Chapter - VII
SUMMARY

Soil is an essential component of terrestrial ecosystems for plant growth, crop productivity and also provides a habitat for diverse and interacting population of soil organisms. The soil organisms have a key role in the cycling and availability of nutrients required by the biological system, the formation of soil organic residues and detoxification of soil components. The development of soil and production of vegetation are so intimately related that it is scarcely possible to study them without the knowledge of the other.

Soil organic matter is the major pool of carbon and nutrients and regulates physical, chemical and biological properties of soil to a large extent. Changes in landuse can have a marked effect on soil carbon contents as a result of the interactions between changes in detrital inputs and subsequent immobilization mediated by soil microorganisms. Such changes are important from the viewpoint of soil fertility and long-term sustainability and for their influence in the environment. Therefore the present study has been undertaken to investigate the physico-chemical, inorganic-N and N-mineralisation under different slash and burn site and abandoned shifting cultivation system.
The study site is located between $24^050'\ N-24^055'\ N$ latitude and $93^045'-93^050'\ E$ longitude in Senapati District, about 14 km from Imphal town at an altitude ranging from 902 to 994 km above mean sea level. The forest is of East Himalayan sub-tropical wet hill forest (Champion and Seth, 1968) and dominated by *Castanopsis tribuloides* and co-dominated by *Quercus dealbata*. The climate is tropical monsoonal with the year distinctly divisible into three seasons, Summer (March-May), rainy (June-October) and winter (November-February).

Four experimental sites were earmarked for the present study. Site-I is a deforested site where slash and burning operation was done by the local people to prepare the burnt patch of land for shifting cultivation and was burnt down two months before the onset of the experimental work in the month of January and thereafter the local people planted maize, lady's finger, cucumber etc., in the slash and burnt site. Site-II is a three year old fallow land; site-III is a seven year old fallow land and site-IV is a natural forest (protected). Soils were collected from depths of 0-10 cm and 10-20 cm in the year March 2004 to February 2006. Soil of the study area was sandy loam in texture and reddish in colour in site-IV and blackish grey in site-I, site-II and site-III.

The soil moisture ranged from 8.45% to 26.80% in the forest site-I, 8.15% to 29.50% in site-II, 9.05% to 28.50% in site-III and
10.00% to 30.10% in site-IV across the soil depths in different months throughout the years. Maximum value of soil moisture was found in rainy season followed by summer season and minimum in winter season in all the study sites in both the year of the study period.

The soil temperature varied from 15.50°C (November) to 28.00°C (August) in site-I, 15.50°C (January) to 23.50°C (August) in site-II, 16.50°C (December) to 24.40°C (August) in site-III, 15.50°C (December) to 23.50°C (July) in site-IV across the soil depths in both the years of the study period.

The bulk density ranged from 1.29 g cm⁻³ to 1.37 g cm⁻³ in site-I, 1.31 g cm⁻³ to 1.40 g cm⁻³ in site-II, 1.34 g cm⁻³ to 1.41 g cm⁻³ in site-III and 1.34 g cm⁻³ to 1.45 g cm⁻³ in site-IV across the two soil depths in different months throughout the two study years.

The soil pH ranged from 4.95 (December) to 6.81 (July) in site-I, 4.80 (November) to 6.30 (July) in site-II, 4.80 (January) to 6.10 (August) in site-III and 4.80 (October) to 5.80 (August) in site-IV across the soil depths in different months throughout the two study years. Highest value of soil pH was recorded in rainy season followed by summer and winter season across the soil depths in both the years of study period except in site-IV in 0-10 cm in the second year of study period where it is summer > rainy > winter.

The soil organic carbon ranged from 0.20% (April) to 4.05% (August) in site-I, 0.14% (November) to 1.55% (August) in site-II.
0.15% (October) to 1.75% (August) in site-III, and 0.16% (April) to 3.66% (August) in site-IV, across the different depths in different months throughout the two study years. Seasonally, maximum value of soil organic carbon was recorded in the rainy season (3.56% for site-I, 0.94% for site-II, 1.21% for site-III and 1.56% for site-IV) across the depths and minimum was recorded in summer and winter season in 0-10 cm and 10-20 cm soil layer respectively in both the years of the study period in all the four study sites.

