The Nitrate Project

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**Abstract**

The purpose of this experiment was to test nitrate concentrations within the Chesapeake Bay in order to determine the overall health of the water. Using spectrophotometric methods, the absorbance of light through the Chesapeake Bay water samples created a measurable calibration curve. The curve revealed the nitrate concentrations of the water. On average, the nitrate concentration was 47.41 ppm.

**Introduction**

The Chesapeake Bay is the largest estuary in the United States, ranging from Havre de Grace, Maryland to Virginia Beach, Virginia. Its average depth is about 6.4 meters. At its deepest point, it is 53 meters. The width of the bay varies at different points. The smallest width is located in Aberdeen, Maryland where it is four miles wide and its largest width can be found at Cape Charles, Virginia. While the Chesapeake Bay is only bordered by Virginia and Maryland, several rivers from external states feed into and contribute to the Chesapeake Bay. These states include New York, Delaware, Pennsylvania, West Virginia, and the District of Columbia.

Today, the Chesapeake Bay is facing critical issues and is under great scrutiny by organizations and scientists dedicated to its survival. These issues include pollution, eutrophication, overfishing, and more. All of the major issues facing the Bay presently, water quality is arguably one of the most important and urgent aspects of the future of the Bay. Currently, the Chesapeake Bay is facing the dangers of high levels of nitrates in its waters. High level of nitrates in the water makes the environment uninhabitable for the aquatic life. In addition, high levels of nitrates limit their performance of their roles in their ecosystems, causing other aquatic systems to be out of balance as well. The 2016 State of the Bay Report released by the Chesapeake Bay Foundation gave nitrogen levels in the water a grade “F”, meaning that the quantity of nitrates in the water is overwhelming.

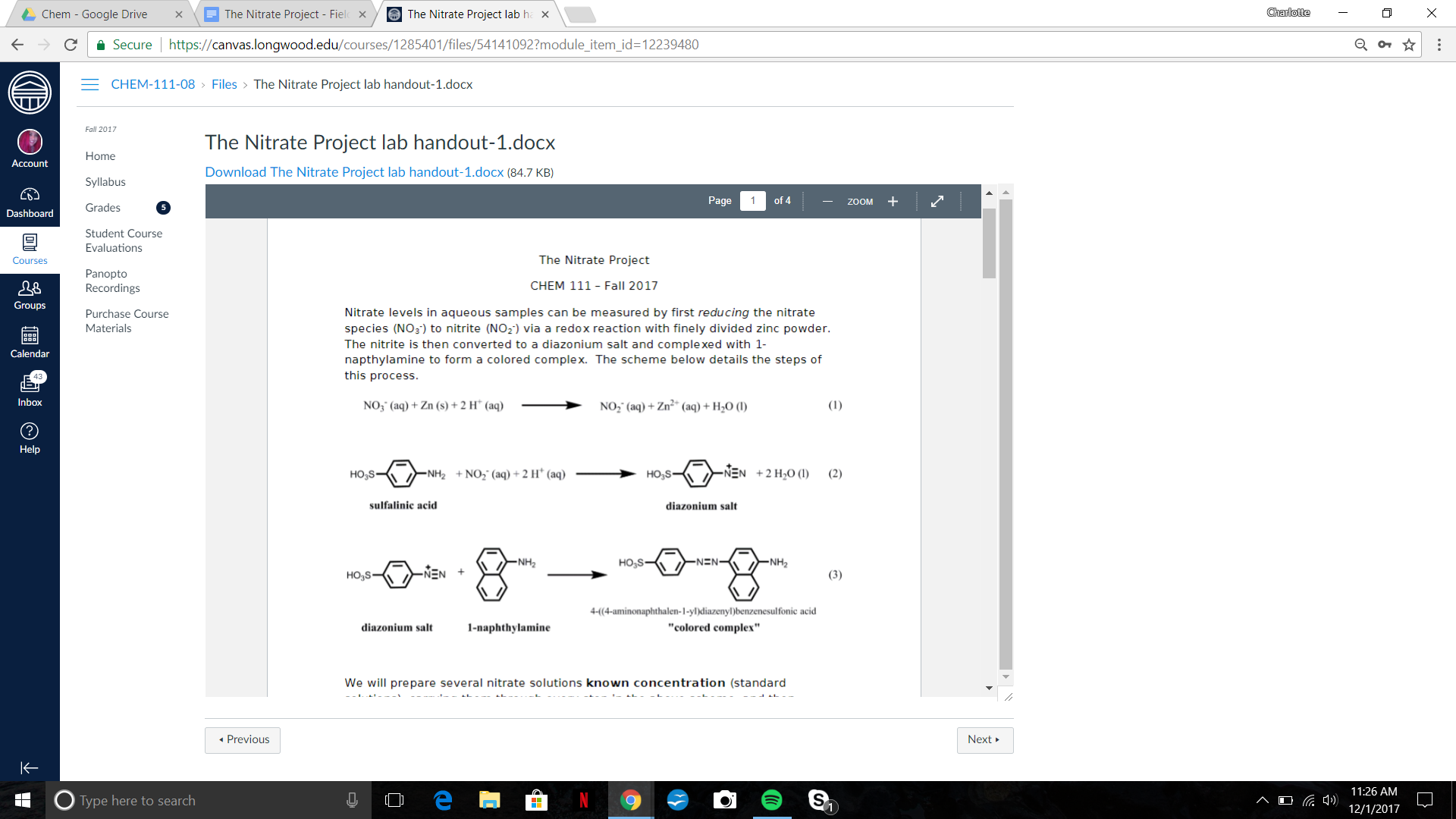
Nitrates are chemical compounds that are composed of nitrogen and oxygen atoms. Nitrate is known to be found in fertilizers and produced by nitrifying bacteria. Nitrate is one of the major chemicals that is introduced into the Chesapeake Bay watershed through runoff from the utilization of fertilizer on farmlands. The nitrates that end up in the water then converts to ammonia by microorganisms. This is a natural process, but as fertilizer use increases as agricultural demands increase, excess quantities end up washing into the Bay. After the nitrogen is biologically oxidized to ammonia, the immense amounts of it serves as the primary contributor to the nitrification process.

