Monitoring of some parameters of water quality: integrating sensor low cost in one floating platform na on amphibius drone

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Highlights:

- The development of na IoT device to monitor water quality has been carried out using low-cost sensors to measure turbidity, temperature, dissolved oxygen and hydrogen potential (pH).

Keywords: low-cost sensors; water quality; IoT technology.

INTRODUCTION

This article presents the results of a systematic literature review, within the scope of the research project by Camargo et al. (2023), aiming to identify the low-cost sensors most used in automatic monitoring of water quality. Sensors available on the market were analyzed based on criteria such as measurement capacity, accuracy, robustness, cost and ease of use. The goal was to provide an overview of available options and guide readers in selecting the sensors best suited to their specific needs. Furthermore, the article discusses the development and testing of a floating platform and an amphibious drone, both integrated with Internet of Things (IoT) technologies. These technologies will enable continuous, real-time monitoring of water quality, addressing challenges faced by sanitation companies, such as the lack of intellectual and human capital for field services. The results obtained show that low-cost sensors can provide data comparable to reference equipment, demonstrating satisfactory accuracy and durability. The practical application of the developed solutions offers an innovative approach to face the challenges of the sanitation sector in water quality management. The main advantage of this solution is its mobility.The durability of the sensors presented for monitoring water quality is one of the technical challenges found when using low-cost sensors. The fact that the sensors are always immersed in the Water directly affects its durability due to the measurement environment itself. Another important point lies in calibration, as many of the sensors need periodic calibrations to ensure reliability of the results. Using a mobile measurement platform, such as an amphibious drone, you can expand the durability of the sensors, as the sensors will only be immersed in water during the measurement. In the end, the drone returns to its base. This type of solution allows more frequent calibrations to be carried out, compared to a floating station or a multiparameter probe that is fixed at a certain local. Furthermore, the drone allows you to monitor several geographic points with a single piece of equipment, which increases data availability and reduces equipment costs.

METHODOLOGY

The sensors were tested in three ways: with standard solutions, with inter-comparison with equipment reference and in the field in the municipal lake of Toledo (Paraná). Test results showed that the lowcost sensors showed satisfactory performance to monitor water quality in time real, as described in the work of Xavier (2021).Standard solution results were obtained using turbidity reference solutions (standard solution commercial formazin with turbidity 20 NTU and confidence interval 0.4 NTU), pH (solutions with pH 4, 7 and 9) and dissolved oxygen (zero dissolved oxygen solution was prepared with anhydrous sodium sulfite (Na2SO3) diluted in water). All tests were performed five times. The sensors were immersed in the solutions and measured values were compared with expected values It is important to highlight that two sensors were used to measure dissolved oxygen. The ENV-50 sensorDO was used because it is more robust and reliable, despite being more expensive, while the SEN0237 sensor. It was used because it was cheaper and simpler, but also less accurate and durable.

RESULTS AND CONCLUSIONS

The results of the sensors with intercomparison with reference equipment were obtained using a portable multiparameter probe from Hanna, model HI9829. The reference equipment has calibrated and certified temperature, turbidity, dissolved oxygen and pH sensors. During the experiment period (42 h), the dissolved oxygen probe of the reference equipment malfunctioned. therefore, dissolved oxygen data is discarded. The low-cost sensors were placed simultaneously with the reference equipment in a container with water. Subsequently, the values collected by both were compared. The temperature sensor showed good agreement with the reference equipment, with differences of less than 0.5°C. The pH sensor presented a measurement curve similar to the response curve of the reference sensor during 20 h of testing, after this period the curves differed considerably. It is concluded that the pH sensor does not have a mechanical structure prepared to be immersed for periods of tens of hours. The turbidity sensor performed inconsistently throughout most of the experiment. However, it withstood being submerged and presented results close to the reference sensor during the first 8 hours of testing. After this time, the difference between the response curves of the two sensors increased continuously . In relation to the area of IoT technologies, the project demonstrated the feasibility and usefulness of integrating security sensors low cost and wireless communication systems to monitor water quality in real time. Not that not only enables automated data collection in remote locations, but also facilitates access and analysis of this data through online platforms. Furthermore, the integration of the devices with an amphibious drone showed how IoT technology can be combined with other emerging technologies to create solutions innovative and versatile solutions for environmental monitoring. Overall, the project contributed to the democratization of water quality monitoring, providing accessible tools that can be used by researchers, environmental managers and interested citizens. Additionally, he showed how IoT technology can be used to improve data collection and analysis environmental issues, potentially leading to better management and protection of water resources. The platform was equipped with an ESP-WROOM-32 microcontroller, an RFM95W LoRa transceiver, an ADS1015 analog-to-digital converter (required for some sensors), an SD card reader and writer to store sensor readings, and a time clock real RTC DS1307. The system was powered by a photovoltaic panel and a rechargeable battery. The data collected by the sensors was transmitted via the LoRaWAN network to an Internet platform. It is important to mention that two sensors were used to measure dissolved oxygen: the robust and reliable ENV-50-DO, despite its higher cost, and the SEN0237, which is lower in cost and simpler, but less accurate and durable. The two sensors were used to evaluate the relationship between cost and performance, comparing the robustness and reliability of the ENV-50-DO sensor with the simplicity and lower cost of the SEN0237 sensor. The amphibious drone, Figure 1, was developed to combine the advantages of aerial and water drones. It is capable of flying and landing on water as needed to collect data on water quality parameters at different geographic points. The drone was equipped with the same types of low-cost sensors used on the floating platform and a communication system via the LoRaWAN network, allowing the collected data to be sent to a web platform in real time. Furthermore, it is equipped with a GPS (Global Positioning System) to determine its location and trajectory.

Figure 1 - Amphibious drone concept

In Figure 2, the correlation between the reference probe (HANNA) and low-cost sensors is presented: A) turbidity measurement, with Pearson's r of 0.96 and coefficient of determination of 0.92. B) temperature measurement, with Pearson's r of 0.99 and coefficient of determination of 0.99

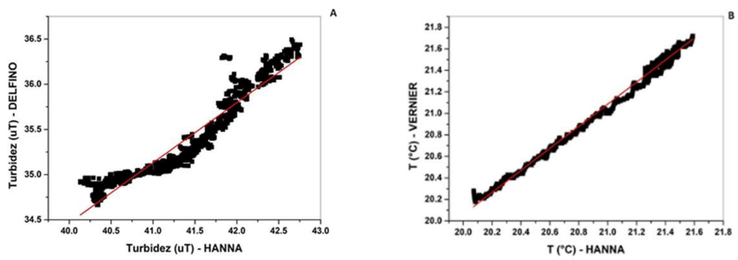

Figure 2 – Correlation between low-cost sensors and the reference probe

In general, low-cost sensors present satisfactory performance for several parameters used in water quality control, as long as they are previously evaluated in comparison to reference probes and confidence intervals are established for each one. They are important as complementary instruments to quickly detect changes in water quality parameters, preventing damage to equipment and, therefore, minimizing maintenance or repair costs. They also help in the water treatment process, as the conditions of the water entering the treatment plant are known in advance. Low-cost sensors must be validated against reference devices to ensure their accuracy and reliability. However, only 18 of the studies analyzed in the work by Camargo et al. (2023) performed this comparison, while 124 did not include reference instruments or validation discussion. Several studies reported the comparison of low-cost sensors with reference probes, even though the test periods were relatively short. Some studies have demonstrated good performance of low-cost sensors, with accuracy and durability comparable to top-of-the-line equipment.

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