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Drinking Water Quality from Stream, Pond, and Well Sources for Cattle in North Georgia, USA

Abstract

Water samples were taken at cattle farms over a two year period to compare sources, promote awareness of drinking water quality issues, and assist with water management decisions. Troughs supplied with well water had the highest percentage of samples meeting the recommended levels for physical and chemical contaminants (77%). Ponds and streams had the fewest number of samples meeting such recommendations (25% and 18%, respectively). The highest fecal coliform bacteria counts occurred in troughs in high density corrals (6333 MPN/100ml average). Pasture troughs had higher average fecal coliform counts (436 MPN/100 ml) than streams (354 MPN/100 ml) and ponds (118 MPN/100 ml). Trough

maintenance practices were recorded at farms to help better understand fecal coliform control measures in cattle drinking water.

Introduction

Water quality is important to animal health, which directly affects farm profit. Decreased water intake and health issues due to water contamination, palatability and inadequate supply can adversely affect animal health, reproduction and growth (National Research Council, 1974; Olkowski, 2009; Raisbeck et al., 2008; Utley, 1970). Investigating drinking water quality for cattle on farms can provide useful information for management decisions that improve animal health.

Research indicates that livestock will drink more, eat more and ultimately gain weight more quickly when provided with high quality water (Bica et al., 2021; Lardner et al., 2005; Utley, 1970; Willms et al., 2002). Lardner et al. (2005) showed that good water quality contributed to a 10% weight gain over a 90-day grazing period and may also reduce animal exposure to pathogenic organisms. Such improvements in cattle health will lead to more efficient growth and better value for beef production.

Cattle are provided drinking water from various sources. These include streams, ponds, well water and a variety of trough systems. Water quality varies widely for each source and delivery method, affecting total water consumption and animal health. Each farm can have unique situations for providing water to livestock with degrees of limitations on access and quality. Managing farm resources for cattle access to high quality water could increase animal productivity by reducing negative health effects of lower water quality (Bica et al., 2021; Lardner et al., 2005; Utley et al., 1970; Willms et al., 2002).

The University of Georgia Cooperative Extension service provided free water sample tests to cattle farms over a two-year period to promote awareness of such drinking water quality issues and assist with water management decisions that improve animal production. Groundwater, stream, and pond drinking water sources were analyzed to classify North Georgia livestock water quality issues and provide producers with useful information for operational decision making. Water sources were compared to determine differences in quality. Producers were surveyed about water trough settings, cleaning frequency, and access to water sources. The information gained from this project will help cattle farmers decide the best approach for water resource management on their farm.

Methods

Fifty-three cattle water sources were sampled in 10 counties across northeast Georgia between August and October 2020 from 30 different farms. These included a variety of water troughs, ponds, and streams. Troughs were supplied with well water from deep or shallow sources, except one trough received municipal water supply. Samples were analyzed for iron, manganese, sulfate, molybdenum, chromium, calcium, copper, sodium, fluoride, chloride, phosphate, soluble salts, total dissolved solids, turbidity, nitrate and nitrite, pH, and fecal coliform bacteria at the Agricultural and Environmental Service Laboratory (AESL) at the University of Georgia. Ten of the samples were also analyzed for arsenic, selenium, cadmium, and lead. A list of the elements and their recommended limit are presented in Table 1. During a second sampling event, between June and July 2021, water samples were taken from 17 troughs and directly from their corresponding well water source to analyze fecal coliform levels at sources and in troughs. A Mann-Whitney U test was conducted on the fecal coliform data comparing contamination levels in well water supplies and in the troughs. One participating farm used a continuous application of chlorine tablets to create approximately a 3 ppm concentration of chlorinated drinking water in the troughs. Samples were taken at this farm in year one and year two. A Mann-Whitney U test was conducted on the fecal coliform data comparing chlorine dosed troughs and those not dosed. Farms were asked how often troughs were cleaned per year to help understand possible impact on bacteria contamination levels. A Mann-Whitney U test was conducted on the fecal coliform data comparing trough cleaning frequencies of once every 6 months or less and once every 12 months or more.

Table 1. Limits of parameters recommended for livestock drinking water quality.

