CHAPTER-6

CONCLUSION

Dimoria region of Kamrup, Assam, which is having a history of repeated pesticide applications, has been selected as the study area for the present study. The people of this region practice different land use systems like food agriculture, bamboo plantation, horticulture, tea plantation, agro-forestry, natural forest, shifting cultivation, etc. In the recent times, people in the area use a range of pesticides and fertilizers to boost the production of the crops like paddy, vegetables and tea, etc. Soil quality and productivity studies have not been done with emphasis on the application of pesticides.

The present study therefore, aimed at analyzing the soil quality of some selected conventional landuse systems of Dimoria Tribal Development Block, Kamrup, Assam, having history of repeated pesticides application, in order to analyse the presence of selected organophosphorus pesticides residues on soil of the selected landuses of the Dimoria Block and to assess the impacts of agrochemicals like pesticides application (mainly focused on organophosphorus pesticides) on soil quality in terms of its physico-chemical properties with special emphasis on heavy metal contamination and to compare the quality of the soil with that of some selected organically managed systems in terms of its nutrient status, considering natural forest as a control sample.

For the purpose of this study, different agrochemicals using land uses of the area were selected. Samples were collected from some selected conventional and organic agro-ecosystems of the area, and one sample was collected from natural forest, which is considered as the control samples for various analytical and microbiological analyses.

A survey of the study area was carried out to assess the extent of widely used pesticides and the farmers' level of awareness on the key issues like on the impacts of pesticide, toxicity of pesticides, handling practices, disposal practices through a well-structured questionnaire and were also ranked accordingly before sample collection and analysis.

Based on the questionnaires, all the respondents used fertilizers and pesticides in the field. The pesticide taken under study, i.e malathion and quinalphos were also used in the selected study sites. On the basis of level of awareness, only 45% of the respondents mainly farmers have fair knowledge of handling practices, followed by moderate (30%) and low (25%). Most of the farmers don't follow safe disposal techniques. In most of the cases, the containers of pesticides after use are thrown in water (40%), followed by throwing openly in fields (35%) and disposal in pits (25%). However, 50% of the respondents said they were aware of the health effects of pesticides, though they don't follow proper handling practices.

In case of the farmer's level of awareness on the impact of pesticides on the environment and human health, 45% of respondents believed that pesticides retained in the vegetables. Most of the farmers have poor knowledge about handling and persistence of chemicals in the environment and moreover the actual health impacts resulting from pesticides use. They are less aware of the management of pesticides including safe pesticide handling, usage of proper class of pesticides and storage. The farmers have to trained in various aspects of pesticides use and management along with the safe disposal techniques. Awareness of the farmers in the area under study, with due regards to environmental and a health effect is the need of the hour.

- **Soil physical and chemical parameters**

Physicochemical analysis of the soil samples, collected from various selected conventional and organic farms along with the control sample were performed which involves the analysis of different physical and chemical properties of soil, along with the determination of heavy metal concentrations and presence of pesticides (Malathion and Quinalphos), under study and the results examined in both the systems were compared to assess the impact of pesticide application on the soil quality of the selected landuse systems.

The soil quality of the selected landuses varied depending on soil conditions like nutrient availability, pH, temperature, moisture etc. **Soil temperature** ranged from 19.3 to 28^0C. In the present study, the temperature range is however suitable for microbial activity and nutrient availability for plant growth. During the present investigation the **moisture content** was found 3.61-22.24%. The variation in moisture content depends on the amount of pore space present in the soil, which is related to soil texture.

In the present study, the **soil texture** was determined qualitatively by feel method and the respective classification was done. Soils in the systems under study were found to be sandy clay loam, clay loam and that of the natural forest was silt loam. The results show that clay dominates over sand and silt in the area. Usually clay loam soil is considered as more preferable for agricultural crops and it seems that good crop production can also take place in the types of soil of the study area.

The present study showed not much variation in **bulk density** of soil samples that ranged from 1.07 to 1.43 g/cm^{3}respectively indicating low permeability and soil

porosity. Bulk density was minimum for soil of Sample-5, representing rice field 1, indicating presence of light organic matter, since it bears an inverse relationship with soil organic matter. As for good plant growth, the bulk density of sand dominated soil is about 1.6 g/cm^{3}and for clay soil, it is below 1.4 g/cm^3. Therefore, as the soil of the study area is dominated by clay and then sand, in terms of bulk density the soil is suitable for good plant growth.

The **water holding capacity** of the soil in the present study ranged from to 29.30 to 65.51%.The water holding capacity increased with the increase in the clay content, as clay can bind the water molecules more effectively, which can be justified if seen along with the soil texture of the study area.

