CHAPTER 1

INTRODUCTION

Carbon dioxide (CO_2) is the most abundant greenhouse gas (GHG) in the atmosphere accounting for 76% of total GHGs [1]. Elevated atmospheric CO_2 strongly influences the ecosystem functions such as C sequestration and nutrient cycling owing to its impact on soil microbial communities [2-4]. Thus, emission of CO_2 from various ecosystems has become one of the growing concerns and the key issues in ecology and global change research [5-7]. Soil respiration is the amount of CO_2 released from the soil due to decomposition of soil organic matter (SOM) and plant respiration. It is considered as one of the most significant sources of atmospheric carbon and ranks second to the gross primary production of CO_2 in terms of magnitude [8-9]. Changes in soil respiration leads to the disruption in the equilibrium of the terrestrial C cycling and eventually affect the ecosystem carbon flux [10-11]. Carbon in soil may occur in both organic and inorganic forms. The soil organic carbon content (SOC) is approximately three times higher than that of atmospheric or terrestrial vegetation pools [12]. These includes decomposed plant biomass, soil macro and microorganisms apart from other carbon containing organic compounds (sugars, carbohydrates, starches, proteins, lignins, resins, waxes and organic acids). Based on their rate of degradability, SOC can be classified as labile or fast turn over and recalcitrant or slow turnover C pools [13-14]. Labile SOC fractions are easily utilised, whereas recalcitrant carbon compounds are arduous to decompose by soil microbes [15]. Thus, microbial driven preferential decomposability of SOC fractions leads to variability in soil respiration especially the heterotrophic respiration.

Forest soil consists of greater than two- third of the total soil organic carbon reserve. This accounts 80% of the surface and 40% of the sub-surface global carbon stocks [16-19]. The soil carbon stock of forest is primarily derived from decaying plant tissues, and root exudates. The decaying process is facilitated by soil microorganisms, which are in dynamic equilibrium with climatic variables [20]. Microbial biomass as well as the composition and structure of bacteria, archaea, and fungal community contribute to the SOC stock through production of biomass. They also release the stored C through processes like decomposition and respiration [16]. Besides the microbial biota, clay mineralogy is important in retention and stabilization of SOC and has much relevance in the global C cycle [21].

Assessment of biospheric carbon fluxes in light of rising atmospheric CO_2 concentration is crucial to understand the carbon sequestration behaviour of an ecosystem. The average residence time of carbon in soils spans from a couple of hours to millions of years [22-23].

Sequestration of organic carbon in forest ecosystems is frequently caused by a slight difference in photosynthetically fixed carbon and ecosystem respiration [24-25]. Total soil respiration is primarily composed of autotrophic and heterotrophic respiration, which respond differently to abiotic and biotic factors [26-29]. Heterotrophic respiration or carbon mineralisation is caused by decomposition of SOM and is primarily governed by the SOC content and metabolic rate of the organisms involved in the process [30-31]. One of the primary causes of global CO_2 emissions from the terrestrial ecosystem is release of carbon via heterotrophic respiration [32]. The mineralisation of stable organic carbon, which comprises 52-98% of the total SOC pool is governed by the present environmental conditions and soil properties [33-37]. Thus, estimation of carbon fluxes from the terrestrial ecosystem necessitates an understanding about the correlation of SOC mineralisation with the climatic factors [38]. Furthermore, the binding strength of organo-mineral associations influences mineralisation rate [39-41]. Clay minerals adsorbed the OC through mechanisms such as electrostatic, H-bonding, hydrophobic, ligand exchange, and π-bonding interactions, and protects the OC against microbial attack [41, 42]. Studies have been conducted at various scales to investigate the SOC stocks as well as potential drivers of SOC mineralisation [43-46]. Climate and vegetation type are extensively documented as the key drivers of SOC mineralisation on larger scales (e.g., globe and continent) and are incorporated in Earth system models [47-48]. Whereas, soil properties such as soil temperature and moisture content account for the majority of the seasonal variation [26, 49-50]. Other factors such as rain events, rewetting of the soil following a period of drought and litter moisture might cause short-term temporal variability [51-53]. Soil microorganisms are extremely sensitive to the seasonal changes in plant residues, root structure and growth, secretions released in root exudates, or decomposition of organic material inputs. Earlier studies have documented large spatial variability in CO_2 efflux due to biotic and abiotic factors. Vegetation characteristics, microbial biomass, root density, root biomass and quality and quantity of organic matter are the biotic factors affecting CO_2 efflux [54-58]. Abiotic factors such as soil texture, and total porosity also play a vital role in SOC dynamics on a relatively smaller scale (e.g., a few hundred ha) by influencing gas diffusion and biological activity [44, 46, 59-62].

Several studies on soil CO_2 flux from different ecosystem of the world such as temperate forest [63-64], tropical forest [65-66] agricultural ecosystem [67], subtropical montane forest [68], subtropical forest [69-70], Mediterranean ecosystems [71], steppe semi-arid ecosystem [72], boreal forest [73], tropical savannas [74], mixed forest [75], bamboo forest ecosystems [76-77], grassland ecosystem [78-79] and dipterocarpus forest [80]. are available. However, these findings are unlikely to be exemplary in the context of Indian forest ecosystems because of their differences in physiography, vegetation pattern and climatic regime. Moreover, there is lack of information on soil CO_2 flux rate under different land-use patterns of NE India. Earlier studies from a NE Indian forest namely Kaziranga National Park (KNP) reported lower annual Net Ecosystem Productivity (NEP) as compared to other similar studied ecosystems of the world. This might be because of higher ecosystem respiration and lower leaf area index of the forest [25]. Whereas, information on soil properties substantiating the recorded lower NEP is lacking which might be a vital information in understanding the mechanism. Findings of this study will help to know the effect of soil properties (at different ecosystems of KNP) in regulating the seasonal CO_2 flux. This will provide an idea about the impact of changing climate on CO_2 flux of a tropical semi-evergreen forest like KNP.

Hypothesis of the study:

- Soil physico-chemical, biological and mineralogical properties influence the CO_2 efflux behaviour at Kaziranga National Park.
- Variation in soil CO_2 efflux behaviour occur across the three seasons and ecosystems due to changes in soil properties.

Objectives of the study:

- ➢ To study the soil physico-chemical and biological characteristics of Kaziranga National Park (KNP) at seasonal scale.
- ➢ To assess the soil mineralogy of KNP and their role on SOC stabilization and C sequestration.
- ➢ To correlate the influence of soil properties in regulating CO_2 efflux from KNP.

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