Determination of Nitrate in Aqueous Media

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Abstract:

The objective of the study was to determine the amounts of inorganic nitrate ions in aqueous media is important in the food industry and environmentally. In the environment high levels of ions like nitrate, nitrite, and phosphate can lead to unhealthy conditions for aquatic species. Similarly, high levels of nitrate and nitrite can cause health issues in humans. One method for determining nitrate levels in aqueous samples involves reducing the nitrate species to nitrite via a redox reaction with finely divided zinc powder followed by conversion to a diazonium salt and complexation with 1-napthylamine to form a colored complex. In the work described herein, this modified version of the Griess reaction was used to spectrophotometrically determine the nitrate concentration in several environmental and food samples.

Introduction:

Nitrogen moves throughout the environment through the nitrogen cycle. Nitrogen gas from the atmosphere undergoes nitrogen fixation to create ammonium, which bacteria then converts into nitrite and nitrate. Nitrate is necessary for plant growth, and therefore necessary to human and animal life. In excess, nitrate can lead to polluted waterways and eutrophication, which is where a significant increase in aquatic plant growth, such as algae, results in the creation of "dead zones[1]." Excess nitrate is also harmful to human health, which is found in both water and food. When humans are exposed to aqueous nitrates, it can cause a plethora of health complications, including but not limited to cancer of the breast, bladder, thyroid, and colorectal areas[2]. In studies it has been found that the risk of health complication was even shown to be increased at nitrate concentrations below the legal regulatory limit. Foods with added nitrate, such as a preservative in processed meat or municipal groundwater consumption can serve as major sources of human exposure to nitrate. However, there are sources of nitrate eaten daily, such as leafy greens, like spinach and kale and other vegetables like beetroot and celery, that can be helpful to human health[3].

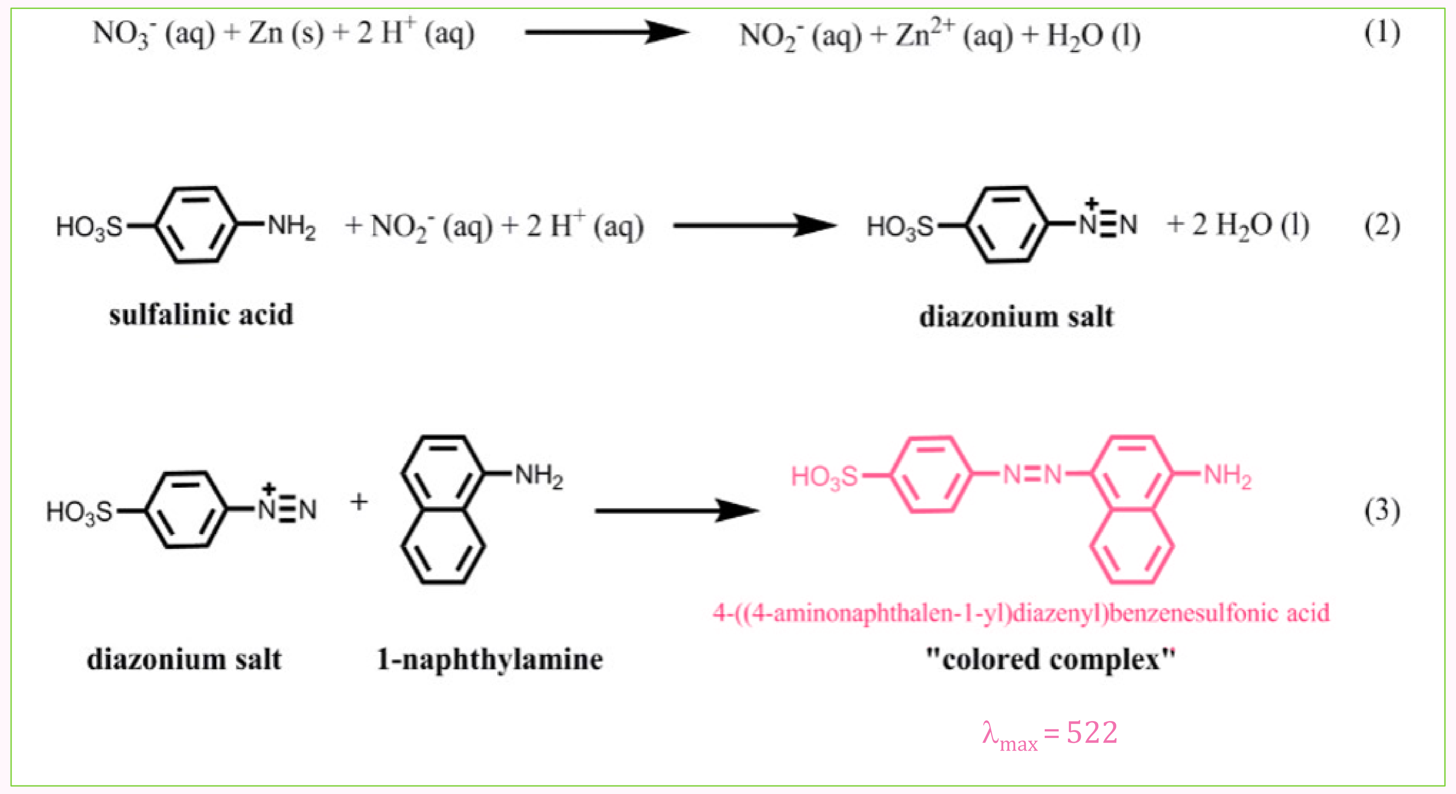
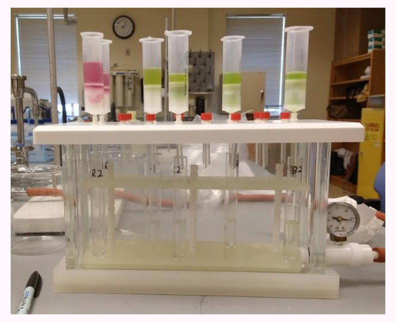


