Quantifying the contribution of subsurface sediment sources using spectrocolorimetry: A case study in coastal catchments exposed to Fukushima radioactive fallout, Japan

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The accident that occurred at the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) in March 2011 resulted in the formation of a radioactive pollution plume on soils of Northeastern Japan. Among the emitted radionuclides, radiocesium (including Cs-137) is the most problematic substance over the medium to long term, because of its abundance and its relatively long half-life. The soils heavily contaminated with Cs-137 are drained by several coastal rivers to the Pacific Ocean, and extensive soil erosion occurring during typhoons may lead to the significant redistribution of these particle-bound radionuclides.

To prepare the return of the local populations in the most contaminated areas, the Japanese authorities carried out remediation works consisting in the removal of the 5-cm topsoil layer heavily contaminated with Cs-137. Accordingly, the application of an alternative sediment tracing technique based on the measurement of spectrocolorimetry parameters was investigated to quantify the effectiveness of remediation. These measurements were conducted using a portable diffuse reflectance spectrophotometer (Konica Minolta 2600d) between 360 and 740 nm, with a 10-nm resolution. Potential sources samples corresponded to (i) topsoil collected under forests or paddy fields before remediation works, and (ii) subsoil material originating from channel bank/landslide erosion, or collected in paddy fields after decontamination. Sediment samples consisted of fine material deposited in the main river channel after the main floods and were systematically collected at the same locations every six months, between 2011–2017, in the Mano and Niida River catchments, Fukushima Prefecture.

The results showed that the contribution of subsoil to sediment strongly varied across space and throughout time, reflecting the significant impact of decontamination works and the continuous – although minor – contribution of landslides as a perennial source of material transiting rivers in this region of the world. The impact of particle size is discussed through the comparison of measurements conducted on both <63 µm and <2mm fractions. The sediment source contributions obtained with spectrocolorimetry are also compared with those derived from radiocesium and organic matter properties.