学位論文内容の要旨

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学位論文題名

Using SWAT model to predict water flow, sediment and nutrients loads in Shibetsu river watershed, eastern Hokkaido, Japan

(SWAT モデルによる北海道東部の標津川流域における水、土砂、養分流出予測)

Sediment, sediment-bound particulate nutrients and water dissolved nutrients loads to rivers are responsible for declining soil fertility, enhancing agricultural loads and water pollution. The Soil and Water Assessment Tool (SWAT) has the ability to predict stream water flow, sediment, nutrients and pesticide loads to rivers with respect to the different management conditions in watershed. However, this model has never been applied to predict potassium (K) load to rivers.

The objectives of this study were to predict the water flow, sediment, sediment-bound particulate nutrients loads with SWAT and to modify the SWAT (SWAT-K) to predict K load in a watershed of eastern Hokkaido, Japan.

This study was conducted in Shibetsu river watershed (SRW, 672 km^2) which is characterized by forest and grassland-based agriculture on volcanogeneous soils. Data of daily stream flow, suspended sediments, particulate organic nitrogen (PON) and phosphorous (POP), and K loads measured at the outlet of SRW from 2003 to 2008 were used to evaluate the SWAT and SWAT-K. Considering the agriculture management practices (harvest, fertilizer and manure applications), firstly SWAT was calibrated to predict the stream flow, sediment, PON, and POP loads. Then, SWAT was further modified (SWAT-K) to predict K load.

The SRW was recognized as receiving external groundwater (EXT) from other watersheds. The EXT contribution to the stream was simplified as 1.38mm day^{-1} in the SWAT. Stream flow was mainly generated from melting snow in spring and from rainfall in summer and autumn in SRW. SWAT well predicted those daily stream flows.

SWAT also provided acceptable prediction on sediment, PON, and POP loads. The predicted mean annual sediment load was 120 t km^{-2} yr^{-1}. Mean annual PON load and

POP load was 0.6 t N km^{-2} yr^{-1} and 0.07 t P km^{-2} yr^{-1}, respectively. Contribution of sediment load in snowfall (December-March), snowmelt (April-May) and rainfall (June-November) seasons to annual total was 11 %, 32 %, and 57 %, respectively, and it associated with PON and POP loads significantly. SWAT simulation results showed channel erosion and sediment deposition did not happen in SRW. The SWAT model identified that critical source area of land surface erosion was located at the upper-stream area of SRW. The management practices effectively controlling soil erosion in the upper-stream area of SRW are recommended.

A simple hypothesis of EXT of 1.38 mm day^{-1} with K concentration of 1.6 mg L^{-1} was used to estimate the amount of K imported by EXT to stream flow in the SWAT-K. Continuous K release from soil mineral weathering was assumed to be small and ignored. SWAT-K well predicted the soluble K loads to stream from 2003 to 2004. Predicted mean annual soluble K load was 21 kg K ha^{-1} yr^{-1}. On the other hand, predicted mean annual sediment absorbed K load was 0.005 kg K ha^{-1} yr^{-1} which only accounted for 0.02% of the total K load. SWAT-K simulation results showed that 13 kg K ha^{-1} yr^{-1} was leached out of soil profile and entered into the groundwater, plant K uptake was 23 kg K ha^{-1} yr^{-1}, and 53 kg K ha^{-1} yr^{-1} was stored in the soil. The large amount of soil storage K was caused by excessive fertilizer application of 90 kg K ha^{-1} yr^{-1}. Reducing the agricultural K application is recommended.

Significant correlation was found between PON, POP and sediment concentrations, indicating that sediment particles bound well with organic matter. This may be a reason why sediment absorbed K load was very low, because K is weakly absorbed by negative charge of organic matter, Overall, SWAT was well applied to understand the hydrology, sediment, PON and POP loads and SWAT-K was proved with applicability for estimating K loads and understanding K cycle.