Abstract: Mathematical Modeling of Algae-Virus Infection Dynamics for Cost-Effective Biofuel Production

by

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With the global push for sustainable energy solutions, microalgae have gained attention as a promising biofuel source, with new methods like virus-assisted lipid extraction helping make algae-based biofuels more cost-effective. This thesis investigated the interaction between *Chlorella* algae and *Paramecium bursaria chlorella virus*-1 (PBCV-1) using variations of the SIR (Susceptible-Infected-Recovered) model to improve algae biofuel production. By leveraging epidemiological modeling, the thesis aimed to understand viral infection dynamics in algae and optimize the viral infection for efficient and effective lipid extraction for biofuels. Two distinct experimental setups were conducted to evaluate how environmental conditions impact infection outcomes. Mathematical models, including SIR and SEIR (Susceptible-Exposed-Infected-Recovered) versions, were calibrated using Bayesian inference and nonlinear optimization to estimate critical parameters such as infection and mortality rates. Key findings reveal that the SIRVII model, which included the initial concentration of infected algae as a model parameter, offered the most reliable fit by balancing biological relevance and statistical performance. In contrast, the SEIR-based models, while able to capture latent infection phases, posed risks of overfitting with too many parameters. The study emphasized the complexity of applying modeling tools to characterize viral infections at scale, suggesting that future research should address potential trade-offs between lipid productivity and infection dynamics. The findings offer potential insights not only for biofuel production but also for broader ecological management strategies, including the targeted control of harmful algal blooms.