B-51.2.2 Field Experiment of the Budget of the Emission/Absorption of CH_4 and N_2O by Land-Use/Cover Change in Tropical Asia*

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Total Budget for FY1996-FY1998 71,814,000 Yen** (FY1998; 24,522,000 Yen)

Abstract

The purpose of this study is to evaluate the influence of land-use/cover change in tropical Asia on the greenhouse gas emissions. An intensive field experiment has started in humid tropical forests in Jambi, Sumatra of Indonesia since January 1997, in collaborating with BIOTROP-GCTE-IC-SEA of Indonesia. The three sites of primary and logged-over forests, a site clear-cut and burned before one year, and a rubber plantation site in a small holder were selected to measure the fluxes of carbon dioxide(CO_2), methane(CH_4), and nitrous oxide(N_2O) from the soil surface to the atmosphere. At all the sites, CO_2 and N_2O were emitted from the soil to the atmosphere, while CH_4 was absorbed to the surface soil except for one site. An incubation experiment was also performed to measure the potential of emission/absorption of greenhouse gases by using the soils at the field sites. The CO_2 and N_2O emission rates were highest in the surface soil (a depth of 0-5cm) in comparison with those in the deeper soil (a depth of 10-25 cm), while the uptake rate of CH_4 was lowest in the surface soil. Both of field and incubation experiments demonstrated that the emission/absorption rates of greenhouse gases were significantly affected after deforestation, and suggest that those rates would be recovered slowly after plantations to the same level as before deforestation. The first field measurement of greenhouse gas emission in peat wetlands was carried out in Banjalmasin, Kalimantan, in Dec. 1998. The N_2O flux to the atmosphere was very high at a site where the concentration of NH_4^+-N was high in the soil possibly due to fertilisation, while the CH_4 fluxes to the atmosphere at all four sites were low compared with in the Amazon.

Keywords: land-use/cover change, humid tropical forests, peat wetlands. greenhouse gases, emission

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* Two sub-programs which had been conducted until 1997 were combined to this sub-program in 1998 , the one was the sub-program B-9.1 entitled "Impacts of Land-Use Change on Greenhouse Gas Emissions in Asia-Pacific Region" since 1996, and the another one was as B-16.1.1 entitled "Studies on Development of Reduction Techniques for Methane and Nitrous Oxide Emissions from Agricultural Fields" since 1995.

** The total budget summing up the two sub-programs described above for three years(1996-1998).

1. Introduction

Land-use/cover change in Asia-Pacific region has been rapidly occurring since 1970's, and forest area has been converted to agricultural fields and plantations. The influence of land-use change on the emission/absorption of greenhouse gases has not been studied in Asia-Pacific region, although the IPCC report(1994) pointed out the possible impacts of the deforestation in tropical regions on global warming. We have started an intensive field program on the influence of land-use/cover change on greenhouse gas emission/absorption since 1997, in collaboration with BIOTROP-GCTE-IC-SEA in Indonesia after a State of Understanding (SOA) was contracted between Indonesia and Japan. In the end of this project, a Workshop on land-use/cover change and greenhouse gas emissions in humid tropical environments was held in Bogor, Indonesia, during 12-13 February 1999, and the major findings from this field experiment was reported at the Workshop.

