Chapter 5

CONCLUSION

5.1 Soil Quality
The capacity of production of plant and agriculture depends on soil environment and nutrients present in it. The physical, biological, and chemical characteristics of a soil, for example its organic matter content, acidity, texture, depth, and water-retention capacity all influence fertility. Soil’s potential for producing crops is largely determined by the environment that the soil provides for root growth. Roots need air, water, nutrients, and adequate space to develop. Soils have capacity to store water. The soil acidity, depth, and density determine how well roots develop. The agro-ecosystems can be considered as ecological systems modified by human beings to produce food, fiber or other agricultural products. Farmers always use economically beneficial agricultural practices rather than environmental friendly practices. There is no data bank on soil quality in the small tea garden areas of Sonitpur district, Assam. The long term exploitation of soil in the tea gardens in the study area decreases the soil fertility and its effects on the production. The tea garden owners focus on maximizing yields through agronomic practices such as high application of inorganic fertilizers, including foliar applications. Excessive use of chemical fertilizers in the on tea gardens is widespread. This is a short term strategy to increase yields but it adversely affects the status of ecological niche in the long term. In this study it was seen that the low organic matter contends in some tea gardens’ soil and high acidic soil of all tea gardens. Low organic carbon results in low water and nutrient holding capacity, thus contributing to decrease in yield. The soils in the study area are acidic in nature, over-fertilization of the fields with acid-forming fertilizers such as ammonium
sulphate is one of the major causes of increasing acidity on tea gardens soil. Failure to maintain satisfactory pH levels will affect the future productivity of the land. In this study, there are some weakness of soil in and around the tea gardens in the study area as follows:

❖ Increasing soil acidity & low organic carbon in some tea gardens soil.
❖ Micronutrients deficiency and depleting fertility of the soil.
❖ Increasing toxic metals and soil rusting.
❖ Clay soil effect on root growth.
❖ Lack of knowledge on soil management by small tea garden owners.

All the above reasons affect the health of the tea in the gardens which, reduces the production of green tea. Therefore, it is not surprising that the tea garden owners' concerted efforts to maximize profits in the short run through intensive application of inorganic fertilizers are always on. The soil in our study area is highly acidic which affects the ability of soil to release nutrients. If the soil pH is too high, then the nutrients can get locked up in the soil and become unavailable to plants. Normally best pH for tea plant is between 4.5 to 5.5, but in this study the mean value inside the tea gardens was found 4.405 and outside the tea gardens i.e. in the paddy fields the mean value was found 5.155 which is extremely acidic for paddy cultivation. The organic carbon found in the study area is low in terms of the percentage. The variation of nitrogen is low to moderate level and seasonal variation was observed due to decrease of microbial activity in acidic soil. The phosphorous level is also critical and seasonal variation was observed. Nitrogen and phosphorous deficiency occur in acid soils due to very slow organic matter decomposition. It was also observed that the potassium
content in the soil samples is not good in terms of fertility rating chart by ICAR (2005), and the potassium level is critical in the study area, the seasonal variation increases significantly from the pre monsoon to the post monsoon season. Zinc content is found low to medium and condition is critical and seasonal variation is very narrow, this is because of high acidity in soil. Calcium and magnesium content is low in the study area and this is expected of the prevailing acidic conditions. The iron content in the soil in the study area is extremely high and it formed insoluble iron oxide Fe₂O₃ i.e. soil rusting takes place, seasonal variation is also observed due to excessive soil erosion. The excess aluminium concentration exceeded the soil environmental standard in the soil of tea gardens. Aluminium toxicity occurs primarily in acidic soil.

Outside the tea gardens i.e the soil of paddy fields around the tea gardens are also in catastrophe with rapid degradation of production. The nutrients in the soil are not in accordance with the fertility rating chart given by ICAR (2005). Soils are strongly acidic and presence of likely occurrence of exchangeable aluminium was also found. Except the organic carbon all other macro and micro nutrients are deficient in soil for rice cultivation. Significant seasonal variations are common for all the soil quality parameters. As found out from the experimental results the soils in and around the small tea gardens of Gohpur and Biswanath Chariali Sub-Divisions, Sonitpur district, Assam, generally have properties that make their management somewhat difficult.

