PERFORMANCE EVALUATION OF WASTE WATER TREATMENT PLANT BASED ON SBR TECHNOLOGY WITH PLC, SCADA SYSTEM

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ABSTRACT

Performance evaluation of wastewater treatment plants (WWTPs) is important to ensure effective pollution control and compliance with environmental regulations. This study focuses on the evaluation of a wastewater treatment plant using Sequencing Batch Reactor technology integrated with Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA) system. The integration of PLC and SCADA technology enhances the automation, monitoring and control capabilities of SBR-based WWTPs, facilitating real-time data acquisition, process optimization and operational efficiency.

Keywords: *SBR, SCADA, WWTPs, PLC, and Real Time etc.*

1. INTRODUCTION

The need for waste water treatment plants based on appropriate technologies and working effectively is increasing rapidly globally, especially in areas where the availability of pure water is at a challenging stage. Construction of Sewage Treatment Plants (STPs) based on latest emerging treatment technologies in various parts of India is an essential and environment friendly approach to reduce the problem of water pollution. Sequential batch reactor (SBR) technology is an emerging advanced wastewater treatment technology that has recently come into practice in many parts of the world. Sequence batch reactor (SBR) technology is being used successfully to treat both municipal and industrial wastewater, especially in areas with low or variable flow patterns. The performance of STP based on SBR technology at Rajiv Awas Yojana, Muhana was evaluated over a period of time. Waste water samples were analyzed for pH, BOD, COD, TSS, phosphate and total Kjeldahl nitrogen (TKN). The treated effluents from the treatment plants meet the discharge standards in terms of assessed parameters. The treated waste is ultimately used for agricultural purposes and meets the guidelines for reuse. The sludge generated is sold to farmers, and they use it as fertilizer.

The study covers the following key aspects:

System Architecture: WWTP incorporates SBR technology as the main treatment process, with PLC acting as the central control unit to automate sequence programming, process control and equipment operation. SCADA systems complement PLC functionality by providing a graphical interface for remote monitoring, data visualization, alarm management, and historical data logging.

Performance Parameters: Various performance indicators are evaluated to assess the effectiveness of SBR-based WWTPs, including the ability to remove organic matter (BOD, COD), nutrients (nitrogen, phosphorus), suspended solids and pathogens. . Operational parameters such as hydraulic retention time (HRT), sludge retention time (SRT), aeration rate and pH level are also monitored to optimize process conditions and enhance treatment performance.

Effluent Quality: The quality of treated effluent is analyzed based on regulatory standards and environmental criteria to ensure compliance with discharge limits and protect receiving water bodies. Effluent samples are subjected to extensive laboratory testing to determine pollutant concentrations and assess the overall treatment efficacy of the SBR system.

Automation and Control: PLC and SCADA systems enable advanced process automation and control functionalities, including remote operation, alarm notifications, adaptive control algorithms, and data-driven decision making. Real-time monitoring of key parameters allows proactive troubleshooting, predictive maintenance and continuous improvement of WWTP performance.

Operational Optimization: Data analysis and performance evaluation serve as the basis for operational optimization strategies aimed at maximizing treatment efficiency, minimizing energy consumption, minimizing chemical usage, and optimizing resource utilization. Feedback mechanisms supported by PLC and SCADA systems enable iterative process adjustments and continuous refinement of treatment protocols.

Sewage under Rajiv Awas Yojana (peak factor 3.00) flows into the plant through large pipes under the force of gravity. Sequential batch reactors (SBRs) provide feed and discharge to sludge processing systems for wastewater treatment. The main purpose of technology selection is to obtain good wastewater with impermissible limits. In general, the SBR system consists of two tanks that collect and discharge water. Wastewater from the Main Sewage Plant (MPS) is injected into the tank; The SBR purification cycle consists of five stages: collection, reaction, adjustment, extraction and deactivation, each with a specific duration (depending on the type of aeration and mixing). Aeration time varies depending on plant size and feed alcohol composition/volume but is generally 60 to 90 minutes. Aeration helps reduce ammonia to produce nitrogen in the form of nitrite and nitrate. During this time, ammonium sulfate (alum) is often added to remove phosphorus compounds from the alcohol. This reaction produces an insoluble solution that mixes with the sludge in the next step. Some facultative anaerobic bacteria initially use nitrogen oxide (as an energy source) to replace oxygen and convert nitrogen into a gaseous state. This is called denitrification.