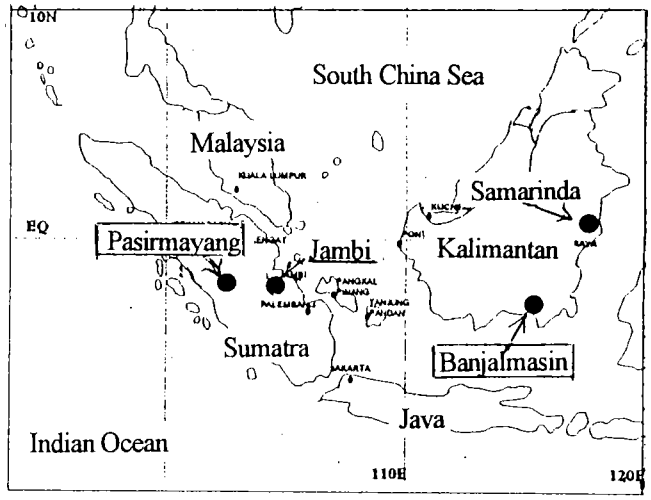

Fig. 1 Sites of field measurement in Indonesia

2. Research Objectives

The purpose of this study is to evaluate the influence of land-use/cover change on the emission/absorption rate of greenhouse gases in tropical Asia, by selecting two research areas in Indonesia. One site was humid tropical forests located in the central part of Sumatra where the forests have been rapidly clear-cutting and burned for plantations, and the another site was peat wetlands located in the southern part of Kalimantan, because peat wetlands have been also developed for agriculture (Fig. 1).

Table 1 The characteristics of 5 sites in Pasirmayang in Jambi, Sumatra

Site	P1	L1	L2	O	R
Land use	primary forest	logged over clear-cut (Feb. 1998) burning (Mar. 1998)	logged over	clear-cutted	rubber
geography	gentle middle slope	gentle upper slope	flat flat	flat top	flat flat
Setting Date	Jan. '97	Jan '97	Sep. '97	Jan '97	Sep. '97
plantation		*Paraserianthes*		*Gmelina arborea*	rubber
Remarks	protected		protected	clear-cutted in 1996	Alan-alan

3. Experimental design

3.1. Humid tropical forests in Jambi, Sumatra

The field experiment for greenhouse gas flux has started since 1997 in and around a forest research station in BIOTROP located in Pasirmayang, Jambi province, Sumatra (Fig. 1). The 6 sampling sites have been fixed, i.e., the sites P1 and P2 in primary forests, L2 and L1 in logged-over forests, O in cutting and burned area, and R in rubber plantation in a small holder, as listed in Table 1. In February and March 1998, the logged-over forest including the site L2 was clearly cut and burned, and "Paraserianthes" was planted. The logged-over forests is defined as forests which has a recent history of cutting and burning. The fluxes of CO_2, CH_4 and N_2O from the surface soils to the atmosphere were measured every month by closed chamber method since September 1997 except for February, April and May 1998. Soil temperature and soil moisture content were also measured in addition to the flux measurement. The chemical and physical analyses of the soils sampled at the sites were performed. The emission/absorption potential of greenhouse gases in the soils collected at three different depths below the surface were measured by incubation experiment.

3.2. Peat Wetlands in Banjalmasin, Kalimantan

In December 1998, the first field measurement was conducted to measure the fluxes of CH_4 and N_2O in peat wetlands in Banjalmasin, in the southern part of Kalimantan, Indonesia (Fig.1). The incubation experiment by using peat soils collected at several sites was performed for further analysis of production/consumption potentials of greenhouse gases in the peat soils.

4. Results and Discussion

4.1. Greenhouse gas emission/absorption in humid tropical forests

4.1.1. Seasonal variation of N_2O and CH_4 fluxes

The seasonal variation of N_2O and CH_4 fluxes at 6 sites are shown in Fig. 2. At all the sites, N_2O emitted from the surface soil, while atmospheric CH_4 was absorbed to the surface soil except for P2 where CH_4 emitted frequently to the atmosphere. There was no apparent seasonal variation in the fluxes of N_2O and CH_4. On the contrary, the CO_2 flux showed a clear seasonal variation, which was higher in wet season and lower in dry season, and the detail was described in a sub-program of B-51.1.1 in this report. The flux of N_2O at P1 and R was lower than those measured in the other tropical region[1]. At the site L1, however, the N_2O flux drastically increased after cutting and burning in Feb.-Mar. 1998, as shown in Fig. 2.

