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# Potential of unmaintained sensors for continuous monitoring of aerated lagoons

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**Abstract:** There is a growing need for reliable and cost-effective online monitoring systems in small and decentralized wastewater treatment plants (WWTPs). Unmaintained sensors can address this need by reducing maintenance requirements and operational costs. This study compares the performance of maintained and unmaintained sensors for measuring dissolved oxygen (DO) and pH in aerated lagoons. The initial results indicate that unmaintained sensors can capture overall process variations effectively, offering valuable insights despite data inaccuracies.

**Keywords**: Automation; unmaintained sensors; aerated lagoons; small-scale WWTPs

## 1. Background

In Quebec, Canada, aerated lagoons are the most common WWTPs, accounting for approximately 67% of the 811 WWTPs (MAMOT, 2014). They are ideal for small communities thanks to their low labour and operational costs. While they effectively treat emerging contaminants, they face challenges such as limited capacity, energy inefficiency, and inadequate nutrient removal, which can lead to violations of effluent standards (Desjardins et al., 2015; Houweling et al., 2007; Patry et al., 2021). Addressing these challenges is crucial to ensuring the sustainability of these systems.

Automated monitoring and control systems can improve the operation of WWTPs and address these challenges. However, such systems are not widely used in small or decentralized WWTPs due to the need for regular sensor maintenance, which is challenging with limited operator presence. One solution can be the use of unmaintained sensors, which reduce operational costs and labour (Schneider et al., 2019). Although these sensors may not provide perfectly accurate data, they can still provide valuable insights. This study evaluates the performance of unmaintained sensors for continuous monitoring of aerated lagoons treatment process.

To achieve this, a monitoring station was installed at the effluent of an aerated lagoon WWTP in Portneuf (Quebec, QC, Canada), as shown in Figure 1.1. The station was equipped with two maintained and two unmaintained sensors. All sensors were equipped with a regular compressed air scour (5 seconds every 5 minutes), and maintained sensors were cleaned weekly. Weekly effluent samples were also collected, and laboratory measurements were conducted for routine wastewater variables such as ammonia and nitrate.

| | |
|---|---|
| Designed average inflow | 1,751.8 $m^3$/day |
| Number of cells | Three cells in series |
| Dimension for each cell | Length :66m<br>Width:22 m |
| Water volume | 10,800 $m^3$ |
| Designed hydraulic retention time for each cell | 6.17 day |

**Figure 1.1** Portneuf aerated lagoons system and its design characteristics (Quebec, QC, Canada).

## 2. Results

Figure 2.1 presents the results of the weekly laboratory measurements for effluent ammonia, nitrate, chlorophyll a, and water temperature from May 15 to November 27, 2024. The results highlight seasonal variations in nitrification and algal activity, with chlorophyll a serving as an indicator of algae growth.

Nitrification began in mid-June as temperatures increased and continued until December. Complete ammonia removal was observed from July 24 to October 16, with nitrate levels peaking at 13.7 mg/L on August 24. These findings demonstrate the temperature dependence of nitrifying bacteria, which require specific conditions for optimal growth and activity in aerated lagoons (Patry et al., 2021).

Figure 2.1 shows that algae growth was seasonal, in the presence of sunlight and nutrients. During summer, rising temperatures enhance microbial activity, leading to increased sediment digestion and nutrient release. Increased sunlight intensity supports photosynthesis, allowing algae to produce oxygen that is consumed by aerobic bacteria.

