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Nutrient leaching losses in lowland forests converted to oil palm and rubber plantations in Sumatra, Indonesia

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In the last two decades, Sumatra, Indonesia is experiencing rapid expansion of oil palm and rubber plantations by conversion of rainforest. This is evident from the 2.9 thousand km^2 decrease in forest area in this region over the last 15 years. Such rapid land-use change necessitates assessment of its environmental impacts. Our study was aimed to assess the impact of forest conversion to oil palm and rubber plantations on nutrient leaching losses. Land-use conversion increases nutrient leaching losses due to changes in vegetation litter input, rooting depth, nutrient cycling and management (e.g. fertilization) practices. Our study area was in Jambi Province, Sumatra, Indonesia. We selected two soil landscapes in this region: loam and clay Acrisol soils. At each soil landscape, we investigated four land-use systems: lowland secondary rainforest, secondary forest with regenerating rubber (referred here as jungle rubber), rubber (7-17 years old) and oil palm plantations (9-16 years old). Each land use in each soil landscape was represented by four sites as replicates, totaling to 32 sites. We measured leaching losses using suction lysimeters installed at 1.5-m soil depth, which was well below the rooting depth, with bi-weekly to monthly sampling from February to December 2013. In general, the loam Acrisol landscape, particularly the forest and oil palm plantations, had lower soil solution pH and higher leaching fluxes of dissolved organic N, Na, Ca, Mg, total Al, total S and Cl than the clay Acrisol of the same land uses (all $P \leq 0.05$). Among land uses in the loam Acrisol landscape, oil palm had lower soil solution pH and higher leaching fluxes of NH_4^+, NO_3^-, dissolved organic C, total P, total S and Cl than rubber plantation whereas forest and jungle rubber showed intermediate fluxes (all $P \leq 0.05$, except $P \leq 0.09$ for total P); oil palm had also higher Na, Ca, Mg and total Al leaching fluxes than all the other land uses (all $P \leq 0.05$, except $P \leq 0.09$ for Na and Mg). In the clay Acrisol landscape, oil palm showed higher leaching losses of dissolved organic C and Ca than forest whereas jungle rubber and rubber plantation had intermediate fluxes; oil palm had also higher Na, Mg and total Si leaching losses than all the other land uses (all $P \leq 0.05$). The low soil solution pH, which was negatively correlated with total Al, and large mineral N and total P leaching losses in oil palm were due to N and P fertilization, and the large base cation losses were attributable to liming and ash from biomass burning. Such increased nutrient leaching losses with forest conversion to oil palm plantation calls for improved management to minimize losses and its effects on ground water quality.