Wave-Powered Filtration Buoy for Oil Spill Cleanup and Microplastic Removal

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Oil spills pose serious threats to marine ecosystems, disrupting biodiversity and causing widespread environmental and economic damage. Conventional cleanup techniques—such as booms, skimmers, and chemical dispersants—are often limited by inefficiency, high operational costs, and potential ecological side effects. This study introduces a novel, wave-powered filtration buoy designed as a passive, energy-independent solution for oil-water separation. The buoy uses wave-induced motion to pressurize a chamber that drives oil-contaminated water through hydrophobic and oleophilic media, eliminating the need for electricity or active pumping systems. Constructed from polyurethane foam and polypropylene mats, the buoy's filtration system captures oil while allowing clean water to exit. Five trials were conducted in controlled freshwater environments, simulating wave motion through induced oscillation. The buoy achieved oil separation rates between 70–80%, filtering an average of 11.14 liters of water per trial. Retained oil remained within the media, which can be cleaned and reused, along with the recovered oil. Key features include an adaptive intake that maintains performance despite fluctuating water levels and a modular design that enables scalability across various aquatic settings. Results demonstrated consistent performance, with minor deviations attributed to wave dynamics and filter saturation. By leveraging natural wave energy, the buoy significantly reduces environmental impact, energy requirements, and logistical barriers—making it ideal for remote or disaster-stricken regions. This system offers a sustainable, cost-effective alternative to traditional methods and marks a promising step toward resilient marine remediation and ecological preservation.

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