In the present study, the experimental result of **pH** distribution in the study area ranged from 4.26-5.9. The soils in the systems under study were acidic in nature and were below the range, according to the IAS- International Agriculture Standard for pH that ranges- 5.8-8.3 and ICAR Rating ranging 6.0-8.5 (Normal). However, according to the ICAR rating, 2015, the soils of the study area were rated as poor i.e. 4.6-5.5(Strongly acid). The factors like constant addition of chemicals to the soil, coupled with high temperature and excessive rainfall might result in severe acidity buildup in the soil systems. This might severely affect the nutrient availability for the crops of the landuse systems.

The **EC** levels of the soil water are a good indication of the amount of nutrients available for your crops to absorb. The values of EC were from 128.7-196.03µS/cm. Based on the findings, it can be concluded the soil of the landuse systems was non-saline and normal for crop production as per ICAR Rating, 2005.

The present study showed variation in **soil organic matter** that ranged from 1.22-4.49%.Organic matter content in soil of the rice fields and the vegetable farms were more compared to that of tea gardens. However, most of the soil samples revealed organic matter near-by or above 3%, which were moderate according to ICAR rating, 1997.

The available **nitrate-nitrogen** examined in the soil of various landuses was 1.9-6.0 mg/kg, which was moderate according to chemical rating chart, ICAR Rating 280-560kg/ha (Medium) (ICAR, 2005). The highly acidic nature of soils of the study area prevents organic matter from breaking down, resulting in an accumulation of organic matter and the tie up of nitrogen, that are held in the organic matter. However, highly acidic or alkaline soil conditions often cause a reduction in the amount of nitrogen fixed by legumes. These might be the reasons behind the moderate content of nitrogen examined in the study area as is evident from the experimental results.

The experimental results of **available phosphorous** distribution in the study area were low (2.21-14.5 kg/ha) in all the landuses, as according to the IAS- International Agriculture Standard for Phosphorus that ranges- 22.5-56 kg/ha. The low availability of P might be due the examined P^H level of the soil that ranges from 4.26-5.9 during the study, as study reveals that low availability of P is very pronounced in acidic soil (pH<5.5) and alkaline soil (pH >7.3). Under acidic soils, P is fixed by iron and aluminum.

The available **potassium** value were also medium to low concentration (43.29-164.2 kg/ha) in the landuse systems, as according to the IAS- International Agriculture

Standard for Potassium that ranges- 150-340 kg/ha. Low amount of K (43.29 kg/ha) was examined in the control sample representing the natural forest.

The amount of nitrate nitrogen, P and K in the rice field, vegetable farm and tea garden exceeded natural forest that might be due to the use of NPK fertilizers in the fields. In terms of NPK availability the soil status can be regarded as of moderate quality.

- **Heavy metal concentrations**

Heavy metals such as **cadmium, copper, chromium, lead, nickel** and **zinc** were analyzed for both the conventionally and organically managed systems, along with the control sample. The mean values of the heavy metal concentrations (mg/kg) in soils of different land uses ranges in the following order; Cd (0.16-0.83) < Ni (2.56-29.06) < Cu (4.66-27.16) < Cr (8.03-46.06) < Zn (26.30-99.83). Lead was not detected in any one of the soil samples. Moreover, metals examined were below detectable limit in the control sample representing the natural forest.

The mean heavy metal concentrations of soil of the present study were compared with the mean values of heavy metals for uncontaminated paddy soils, mean values for worldwide normal surface soils, critical concentrations for contaminated soils, Indian standards, and European Union standards and the results also showed that the soils could not be said to be contaminated with heavy metals for now because metal content levels conformed to the worldwide background content of metals range in the soil. However, in accordance with the Environmental Quality Standard for Soils (National Environmental Protection Agency of China, 1990) only one field (rice field 1) out of rest sampled exceeded Chinese maximum allowable concentrations for Cd for agricultural soils, which might be due to extensive reliance on agrochemicals. However, the rest were below the limit.

The study further revealed that there were no significant differences between organic and conventional management for most of the soil physical and chemical properties measured. However, soil samples from the conventionally managed system exhibited slightly higher values of soil water holding capacity and significantly higher values of electrical conductivity (EC) and higher concentrations of K. Considering the mean values of the heavy metal concentrations of both the systems, it was observed that the heavy metal concentrations of the conventional farms exceeded to that of organic farms, especially, Cu and Zn concentrations, which were likely the result of extensive agrochemicals application (in the forms of chemical fertilizers and/or pesticides). Application of excess amount of nitrate and DAP fertilizers, Cu based fungicides and pesticides are the main reason to enhance the level of heavy metals in agricultural soils.

The presence of pesticides (malathion and quinalphos), were examined with the help of Gas Chromatograph. Out of the two pesticides, taken for the study, only malathion was detected in four soil samples viz. both the vegetable farms and the paddy fields in trace amount. However, in none of the soil samples quinalphos was detected. This indicates that in the present study the pesticides might get metabolized by organisms or free enzymes in the soil to some other compounds or might move through soil with water, as it was examined in very trace amount in the soil.

