CHAPTER – 4

PHYSICOCHEMICAL PROPERTIES OF SOIL

4.1 INTRODUCTION:

Soil is the basis for all life in the universe, directly or indirectly. Soil is one of the most important ecological factors and also is the most characteristic features of terrestrial environments. It is the loose, friable, unconsolidated top layer of earth’s crust and is the mixture of weathered rock materials (i.e. minerals) and organic detritus, both of which are formed through the physical, chemical and biological processes occurring slowly and slowly for a long period at earth’s surface. Soil is the most valuable resources and serves as one of the prime requisite of life. It is a finite and valuable resource upon which we depend for our food, fiber and fuel wood, which are the basic amenities of life. Soil supports all agricultural activities and plant growth and thereby acts as the most important element of the natural ecosystem. For majority of land plants, soil is the most important substratum which influences the growth and development. It is the most complex and dynamic medium for growth of the plants. For almost all terrestrial plants, the main source of water and mineral substances is the soil, which is absorbed by the root system.

The word soil is derived from a Latin word ‘solum’ meaning earthy material in which plants grow. The science which deals with the study of soil is called soil science or pedology. A fully developed or mature soil is that state of soil that has assumed the profile features (i.e., succession of natural layers), characteristics of
predominant soils on the smooth uplands within the general climate and botanic regions in which it is found (Singh, 1996). According to Dokyachev (1879), the first scientist, the soil is a result of the action and reciprocal influences of parent rocks, climate, topography, plants, animals and age of the land.

Soil, especially the top soil, is classified as a renewable resource because it is continuously regenerated by natural process through at a very slow rate. It is a major component of the physical environment second only to climate in influencing the development and distribution of plants.

Soil provides minerals and water to plants. The major part of known and unknown biodiversity is found in the soil, in the form of invertebrates (earthworms, woodlice, millipedes, centipedes, snails, slugs, mites, springtails, enchytraeids, nematodes, protists), bacteria, archaea, fungi and algae, and most organisms living above ground have part of them (plants) or spend part of their life cycle (insects) belowground. Above-ground and below-ground biodiversities are tightly interconnected (Ponge, 2005, Deyn, 2003), making soil protection of paramount importance for any restoration or conservation plan.

Soils provide mechanical anchorage to plants and hold water and mineral ions on which plants depend for their nutrition. They provide a substrate for the activities of microorganisms and animals. Soil is the shallow upper layer of the earth’s crust, whose initial characteristics depend upon the parent rock material and whose later development depends upon the climate, topography and vegetation. It is the part of
earth’s crust in which plants are anchored and nutrients released from dead organic matter by a variety of organisms for utilization by plants.

Soil serves as a reservoir of nutrients and water for crops, provide mechanical anchorage. The components of soil are mineral matter, organic matter, water and air, the proportions of which vary and which together form a system for plant growth. Soil is a natural body consisting of layers (soil horizons) of mineral constituents of variable thicknesses, which differ from the parent materials in their morphological, physical, chemical, and mineralogical characteristics (Birkeland, 1999). It is composed of particles of broken rock that have been altered by chemical and environmental processes that include weathering and erosion. Soil differs from its parent rock due to interactions between the lithosphere, hydrosphere, atmosphere, and the biosphere (Chesworth, 2008). It is a mixture of mineral and organic constituents that are in solid, gaseous and aqueous states (Voroney, 2006). Also, soils differ among themselves in some or all the properties, depending on the differences in the genetic and environmental factors. Thus some soils are red, some are black; some are deep and some are shallow; some are coarse textured and some are fine-textured.

In nature, the soil represents the combined effect of all the natural forces in the landscape working together—the rocks, the vegetation, the slope and the climate, acting in time. It is impossible to see the influence of any one of these alone. Each combination of forces produces a different soil. Some soil type differs from one another in only a few characters, whereas others may differ in almost every aspect and have no common characteristics. They are adapted to different crops and require entirely
different system of management. Each soil represents the total effect of origin and development and prevailing environment conditions.

Soil is made up of substances existing in solid, liquid and gaseous states with colloidal particles or organic and inorganic origin. The soil contains the top soil, which may be of different colour depending upon the type of humus and mineral materials present. Root of herbaceous plants and other small plants are also found here. The top soil is followed by the subsoil, which contains the root of most plants, humus and minerals. The proportion of clay here is usually more than in the top soil. The sub soil is followed by loose rock and finally the bedrock (parent rock material). Soil also absorbs rainwater and releases it later, thus preventing floods and drought. Soil cleans the water as it percolates. Soil is the habitat for many organisms.

