INTRODUCTION
Chapter I
INTRODUCTION

Wetlands are distinguished by the presence of water, either at the surface or within the root zone. They are characterized by the presence of hydric soil and support hydrophytes that are adapted to this unique environment. The hydrology of a wetland creates the unique physicochemical condition that makes it a perfect niche for methanogens; forming a major source of methane gas (Mitsch and Gosselink, 2000). Methane is a greenhouse gas that contributes to global warming (IPCC, 1994). Wetlands contribute nearly 20% of the biologically produced methane (Watson et al., 1992).

Wetland have been classified by several authors on the basis of either their location (Cowardin et al., 1979), geomorphology and hydrology (Brinson, 1993a; b) or considering several environmental factors (Gopal et al., 1990). On the basis of environmental factors such as water regime, nutrient supply, main plant forms, and sediments, wetlands could be mires or peatlands (bogs, fens, swamps), temporary wetlands (temporary lakes and marshes) and water bodies (permanent lakes) (Gopal et al., 1990). Wetland soils could be characterized on the basis of their organic matter content. Mineral soils are poor in organic matter (less than 35% on a dry weight basis) content and found in rice fields whereas organic soils are rich in organic matter (more than 35% on a dry weight basis) and generally found in peatlands. Quantitatively half of the organic matter in a soil is composed of organic carbon that forms the major substrate for methanogens (Mitsch and Gosselink, 2000).

In wetlands the submergence of land initiates a chain of reactions wherein a consortium of different species of microbes act upon the available substrates one after another or together in the order of their potential to utilize hydrogen ions (DeLaune et al., 1983; Lovely and Klug, 1986; Bartlett et al., 1987; Lovely and Phillips, 1986; Burdige, 1993; Roden and Wetzel, 1996). According to sequential oxidation-reduction order, molecular $O_2$ is the first to be reduced at an Eh of about +30 mV followed by $NO_3^-$ and $Mn^{4+}$ at 250 mV, $Fe^{3+}$ at +125 mV and $SO_4^{2-}$ at -150 mV. Subsequent to $SO_4^{2-}$ reduction, methanogens will start producing methane at -150mV.
(Jakobsen et al., 1981; Patrick and Reddy, 1978; Ponnamperuma, 1972). This interaction is complex wherein the microbes have a competitive as well as symbiotic interaction.

Methanogens play a key role in the terminal step of C mineralization (Woese et al., 1978). Methanogens are basically C1 users and they are grouped according to their preference of substrate usage. They are either hydrogenotrophic \( \left( \text{H}_2/\text{CO}_2 \right) \) or acetoclastic (acetate) depending upon the substrate they mineralize (Kelly & Chynoweth, 1981; Zehnder, 1978; Schink, 1992 Thauer, 1998). Studies show that these groups of methanogens vary in different wetlands and in different depths too (Popp et al., 1999; Svensson, 1984; Whiticar et al., 1986; Avery Jr. et al., 2002; Lansdown et al., 1992; Horn et al., 2003).

As any other life process, methanogenic activity is also influenced by the change in temperature (Svensson, 1984; Moore and Knowles, 1987; Crill et al., 1988). Earlier studies have shown the optimum temperature of potential methane production to be far higher than the in-situ temperature (Zeikus and Winfrey, 1976; Schulz et al., 1997; Avery Jr. et al., 2002).

Plants transport the gas produced in the anoxic soil through the interconnected air-spaces in their tissues to the atmosphere. Different species of plants vary in their capacity to transport methane (van Veen et al., 1989; Whiting and Chanton, 1992; Minoda and Kimura, 1994). Plants of same species grown in different soil types may also vary in their capacity to emit methane. The probable underlying cause could be the variation in the methanogenic activity with the change in substrate quality and quantity corresponding to the change in soil types. Plants also influence the methanogenic activity antagonistically. The root exudates in the rhizospheric zone are rich in substrates that promote the methanogenic activity (Marschner, 1995; Kimura et al., 1997). At the same time oxygen is transported to the rhizosphere; which reduces the viability of the strictly anaerobic methanogens (Chanton and Dacey, 1991; Chanton et al., 1997; Watson et al., 1997; Frenzel, 2000).
Methane oxidation occurs in oxic zones like rhizosphere, soil-water interface and even on aboveground parts of plant. Most estimates for the quantitative importance of methane oxidation have been studied in rice plants. In rice plants, the amount of methane oxidation is attributed to plant associated methane oxidation. Rates vary widely between 30 and 90% of total methane production (Banker et al., 1995; Bosse and Frenzel, 1997; Denier van der Gon and Neue, 1996; Gilbert and Frenzel, 1995; Holzapfel-Pschorn et al., 1985, 1986; Sass et al., 1990; Schutz et al., 1989).

The flooding of soil is a pre-requisite for methane production but methane emission from plants is also affected by the change in the water level suggesting that the water height above the soil surface and the overlying pressure also influences methane emission (Orawan and Suphasuk, 2002).

Thus, methane release from wetlands is controlled by several environmental parameters and is the net result of both production and consumption (Conrad, 1989). A detailed study to characterize the gas, its sources and sink as well as factors that govern the production and its escape to the atmosphere is a priority throughout the world. In India, National Methane Campaign was set up at 1991 to quantify methane produced from the ricefields across the country (Parashar et al., 1996). Over the past few years studies on methane emission from natural wetlands such as mangroves (Purvaja and Ramesh, 2001; Purvaja et al., 2004) and estuaries (Verma et al., 2002) have been reported but the major focus still remains on ricefields. As methane production and emission from wetlands other than rice fields are poorly studied in the Indian subcontinent, the present study was undertaken in two natural wetlands differing in organic matter content. The occurrence of peat soil is limited to few pockets in the upper Himalayan region. Lake Khajjiar in Himachal Pradesh rich in peat soil represents the natural wetland containing higher organic matter. On the other hand, Lake Bhalswa on the outskirts of Delhi, is a wetland that contains mineral soil. The above wetlands were selected to study the factors regulating methane production and emission. The influence of factors like organic matter content, temperature, presence of electron acceptors on methane production was studied from soils at the above sites. The role of the dominant vegetation present at both the sites on methane emission was studied. In addition, the influence of different water depth and different organic matter content on methane emission from *Scirpus* plants was also estimated.
Aim and Objectives of the study

The specific aim and objectives of the study include:

I. Assess the role of dominant plants in methane emission present in Lake Khajjiar.

II. To investigate the diurnal rate of methane emission from *Scirpus* plants subjected to different hydrological and edaphic conditions.

III. To investigate the effect of different nature of organic matter and soil on the rate of methane emission.

IV. To investigate the effect of water regime on methane emission.

V. Determination of the influence of temperature on the rate of methane production from two natural wetlands.

VI. Identification of the dominant pathway of methane production in two natural wetlands and molecular characterization of methanogens from Lake Khajjiar at different temperatures and soil depth.

VII. Study the response of methanogens in the presence of alternate electron acceptors (added externally) from two natural wetlands.