Assessing GHG emission reduction potential of covered lagoons in the Northwest

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INTRODUCTION

- Livestock manure management is a major source of methane, a greenhouse gas with a much higher global warming potential than CO_2.
- Covered Animal Manure Lagoons (CAML) can capture this methane and use it as a renewable energy source, but their performance in cold regions like the Pacific Northwest is not well quantified.
- Widely used models such as ADM1 assume well-mixed, reactor-like conditions and do not capture the stratified, seasonally variable behavior of manure lagoons.
- There is currently no region-specific prediction tool that links lagoon design, manure characteristics, and local climate to methane production for Washington dairies.
- This project develops and validates a hybrid kinetic–AI model and a user-facing application to predict methane yield from CAML and support climate-smart manure management in the Northwest.

OBJECTIVES

- Develop a predictive model for methane production from covered animal manure lagoons under Washington climate conditions.
- Integrate first-order kinetics and temperature dependence with AI (LSTM + SNN) to capture both biochemical constraints and temporal dynamics.
- Validate the model using laboratory experiments, open lagoon field data, and national digester benchmarks.
- Deploy the model as an accessible decision-support tool for farmers, engineers, and policymakers to optimize CAML design and operation.

MATERIALS & METHODOLOGY

- Dairy manure slurries (2–6% TS) were digested at controlled temperatures (4–45 °C) to estimate first-order and Arrhenius-based kinetic parameters; these lab-derived relations were combined with lagoon volume growth and a hybrid LSTM–Spiking Neural Network (SNN) to predict methane yield and emissions, with the detailed simulation workflow shown in the figure.

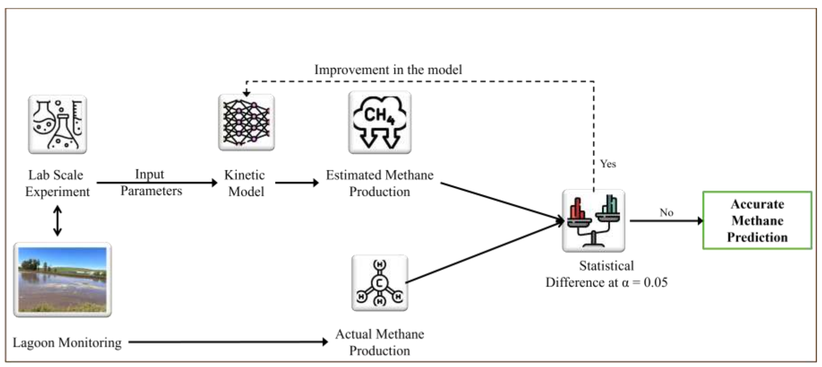

Fig. 1. Overall workflow of the GHG mitigation model

RESULTS & DISCUSSION

- Temperature effect: 30-day methane yield increased from ~105 mL CH_4/gVS at 25 °C to ~242 mL CH_4/gVS at 45 °C, with corresponding rate constants rising from 0.072 to 0.122 d^{-1}.
- Model accuracy: The hybrid LSTM–SNN achieved high agreement with lab data (R^2 ≈ 0.95, low MAE), outperforming purely data-driven models by enforcing kinetic structure.
- Field-scale validation: Predicted methane from WA lagoons and an AgSTAR digester case study matched independent estimates within about 10–15%, demonstrating transferability.
- Decision support: The deployed tool converts farm inputs and weather data into daily/seasonal methane curves, helping users assess GHG reduction and energy recovery potential of covered lagoons.