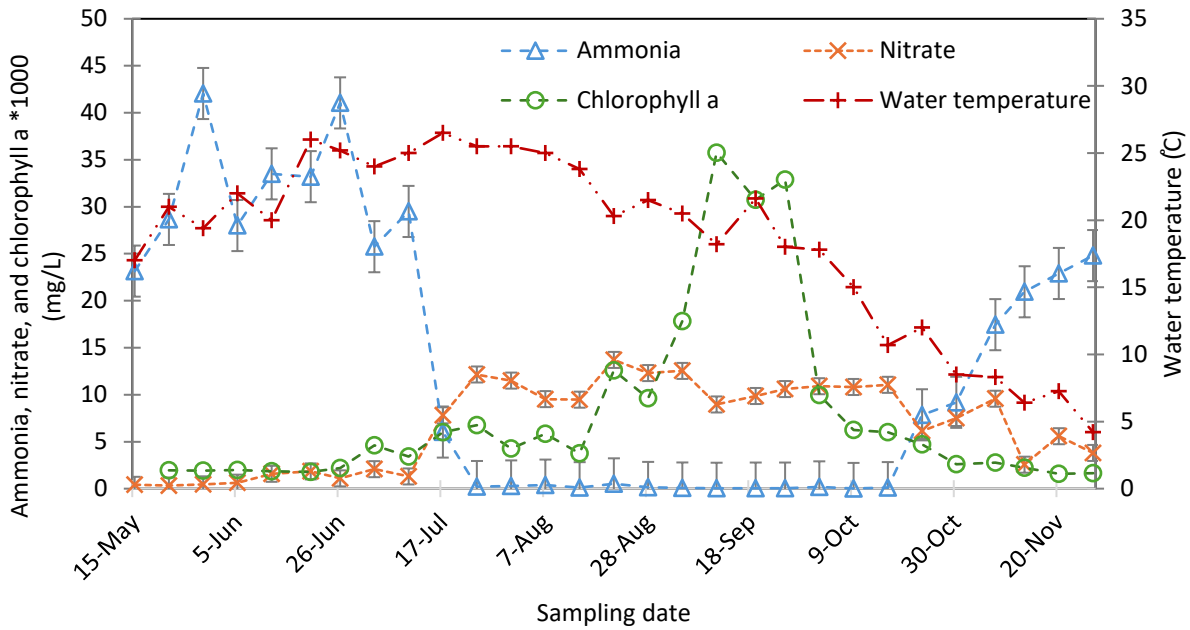


**Figure 2.1** Algae and nitrogen species in the aerated lagoon effluent.

Using Figure 2.2 and Figure 2.3, the performance of maintained and unmaintained sensors will be compared. Figure 2.2 presents data from DO (top) and pH (bottom) sensors installed at effluent point.

Figure 2.2 (top) shows that the unmaintained DO sensor failed to track changes in DO levels until July 22. However, it performed reasonably well after this date, responding to major process variations. However, by the end of October, it failed again to measure DO values effectively. Remarkably, the unmaintained sensor provided good results during the most important period. It is hypothesized that the higher biological activity at the higher summer temperatures provided an auto-cleaning environment for the sensors.
Figure 2.2 (bottom) shows that pH levels decreased overall in July, which can be attributed to the initiation of nitrification, reflecting an annual pattern. Both maintained and unmaintained pH sensors recorded this reduction in pH.