The importance of measuring this potential resource in India was realized as early 1928 by the royal commission on agriculture, and as a follow up action, sporadic country wide soil survey program was initiated in 1956 by all India Soil and Land Use Survey, Ministry of Agriculture, Govt. of India and soil maps of national level were published. Soil provides the reservoir for some fourteen mineral elements essential to normal plant development. Deficiency of any one can inhibit or prevent specific enzymatic reactions and significantly limit plant growth. Nutrient elements are continuously used by the plants, and the supply ultimately becomes depleted where the crop is removed year after year and must be replenished. But nature, by breakdown of plant residues and other organic materials, constantly renews the supply. Excess of essential elements can also cause plant stresses.
Among the essential element present in the soil, Nitrogen (N), Phosphorous (P) and Potassium (K) are known as primary nutrient for plant growth. Calcium (Ca), Magnesium (Mg) and Sulphur (S) are known as secondary nutrients.

Soil life plays a major role in many natural processes that determine nutrient and water availability for agricultural productivity. The primary activities of all living organisms are growing and reproducing. By-products from growing roots and plant residues feed soil organisms. In turn, soil organisms support plant health as they decompose organic matter, cycle nutrients, enhance soil structure and control the populations of soil organisms, both beneficial and harmful (pests and pathogens) in terms of crop productivity.

The soil ecosystem can be defined as an interdependent life-support system composed of air, water, minerals, organic matter, and macro and micro-organisms, all of which function together and interact closely. One of the most important constituent of the soil is Organic Matter (OM). It helps in the building up of soil fertility for raising healthy crops. Since Organic Matter is the residue of the living organisms which took nutrients from some sources for their survival, therefore, it is obvious that organic substances would liberate plants nutrients in available form during mineralization (Singh, 1996). T.R. Abu-Zahra and A.B. Tahboub (2008) studied the effect of Organic Matter sources on chemical properties of the soil and yield of strawberry under organic farming conditions. Organic Matter after decomposition forms humus, which improves the soil structure, drainage, aeration, increase water holding and buffering capacity, influence the solubility of the minerals and supplies energy for growth and
development of the microorganisms and all these lead to building up soil fertility. The living part of soil organic matter includes a wide variety of micro-organisms such as bacteria, viruses, fungi, protozoa and algae. It also includes plant roots, insects, earthworms, and larger animals such as moles, mice and rabbits that spend part of their life in the soil.

When plant residues are returned to the soil, various organic compounds undergo decomposition. Decomposition is a biological process that includes the physical breakdown and biochemical transformation of complex organic molecules of dead material into simpler organic and inorganic molecules (Juma, 1998).

Water is essential for plant growth. Soil is capable of being a storehouse of water and becoming the main source of water for land plants. Soil water plays a significant role in several natural processes i.e. evaporation, infiltration and drainage of water, diffusion of gases, conduction of heat, and movement of salts and nutrients are all dependent upon the amount of water present in soil. Plants meet their water requirement from water stored in soil. Without enough water, normal plant functions are disturbed, and the plant gradually wilts, stops growing, and dies. Plants are most susceptible to damage from water deficiency during the vegetative and reproductive stages of growth.

The role of soil in the soil-plant-atmosphere continuum is unique. Plants are grown in the soil and soil properties directly affect the availability of water and nutrients to plants. Soil water affects plant growth directly through its controlling effect on plant water status and indirectly through its effect on aeration, temperature, and
nutrient transport, uptake and transformation. The understanding of these properties is helpful in good irrigation design and management. The soil system is composed of three major components i.e. solid particles (minerals and organic matter), water with various dissolved chemicals, and air. The percentage of these components varies greatly with soil texture and structure. An active root system requires a delicate balance between the three soil components, but the balance between the liquid and gas phases is most critical, since it regulates root activity and plant growth process.

Most of the water that enters the plant roots does not stay in the plant. Less than 1% of the water withdrawn by the plant is actually used in photosynthesis (i.e. assimilated by the plant). The rest of the water moves to the leaf surfaces where it transpires (evaporates) to the atmosphere. The rate at which a plant takes up water is controlled by its physical characteristics, the atmosphere and soil environment.

