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学位論文題名

The variability of water discharge and chemical flux from a subarctic river basin with different land cover: Observations and modelling

（異なる土地被覆をもつ亜寒帯河川流域からの流量・化学フラックスの変動機構:観測とモデリング）

学位論文内容の要旨

Abstract

The objective of my research is to clarify how soil water behaviors on the basin slope are related to river runoffs and simultaneous nutrient loads by field observations, chemical analyses and modelling. In this study, time series of water discharge and nutrient load from the subarctic Saromabetsu river basin, Hokkaido are simulated for rainfall and snowmelt events by a conceptual model, the tank model, and the simulated results are related to the soil water behaviors observed on the slopes of grassland and forest. The land cover of the river basin in 2005 consists mostly of forest (75.2 % in area) and farmland (21.5% in area; mainly, grassland, wheat field and corn filed). The soil layer, common to the slopes of forest and grassland, is composed of a porous organic layer (A layer) less than 0.3 m thick and an organic/inorganic layer (B layer) about 2 m to 5 m thick. The B layer is silty clay with the low hydraulic conductivity of 10^{-4} cm/s order. The 4-channel electromagnetic profilers (8cm, 18cm, 28cm and 38cm in soil depth) for measurements of volumetric water content (cm^3/cm^3) indicated that, common to rainfall and snowmelt events, the 8 to 28 cm layers at forest stores infiltrated water for a few days after events, and then returns to the previous moisture level by gradual drainage. At grassland, the drainage after the events was slight except for 8 cm depth. At a rainfall of more than 20 mm/h, the saturated zone appeared at 38 cm depth in forest and at depths of more than 8 cm in grassland. Hence, in the events, the percolation and subsurface flow are considered to be active. The percolation at 38 cm depth of forest and grassland was calculated for rainfall and snowmelt events. Meanwhile, the discharge by the tank model very successfully simulated observed discharge for both rainfall and snowmelt runoffs (R^2 = 0.934 and 0.973, *RMSE* = 0.902 m^3/s and 0.961 m^3/s, respectively). As a result, the river runoff analyses revealed that, in the Saromabetsu river basin, the surface and intermediate runoffs account for more than 70% of rainfall or snowmelt runoffs. There

existed the definitely linear relationship between the calculated percolation at 38 cm depth and the surface runoff plus intermediate runoff for the events (R^2= 0.945 or 0.881, P < 0.002). Hence, it is suggested that the surface and intermediate runoffs from the runoff analyses occur as the percolation and subsequent subsurface flow below the soil surface layer.

In order to estimate each contribution of forest and farmland areas to the nutrient load of the Saromabetsu River, the time series of nutrient load in the typhoon and snowmelt events were simulated by the tank model and some specified nutrient concentrations. The two tank series named "forest tanks" and "farmland tanks" were set up for the forest and farmland areas, respectively. Each tank series, consisting of three sequential tanks, was then applied to separate each runoff at the forest and farmland areas into the surface runoff, intermediate runoff and baseflow. As a result, the simulation was reasonable (R^2 = 0.76, $RMSE$ = 3.53 m^3/s) between the simulated and observed discharges. By using the simulated discharge, total NO_3-N load and PO_4-P load from forest and farmland areas were calculated. As a result, the NO_3-N loads by surface runoff, intermediate runoff and baseflow were 750, 840 and 60 g/s in forest area, respectively, while, in farmland area, they were 11,000, 7,500 and 1,600 g/s, respectively. The NO_3-N concentration calculated by the simulated loads was reasonable in magnitude to that of soil water sampled in the summer and snowmelt seasons. Hence, it is concluded that, according to the seasonal fertilizing, the surface and intermediate runoffs from the farmland area make the relatively high contribution to the NO_3-N load of the river. Meanwhile, the forest and farmland areas give the similar contribution to the PO_4-P load of river. The farmland area, producing such high NO_3-N load, is part of the riparian zone directly connected to the river channel. Thus, the percolation of meltwater or rainwater and subsequent formation of surface and intermediate runoffs may leach the nutrient easily to the river channel as the seepage flow.

学位論文審査の要旨

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In conclusion, the author has new findings of the relationship between observed percolation and simulated river runoffs for both rainfall and snowmelt events, and these will contribute to predict and forecast river floods or high river runoffs and to plan the strategy of flood control and water management.

Therefore, we acknowledge that the author is qualified to be granted the doctorate of Science from Hokkaido University.