The total soil nitrogen in site-I ranged from 0.05% (March) to 0.41% (August), 0.03% (March) to 0.18% (August) in site-II, 0.04% (April) to 0.32% (August) in site-III and 0.05% (January) to 0.28% in site-IV across the different soil depths and months throughout the two study years. The total soil N was recorded to be maximum in the rainy season and minimum in summer season in all the four study sites in both the years of the study period except in the depth (10-20) cm where the minimum total soil nitrogen was recorded in winter season.

The total soil phosphorous ranged from 210 µg g⁻¹ of soil (December) to 680 µg g⁻¹ (August) in site-I, 195 µg g⁻¹ of soil (December) to 580 µg g⁻¹ (July) in site-II, 200 µg g⁻¹ of soil (December) to 590 µg g⁻¹ (July) in site-III and 210 µg g⁻¹ of soil (December) to 650 µg g⁻¹ (July) is site-IV. The total soil phosphorous was maximum in the rainy season followed by winter and summer season in both the soil depths in both the years of the study period.
In site-I, NH$_3$-N ranged from 4.20 μg g$^{-1}$ (August) to 14.18 μg g$^{-1}$ (January), 1.76 μg g$^{-1}$ (August) to 10.90 μg g$^{-1}$ (January) in site-II, 3.49 μg g$^{-1}$ (September) to 11.50 μg g$^{-1}$ (February) in site-III and 3.00 μg g$^{-1}$ (August) to 13.15 μg g$^{-1}$ (December) across the years in both the soil depths. Maximum value of NH$_3$-N was found to be in winter season and minimum in rainy season in all the four study sites in both the years of the study period.

NH$_4$-N concentration in different months was significantly correlated with soil moisture, total soil organic C, total soil nitrogen, soil temperature and soil pH in different sites (P<0.05 and P<0.01) in both the year and in both the soil depths.

The NO$_3$-N varied from 3.21 μg g$^{-1}$ (July) to 7.92 μg g$^{-1}$ (January) in site-I, 2.60 μg g$^{-1}$ (August) to 6.80 μg g$^{-1}$ (February) in site-II, 2.50 μg g$^{-1}$ (August) to 7.15 μg g$^{-1}$ (January) in site-III and 2.76 μg g$^{-1}$ (July) to 7.10 μg g$^{-1}$ (January) in site-IV in different months throughout the two years in both the soil depths. Seasonally, maximum NO$_3$-N was found to be highest in winter season and minimum in rainy season in all the four study sites in both the soil depths.

NO$_3$-N concentration in different months was significantly correlated with soil moisture, total soil organic C, total soil nitrogen, soil temperature and soil pH in different sites (P<0.05 and P<0.01) in both the year and across the soil depths.
The inorganic nitrogen ranged from 7.88 $\mu g$ g\textsuperscript{-1} (August) to 22.10 $\mu g$ g\textsuperscript{-1} (January) in site-I, 4.36 $\mu g$ g\textsuperscript{-1} (August) to 17.40 $\mu g$ g\textsuperscript{-1} (January) in site-II, 6.70 $\mu g$ g\textsuperscript{-1} (August) to 18.58 $\mu g$ g\textsuperscript{-1} (January) in site-III, 7.50 $\mu g$ g\textsuperscript{-1} (August) to 20.11 $\mu g$ g\textsuperscript{-1} (January) in site-IV in different months throughout the two years in both soil depths. Seasonally, inorganic-N was found to be maximum in winter season and minimum in rainy season in all the four study sites across soil depths in both the years.

Inorganic-N concentration in different months was significantly correlated with soil moisture, total soil organic C, total soil nitrogen, soil temperature and soil pH in different sites ($P<0.05$ and $P<0.01$) in both the year across the soil depths.