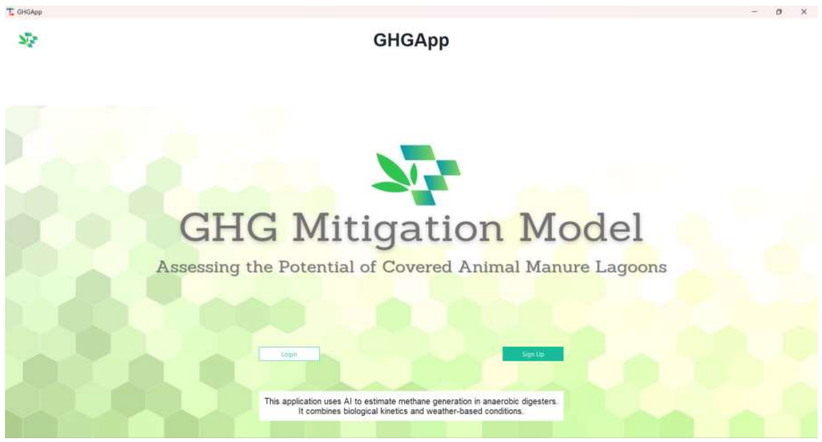

Fig. 2. GHG Methane Prediction App homepage.

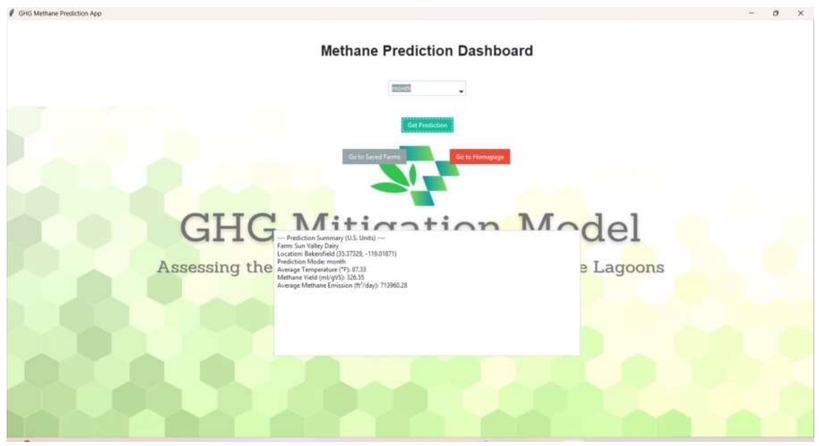

Fig. 3. GHG Methane Prediction App dashboard showing monthly predictions for a case-study dairy.

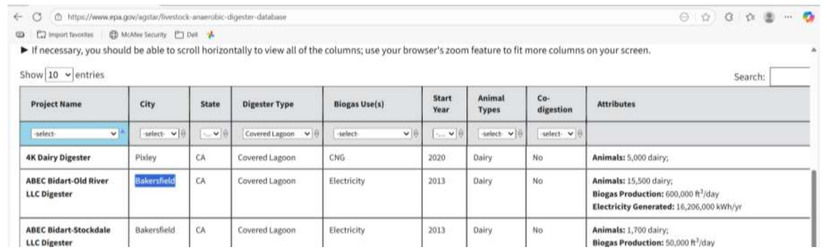

Fig. 4. Excerpt from the U.S. EPA AgSTAR livestock anaerobic digester database.

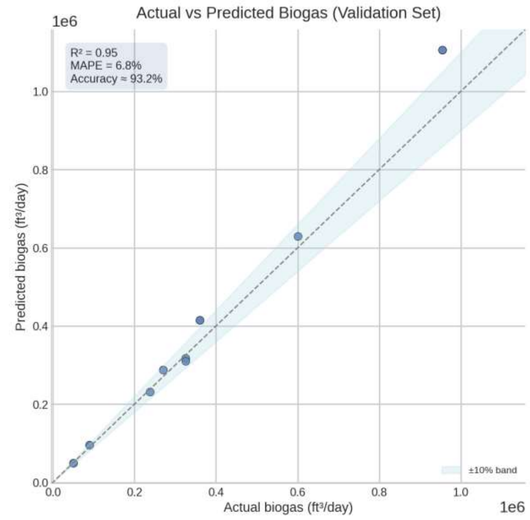

Fig. 5. Actual vs predicted biogas production for the validation set.

CONCLUSION

- A hybrid kinetic–AI framework was successfully developed to predict methane production from CAML under Northwest climate conditions.
- This work supports climate-smart manure management by quantifying the GHG reduction and renewable energy potential of CAMLs in Washington and beyond.

ACKNOWLEDGEMENT

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