E. coli and Coliform Bacteria Levels in Sediment of Lake Wingra

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Abstract

Bacteria levels (specifically *E. coli*) in Lake Wingra are closely monitored in the summer by the City of Madison Public Health Department to assess swimming safety. Vilas Beach, Madison's most heavily used beach, is often closed to swimming because of elevated bacterial levels (Health of Vilas Beach, 1999). Geese feces contain high levels of bacteria, and it is believed that these feces contribute to the high levels in Lake Wingra. We sampled both water and lake sediment from five locations in Lake Wingra to determine the potential importance of sediment as a reservoir for *E. coli*. We found the levels of both total coliform bacteria and *E. coli* in lake sediments were much higher than those of the overlying water, supporting the idea that the sediment is serving as a reservoir for bacteria, perhaps arising from goose feces. We discuss the implication of our results for Lake Wingra water quality and the safety of its users. Our results should be a concern to the Madison Public Health Department, since they do not test lake sediments to determine if Lake Wingra and other lakes in Madison are safe for swimming.

Introduction

E. coli is a very common type of coliform bacteria that is usually found in the intestinal tracts of humans and animals. It may enter lakes through many external sources such as rain, geese feces, and water runoff. When it is found in the water at high levels it becomes a problem to the safety of the swimmers and animals that may enter the water. Lake Wingra has been closed down many times over the years due to these high levels of coliforms bacteria, which can cause serious illness (Bruesewitz et al., 2005).

The Madison Public Health Department tests Lake Wingra to determine various levels of bacteria and then decides if the levels are at a dangerous level to close the beach to swimmers. The level of bacteria in the water is the only factor that is involved in the testing to determine if the beach should be closed. There is a large population of geese residing by Lake Wingra and it is believed that their feces account for the high bacteria levels in the water. On January 31st 2005, a group of students testing bacteria levels in Lake Wingra used an auger to cut a hole in the ice. The auger caused the sediment from the bottom of the lake to be stirred up and resulted in a high level of total coliforms and *E. coli.* The students hypothesized that bacteria had settled into the sediment which caused the high level of bacteria in the water sample that was taken that day (Bruesewitz et al., 2005). These high levels should have dropped over the winter months due to "cold water temperatures, lack of geese droppings being carried to the lake, and lack of human usage." Due to their findings we decided to look into the bacteria levels of the sediment in Lake Wingra. Our hypothesis is that the sediments are acting as a reservoir for bacteria and should be taken into consideration when testing the water for levels of bacteria when determining if the beach should be closed.

Materials and Methods

On November 7, 2005 we tested water and sediment samples from the Lake Wingra Bridge in order to find the best procedure for future testing. We took three water samples and two sediment samples. We tried various methods of testing on these samples. One was to test the top water, which is the surface water without any sediment in it. Another method was shaking up the mixture of sediment and water. The last method of testing was to dilute a mixture which consisted of 90mL of lake water and 10mL of the shaken mixture; this is a 100:1 dilution.

From these sample methods we decided how to go about testing for our actual experiment (Figure 1). To test the sediment samples we diluted them with de-chlorinated tap water. We used

990mL of tap water and 10mL of the sediment sample. We chose this method to test the sediment samples because the dilutions allowed for us to get results in a readable range with our total coliform and *E. coli* test.

Step	Description
1	Original Sediment Sample was shaken up
2	10mL of shaken sample was poured into small beaker (6 times)
3	Took left over sediment to dry and weigh
4	Took sample sediment to dry and weigh
5	Took 10 mL subsample, added it to 990 mL of water to create 1000mL diluted sample
6	Took 100 mL of the diluted sample and used it for colilert test