Figure 1. Griess Method

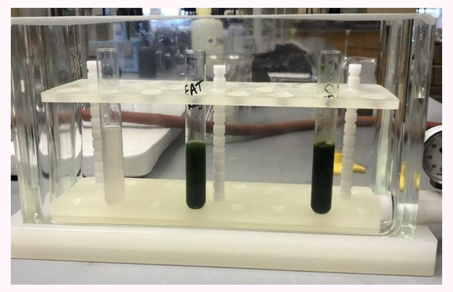
Experimental Procedure:

Collect, wash and prepare

Filter



Solid phase extraction



Collect extracted liquid

Griess reaction

Spectrophotometry

Results:

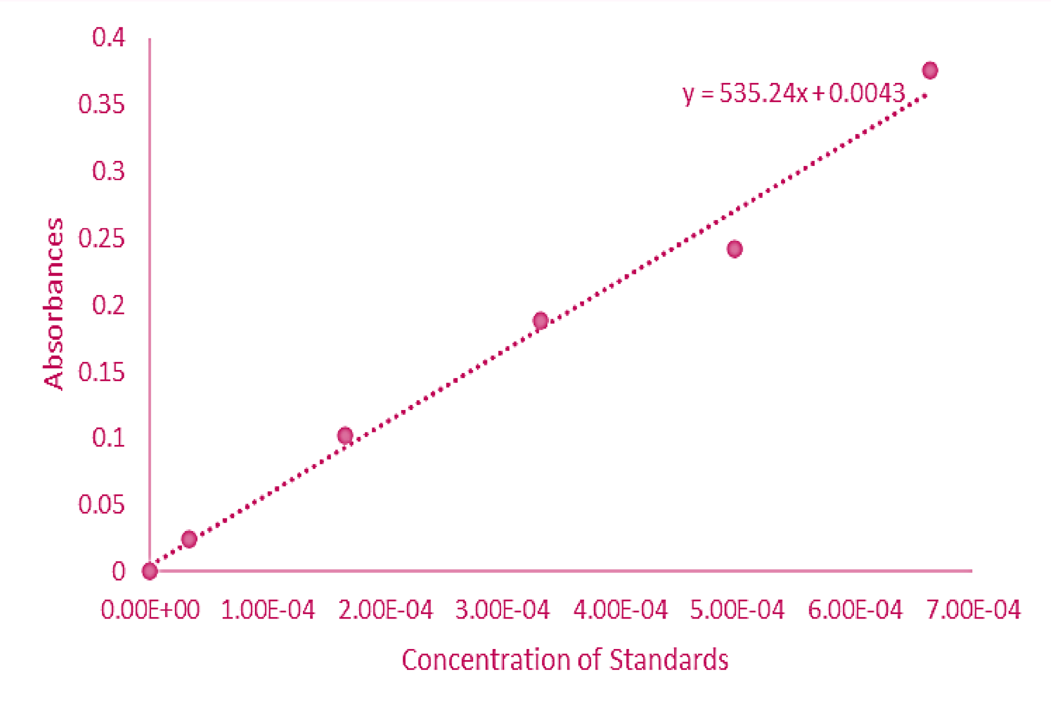


Figure 2. Calibration curve for standard solutions at lmax (522 nm)

