J. Dairy Sci. 91:2082–2085
doi:10.3168/jds.2007-0597

Short Communication: Turbidity as an Indicator of *Escherichia coli* Presence in Water Troughs on Cattle Farms

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ABSTRACT

Studies have shown that water-drinking troughs are an important source of *Escherichia coli* infection on cattle farms, and a study was designed to provide farmers with an easy-to-use tool to monitor trough contamination and help determine when to empty and clean water troughs. A total of 164 water troughs were sampled on 33 cattle farms, and the on-farm turbidity tester results were found to be significantly correlated with laboratory turbidity results. Turbidity was associated with *E. coli* concentration, although the association was not linear. Emptying the troughs within a week of sampling was shown to reduce the turbidity score, but no linear association between time of emptying and *E. coli* concentration was discovered. A turbidity score of 4 was set as a cutoff point for when to clean a trough, yielding a sensitivity of 0.94 and a specificity of 0.03 for identifying a level of *E. coli* concentration that was more likely to contain *E. coli* O157 (>5,800 cfu/100 mL).
Key words: *Escherichia coli,* drinking water, turbidity, England and Wales

Zoonotic pathogens such as verocytotoxic *Escherichia coli* O157 (VTEC O157) often result in asymptomatic infections in farm animals; thus, the farmer is often unaware of the presence of human pathogens in the stock. Simple methods of assessing the risk of exposure to such organisms would assist farmers in reducing the transmission among farm stock and may result in reducing the risk of onward transmission to people. Dirty drinking troughs may act as environmental reservoirs for VTEC O157 and other pathogens and allow recirculation of infection among animals. The presence of *E. coli* in dirty trough water has been associated with the presence of *E. coli* O157 in cattle, and *E. coli* O157 has been reported to persist for up to 8 mo in water trough sediment and still be infectious to calves after 6 mo (Lejeune et al., 2001a,b; Ellis-Iversen et al., 2005). Lejeune et al. (2001b) showed that water troughs with *E. coli* O157 present had significantly greater *E. coli* concentrations, and Rice and Johnson (2000) showed that the indicator wild-type *E. coli* was always present in troughs when the pathogenic strain *E. coli* O157 was also present.

Turbidity testing is generally used to estimate the suspension of OM in water by measuring the degree of light reflection caused by the suspended particles. Turbidity testing is used as an indicator of when to clean swimming pools, because high levels of turbidity can indicate high concentrations of bacteria and other OM, which can reduce the effectiveness of disinfectants. In a recent study, turbidity was also found to be an indicator of *Eimeria* cyst concentration in water (Ellis-Iversen et al., 2005).

This study aimed to develop and test a predictive tool that can be used by farmers to estimate the level of *E. coli* contamination of drinking trough water and thus to decide when to empty and clean such troughs. The objectives were 1) to investigate whether water turbidity can be used as a predictor for the presence of presumptive *E. coli* in water troughs; and 2) to assess the accuracy of an on-farm turbidity testing tool and recommend when a trough should be cleaned. Lejeune et al. (2001b) showed that troughs contaminated with *E. coli* O157 had, on average, 1.76 *E. coli* ($\log_{10}$)/mL, which equates to 5,800 cfu/100 mL. This information was used to set a visual turbidity score (**VTS**) cutoff from which the trough is, on average, more likely to contain the O157 pathogenic strain of *E. coli.*

The data for this study were collected on 33 farms that had recently been tested and found to have at least one cow shedding VTEC O157 in its feces, which was monitored as part of a different study (Ellis-Iversen et al., 2007). The farms represented most regions of England and Wales and were sampled between March 16 and June 7, 2004 (3 farms were sampled twice).

