International Journal Of Scientific And University Research Publication

ISSN No **2364\2018**

Listed & Index with

ISSN Directory, Paris

Multi-Subject Journal

Volum : **(3)** | Issue : **211** |

INTERNATIONAL JOURNAL OF SCIENTIFIC AND UNIVERSITY RESEARCH PUBLICATION

IJSURP International Journal Research

www.ijsurp.com

Research Paper

ABIOTIC FACTORS INFLUENCES SOIL CARBON DIOXIDE FLUX IN THE SUB-TROPICAL FORESTS, MANIPUR, NE INDIA

Scientist Mariane

ABSTRACT

Seasonal variations in the soil CO2 flux were studied in two forest stands of sub-tropical forests in Senapati district of Manipur from April 2011- March 2012. The rate of soil CO2 flux was measured using alkali absorption method. The soil CO2 flux ranged from 69.655 to 382.194 mgCO2m-2hr-1 and 72.297 to 392.985 mgCO2m-2hr-1 for forest stand I and II respectively in different months throughout the year. The soil CO2 flux rate was recorded to be maximum during rainy season followed by summer season and winter season. The significant positive relation in soil CO2 flux rate and abiotic factors i. e. soil moisture, soil temperature, relative hu- midity, mean air temperature and rainfall shows that soil CO2 flux rates were highly influenced by abiotic factors in the sub-tropical forests of Manipur, N.E. India.

KEYWORDS :

INTRODUCTION

Atmospheric CO2 concentration have been increasing in re- sponse to the disruption of the global carbon cycle by anthropo- genic activities such as deforestation, agricultural practices and burning of fossil fuels. This results in large changes in the car- bon pools. A forest in particular plays an important role in car- bon cycle, as they contain respectively 80% and 40% the above ground and belowground global carbon stock (Dixon et al, 1994) [16]. Carbon dioxide is released from the soil through soil respi- ration which involves three biological process namely faunal res- pirations, microbial respiration and root respiration. Root respi- ration is one of the main fluxes in the global carbon cycle since soil is a major carbon reserve in the terrestrial ecosystems. Since soil respiration is directly related to both microbial and root ac- tivities, its temporal and spatial variations are largely controlled by environmental factors such as precipitation, soil moisture and temperature (Phongthep Hanpattanakit et al, 2009)[12]. The seasonal variability is mostly explained by soil temperature and soil water content. Seasonal changes in soil microclimate play a key role in defining seasonal differences in soil carbon dioxide emission within sites and climatic differences generate differ- ent soil respiration rates among distant sites (Raich and Potter,1995)[13].

The soil CO2 flux varied in different ecosystem depending upon the different environmental conditions. Many studies have been done to quantify soil carbon dioxide emission of different eco-

systems and to understand the influences of abiotic variables on soil carbon dioxide emission [2],[3],[4],[5],[6]. So the objective of the present study is to investigate the monthly changes in the emission of CO2 from the forest soil and effect of soil tempera- ture, soil moisture and relatively humidity of air on CO2 emission.

Materials and methods

Description of study sites

Two forests sites were earmarked for the present study. The for- est stand I is situated at Sauntak Molnom at 25003’ N latitude and 93055’ E longitude at an altitude 988m above mean sea level in Senapati District at a distance of 36 Km from Imphal City. The forest stand II is located at 24055’ N latitude and 93048’E longitude at an altitude of 1294 m above mean sea level at Kon- shram Konshakhul in Senapati district of Manipur at a distance of 32 Km from Imphal city. The climate of the area is monsoonic with warm moist summer and cool dry winter. The mean maxi- mum temperature varied from 25.80C (January) to 34.50C (Sep- tember) and mean minimum temperature ranged from 2.40C (January) to 21.30C (June). The mean annual rainfall is 1230.9 mm. The average relative humidity of air varied between 54%

(February) to 79% (August). The study was conducted during the 2011-2012. Soils of the study area were sandy loam in texture and reddish in colour in forests stand I and blackish brown in forest stand II. Forest stand I is dominated by Quercus serrata and Schima wallichii and is situated at the base of the hill. For- est stand II is dominated by Ficus virens and Cinnamomum zey- lanicum.

Sampling and analysis

Soil PH was determined by (1:5; soil water suspension) by a PH meter (Systronics). Soil bulk density is weight of oven dry soil per unit volume which is usually expressed in gcm3. The soil tex- ture was analysed by International pipette method of mechani- cal analysis (Gee and Bauder 1986). The soil organic carbon was estimated by Walkley- Black method[1]. Total soil nitrogen was measured using 2100 Kjeltec system and available soil phospho- rus was determined following the method given by Bray and Kurtz (1945).

10 plots of 1mX1m size quadrat in each forest sites were laid down randomly and previously accumulated litter on the floor was cleared. Litterfall was collected at the end of every month with the help of a plastic bag. The litter was brought to the labo- ratory and oven-dried at 800C for 48hrs and dry weight is meas- ured.