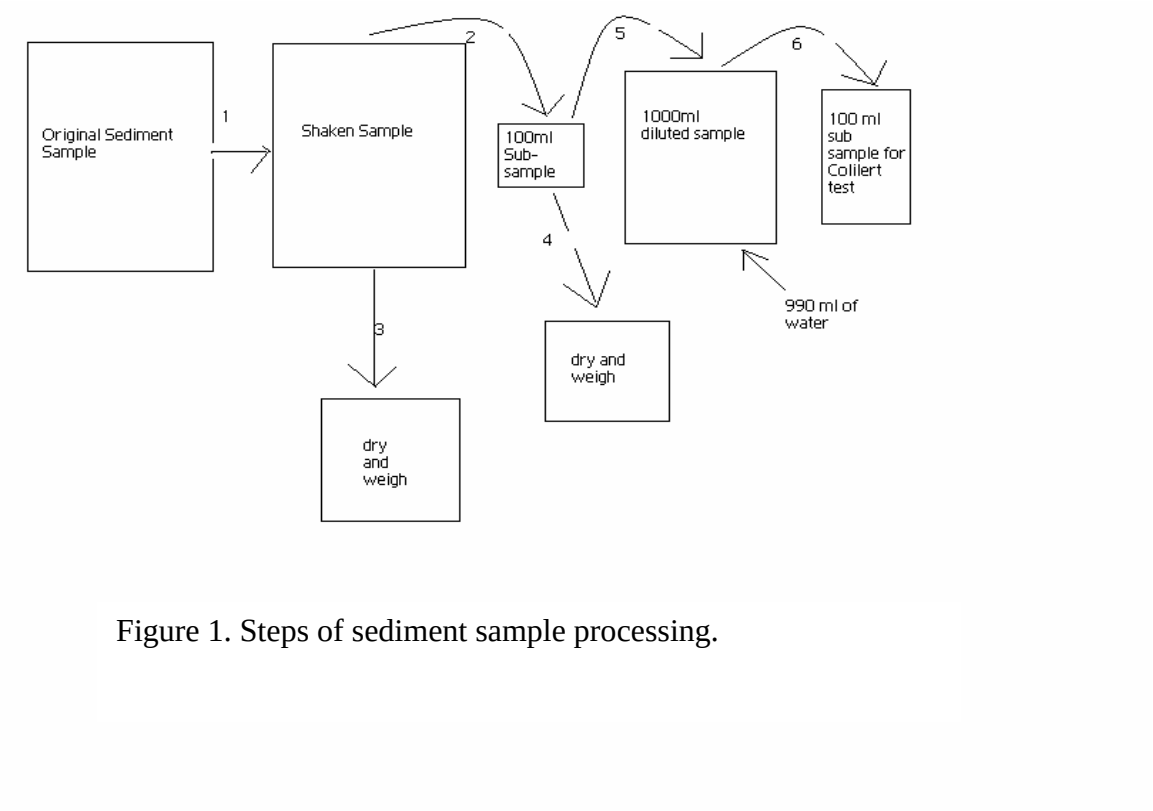

Figure 1. Steps of sediment sample processing.

On November 28, 2005 we tested water and sediment samples from five locations on Lake Wingra. These five locations included: the pier, beach, bridge, and two locations in the lagoon(Figure 6). We created three dilutions from each site to test the samples for *E.coli* and total coliform bacteria using the Colilert® Test Kit with Quanti-Tray Enumeration Procedure. We interpreted the results using the MPN, which is the most probable number.

Due to the different amounts of sediment that was collected at each location we wanted to find out how much bacteria was in 10mL sediment sub-samples (Figure 1, step 4). We did this in hopes to find the correlation between the amount of sediment and the level of bacteria present within the sediment. Since there is no easy way to describe the bacteria found in the sediment, we also dried the remainder of sediments from each location because in the future it may be important for us to know the total amount of sediment per sample rather than from the 10mL dilution (Figure 1, step 3).