Moreover, isolation of various microbial strains can immensely help degrading various pesticide residues in soil and can help in bioremediation of the contaminated sites. Thereby an attempt was made to isolate microbial strains capable of degrading the pesticides taken under study viz. malathion and quinalphos insecticides residues from the soil of selected landuse systems of Dimoria Tribal Development Block, Kamrup,

Assam, which is having a history of repeated pesticide applications, and study the growth rate of the bacterial isolates at different conditions like at different temperature, P^H, carbon and nitrogen sources with a view of bioremediation of contaminated sites. Two different pesticides *viz*., malathion and quinalphos were used in this study.

The study revealed that the bacterial isolates *designated as MS 1, MS 2, QS 1, and QS 2* have the capacity to utilize the pesticide and grow well in the medium supplemented with pesticides. Moreover, among the four bacterial isolates the bacteria, *MS 1*utilized the pesticides effectively and showed maximum growth followed by *MS 2, QS 1,* and *QS 2*. The bacterial isolates showed maximum growth in the Minimal salt broth containing malathion followed by quinalphos. The maximum growth rate of bacteria was recorded at 35°C followed by 25°C, 45°C and 55°C and pH 7 followed by pH 6, pH 8, pH 5 and pH 4 . Moreover, the growth of bacteria was maximum in the presence of dextrose followed by fructose and lactose and in peptone followed by yeast extract and beef extract.

This preliminary study helped in screening of bacterial isolates which can be used for bioremediation of pesticides, specifically malathion and quinalphos, contaminated agricultural field where such contamination has made a huge loss in the agricultural products. Using an environmental friendly approach, like use of potent bacterial isolate as screened in the study and application of proper consortia as well is expected to greatly reduce this burning issue. However, further works have to be carried out towards proper identification and screening of efficient bacterial isolates and sequencing of highly efficient bacterial isolates that can be commercially applied to pesticides contaminated soil with a view of bioremediation.

Agricultural sustainability depends on productive soil. The significance of the present study, therefore, lies in scientific assessment of soil quality to assess the impact of pesticides on soil quality, which is essential to monitor the sustainability of agricultural systems. Moreover, using an environmental friendly approach, like use of potent bacterial isolate as screened in the study and application of proper consortia as well is expected to greatly reduce this burning issue.

The dynamic nature of soil biology, and the effects of environment on the fate of chemical or fertilizer added and on the populations of different functional groups of biota, makes it very difficult to draw conclusions about the impacts of various inputs in our agricultural systems. Healthy soil is essential for the production of crops used to feed humans and livestock. In addition to providing a stable base to support plant roots, soil stores water and nutrients required for plant growth.

Unfortunately, industrial agriculture practices which rely on modernization is continuing in the damage and depletion of valuable natural resource like soil, water etc. Modern agricultural practices like intensive plowing and monocrop agriculture systems have caused nutrient depletion and wide-scale soil erosion, while, over-application of fertilizers and pesticides has contaminated various environmental matrices deteriorating our soils quality and polluting our waterways. Understanding the impact of agricultural chemicals on soil and water quality will have a direct bearing on how farmers should use their agricultural chemicals in such a way that it will not continue to contaminate soil and water resources. It would hopefully raise people's awareness on these important environmental issues and develop mitigation measures to address these issues for the benefit of both present and future generations.

There are proven alternatives to this expensive agriculture system, however farmers now-a-days are aware of these issues and of various eco-friendly agricultural practices and already adopted organic and sustainable techniques that work with nature, not against it, for fertilizing soils and protecting crops and different agricultural related practices. Fortunately, many farmers are choosing to use sustainable agricultural techniques such as conservation tillage, crop rotation, and organic fertilization in order to protect our valuable soil resources.

Future scope of study-

The present work will be helpful in predicting the fertility status of soil in the selected landuse systems of Dimoria Tribal Development Block of Kamrup, Assam district. It has yielded a rich database on general quality of the soil and provides a broad view on the impact of agrochemicals application on soil quality.

This preliminary study also helped in screening of bacterial isolates which can be used further for bioremediation of pesticides, specifically malathion and quinalphos, contaminated agricultural field where such contamination has made a huge loss in the agricultural products. Results from this work can be used to help regional-scale studies of soil in future.

The present work may serve as the starting point for many other future studies, which should address specific issues pertaining to soil contamination.

The following maybe considered as future initiatives in this regard;

- Increasing the number of sampling points for soil so that better statistical predictions may be made.
- Proper quantification and adequate characterization of various pesticides residues in the soil.
- Study the impact of long-term application of various pesticides on soil organisms and plants, and thus measuring the residue in the plants.
- Identification of the toxicity symptoms of commonly used pesticides on plants and thus, suggests the crop safety limits.
- Proper identification and screening of efficient bacterial isolates and sequencing of highly efficient bacterial isolates that can be commercially applied to pesticides contaminated soil with a view of bioremediation.