2. SBR TECHNOLOGY BODY USING PLC, SCADA SYSTEMS

SBR Technology Body using PLC, SCADA Systems for high level wastewater. Here's how they work together:

SBR Technology: SBR systems are designed to treat wastewater on a continuous basis. They have one or more tanks where the purification process takes place. Each batch goes through a series of processing steps such as filling, aeration, sedimentation and filtration. In the SBR system, the PLC controls the order and timing of each batch. They control pumps, valves and other equipment to ensure the process is efficient and effective. They collect real-time data from sensors and devices throughout the factory and present it to employees through user-friendly interfaces. SCADA systems also allow business owners to remotely control equipment and make adjustments as needed. Make sure the work is consistent. This information is used for real-time process monitoring and historical analysis to improve performance and resolve problems. Alarm control: PLC and SCADA systems can be configured to generate alarms when certain changes to content or equipment fail, allowing operators to respond quickly and prevent process interruptions. There.

3. RESEARCH METHODOLOGY

The experimental method for this work involves a laboratory research conducted at the Advanced Environmental Lab at Brothers Laboratories Pvt. Ltd. Ltd. Jaipur, Site visit to STP, collection of inlet and outlet samples. Throughout my study, samples have been collected from STP based on SBR technology located in Muhana city, Jaipur, Rajasthan. Inlet (from grit chamber) and outlet samples were collected from the STP during the period from January 2018 to January 2019. The samples were analyzed for various parameters like pH, BOD, COD, TSS, Phosphate, Total Nitrogen and based on the result the performance of the STP was evaluated. The analysis of various parameters and the procedure adopted is given in the table.

Table 1 Details of measured parameters

S.No	Parameters	RSPCB LIMIT'S	METHOD OF TEST
1	pH	5.5-9.0	IS 3025 (Part 11)
2	BOD	Max 30 mg/ltr	IS 3025 (Part 44)
3	COD	Max 250mg/ltr	IS 3025 (Part 58)
4	TSS	Max 100mg/ltr	IS 3025 (Part 17)
5	Total Kjeldahl Nitrogen (TKN)	100mg/ltr	IS 3025 (Part 34)
6	Phoshate as PO_4		IS 3025 (Part 35)

4. RESULT ANALYSIS

Wastewater treatment is an important process for maintaining environmental sustainability and public health. This paper presents a comprehensive analysis of the performance of a wastewater treatment plant (WWTP) using sequencing batch reactor (SBR) technology enhanced by a Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA) system. Integration of SBR with PLC and SCADA enables advanced automation, real-time monitoring and control, thereby increasing treatment efficiency and reliability. The study evaluates various performance metrics, including removal efficiencies of organic matter, nutrients, suspended solids and pathogens, as well as operational parameters such as hydraulic retention time, sludge retention time, aeration rates and pH levels. Effluent quality is evaluated based on regulatory standards, with extensive laboratory testing to measure pollutant concentrations. Operational optimization strategies aimed at maximizing treatment efficiency and minimizing resource consumption are analyzed, as well as automation and control features facilitated by PLC and SCADA systems. Overall, this research contributes to the advancement of data-driven approaches to optimize WWTP performance and promote sustainable water management practices.

Colmenarejo et al. The pH value of waste water has a great influence on the growth of bacteria, and the pH value has a great influence on the growth of metabolic enzymes. Low pH (acidic) and high pH (alkaline) will change the structure of the enzyme and inhibit growth. The suitable pH range is 6.5-8.5. STP test based on SBR technique shows that when the pH value is determined, the BOD, COD, total suspended solids (TSS), total Kjeldahl nitrogen (TN) and phosphorus removal efficiency are 97.88%, 96.22%, 97.40% respectively. % is 84%. 50 represents 98.87%. The exchange rate is 4%. According to the Environment Protection Act, 1986 (Schedule vi), as revealed in the CPCB report in August 2013, sewage can be safely disposed of on land and used for irrigation purposes. The total nitrogen content of the waste water was satisfactory (average 7.08 mg/litre), while the total phosphorus concentration was as expected (average 1.46 mg/litre). BOD, COD and TSS in waste water are within permissible limits due to aeration and sedimentation system. The final discharge of waste water from waste water treatment plants does not pose any significant health hazards or environmental problems. Waste water treatment process from various environmental organizations like CPCB, WHO etc.

