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Perspective

Portable Laser Diode Based Lidar System for the *In-situ* Detection of Plastics

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DESCRIPTION

Plastic pollution is a growing global issue, with significant impacts on water quality and ecosystems. Plastics such as polystyrene, polyvinyl chloride, polypropylene, polyethylene terephthalate and high-density polyethylene are major contributors to environmental contamination. As the need to monitor plastic litter in natural waters intensifies, this study introduces a portable laser diode based fluorescence lidar system designed for the *in-situ* detection of plastics in surface waters. The system uses excitation-emission fluorescence spectroscopic data to identify plastic materials in real-time.

The study was conducted in a controlled setting using a fluorescence lidar system that operates with a 405 nm excitation wavelength. The system was used to observe fluorescence signals from various plastics, with a focus on detecting the fluorescence at an emission wavelength of 470 nm. Additionally, the study examined how chlorophyll from *Chlorella vulgaris* influences the fluorescence signals in surface waters, as it is important to distinguish between plastics and other environmental factors. To further analyze the plastics, attenuated total reflection Fourier transform infrared spectroscopy was used to study their chemical composition before and after submersion in water. Scanning Electron Microscopy (SEM) and high-resolution camera microscopy were also employed to assess the surface morphology of the submerged Poly Ethylene Terephthalate (PET) samples.

Plastic pollution, particularly in marine environments, has long been recognized for its negative impact on water quality. The entry of plastics into oceans, rivers and lakes stems from industrial, agricultural and urban activities. These plastics can range from large items such as mega plastics to smaller particles like micro plastics. While much research has focused on Marine Plastic Litter (MPL), freshwater plastic contamination is gaining attention due to its implications for drinking water and its role in linking land-based plastic sources to the oceans.

Traditional methods for detecting plastic litter include visual inspection, microscopy, Fourier infrared spectroscopy, fluorescence imaging and thermal pyrolysis analysis. While these methods can identify and characterize plastics, they typically require water samples, making *in-situ* detection challenging. Recent advancements in remote sensing, however, offer new possibilities for detecting plastic pollution. Techniques such as multi-angle polarimetry, thermal infrared sensing and fluorescence imaging have shown potential in controlled studies, though the application of lidar techniques to plastic detection has been limited.

Lidar systems, including fluorescence lidar, are used in both atmospheric studies and aquatic environments. These systems are capable of detecting various optical properties in water, such as Colored Dissolved Organic Matter (CDOM) and phytoplankton. Fluorescence lidar, in particular, has been applied to environmental monitoring, providing valuable data on pollutants and biological matter in freshwater and marine ecosystems. However, the use of fluorescence lidar for detecting plastic debris, especially in scenarios where algae and plastics coexist, is still relatively unexplored.

Traditional detection methods such as microscopy can be slow and inefficient, especially for transparent plastics. However, the Laser Diode (LD)-based fluorescence lidar system offers real-time, *in-situ* monitoring capabilities. This system can distinguish between plastics and natural substances like microalgae, which also fluoresce. In experiments, the system successfully detected both plastics and *C. vulgaris,* highlighting its potential for monitoring plastic pollution in environments with varying fluorescence sources.

The study also revealed the impact of fluorescence interference from natural water constituents, such as Raman scattering and chlorophyll, on the detection of plastics. Despite these challenges, the fluorescence lidar system demonstrated its ability to detect submerged plastics at depths as shallow as 10 cm. The system's portable and durable design makes it suitable for use in coastal areas, where plastic pollution from residential and industrial sources is prevalent.

CONCLUSION

In conclusion, the portable LD-based fluorescence lidar system developed in this study shows great potential for *in-situ* detection of plastic pollution in surface waters. By utilizing fluorescence excitation-emission spectra, the system successfully identifies

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various plastics, including PET, even in the presence of natural water components like microalgae. This technology offers real-time, efficient monitoring, which is vital for managing plastic pollution in aquatic environments. Further development and testing will improve the system's accuracy, supporting better environmental management and contributing to global efforts to combat plastic contamination in freshwater and marine ecosystems.