Designing a Sediment Management Program for the Lower Ebro River

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Introduction: The Ebro River basin (85,530 km^2), located in the north-eastern part of the Iberian Peninsula, is regulated by approximately 190 dams. Dams impound almost 60% of the annual runoff. The fluvial regime of the lower Ebro River has been altered by the largest complex of reservoirs (Mequinenza-Riba-Roja-Flix) of the whole Ebro basin. Frequent floods (i.e. Q2 to Q25) have been reduced by around 25%, on average [1] and reduced water flow caused an increase of the saline wedge [2], the proliferation of the macrophytes and a massive apparition of the simulids. Dams also interrupt the sediment transport continuity. Most of the suspended load (> 85%) and all bedload is trapped by reservoirs, producing a mean incision of 33 mm over the 28 km long reach downstream dams [3]. Moreover, the lack of sediment delivery downstream from dams caused changes in river channel morphology, mainly vegetation of formerly active areas [4], and can be identified as the main reason for the retreat of the Ebro delta. In addition, over 4 years, the riverbed has been continuously dredged to ensure the navigability of the river for tourism purposes, affecting fish habitat and contributing to the disequilibrium of the river's sedimentary system [5]. Therefore, it is expect an increase of the delta surface located below the sea level since the subsidence (sediment compactation) and the sea level rise (climate change) is not compensated by sedimentation from river floods [6]. In this context, it is necessary to restore the sediment transference from reservoirs to the delta, and guarantee the minimum sediment flow to maintain the fluvio-deltaic system.

Methods: The sustainability (that is, the long-term conservation in a good morphological and ecological state) of the fluvial system and delta can only be guaranteed with the allocation of an appropriate flow regime, which must include not only a liquid flow, but also a solid flow (sediment). To transport these sediments to the river mouth and delta area, the river requires a specific flow system, including periodical pulses (floods), which are vital for the ecological and physical maintenance of river, delta and estuary. In addition, the EU Water Framework Directive (2000/60/CE) requires the protection and improvement of the water quality with the purpose of obtain a good ecological status. Hence, a combined detailed analysis of the minimum sediment flux (needed to maintain the physical and ecological stability of the lower river channel and its delta) and the design of the optimum fluvial regimen (to entrain and transport the sediment to the Sea) is essential.

We are developing a water and sediment management program in the Lower Ebro River to assess, from a geomorphological and ecological point of view, the minimum solid discharge needed to maintain the sustainability of the river and delta area. It is pursued the design of the required discharges to entrain and transport the different diameters of riverbed particles, identifying the relationships between the natural processes, and integrating the morph-ecological needs and the socio-economic demands (i.e. hydro-power generation, flooding prevention, water supply), in order to arise the sustainability of the fluvio-deltaic system. In addition, we are analysing the applicability of several methods (i.e. flushing floods, by-pass, etc.) to remove the sediment stored into the reservoirs and transfer to the delta. Preliminary studies [7] show the potential viability (technical and economical) of the flushing floods to remove the sediment deposited into the Riba-Roja reservoir and release it below the dam through the fluvial channel to its the delta and marine zone.

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