

## Infrared Lightbox and iPhone App for Improving Detection Limit of Phosphate Detecting Dip Strips

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**Abstract :** In this paper, we report the development of a portable and inexpensive infrared lightbox for improving the detection limits of paper-based phosphate devices. Commercial paper-based devices utilize the molybdenum blue protocol to detect phosphate in the environment. Although these devices are easy to use and have a long shelf life, their main deficiency is their low sensitivity based on the qualitative results obtained via a color chart. To improve the results, we constructed a compact infrared lightbox that communicates wirelessly with a smartphone. The system measures the absorbance of radiation for the molybdenum blue reaction in the infrared region of the spectrum. It consists of a lightbox illuminated by four infrared light-emitting diodes, an infrared digital camera, a Raspberry Pi microcontroller, a mini-router, and an iPhone to control the microcontroller. An iPhone application was also developed to analyze images captured by the infrared camera in order to quantify phosphate concentrations. Additionally, the app connects to an online data center to present a highly scalable worldwide system for tracking and analyzing field measurements. In this study, the detection limits for two popular commercial devices were improved by a factor of 4 for the Quantofix devices (from 1.3 ppm using visible light to 300 ppb using infrared illumination) and a factor of 6 for the Indigo units (from 9.2 ppm to 1.4 ppm) with repeatability of less than or equal to 1.2% relative standard deviation (RSD). The system also provides more granular concentration information compared to the discrete color chart used by commercial devices and it can be easily adapted for use in other applications.

**Keywords :** infrared lightbox, paper-based device, phosphate detection, smartphone colorimetric analyzer

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