Soil structure is the arrangement of soil particles into aggregates. These may have various shapes, sizes and degrees of development or expression (Soil Survey Division Staff, 1993). Soil structure affects aeration, water movement, resistance to erosion and plant root growth. Structure often gives clues to texture, organic matter content, biological activity, past soil evolution, human use, and chemical and mineralogical conditions under which the soil formed.

Soil texture is one of the most important characteristics of the soil. Many of the important soil properties are related to texture. Soil texture refers to sand, silt and clay composition. Soil content affects soil behavior, including the retention capacity for nutrients and water (Brown, 2003). Sand and silt are the products of physical
weathering, while clay is the product of chemical weathering. Clay content has
retention capacity for nutrients and water. Clay soils resist wind and water erosion
better than silty and sandy soils, because the particles are more tightly joined to each
other. When water drains from sandy soils, it often carries nutrients along with it. This
condition is called leaching. When nutrients leach into the soil, they are not available
for plants to use.

Clay soils show high water holding capacity, high plasticity, and stickiness and
swelling whereas sandy soils are conspicuous by the absence of these properties. The
most important way in which soil texture affects plant growth is water and with it the
nutrient supply. The available water holding capacity of soil is related to soil texture.
Soil contains particle of different sizes, which are very important for determination of
the water holding capacity and aeration determine the type of vegetation that can grow.

Sixteen (16) chemical elements are known to be essential for growth of
plants. Plants nutrients like hydrogen(H), Carbon (C) and Oxygen(O) are received by
plants from air and water, Phosphorous, Potassium, Sulfur, Calcium, Magnesium, Iron,
Boron, Manganese, Copper, Zinc, Molybdenum and Chlorine from the soil and
nitrogen from both air and soil. 13 of the 16 mineral nutrients, which come from the
soil, are dissolved in water and absorbed through a plant's roots. All of these 13 except
Nitrogen originate in the parent rock from which soil developed. There are not always
enough of these nutrients in the soil for a plant to grow healthy. This is why many
farmers and gardeners use fertilizers to add the nutrients to the soil.
The mineral nutrients present in the soil are divided into two groups - macronutrients and micronutrients. Macronutrients can be divided into two more groups- primary and secondary nutrients. The primary nutrients are nitrogen (N), phosphorus (P), and potassium (K). These major nutrients usually are lacking from the soil first because plants use large amounts of these nutrients for their growth and survival. The secondary nutrients are calcium (Ca), magnesium (Mg), and sulfur (S). Also, large amounts of Calcium and Magnesium are added when lime is applied to acidic soils. Sulfur is usually found in sufficient amounts from the slow decomposition of soil organic matter, an important reason for not throwing out grass clippings and leaves.

Nitrogen (N) is one of the basic compounds in plant nutrition and its deficit directly is one of important growth limiting factors in plants because the need of plants to this element is much more than the other ones (Alizadeh, 2002). Nitrogen consists of 2-4% of plant dry weight. No other element such nitrogen can stimulate plant growth. Nitrogen takes part in the construction of chlorophyll, some vitamins, Hormones, cell wall and enzymes (Kafi et al., 2005). Nitrogen is a part of all living cells and is a necessary part of all proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy. Nitrogen is a part of chlorophyll, the green pigment of the plant that is responsible for photosynthesis. It helps plants with rapid growth, increasing seed and fruit production and improving the quality of leaf and forage crops. The chief source of nitrogen is the soil. Plants absorb it either in the form of nitrate or ammonical salts. Some bacteria and heterocyst containing blue green algae fix the nitrogen of atmosphere which can be utilized by plants.
Like Nitrogen, Phosphorus (P) is an essential part of the process of photosynthesis. It involved in the formation of all oils, sugars, starches, etc. It also helps in the transformation of solar energy into chemical energy, proper plant maturation and withstanding stress. Phosphorus effects plants rapid growth. It encourages blooming and root growth. Phosphorus often comes from fertilizer, bone meal, and superphosphate.

Potassium (K) is absorbed by plants in larger amounts than any other mineral element except Nitrogen and possibly calcium. This element plays an important part in many of the vital physiological processes in the plant. It is needed for the plant cell's metabolic processes and apparently has a role in influencing the uptake of certain other mineral elements, in regulating the rate of respiration, affecting the rate of transpiration and in influencing the action of enzymes, as well as in aiding the synthesis and translocation of carbohydrates. It helps in the building of protein, photosynthesis, fruit quality and reduction of diseases. Potassium is supplied to plants by soil minerals, organic materials, and fertilizer.

