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How water storage for energy and food production affects the Zambezi River's water quality

Elisa Calamita (1), Martin Schmid (2), Bernhard Wehrli (1,2)

(1) ETH Zurich, IBP, D-USYS, Zurich, Switzerland (elisa.calamita@usys.ethz.ch), (2) EAWAG, Swiss Federal Institute of Aquatic Science and Technology, Kastanienbaum, Switzerland

Exploitation of water resources to ensure water supply, food and energy production for the fast growing African population is leading to major changes in tropical ecosystems. As a result, African river basins are experiencing major anthropogenic changes. The ongoing boom of large dam constructions will change water quantity and quality and will increase pressure on aquatic environments. The increased hydrologic residence time imposed by dams and the potential for stratification of their reservoirs affect downstream water quality. The timing and magnitude of such effects are well documented for temperate and boreal setting, but the physical and chemical behaviour of tropical reservoirs is limited by scarce data and limited modelling efforts resulting in limited knowledge about their impact on downstream aquatic ecosystems.

In this study, we explore a framework to assess the effect of dams on water quality in tropical regions. Our case study is Kariba Dam, which created the largest artificial lake in the world by volume. The reservoir is located in the Zambezi River Basin at the border between Zambia and Zimbabwe. We aggregated a unified database of observed lake water temperature and dissolved oxygen profiles for the sixty years of Lake Kariba in order to generate a comprehensive assessment of current knowledge about the reservoir's stratification dynamics. We present the statistical analysis of the database in the form of frequency maps, which describe the seasonality and interannual variation of water temperature and dissolved oxygen at each lake depth. Finally, through a modelling approach, we assessed and quantify the impact of the reservoir on downstream water temperature and dissolved oxygen concentrations. Moreover, we investigated how different possible scenarios for food and energy production affect dam operations, which affect downstream water quality.

Results show that Kariba dam largely modifies the river natural thermal and oxygen regimes. A simple statistical analysis of observed lake profiles represent a meaningful tool for a first assessment of downstream impact of dams on water quality. The lake model integrates this data and provides quantitative information about the timing of such water quality impacts. Moreover, the lake model allows for a direct comparison of such impacts under different dam management strategies.