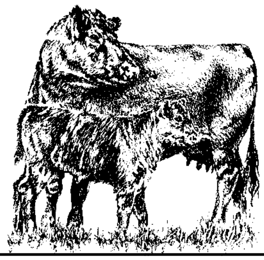

Western Beef Resource Committee *Fourth Edition*

**Cattle Producer's Handbook**

Animal Health Section 609

# Analysis of Water Quality for Livestock

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Animals are able to ingest a wide variety of different types of water and survive. However, some salts and elements at high levels may reduce animal growth and production, or may cause illness and death.

The measures used to evaluate water quality include salinity, hardness, pH, sulfate, nitrate, and analysis for other specific elements known to be toxic. Waters can be evaluated for these characteristics at university or commercial laboratories. Microbiological agents (bacterial, viral, and protozoan) can be spread through water and cause disease. These are not usually evaluated in livestock waters, but samples could be submitted to an animal disease diagnostic laboratory for culture. Only certain laboratories are prepared to test for pesticides and organic toxins.

## Salinity

Salinity refers to salts dissolved in water. The anions (negatively charged ions) commonly present include: carbonate, bicarbonate, sulfate, nitrate, chloride, phosphate, and fluoride. The cations (positively charged ions) include calcium, magnesium, sodium, and potassium.

Salinity may be measured as Total Dissolved Solids (TDS) or Total Soluble Salts (TSS), and is expressed as parts per million (ppm), which is equivalent to mg/l or ug/ml. Salinity may also be measured by electrical conductivity (EC), and is then expressed as reciprocal micro ohms per centimeter (umhos/cm) or decisiemens per meter (dS/m). There is a close correlation of EC and ppm with the values of ppm being about three-fifths of those for EC (@ 300 ppm, EC=500 umhos/cm and @ 3,000 ppm, EC=5,000 umhos/cm). The effects seem to be the same whether one or several salts are involved. The conversion factors are listed in Table 6.

An abrupt change from water of low salinity to water of high salinity may cause animals harm, while a gradual change would not. Animals can consume water of high salinity for a few days without harm, if they are then given water of low salinity. Animal tolerance also varies with species, age, water requirement, season of the year, and physiological condition.

As the TDS of water increases, intake also increases, except at very high content where the animals refuse to drink. Depressed water intake is accompanied by depressed feed intake.

The ions of magnesium (Mg), calcium (Ca), sodium (Na), and chloride (Cl) all contribute to the salinity of water, and they may cause toxic effects because of this salinity effect or by interference with other elements, but these are not usually considered toxic otherwise.

Salinity by itself tells nothing about which elements are present, but this may be of critical importance. So when the salinity is elevated, the water should be analyzed for the specific anions and cations.

Tables 1 and 2 give guidelines on potential uses of water of various salinity.

## Hardness

Water containing appreciable amounts of calcium and magnesium are called "hard" because it is hard to make such water lather with soap. The free calcium and magnesium react with soap to form an insoluble curd-like material. If they are removed, the water will lather easily.

Water "hardness" is not necessarily correlated with salinity. Saline waters can be very soft if they contain low levels of calcium and magnesium (the cations that cause hardness). Calcium and magnesium are usually present at less than 1,000 ppm in water. The calcium carbonate content of waters of various hardness is classed as:

| Water hardness | mg/l |
|---|---|
| Soft | 0 to 60 |
| Moderate | 61 to 120 |
| Hard | 121 to 180 |
| Very hard | more than 180 |

Hardness does not cause urinary calculi.

**Table 1. TDS and species variation.**

| Species | Excellent | Good | Fair | Poor | Limit |
|---|---|---|---|---|---|
| | Total Dissolved Solids (ppm) | | | | |
| Humans | 0 to 800 | 800 to 1,600 | 1,600 to 2,500 | 2,500 to 4,000 | 5,000* |
| Horses—working | 0 to 1,000 | 1,000 to 2,000 | 2,000 to 3,000 | 3,000 to 5,000 | 6,000 |
| Horses—others | 0 to 1,000 | 1,000 to 2,000 | 2,000 to 4,000 | 4,000 to 6,000 | 10,000 |
| Cattle | 0 to 1,000 | 1,000 to 2,000 | 2,000 to 4,000 | 4,000 to 6,000 | 10,000 |
| Sheep | 0 to 1,000 | 1,000 to 3,000 | 3,000 to 6,000 | 6,000 to 10,000 | 15,000 |
| Chickens and poultry | 0 to 1,000 | 1,000 to 2,000 | 2,000 to 3,000 | 3,000 to 5,000 | 6,000 |
| Swine | (Young pigs and market pigs appear to tolerate less than cattle) | | | | |

*The limit for drinking water in Utah is 2,000 ppm.
Source: Boyles et al. 1988.