Results

We found in the water sample that all 5 locations had high levels of *E. coli* concentration (Figure 2). Our data shows the highest concentration of bacteria in the water samples was at the pier and the bridge, the lowest concentrations was at the beach and the two lagoon sites (Figure 2). We found a high level of *E. coli* in the sediment samples at each of the 5 sites (Figure 3). The highest amount of *E. coli* was found at the Bridge and the lowest amount was at the first lagoon site. After reviewing our data in table form we were able to see that the bacteria levels in each of the locations had higher levels of bacteria in the sediment compared to the levels of bacteria in the water.

Due to the fact that we had collected different amounts of sediment at each site, we wanted to find out if the amount of bacteria in the sediment subsamples were directly related to the amount of bacteria found in the total amount of sediment collected. Lagoon 1 had the highest amount of bacteria in the dry sediment (Figure 4). The amount of *E. coli* per gram in the dry weight sediment had higher levels in lagoon 1 than in the bridge. When we look at the total amount of sediment collected from the bridge the bacteria levels was lower. There was generally a linear relationship between the total amount of sediment collected in each sample and the

amount of sediment contained within 10 mL subsamples; however, this linear relationship was not perfect (Figure 5).

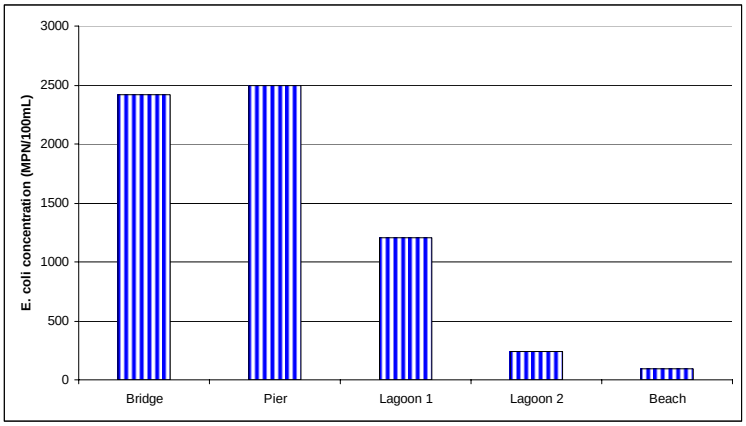

Fig.2 *E. coli* concentration in water samples

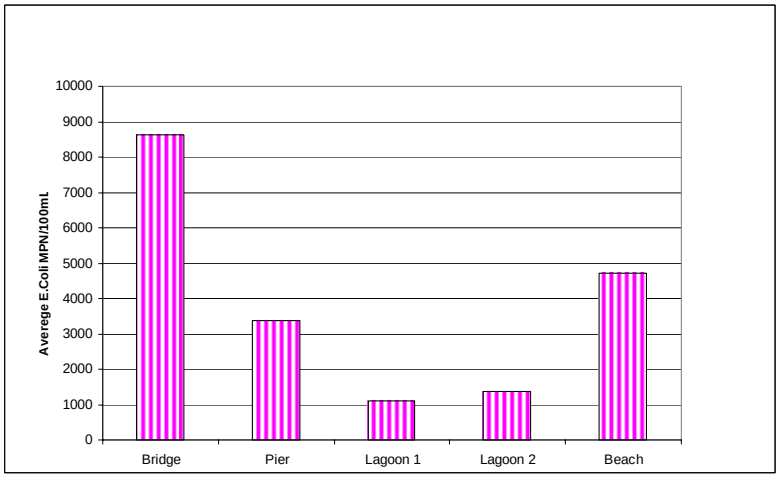

Fig. 3 Average *E. coli* concentration in sediment samples.

