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# A data-pipeline for autocalibration of soft sensors: A case study from a Norwegian WRRF

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**Abstract:** Water Resource Recovery Facilities (WRRFs) are embracing digital transformation through advancements in online monitoring, low-powered IoT devices, and machine learning (ML) algorithms that convert raw data into actionable insights. Among these innovations, soft sensors have gained popularity for their ability to estimate water-quality parameters that are difficult or impossible to measure directly with physical sensors. Despite their advantages, soft sensors require regular calibration to address drift caused by changes in water quality or operational conditions, a process that is traditionally time-consuming and labour-intensive. To tackle this challenge, this study introduces an automated calibration pipeline designed to streamline the process by integrating data cleaning, model recalibration, and deployment. The pipeline is engineered to automatically trigger when discrepancies are detected between soft sensor outputs and reference data obtained from standardized lab measurements. Deployed at a full-scale WRRF the system demonstrates a potential to reduce manual effort, ensure consistent estimation accuracy, and enhance operational efficiency. Although results and evaluations are still pending, the deployment represents a significant step toward automating sensor calibration and improving reliability. This work highlights the promise of integrating data-driven solutions to address operational challenges, paving the way for more efficient and sustainable WRRF practices.

**Keywords**: Data pipeline, soft sensor, auto-calibration

## Introduction

The Søndre Follo WRRF is a full-scale wastewater treatment plant located in Vestby municipality, approximately about 35 kms from Oslo. With a treatment capacity of 29000 population equivalent (p.e), the WRRF uses chemical coagulation/flocculation followed by sedimentation as its primary process for removing particles and total phosphorus from municipal wastewater. Detailed information about the treatment process is available in Nair et al. (2022). The WWRF features a state-of-the-art monitoring system equipped with hybrid soft sensors (Ching *et al*. 2021, Nair *et al.* 2020) to estimate Chemical Oxygen Demand (COD) and Total Phosphorus (TP) concentration at both the raw and treated wastewater. These soft sensors provide high frequency real-time data, which support control strategies and generate real-time alerts in the event of process failures. Figure 1.1 illustrates the user interface of the system in its DOSMON platform.

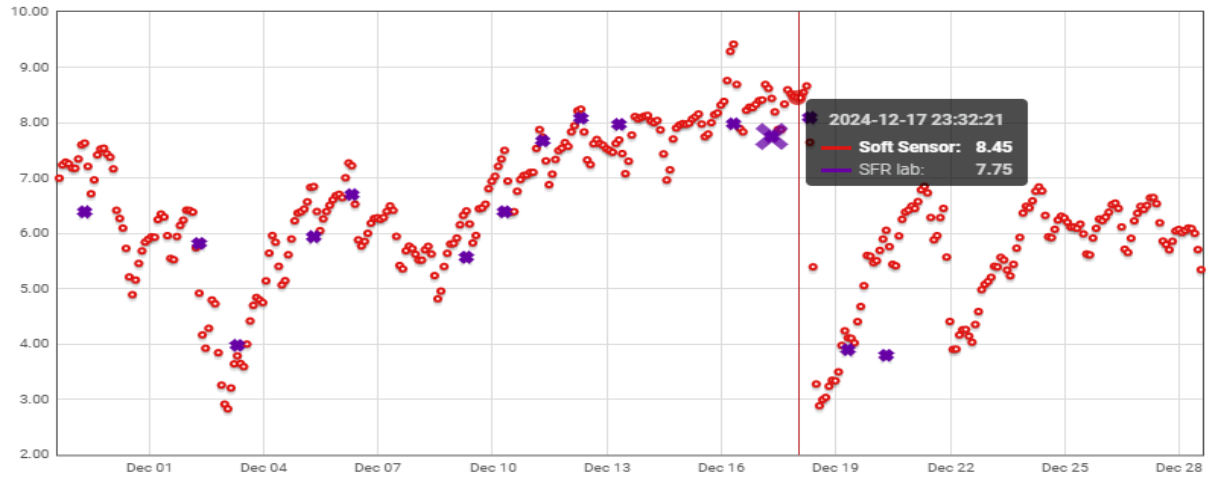


**Figure 1.2** A soft sensor for monitoring inlet TP in the SFR WRRF.

Soft sensors, while generally reliable, can occasionally exhibit gradual drifts in their estimates due to long-term changes in water quality and process conditions. To ensure accuracy, plant operators routinely check soft sensor estimates against daily laboratory measurements (Figure 1.1). Additionally, the sensors undergo periodic calibration every few months or whenever significant deviations are detected. This recalibration process updates the model to maintain alignment between sensor estimates and actual laboratory measurements.

