The African Dams Project: reservoir impacts and floodplain biogeochemistry in the Zambezi River Basin

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ABSTRACT

The goal of the African Dams Project (ADAPT) is to adapt planning and operation of large dams to social needs and environmental constraints in a tropical wetland area in Zambia. Our integrated water resource management (IWRM) study in the Zambezi river basin combines expertise from biogeochemistry, aquatic physics, ecology, economy, political science, hydraulic engineering and hydrology. With the involvement of partner universities and stakeholders from governmental institutions, NGOs, environmental agencies, and the energy and agricultural sector, we promote knowledge exchange and the identification of knowledge gaps and research needs for implementing adequate IWRM. During its four years duration this interdisciplinary project enhanced the scientific basis of IWRM by developing new models that can be used to improve the operation of existing large hydraulic structures and in designing future schemes at the basin-scale. In a final phase we assess the water-use conflicts in the area between hydropower, food production and the environment/tourism.
In this contribution we document how to analyze the biogeochemical processes in a large subcatchment and how to derive operation rules for mitigating downstream effects of hydropower operations. Dams may have negative effects on downstream wetlands due to (i) releasing anoxic water or due to (ii) nutrient trapping in upstream reservoirs. A study on the Itezhi-Tezhi reservoir on the Kafue river system in Zambia aimed at quantifying nutrient and sediment retention and at defining optimized turbine withdrawal to prevent anoxia and to relieve nutrient deficits in the downstream kafue flats floodplain. A biogeochemical model was used for simulating reservoir-internal processes and the outflow water quality. Changing the current practice of spilling exclusively surface water to releasing hypolimnetic water via turbines was shown to result in anoxia during up to 200 days. On the one hand, this translates to a lower average outflow do of 3.4 to 6.5 mg L-1 compared to the current 7.6 mg L-1. On the other hand, due to withdrawing nutrient-rich hypolimnetic water instead of nutrient-depleted surface water, n and p sediment losses were most effectively compensated for. Outflow do as well as n and p output loads may be optimized by replacing 50% of the hypolimnetic turbine water with epilimnetic water originating from ~10 m depth. In this optimal scenario, anoxia was prevented entirely, and higher n and p loads were released to the kafue flats, in comparison to the current loads.
A study on the dynamics of the downstream wetland, the Kafue flats revealed that the seasonality of the hydrological exchange between river and floodplain remained similar before and after dam closure in 1972, but the amplitude of the overflow and downstream recharge is now reduced to 50% resulting in significant changes in the biogeochemical functioning of the downstream wetland. Therefore the planned modification of dam operations holds the potential for additional positive or negative ecological changes and presents an illustrative case study for IWRM in action.

KEY WORDS: *Dams, river systems, water resource management, wetlands, water conflicts.*