Calcium is a part of many minerals, such as dolomite, calcite and calcium feldspars. Upon their disintegration and decomposition, calcium is released. Calcium is an extremely important mineral in plant nutrition. Calcium, an essential part of plant cell wall structure, provides for normal transport and retention of other elements as well as strength in the plant. Calcium is also important in root development, since short roots are observed on calcium deficient plants. It is also thought to counteract the effect of
alkali salts and organic acids within a plant. Sources of calcium are dolomitic lime, gypsum, and superphosphate.

Magnesium is also absorbed by plants in the ionic forms. This absorption takes place from the soil solution or possibly by contact exchange. Magnesium plays a vital role in photosynthesis, as it is the central atom in the chlorophyll molecule. It is involved in many enzyme reactions. It reacts with phosphorus in uptake and transport. Magnesium in the soil originates in the decomposition of rocks containing minerals such as bronteite, dolomite and olivine. Upon decomposition, these minerals set magnesium into the surrounding soil solution. Soil minerals, organic material, fertilizers, and dolomitic limestone are sources of magnesium for plants.

Sulfur may be supplied to the soil from rainwater. It is also added in some fertilizers as an impurity, especially the lower grade fertilizers. The use of gypsum also increases soil sulfur levels. It is essential for production of protein. It promotes activity and development of enzymes and vitamins, helps in chlorophyll formation, improves root growth and seed production and helps in vigorous plant growth and resistance to cold.

Soil $p^H$ is one of the most important soil properties that affect the availability of nutrients. $p^H$ is the negative logarithm of the $H^+$ ion concentration in the solution is another very important factor of soil. It expresses the soil reaction capacity. $p^H$ has a pronounced effect on a number of soil constituents and especially on soil minerals, soil microorganisms and on plant roots. High $p^H$ favors the weathering of minerals into the release of various ions like $K^+$. In lower $p^H$, salt like phosphate, carbonate, sulphate
show high solubility. Soil pH also regulates nutrient uptake pattern. Nitrate and Phosphate are absorbed at higher rate under lower pH value (Singh, 1996). Assam is one of the richest floristic regions of India and has been a source of various valuable medicinal plants. These plants are found growing luxuriantly in diverse habitat conditions having diverse climatic conditions as well. The growth and development of these plants are greatly influenced by its climate, soil, and other factors. Since climate and soil greatly influence the characteristics of plant species, these species also show differences in their morphological characters and anatomical characters. Based on these diversities the medicinally important plant population may contain diverse active compounds which are important from the medicinal point of view.
4.2 MATERIALS AND METHODS:

Samples Collection and Preparation:

Soil samples were collected from the seven different study sites. Samples were collected from 8 spots within each study site. Samples were collected from 10-15 cm depth from soil surface. Collected soil samples of each study sites were mixed well and removed the debris. Soil samples were air-dried under shade and breaked all the lumps by and also using wooden millet, converted to powder without breaking individual grain. The soil samples were packed in suitable poly bags and labeled. From the prepared soil samples, following physical and chemical properties were analyzed.

Soil Texture:

Texture is determined by particle size analysis. Particle size was carried out by two methods.(Piper,1966).

a. Sieve Analysis Method:

Dry sediments were poured on the top screen and passed the sediment through successive sieve of 10, 18, 35, 60,120, 230 mesh sizes and soil particles were grouped following International Society of Soil Sciences (ISSS) into coarse sand, fine sand, silt and clay.

b. International Pipette Method:

Clay and silt contains cementing materials can not be separated by sieving. For separation of individual particle in clay and silt, two methods are commonly used.
International pipette method and Hydrometer method (Bonyoucons 1962). Here we followed the International pipette method (Piper, 1966).

Soil $p^H$:

$p^H$ of the soil samples were calculated by using electrical $p^H$ meter.

**Organic Matter:**

Organic Carbon content of the soil samples were determined by Titrimetric Method. Organic matter is obtained by multiplying it with “Von Bemmlen factor” (1.724), (Jackson, 1973).

$$OM\% = OC\% \times 1.724$$

**Available Nitrogen (N):**

Available Nitrogen was determined by Alkaline Potassium Permanganate Method (Jackson, 1973).

