

Drinking Water Quality Guidelines for Cattle

Stephen F. Higgins, Carmen T. Agouridis, Biosystems and Agricultural Engineering, and Amanda A. Gumbert, Agricultural Programs

An adequate drinking water supply is an essential component of cattle production. Producers need to be concerned with the amount of water supplied and the quality of that water. This publication provides information related to drinking water quality requirements for cattle as well as water sampling and testing guidelines.

Why Test Water Quality for Cattle?

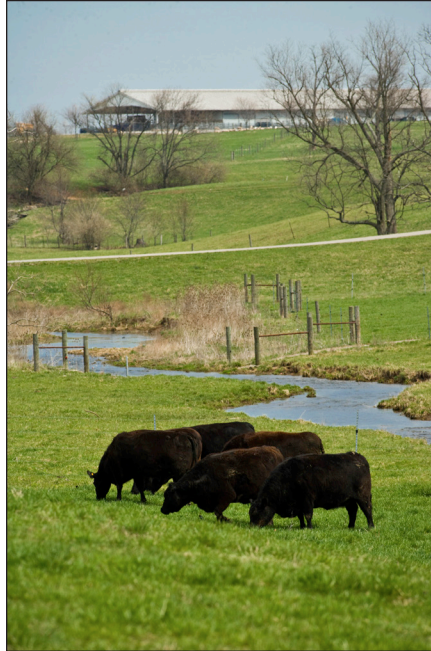
Many cattle producers in Kentucky utilize surface waters as drinking water sources for their herds. However, live-stock growth and production can be diminished when animals consume water containing high levels of contaminants. Cattle often drink less contaminated water, which leads to reduced feed intake and increased vulnerability to heat stress. Consideration should be given to all available water sources, because contaminant types and levels are not similar throughout a cattle production practice.

Assessing Water Quality

Water quality assessment is generally based on:

- Physical properties
- Physiochemical properties
- Excess nutrients
- Toxic compounds
- Microbiological agents

The following descriptions provide information on each assessment type.



Physical Properties

When the air temperature increases above 40°F (4.4°C), cattle consume additional water based on dry matter consumption. Cattle typically prefer drinking water at temperatures between 40°F (4.4°C) and 65°F (18.3°C). When the temperature is more than 80°F (27°C), water and feed intake rates often decrease, affecting animal productivity. On hot summer days, the temperature of water sources located in direct sunlight can quickly increase. To reduce heat loads

from the sun, producers can build shades over small sources such as tanks. A water supply with a temperature of more than 85°F (29°C) should be chilled. Insulated or heated tanks can be used during the winter months. Water consumption requirements are listed in Table 1.

Physiochemical Properties

Physiochemical properties are those that deal with the physical properties and the chemical composition of a sample, and include parameters such as salinity, hardness, and pH.

Salinity

Salinity refers to the mass of dissolved constituents contained in a solution and is typically determined indirectly by measuring total dissolved solids (TDS), total soluble salts (TSS), or electrical conductivity (EC). Salinity is often due to sodium chloride, but bicarbonate, sulfate, calcium, magnesium, and silica levels may also be significant. A lower percentage of salinity might include iron, nitrate, potassium, phosphorus, boron, strontium, and fluoride.

Research has been mixed on the effects of high salinity levels on livestock performance, largely due to the nature of these measurements, which do not identify specific contaminants and their associated concentrations. Two water sources may have similar salinity levels

Table 1. Water consumption requirements for cattle (gal/head/day).

Temperature (°F)	Gal/lb DM*	500 lb Calf (12 lb DMI*)	750 lb Calf (16.6 lb DMI)	1,100 lb Dry Cow	1,100 lb Lactating Cow
40	0.37	4.4	6.1	7.4	8.1
60	0.46	5.5	7.6	9.2	10.1
80	0.62	7.4	10.3	12.4	13.6
90	0.88	10.6	14.6	17.6	19.4

*DM = dry matter; DMI = dry matter intake.

