Appearance of liquid manure in water at various dilutions

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Introduction

Occasionally, liquid manure spread onto the soil surface gains entry to tile drains through soil macropores. This leads to surface water contamination and poses a threat to the aquatic environment. This phenomenon is fairly well documented in Ontario, as are the steps needed to avoid the problem. No matter what steps a farmer may take to reduce or eliminate the risk of macropore flow of liquid manure, it is still recommended that they check tile drain outlets both during and following manure spreading. This recommendation is based on the premise that if manure is in the tile water, it is very easy to detect - it turns the water a dark colour and the water has an easy-to-detect Amanure@ odour.

In light of the intense scrutiny placed on some farmers, it is appropriate to review the existing recommendations and see if some more detailed guidance is needed. The following questions should be answered:

$ Is this a good enough test?
$ What does the water look like when very small amounts of manure have entered the drains?
$ Can the water run clear but still present a manure contamination problem?

With this in mind, we set out to dilute a sample of typical liquid swine manure and to measure the differences in various parameters. This was intended as a preliminary study, hopefully pointing the way to further efforts in measuring the presence of manure in tile water.

Objectives

1. Determine if visual assessments are reliable indicators of manure contamination of tile drains.
2. Develop visual aids to help land-owners picture varying degrees of manure contamination in tile drains.

Study Description

A test facility was set up at Ridgetown College. It consisted of a length of corrugated steel drainage pipe (similar to a tile outlet), a large plastic tub and a pump. The test setup is shown in Figure 1. On August 12, 2002, 400 L of tap water (municipal supply) was added to the tub. It was left for three days to reduce any possible impacts of residual chlorine on the bacteria testing. All sampling was done on August 15. One sample of liquid swine manure was used for the testing. Liquid manure was added in precise amounts throughout the test to give predetermined ratios of manure to water.

Figure 1 Test setup at Ridgetown College

The following manure:water concentrations were chosen:

1:1	1 part manure to 1 part water
1:10	1 part manure to 10 parts water
1:50	1 part manure to 50 parts water
1:100	1 part manure to 100 parts water
1:500	1 part manure to 500 parts water
1:1000	1 part manure to 1000 parts water
1:5000	1 part manure to 5000 parts water
0:1	water only

The rationale for going to a 1:5000 mix was based on expected bacteria numbers. Manure samples often contain *E. coli* in the range of 10^5 to 10^6 colony forming units (cfu) per 100 mL. Even if diluted at 1 part manure to 5000 parts water, the remaining bacteria numbers would still be unacceptably high.

This manure/water mixture was pumped through the pipe. At the pipe outlet, the liquid dropped into the receiving tank and the pump kept the liquid circulating. Samples were collected at this outlet pipe end and photos were taken. The samples were analyzed for turbidity (APHA test 2103, performed at Envirotest Labs), pH, conductivity and concentrations of nitrate-N, ammonium-N, and *E. coli* bacteria (all performed at Lab Services, University of Guelph). In addition, conductivity was measured on site using two tester pens (TDSTestr 4 and ECTestr).

Results

Manure sample - The initial manure was liquid swine manure that came out of a long-term storage (i.e. it was not necessarily fresh manure). It was deemed to be fairly representative of swine manure, given that there is a wide range of properties in the manure from one farm to the next.

Bacteria - The *E. coli* test proved to be inadequate under the circumstances, perhaps due to low initial levels and the possible die-off of organisms as the test progressed. The 1:1 dilution contained E. coli at 1500 cfu/100 mL. This level is about three orders of magnitude less than levels normally found in fresh manure. No other samples contained *E. coli* at levels above the lower detection limit of 100 cfu/100 mL.

Nitrate-N - This also proved to be a poor indicator of the presence of manure (as expected). The concentration in fresh water (i.e. no manure) was 0.07 mg/L and all other samples were below the detection limit of 0.02 mg/L.

Ammonium-N - There was good agreement between the measured concentration of ammonium-N and the predicted concentration at all dilution levels. Figure 2 shows this relationship. The predicted value was calculated based on the concentration found at the 1:1 dilution. For clarity, the y-axis is plotted as a log scale. Past studies have shown that typical levels of ammonium are very low in tile drain water (other than shortly after certain fertility applications). Therefore, ammonium concentrations should provide accurate

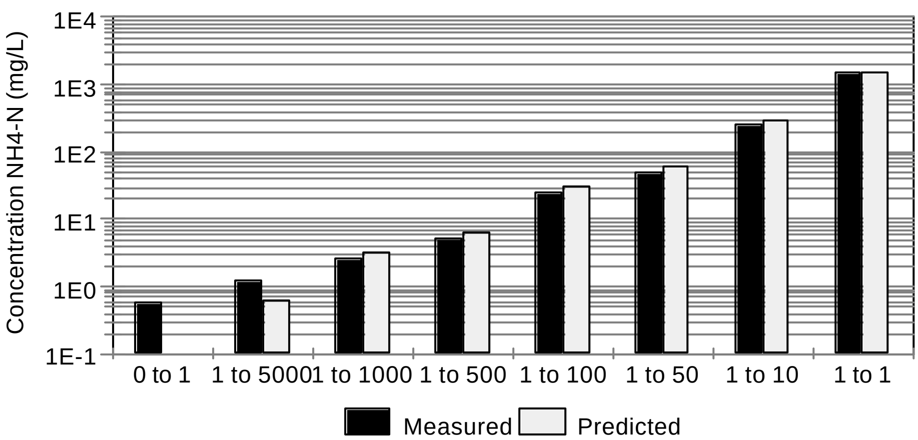

Figure 2 Measured and predicted concentrations of ammonium-N in various manure/water solutions

information about possible manure entry into water.