Element	Recommended Limit	Units	Element	Recommended Limit	Units
pH	6 to 9 (8 Dairy)		Nitrite – Nitrogen, NO^{2}-N	10	ppm
Calcium, Ca	200	Ppm	Arsenic, As	0.2	ppm
Copper, Cu	0.5	Ppm	Cadmium, Cd	0.05	ppm
Cobalt, Co	1	Ppm	Chromium, Cr	1	ppm
Iron, Fe	0.3	Ppm	Lead, Pb	0.1	ppm
Manganese, Mn	0.05	Ppm	Mercury, Hg	0.01	ppm
Molybdenum, Mo	0.5	Ppm	Vanadium, V	0.1	ppm
Sodium, Na	1000	Ppm	Zinc, Zn	24	ppm
Phosphorus, P	1	Ppm	Selenium, Se	0.05	ppm
Total Dissolved Solids, TDS	1000	Ppm	Conductivity	1560	uS/cm
Fluoride, F	2	Ppm	Turbidity	30	NTU
Nitrate - Nitrogen, NO^{3}-N	25	Ppm	Fecal Coliform	10 (1 calves)	MPN/100 ml
Sulfate, SO^{4}	1000 (250 taste)	Ppm			

Modified from Higgins et al., 2008; National Research Council, 1974; Oetzel, 2008; and Pfost et al., 2001.

Results

Chemical and physical elements were safely within the recommended limits for 53% of samples collected across all water sources. Troughs supplied with well water had the highest percentage of samples meeting the recommended levels (73%). However, they had the greatest variety of contaminants present (six). Ponds and streams had the fewest number of samples meeting safe recommendations for chemical and physical contaminants (25% and 18%, respectively), but they had a smaller variety of contaminants detected (three and four, respectively). The most common elementals above the limit were iron (32% of samples) and manganese (26%). Observed pH levels were outside of the acceptable range in 13% of samples. High iron levels occurred more often in ponds and streams; 47% of high iron samples were from ponds, 41% were from streams, and only 12% were from troughs. High manganese levels were detected in five pond samples, four stream samples and five trough samples. Four wells and three streams had unacceptable pH levels. Two trough samples from shallow drilled wells had nitrate-nitrogen levels greater than the recommended 25 ppm limit (42.12 ppm and 69.58 ppm). Copper was higher than recommended in one sample from a municipal water supply, and phosphorous was higher than recommended in one trough sample. Turbidity levels were unacceptable in one stream and one pond. Table 2 lists the extent of contamination for chemical and physical elements in different water sources along with the frequency of samples outside of the recommended limits. Troughs had six different chemical contaminants, while streams had four and ponds had three.

Table 2. Average element concentration, maximum value, and frequency for pond, stream, and trough water sources with contaminants outside of the recommended limit (12 ponds, 11 streams, and 30 troughs were sampled).

Element	Recommended Limit and Units	Water Source	Average	Maximum	Percent of Samples Outside Limit
pH	6 to 9 (8 Dairy)	Pond	6.9	7.8 (Min 6.1)	0%
		Stream	6.5	7.0 (Min 5.5)	27%
		Trough	7.1	9.3 (Min 4.0)	13%
Copper, Cu	0.5 ppm	Pond	< 0.05	< 0.05	0%
		Stream	< 0.05	< 0.05	0%
		Trough	0.30	0.75	3%
Iron, Fe	0.3 ppm	Pond	0.75	2.38	67%
		Stream	1.06	4.57	64%
		Trough	0.10	1.39	7%
Manganese, Mn	0.05 ppm	Pond	0.11	0.57	42%
		Stream	0.05	0.21	36%
		Trough	0.10	1.17	17%
Phosphorus, P	1 ppm	Pond	0.03	0.09	0%
		Stream	0.02	0.05	0%
		Trough	0.10	1.00	3%
Nitrate - Nitrogen, NO^3-N	25 ppm	Pond	0.32	1.47	0%
		Stream	1.05	3.30	0%
		Trough	5.20	69.58	7%
Turbidity	30 NTU	Pond	15.06	59.50	8%
		Stream	12.53	80.00	9%
		Trough	2.60	20.50	0%

Fecal coliform levels were higher than recommended in 87% of the samples in year one. Some of the highest counts (5000 to 9000 MPN/100ml) were from troughs in high density corrals. Pasture troughs had higher average fecal coliform counts (436 MPN/100 ml) than streams (354 MPN/100 ml) and ponds (118 MPN/100 ml). Counts were highly variable in pasture troughs (10 to 5000 MPN/100ml) and streams (20 to

1700 MPN/100ml), but less variable in ponds (10 to 500 MPN/100ml). Table 3 shows the fecal coliform contamination levels for various drinking water sources tested in year one. A distribution of the data in binned categories is displayed in Figure 1.

Table 3. Fecal coliform contamination levels (MPN/100ml) in ponds, streams, pasture troughs, and corral troughs recorded in year one of the survey.