The on-farm turbidity tester consisted of a 1-L glass jug onto which an equally graduated test strip of increasing darkness was attached [marked from 1 (clear) to 10 (black)]. Each sample was collected by drawing

Received August 9, 2007.
Accepted January 20, 2008.
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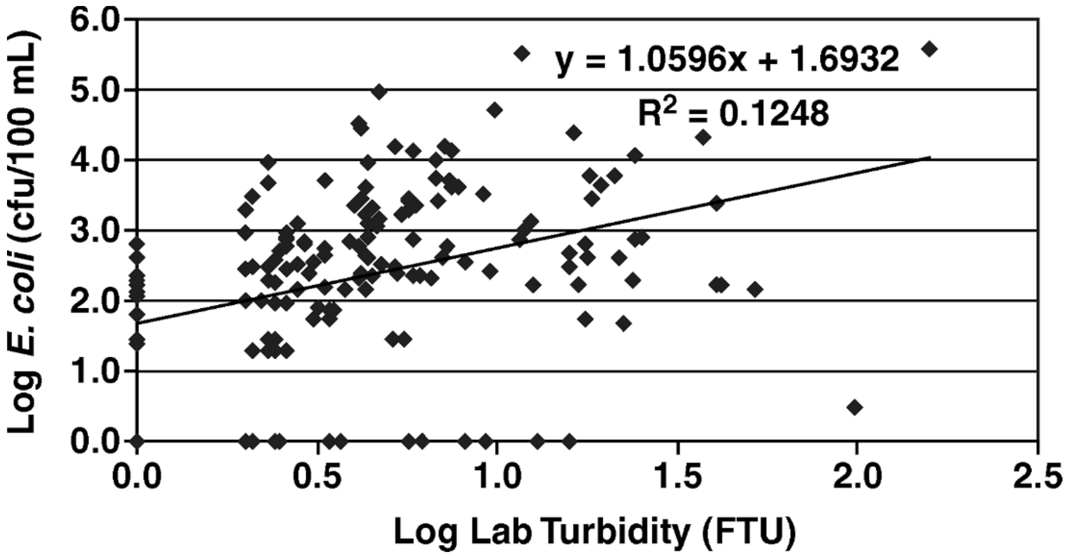

Figure 1. The relationship between water turbidity measured in a laboratory by spectrophotometry [fluorescent turbidity units (FTU)] and the concentration of *Escherichia coli* in the sample.

the bottle through the water in the trough, without stirring the water, and resuspending the sludge at the bottom of the trough. The VTS was scored as the lowest number visible when the jug was filled with water, and 5 readings were taken from different water troughs at each farm visit. The water samples were then sent to the National Laboratory Service in transport flasks containing 18 mg of sodium thiosulfate, to counteract bacterial numbers being reduced by the possible presence of chlorine, and tested within 24 h of collection. A subsample of 100 to 150 mL was tested for turbidity and up to 1 L was tested for *E. coli* enumeration. Turbidity was measured by using a tungsten spectrophotometer (Environment Agency, 1981) and expressed as fluorescent turbidity units. Presumptive *E. coli* colonies were enumerated by membrane filtration and spread plating (Environment Agency, 2002) and reported as colony-forming units per 100 mL, with a lower limit of detection of 10 colonies/100 mL.

Because some samples had a zero count, one was added to all counts to enable the log-conversion of all samples to reduce the effect of outliers. Visual turbidity score, laboratory turbidity, and bacterial concentrations were described by using Microsoft Excel scatter plots and compared by linear regression analysis clustered on farm and including visit month as an a priori confounder. The average VTS and enumeration results were also compared against individual water trough management practices (which were recorded on a sample collection form) by using either *t*-tests or Mood's median test. Geometric means were used to provide summaries of the skewed enumeration data. All analyses were completed by using STATA 9 (Stata Corp., College Station, TX) software.

A total of 164 water trough samples were collected from 36 farm visits [mean 4.6 samples per visit (minimim 2, maximum 5)]. The linear regression model and the linear trend line showed that the turbidity of a

Table 1. Sensitivity and specificity scores for the effectiveness of an on-farm turbidity tester to detect concentrations of *Escherichia coli* linked to the presence of *E. coli* O157 in cattle water troughs

	E. coli >5,800 cfu/100 mL					
VTS[1]	Positive	Negative	Positive, %	VTS comparison	Sensitivity	Specificity
1	3	77	3.8	1 vs. 2–8	0.17	0.46
2	4	32	11.1	1–2 vs. 3–8	0.39	0.24
3	4	25	13.8	1–3 vs. 4–8	0.61	0.06
4	6	5	54.5	1–4 vs. 5–8	0.94	0.03
5–8	1	4	20.0			

[1]Visual turbidity score.