4.1.2 Long-term trend of N_2O, CH_4 and CO_2 fluxes due to land-use change

The five sites were re-arranged in order of P1, L2, L1, O and R, following land-use change in tropical Asia. The long-term trend of greenhouse gas fluxes due to land-use change was estimated by using the annual mean flux at these sites, as shown in Fig. 3. The N_2O emission rate which is very low in primary forests drastically increases after clear-cutting and burning, and then decreases in rubber plantation to the same level as that in primary forests. The CH_4 uptake rate which is higher in primary forests decreases after clear-cutting and burning, and increases again in rubber plantation. The long-term trend of CO_2 which decreases after deforestation is different from that of N_2O emission and CH_4 uptake. The major factors which control the systematic change in flux will be analyzed in detail in future..

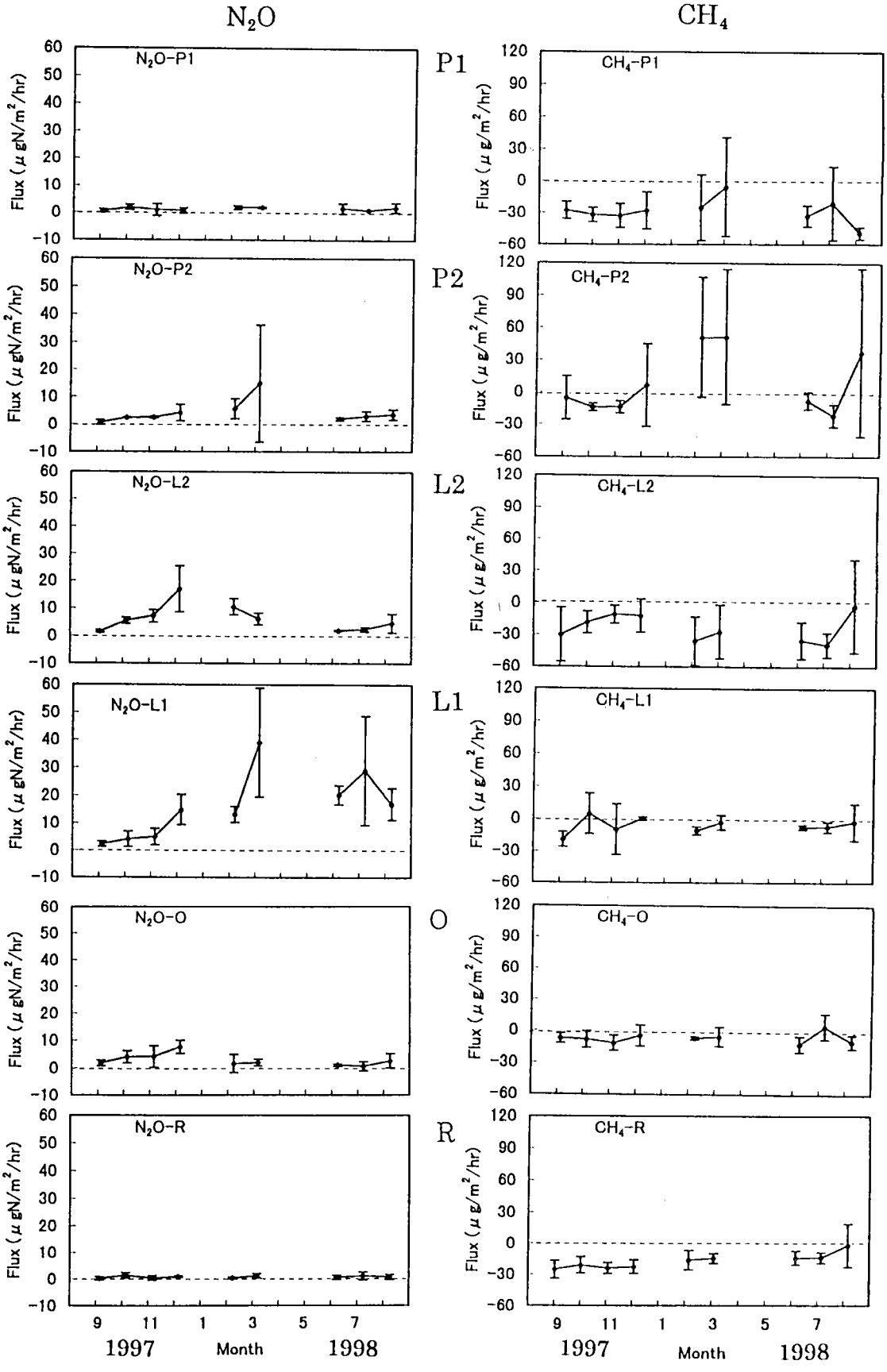

Fig. 2 Seasonal variation of N_2O and CH_4 fluxes at 6 sites (P1, P2, L2, L1, O, R) in Pasirmayang. (September 1997-August 1998)

4.1.3 Potential of N_2O and CO_2 emissions and CH_4 uptake rates by incubation experiment

