
271. Hassan G.; Ismail K.M.; Persaud N. and Reneau R.B. Jr; (2004), “*DEPENDENCE OF THE DEGREE OF LINEAR POLARIZATION IN SCATTERED VISIBLE LIGHT ON SOIL TEXTURAL FRACTIONS*”, Soil Science, 169(11), 806.
272. Dolui A.K. and Maity B; (2004), “*Nature of Soil Acidity in Relation to Different Forms of Iron and Aluminium of Some Alfisols of West Bengal*”, J. Indian Soc. Soil Science, **52(4)**, 415-420.
273. Hseu Zeng-Yie; Tsai Chen-Chi; Lin Ching-Wei and Chen Zueng-Sang; (2004). “*TRANSITIONAL SOIL CHARACTERISTICS OF ULTISOLS AND SPODOSOLS IN THE SUBALPINE FOREST OF TAIWAN*”, Soil Science, **169(6)**, 457.
274. Patel K.P.; Pandey R.R.; Maliwal G.L.; Patel K.C.; Ramani V.P. and George V; (2004), “*Heavy Metal Content of Different Effluents and their Relative Availability in Soils Irrigated with Effluent Waters around Major Industrial Cities of Gujarat*”, J. Indian Soc. Soil Science, **52(1)**, 89-94.

275. Sharma V.K.; Sharma P.D.; Sharma S.P.; Achary C.L. and Sood R.K; (2004), “*Characterization of Cultivated Soils of Neogal Watershed in North-West Himalayas and their Suitability for Major Crops*”, J. Indian Soc. Soil Science, **52(1)**, 63-68.
276. Trilochan; (2004), *Physico-Chemical Characteristics of the main soil types of the Bhabar region of Kumaun*, Ph.D. Thesis, Kumaun University, Nainital.
277. Das Madhumita; (2004), “*Alliance among Hydro-physical and Physico-chemical Properties of Soil*”, J. Indian Soc. Soil Science, **52(1)**, 1-5.
278. Lama T.D.; Mallick S.; and Sanyal S.K; (2004), “*Solute Transport and Retention in Some Soils of West Bengal*”, J. Indian Soc. Soil Science, **52(1)**, 5-11.
279. Lu Dianqing; Shao Mingan; Horton Robert and Liu Chunping; (2004), “*EFFECT OF CHANGING BULK DENSITY DURING WATER DESORPTION MEASUREMENT OF SOIL HYDRAULIC PROPERTIES*”, Soil Science, **169(5)**, 319-329.
280. Bhattacharya Ranjan; Prakash Ued; Kundu S.; Srivastva A.K. and Gupta H.S; (2004), “*Effect of Long-term Manuring on Soil Organic Carbon, Bulk Density and Water Retention Characteristics under Soyabean-Wheat Cropping Sequence in North-Western Himalayas*”, J. Indian Soc. Soil Science, **52(3)**, 238-242.
281. Jena D.; Mishra B.K.; Dash A.K. and Das A.K; (2004), “*Transport of Nitrogen Contained in Urea Super Granules Placed in Flooded Rice Soils*”, J. Indian Soc. Soil Science, **52(3)**, 242-247.
282. Brye K.R. and West C.P; (2005), “*GRASSLAND MANAGEMENT EFFECTS ON SOIL SURFACE PROPERTIES IN THE OZARK HIGHLANDS*”, Soil Science, **170(2)**, 63-73.

283. Olness Alan and Archer David; (2005), "*EFFECT OF ORGANIC CARBON ON AVAILABLE WATER IN SOIL*", Soil Science, **170**(2), 90-101.
284. Solomon Dawit; Lehmann Johannes; Kinyagi James; Liang Biqing and Schafer Thorten; (2005), "*Carbon K-Edge NEXAFS and FTIR-ATR Spectroscopic Investigation of Organic Carbon Speciation in Soils*", Soil Sci. Soc. Am. J., **69**, 107-119.
285. Brouder S.M.; Hofmann B.S. and Morris D.K; (2005), "*Mapping Soil pH: Accuracy of Common Soil Sampling strategies and Estimation Techniques*", Soil Sci. Soc. Am. J., **69**, 427-442.
286. Sorensen L.K. and Dalsgaard S; (2005), "*Determination of Clay and Other Soil Properties by Near Infrared Spectoscopy*", Soil Sci. Soc. Am. J., **69**, 159-167.
287. Allen C.E; (2005), "*Physical and Chemical Characteristics of Soils Forming on Boulder Tops, Kärkevagge, Swedan*", Soil Sci. Soc. Am. J., **69**, 148-158.

