# How much $N_2O$ is in your $H_2O$?

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## Introduction

Did you know that when you turn on your tap, you could be contributing to global warming?

Your drinking water might contain a gas called nitrous oxide ($N_2O$), a very potent greenhouse gas, with a warming potential 310 times that of carbon dioxide ($CO_2$)[(1)]. Greenhouse gases trap heat in the earth's atmosphere, leading to an increase in temperature. The main greenhouse gases include water vapor, $CO_2$, methane and $N_2O$.

The concentration of $N_2O$ in the atmosphere is currently 319 ppb [(2)] and rising at a rate of 0.5-1.2% per year or 15 million tonnes. The burning of fossil fuels produces less than 1% [(1)]. Most emissions result from sources such as fires, waste and bacteria. Other major sources of $N_2O$ are industry, agriculture and other natural sources, such as rivers, wetlands and soils.

Every organism needs nitrogen to survive; however, nitrogen in the atmosphere ($N_2$) can't be readily used, so it has to be fixed to ammonia/ammonium ($NH_3$/ $NH_4$) and then to nitrate ($NO_3$) by bacteria [(3)]. This process is called nitrification. $NO_3$ can be used by organisms, where it is converted back into $NH_4$. To keep balance, some $NO_3$ has to be converted back into $N_2$. This process is called denitrification, where $NO_3$ is converted to $N_2O$ then to $N_2$. This process is not always complete, and some of the $N_2O$ which is produced is released into the atmosphere. $N_2O$ can also be produced during nitrification. Inorganic fertilizer is made by fixing atmospheric $N_2$.

Agricultural practices and waste water treatment plants can lead to an increase of $NH_4$ and $NO_3$ in both ground water and surface water supplies. Due to the presence of these nitrogen compounds in water used for municipal use, it is possible $N_2O$ will be present as well. When used, this water will release dissolved $N_2O$ into the atmosphere, thus contributing to global warming.

## Purpose and Hypothesis

The purpose of this project was to determine which source of water would contain the most $N_2O$: municipal surface water, municipal groundwater, a mixture of the two municipal sources or private well water, and if the water is a significant contribution to the $N_2O$ in the atmosphere.

My hypothesis was that water supplied from groundwater sources would contain more $N_2O$ than surface water sources. I hypothesized this because denitrification in groundwater can be high [3], and $N_2O$ cannot escape so it would become more concentrated.

## Procedure

1. Created a survey and instructions for volunteers to sample their own drinking water.
2. Distributed sample kits.
3. Gathered the samples, and prepared them for analysis.
4. Analyzed samples for $N_2O$, $NO_3$, and $NH_4$ concentration.
5. Created graphs from the data so it was easier to interpret.
6. Drew conclusions, wrote report and prepared presentation.

## Materials and Equipment

Glass bottles, plastic bottles, tape, computer, exetainers, syringes, needles, bags. Balance, Orbital shaker, Varian gas chromatograph, Dionex ion chromatograph, Technicon Auto-analyzer.

## Results and Discussion

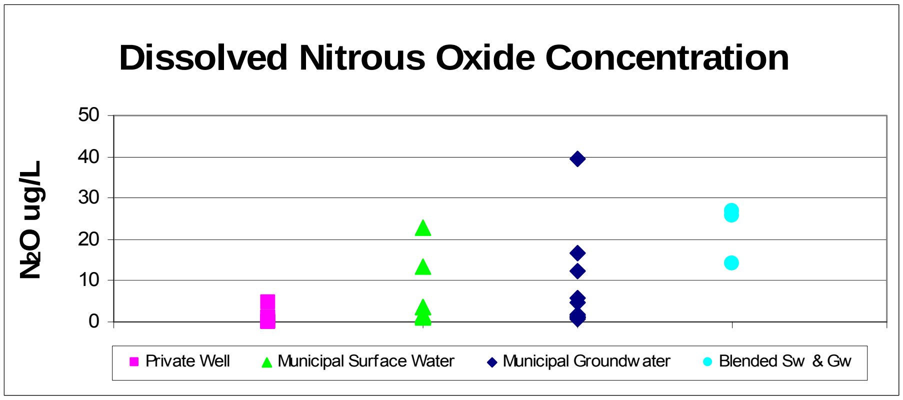


Figure 1: Dissolved Nitrous Oxide concentrations in drinking water supplies

The greatest concentration of $N_2O$ was found in a municipal groundwater supply. Concentrations in private wells and surface water sources were generally lower than groundwater and blended groundwater. My hypothesis that groundwater supplies would be the highest was correct. I hypothesized this because $N_2O$ is produced from $NO_3$ or $NH_4$ and $N_2O$ can become more concentrated in groundwater compared to surface water, as it can not escape easily. Of the groundwater and blended groundwater sources, I thought that private wells would have the most $N_2O$ because they would be shallower and in rural areas, where fertilizers and waste could potentially seep into them. This is not the case in the private wells I sampled, as the private wells actually had the least amount of $N_2O$.

