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

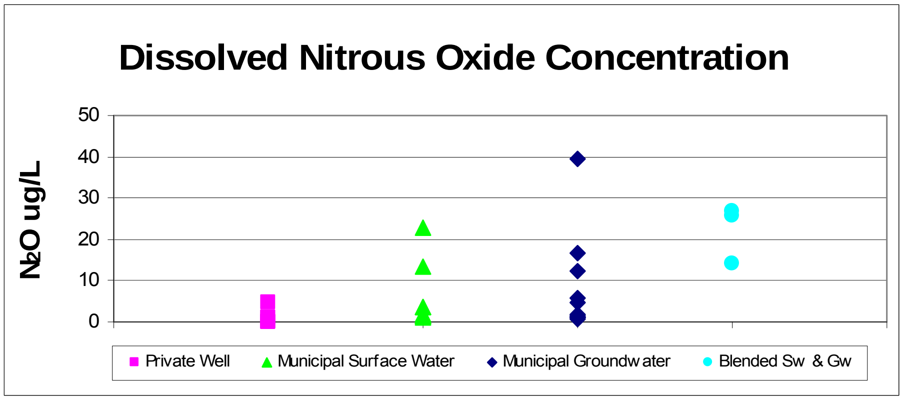

Figure 1: Dissolved Nitrous Oxide concentrations in drinking water supplies

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 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.

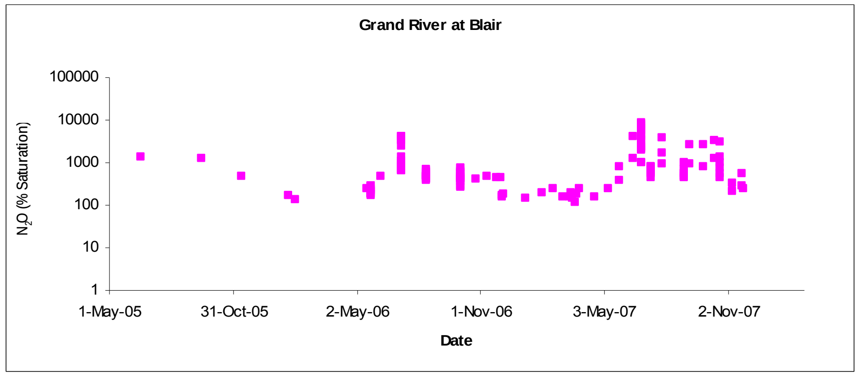

Figure 2: N_2O concentrations in the Grand River [9]

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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