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Sediment mobilisation in Lake Alaotra catchment, Madagascar

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Madagascar shows very high erosion rates and, in some regions, the landscape is dotted by major gullies called “lavaka”. Lavaka are also very frequent in the surroundings of Lake Alaotra, a large, shallow lake in the Malagasy highlands. A central question with respect to landscape evolution in Madagascar is to what extent human impact has triggered environmental change in terms of vegetation, erosion rates (lavaka formation) and sediment dynamics. Sedimentary archives in lakes such as lake Alaotra can be of great help to resolve this question provided that we understand how sediment and carbon are mobilised and transported through the landscape.

In this study, we traced pathways of sediment and carbon fluxes through this eroding landscape, from the eroded hillslopes over various sediment deposition zones (floodplains, reservoirs, marshes..) to Lake Alaotra. Detailed profiles taken along convex hillslope transects (grasslands and primary forest), in the marsh peat, floodplains and lake were analyzed for carbon and nitrogen content, texture, and stable carbon isotope ratios ($\delta^{13}C$). Along the grassland hillslopes, soil OC content is extremely low, from 0.4 to 1.8% in the top layer and rapidly decreasing to <0.2 % below 100 cm depth. The current vegetation predominantly consists of C4 grasses ($\delta^{13}C$ ~-13 ‰), yet soil $\delta^{13}C$ ranges between -24 and -18‰, and most profiles show a decrease in $\delta^{13}C$ with the depth – in contrast to observations in most C3-dominated systems. Contrary to our expectations, Lake Alaotra was found not to be a major sink of hillslope-derived sediments and/or carbon. Sediment cores from different parts of the lake have high OC contents (5 to 18%) and contain only minor amounts of sand, the dominant grain size class on the hillslopes. The high OC content of the lake sediments, in combination with data on C/N ratios and $\delta^{13}C$ indicate that the OC in the lake sediments is mainly derived from the surrounding marshes and in situ primary production rather than from terrestrial C eroded from the catchment. Floodplains are likely a key sink for soil-derived sediments: similar to hillslope soils, sediment profiles in the floodplains show a low %OC and relatively high $\delta^{13}C$ values ranging between -21 and -14‰.

We conclude that most of the detritic sediments and carbon mobilised on the hillslopes through erosion do not reach lake Alaotra, even though erosion rates in the landscape are extremely high. Studying sedimentary profiles in the lake may provide information on environmental change (e.g. through changes in carbon contents and/or characteristics) but is insufficient to understand the entire sediment and carbon cascades in the Malagasy landscape.