Assessing the origin of suspended particulate matter in the Rhône River from the geochemical signature of the particulate residual fraction and hydro-sedimentary numerical modelling

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Suspended particulate matter (SPM) transport through rivers is a major vector for nutrient and pollutant fluxes to continental shelf areas. Since physico-chemical properties of SPM from each sub-catchment will determine pollutant reactivity, it is necessary to obtain relevant information on the origin of SPM, in order to apply effective strategies for sediment management. Fingerprinting approaches based on the concentrations of trace metals, rare earth elements, mineralogy or radionuclides, have been developed allowing identifying SPM at the sub-catchment scale. However, confounding factors such as non-conservative behavior and enrichment/depletion of elements during the sediment delivery process represent a main concern. In this way, few studies addressed SPM origin in large river systems from the upstream part to the coastal environment by applying multi-tracer signatures. This is probably due to evolution of non-conservative element signatures during transport linked to biogeochemical processes (e.g. organic matter degradation, flocculation, desorption).

To avoid the problem of non-conservative element signatures, we propose a significant improvement of finger-printing approaches based on the concentrations of major elements and trace metals measured in the residual (conservative) fraction of SPM. The aim of our study was to apply this original geochemical approach to the upper part of the Rhône River (France). This approach was used to estimate, at each given time in the Rhône River, the SPM inputs contribution of several sub-basins (Arve, Ain, Fier, Guiers and Bourbre rivers). The concentrations in the residual fraction were estimated by the difference of concentrations obtained after two different extraction methods on SPM (a total extraction by using a mixture of HNO_3, HCl and HF acids; and a soft extraction by applying only HCl 1M). By this method, we were able to determine a geochemical signature typical of each sub-basin which should be conservative in time and space. We identified 6 elements (Cr, Cu, Fe, Mg, Ni and Ti) allowing discriminating the 5 sub-basins. Then, by applying a mixing model we were able to determine the relative contribution of each sub-basin, for different hydrological conditions (low flow, flood events, dam flushing) at the annual scale. The comparison of our results with a 1D hydro-sedimentary numerical model shows similar contributions of SPM inputs during low flow, mainly represented by SPM inputs from the Arve River. However, during flood events or dam flushing, contributions obtained by the two approaches strongly differed, highlighting the mains advantages of each approaches and their complementarity. For example, the 1D hydro–sedimentary model approach was able to quantify the amount of resuspended SPM during a flood event, while the geochemical approach allowed to determine the original sub-basin of the resuspended sediment.