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Exploring flocculation of suspended burned sediment using an annular flume

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The frequency and severity of wildfire events are predicted to increase in many fire-prone areas of the world with implications for erosion, sediment transport and sedimentation. While cohesive suspended sediment is known to be transported primarily as flocculated material in river channels, with important implications for catchment nutrient and contaminant fluxes, there has been little work to date to explore the effect of burning on suspended sediment flocculation processes. Since heating has profound effects on surface soil biogeochemistry, it can be hypothesised that in-channel flocculation processes may also be affected as burned eroded material is transported through the catchment system. Using an annular flume and LISST-ST (Laser in Situ Scatter and Transmissometry with Settling Tube) particle size analyser, short-term suspended sediment flocculation dynamics were examined in burned and unburned sediment collected from a wildfire-impacted catchment, Southern Peloponnese, Greece.

Fine sediment (< 63 μm) samples were introduced to a small annular flume (45 L capacity) which was operated at range of turbulent shear stresses (0.1, 0.3, 0.6 and 0.9 Pa). Experiments were undertaken for a range of suspended sediment concentrations (111, 222 and 333 mg l^{-1}) of burned and unburned material. For each shear and sediment concentration scenario, the flume was operated for 30 minutes to induce a theoretical equilibrium between flocs and fluid shear stress after which 5 replicate subsamples were collected and analysed for effective particle size using the LISST-ST. Material was also analysed for absolute particle size following chemical and ultrasonic dispersion.

At the two higher sediment concentrations, the effective particle size distribution of unburned material notably coarsened at shear stresses of 0.1-0.3 Pa in comparison to the absolute particle size distribution. This is reflected in a reduction of the percentage of $<$63 μm material (by volume) from 96 $\pm$ 2 % in the disaggregated material to between 49 and 65 % in flocculated sediment. At higher shear stresses (0.6 – 0.9 Pa), larger flocs apparently broke down reflected in a reduction in percentage of material ($>$250 μm) e.g. from 14.4 $\pm$ 4.1 % to 5.9 $\pm$ 2.0 % at the highest sediment concentration. While similar increases in effective particle size were seen at the lower sediment concentration, there was no apparent break down of flocs at higher shear stresses. In burned sediment a similar increase in effective particle size was observed but only when shear stress reached 0.3 Pa. At 0.1 Pa the particle size distribution of the lowest and highest sediment concentrations was similar to that of the disaggregated material. There was no apparent breakdown of flocs at higher shear stresses. Data suggest that while burning leads to the formation of more robust sediment flocs, greater particle interaction (at higher turbulent shear stress) is required to initiate formation. Further replication with a greater range of mixing times is required to confirm these preliminary observations.