Electrical Conductivity – There was excellent agreement among the three methods of measuring the electrical conductivity (i.e. the lab results and those of the two portable testers). Results are shown in Table 1. However, the readings were similar to tap water for the three most dilute manure/water solutions. It appears that this test method may be used to confirm contamination at dilutions of 1:50 or more concentrated, but it is likely not a reliable indicator for very dilute mixtures. Of course, the presence of other dissolved salts in the background tile water would also impact these readings – it would be very important to have data for background samples (i.e. "clean" water).

Table 1 – Electrical conductivity measured using three methods

parts manure	parts water	lab (mS/cm)	TDSTestr4 (mS/cm)	ECTestr (mS/cm)
0	1	0.36	0.4	0.32
1	5000	0.325	0.4	0.32
1	1000	0.35	0.4	0.36
1	500	0.37	0.5	0.39
1	100	0.65	0.8	0.64
1	50	0.8	1.1	0.97
1	10	2.5	3.2	3.03
1	1	10.5	11	11.6

pH – The pH of the tap water was 8.0. All other pH values were in the range 7.4 to 7.6. As expected, pH was not a good indicator of the presence of manure in water.

Turbidity – While turbidity may be detected with the naked eye, there are test methods that can accurately measure this property. Similar to ammonium, there was very good agreement between the measured values and those predicted (based on the concentration found at the 1:1 dilution). Figure 3 shows this relationship. Once again, the y-axis is a log scale, to make interpretation easier.

For measurement of tile water turbidity, it is important to know the levels in background samples. Values may be affected by soil organic matter levels, flow rate in the tile, temperature, and other factors.

The samples collected during this test were placed in clear glass bottles and photographed against a white background. The goal was to prepare reference photos to allow for estimations of manure concentrations in water. Figure 4 shows the group of bottles (best viewed in colour). For clean non-turbid water, such as was used in the test, it seems reasonable to conclude that concentrations of 1:500 to 1:5000 (manure:water) may be detectable by the naked eye. A close-up of the 1:500 dilution as it flows from the tile outlet is shown in Figure 5.

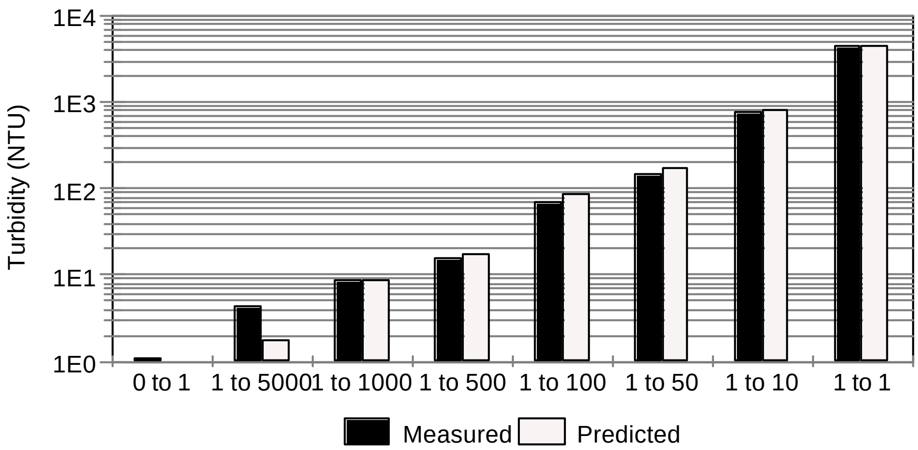

Figure 3 Measured and predicted turbidity levels in various manure/water solutions

Figure 4 Manure/water solutions at varying ratios – (left to right) 0:1, 1:5000, 1:1000, 1:500, 1:100, 1:50, 1:10, 1:1

A colour chart was created by cropping close-up photographs of the sample bottles. This is shown in Figure 6. It may serve as a rough guide in estimating manure concentrations in clear water. Once again, it should be viewed in colour.

Figure 5 Appearance of flowing water - containing manure at a ratio of 1 part manure to 500 parts water

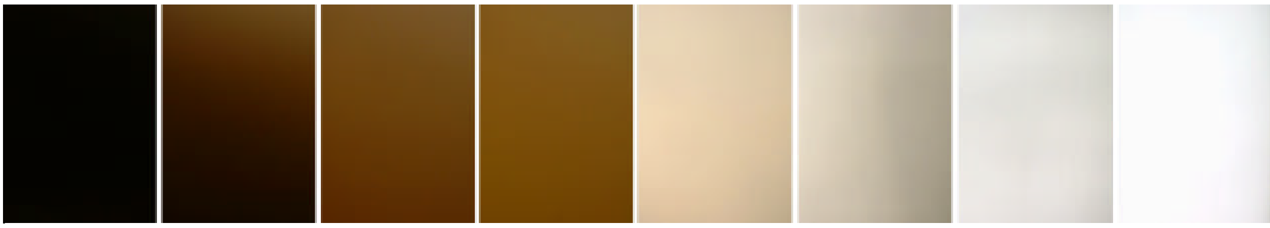

Figure 6 Colour chart showing manure /water solutions at various concentrations - (left to right) 1:1, 1:10, 1:50, 1:100, 1:500, 1:1000, 1:5000, 0:1

Summary

Based on the observations using one sample of liquid swine manure, the following appear to be true:

- Manure in water at a ratio of 1:5000 was barely visible when the initial water was clear. Concentrations of 1:500 should be visible in most cases. It is therefore possible that water could contain unacceptable levels of manure-sourced bacteria even though it appears to be clear.
- Turbidity and ammonium in water appear to be better indicators of trace amounts of manure contamination than nitrate-N, electrical conductivity or pH.
- In order to use these tests, there must be some way to measure levels in "background" water samples.