Automation in wastewater treatment to increase STPs' efficiency

Introduction

Wastewater treatment is the process of removing contaminants from domestic and industrial sewage, and producing effluent that meets the environmental standards for discharge or reuse. Sewage treatment plants (STPs) are facilities that perform wastewater treatment using various physical, chemical and biological methods. Parameters like Biochemical Oxygen Demand, Dissolved Oxygen, and Dissolved Solids need to be carefully managed in modern STPs to provide optimum water quality.

The design and management of STPs is an important task. It needs the consideration of various technical, economic, social and environmental factors. The design and management of large utility-scale Sewage Treatment Plants and Industrial Effluent Treatment Plants differ significantly. In this problem statement, we will focus on decentralized, small-scale STPs that are in residential complexes, owned by Resident Welfare Associations, and operated by appointed third party contractors.

These small scale STPs require proper design, implementation and operations to ensure their efficiency and long-term operability. We have seen that most systems are poorly run due to gaps in design and knowledge.

A typical STP needs the following elements in its design and operation.

- Selection of process: Choosing the appropriate treatment technologies and unit operations for the STP, based on the treatment objectives, influent water quality, effluent standards, operational and maintenance requirements, and cost-effectiveness.
- Design: Calculating the dimensions, capacities and operating parameters of each unit process, based on the design criteria, hydraulic and mass balances, and empirical formulas, which is based on estimating the quantity and quality of the wastewater to be treated, based on the population, water consumption, industrial activities, and seasonal variations.

The management of STP looks at the following aspects.

Operation and maintenance: Running and maintaining the STP in a safe and efficient manner, ensuring the optimal performance of each unit process, and complying with the effluent standards and regulations.

Monitoring and testing: Measuring and analyzing the wastewater's physical, chemical and biological parameters, sludge, and effluent, using appropriate sampling methods and laboratory techniques, and recording and reporting the results.

Troubleshooting and optimization: Identifying and resolving the problems and issues that may arise in the STP, such as process upsets, equipment failures, odor complaints, and effluent violations, and implementing corrective and preventive actions.

Energy and resource recovery: Reducing the energy consumption and greenhouse gas emissions of the STP, and recovering the valuable resources from the wastewater and sludge, such as biogas, nutrients and water.

Safety and environmental management: Ensuring the health and safety of the STP staff and the public, and minimizing the environmental impacts of the STP, such as noise, dust, and odors.

How can decentralized STPs be made more efficient through automation?

Automating wastewater treatment ensures that STPs are efficiently used with minimal interventions. Automation uses various technologies and systems to monitor, control and optimize the processes and operations of wastewater treatment plants. It can enhance the efficiency, reliability and sustainability of wastewater treatment.

An ideal system should be: (a) cost effective; (b) easy or simple to be used by less trained operators and not so qualified RWA members; (c) robust, so that instrumentation doesn't go into repair and hence disuse at the slightest opportunity. These may have implications on what parameters need to be picked for broadly assessing system performance (something simple and easy to measure). Furthermore, we can also look at what kind of instrumentation should be considered. For example, it should not require continuous power supply for it to be effective, economical, etc.

Taking the above into consideration and looking at the following factors, think of automated solutions for efficient design and maintenance of STPs.

Real-time data-measurement and recording various physical, chemical and biological parameters of the wastewater, sludge, and effluent, such as flow, level, pH, temperature, dissolved oxygen, turbidity, nitrogen, phosphorus, and microbial activity. These data can help to assess the performance and compliance of the treatment processes, and to identify and resolve any problems or issues that may arise.

Data-driven insights-systems can analyze and visualize the data collected from the monitoring devices, using various tools and techniques. These include dashboards, graphs, charts, trends, alarms, reports and artificial intelligence. These insights can help to optimize the treatment processes, such as adjusting the aeration, chemical dosing, sludge removal, and energy consumption, based on the changing conditions and requirements.

Enhanced process control: Automation systems can control and regulate the operation of various equipment and components of the treatment plant, such as pumps, valves, blowers, mixers, filters and sensors, using programmable logic controllers (PLCs), supervisory control and data acquisition (SCADA) systems, and remote terminal units (RTUs). These systems can enable the automation of routine tasks, the coordination of multiple processes, and the implementation of advanced control strategies, such as feedback, feedforward, and model predictive control.

Maintenance: Systems that detect and diagnose the faults and failures of the equipment and components, using various methods, such as vibration analysis, acoustic emission, infrared thermography, and machine learning. These systems can also predict the remaining useful life and the optimal maintenance schedule of the equipment and components, using various techniques, such as reliability analysis, risk assessment, and condition-based maintenance.

Skilled personnel: In aerobic treatment methods, process control is important for efficient functioning. Hence, monitoring of various parameters and responding to the same by a trained, skilled operator becomes important. Automation can play a role in making up for the lack of skills of an operator. Anaerobic systems are more passive systems and inherently robust. These need less process control and automation. However, these systems struggle to give high quality output for reuse purposes.