Hyperspectral reflectance of dry, wet and submerged plastics polymers under environmentally relevant conditions

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Harbours, rivers, and coastal areas are focal points for economic development and crucial areas for maritime transport. However, due to poor waste management or accidental release of debris, these areas are hotspots for marine litter, including plastics. To improve plastic-related mitigation policies there is a need to develop methodologies that provide an efficient yet large-scale quantification of plastic litter in aquatic environments with as little disruption of maritime transport as possible.

In recent years, progress has been made on innovative solutions for the detection and tracking of plastics by using remote sensing techniques. Currently, most techniques are mainly based on the analysis of images and spectral information acquired from pristine polymers in laboratory settings with limited field validation. To obtain environmentally relevant and realistic information there is a need to assess empirical data on diagnostic spectral properties of not only pristine but also weathered and biofouled plastics. Particular attention should be given to their reflectance when in water since water is strongly absorbing light in the near-infrared (NIR) and the short-wave infrared (SWIR) spectra, modifying the reflected signal. In addition, the reflected signal could also be altered by particulates in suspension such as algae or sediment.

In this study, as part of the Plastic Flux for Innovation and Business Opportunities in Flanders (PLUXIN) project, we collected hyperspectral reflectance information of plastic polymers (e.g., polyethylene - PE, polypropylene - PP, polystyrene - PS, polyethylene terephthalate - PET) under environmentally relevant settings and treatments. To conduct all the measurements, we used the Analytical Spectral Devices (ASD) FieldSpec 4 equipped with either an 8° or 1° field of view. Samples analysed consisted of pristine, artificially weathered, and biofouled plastics. To mimic the effect of solar radiation, pristine plastic polymers were exposed to UV radiation in an Atlas SunTest CPS+ weathering chamber for 917 h. To investigate the influence of biofilm on the spectral reflectance, we induced biofilm growth on pristine plastic polymers. An aquarium was filled with seawater, kept at an average of 20 degrees, and aerated by an air pump. In addition, field-collected plastic items from the Port of Antwerp (Belgium) and the area of the Temse Bridge in the river Scheldt (Belgium) were analysed. The spectral reflectance of each sample was measured in dry conditions in the Flemish Institute for Technological Research (Mol, BE) optical calibration facility. For a subset of the samples, the hyperspectral reflectance was measured in wet and submerged conditions in a silo water tank at Flanders Hydraulics Research (Borgerhout, BE). In the silo, we mimicked environmentally relevant conditions by testing clear water, and by adding freshwater microalgae and sediment in suspension.

Our preliminary results indicate that: (i) the strong absorption of the water results in lower reflectances of wet plastic in the near and short-wave infrared and almost negligible values when the plastic is submerged; (ii) weak difference is found in the spectral reflectance of clear water and water with added concentrations of freshwater algae; (iii) weathered plastics have a higher reflectance in the first short wave infrared region compared to the pristine sample; and (iv) biofouling influences the reflectance in the visible portion of the light. To quantify the degree of spectral shape similarity between the measured reflectances, we will calculate a spectral contrast angle by converting the spectra of two samples into a multi-dimensional vector, only depending on the shape of the spectra. This angle (θ) is ranging from 0˚,

which indicates a high degree of similarity, to 90° indicating no similarity. We expect that our results will contribute to defining optical spectral bands and developing algorithms for the detection and discrimination of plastics in a (semi-) operational environment.

Keywords: Hyperspectral reflectance; Plastic pollution; Pristine; Biofilm; Weathered