Sources: Winchester and Morris (1956); Henning et al. (2000).

but different effects, depending on the contaminants present. For example, saline waters in which the causative agent is sulfate may reduce milk production; waters high in sodium may not. Overall, research indicates that elevated levels of dissolved salts lead to reduced feed intake and growth rates in cattle. Cattle tend to become acclimated to small changes in salinity, but large increases can result in illness or even death. Salinity categories are listed in Table 2.

Hardness

Hardness is a measure of the concentration of divalent metallic cations (++) dissolved in water and is generally expressed as the sum of calcium and magnesium concentrations expressed as equivalents of calcium carbonate. Other divalent metallic cations such as iron and manganese can contribute to hardness, but concentrations are usually much lower than calcium and magnesium.

Trace element nutrition research indicates that waters with high iron concentrations (greater than 0.3 mg/L) can affect cattle health and performance by impacting copper and zinc absorption. Limited research also suggests that high levels of dietary calcium consumption (greater than 12.5 g calcium/kg diet) can reduce selenium absorption. Hard waters can also be problematic to low pressure and low flow watering systems due to the accumulation of insoluble calcium and magnesium carbonate deposits. Producers located in karst regions should give additional consideration to hardness because elevated levels of calcium and magnesium are associated with limestone (karst) geology. Hardness guidelines are listed in Table 3.

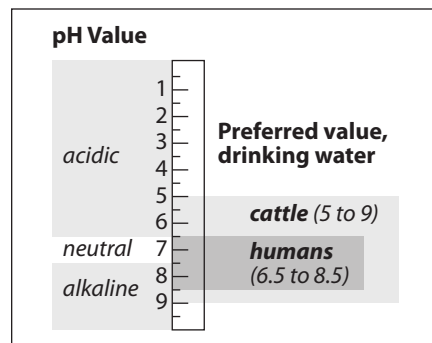
pH

pH is a measure of the degree of acidity or alkalinity in water. Acidic waters have a pH value less than 7. Neutral waters have a pH of 7. The preferred drinking water pH for humans is between 6.5 and 8.5. Little is known about the effects of pH value on water intake rates and cattle performance. Producers should provide water with a pH range of 5 to 9. pH levels are detailed in Figure 1.

Total soluble salts (mg/L)	Comments
<1,000	Safe to drink; should pose no health problems.
1,000-2,999	Typically safe to drink; may cause mild diarrhea.
3,000-4,999	Cattle may initially refuse; may cause diarrhea; optimal performance not achieved due to lower water intake rates.
5,000-6,999	May be offered if optimal performance is not required; avoid providing to lactating or pregnant cattle.
7,000-10,000	Avoid if possible; consumption will likely result in health problems.
>10,000	Unsafe to drink; do not use under any conditions.

Hardness (mg/L)	Category
0-60	Soft
61-120	Moderately hard
121-180	Hard
181-350	Very hard
>350	Brackish

Figure 1. Guidelines for pH value.



Excess Nutrients

Nitrate

Background concentrations of nitrate in surface waters are largely determined by the geology of the watershed. However, heavy upstream stocking rates, especially when the ground is frozen, can lead to dangerously high spikes in nitrate levels following rainfall events.

These spikes are usually short in duration and not easily detected. When excessive levels of nitrates are present, nitrites can accumulate in the rumen. Nitrites absorbed into the bloodstream interfere with the oxygen-transporting capacity of hemoglobin, thus interfering with respiration. In severe cases, asphyxiation can occur. Moderate levels of nitrate poisoning have been linked to a host of problems including poor growth, infertility, abortions, and vitamin A deficiencies. Signs of acute nitrate poisoning include labored breathing, rapid pulse, frothing at the mouth, convulsion, blue muzzle, and a blue tint around the eyes. Signs of chronic nitrate poisoning are generally not as evident, but can include reduced weight gain, decreased appetite, lower milk production, and increased susceptibility to infection. Guidelines for safe nitrite concentrations are shown in Table 4.

