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A methodology for quantifying time variations of the turbidity/electrical conductivity relationship during complex floods: application to the delineation of particle and dissolved materials transfer at a karst spring

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In Upper Normandy, where drinking water supply comes from karst aquifers, rainfall events may involve turbid runoffs. These events induce sanitary crises and shutdowns of the water supply. The springs of Fontaine-Sous-Préaux provide 60% of Rouen's population (400,000) (France). These springs are highly vulnerable and their exploitation is confronted with the recurrence of turbid events, which can reach up to 150 NTU during highly rain events. The turbidity observed at karst springs is a complex signal composed by two parts of different origins: a first part coming from the direct transfer of particles from the surface following runoff events, and a second part involving the resuspension of materials previously deposited within karst conduits. The disctinction between those two part has always been very challenging. In this study, taking the example of a karst spring in Upper Normandy (Fontaine Sous Préaux spring), we attempted to refine a turbidigraph decomposition method based on the comparison between electrical conductivity (EC) and turbidity (T) using separated modelled hysteresis curves. In a first step, the EC and T breakthrough curves are modelled using an appropriate number of sub-peaks. Second, local EC-T hysteresis curves are builded up in order to characterize the time-varying changes of the dissolved/particulate transports relationships and to assess the respective contribution of the direct transfer and resuspended parts of turbidity throughout complex floods. Associated to cross-correlation analyses of the EC and T sub-peaks separated, the method allowed identification of the (potentially changing) lag time between EC and T. The results obtained highlighted the pre-eminence of resuspension phenomena at the spring for all floods studied. Nevertheless, four different types of hysteresis curves could be distinguished: i) wide clockwise hysteresis expressing the pre-eminence of resuspension accompanied by pressure pulse transfer phenomena; ii) wide clockwise hysteresis expressing the pre-eminence of resuspension of sediments arriving simultaneously with surface waters; iii) a thin hystérésis equivalent to an almost linear relationship between EC and T, corresponding to a simultaneous transfer of surface water and particles, iv) a thin and curved counter-clockwise hysteresis representing a direct transfer of particles and water from the surface characterizing a deficit of available sedimentary stock.

Keywords : transport processes, hysteresis, resuspension, direct transfer, deposition.