Soil CO2 emission was measured by alkali absorption method (Anderson 1982). An open ended aluminium cylinder (25cm tall and 13cm diameter) was inserted into the soil up to 15 cm depth. Six identical cylinders were used in each of the forest sites. Fifty ml of 0.25N NaOH solution in each cylinder was main- tained for 24 hours and all green vegetation inside the cylinder was removed. After 24 hours the alkali was titrated with 0.25N HCl solution using Phenolphthalein as an indicator. CO2 ab-

sorbed from the soil was calculated using the formula proposed by Anderson and Ingram (1993):

VxNx22= CO2 mg

where V= volume of HCl, N=Normality of HCl.

Results

The soil was sandy loam in which 68.83% is sand, 18.66% silt and 12.26% clay in forest stand I and in forest stand II 72.73% is sand, 16.66% silt and 10.66% clay. Soil moisture varied from

19.88% to 46.76% and 17.98% to 36.89% in forest stand I & II respectively. Soil temperature varied from 13.360C to 22.680C in stand I and 11.340C to 21.360C in stand II. Soil pH ranged from

4.35 to 4.71 and 5.17 to 5.57 in forest stand I and II respectively. (Table 1)

Table 1: Abiotic variables of soils in forest stand I and stand

Abiotic variables	Stand I	Stand II
Soil temperature(0C)	18.92	17.59
Soil Moisture (%)	31.58	28.515
Soil texture	Sandy loam	Sandy loam
Sand (%)	68.83	72.73
Silt (%)	18.66	16.66
Clay (%)	12.26	10.66
Bulk Density(gcm-3)	1.279	1.33
Soil PH	4.35-4.71	5.17-5.57
Organic Carbon (%)		
Total Nitrogen (%)		
Available Phosphorus (%)		

C/N Ratio

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Fig. 1 Monthly variation of litter fall rate in Forest stand-Iand Forest stand-II

Litter fall rate varies from 23.58gm-2 (July) to 138gm-2 (February) and 28.7gm-2 (August) to 137.08gm-2 (February) in site I and II respectively for different tree species. The total litter fall rate was recorded to be 7.89t ha-1 yr-1 for site I and 7.49t ha-1 yr-1 for site II. (Fig. 1)The litter fall rate is maximum in the month of Febru- ary in both the forest stand. Then the rate of litter fall decrease consistently upto July in stand I leading to minimum litter fall

450
400
350
300
250
200
150
100
50
0

Forest stand-I Forest stand-II

A'11 M J J A S O N D J'12 F M

Months

and then increases thereafter. In forest stand II the minimum litter fall was observed in the month of August which thereafter increases until maximum. The difference in the two stands may be due to difference in species composition.

Fig.2. Monthly variation of soil CO2 emission rate (mg CO2 m-2 hr-1) in Forest stand-I and Forest stand-II

Season		Stand I
Summer (March – May)		180.5[illegible]8
Rainy (June – October)		392.9[illegible]
Winter(November-February)		112.9[illegible]6
Mean Annual		220.2[illegible]

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6

2

Table

Seasonal variation in soil CO2 emission rate (mg 2 2

The soil CO

flux ranged from 67.69 to 382.35 mg CO m-2 hr-1and**CO m-2 hr-1) in Forest stand-I and Forest stand-II** 2

74.60 to 394.88 mg

CO m-2hr-1

forest stand I and II respectively.Maximum CO2 flux rate were recorded in the month of August in both the forest stands which then decreased consistently till Jan- uary and thereafter increased (Fig 2). Seasonally, the mean CO2 flux rate was recorded maximum during rainy season followed by summer season and winter season. The soil CO2 flux rate cor- related positively and significantly with abiotic factors viz., soil moisture, soil temperature, relative humidity, mean air tempera- ture and rainfall in both the forest stands I and II (Table3). The variability in soil CO2 flux was recorded to be 88.1% and 82.0% due to soil temperature and soil moisture respectively in forest stand I and 88.3% and 72.4% due to soil moisture and soils tem- perature respectively in forest stand II.

Parameters	Stand I	Stand II
Soil moisture (%)	0.829	0.871
Soil Temperature 0 (C)	0.938	0.850
Relative Humidity (%)	0.828	0.798
Mean Air Temperature (0C)	0.880	0.825
Rainfall	0.647	0.586

Table 3: Correlation coefficient (r) for the relationship of soil CO2 emission rate with the abiotic variables measured in the two forest stands 2 2

The relationship between rate of soil CO flux (mg

CO m-2hr-1)

and soil properties, i.e. soil temperature (X1), soil moisture (X2) and soil organic carbon (X3) has been analysed by multiple re- gression in both the study sites and is summarized as follows:Site-I

Y= -655.568 + 11.29X1 + 2.804X2 + 402.179X3, (r1 = 0.93; r2 = 0.90; r3 = 0.52) at P< 0.05.

