World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:19, No:03, 2025

Experimental Investigation of Seawater Thermophysical Properties: Understanding Climate Change Impacts on Marine Ecosystems Through Internal Pressure and Cohesion Energy Analysis

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Abstract : The unprecedented rise in global temperatures has triggered complex changes in marine ecosystems, necessitating a deeper understanding of seawater's thermophysical properties by experimentally measuring ultrasonic velocity and density at varying temperatures and salinity. This study investigates the critical relationship between temperature variations and molecular-level interactions in Arabian Sea surface waters, specifically focusing on internal pressure (π) and cohesion energy density (CED) as key indicators of ecosystem disruption. Our experimental findings reveal that elevated temperatures significantly reduce internal pressure, weakening the intermolecular forces that maintain seawater's structural integrity. This reduction in π correlates directly with decreased habitat stability for marine organisms, particularly affecting pressure-sensitive species and their physiological processes. Similarly, the observed decline in cohesion energy density at higher temperatures indicates a fundamental shift in water molecule organization, impacting the dissolution and distribution of vital nutrients and gases. These molecular-level changes cascade through the ecosystem, affecting everything from planktonic organisms to complex food webs. By employing advanced machine learning techniques, including Stacked Ensemble Machine Learning (SEML) and AdaBoost (AB), we developed highly accurate predictive models (>99% accuracy) for these thermophysical parameters. The results provide crucial insights into the mechanistic relationship between climate warming and marine ecosystem degradation, offering valuable data for environmental policymaking and conservation strategies. The novelty of this research serves as no such thermodynamic investigation has been conducted before in literature, whereas this research establishes a quantitative framework for understanding how molecular-level changes in seawater properties directly influence marine ecosystem stability, emphasizing the urgent need for climate change mitigation efforts.

Keywords : thermophysical properties, Arabian Sea, internal pressure, cohesion energy density, machine learning
Conference Title : ICCICC 2025 : International Conference on Climate Informatics and Climate Change
Conference Location : Tokyo, Japan
Conference Dates : March 17-18, 2025