Chapter 7

Summary
The importance of nitrogen and its availability has not received due attention specially in tropical forest ecosystems. Although a number of studies have been done on the nitrogen budgets, its transformation from organically bound form into inorganic available form after mineralization has yet to be studied. Further, the soil-litter subsystem which is a gate way to all nutrients and energy has long been observed by ecologists in tropical regions. The present work deals with the process of nitrogen mineralization and nitrification to assess the availability of nitrogen in tropical dry deciduous forest ecosystems in central India. Further, the present study also aims to work out the population dynamics of soil nitrifying bacteria in different seasons to look into their importance in the process of nitrification in these forests.

Three sites viz, mature teak forest (Site I), young teak forest (Site II) and mixed forest (Site III) were selected around Sagar town in Central India. The sites are situated on more or less similar i.e. on basalt formation. Species composition of these sites showed that they were dominated by teak and its associates. The purpose of selection of sites was also such that they can be percieved as different successional stages i.e., different secondary seres.

Soil-litter subsystem was divided into three different layers viz. litter, decomposed and mineralized layers and all the parameters considered for the study were taken separatively from these three layers. Total nitrogen content were estimated at the beginning of study. Soil moisture and pH were measured every time when ever the samples were taken. The incubation method was employed to determine the nitrogen mineralization. In order to achieve a near aproximation to natural conditions, soil sample
were stored on sites in different soil layers. Soil sample taken from different layers were processed for removal of pebbles and roots, and were enclosed in polyethylene bags before replacing them in their respected soil layers. On site storage is usually effected by enclosing the soil samples in polyethylene bags, since these prevent both the absorption by roots and leaching of mineralized nitrogen (N$_{min}$), neither nitrification nor mineralization are impaired. A six week duration was taken for determining mineralization and samples were replaced every six weeks in different seasons. At site II, studies were carried out throughout the year. Apart from the on site incubation, samples were also incubated at room temperature for the incubation. Effect at temperature namely 27 and 37°C was also studied on mineralization.

Population dynamics of soil nitrifiers i.e. *Nitrosomonas* and *Nitrobacter* was studied by MPN method (Most probable number) throughout the season in all the three layers of soil. An attempt has also been made to work out for the quantitative estimation of soil dehydrogenase activity by triphenyl-tetrazolium chloride method. Soil reducing sugar content were also determined to findout its possible relation with the above processes.

Total nitrogen capital bound in litter, decomposed and mineralized layers of soils varied in different sites. The total nitrogen content varied from 0.2 t ha$^{-1}$ to >1 t ha$^{-1}$ in all the three sites. As far as the available or N$_{min}$ content were concerned, statistical analysis revealed no significant differences among sites. However, differences in depthwise N$_{min}$ content were significant. In general both NH$_4$-N and NO$_3$-N were found to maximum amount in rainy and winter seasons respectively, and minimum during summer season. It
was interesting to observe that the total Nmin content were maximum during winter and minimum in summer. Seasonal variations were found having significant differences.

Effect of temperature on availability of NH₄-N showed that high temperature (37°C) caused a decline whereas a slight increase in NO₃-N content was found at 37°C temperature.

Maximum net nitrogen mineralization rates were found during rainy season while these rates were comparatively lower during summer. During winter no mineralization could be estimated expecting a few variations at sites. Maximum net mineralization rates were observed at Site III. Similar trends were found for nitrification rates. It was surprising that at times nitrification was observed without net mineralization. Comparative analysis of laboratory and field incubation methods showed higher rates in the former. Maximum upto 75% net nitrogen mineralization was recovered as nitrification. At times even more than 100% mineralization was recovered as nitrification. The data indicate that the process of nitrification was very much intense in these forests.

Studies pertaining to the population dynamics of soil nitrifiers showed that most probable number count revealed maximum population during rainy season and minimum during winter, However, a clear pattern did not emerge so as to correlate the nitrifier population with mineralization or nitrification processes. Effect of temperature or Nitrosomonas population showed that at high temperature its population declined. On the other hand Nitrobacter population showed an increase. Data revealed a great bearing of moisture content rather than the temperature on nitrite oxidizers. Methodological
considerations showed that MPN technique is not the most reliable method for a number of reasons.

Soil dehydrogenase activity was not found indicative of nitrifier population as the results of the present showed higher activity during summer. Since dehydrogenase activity showed the total microbial respiration particularly those of gram positive group, nitrifiers being a group of gram negative bacteria could not be indicated by this method. The reducing sugar content of the soil showed some correlation with the nitrification. However it was pertinent only for the decomposed layer of the soil.

In general, rate of mineralization and nitrification in the present study observed in tropical dry deciduous forest ecosystems were comparatively higher than those reported from different parts of the world, especially those of the temperate forests. Further, the seasonal variations were marked showing a greater bearing of soil moisture and temperature.

The result when expressed in terms of successional stages showed that rate of mineralization particularly that of nitrification gradually decrease with increasing succession i.e. the secondary successional seres in the present study. Although it seems that results support the inhibition of nitrification by allelochemicals hypothesis proposed by Rice and Pancholy (1972), yet seasonal variation did not support the same. Since effect of allelochemicals were not studied, it is difficult to assertain the cause.

Further, the data of the present study appear to support the hypothesis of dependency of nitrification on mineralization as both the processes showed similar pattern in secondary seres.
Another view may further be considered that at mature stages nitrogen immobilization particularly that of nitrate is more due to absorption by microbial population (Stark and Hart, 1997). It may be the case in the present study.

On the basis of the data obtained in the present study, the following conclusions can be drawn for the tropical dry deciduous forest ecosystems on the nitrogen dynamics:

1. These forest consist of a comparatively higher amount of total nitrogen bound in organic form as well as the mineralized nitrogen.

2. Rate of nitrogen mineralization and nitrification are more as compared to temperate forest ecosystems.

3. Population dynamics of nitrifier population as determined in terms of MPN technique is not very much reliable and can not be correlated with nitrogen mineralization.

4. Similarly, soil dehydrogenase activity cannot be considered to be as indicator of nitrifiers population.

5. The data reveal that in the tropical dry deciduous forest ecosystems, the nitrification process is more intensive hence the loss of nitrate due to leaching could be more.

As the present study provides a base line data for the process of nitrogen mineralization indicating nitrate dominated form of nitrogen, further researches are needed to work out the manifestation of leaching of nitrogen and its deposition in other areas. Nitrogen dynamics in secondary succession is also required for further studies to understand the role of these processes in tropical forests.