Site-II

Y= -794.313 + 3.892X1 +3.116X2 + 532.890X3, (r1 = 0.85; r2 = 0.93; r3 = 0.51) at P< 0.05.

NS- not significant; P<0.05

Discussion

The study shows that there is significant positive relationship between soil CO2 flux rates and abiotic variables. Soil moisture, soil temperature and soil organic carbon has strong influence on the release of CO2 into the atmosphere from the soil in both the ecosystems. Similar findings have also been reported in different ecosystems by several workers.[2],[3],[6],[7],[10].

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RESEARCH

Research Paper
Volume : 4 | Issue : 5 | May 2015 • ISSN No 2277 - 8179

The soil CO_2 flux shows negative relationship with the litter fall in different months in both the forest stands. There is a sig- nificant high litter fall during the dry and cool winter season as compared to the rainy season. But on the contrary soil CO_2 emission is minimum during winter and maximum during rainy season. Thus this shows that monthly plant litter fall does not show any effect on soil CO_2 emission.

The rate of soil CO_2 flux was recorded to be maximum in the month of August in both the forest stands as the micro flora and micro fauna becomes active due to availability of higher soil moisture coupled with soil temperature. The decomposition of plant litter enhanced during this period thereby increasing the rate of soil CO_2 flux. The rate of soil CO_2 flux was recorded to be minimum in the month of January in both the forests stands which may be due to low moisture content of soil and tempera- ture thereby inhibiting the microbial activity and decomposi- tion (Devi and Yadava, 2006)[4].Thus leading to low carbon di- oxide emission. Thereafter there is a consistent increased in the soil CO_2 flux till August which may be due to high temperature and soil moisture with the onset of summer season. The differ- ence in the rate of soil CO_2 flux in the two forests stands may be due to the difference in the diversity of micro flora, micro fauna and tree species. The mean soil CO_2 emission rate was found to be higher in the forest stand I as compared to forest stand II which may be due to higher soil moisture and higher soil tem-

perature thereby enhancing the rate of higher microbial activity. A maximum rate of soil CO_2 flux in either spring or early sum- mer season has been reported by several workers (Davidson et al, 2002[2], Laishram et al, 2002[9], Rastogi et al, 2002[15]). On the contradictory to their finding, we found a maximum rate of soil respiration in rainy season. Similar trend has also been re- ported by Devi, N.B. and Yadava, P.S. 2008 in a Subtropical Mixed Oak Forest of Manipur, North-eastern India [3]. Several reports on high soil respiration rate in wet season are also exist (Kursar

1989, in a lowland moist forest panama[8]; Rajvansi and Gupta

1986 in Tropical Dalbergia sisoo forest[14]; Savage and Davidson

2001 in Harvard forest[18]; Saraswathi et al, 2008, in a semi-arid soil of India[17] which are in conformity with our observations. An increased in soil respiration rate immediately after the rain-

fall events have also been reported (Holt et al, 1990[5] and Law et al, 2001[11]. In both the forest stands a high correlation shows that soil CO_2 emission is positively affected by soil moisture, soil

temperature, relative humidity, mean air temperature and rain-

fall. However soil temperature and air temperature have strong influenced on soil CO_2 flux in comparison to other factors i.e., by soil moisture, relative humidity, and rainfall in forest stand I. In forest stand II soil moisture and air temperature have strong in- fluenced on soil CO_2 flux as compared to other factors.

CONCLUSION

The rate of soil CO_2 flux was recorded to be maximum in the month of August in both the forest stands as the micro flora and micro fauna becomes active due to availability of higher soil moisture coupled with soil temperature. The decomposition of plant litter enhanced during this period thereby increasing the rate of soil CO_2 flux. The rate of soil CO_2 flux was recorded to be minimum in the month of January in both the forests stands which may be due to low moisture content of soil and tempera- ture thereby inhibiting the microbial activity and decomposi- tion (Devi and Yadava, 2006)[4].Thus leading to low carbon di- oxide emission. Thereafter there is a consistent increased in the soil CO_2 flux till August which may be due to high temperature and soil moisture with the onset of summer season. The differ- ence in the rate of soil CO_2 flux in the two forests stands may be due to the difference in the diversity of micro flora, micro fauna and tree species. The mean soil CO_2 emission rate was found to be higher in the forest stand I as compared to forest stand II which may be due to higher soil moisture and higher soil tem- perature thereby enhancing the rate of higher microbial activity. A maximum rate of soil CO_2 flux in either spring or early sum- mer season has been reported by several workers (Davidson et al, 2002[2], Laishram et al, 2002[9], Rastogi et al, 2002[15]). On the contradictory to their finding, we found a maximum rate of soil respiration in rainy season. Similar trend has also been re- ported by Devi, N.B. and Yadava, P.S. 2008 in a Subtropical Mixed Oak Forest of Manipur, North-eastern India [3]. Several reports on high soil respiration rate in wet season are also exist (Kursar
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