Results expressed in Kg/ha.

**Available Phosphorous (P):**

Available Phosphorous was determined by Bray’s method (Bray and Kuntz, 1945) and converted to Kg/ha by using converting factor (2.24). (Jackson, 1973).
Available Potassium (K):

Available potassium was determined by Ammonium Acetate Extraction for Exchangeable K using flame photometer and converted to Kg/ha by multiplying with converting factor 2.24.

Determination of Sulphur(S):

Available sulphur(S) was determined by Turbidimetric method (Massoumi and Cornfield, 1963).

Estimation of Calcium (Ca) and Magnesium (Mg):

Ca and Mg of the soil samples were determined by Complexometric Titration method, involving Ethylene Diamine Tetra-acetic Acid (EDTA) by Schwartzenbach et al (1946). Ca and Mg were represented as Meq/100gms of soil. (Jackson, 1973).

Different soil parameters have been represented in tabulated form. Correlation coefficients among different soil parameters with different morphological, anatomical characters and with different chemical constituents (phenol, alkaloid) were calculated following the method of Pearson’s coefficient of correlation.
4.3 RESULTS AND DISCUSSION:

Textural status of soil of different study sites showed significant differences like- Santipur and Barpeta showed sandy clay loam type of soil, G.U. campus and Mongaldoi showed sandy loam type of soil, whereas Boragaon, Deepor beel, and Sivasagar showed clay loam type of soil. The percentage of finer fractions of the soil like clay content were low in the soils of G.U. campus and Mongaldoi (14.20% and 14.80% respectively), whereas it was higher in the soils of Santipur, Boragaon, Deepor beel, Barpeta and Sivasagar(33%, 35.5%, 39.20%, 30.80% and 36% respectively). Percentage of coarse content were higher in soils of G.U. campus and Mongaldoi (65.20% and 66.80% respectively), whereas it was low at Boragaon and Sivasagar (39% and 39.60% respectively). (Table 35)

Results revealed that $p^H$ level showed significant differences among different study sites. $p^H$ level was slightly acidic in nature at G.U. campus, Mongaldoi and Santipur (6.38, 6.38 and 6.26 respectively) while it was medium acidic in nature at Boragaon and Deepor beel (5.68 and 5.68 respectively). Soils Boragaon and Sivasagar showed extremely acidic soil (4.09 and 4.34 respectively). (Table 36, Fig. 13). Soils of all the sites found to be acidic in nature which may be due to more soil organic matter contents. This is occurring by addition of hydrogen, due to decomposition of organic matter (Miles, 1986).

Though soils of all the sites showed high organic matter concentration, all the sites showed significant differences among them. For example soils of Sivasagar showed high (4.77%) organic matter concentration, whereas those from Santipur, Boragaon, Deepor beel, Barpeta showed medium (2.23%, 2.22%, 2.35% and 2.55% respectively), and those of Mongaldoi and G.U. campus showed low (1.794% and
Nitrogen concentration showed significant differences among the study sites. It was high at Santipur, Mongaldoi and Sivasagar (1327.60 Kg/ha, 596.92 Kg/ha and 921.33 Kg/ha respectively), whereas it showed medium concentration at Boragaon (428.46 Kg/ha, 324.24 Kg/ha, 453.55 Kg/ha and 493.11 Kg/ha respectively) (Table 36, Fig. 14). Soils of G.U. campus, Deepor beel and Barpeta. Nitrogen concentration of all the sites showed high and medium concentration which may be due to the high organic matter concentration. This is supported by the report of Gustafson (2005) who showed that organic matter is the natural source of nitrogen in the soil for higher plants. Tan (1994) and Schnitzer (1986) also reported that organic can serve as sources of nitrogen.

Phosphorous concentration was high at G.U. campus, Barpeta and Sivasagar (112.85 Kg/ha, 423.36 Kg/ha and 56.43 Kg/ha respectively), though they showed significant differences among them. Soils of Boragaon (11.54 Kg/ha), Deepor beel (5.13 Kg/ha) and Mongaldoi (5.13 Kg/ha) showed very low phosphorous concentration. (Table. 36, Fig.15). Soils of site Barpeta showed high concentration which may be due to high organic matter concentration. Tan (1994) and Schnitzer (1986) reported that organic matter can serve as sources of phosphorous. Steward (1963) also earlier reported that fresh organic matter has a special function in making soil organic phosphorous more readily available into inorganic form. Phosphorous concentration...
was high at G.U. campus and medium at Santipur which may be due to slight acidic nature soil and it was low at Boragaon which may be attributed to extremely acidic nature soil. Gustafson (2005) reported that phosphorous is most readily available to the plants in the zone of slight acidity and become less readily available with increasing concentration of H ions.

