学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Study on stream water discharge and organic carbon concentrations, loads and yields of tropical peat swamp forest of Riau, Sumatra, Indonesia

(インドネシア国スマトラ島リアウ州の熱帯泥炭湿地林における河川流出と有機態炭素流出に関する研究)

Approximately 11 % (4.41 × 105 km^2) of the global area of peatland lies within the tropics. Of this, 56 % (approximately 2.48 × 105 km^2) is located in Southeast Asia, mostly in Indonesia and Malaysia. The 88.6 GT of carbon (C) stored in tropical peat accounts for 11–14 % of the global peat C store, and Southeast Asia's peat deposits are estimated to contain 77 % (68.5 Gt) of this. The largest accumulations of tropical peat C are in Indonesia (57.4 Gt C, i.e. 65 % of the total C in tropical peat) and Malaysia (9.1 Gt, 10 %). Tropical peat swamp forest (PSF) is formed when organic matter accumulates as a peat layer. It has important roles in regulating water movement, the hydrological cycle, C storage and the regional and global C cycles. When affected by human activities, the organic C pool in peatlands can potentially release large amounts of C into the environment as gaseous emissions and waterborne (fluvial) losses.

Organic C is released from peatlands in substantial amounts and waterborne C may constitute a substantial part of the peatland C balance, as reported for boreal peatland. Carbon is released into watercourses in both organic and inorganic forms and partly as free (gaseous) CO_2 and CH_4. Organic forms include dissolved organic carbon (DOC) and particulate organic carbon (POC). It is well known that the water in tropical peatland rivers has very high DOC concentrations and lower POC concentrations.

Despite increasing interest in C release via PSF river systems, few studies have been conducted. To improve accuracy and to clarify how discharge variability influences the organic C load in PSF watercourses, it is necessary to have continuous measurements of water discharge. This is because both rainfall events and discharge responses affect the rate of flow in streams and rivers. Periodic measurements of stream discharge combined with continuous recording of stream water level (stage) can provide accurate continuous flow rate data if the rating curve (i.e. a graph of discharge versus stage) is available.

The purpose of this study was to quantify the C loads of watercourses draining from PSF in Riau Province, Sumatra, Indonesia, by combining continuous flow data with measurements of organic C concentration in the water, and thus to estimate catchment yields of organic C. This study also compares results obtained using continuous measurements of organic C load with those that would be indicated by periodic measurements.

Two watercourses were selected for hydrological measurements. One is a small artificial stream named Meranti Ditch (MD) and the other is Turip River (TR). There were significant differences in the estimates of organic C load that obtained using continuous and periodic data. However, regardless of the calculation method, it was clear that almost all of the TOC contained in PSF streamwater was in the form of DOC, with only 0.2–5.0 % occurring as POC. The TOC load transported from the PSF catchment to the stream during the study period was estimated at 0.23 Gg C yr^{-1} for MD and 14.0 Gg C yr^{-1} for TR. Seasonal monitoring at these two sites showed that TOC and DOC concentrations in the stream were fairly stable and were not affected by the flow rate. The streamwater was acidic with pH in the range 3.4 – 4.1 and an EC of 73 – 151 µs cm^{-1}, but the concentrations of TOC and DOC were not affected by variation in either these factors or discharge. There was also no relationship between fluctuations of groundwater depth in the catchment and the concentrations of TOC and DOC in the stream. This invariability of C concentrations in PSF water could be attributed to the intact condition of the PSF and its consequently high organic C content, which enables it to provide a nearly constant supply of organic C to drainage water regardless of the rate at which water is moving through the system.

Stream TOC concentrations in MD (85 – 94 mg C L^{-1}) were higher than in TR (50 – 58 mg C L^{-1}). The high concentrations in MD are not surprising, as this catchment has been much disturbed by repeated rounds of logging which also involved the excavation of a dense network of ditches approximately ten years ago, with associated changes in peatland gradient and topography (subsidence). Under these conditions it seems likely that surface and subsurface water flow will readily flush peat C into streams. By comparison, TR has a large catchment of which 75 % is covered by intact PSF, including a large peat plain headwater that has never been logged and, therefore, contributes less organic C to streamwater.

From the comparison between this study and previously published studies of DOC concentrations in streamwater from several locations and regions with a variety of catchment types, the DOC concentration recorded at MD was high compared to other sites. Several other PSF locations also had high DOC concentrations. Also from the summaries of DOC yields reported for different catchment types and regions, it is clear that PSF has a high DOC yield compared to other catchment types in boreal and temperate regions.

In this study, TOC yields ranged from 41.6 to 55.5 g C m^{-2} yr^{-1} in the small (4.8 km^2) MD catchment and from 26.2 to 34.9 g C m^{-2} yr^{-1} in the larger (458 km^2) TR catchment. This result matches the findings of previous study, which reported that smaller catchments in C-rich landscapes typically have higher C yields or fluxes than similar but larger catchments. The quantities of organic C discharged by the MD and TR streams, *per* unit area of PSF, were only 2.7 – 5.4 % of current estimates of the total amount of C released to the atmosphere from PSF, e.g., 974.0 – 1,035.3 g C m^{-2} yr^{-1}. Our report of relatively small amounts of C being released through streamwater is relevant to improving estimates of the C budget of PSF, as well as to our understanding of how C is transferred between PSF and the hydrosphere.