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Development of stream-subsurface flow module in sub-daily simulation of Escherichia coli using SWAT

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Water contaminated with pathogenic bacteria poses a large threat to public health, especially in the rural areas in the tropics where sanitation and drinking water facilities are often lacking. Several studies have used the Soil and Water Assessment Tool (SWAT) to predict the export of in-stream bacteria at a watershed-scale. However, SWAT is limited to in-stream processes, such as die-off, resuspension and, deposition; and it is usually implemented on a daily time step using the SCS Curve Number method, making it difficult to explore the dynamic fate and transport of bacteria during short but intense events such as flash floods in tropical humid montane headwaters. To address these issues, this study implemented SWAT on an hourly time step using the Green-Ampt infiltration method, and tested the effects of subsurface flow (LATQ+GWQ in SWAT) on bacterial dynamics. We applied the modified SWAT model to the 60-ha Houay Pano catchment in Northern Laos, using sub-daily rainfall and discharge measurements, electric conductivity-derived fractions of overland and subsurface flows, suspended sediments concentrations, and the number of fecal indicator organism Escherichia coli monitored at the catchment outlet from 2011 to 2013. We also took into account land use change by delineating the watershed with the 3-year composite land use map. The results show that low subsurface flow of less than 1 mm recovered the underestimation of E. coli numbers during the dry season, while high subsurface flow caused an overestimation during the wet season. We also found that it is more reasonable to apply the stream-subsurface flow interaction to simulate low in-stream bacteria counts. Using fecal bacteria to identify and understand the possible interactions between overland and subsurface flows may well also provide some insight into the fate of other bacteria, such as those involved in biogeochemical fluxes both in-stream and in the adjacent soils and hyporheic zones.