An Integrated Detection & Delivery System to Abate Contaminants in Water Bodies

Natarajan, Sharanya (School: Edgewood Junior Senior High School)

Estuaries are vital breeding grounds for species of flora and fauna, supporting resources for coastal communities worldwide. However, the ecosystem is rapidly declining due to eutrophication driven by nutrient enrichment across all regions. There is an urgent need to trap nutrient loads and mitigate the severity of eutrophication episodes through innovative approaches that integrate sustainable materials with technology. This research aimed to develop a real-time detection and delivery system for targeted contaminant management in marine habitats. Zeolite was selected through static analytical colorimetry for nitrate sequestration, and its effectiveness was enhanced by surface modification to improve absorption and retention. A detection system was engineered to assess conditions conducive to microorganism growth and prevent algal proliferation through targeted actions. Subsequently, a bespoke delivery system was fabricated in the lab to remotely deploy the zeolites for nitrate sequestration using a servo-pulley mechanism. Both systems were integrated into a remotely operated surface water vehicle. The final configuration included bi-directional protocols for navigational control, real-time data transmission to multimodal dashboards optimized for user-specific requirements, and triggered interventions to prevent harmful effects. Field tests were conducted locally in Lake Washington and the Indian River, with water quality monitored via cloud-based dashboards. A third-order polynomial regression machine learning model predicted high-nutrient environments with 92% accuracy. This cost-effective system offers engineers a scalable solution to promote cleaner waters, supporting UN Goal 14.1, which aims to significantly reduce marine pollution by 2025.

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