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Modelling wildfire ash transport by concentrated flow

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Wildfire ash is a mixture of pyrogenic organic and inorganic materials with high concentration in nutrients and potential contaminants that is easily mobilized by runoff. Ash has been identified as a major threat to water quality since it can impact aquatic life and disrupt water treatment operations when is washed off into water bodies. The ability to modelling ash transport, however, is in its infancy. One reason for this is that the relationship between runoff and ash transport for concentrated flow has not been described yet, limiting the capabilities of current runoff-erosion models to predict ash transport and delivery in fire-affected areas.

To fill this knowledge gap, we conducted a series of laboratory experiments on ash transport using concentrated flow on flumes. Ash collected from US conifer forest burned at high severity was applied at two different rates (corresponding to layers of 1 and 3 cm thickness) to an artificial substrate of gravel and sand attached to the bottom of the flumes that simulates soil roughness. Three different flow rates were consecutively applied to each flume in all possible combinations (6 flow rate combinations and 6 replicates per combination and ash thickness).

The results show that ash is easily transported by concentrated flow, confirming previous observations on ash mobility. The runoff rate required to start transporting the ash was close to 0 (0.005 L min^{-1} for both 1 and 3 cm ash layers) and the average concentration of ash in the runoff once this process started was considerably high (120 and 176 g L^{-1} for 1 and 3 cm ash layers respectively), probably due to the low density and cohesion of this fire by-product. The results also show that ash depletion is a critical process when modelling ash transport and, thus, that ash transport by concentrated flow is better modelled using a variable sediment transport rate to account for ash decay with consecutive rainfall events. This is especially true for the 1 cm ash layer. The relationships between runoff and ash transport for concentrated flow obtained here for the evaluated ash type and loads are critical parameters to predict ash transport and will be used to refine ash transport capabilities of WEPPcloud-WATAR, a new tool aimed at predicting ash contamination risks after wildfires.