Currently, the calibration procedure is performed manually, requiring significant man-hours. The process involves several labour-intensive stages, including data cleaning and preprocessing, model development, and deployment to production. These tasks are not only time-consuming but also lack standardization, which can further complicate the workflow.

This work proposes streamlining and automating the soft sensor calibration process through a Continuous Integration/Continuous Deployment (CI/CD) framework. The proposed solution consists of modular components designed to handle specific tasks in sequence: automatic detection of sensor drift, recalibration of the soft sensor, and deployment to production. This approach aims to enhance efficiency, reduce manual effort, and standardize the overall process.

**Materials and methods**

The soft sensor deployed at SondreFollo WRRF utilizes data from physical sensors such as flow, Total Suspended Solids (TSS), conductivity, and pH, to estimate TP and COD. Detailed information on the mathematical model, data query module, and code deployment infrastructure is available in one of our previous works (Nair *et al.* 2022).

The proposed data pipeline, illustrated in Figure 1.2, outlines the sequential workflow of key modules. These include a drift detection system, a data-cleaning and consolidation algorithm, and a soft sensor recalibration algorithm, all implemented in Python. The CI/CD process uses Jenkins, an open-source automation server, to streamline software development by automating tasks such as building, testing, and deploying applications. Jenkins facilitates Continuous Integration (CI), where developers regularly merge code into a shared repository, triggering automated builds and tests to ensure the codebase remains deployable. It also supports Continuous Delivery (CD) by automating the deployment of tested code to staging or production environments. This integration minimizes manual intervention, reduces errors, and accelerates feedback loops. The Jenkins-driven infrastructure is designed for scalability, reliability, and ease of integration, enhancing operational efficiency. Additionally, it supports seamless updates, fault tolerance, and efficient resource management, providing a robust foundation for long-term deployment.

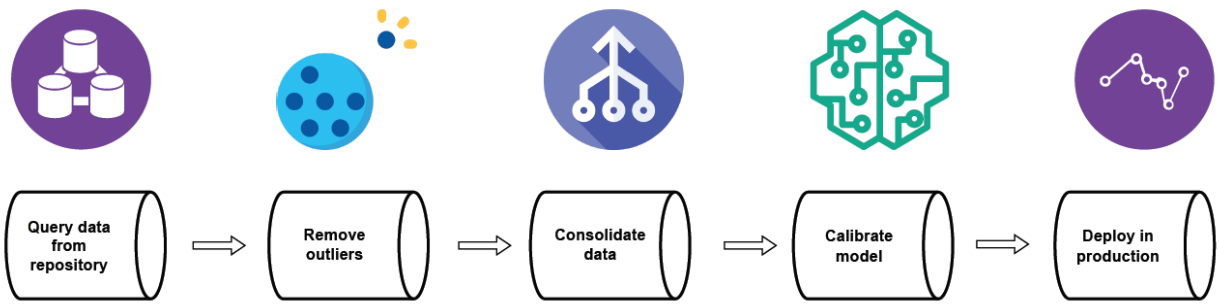


**Figure 1.2** Workflow of different processes along the autocalibration data pipeline.

As a proof of concept, the autocalibration pipeline has been deployed for the automatic recalibration of inlet TP and COD soft sensors. The similar deployment strategy as described in (Nair *et al.* 2024) has also been used to test the autocalibration pipeline. The pipeline will be tested in a production environment over a four-month period to evaluate its effectiveness in continuously realigning soft sensor estimates with laboratory-measured values, thereby ensuring accuracy and reliability over time. Additional metrics on the number of manhours saved will also be evaluated during the evaluation period.

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