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Enhancing Fouling Index Predictions: A Hyperspectral and Deep Learning Approach to HAB Management

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ABSTRACT

Global warming significantly impacts ocean temperatures, influencing the frequency and severity of harmful algal blooms (HABs). These blooms pose substantial challenges for seawater desalination processes, primarily due to the increased fouling of reverse osmosis and micro/ultrafiltration membranes, which can halt the operation of desalination facilities, causing significant economic impacts. This study explores the application of hyperspectral imaging combined with deep learning models to improve the detection and analysis of algal organic matter and fouling indices, which are critical in managing and mitigating the effects of HABs on desalination systems. We utilize three deep learning techniques—Convolutional Neural Networks (CNN), Random Forest, and Ridge Regression—to analyze spectral data related to fouling indices such as Silt Density Index (SDI) and Modified Fouling Index (MFI). Our findings reveal that these methods can effectively correlate specific spectral bands with fouling propensity and algal presence, enhancing the predictive maintenance of desalination plants. The integration of hyperspectral imaging and artificial intelligence offers a promising approach to optimizing the pretreatment stages of seawater desalination, providing a substantial leap forward in the operational management of facilities affected by HABs.

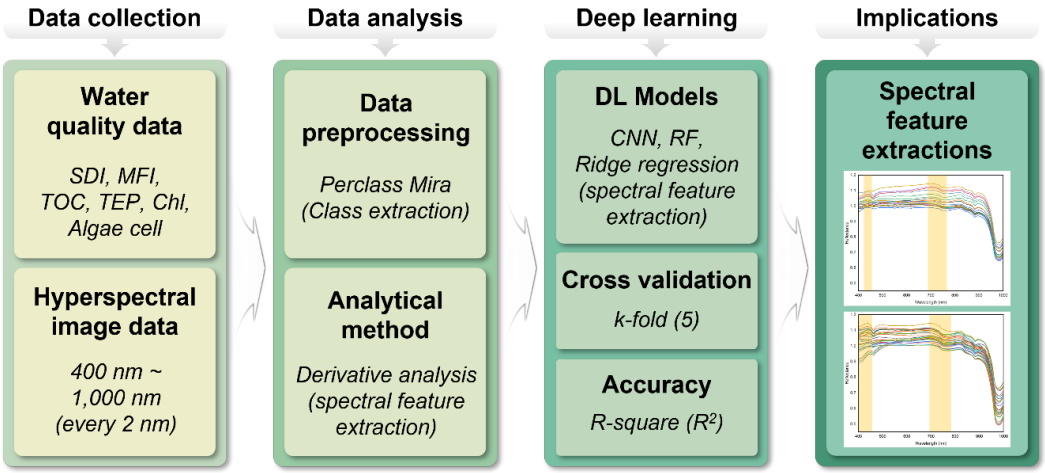

Fig 1. Schematic diagram of research flow

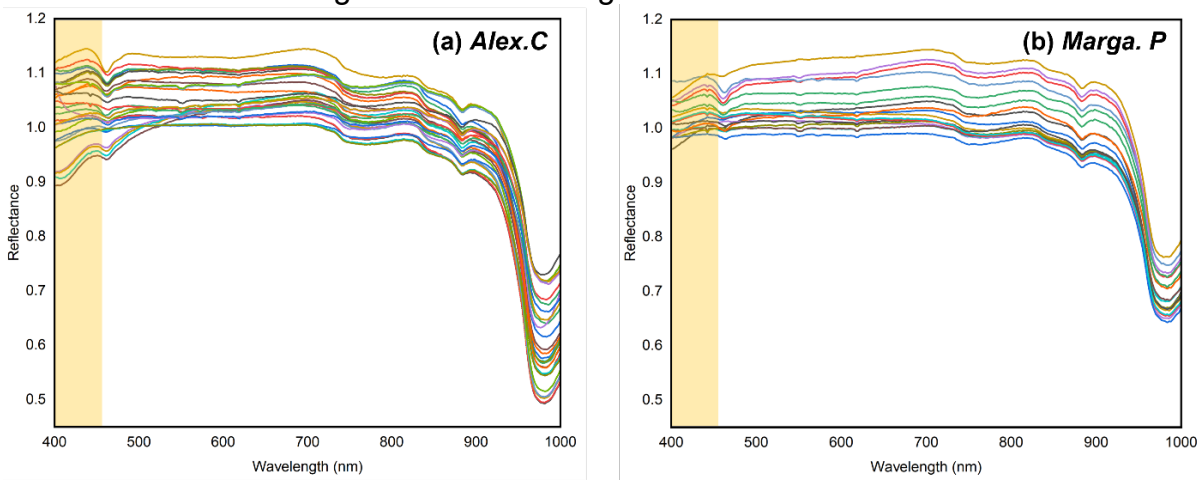

Fig 2. Key spectral features in algal species: (a) *Alex. C* and (b) *Marga. P.*

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