Median	Average	Minimum	Maximum	Water Source (# of samples)
30	118	10	500	Ponds (12)
170	354	20	1700	Streams (11)
110	436	10	5000	Pasture Troughs (27)
5000	6333	5000	9000	Corral Troughs (3)

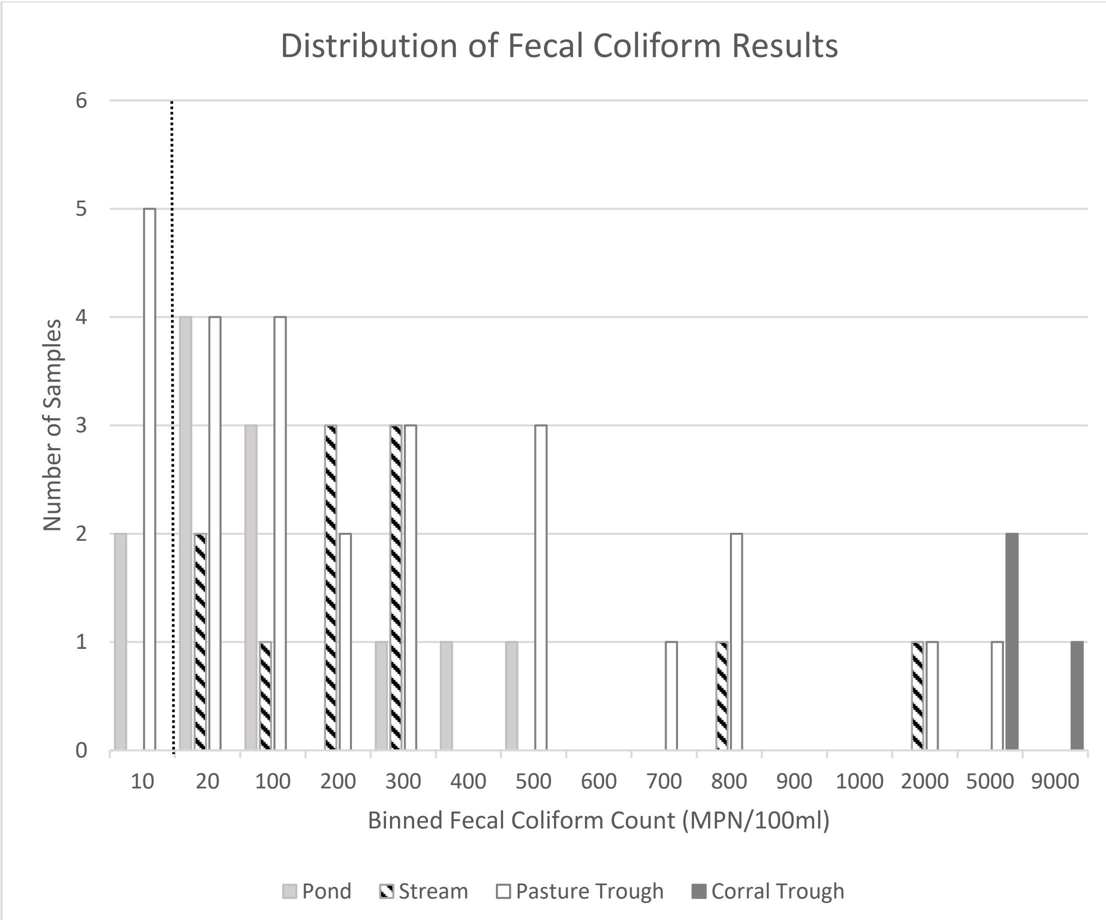

Figure 1. Distribution of fecal coliform count data (MPN/100 ml) in ponds, streams, pasture troughs, and corral troughs sampled in northeast Georgia during year one of the survey. The dotted vertical line (⁝) indicates recommended maximum fecal coliform contamination level of 10 MPN/100 ml.

During the summer of 2021, seventeen troughs and their well water source were sampled for fecal coliform contamination. All seventeen wells had 10 MPN/100 ml fecal coliform bacteria contamination levels and the average value for water sampled from troughs was 1680 MPN/100 ml, with a median value of 400 MPN/100 ml. There was a significant difference in fecal coliform bacteria levels between trough and well water source ($p < 0.00001$).

The farm using chlorine dosing was sampled once each at three different troughs during year one and twice at a single trough in year two for fecal coliform bacteria contamination. The average value across both years was 18 MPN/100 ml and the median value was 10 MPN/100 ml. This was significantly different from troughs not dosed with chlorine at all other locations; 1888 MPN/100 ml average and 500 MPN/100 ml median ($p = 0.00338$)

Trough cleaning frequency of 6 months or less produced lower fecal coliform contamination levels (average 67 MPN/100ml) than those troughs cleaned at or greater than every 12 months (average 811 MPN/100ml; $p = 0.00087$). All water test results were shared with participating farms for consideration of management changes that might improve drinking water quality for cattle.

