Evaluating Low-Cost Nitrate Test Strips for Drinking Water Using Algorithm-Based Color Interpretations.

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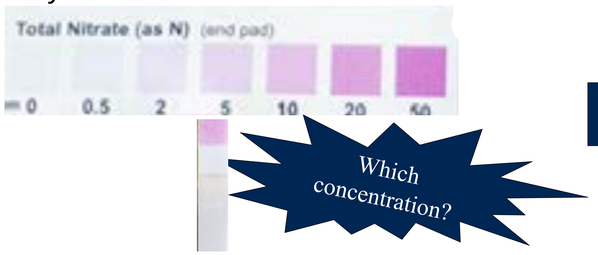
Introduction

- Nitrate (NO_3) is a common contaminant present in NC's drinking water and can cause major health issues.
- Current low-cost testing method for nitrate in drinking water involve interpret color of testing strip against manufacturer chart
  - **This method is very subjective and produces a lot of errors and bias**
- High-sensitively numeric nitrate meters are inaccessible



Purpose

- Develop a calibration curve of nitrate concentration and the color parameter value (RGB) of nitrate testing strip's photo.
- Use such calibration curve to develop an algorithm-based interpretation method for nitrate concentration range based on an input of nitrate testing strip photo

Materials

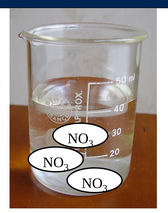
- **Hannah industries marine nitrate colorimeter**
  - Serial dilutions are added ~0.35g of NaCl to mimic marine water
  - Range of nitrate detection: 0-75 ppm

- **Bartovation drinking water nitrate testing strip**
  - Range of nitrate detection: 0-500 ppm

- **DataColor color calibration card**
  - Nitrate testing strip is placed on top of the calibration card and photos are taken for analysis
  - a software is used to standardize photos in different lighting conditions, angles and camera models.

Method

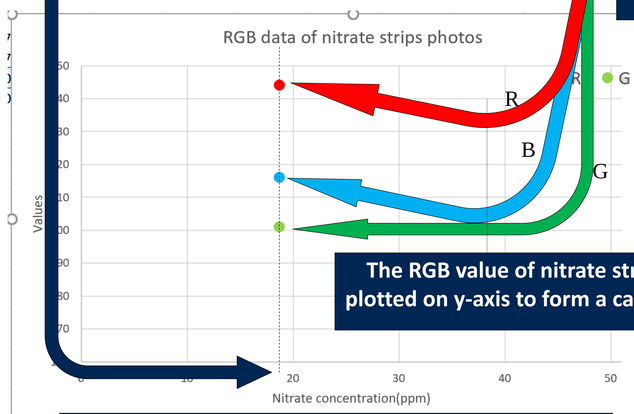
Serial dilution is performed to obtain nitrate at different concentration level (ppm)



A portion of this solution is sent to a nitrate meter

A portion of this solution is dipped in the nitrate testing strip

The Nitrate testing strip's photo is calibrated and analyzed using a software



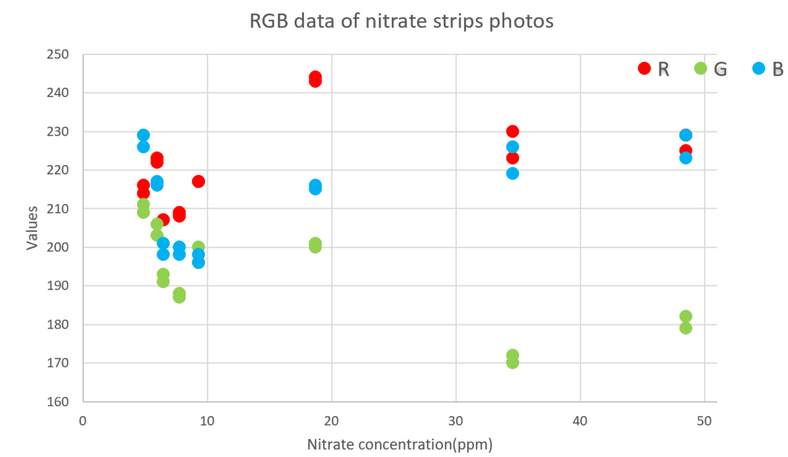
The RGB value of nitrate strip's photo is plotted on y-axis to form a calibration curve

The nitrate meter value is considered reference value and plotted on x-axis

References

- https://upload.wikimedia.org/wikipedia/commons/a/a8/Water_in_a_beaker.JPG
- https://cdn.pixabay.com/photo/2020/08/08/20/27/cellphone-5473878_1280.png
- Haque E, Mailloux BJ, de Wolff D, et al. Quantitative drinking water arsenic concentrations in field environments using mobile phone photometry of field kits. *Science of The Total Environment*. 2018;618:579-585. doi: 10.1016/j.scitotenv.2017.11.1[illegible]
- Sicard C, Glen C, Aubie B, et al. Tools for water quality monitoring and mapping using paper-based sensors and cell phones. *Water Research*. 2015;70:360-369. doi: 10.1016/j.watres.2014.12.005

Result: Graph 1. Trend of RGB vs nitrate conc(ppm)



Conclusions

- As concentration of nitrate increases, the color of nitrate testing strip become darker and closer to black.
- Green in nitrate photo's RGB values are the most sensitive predictor
- The trend of RGB value decreases as concentration of nitrate increases.
- RGB value become unreliable after certain concentration

Future perspective

- Better method for image standardization across different camera models.
- Package the calibration curve into a cell phone app with integrated feedback (Figure 1.)
- Compare the performance of RGB values with other color parameters(CMYK?LAB?)

Next step

- Increase the number of Nitrate photo samples on calibration curve
- Data analysis: mathematical relationship between concentration of nitrate and RGB values of testing strip.

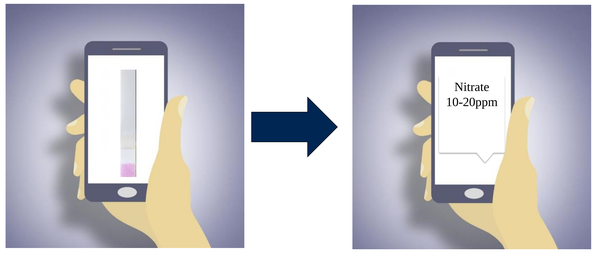


Figure 1. desired project goal with integrated cell-phone based interpretation of nitrate testing strip and feedback