NO ₃ (mg/L)	NO ₃ -N (mg/L)	Comments
0-44	0-10	Safe for consumption
45-132	11-20	Safe with low nitrate feeds and balanced diet
133-220	21-40	Potentially harmful if consumed for long periods
221-660	41-100	Cattle at risk of death
>661	>101	Unsafe for consumption



Microbiological Agents

Fecal coliforms

Because pathogens are not easily or cheaply detected in water, their presence is inferred by using indicator organisms. Indicator organisms are those whose presence in water signifies the presence of fecal matter and possibly pathogens. Fecal coliforms are one such indicator organism commonly used. Some sources recommend livestock drinking water contain less than 1 CFU (colony forming unit) per 100 mL for calves and 10 CFU per 100 mL for adult cattle, but these values may be difficult to achieve in the presence of cattle.

Cyanobacteria (Blue-green Algae)

Water sources can become stagnant during drought or low flow periods. If nutrient loading occurs and water temperatures are elevated, algae blooms can occur. These blooms may contain a type of photosynthetic bacteria called cyanobacteria, or blue-green algae. There have been documented cases in which cattle have become sick or died from drinking water containing toxins (microcystins) released by blue-green algae. Waters contaminated with microcystins will have a moldy, musty, or septic tank odor. Although odor is not a test that is typically conducted, waters with these contaminants will also have high TDS, nitrogen, and phosphorus concentrations.

Sulfate

Sulfate is present in most water sources and is commonly found in the form of calcium, iron, sodium, and magnesium salts. Elevated levels of these salts can make the water taste objectionable to cattle. Guidelines for sulfates in water are not well defined, but high concentrations cause diarrhea and in some instances copper deficiencies. High sulfate concentrations also help development of polioencephalomalacia (PEM), which is a neurological disorder characterized by weakness, muscle tremors, lethargy, and even paralysis and death. High sulfate water consumption often requires changes to the supplied mineral mix. The form of sulfur is also important in determining toxicity. Sulfur in the form of hydrogen sulfide can lead to reduced water intake at levels as low as 0.1 mg/L. Table 5 contains maximum recommended sulfate levels.

Table 5. Maximum recommended sulfate (SO₄) and sulfate sulfur (SO₄-S) levels.

SO ₄ (mg/L)	SO ₄ -S (mg/L)	Types
<500	<167	Calves
<1,000	<333	Adults

Toxic Compounds

Table 6 contains a listing of additional substances that may be found in water and can pose health hazards to cattle. Several factors related to diet, physiology, and environment prevent determining precise problematic concentrations. If these concentrations are exceeded, look for alternate water sources or seek treatment.

Table 6. Generally considered safe levels of potentially toxic substances.

Substance	Upper-limit guideline (mg/L)
Aluminum (Al)	5.0
Arsenic (As)	0.2
Boron (B)	5.0
Cadmium (Cd)	0.05
Chromium (total) (Cr)	1.0
Cobalt (Co)	1.0
Copper (Cu)	0.5
Fluorine (F)	2.0
Lead (Pb)	0.1
Manganese (Mn)	0.05
Mercury (Hg)	0.01
Selenium (Se)	0.05
Vanadium (V)	0.1
Zinc (Zn)	24.0

Water Sample Collection

Collected water samples can be submitted to commercial or university laboratories for analysis. Likewise, producers can purchase water quality test kits from online sources or even local hardware stores if the water supply needs to be tested for a limited number of contaminants.

When collecting a water sample, it is important to follow the sampling protocol outlined by the laboratory to ensure that accurate results are obtained. If collection and handling are done in a manner that allows the sample to deteriorate or become compromised before analysis, the results will be meaningless.

For example, water samples for microbial analysis should be analyzed within 24 hours to be meaningful and within 8 hours for regulatory purposes. The laboratory will specify the type of container to use, what forms to complete, and how the sample should be packaged and shipped. Manufacturers offer a variety of water quality kits from test strips to portable laboratories to accommodate a range of budgetary and accuracy needs. Producers may need to collect water samples that represent different times of the year (e.g. seasonal influence), hydrologic conditions (e.g. wet and dry), and production levels, because these factors will affect contaminant concentrations in natural water sources. Table 7 contains common sample collection and handling guidelines.