The capacity of soil in the study area is decreasing because of the use of long term tea cultivation, so it is very urgent to improve the quality of soil for better production by application of external inputs such as inorganic fertilizers and pesticides. Among
various chemical parameters of soil quality i.e. pH, available N, P, K and % C are considered to be sensitive environmental parameters and have direct bearing on the productivity and fertility of soils. A concise statistical analysis of soil nutrients has been carried out viz. mean, median, skewness, kurtosis and correlation for each parameters which illustrate that all these parameters exhibit non-uniform distribution in the study area with a long asymmetric tail either on the right or left side of the median in both the pre and post monsoon season. Thus the inherent fertility of soil in the study area is poor because of low nutrient status in soils. Soil nutrient imbalance is the key issue that needs to be taken up in the area. High soil acidity is the primary cause behind the nutrient imbalance in soils of the study area. Thus, it may be concluded that the intrinsic quality of soils in and around the tea gardens of study area is not encouraging because of either low or high nutrient status in soils. The researcher feels that environmental aspects of soil quality of this area need serious attention in near future for better agricultural practices.

To make the tea plantation viable in the long run, management strategies have to be restructured. Soil organic carbon can be improved through the application of organic manure. Application of soil amendments such as dolomite, lime etc. is necessary to maintain soil acidity at a satisfactory level. Adequate attention needs to be given to soil conservation. With proper drains, terraces, mulches and cover crops, soil erosion could be minimized. A sustainable soil management system must exhibit a wide range of nutrients for healthy plant growth. Widespread nutrient deficiencies and deteriorating soil health are causing low productivity. Utilizing all indigenously available nutrient sources to reduce dependence on imports, effective soil testing...
service to back up precise fertilizer use, creating awareness amongst farmers on
benefits of balanced fertilization, opening more soil testing laboratories at least one
each in different districts with state of art facilities, laboratories participating in the
preparation of geo-reference soil fertility maps at district and block levels may be
undertaken with immediate effect.

5.2 Water Quality

Access to safe drinking water is very essential to health, a basic human right and a
component of effective policy for health safety. The study has provided useful
baseline information on the shallow ground water (ring well and tube well) quality
(physical and chemical content) in and outside the small tea gardens for better
management. Groundwater provides drinking water to more than 1.5 billion people
daily in the world. Chemicals which are used in tea gardens leached to the ground
water due to excessive rainfall and over irrigation which contaminated the ground
water sources of the inside and nearby area. The 86.66% of pH of the shallow ground
water samples in both seasons, inside the tea gardens are ideal within the WHO/BIS
limit and 13.38% are slightly acidic, similarly outside the tea gardens the pH of
95.55% are within WHO/BIS limit and 4.44% are slightly acidic in nature. In case of
TDS no sample has been found above permissible limit of the WHO/BIS. The TDS is
due to the use of chemicals which are used in tea gardens leaching to the drinking
water sources. Nearly 32.24% of total samples for all seasons spread between hard and
very hard types. The major anions of $\text{SO}_4^{2-}$, $\text{NO}_3^-$ and $\text{Cl}^-$ were within permissible
limits of the WHO/BIS. But in case of Phosphate, 71.77% inside and 51.11% outside
tea gardens in both seasons fall above the permissible limit. This is because of
phosphate may be percolated to the ground water sources. From this study, it was found that the fluoride concentration of some water samples were more than 1.5 ppm and ranging up to 5.60 ppm which was above the permissible limit of the WHO/BIS. In the tea garden 17.77% and outside tea garden 24.44% samples have fluoride content more than the WHO/BIS permissible limit. The fluoride content in water samples may come from phosphate fertilizers and pesticides, (fluoride is one of the major impurities in the phosphate fertilizers) or rocks like fluorspars, rock phosphate and phosphites etc. Among the major cations Ca, Mg, Na, and K were within the WHO/BIS permissible limit. In most of the samples the Fe concentrations were much higher than the guideline value of the WHO/BIS (0.3 ppm) i.e. 95.55% in the inside and 92.215% in the outside tea gardens samples have iron content above the WHO/BIS permissible limit in both seasons. If ground water contains pH in between 6 to 8 then it retains up 50 mg of ferrous ion per litre at equilibrium. The water at first is clean when drawn from tube well then it turns cloudy on standing and then brownish due to the precipitation of ferric hydroxide the ring well water is brownish colour due to this ferric hydroxide. Iron content in water sources was heterogeneously distributed and its high content is due to soil origin, rocks, clay or humic compounds. Manganese content was also higher than the WHO/BIS permissible limit and the steady seasonal variation was also observed. The higher concentration of iron and occurrence of manganese would have pointed to their co-existence in rock structure. Zinc content in all the water sources was found within the WHO/BIS permissible limit. The trace metal copper was also within the WHO/BIS permissible limit which is safe for drinking purposes. The scope of the present work is limited and confined to the assessment of
quality of drinking water on the basis of physico-chemical characteristics in the small tea gardens and nearby outside area. No data in detail was recorded before undertaking this work. The study of water parameter assessment will help the concerned government authority to adopt proper policy to improve the water quality in future which will be great help of to a large section of the society who are directly or indirectly involved in tea production.