Higher concentration of NH$_4$-N, NO$_3$-N and inorganic-N were recorded in the upper soil layer of 0-10 cm soil depth and the concentration decreased with the increase in the depth of soil in all the four study sites in both the years except in site-I where the NO$_3$-N concentration is significantly higher in the deeper soil 10-20 cm (3.75 $\mu g$ g\textsuperscript{-1} month\textsuperscript{-1} to 7.15 $\mu g$ g\textsuperscript{-1} month\textsuperscript{-1}) than the surface soil layer 0-10 cm (3.21 $\mu g$ g\textsuperscript{-1} month\textsuperscript{-1} to 7.09 $\mu g$ g\textsuperscript{-1} month\textsuperscript{-1}) only in first year of the study period.

The proportion of NH$_4$-N to inorganic-N was on average 66.83% in site-I, 63.09% in site-II, 62.45% in site-III and 66.50% in site-IV.
Comparing the four study sites, it was found that NH$_3$-N, NO$_3$-N and inorganic-N were comparatively higher in the site-I, followed by site-IV, site-III and lowest in site-II in both the year and in both the soil depths.

The monthly variation in the rate of ammonification in site-I ranged from 1.45 $\mu$g g$^{-1}$ (March) to 9.12 $\mu$g g$^{-1}$ (August). In site-II, it ranged from 1.22 $\mu$g g$^{-1}$ (January) to 4.14 $\mu$g g$^{-1}$ (August), in site-III, it ranged from 1.37 $\mu$g g$^{-1}$ (December) to 6.82 $\mu$g g$^{-1}$ (August) and 1.22 $\mu$g g$^{-1}$ (January) to 8.06 $\mu$g g$^{-1}$ (August) in site-IV in both the soil depths in different months throughout the two study years. Seasonally, ammonification rate was recorded to be highest in the rainy season followed by summer season and winter season in all the four study sites in both the soil depths except in site-I where the lowest ammonification rate was recorded in summer season.

The mean annual rate of ammonification was highest in site-I and lowest in site-II in both the soil depths in the first year of the study period. Similar pattern was observed in the second year of the study period. The ammonification rate in different months was significantly correlated with soil moisture, total soil organic C, total soil nitrogen, soil temperature and soil pH in different sites (P<0.05 and P<0.01) in both the year and in both the soil depths.
The rate of nitrification in site-I ranged from 1.44 μg g⁻¹ (December) to 6.81 μg g⁻¹ (July), 1.00 μg g⁻¹ (November) to 6.52 μg g⁻¹ (July) in site-II, 1.00 μg g⁻¹ (November) to 5.01 μg g⁻¹ (July) in site-III and 0.86 μg g⁻¹ (December) to 4.23 μg g⁻¹ (July) in site-IV across the soil depths and in different months throughout the two study years. Seasonally, maximum rate of nitrification was recorded during the rainy season followed by summer season and minimum was recorded during the winter season in all the four study sites in both the soil depths in both the years.

The mean annual nitrification rate in the first year of the study period was found to be highest in site-I followed by site-II, site-III and lowest in site-IV in both the soil depths. Similar pattern was observed in the second year of the study period.

The rate of nitrification in different months was significantly correlated with soil moisture, total soil organic C, total soil nitrogen, soil temperature and soil pH in different sites (P<0.05 and P<0.01) in both the year and in both the soil depths.

The monthly rate of N-mineralisation ranged from 3.63 μg g⁻¹ (December) to 15.70 μg g⁻¹ (August) in site-I, 2.49 μg g⁻¹ (November) to 9.92 μg g⁻¹ (July) in site-II, 2.76 μg g⁻¹ (December) to 11.80 μg g⁻¹ (August) in site-III and 2.78 μg g⁻¹ (January) to 11.80 μg g⁻¹ (August) in site-IV across the soil depths and in different months throughout the
two years of the study period. Seasonally, N-mineralisation was found to be maximum in rainy season and minimum in winter season in all the four study sites except in site-I in the 10-20 cm soil depth in the second year of the study period where minimum N-mineralisation rate was recorded during the summer season.

N-mineralisation rate in different months was significantly correlated with soil moisture, total soil organic C, total soil nitrogen, soil temperature and soil pH in different sites ($P<0.05$ and $P<0.01$) in both the year and in both the soil depths.