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The Nitrate Project: An Analysis of Water Samples

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The Nitrate Project: An Analysis of Water Samples

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Research Question

How do scientists determine the nitrate content of water samples?

Introduction

- The **Chesapeake Bay**, an important coastal body of water, is a watershed that spans thousands of miles ranging from Maryland to New York.[1]

- **Nitrate (NO_3^-)** is necessary for plant growth, but when in excess can lead to polluted waterways and eutrophication. Eutrophication causes a significant increase in aquatic plant growth, such as algae, which can result in the creation of dead zones.

- Excess nitrate is also **harmful to human health**, which can be found in both water and food.

- The Safe Water Drinking Act states that **10 ppm** is the safe level for nitrates in water.[2]

Methods

A modified version of the Griess reaction[3] (Figure 1) was used to determine the nitrate concentration in environmental and drinking water samples.

1.0 mL of HCl, 1.0 mL sulfalinic acid solution, and 2.5 g of Zn/NaCl powder were added to all water samples.	Solutions were stirred for 7 minutes and filtered. The filtrates were collected in 100-mL volumetric flasks.	1.0 mL of naphthylamine hydrochloride and 1.0 mL sodium acetate reagents were added to all flasks.	The solutions were allowed to sit for 10 minutes. Each solution was diluted to the mark with deionized water.	The Vernier SpectroVis spectrometer was calibrated, and the visible spectrum was collected for all solutions. The analysis was conducted using the absorbance at 522 nm.

$$NO_3^- (aq) + Zn(s) + 2H^+ (aq) \rightarrow NO_2^- (aq) + Zn^{2+} (aq) + H_2O(l) \quad (1)$$

$$HO_3S-C_6H_4-NH_2 \text{ (sulfanilic acid)} + NO_2^-(aq) + 2H^+(aq) \rightarrow \text{diazonium salt} + 2H_2O(l) \quad (2)$$

$$\text{diazonium salt} + \text{1-naphthylamine} \rightarrow \text{"colored complex"} \quad (3)$$

4-((4-aminonaphthalen-1-yl)diazenyl)benzenesulfonic acid

$\lambda_{max} = 522$ nm

Figure 1. Schematic diagram of the modified Griess reaction.

Using Beer's law and visible spectrometry, various drinking water and environmental samples had their nitrate levels tested.

Beer's Law
$$A = \varepsilon bc$$

A= absorbance, ε=molar absorptivity, b=path length, c=concentration

Results & Discussion

- Figure 2 shows the visible spectrum for the colored complex, which directly relates to nitrate levels in the samples.
- The calibration curve was used to determine nitrate concentration by plugging in absorbance values from samples in for "y" and solving for "x".
- The percent error could have been caused by allowing samples to sit for too long before collecting absorbance data.
- Without multiple trials, this left room for error.
- Most of the samples are considered safe, except for Environmental Sample #3.

Figure 2. Visible absorbance spectrum for the colored complex.

Figure 3. Calibration curve for standard solutions. The equation of the straight line was y = 0.0241x - 0.0127.

Water Sample	Experimental Nitrate Concentration (ppm)	Actual Nitrate Concentration (ppm)	% error
Environmental Sample #1	2.2	1.2	83
Environmental Sample #2	6.6	4.0	65
Environmental Sample #3	11.0	14.0	-21
Perrier	6.4	7.3-7.8	-12 to -18
San Pellegrino	5.8	2.2	164
Evian	6.6	3.8	74

Table 1. Nitrate Concentrations and % error of Water Samples

References

1. CBF, Chesapeake Bay Foundation. 2022. "State of the Bay Report 2022." (accessed February 3, 2023).
2. *Laws and Regulations.* EPA. 1974. "Summary of the Safe Drinking Water Act",42 U.S.C. §300f et seq. Access at: https://www.epa.gov/laws-regulations/summary-safe-drinking-water-act
3. Nelson, J. L.; Kurtz, L. T.; Bray, H. (1954). "Rapid determination of nitrates and nitrites", *Analytical Chemistry,* 26, 1081-1082.

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