Municipal water sources are disinfected with chlorine. Some municipalities also use chloramine, a mixture of chlorine and $NH_4$, because it is more effective against a wider variety of germs, and maintains high water quality for a longer time than chlorine alone. The addition of chloramine can also produce $N_2O$ (4). Waterloo Region uses chloramine (5), which may explain high $N_2O$ concentrations in samples from this region.

**Conclusion**

To determine if $N_2O$ released into the atmosphere from regular water use could be a significant contributor to global warming, the data needs to be converted into a similar mass unit so that it can be compared with other sources. Table 1 shows an example of this calculation for the Region of Waterloo.

| Avg. Daily use (L) | L per Year | Avg. $N_2O$ Conc. | µg $N_2O$-N / L | Area (Ha) | $N_2O$-N kg/ha/yr |
|---|---|---|---|---|---|
| 164.64 million | 6.01 E + 10 | 22.26 µg | 1.34 E + 12 | 138200 | 0.009 |

Table 1: Potential $N_2O$ release from water used (2006) in Kitchener, Waterloo and Elmira (6, 7).

Table 2 indicates that the amount contributed from even the highest source measured in the Waterloo Region may not be a significant amount as it is less than half the amount of the flux from a low flux forest.

| Source | $N_2O$-N kg/ha/yr |
|---|---|
| Fertilized Crop Land | 2.0 |
| Pasteur | 0.04 |
| Forest | 0.02 |
| Municipal Water<br>Waterloo Region | 0.009 |

Table 2: $N_2O$ flux from different sources (8)

Although this is a small amount, it is still an important measurement because any increase in atmospheric $N_2O$ will increase global warming. This is an underestimate, because $N_2O$ present in private wells is not included in the results. If people understand how $N_2O$ is produced, it might help them understand the importance of better managing waste and fertilizer use and reducing $N_2O$ emissions.

## Future Research

In the future, collecting samples at different times of the year would allow an analysis of any seasonal changes in $N_2O$ concentration. This possibility is shown in Figure 2, where a seasonal variation in $N_2O$ saturation is observed in the Grand River; the surface water source for the Region of Waterloo.

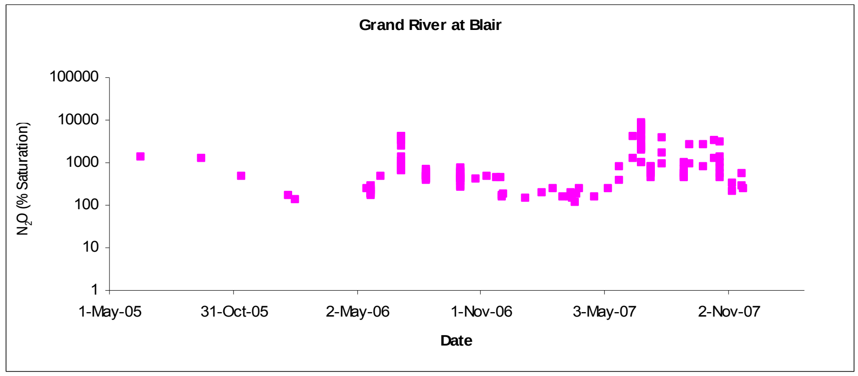


Figure 2: $N_2O$ concentrations in the Grand River [9]

Decreases in $N_2O$ occur in fall and winter, while there is an increase in the late winter and spring. $N_2O$ concentrations are highest in summer. Increases in $NH_4$ and $NO_3$ in late winter and spring may be high due to inputs from agricultural sources and reduced plant growth. The additional $NH_4$ and $NO_3$ may eventually be converted into $N_2O$. As samples were collected in late winter, it could explain why some $N_2O$ concentrations are quite high.

Dissolved oxygen concentrations and stable isotope analyses could determine if $N_2O$ is produced through nitrification or denitrification. Additional information about the distribution and mixing of water sources, and water treatment processes, would also provide a better understanding of $N_2O$ concentrations in different municipalities.

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## Appendix A

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