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Bedload transport in an African sand-bed river (Ethiopia)

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Little is known about the contribution of bedload flux to the total sediment load exported from tropical sand-bed rivers. Yet, predicting bedload transport rates contributes to accurate knowledge of sediment delivery rates, what greatly benefits sediment-related water resources management. Bedload, suspended load and runoff discharge were measured at the lower Gilgel Abay River in the Blue Nile catchment of Ethiopia. Catchment area is 3887 km^2, average stream discharge in the rainy season 315 ($\pm$ 164) m^3 s-1, and the stream surface gradient at the sampling station 0.0004 m m-1. A standard Helley-Smith (U.S. BL-84) cable-suspended sampler was used to take 315 samples to measure bedload fluxes for the 2017 rainy season. The bedload predominantly comprises well to moderately well sorted, medium sized sand (250–500 μm) with a symmetric and leptokurtic distribution. The mean daily observed bedload discharge varies from 0.7 to 427.5 Mg d-1 with an average rate of 175.1 Mg d-1. Field observations also show that the bedload dynamics become larger near the river banks and decrease towards the middle of the river section due to presence of a central bridge pier. The average suspended load ranges from 247 to 220,028 Mg d-1 and dominates the total sediment yield (99.3%). Thus, the bedload accounts for only 0.1 to 5.4% of the total sediment load. The elongated planform growth of the Gilgel Abay River delta in Lake Tana is also in line with the predominance of very fine, suspended load in the sediment dynamics, in addition to limited alongshore drifting given the low Tana lake waves. Among the tested bedload prediction criteria, the stream power based equations of Martin and modified Bagnold perform very well. Alternatively, the bedload prediction performance of simple power regression equations based on runoff discharge and stream power parameters provided satisfactory agreement with the observed bedload data. Finally, this study provides plausible estimates of bedload fluxes that are within predicted ranges reported for alluvial rivers in African and other tropical regions.