Hydraulic experiments to investigate how vegetation coverage affects sediment transport during a tsunami

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During a tsunami, coastal forests can trap sediment and reduce the water level and velocity of the tsunami wave. The coastal forest in Tohoku, Japan, was severely damaged by the tsunami that was triggered by the earthquake on 11 March 2011. The forests were redeveloped on a coastal embankment. So that the roots could penetrate, the soil on the embankment was dug and softened. However, while this was necessary for the plants to grow, it was also important that the softened embankment could still resist the tsunami and prevent the generation of flood wood by scouring. Softness and scour can be prevented by implementing countermeasures on the surface of the embankment—for example, by covering the surface with vegetation. To date however, there is no method for evaluating how vegetation coverage affects sediment transport.

In this study, hydraulic experiments were carried out to determine how vegetation cover affects the amount of sediment transported. The experiments were carried out in a two-dimensional water channel that comprised a water tank (5 m^3), a water channel (30 m), and a tank that drained water from the upstream. The experiments comprised two parts. In the first, the bed was fixed and hydraulic data were measured at various points. The second involved a fixed sand bed, a box that contained sand and vegetation, that moved when there was flow in the channel. Changes in the amount of sediment trapped by vegetation cover were measured. A wave that imitated a tsunami was generated in the water tank by opening the gate rapidly. The slope, sand bed section, and flat section were installed downstream of the channel. In the sand bed section, sand (d_{50}=0.287 mm) and vegetation were installed with different proportions, namely 0% (sand only), 30%, 50%, and 100%. When the sand covers were 30% and 50%, the amount of deposition in the sand bed section changed. The net amount of sand deposited by the plankton downstream of the flat section and the dry weight of sand deposited on the flat section were measured. The results showed that the amount of sediment transport decreased and the ability of the vegetation to capture sediment increased as the coverage increased. When we considered where the vegetation was planted, we found that more sediment was transported when vegetation was planted upstream of the sand bed section than when it was planted downstream. Additionally, the scouring was deeper when the vegetation was planted upstream rather than downstream. These results highlight the importance of both the deposition and the degree of vegetation cover.

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