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How does conversion from peat swamp forest to oil palm plantation affect emissions of nitrous oxide from the soil? A case study in Jambi, Indonesia

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Half of the peatlands across Peninsular Malaysia, Borneo and Sumatra are 'managed'. Conversion of peat swamp forest to workable oil palm plantation requires a drastic, potentially irreversible, change to the landscape, to which fertilizers are then routinely applied. A combination of these factors is now widely thought to increase soil nitrous oxide (N2O) emissions, although there is high uncertainty due to gaps in the knowledge, both regionally and nationally. Despite the widespread use of fertilizers in plantations on peats, studies observing their effects remain very limited. Therefore, there is a need for in situ studies to evaluate how environmental parameters (edaphic properties, climate, soil moisture and N availability indicators) influence soil emissions. This 18 month study was located in plots local to each other, representing the start, intermediate and end of the land conversion process; namely mixed peat swamp forest, drained and logged forest and industrial oil palm plantation. Spatial variability was taken into account by differentiating the hollows and hummocks in the mixed peat swamp forest, and the fertilized zone and the zone without fertilizer addition in the oil palm plantation. Gas samples were collected each month from static chambers at the same time as key environmental parameters were measured. Intensive sampling was performed during a 35 day period following two fertilizer applications, in which urea was applied to palms at rates of 0.5 and 1 kg urea palm-1. Soil N2O emissions (kg N ha-1 y-1 $\pm$ SE) were low overall, but they were greater in the oil palm plantation (0.8 $\pm$ 0.1) than in the mixed peat swamp forest (0.3 $\pm$ 0.0) and the drained/logged forest (0.2 $\pm$ 0.0). In the mixed peat swamp forest, monthly average fluxes of N2O (g N ha-1 d-1 $\pm$ SE) were similar in the hollows (0.6 $\pm$ 0.2) and the hummocks (0.3 $\pm$ 0.1), whereas in the oil palm plantation they were consistently higher in the zone without fertilizer (2.5 $\pm$ 0.4) than in the fertilized zone (0.5 $\pm$ 0.1), even after fertilizer application. In the fertilized zones, the N2O fluxes following the two fertilizer applications were 2.4 and 4.5 times higher respectively than fluxes observed in the absence of fertilizers. No change in emissions was observed in the neighboring unfertilized zone at the time of fertilizer application. Soil N2O emissions were related to changes in air and soil temperature in the mixed peat swamp forest, air temperature and water table depth in the drained and logged forest, and rainfall on the day of measurement in the oil palm plantation. This research confirms that peat forest conversion to oil palm plantation has negative consequences on the emissions of N2O. It also corroborates an increase in emission due to fertilizer application, with a magnitude comparable to the emission factor provided by the IPCC guidelines, but this is restricted to the limited area of fertilizer application.