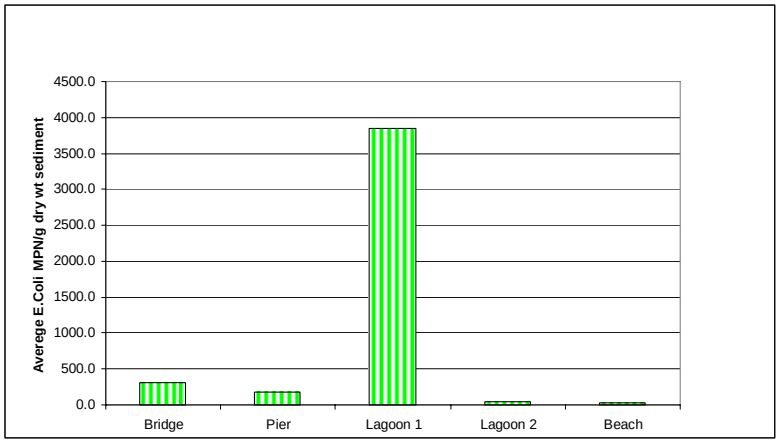

Fig. 4 Average *E. coli* concentration per gram dry weight of sediment.

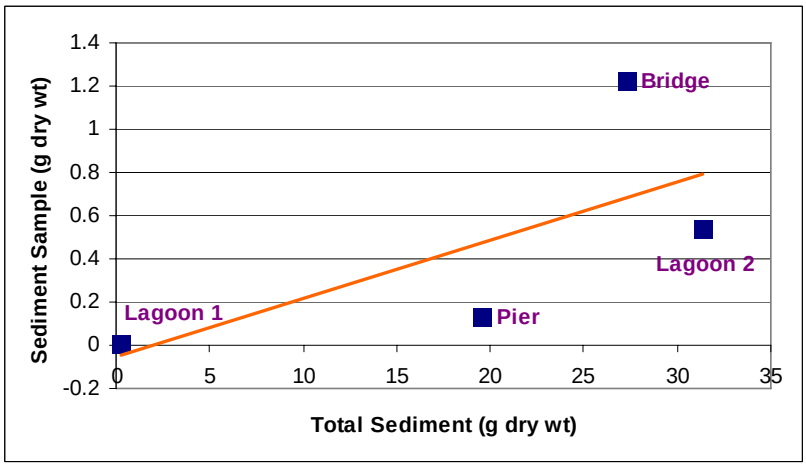

Fig. 5 Relationship between the total amount of sediment collected and the amount of sediment in 10 mL subsamples.

Discussion

When beginning this experiment, we felt we would find that the sediment contained high levels of bacteria. In the summer, the beach is sometimes closed due to high bacteria levels. Therefore, we thought that bacteria would be held in the sediment too. Our water testing supports our hypothesis. The bacteria levels in the sediment have tested higher than the bacteria levels in the water. Therefore, we think that the bacterium settles to the bottom of the lake embedding itself inside the sediment.

Sediment collected at the bridge had the highest concentration of bacteria and lagoon 1 had the lowest concentration of bacteria. This could be because the highest total amount of sediment

was collected at the bridge and the least total amount of sediment was collected at lagoon 1. It could also mean that the more sediment collected at one location, the higher levels of bacteria. In figure 5, we were hoping that each location would line up along the diagonal line. This would have meant that the subsamples of sediment would have been directly related to the total amount of sediment extracted from each location. However, the linear relationship was not perfect, which means we cannot be confident that the bacteria readings are at the levels they are because of the actual bacteria present or the actual amount of sediment collected.

This is the first time an experiment has been performed to test the level of bacteria in the sediment of Lake Wingra. Therefore, there was no standard testing procedure for us to follow; this could be a possible source of error. A second source of error was the collecting of sediment, there was not a standard amount of sediment attained at each site.

If we were to repeat this experiment, there are things we would have done differently. We would have collected samples more often, in order to have more data. When collecting the sediment from Lake Wingra we would have designed a standard procedure in order to collect the same amount of sediment at each location. These changes would have made our experiment more precise. We could have monitored the number of geese near our testing areas on Lake Wingra. It would have been good to know how large the population of geese was while we were testing because of the belief that the geese feces contribute to the high levels of bacteria in the water and sediments. This information could be used in the future in case there is an increase or decrease in the geese population which could then be compared to the levels of bacteria found in the water and sediment.