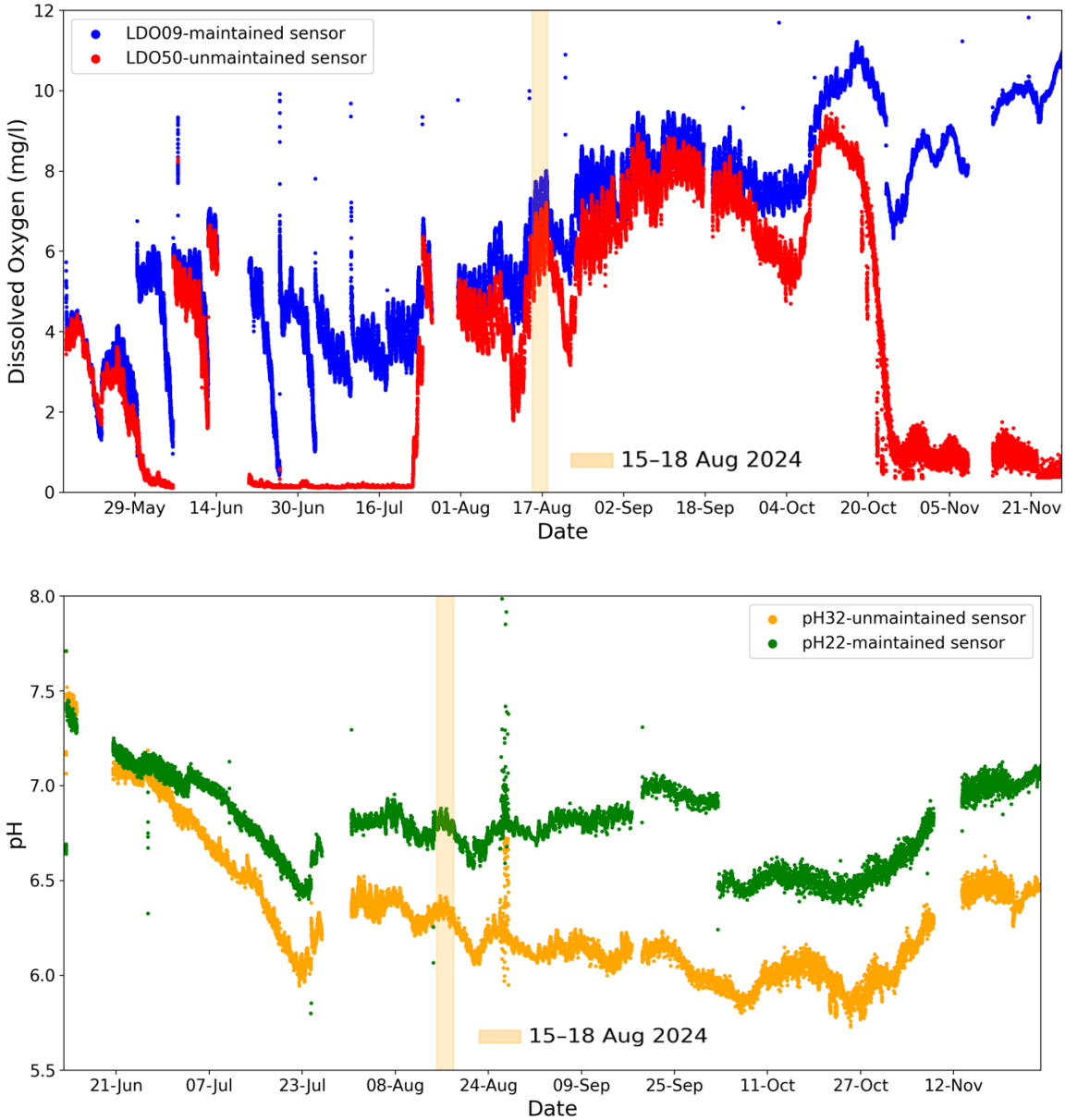


**Figure 2.2** Comparison between maintained and unmaintained DO sensors (top) and pH sensors (bottom) in the effluent for the summer of 2024.

Figure 2.3 provides a more detailed view of the DO and pH data between August 15 and 18, 2024.

Both maintained and unmaintained sensors recorded the daily fluctuations of DO and pH levels caused by algal activity: At daytime, photosynthesis increases oxygen levels and consumes carbon dioxide, raising the pH. At night, respiration by algae and bacteria consumes oxygen and produces carbon dioxide, lowering the pH.

Figures 2.2 and 2.3 show that unmaintained sensors in aerated lagoons can provide useful data similar to maintained sensors, even though they are less accurate in measuring DO and pH levels. As shown in Figure 2.3, the unmaintained sensors showed fluctuations with similar amplitudes to those of the maintained sensors, indicating that they tracked changes in the monitored variables equally well, despite the lack of regular maintenance. This strongly suggests that unmaintained sensors can still be effective for monitoring wastewater treatment processes.

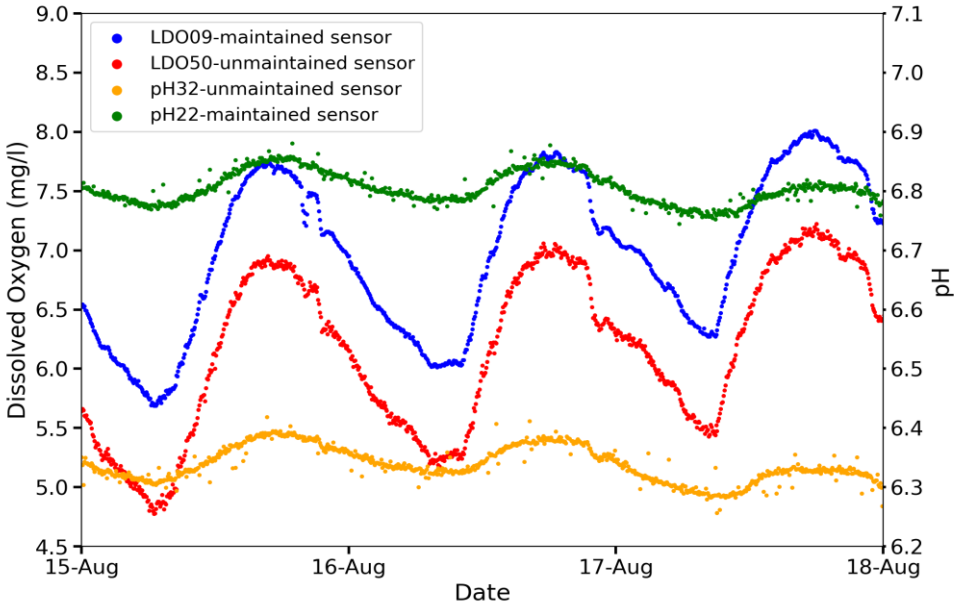


**Figure 2.3** Comparison of maintained and unmaintained DO and pH sensors in the effluent for the period 15–18 August 2024.

## 3. Future Steps

Future steps that will be reported at the conference, involve testing various data preprocessing techniques to identify the most effective approach for extracting valuable information from the unmaintained sensor data. Also, further data collection is required to determine whether the decrease in pH levels is associated with the initiation of nitrification, as other factors, such as the addition of ferric sulphate for phosphorus removal, could also contribute to pH reduction.

## 4. Impact

This study explores the use of unmaintained sensors in small, decentralized WWTPs as a cost-effective solution for automated monitoring. These sensors reduce maintenance costs while providing valuable data for real-time performance monitoring and process optimization. By integrating data from unmaintained sensors into SCADA systems, operators can track key parameters, ensuring regulatory compliance and improving operational efficiency. This data can eventually be used in machine learning models to forecast performance and enable predictive maintenance, enhancing decision-making and process control. This approach optimizes wastewater treatment processes, reduces operational costs, and enhances the sustainability of these systems.

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