Some precautionary measures should be taken to reduce contamination for ideal drinking water. In order to reduce the contamination of water the drinking water sources should be properly treated. It should avoid over-fertilization in the tea gardens and paddy fields, the rate of use of nitrogen and phosphate fertilizers needs to be calculated on the basis of the “crop nutrients balance”. The farmers should be encouraged to use bio-fertilizers and bio-pesticides to avoid the soil and ground water contamination. Lime or bleaching powder should be used periodically.

For removal of arsenic and $F^-$ (in natural water arsenic is mostly found two state arsenite [As (III)] or arsenate [As (V)] the activated alumina (granulated form of $\text{Al}_2\text{O}_3$) can be used which, have large surface area (range of 200-300 m$^2$/g) and can be used for the removal of As (Bellack, 1971) and $F^-$. The adsorption process can remove As up to 95%, for both As (III) and As (V), Lime softening is a similar process to coagulation with metal salts. Lime $\text{Ca(OH)}_2$ hydrolyzes and combines with carbonic acid to form calcium carbonate, which acts as the sorbing agent for As removal. Metal oxides can also be used for arsenic removal, metal oxides have strong affinities for As, and can serve as effective sorbents, and in some cases as oxidants. In recent years many researchers have used this principle to develop low-cost As removal methods.
using locally available materials. The Fe coated sand can remove both arsenite and arsenate.

Simple sand filtration is a common low cost method for removal of arsenic from arsenic contaminated water, water having high concentration of iron too can remove the arsenic partially (Berg, M., et al, 2006). For removal of fluoride, limestone can be used which removes fluoride from $\text{F}^-$ contaminated water. This is called adsorption based fluoride removal technique, in this process the calcium present in the limestone reacts with fluoride and precipitate as $\text{CaF}_2$. Removal of fluoride from drinking water is normally accomplished by adsorption and precipitation processes. Among the technologies for fluoride removal, activated alumina filtration is the most effective method. Various adsorbents such as activated carbon zeolites (clinoptilolite and chabazite) and synthetic molecular sieves also can also be used for removal of fluoride.

Cost-effective, user friendly technologies providing pure water are required to counter the serious health hazards due to consumption of contaminated water. A holistic approach involving medical practitioners, scientists and social workers are important to work coherently to find out a solution for safe drinking water. Awareness and training programmes should be conducted by NGO’s and social organizations for the sustainable use and management of ground water of this region. A short and long term management action plan should be taken by the concerned authority for the efficient use of ground water resources because water is positively correlated with health.