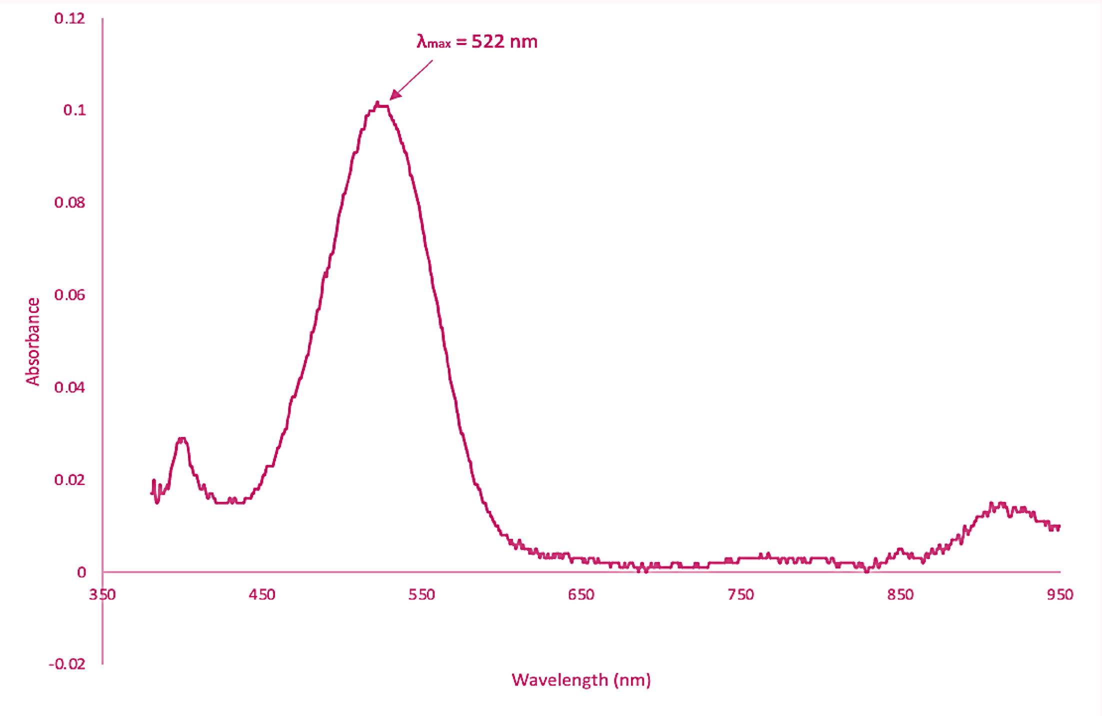


Figure 3. Absorbance spectrum of standard.

Table 1. Dilutions and concentrations of standard solutions

Standards Samples	Volume of Stock KNO3 (mL)	Concentration of Standard	Absorbances at 522 nm
1	0	0	N/A
2	1.00	3.32×10^{-5}	0.024
3	5.00	1.66×10^{-4}	0.102
4	10.00	3.32×10^{-4}	0.188
5	15.00	4.98×10^{-4}	0.242
6	20.00	6.64×10^{-4}	0.376

Table 2. Nitrate concentrations of water samples

Sample	$[NO_3^-]$ (M)	$[NO_3^-]$ (ppm)
Well (Powhatan Co.)	$2.065\times10^{-5} \pm 1.365\times10^{-5}$	0.0022 ± 0.001
Well (Prince Edward Co.)	$5.52\times10^{-5} \pm 1.34\times10^{-5}$	0.007 ± 0.002
Perrier^tm Water	$1.352\times10^{-4} \pm 5.795\times10^{-5}$	0.017 ± 0.007

Table 3. Nitrate concentrations of vegetables

Sample	$[NO_3^-]$ (M)	$[NO_3^-]$ (mg/100g fresh)
Celery	$0.001 \pm 1.59\times10^{-4}$	24.9 ± 3.55
Radishes	$0.001 \pm 9.19\times10^{-4}$	37.0 ± 28.8
Bok Choy	$0.002 \pm 6.95\times10^{-4}$	81.5 ± 28.0

Discussion and Conclusion:

The highest nitrate levels belonged to leafy green vegetables and root vegetables, perhaps due to the specific mechanisms of the nitrogen cycle in relation to the produce we used in our research. In plants, nitrogen is usually taken in through the roots to be used in photosynthetic sites. This may explain the high concentration of nitrate in bok choy and radishes, with one being high in photosynthetic sites and the other being a root vegetable. The lack of nitrate found in the pond water sample was surprising, given that geese inhabit the nearby area and their feces can cause nitrate pollution into the water. The processed sparkling water that was analyzed was highest in nitrate concentration by a large magnitude, followed by well water sampled from Prince Edward County. This processed water is allegedly taken from a natural spring, indicating that groundwater nitrate saturation may constitute a more long-lasting problem than our data would indicate.

This experiment was successful in quantifying nitrate concentrations in both water samples and vegetable samples. Future studies will focus on finding a more efficient method in stripping chlorophyl from leafy greens.

References: