Introduction

"The nation that destroys its soil destroys itself"

Franklin D. Roosevelt

Indian Himalayas occupies a unique place in mountain ecosystem of the world. With the increasing realization that the natural resources of mountain areas are vital for upland and down land people, the emphasis for sustainable development has brought mountains to sharp focus. The people of the Himalayan region are heavily dependent for their livelihood on their immediate natural resources and production from primary sectors such as agriculture, forestry, livestock, etc. The dependency of the continually growing population on finite resources, lack of viable technologies and adequate inputs to mitigate the mountain specificities and enhanced production to meet the demands are depleting the resources along with increasing marginality of farmers, and deteriorating soil health. Huge pressure of growing population, increased demand for food, fuel wood and shelter combined with industrial activities have essentially led to drastic change in land use/land cover patterns. Recent studies carried out in the region focusing on development interventions/initiatives reflect the unscientific exploitation of resources leading to increasing environmental degradation. Assessing soil health of this region is of paramount importance for our nation to develop potential strategies for improving agricultural sustainability.

Soil quality defined as "The capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, maintain the quality of air and water environments, and promote plant, animal, and human health" and the soil quality is inextricably link to sustainability (Doran et al., 1996). Soil quality understanding leads to sustainable management of the soil and its functions can be optimized and prevent its degradation for future use. Soil quality may not be directly measurable due to its complex functional state; however, it may be inferred from
measurable soil properties (Acton and Padbury, 1993). There are several studies have been proposed for quantitative and qualitative evaluation of soil quality comprising of soil physical, chemical and biological factors (Knoepp et al., 2000). Initially soil qualities were evaluated from soil physical and chemical properties. Nowadays, it has been suggested that soil biological and biochemical properties can serve as early and sensitive indicators of soil degradation (Kennedy and Papendick, 1995). Physical, chemical and biological indicators must be quantified to document the degradation of soil quality (Larson and Pierce, 1994). These categories are not always clearly defined since a soil property or indicator can affect multiple soil functions or categories. Computing these variables through long term monitoring may lead to proper understanding about the impact of land use and management practices and natural or anthropogenic disturbance on the soil component consequently on soil quality. However, as with any indicator or experiment, an appropriate baseline or reference is critical to its utility and interpretation.

Soil assessment indicators should be limited and manageable in number by different type of users, simple, reliable and easy to measure, cover the largest possible soil types including temporal variation and be highly sensitive to environmental change and soil management practices (Dick et al., 2000; Doran and Zeiss, 2000; Cantu et al., 2007).

Soil enzymatic activities are associated with biogeochemical cycles and organic matter degradation indicators and together they can determine the quality of the soil (Acosta-Martinez et al., 2007; Gelsomino et al., 2006). Among biological properties, soil enzyme assays are indicators of the soil potential to degrade or transform substrates. They can be an integrative index of past soil biological activity as influenced by soil management (Nannipieri, 1984; Dick et al., 1996). Soil enzymes are efficient indicators because they have close relationship with soil organic matter, physical characteristics and microbial activity of soil (Dick, 1996; Nielsen and Winding, 2001). Studies of soil enzyme activities provide information on the biochemical processes occurring in soil (Kilzilkaya and Dengiz, 2010). Soil enzymes play pivotal role in overall biochemical function of organic matter decomposition in soil and during that catalyze several reaction, necessary for life processes in soils and provides an early indication on change in agricultural management (Ebersberger et al., 2003; Kandeler et al., 2006) before they are detected by other soil analyses (Ndiaye et al., 2000). Soil enzyme activities
assessment is quite simple and reliable as compared to other biochemical analysis (Ndiaye et al., 2000) and can be correlated to other soil properties (Acosta-Martínez et al., 2007; Klose et al., 1999; Moore et al., 2000). There are significant correlations of soil enzyme activities with total organic C, and C and N microbial biomass. To understand the functioning of soils and to prevent soil damage due to anthropogenic and climatic factors, it is important to have suitable instruments for the assessment and quantification of soil processes performed by soil enzymes secreted by microorganisms (Baldrian, 2009) as they are very sensitive to the change. Although enzymes are primarily of microbial origin, they also originate from plants and animals. These enzymes are constantly being synthesized, could be accumulated, inactivated and/or decomposed in the soil. Assuming that these processes are going on in the soil, great importance is attached to the recycling of nutrients (Bloem et al., 1997). Enzyme activities can be used as an index of soil fertility (Ceccanti et al., 1993). Soil contains a large diversity of microbial taxa with wide variety of metabolic activities. Soil microbial biomass compared with that of eukaryotic organism is a more sensitive indicator and is influenced by ecological factors like plant diversity, soil organic matter, pH, moisture, climate change and long-term use of organic and inorganic fertilizers (Martinez-Salgado et al., 2010).

Microorganisms play a key role in nutrient cycling and energy flow (Li et al., 2004) and provide information on the impact of intercropping, incorporation of organic matter, management practices (Shannon et al., 2002). Microbial communities respond to environmental stress or ecosystem disturbance, affecting the availability of energetic compounds that support microbial population (Marinari et al., 2007). However, it is important to know that microbial indicators have advantages and disadvantages and should be selected based on easiness of measurement, reproducibility and sensitivity to variables that control quality and soil health. In addition, many of the microbial groups are culture-independent, making essential the use of molecular techniques, which complement the traditional culture techniques (Nielsen and Winding, 2001). Traditionally, methods to analyze soil microorganisms have been based on cultivation and isolation (Elsas et al., 1998), but these approaches access only less than 1 % microorganism in over all soil biota (Torsvik et al., 2002). In recent years culture
independent techniques has been developed that can recognize about 4000 different sizes of microbial genomes per gram of soil, representing around 13,000 different species (Torsvik et al., 1990). Several approaches to study the community structure and composition has been developed to understand the soil microbial diversity associated functions such as denaturing gradient gel electrophoresis (DGGE) (Heuer et al., 1997; Muyzer et al., 1993), amplified rDNA restriction analysis (ARDRA) (Massol-Deya et al., 1995), terminal restriction fragment analysis (T-RFLP) (Liu et al., 1997), automated ribosomal intergenic spacer analysis (ARISA) (Ranjard et al., 2001). However, these current molecular approaches to study the soil microbial diversity lacks to evaluate the functional aspect of the soil and not able to draw conclusion on biodiversity loss (Muyzer et al., 1993) as the dead cells also contributes in analysis. Phospholipid (PLFA) relative abundance provides a fine measure of viable microbial biomass (White, 1993; Tunlid and White, 1992) as phospholipids were not found in non-viable cells and thus are efficient indicators of metabolic functional diversity of soil.

Soil organic matter (SOM) is central to soil fertility, productivity and quality. Since decline of SOM creates an array of negative effects on crop productivity; maintaining and improving its level is pre-requisite for ensuring soil quality, future productivity, and sustainability (Katyal et al., 2001). The SOM is an extremely important attribute of soil quality and soil health, as it influences soil physical, chemical, biological properties and processes. It is a source of energy and nutrients for soil biota, which affects the nutrient supplying capacity of soil via mineralization. It also affects aggregate stability, traffic ability, water retention and hydraulic properties (Haynes, 2005). In addition to being a direct source of plant nutrients, SOM also indirectly influences nutrient availability in soil. Soil carbon is a major determinant of sustainability of agricultural systems and changes in the quality of SOM can occur in both total and active, or labile C pools. Availability of various nutrients like nitrogen, sulphur etc in soil is closely associated with both quality and quantity of soil organic carbon (SOC). Fractionation of soil organic matter generally distinguishes small pools with a high turnover rate from pools of greater size with slower turnover rate. Changes in soil management practices such as tillage within agricultural systems usually bring too subtle changes in total organic carbon content in soil to be measured on short-term
basis because of the relatively large variability and quantity of background organic matter. On the other hand, labile pools of soil organic carbon have proved to be more sensitive to changes in agricultural management practices and land use than total organic carbon (TOC) (Haynes, 2005). Maintenance of SOM in agricultural soils is primarily governed by climate, particularly annual precipitation and temperature and land use systems (Jenny and Raychaudhuri, 1960). Comparative studies have documented that microbial communities can change in response to soil disturbances (Ovreas and Torsvik, 1998) and differences have been observed between microbial communities in fields with different histories of soil management and plant community structure (Patra et al., 2005). There are lack of literature on the amount and form of soil carbon fraction in the central Indian Himalayas and no studies have been conducted so far to determine the effect of different land use systems on the storages and partitioning of the soil carbon in these ecosystems.

Available nitrogen is produced through a process where more protein and allied compounds of organic matter are hydrolyzed first to ammonium (NH$_4^+$) and then to nitrate (NO$_3^-$) called N mineralization. Ammonium-oxidizing bacteria (AOB) and Nitrite-oxidizing bacteria (NOB) are largely responsible for the net conversion of NH$_4^+$ to NO$_3^-$ in the environment. The rates of nitrogen mineralization and nitrification are quality indicators of soil ability to supply nitrogen for plant (Neill et al., 1995). The nutrient status of soil changes quickly when land under forest or grassland vegetation is brought under cultivation. Therefore, there is a need to characterize the nutrient supplies in central Indian Himalaya land use types in order to have a better knowledge of the rate of supply of nutrients like nitrogen, for practical purposes, for example, in evaluation of sustainability of land use systems (Ghosh and Dhyani, 2005).

Phosphorus (P) is a major growth-limiting nutrient, and unlike the case for nitrogen, there is no large atmospheric source that can be made biologically available (Ezawa et al., 2002). Large amount of P applied as fertilizer enters in to the immobile pools through precipitation reaction with highly reactive Al$_3^+$ and Fe$_3^+$ in acidic, and Ca$_2^+$ in calcareous or normal soils (Gyaneshwar et al., 2002; Hao et al., 2002). However, many soil microorganisms have the ability to solubilize and mineralize P from inorganic and organic pools of total soil P, making the element available for plants. Phosphorus
solubilizing activity is determined by the ability of microbes to release metabolites such as organic acids, which through their hydroxyl and carboxyl groups chelate the cation bound to phosphate, the latter being converted to soluble forms (Sagoe et al., 1998). In the central Indian Himalayan, the diverse vegetation, altitude and acidic soil quality offers an excellent opportunity to explore the hidden phosphate solubilizing microbial population.

Keeping these points in view present investigation was undertaken with the following objectives:

a) To study the impact of land use systems and management practices on microbial community composition and diversity at ecosystem level.

b) To compare the genetic finger prints of bacterial communities in soils of different land use systems.

c) To study the impact of land use and management practices on soil biological and biochemical indicators.

d) To access soil carbon fractions and enzyme activities under different land use system and their relationship.

e) To study the effects of land cover change on nitrogen mineralization and nitrification.

f) To study the phosphomonoesterase activities and phosphorus pools in soils as affected by land use changes and screen potent phosphate solubilizing bacteria.

g) To study the impact of canopy and altitude on soil biochemical indicators and relate them.