Historical contribution of sediments to a hydropower reservoir: a case study in central Chile.

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Introduction: Soil erosion increases mobilisation of sediment to downstream water bodies affecting water and sediment quality with degradation of natural or artificial reservoirs [1]. Anthropogenic activity in river basins has a profound impact on the quality of reservoir sediments that compromises water supply and ecosystem services e.g. fisheries. In terms of changes in sediment quantity, hydrographic systems such artificial reservoirs (dams) are very susceptible to sediment accumulation and production efficiency of hydropower can be directly affected by soil erosion upstream. This is the case of the study site, an artificial reservoir built in 1968 located in the VI Region of Chile created for energy production, recreational and irrigation purposes. Since its creation, the dam has received inputs of sediment from the upper Raple river basin (13,000 km^2) the Rapel river basin. This study focuses on determining the value of the reservoir sediment column to elucidate historical sediment source contributions in response to human and climate change factors.

Methods: Radioisotopic techniques, multi-elemental analysis, multi-parametric analysis and a Bayesian mixing model were used to determine the nature and the relative contribution of the different sediment sources. Source samples were taken from sediment deposited within channels of tributary rivers in the different sub-basins. A 120 cm sediment core was taken and sectioned every 2 cm in situ. Samples were sieved at < 63 μm and analysed by WD-XRF to quantify major and minor geochemical elemental composition. All source-related statistical analysis of the data was performed with the program R study version 4.0.2 and the MIxSIAR package was used as mixing model. For core dating, Pb-210 geochronolology was used and contrasted with historical records of catchment process.

Results: Four main sources of sediment to the reservoir were considered. Soils affected by agricultural and mining activity as well as rivers resulting from the melting process of glaciers and finally flow fed by mountain snowmelt. The age and accumulation rates of the sediment core were determined. The date ranged from 1968-2019 and the sections were sub-grouped according to the mass accumulation rate (MAR) calculated from the dating with Pb-210. From these, eleven mixing zones within the core were selected. Finally, the mixing model showed as main contributors the two anthropogenic activities, agriculture and mining, that historically represent over 50% of the historical contribution in the sediment.

Discussion: Mining and agriculture activities were demonstrated to be the main historical sources of sediment within the catchment, and non-anthropogenic sources e.g. Andean mountain erosion, provided minimal historical contribution. Results were compared with historical records of flow into the reservoir wherein extreme events were observed to be closely related to patterns in the rate of sediment accumulation. Agricultural activity is widely known to enhance sediment transport [2]. While there has historically been a high commercial demand for agricultural production in the region due to fertile valley floor soils and a favourable climate, recent years have seen an advanced degree of erosion linked to expansion of some productive sectors (e.g. citrus fruits, avocadoes and olives) into steeper terrain converted from natural vegetation cover. In parallel, mining represents a problem of transport of heavy metals, harmful to the environment and to the entire trophic chain that coexists with the ecosystem. Interaction between mine pollutants and high sediment loads presents a critical problem of pollutant storage in the sediment column requiring a holistic system-wide approach for co-design of solutions to reduce pollutant and sediment loads to the reservoir.

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References: [1] Blake, W. H., et al. (2018). *Scientific Reports*, **8**, 13073. [2] Reusser, et al. (2015). Geology. **43**(2):171-174.