Effortless Alkalinity Analysis Using AI and Smartphone Technology, No Equipment Needed, From Freshwater to Saltwater

Han, Zachary (School: Solon High School)

Alkalinity is a crucial water quality parameter with significant environmental and engineered system applications. Various analysis methods exist, from traditional titrations to advanced spectrophotometric and electrochemical techniques, each with specific benefits and limitations. Developing simple, affordable techniques for alkalinity analysis is essential to facilitate extensive and reliable water quality monitoring, empowering citizen scientists, and overcoming financial barriers in traditional monitoring programs. In this work, we developed an equipment-free, user-friendly alkalinity analysis approach accessible to a broad demographic. Specifically, we employed low-cost commercial reagents to generate color changes in response to alkalinity levels in various freshwater and saltwater samples. These images were captured with a smartphone and processed using machine learning models to correlate color intensity with alkalinity levels. After examining the effects of container type, lightning condition, ML algorithms, and sample size, we obtained the best models with R^2 values of 0.868±0.024 and 0.978±0.008, and root-mean-square-error values of 29.5±2.6 and 14.1±2.0 for freshwater and saltwater, respectively. When five inexperienced users utilized this method for alkalinity analysis, they achieved comparable results in performance. Additionally, we developed a user-friendly website where users, without prior experience, can upload images to obtain alkalinity readings for their water samples. This AI-powered, equipment-free technology represents a significant advancement in water quality monitoring.

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