



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study : Ph.D.

Thesis Title: **APPLICATION OF MACHINE LEARNING ALGORITHMS FOR INTEGRATED SOLID WASTE MANAGEMENT IN GUWAHATI CITY**

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SHORT ABSTRACT

Rapid urbanization and enhanced consumption patterns lead to substantial growth in the municipal solid waste (MSW) generation rates. Social and environmental challenges are ever increasing due to world-wide enhancement in the per capita waste generation. Technological interventions will foster the integrated city-wide solid waste management in several important yet mandatory themes. Notable among these are accurate prediction and forecasting of total solid waste, compost production rate, biogas production rate, greenhouse gas (GHG) emissions from landfills and incinerators, and design specification-based techno-economic analyses of composting and anaerobic biogas digester systems. With such efforts, environmental planning of solid waste managerial infrastructure can be established through effective planning strategies.

The Ph.D. thesis fulfilled eight major objectives namely (a) survey-based quantification and seasonal classification of waste among socio-demographic groups in the Guwahati City; (b) modelling waste generation rate using ensemble tree-based ML algorithms and forecasting with moving average methods in the Guwahati City; (c) efficient prediction of organic and recyclable waste generation with supervised ML algorithms and autoregressive integrated moving average models (ARIMA) in Guwahati city; (d) ML-based prediction and forecasting of GHG emissions and particulate matters from MSW landfill and incineration sites in Guwahati City; (e) prediction and forecasting of composting rates using meteorological parameters and organic waste data with ANN and hybrid ML for Guwahati City; (f) prediction and forecasting of anaerobic digestion rates using meteorological parameters and organic waste data with ML and hybrid ML models for Guwahati City; (g) development of a techno-economic calculator for biogas production based on alternate designs and optimal forecasting of biogas generation rate in Guwahati City and (h) development of a techno-economic calculator for composting facilities based on alternate scales and optimal forecasting of compost production in Guwahati City. For the techno-economic analysis of biogas plants and compost plants, the selling price of biogas and compost were considered in Indian context and in the range of 0.25 – 0.75 \$/m³ and 10 – 25 \$/ton respectively. Accordingly, negative profit for biogas plants and modest profits for compost plants were realized with a payback period ranging about 5 – 7 years. A statistical tool namely SPSS software was deployed to achieve relevant statistical results. Also, Python version 3.8 with NumPy, Scikit-learn, Pandas, and Matplotlib libraries for data analysis, modelling, and automated data processing on an i7-4790 CPU @ 3.60 GHz processor was deployed.

In summary, the Ph.D. thesis affirmed that ML techniques, time series and hybrid ML models can accurately predict and forecast MSW generation patterns. Thus, they can assist in the efficient waste management in the Guwahati city. These models also demonstrated their potential to optimize composting and biogas processes under different climatic conditions.

The integration of an AD calculator, ML techniques, and GIS data enhanced the pragmatic characteristics of the modelling efforts for relevant and optimal biogas and compost facilities. Such a modelling framework can assure improved operational efficiency, increased energy generation, and cost-effective operations. Considering the thesis findings, it can be concluded that the ISWM of Guwahati city can be best realized through the application of machine learning algorithms for solid waste rate prediction and subsequent planning of organic waste recycling strategies. Such efforts can enable the policy makers of the city for put forth a feasible and practical sustainable waste management plan in the forthcoming decade that is about to witness rapid economic growth, urbanization and associated complexities in the solid waste management challenges on a city-wide basis. Also, the selling price of biogas and compost shall increase or Government of India shall provide a substantial price subsidy for the consolidation of the sustainable solid waste management in the city environments. This is a major outcome of the PhD thesis findings.