Potassium concentration was high at Boragaon, G.U. campus, Mongaldoi and Sivasagar (514.08 Kg/ha, 362.88 Kg/ha, 1108.8 Kg/ha and 423.36 Kg/ha respectively) whereas it was medium at Santipur and Deepor beel (336.00 Kg/ha and 174.72 Kg/ha respectively) and low at Barpeta (120.96 Kg/ha). (Table 36, Fig. 16). Soils of sites G.U. campus, Mongaldoi showed high potassium concentration and those of Santipur and Deepor beel showed medium concentration which cause may be contributed to high pH levels. High pH levels favour the weathering of minerals into the release of various ions like potassium (Singh, 1996). Likewise site Boragaon and Sivasagar showed high concentration which may be due to high organic matter concentration. Hewitt (1953) reported that humus (decomposed organic matter) provides a store house for exchangeable and available potassium, calcium and magnesium.

Likewise sulphur concentration was high at G.U. campus and Mongaldoi (187.5 Kg/ha and 76.56 Kg/ha respectively), it was medium at Boragaon and Deepor beel, (31.5 Kg/ha, 28.0 Kg/ha respectively), whereas it was low at Santipur, Barpeta and Sivasagar (14.0 Kg/ha, 12.6 Kg/ha and 12.5 Kg/ha respectively). (Table 36, Fig. 17) Soils collected from G.U. campus and Mongaldoi showed high concentration of sulphur which may attributed to high organic matter concentration. Tan (1994) and Schnitzer (1986) reported that organic matter can serve as sources of sulphur. Soils of all the sites showed high and medium sulphur concentration which may be due to acid soils.
According to Steward (1963), in some marginal soils and grasslands, acidification increases the supply of plant nutrients like sulphur and nitrogen.

Calcium level was high in the soils of Santipur and G.U. campus (4.6 Meq/100gms, 3.8 Meq/100gms respectively) which may be due to slightly acidic soil or may be due to organic matter concentration. Humus (decomposed organic matter) provides a store house for exchangeable and available calcium (Hewitt, 1953). While calcium concentration was medium at Sivasagar (2.0 Meq/100gms) and was very low at Deepor beel, Mongaldoi and Barpeta (1.0 Meq/100gms, 1.0 Meq/100gms and .6 Meq/100gms respectively) may be due to highly acid soils and may be due to high organic matter concentration. According to Miller (2004) calcium deficiency is one cause for the restricted growth of many plants on highly acid soils. (Table 36, Fig. 18).

Likewise soils of Santipur, Barpeta and Sivasagar showed high magnesium concentration (1.6 Meq/gms, 1.4 Meq/gms, 1.4 Meq/gms respectively) which may be due to high organic matter. Humus (decomposed organic matter) provides a store house for exchangeable and available magnesium (Hewitt, 1953), whereas Boragaon, G.U. campus, Deepor beel and Mongaldoi showed low concentration of magnesium (.3 Meq/100gms, .2 Meq/100gms, .2 Meq/100gm and .2 Meq/100gms respectively) which may be due to extremely acidic and medium acidic soils. Hewitt (1953) reported that magnesium availability is low in acid soils. (Table 36, Fig. 18).

Results of correlation coefficients among different parameters of soils of *A. sessilis* and *E. prostrata* showed that phosphorous levels were negatively correlated with organic matter concentration and sulphur levels were also negatively correlated with organic matter concentration at 0.05 level of significance. Likewise magnesium levels were positively correlated with nitrogen concentration at 0.01 level of
Results of correlation coefficients indicate that soils of G.U. campus showed high phosphorous concentration which may be due to lower concentration of organic matter concentration. Likewise site Boragaon and Deepor beel showed lower concentration of phosphorous which may be attributed to the lower concentration of organic matter in the soil. Soils of site G.U. campus showed high concentration of sulphur which may be due to lower level of organic matter. Magnesium showed positive correlation with nitrogen concentration in the soils. Site Santipur showed high concentration of nitrogen which may be attributed to the high concentration of magnesium.