The potential of emission/absorption rate of greenhouse gases was measured by soil incubation experiment. The incubation experiment showed that the N_2O emission potential was lowest in the soils of P1 and R, and the potential of CH_4 uptake was lowest in the soils of O. These results by incubation experiment were consistent with those from the flux measurement of greenhouse gases in the field experiment described in the previous section. The potential of N_2O and CO_2 emission rates was higher in the surface soil of a depth of 0-5cm than in the deeper soils, while the potential of CH_4 uptake was lowest in the surface soil.

The long-term trends of emission/absorption of greenhouse gases were estimated due to land-use change by the incubation experiment. The patterns of long-term trend of emission/absorption rates were almost equal to those which were estimated independently by the measured flux data in the field experiment. Both of experiments suggest that microbial activity affected by clear-cutting and burning will recover slowly after plantation to the same level as that before deforestation.

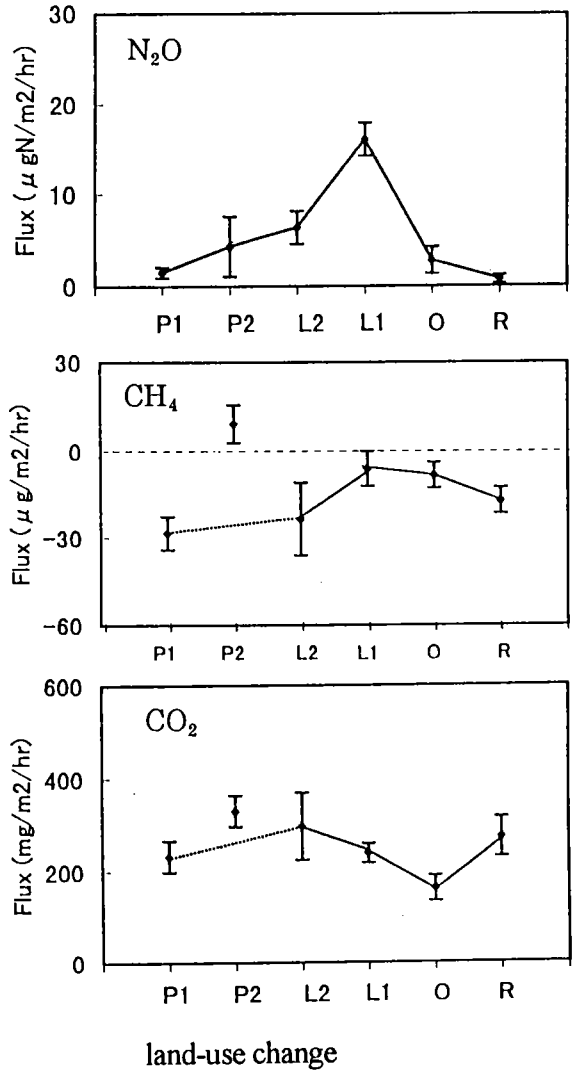

Fig. 3 Annual mean fluxes of N_2O, CH_4, and CO_2 at 6 sites.

