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Hybrid data-driven modelling and control of coagulation-flocculation in water treatment

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Motivation

Coagulation and flocculation are among the most crucial steps in wastewater treatment processes, yet they also account for a significant share of operational costs due to chemical consumption. In many treatment plants, chemical dosing is still largely based on operator experience, trial-and-error approaches, and labor-intensive practices, which can lead to inaccurate dosing and excessive chemical use. Overdosing not only increases costs but also contradicts sustainability goals and can negatively impact downstream treatment and the environment. These limitations highlight the need for a further, enhanced understanding of coagulation-flocculation processes to provide insight into optimized, and potentially automated, dosing strategies that can improve efficiency, reduce chemical consumption, and support sustainable wastewater treatment operations.

Advanced System Control

Moving toward more sustainable and cost-efficient decision-making has accelerated the integration of advanced technologies into industrial processes, including wastewater treatment plants. In this context, system control has emerged as a powerful and growing field in water resources engineering, enabling real-time monitoring, optimization, and informed decision-making. By leveraging hybrid data-driven approaches, system control frameworks can dynamically identify optimal operating conditions for coagulation and flocculation processes [1,2]. These technologies support adaptive control of chemical dosage, improving treatment performance while reducing operational costs and environmental impacts, ultimately leading to more efficient and sustainable treatment systems.

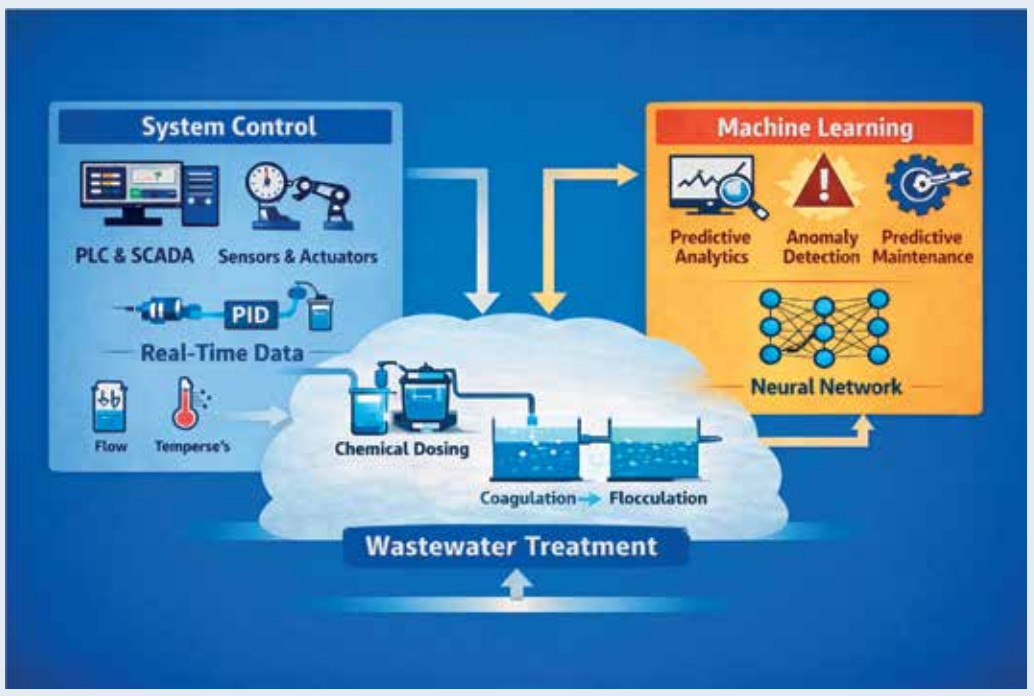

Fig 1. Schematic overview of a system control for coagulation and flocculation in wastewater treatment

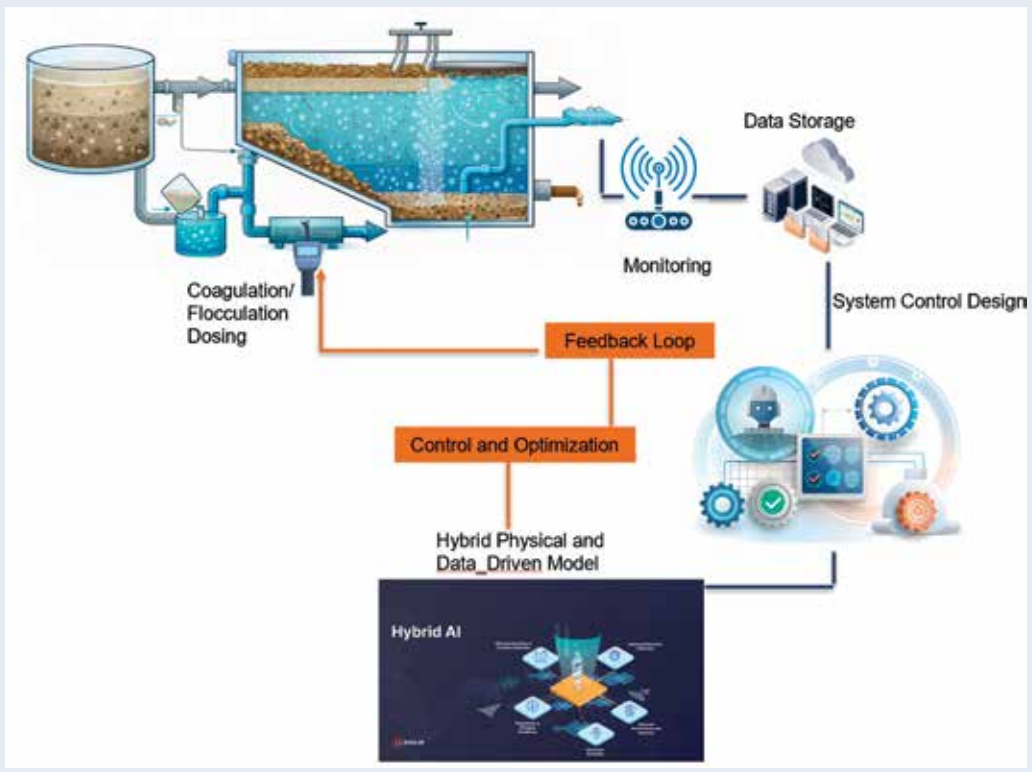

Fig 2. Schematic overview of a hybrid physics-based and data-driven modeling and control framework for coagulation and flocculation in wastewater treatment

Research goals

The main goal of this research is to gain further insight into coagulation-flocculation processes to eventually develop a system control framework that couples this knowledge with data-driven approaches to improve the accuracy and efficiency of the overall process. This framework relies on robust monitoring through sensor-based measurements, systematic data collection, and advanced model development. By integrating real-time process data with hybrid modeling techniques, the proposed system aims to enable optimized and adaptive chemical dosing, leading to more efficient, cost-effective, and sustainable wastewater treatment operations.

References

[1] Castelletti, A., Ficchì, A., Cominola, A., Segovia, P., Giuliani, M., Wu, W., Lucia, S., Ocampo-Martinez, C., De Schutter, B., & Maestre, J. M. (2023). *Model predictive control of water resources systems: A review and research agenda.*

[2] Bello, O., Hamam, Y., & Djouani, K. (2014). *Nonlinear model predictive control of a coagulation chemical dosing unit for water treatment plants.*