Results of correlation coefficients among different parameters of soil of *C. asiatica* showed that organic matter concentrations were negatively correlated with pH levels at 0.01 level of significance. Results indicate that site G.U. campus and Mongaldoi showed high pH level which may be due to lower concentration of organic matters in soil. Likewise site Sivasagar showed low pH level (extremely acidic) which may be due to high organic matter concentration, resulting in high organic acid production. As per the report of Miles (1986), this was occur by addition of hydrogen, due to decomposition of organic matter.

Results of correlation coefficients among different parameters of soils of *S. cordifolia* showed that sulphur concentrations were negatively correlated with organic matter concentrations at 0.01 level of significance. Likewise magnesium concentrations were positively correlated with nitrogen concentration at 0.05 level of significance. Results indicate that soils of site G.U. campus and Mongaldoi showed high sulphur concentration which may be attributed to lower organic matter.
Likewise site Santipur and Barpeta showed medium concentration of sulphur which may be attributed to higher concentration of organic matter in soil.

Table 35: Texture of soil samples collected from different study sites.

<table>
<thead>
<tr>
<th>Site</th>
<th>Texture</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santipur</td>
<td>Sandy Clay Loam</td>
<td>52.60</td>
<td>14.40</td>
<td>33.00</td>
</tr>
<tr>
<td>Boragaon</td>
<td>Clay Loam</td>
<td>39</td>
<td>25.5</td>
<td>35.5</td>
</tr>
<tr>
<td>Gauhati University</td>
<td>Sandy Loam</td>
<td>65.20</td>
<td>15.60</td>
<td>14.20</td>
</tr>
<tr>
<td>Deepor beel</td>
<td>Clay Loam</td>
<td>40.40</td>
<td>20.40</td>
<td>39.20</td>
</tr>
<tr>
<td>Mongaldoi</td>
<td>Sandy Loam</td>
<td>66.80</td>
<td>18.40</td>
<td>14.80</td>
</tr>
<tr>
<td>Barpeta</td>
<td>Sandy Clay Loam</td>
<td>55.40</td>
<td>13.8</td>
<td>30.80</td>
</tr>
<tr>
<td>Sivasagar</td>
<td>Clay Loam</td>
<td>39.60</td>
<td>24.40</td>
<td>36</td>
</tr>
</tbody>
</table>

Table 36: Different physico-chemical parameters of soil samples collected from different study sites

<table>
<thead>
<tr>
<th>Site</th>
<th>pH</th>
<th>%OM</th>
<th>N (Kg/ha)</th>
<th>P (Kg/ha)</th>
<th>K (Kg/ha)</th>
<th>S (Kg/ha)</th>
<th>Ca (Meq/100 gms soil)</th>
<th>Mg (Meq/100 gms soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santipur</td>
<td>6.26</td>
<td>2.23(H)</td>
<td>1327.60(H)</td>
<td>34.62(M)</td>
<td>336.00(M)</td>
<td>14.0(L)</td>
<td>4.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Boragaon</td>
<td>4.09</td>
<td>2.22(H)</td>
<td>428.46(M)</td>
<td>11.54(L)</td>
<td>514.08(H)</td>
<td>31.5(M)</td>
<td>1.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Gauhati University</td>
<td>6.38</td>
<td>.975(H)</td>
<td>324.24(M)</td>
<td>112.85(H)</td>
<td>362.88(H)</td>
<td>187.5(H)</td>
<td>3.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Deepor beel</td>
<td>5.68</td>
<td>2.35(H)</td>
<td>453.55(M)</td>
<td>5.13(L)</td>
<td>174.72(M)</td>
<td>28.0(M)</td>
<td>1.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Mongaldoi</td>
<td>6.38</td>
<td>1.794(H)</td>
<td>596.92(H)</td>
<td>5.13(L)</td>
<td>1108.8(H)</td>
<td>76.56(H)</td>
<td>1.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Barpeta</td>
<td>5.68</td>
<td>2.55(H)</td>
<td>493.11(M)</td>
<td>423.36(H)</td>
<td>120.96(L)</td>
<td>12.6(L)</td>
<td>0.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Sivasagar</td>
<td>4.34</td>
<td>4.77(H)</td>
<td>921.33(H)</td>
<td>56.43(H)</td>
<td>423.36(H)</td>
<td>12.5(L)</td>
<td>2.0</td>
<td>1.4</td>
</tr>
</tbody>
</table>