Most of the major sources of excess nitrates and nitrogen levels in bodies of water are anthropogenic. When humans burn coal, oil, gasoline, biomass, and other common resources near bodies of water, we are increasing the rate of deposition of nitrates.1 Nitrates can also find their way into bodies of water from runoff in urbanized areas, which brings harmful compounds and pollutants into those aquatic ecosystems. The accumulative amount of nitrogen that is entering our lakes, rivers, and oceans, is quickly rising above previous records, disrupting the crucial equilibrium within ecosystems and plant life.2

Nitrates are a necessary component in how plants in the Chesapeake Bay obtain nutrients, however; high levels of nitrate in the Chesapeake Bay are crippling to its health in a variety of ways. When there are excessive levels of nitrates in water, algae growth is increased and water clarity decreases. This is an important factor, because when algal growth becomes more prevalent, sunlight cannot successfully promote autotrophic photosynthesis. As more and more algae is produced, we have a resulting amount of dead organic matter that falls to the bottom, where bacteria then decomposes them. All of the bacteria need oxygen to break down the dead algae, and this deprives oxygen from other fish. This is problematic for the structural integrity of ecosystems and food webs because excessive an uncontained algae growth will lead to an overall decrease in oxygen levels in the Bay, which leads to less organisms throughout the system only leaving organic waste.2 If the rate of excess nitrogen continues, then the Chesapeake Bay will be thrown out of balance and eventually die.

When nitrate levels are higher, there are lower levels of oxygen. In more affected areas, the presence of oxygen is almost non-existent due to the high levels of nitrates. This causes fish and other marine creatures to migrate elsewhere because of the low oxygen levels in the water. Oxygen in the water is necessary for marine life live, and when it is absent, they must move elsewhere and biodiversity is lost. The reason most of this oxygen is used up and another way to detect higher nitrate levels is that there can be colonies of phytoplankton and algae living in the area. The algae and phytoplankton use up the oxygen in the area, leaving areas with little to no oxygen which is why creatures that were living there will move away or die. Since the algae and phytoplankton are living in these areas, the nitrate cannot be filtered out, leaving the levels only to rise.2 Determining the quantitative absence of oxygen is one method of detecting nitrate levels.

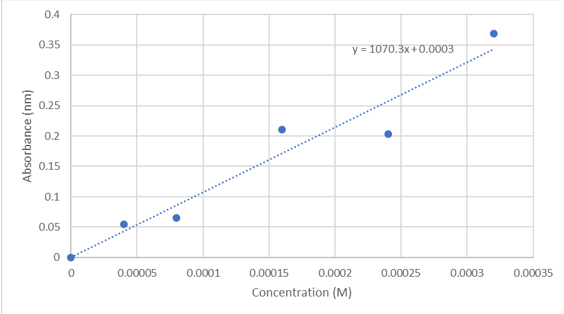
In bodies of water similar to the Chesapeake Bay, high levels of nitrate are easier to recognize as a problem because bodies of water closer in proximity to urban areas tend to have higher nitrate levels.One of the ways to determine nitrate levels in the water is by first reducing the nitrate to nitrite via a redox reaction using a zinc powder. The nitrite is then converted to a diazonium salt and complexed with 1-naphthylamine to form a colored complex. The absorbance reading create a calibration curve and the line of best fit will determine the concentration of nitrate in the water.



**Figure 1.** Reaction scheme for the detection of nitrite⁴.

**Results and Discussion**

To determine the nitrate concentration in an aqueous sample, five standard nitrate solutions were prepared with known concentrations. Each solutions was carried through the reaction scheme shown above in order to measure the absorbance of the colored product at 519 nm. The absorbance at 519 nm is proportional to the original nitrate concentration in each solution. Figure 2 shows the calibration curve constructed from using the five standard nitrate solutions.



**Figure 2.** Nitrate calibration curve

Using the linear regression from the graph shown in figure 2, the nitrate concentrations of three Chesapeake Bay water samples were determined. Table 1 shows the results of this analysis.

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| --- | --- |
| Sample | [NO3-] (M) |
| 1 | 7.28\*10-4 |
| 2 | 8.24\*10-4 |
| 3 | 7.42\*10-4 |
| Average | 7.6467\*10-4 |
| Standard Deviation | 5.186\*10-5 |
| % RSD | 6.78% |

**Table 1.** Results for nitrate concentrations.

The average nitrate concentration of the Chesapeake Bay water samples was converted from molarity to parts per million, which equaled 47.41 ppm..

**Sources**

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<https://www.chesapeakebay.net//bay-101> (accessed October 27th, 2017).

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<https://www.chesapeakebay.net/issues/nutrients> (accessed October 31st, 2017).