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Modelling phosphorus transport and its response to climate change at upper stream of Poyang Lake-the largest fresh water lake in China

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Phosphorus losses from excessive fertilizer application and improper land exploitation were found to be the limiting factor for freshwater quality deterioration and eutrophication. Phosphorus transport from uplands to river is related to hydrological, soil erosion and sediment transport processes, which is impacted by several physiographic and meteorological factors. The objective of this study was to investigate the spatiotemporal variation of phosphorus losses and response to climate change at a typical upstream tributary (Le'An river) of Poyang Lake. To this end, a process-oriented hydrological and nutrient transport model HYPE (Hydrological Predictions for the Environment) was set up for discharge and phosphorus transport simulation at Le'An catchment. Parameter ESTimator (PEST) was combined with HYPE model for parameter sensitivity analysis and optimisation. In runoff modelling, potential evapotranspiration rate of the dominant land use (forest) is most sensitive; parameters of surface runoff rate and percolation capacity for the red soil are also very sensitive. In phosphorus transport modelling, the exponent of equation for soil erosion processes induced by surface runoff is most sensitive, coefficient of adsorption/desorption processes for red soil is also very sensitive. Flow dynamics and water balance were simulated well at all sites for the whole period (1978-1986) with NSE$\geq$0.80 and PBIAS$\leq$14.53%. The optimized hydrological parameter set were transferable for the independent period (2009-2010) with NSE$\geq$0.90 and highest PBIAS of -7.44% in stream flow simulation. Seasonal dynamics and balance of stream water TP (Total Phosphorus) concentrations were captured satisfactorily indicated by NSE$\geq$0.53 and highest PBIAS of 16.67%. In annual scale, most phosphorus is transported via surface runoff during heavy storm flow events, which may account for about 70% of annual TP loads. Based on future climate change analysis under three different emission scenarios (RCP 2.6, RCP 4.5 and RCP 8.5), there is no considerable change in average annual rainfall amount in 2020-2035 while increasing occurrence frequency and intensity of extreme rainfall events were predicted. The validated HYPE model was run on the three emission scenarios. Overall increase of TP loads was found in future with the largest increase of annual TP loads under the high emission scenario (RCP 8.5). The outcomes of this study (i) verified the transferability of HYPE model at humid subtropical and heterogeneous catchment; (ii) revealed the sensitive hydrological and phosphorus transport processes and relevant parameters; (iii) implied more TP losses in future in response to increasing extreme rainfall events.