Discussion

We found troughs supplied by wells had the greatest frequency of acceptable water quality for physical and chemical contaminants, followed by ponds and streams. However, troughs had three chemical contaminants that were not present in ponds or streams; copper, phosphorus, and nitrate-nitrogen. These contaminants were rare, occurring once or twice in four of the thirty trough samples. Two of the most common contaminants in cattle drinking water, iron and manganese, were found at levels that might contribute to water palatability issues, possibly decreasing water intake (Olkowski, 2009). The occurrence of higher iron levels was somewhat localized, with four of thirty farms producing 59% of these results.

While only two samples produced high turbidity concerns, such contamination of drinking water can deter intake and affect weight gain (Lardner et al., 2005). This would be expected to occur less often in troughs supplied by well water and more often in streams and ponds affected by rainfall runoff, erosion, stagnant drought conditions, and sediment disturbance by animals. However, high turbidity can occur in well water supplies when pump intakes are too close to the bottom or a compromise in the structure introduces sediment.

Some contaminants were not prevalent or outside acceptable levels in north Georgia drinking water and might not need testing, although they are included in basic testing services by the AESL. These were calcium, sodium, molybdenum, total dissolved solids, fluoride, sulfate, nitrite-nitrogen, and selenium. An initial test of well water might be all that is needed for these minerals and certain trace elements such as arsenic, cadmium, chromium, and lead. Contamination of some water supplies will also be a result of site-specific geology, land use (historical and present), and hydrology (Beck et al., 1985). Past and current fertilizer use or high concentration of animal manure in surrounding landscapes, for example, could impact nitrate concentrations in shallow bored wells susceptible to land use activity (Beck et al., 1985; Bouwer, 1990; Richards et al., 1996). The presence of certain geologic formations underground can also affect contamination levels in deep-drilled well water (100 feet or greater; Glanville et al., 1997).

Ponds and streams had lower average fecal coliform contamination than either pasture or corral troughs, but the distribution of sample data for all sources was wide and the median values for pasture troughs was lower than that of streams. Sample data variation could be due to cattle density, air and water temperature, surface drainage quality, wildlife presence, trough cleaning frequency, and water chemistry (Agouridis et al., 2005; Gregory & Frick, 2000; St. Laurent & Mazumder, 2014). Well water sources had acceptable levels of fecal coliform bacteria in year two samples, suggesting the contamination of troughs occurred at the surface from cattle or wildlife activity.

While not many troughs had acceptable levels of fecal coliform, our survey data show a higher trough cleaning frequency or mild bleach application appeared to help lower the bacteria concentrations. For ponds and streams, appropriately placed fencing and vegetation buffers with designated livestock access paths can be used to reduce bacteria load in the water supply (Agouridis et al., 2005; Grudzinski et al., 2020). Further investigation of bacteria control in trough water using bleach and its related effects on animal health is needed.

Previous studies indicating that cattle perform better on clean water described a clean water source as troughs with low bacteria counts and characterized poor water quality as low palatability, due to algae, fecal contamination, or chemical constitution (Bica et al., 2021; Lardner et al., 2005; Wilms et al., 2002). Our survey showed high variability of bacteria levels across all types of water delivery and higher concentration of elements linked to palatability issues in streams and ponds (iron and manganese). Fecal coliform differences in troughs were possibly due to different cleaning frequencies and exposure at the farms sampled. While the iron and manganese variation in streams and ponds is related to local geologic formations. These survey results suggest cattle drinking water supplies should be analyzed and managed appropriately on a farm-by-farm basis for potential improvement of animal performance. Troughs supplied with well water could be cleaner and safer than streams and ponds in north Georgia, but only when bacteria contamination is controlled.

Conclusions

Each water source can prove to be beneficial to cattle operations, but water quality can vary by location, delivery, and maintenance. Our results indicate that fecal coliform contamination was the most common issue with water quality in north Georgia, followed by potential iron and manganese palatability issues. We found that bacteria results can vary greatly, regardless of water source, and may be affected by other controllable or uncontrollable factors. Troughs can provide some of the best drinking water for cattle if they are cleaned frequently. An issue with pond and stream water in need of further investigation is turbidity levels. Frequent changes based on weather conditions could cause high turbidity levels and affect cattle water intake which may require alternative water supply access for animals, such as well water in a trough. Water sources for livestock can be affected by pasture conditions, regional watershed issues, and water supply protection. It would be worthwhile to test water supplies for any issues and adjust water delivery options or try new maintenance techniques to improve water quality. Using the highest quality water available and most optimal delivery method could contribute to improved production of cattle by preventing negative health effects and ensuring sufficient water consumption.

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