World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:19, No:07, 2025

Thermodynamic Analysis of Surface Seawater under Ocean Warming: An Integrated Approach Combining Experimental Measurements, Theoretical Modeling, Machine Learning Techniques, and Molecular Dynamics Simulation for Climate Change Assessment

Authors : Nishaben Desai Dholakiya, Anirban Roy, Ranjan Dey

Abstract : Understanding ocean thermodynamics has become increasingly critical as Earth's oceans serve as the primary planetary heat regulator, absorbing approximately 93% of excess heat energy from anthropogenic greenhouse gas emissions. This investigation presents a comprehensive analysis of Arabian Sea surface seawater thermodynamics, focusing specifically on heat capacity (Cp) and thermal expansion coefficient (α) - parameters fundamental to global heat distribution patterns. Through high-precision experimental measurements of ultrasonic velocity and density across varying temperature (293.15-318.15K) and salinity (0.5-35 ppt) conditions, it characterize critical thermophysical parameters including specific heat capacity, thermal expansion, and isobaric and isothermal compressibility coefficients in natural seawater systems. The study employs advanced machine learning frameworks - Random Forest, Gradient Booster, Stacked Ensemble Machine Learning (SEML), and AdaBoost - with SEML achieving exceptional accuracy ($R^2 > 0.99$) in heat capacity predictions. the findings reveal significant temperature-dependent molecular restructuring: enhanced thermal energy disrupts hydrogen-bonded networks and ion-water interactions, manifesting as decreased heat capacity with increasing temperature (negative $\partial Cp/\partial T$). This mechanism creates a positive feedback loop where reduced heat absorption capacity potentially accelerates oceanic warming cycles. These quantitative insights into seawater thermodynamics provide crucial parametric inputs for climate models and evidence-based environmental policy formulation, particularly addressing the critical knowledge gap in thermal expansion behavior of seawater under varying temperature-salinity conditions.

Keywords : climate change, arabian sea, thermodynamics, machine learning
Conference Title : ICESCC 2025 : International Conference on Environment, Sustainability and Climate Change
Conference Location : Singapore, Singapore
Conference Dates : July 03-04, 2025