Remote Sensing and In-Situ Monitoring of Macro Plastics in Coastal Waters Using Hyperspectral UAV Imaging: A Comprehensive Study near Tharangambadi, Tamil Nadu, India

Vimalathitthan Shanmugam and Shanmugam Palanisamy
Ocean Optics & Imaging Laboratory, Department of Ocean Engineering, Indian Institute of Technology Madras
(vsv.voice@gmail.com)

In the current discourse of marine science, the issue of anthropogenic plastic pollution poses a growing existential threat to marine ecosystems and their inhabitants. The relentless increase in global plastic production further intensifies this ecological challenge, necessitating the adoption of innovative monitoring approaches for marine debris management. This investigation outlines the effectiveness and precision of remote sensing technologies in documenting and monitoring the distribution of macro plastics in marine and coastal environments. It addresses the intricate difficulties in detecting individual plastics due to their diminutive size and demonstrates how remote sensing can surmount these obstacles by identifying accumulations of plastics, with the assistance of natural oceanographic processes like hydrodynamic fronts and eddies. This study is conducted near the fishing harbor in Tharangambadi, Tamil Nadu, India. Experimental methodologies are employed at depths of approximately ten meters to minimize the impact of bottom reflectance and obtain precise spectral signatures of both water and plastics. Utilizing a Fishing Harbor Jetty as a stable platform for drone operations counters challenges related to drone endurance and operational range. A comprehensive setup, employing High-Density Polyethylene (HDPE) nets, buoyancy aids, and anchoring systems, facilitates the deliberate collection of plastic debris for remote detection.

The research methodology incorporates the aggregation of various distinct polymer categories. The experimental setup features two 30 x 30 meter testbeds where waste plastics are secured to HDPE nets using Ziploc ties. These testbeds are strategically placed to enhance the differentiation between water and plastic reflectance. A designated benchmark site near the operational center ensures accurate georectification of images obtained from Unmanned Aerial Vehicles (UAVs), synchronized with the overpass of Sentinel, Landsat, and Planet Scope satellites. Unlike previous studies that used high-resolution aerial RGB imagery from drones to calculate the percentage of plastic coverage in satellite images, this study employs UAVs equipped with push-broom hyperspectral sensors to capture high-resolution (approximately 3nm) spectral signatures ranging from approximately 400nm to 1000nm of aggregated plastics. This approach confirms the feasibility of using satellites to identify macro plastic conglomerations. Concurrent in-situ measurements of the properties of water and plastics provide essential data on the detection of marine macro plastic contaminants.
A comparative analysis between the radiometric measurements of macro plastics' spectral signatures and the hyperspectral data acquired by the drone was conducted. The results demonstrate a strong correlation, suggesting that drone-based hyperspectral data could effectively replace radiometric measurements in future satellite validation or matchup activities. This research represents a significant stride in the remote monitoring and evaluation of plastic pollution, offering a scalable solution with considerable implications for the conservation of marine ecosystems.

**Keywords:** Macro Plastics, UAV, Hyperspectral Remote Sensing