Category	Comment
Location	Sample should be representative of water that animals drink; grab samples from the stream should be taken at the mid-channel and mid-depth; flush watering lines for 3 to 5 minutes before sampling.
Container	Should be clean and free of contaminants; do not pre-rinse; open container only to collect sample.
Label	Specify name, date, time and sample location
Holding Time	Check with laboratory or manufacturer; varies with contaminant; pH must be analyzed in the field.
Holding Temperature	Store at 4°C (39°F).
Volume	Fill container full for organic compound determination; leave space for aeration and mixing for inorganic and microbiological determinations; amount should be sufficient to conduct all required tests.
Preservation	Check with laboratory or manufacturer; varies with contaminant; care should be taken to add specified volume of sample to maintain correct sample to preservative ratio.
Safety	Care should be exercised in collecting, handling, transporting and storing samples; personal protective equipment may be required; do not store samples with food.

References

- Bagley, C.V., J. Kotuby-Amacher, and K. Farrell-Poe. 1997. Analysis of Water Quality for Livestock. Utah State University Extension Publication AH/Beef/28.
- Barrio, J.P., S.T. Bapat, and J.M. Forbes. 1991. The Effect of Drinking Water on Food-intake Responses to Manipulation of Rumen Osmolality in *Sheep*. *Proc. Nutr. Soc.* 50:98A.
- Beede, D.K. 2005. Assessment of Water Quality and Nutrition for Dairy Cattle. Mid-South Ruminant Nutrition Conference, Arlington, April 27-28.
- Clesceri, L.S., A.E. Greenberg, and A.D. Eaton. 2001. Standard Methods for the Examination of Water and Wastewater. 20th ed. American Public Health Association, Washington, D.C.
- Embry, L.B., M.A. Hoelscher, R.C. Wahlstrom, C.W. Carlson, L.M. Krista, W.R. Brosz, G.F. Gastler, and O.E. Olson. 1959. Salinity and Livestock Water Quality. *S. Dak. Agr. Stat. Bil.* 481.
- Glauert, S. Livestock and Water Salinity. *Farmnote*: 249. Government of Western Australia, Department of Agriculture and Food.
- Henning, J., G. Lacefield, M. Rasnake, R. Burris, J. Johns, K. Johnson, and L. Turner. 2000. Rotational Grazing (IS-143). University of Kentucky, Cooperative Extension Service.
- Mitchell, C. 2004. Poor Water Quality Can Steal Cattle Blind. *Cattle Today Online*. Available at: www.cattletoday.com/archive/2004/March/CT317.shtml.
- National Academy of Sciences. 1974. Nutrient and Toxic Substances in Water for Livestock and Poultry. Washington, D.C.
- National Research Council. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. National Academy Press, Washington, D.C.
- Spears, J.W. 2003. Trace Mineral Bioavailability in Ruminants. *J. Nutr.* 133(5): 1506S-1509S.
- Waldner, D.N., and M.L. Looper. Water for Dairy Cattle. Oklahoma Cooperative Extension Service Publication F-4275. Available at: <http://osueextra.okstate.edu/pdfs/F-4275web.pdf>
- Weeth, J., and J.E. Hunter. 1971. Drinking of Sulphate Water by Cattle. *J. Anim. Sci.* 34:256-260.

Cooperative Extension Service

Agriculture and Natural Resources
 Family and Consumer Sciences
 4-H Youth Development
 Community and Economic Development

MARTIN-GATTON COLLEGE OF AGRICULTURE, FOOD AND ENVIRONMENT

Educational programs of Kentucky Cooperative Extension serve all people regardless of economic or social status and will not discriminate on the basis of race, color, ethnic origin, national origin, creed, religion, political belief, sex, sexual orientation, gender identity, gender expression, pregnancy, marital status, genetic information, age, veteran status, physical or mental disability or reprisal or retaliation for prior civil rights activity. Reasonable accommodation of disability may be available with prior notice. Program information may be made available in languages other than English. University of Kentucky, Kentucky State University, U.S. Department of Agriculture, and Kentucky Counties, Cooperating. Lexington, KY 40506 Revised 04-2024



Disabilities accommodated with prior notification.