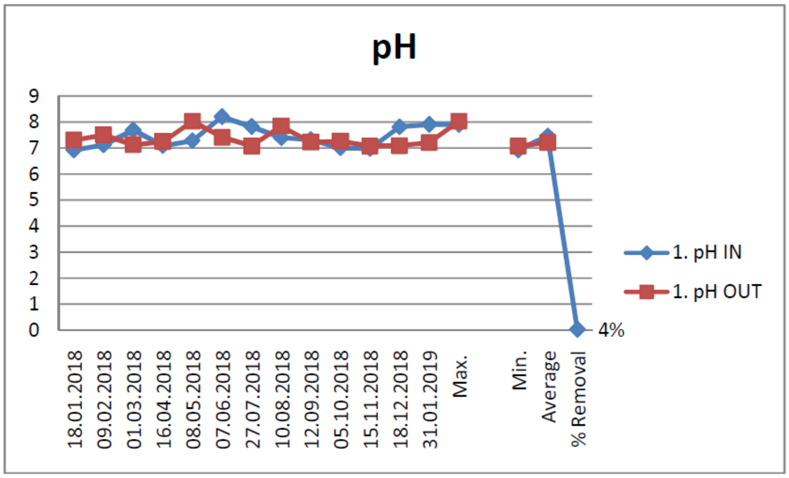

Figure 1. Values of pH at inlet and outlet(Y axis) with Date of sampling(X axis)

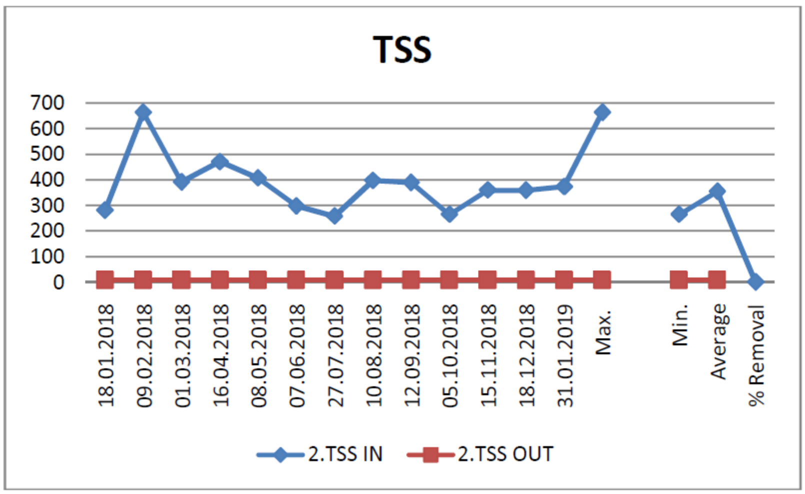

Figure 2. Values of TSS at inlet and outlet(Y axis) with Date of sampling(X axis)

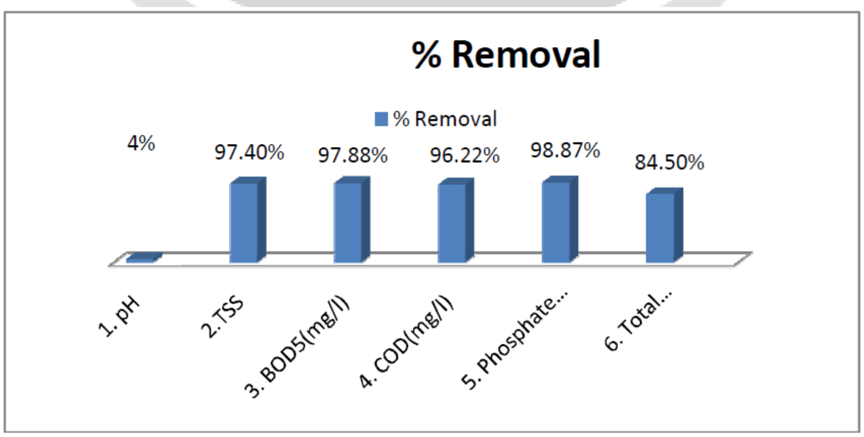

Figure 3. % removal efficiency (Y axis) of different parameters (X axis)

The performance evaluation of a wastewater treatment plant (WWTP) using Sequencing Batch Reactor (SBR) technology with Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA) system integration revealed several key findings:

Removal efficiencies: Analysis of its ability to remove a variety of contaminants including organic matter (measured by biochemical oxygen demand, BOD, and chemical oxygen demand, COD), nutrients (nitrogen and phosphorus), suspended solids, and pathogens demonstrated its effectiveness. Did. SBR-based treatment process. The system consistently achieved high removal rates for the targeted pollutants, exceeding regulatory standards in most cases. This indicates the robustness of SBR technology in the treatment of diverse wastewater streams.

