

A comparison of soil CO₂ efflux rate in young rubber plantation, oil palm plantation, recovering and primary forest ecosystems of Malaysia

ABSTRACT

Tropical deforestation and land conversion has been an environmental challenge over time and this is likely to have wide-reaching consequences for soil CO₂ efflux. Such soil-carbon dynamic disturbances are critical in light of climate change, as tropical forests store almost 30% of global forest carbon. Soil CO₂ efflux and environmental factors were determined in four different forest ecosystems of primary Dipterocarp forest, a 50-year-old recovering Dipterocarp forest, and a 5-year-old rubber and oil palm plantation using an automated soil CO₂ chamber technique (Li-Cor 8100) with an in-built infrared gas analyzer. The forest sections are located within 1,800 m of each other while the plantation is 1,500 m away in the tropical lowland forest of Pasoh, Peninsular Malaysia. The aim was to determine the influence of environmental factors influencing soil CO₂ efflux in relation to different forest ages and stand densities as a result of forest disturbance. Multiple regression analysis has been conducted on the relationship between soil CO₂ and environmental factors. Soil CO₂ efflux rate was found to range from 1.47-13.22 $\mu\text{molCO}_2 \text{ m}^{-2}\cdot\text{s}^{-1}$ (5.37 $\mu\text{molCO}_2 \text{ m}^{-2}\cdot\text{s}^{-1}$), 1.18-10 $\mu\text{molCO}_2 \text{ m}^{-2}\cdot\text{s}^{-1}$ (5.107 $\mu\text{molCO}_2 \text{ m}^{-2}\cdot\text{s}^{-1}$), 0.88-12.07 $\mu\text{molCO}_2 \text{ m}^{-2}\cdot\text{s}^{-1}$ (3.260 $\mu\text{molCO}_2 \text{ m}^{-2}\cdot\text{s}^{-1}$), and 2.33-7.89 $\mu\text{molCO}_2 \text{ m}^{-2}\cdot\text{s}^{-1}$ (4.678 $\mu\text{molCO}_2 \text{ m}^{-2}\cdot\text{s}^{-1}$) in the 50-year-old recovering forest, primary forest, oil palm plantation, and rubber plantation, respectively. Likewise, the highest forest biomass occurred in the primary forest and was followed by the 50-year-old recovering forest, rubber and oil palm plantation. Although the mean soil CO₂ efflux rate did not differ significantly, differences were evident in the environmental factors such as soil temperature and moisture occurring at a range of 23 to 32°C and 15 to 35.56%, respectively, to influence soil CO₂ efflux. The highest CO₂ efflux rate was recorded in the 50-year-old recovering forest and followed by the primary forest, and rubber and oil palm plantation. The finding revealed a significant and strong correlation between soil CO₂ efflux and soil temperature, moisture, and forest carbon input. Furthermore, the spatial variation in soil CO₂ efflux was attributed to total above-ground biomass, below ground biomass, and forest carbon stock. We can conclude that the spatial variation in Soil CO₂ efflux across the four different forest ecosystems is as a result of forest disturbance and land conversion triggering changes in environmental factors as well as forest carbon, thereby increasing microbial activity to emit soil CO₂.

Keyword: Forest ecosystem; Recovering forest; Plantation; Primary forest; Soil CO₂ efflux; Soil temperature