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Decay extent evaluation of wood degraded by a fungal community using NIRS: application for ecological engineering structures used for natural hazard mitigation

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Ecological engineering corresponds to the design of efficient solutions for protection against natural hazards such as shallow landslides and soil erosion. In particular, bioengineering structures can be composed of a living part, made of plants, cuttings or seeds, and an inert part, a timber logs structure. As wood is not treated by preservatives, fungal degradation can occur from the start of the construction. It results in wood strength loss, which practitioners try to evaluate with non-destructive tools (NDT). Classical NDT are mainly based on density measurements. However, the fungal activity reduces the mechanical properties (modulus of elasticity - MOE) well before well before a density change could be measured. In this context, it would be useful to provide a tool for assessing the residual mechanical strength at different decay stages due to a fungal community. Near-infrared spectroscopy (NIRS) can be used for that purpose, as it can allow evaluating wood mechanical properties as well as wood chemical changes due to brown and white rots. We monitored 160 silver fir samples (30x30x6000mm) from green state to different levels of decay. The degradation process took place in a greenhouse and samples were inoculated with silver fir decayed debris in order to accelerate the process. For each sample, we calculated the normalized bending modulus of elasticity loss (Dw moe) and defined it as decay extent. Near infrared spectra collected from both green and decayed ground samples were corrected by the subtraction of baseline offset. Spectra of green samples were averaged into one mean spectrum and decayed spectra were subtracted from the mean spectrum to calculate the absorption loss. Partial least square regression (PLSR) has been performed between the normalized MOE loss Dw moe ($0 < \text{Dw moe} < 1$) and the absorption loss, with a correlation coefficient R^2 equal to 0.85. Finally, the prediction of silver fir biodegradation rate by NIRS was significant (RMSEP = 0.13). This tool improves the evaluation accuracy of wood decay extent in the context of ecological engineering structures used for natural hazard mitigation.