H=high, M=medium, L=low

<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;272</td>
<td>272-544</td>
<td>&gt;544</td>
</tr>
</tbody>
</table>
Phosphorous: $<22.5 \quad 22.5-56.0 \quad >56.0$

Potassium: $<136 \quad 136-337.5 \quad >337.5$

Sulphur: $<20 \quad 20-60 \quad >60$

Table 37: Correlation coefficients among different parameters of *A. sessilis* and *E. prostrata* growing soils of Santipur, Boragaon, G.U. campus and Deepor beel

<table>
<thead>
<tr>
<th></th>
<th>$P^H$</th>
<th>OM</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>S</th>
<th>Ca</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P^H$</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OM</td>
<td>0.595</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>0.785</td>
<td>0.406</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>-0.440</td>
<td>-0.977*</td>
<td>-0.204</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>-0.638</td>
<td>-0.157</td>
<td>-0.081</td>
<td>0.120</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>-0.633</td>
<td>-0.989*</td>
<td>0.522</td>
<td>0.941</td>
<td>0.096</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>0.267</td>
<td>-0.462</td>
<td>0.623</td>
<td>0.639</td>
<td>0.029</td>
<td>0.342</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>0.713</td>
<td>0.321</td>
<td>0.993**</td>
<td>-0.117</td>
<td>0.005</td>
<td>-0.447</td>
<td>0.687</td>
<td>1</td>
</tr>
</tbody>
</table>

** significant at 0.01 level
* significant at 0.05 level

Table 38: Correlation coefficients among different parameters soil of *C. asiatica* growing soils of Santipur, G.U. campus, Mongaldoi, Barpeta and Sivasagar

<table>
<thead>
<tr>
<th></th>
<th>$P^H$</th>
<th>OM</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>S</th>
<th>Ca</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P^H$</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OM</td>
<td>-0.959**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>-0.209</td>
<td>0.432</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>-0.091</td>
<td>-0.013</td>
<td>-0.431</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>0.273</td>
<td>-0.176</td>
<td>-0.080</td>
<td>-0.642</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.519</td>
<td>-0.704</td>
<td>-0.656</td>
<td>-0.198</td>
<td>0.192</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>0.299</td>
<td>-0.277</td>
<td>0.461</td>
<td>-0.469</td>
<td>-0.264</td>
<td>0.300</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>-0.525</td>
<td>0.638</td>
<td>0.684</td>
<td>0.318</td>
<td>-0.640</td>
<td>-0.851</td>
<td>0.077</td>
<td>1</td>
</tr>
</tbody>
</table>

** significant at 0.01 level
Table 39: Correlation coefficients among different parameters soil of *S. cordifolia* (Santipur, G.U. campus, Mongaldoi and Barpeta)

<table>
<thead>
<tr>
<th></th>
<th>PH</th>
<th>OM</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>S</th>
<th>Ca</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OM</td>
<td>0.403</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>0.722</td>
<td>0.583</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>-0.510</td>
<td>-0.847</td>
<td>-0.287</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>K</td>
<td>0.489</td>
<td>0.068</td>
<td>-0.220</td>
<td>-0.580</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>-0.470</td>
<td>-0.996**</td>
<td>-0.647</td>
<td>0.837</td>
<td>-0.069</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>0.072</td>
<td>-0.231</td>
<td>0.548</td>
<td>0.639</td>
<td>-0.748</td>
<td>0.176</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>0.517</td>
<td>0.526</td>
<td>0.964*</td>
<td>-0.117</td>
<td>-0.470</td>
<td>-0.582</td>
<td>0.687</td>
<td>1</td>
</tr>
</tbody>
</table>

** significant at 0.01 level  
* significant at 0.05 level
Fig 13: Variations of $P^\text{H}$ level and Organic matter concentration at different study sites

Fig 14: Variations of Nitrogen concentration at different study sites.
Fig 15: Variations of Phosphorous concentration at different study sites

Fig 16: Variations of Potassium concentration at different study sites
Fig 17: Variations of Sulphur concentration at different study sites

Fig 18: Variations of Calcium and Magnesium concentration at different study sites