The results of our experiment are important to Lake Wingra users. We hope that the Madison Public Health Department will consider testing the sediments in the summer months for levels of coliform bacteria when deciding to close the beach. If there are high levels of bacteria in

the sediments during the winter months there should also be high levels in the summer months. The high levels of bacteria in the sediment should be a concern to the lake users because this is not a factor in determining if Madison beaches should be closed.

The high levels of bacteria in the water and sediment may be caused by the overpopulation of geese around our testing sites. Geese feces contain high levels of *E. coli* it is important for the Wingra community to find ways to control the population of geese around the lake. For further information on the management of geese please refer to appendix I.

Figure 6. Five testing sites.

References

Bruesewitz, Sara, Jenny Farnam, Kate Stewart, and Tracey Corder, comps. Seasonal Changes in Levels of E. Coli and Total Coliforms Bacteria in Lake Wingra. 2005. Edgewood College. 27 Mar. 2006 <http://natsci.edgewood.edu/wingra/student%5Fprojects/bacterialevels/bacteria%20science%20report.pdf>.
This watershed project gave us the idea to test the bacteria levels in sediment.

"Colilert Instructional Manual." Westbrook: IDEXX, 2002.
This was the manual that gave us the MPN results when testing for the bacteria levels in the sediment.

Health of Vilas Beach. 1999. Dept. Natural Science, Edgewood College. 1 Nov. 2005 <http://natsci.edgewood.edu/wingra/wingra_vilas.htm>.
This report included information on Wingra beach and the procedure for testing the bacteria levels.

Lake Wingra Watershed Management Plan-Invasive Species. Feb. 2006. 6 April 2006. http://lakewingra.org/resources/invasive_plan_10003.pdf
This was our appendix on the management of geese around Lake Wingra.

Lorman, Jim. Personal Interview. 27 March 2006.
Dana and Katie talked with Jim with regards to reading the results of our experiment.

Appendix I:

Recommendations for Nuisance Waterfowl

Canada geese (*Branta canadensis*) (immediate action)

Urban populations of the giant Canada goose (*Branta Canadensis maxima*) have increased dramatically in recent decades throughout North America, creating frequent goose-human conflicts (Smith, et al, 1999). Geese have become increasingly adapted to urban and suburban environments, often breeding in cities. In 2002 in Vilas Park, there were 23 adult resident (locally nesting) giant Canada geese that produced 33 young (Lorman, 2003). In addition, there were 100 to 700 migrating geese during the same period. In Vilas Park in November of 2002, the 23 adult resident geese produced an average of 100 lbs dry-weight feces per acre.

Year-round resident populations of this species cause shoreline erosion, which sends sediment, and nutrient loads to the lake, and an accumulation of feces, which contributes nutrient and bacterial contamination to Lake Wingra. In addition, geese can transmit diseases to other animals and are known to attack people, especially during the nesting season.

Spring Trail Pond. Shoreline erosion caused by resident (non –migratory) Canada geese and mallards.

Current management actions—the Madison City Council has created an ad hoc committee on integrated waterfowl management. This committee has recommended various educational and outreach efforts; creation of scientific protocols to study the local situation and careful consideration of management strategies. Researchers at Edgewood College conduct population counts and document the effects of geese in Vilas Park.

Recommendation

FOLW recommends that the giant Canada goose populations in the watershed be managed to reduce their impact on the lake and watershed. These steps should be taken:

- Set desired population levels for Vilas Park and other locations in the watershed.
- Experiment with management/control strategies to reduce geese and mallard populations.
- Enforce existing regulations that prohibit the feeding of geese and mallards.
- Restore shoreline vegetation to stabilize banks, reduce erosion and discourage flocks of these two species.

Friends of Lake Wingra support the work of the Madison City Parks Department and its partners in their efforts to find an integrated approach to urban goose management.