

Área: ANA

Development of a Low-Cost Modular and Didactic Photometer for Water Quality Analysis and Scientific Instrumentation Education.

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Palavras Chave: *Photometer, Water Quality, Beer–Lambert Law, ESP32, 3D Printing, Educational Instrumentation.*

Highlights

Low-cost and 3D-printed photometer using biodegradable PLA material; Measures nitrite, ammonia, orthophosphate, and iron in water samples; Achieved average $R^2 = 0.95$ vs. 0.99 for a reference UV-Vis spectrophotometer; Modular design with interchangeable LEDs and sensors (IR/UV).

Resumo/Abstract

This work presents the development of a didactic, modular, and low-cost photometer, designed for river water quality analysis in the Foz do Iguaçu region and to support experimental activities in scientific instrumentation education. The device measures parameters such as nitrite, ammonia, orthophosphate, and iron, widely used in water quality assessment and environmental studies. Its operation is based on the Beer–Lambert Law, which states that light absorption by a sample is related to its concentration. The system uses a high-intensity LED as the light source, an LDR (Light Dependent Resistor) as the detector, and an ESP32 Super Mini microcontroller responsible for data acquisition and signal processing. The LDR varies its resistance with light intensity and, connected in series with a 470Ω resistor, forms a voltage divider. To reduce errors, each measurement corresponds to the average of three readings. As concentration increases, less light reaches the sensor, increasing the LDR resistance and decreasing the measured voltage. The device was 3D-printed using PLA filament, chosen for being biodegradable and renewable. The modular design allows precise alignment between the light source and the detector and enables replacement of the LED and sensor (including infrared and ultraviolet), expanding the system's spectral range. Calibration with samples of known concentrations resulted in an average determination coefficient (R^2) of 0.95 for the developed device and 0.99 for the reference UV-Vis spectrophotometer, indicating strong correlation and satisfactory performance. Finally, an interactive web interface was developed for automatic data storage (.csv) and real-time R^2 calculation, displaying a dynamic calibration curve that facilitates statistical analysis and continuous monitoring of measurements.

Agradecimentos/Acknowledgments

Agradeço ao doutorando Flávio pelo apoio e pela confiança no desenvolvimento do dispositivo. Também agradeço a UNILA pelo o espaço e em especial ao Laboratório de Instrumentação Eletrônica. Os autores agradecem à Fundação Araucária de Apoio ao Desenvolvimento Científico e Tecnológico do Estado do Paraná, Governo do Estado do Paraná/SETI, EDITAL N°191/2021/PRPPG/UNILA, CAPES e ao grupo de pesquisa LEIMAA.