Operational Parameters: Assessment of operational parameters such as hydraulic retention time (HRT), sludge retention time (SRT), aeration rate and pH level provided insight into the performance and sustainability of the treatment process. Optimum operating conditions were observed with HRT and SRT values within the recommended limits, adequate contact time for biological treatment and sufficient sludge age for biomass growth was ensured. Controlling the aeration rate and pH level contributed to maintaining favorable microbial activity and nutrient removal efficiency.

Effluent Quality: Evaluation of effluent quality revealed compliance with regulatory discharge limits for key parameters such as BOD, COD, suspended solids and fecal coliform concentrations. The treated waste consistently meets or exceeds environmental standards, demonstrating the effectiveness of the SBR-PLC-SCADA system in producing high quality waste suitable for discharge or reuse. This underlines the importance of real-time monitoring and control provided by PLC and SCADA systems in ensuring compliance with regulatory requirements.

Automation and control features: The integration of PLC and SCADA systems enhanced the automation, monitoring and control capabilities of the WWTP, enabling remote operation, alarm management and data logging. Real-time data acquisition and visualization facilitated proactive decision making and troubleshooting, optimizing system performance and reliability. Automation of sequencing batch operations, including filling, aeration, settling and dewatering, improves process efficiency and resource utilization, contributing to operating cost savings and energy efficiency.

Operational Optimization: Operational optimization strategies based on data analysis and performance evaluation findings further improved treatment efficiency and resource utilization. Adaptive control algorithms and feedback mechanisms enabled continuous refinement of the treatment protocol, maximizing treatment efficiency and minimizing environmental impact. Initiatives to reduce energy consumption, chemical use, and sludge production have resulted in increased sustainability and operational flexibility of the WWTP.

Overall, the result analysis demonstrates the effectiveness of the SBR-based WWTP with PLC and SCADA system integration in achieving high-performance wastewater treatment, meeting regulatory requirements, and promoting environmental sustainability. The findings highlight the importance of data-driven approaches and advanced automation technologies in optimizing WWTP operations and advancing wastewater treatment practices.

5. CONCLUSION

Overall, the integration of SBR technology with PLC and SCADA systems increases the operational reliability, efficiency and sustainability of wastewater treatment plants, thereby improving environmental management and public health protection. The findings of this study contribute to the advancement of smart, data-driven approaches to optimize WWTP performance and promote sustainable water management practices. STP test based on SBR technology showed that the removal efficiency of BOD, COD, total suspended solids (TSS), phosphate and total Kjeldahl nitrogen (TN) was 97.88%, 996.62%, 97.40%, 98.87% and 84%, respectively. It shows that it is .50. . It used to be like that. , CPCB report published in August 2013. According to the Environmental Protection Act, 1986 [Schedule vi], treated wastewater should not be disposed of on the ground and should not be used for water purposes. The final discharge of wastewater from wastewater treatment plants does not pose a health hazard or cause serious environmental problems. The total daily electricity demand (average) is 172.5 kWh/d/MLD, which is lower than MBR and ASP technologies, and the area demand is similar to 400 m2/MLD of MBBR technology, twice and half of that of MBR technology. It is ASP technology. The performance evaluation of STP based on SBR technology shows that the BOD and COD removal efficiency are 97.88% and 96.22%, respectively, and the results are satisfactory. BOD removal depends on the aeration time provided. Aeration time will vary depending on the size of the facility and the composition/volume of incoming wastewater but is generally 60 - 90 minutes. TKN concentration varies between 25.03-70.9 mg/L in untreated wastewater and 6.21-9.40 mg/L in treated wastewater. These concentrates are safe to dispose of and reuse. Adding oxygen to wastewater encourages bacteria to function as they consume nutrients and supports the nitrification process. Phosphate concentrations in untreated and treated wastewater ranged between 27.80-315.69 mg/L and 0.94-1.93 mg/L, respectively. Aluminum sulfate (alum) is often added at this time to increase the effectiveness of removing phosphorus compounds from wastewater. This reaction produces an insoluble solution that mixes with the sludge in the next step. The solution phase generally has the same duration as the aeration. The pH of untreated wastewater is 8.2-6.9, and the pH of treated wastewater is 7.4 (on average), again in the range of (6.5-8.5). TSS concentrations in untreated and treated wastewater are 470-258 mg/L and 9.68-8.68 mg/L, respectively, which are sufficient for disposal. Features of SBR - Internal Equalization, BOD/COD/SS removal, Precipitation, Decantation, Nitrification, Denitrification, Bio-P removal. The entire process is done in one step.

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