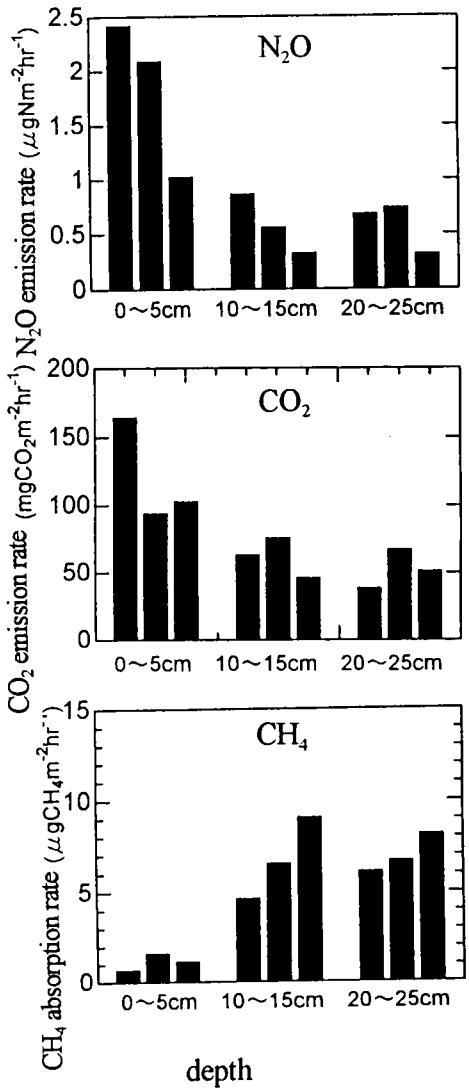

Fig. 4 Potentials of N_2O and CO_2 emission and CH_4 uptake in the soil of L1 by incubation experiment

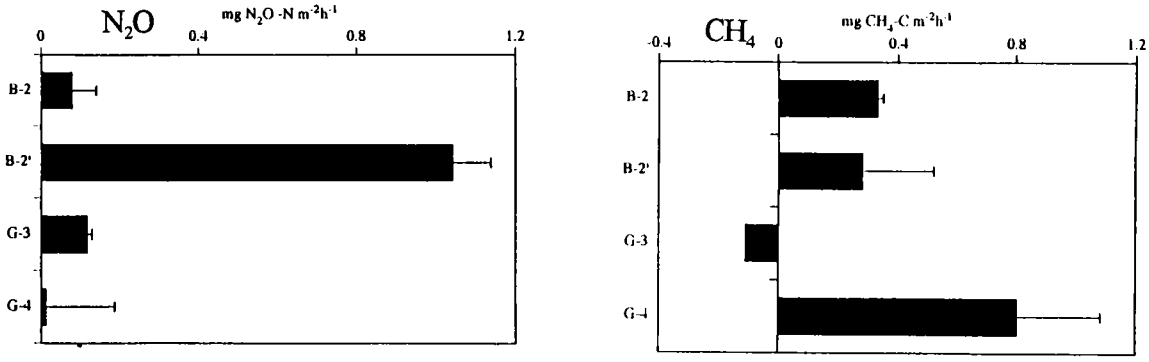

Fig. 5 Fluxes of N_2O (left) and CH_4 (right) at 4 sites in peat wetlands in Banjalmasin

4.2. CH_4 and N_2O emissions in peat wetlands, Kalimantan

The fluxes of CH_4 and N_2O measured in some peat wetlands in Banjalmasin were shown in Fig. 5. The CH_4 flux was very low, compared with that measured in the Amazon[2], suggesting that the magnitude of easily decomposable organic matter which produces CH_4 was very different in these two wetlands. On the contrary, extraordinary high flux of N_2O was observed at one site, and a source of N_2O was estimated to be the application of nitrogen fertiliser to the field that has been changed from wetlands. Thus, the first experiment demonstrated that the land-use change affected the emission rate of N_2O even in peat wetlands.

References

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2) Bartlett, K.B. and R.C. Harris (1993): Review and assessment of methane emissions from wetlands, Chemosphere, 26, 261-320.