**Table 2. A guide to the use of saline waters for livestock and poultry.**

| Total Soluble Salts content of waters (mg/L or ppm) | Comment |
|---|---|
| Less than 1,000 | These waters have a relatively low level of salinity and should present no serious burden to any livestock or poultry. |
| 1,000 to 2,999 | These waters should be satisfactory for all classes of livestock and poultry. They may cause temporary and mild diarrhea in livestock not accustomed to them, or watery droppings in poultry (especially at the higher levels), but should not affect their health or performance. |
| 3,000 to 4,999 | These waters should be satisfactory for livestock, although they may cause temporary diarrhea or be refused at first by animals not accustomed to them. They are poor waters for poultry, often causing watery feces and (at the higher levels of salinity) increased mortality and decreased growth, especially in turkeys. |
| 5,000 to 6,999 | These waters can be used with reasonable safety for dairy and beef cattle, sheep, swine, and horses. Avoid the use of those approaching the higher levels for pregnant or lactating animals. They are not acceptable waters for poultry, almost always causing some type of problem, especially near the upper limit, where reduced growth and production or increased mortality will probably occur. |
| 7,000 to 10,000 | These waters are unfit for poultry and probably for swine. Considerable risk may exist in using them for pregnant or lactating cows, horses, sheep, the young of these species, or for any animals subjected to heavy heat stress or water loss. In general, their use should be avoided, although older ruminants, horses, and even poultry and swine may subsist on them for long periods of time under conditions of low stress. |
| More than 10,000 | The risks with these highly saline waters are so great that they cannot be recommended for use under any conditions. |
| More than 35,000 | Brine |

Source: National Academy of Sciences. 1974.

Softening the water through exchange of calcium and magnesium with sodium may cause problems if the water is already high in salinity.

## pH

The pH is a measure of acidity or alkalinity. A pH of 7 is neutral, under 7 is acidic, and over 7 is alkaline. Most waters in the western states are slightly alkaline. The preferred pH is 6.0 to 8.0 for dairy animals, and from 5.5 to 8.3 for other livestock. Highly alkaline waters may cause digestive upsets, diarrhea, poor feed conversion, and reduced water/feed intake.

## Sulfate

Sulfate imparts a bitter taste to the water, but animals can acclimate to it. Consider diluting high sulfate water for weanling pigs and for animals who are not accustomed to it. Table 3 shows the maximum recommended levels.

Magnesium sulfate (Epsom salt) and sodium sulfate (Glauber salt) tend to make water taste objectionable. Sulfate levels up to 1,500 ppm produce slight effects on livestock, and levels of 1,500 to 2,500 produce temporary diarrhea. When the sulfate level reaches 3,500

**Table 3. Maximum recommended levels of sulfate.**

| Animals | ppm Sulfate ($SO_4$) | ppm Sulfate as Sulfur ($SO_4$-S) |
|---|---|---|
| Calves | less than 500 | less than 167 |
| Adult cattle | less than 1,000 | less than 333 |

ppm, it is unfit for sows. Water with levels above 4,500 ppm should not be used (Kober 1996).

## Nitrate

Nitrate toxicity is seldom caused by a water source alone, but it may contribute to a problem feed source. The nitrate ion ($NO_3^-$) itself is not especially toxic. However, nitrite ($NO_2^-$) is readily absorbed and is quite toxic (10 times more than nitrate). The bacteria present in the digestive tract of ruminants and herbivores can readily convert nitrate to nitrite.

The clinical signs of nitrate poisoning in animals include lack of coordination, labored breathing, blue discoloration of mucous membranes, vomiting, and abortions. Dairy cows can have reduced milk production without showing any clinical signs. If animals show signs of nitrate poisoning or a problem is suspected, a veterinarian should be consulted to determine if nitrate is the problem, and administer an antidote if needed.

Table 4 can be used as a guide for nitrate in water but must be considered along with the forage level.

**Table 4. Nitrate content (ppm).**

| Nitrate-N ($NO_3$-N) | Nitrate ($NO_3$) | Potassium Nitrate ($KNO_3$) | Interpretation |
|---|---|---|---|
| **Water (ppm)** | | | |
| 0-100 | 0-440 | 0-720 | Considered safe. |
| 100-300 | 440-1,300 | 720-2,100 | Exercise caution. Consider additive effect of nitrate in feed. |
| > 300 | > 1,300 | > 2,100 | Potentially toxic. |
| **Forages (%)** | | | |
| 0-.15% | 0-0.65% | 0-1% | Considered safe. |
| 0.15-0.45% | 0.65-2% | 1-3% | Exercise caution. May need to dilute or limit feed forages. |
| > .45% | > 2% | > 3% | Potentially toxic. |

**Other elements**

Several other elements can contaminate water under special circumstances. These will require special tests and are usually not performed unless indications of a problem exist. Questions of cost, accuracy, and range of detection must be evaluated. Then a request should be made for the specific elements desired.

Source: Boyles et al. 1988.

### References


Boyles, S. et al. 1988. Livestock and Water. North Dakota State University, Extension Service Bulletin #AS-954.

Carson, T. L. 1993. Water Quality for Livestock. *In* Current Veterinary Therapy, Food Animal Practice 3. W. B. Saunders and Co., pp. 375-377.

Kober, J. A. 1996. Water: The Most Limiting Nutrient. Agri-Practice 14:39-42, February.

National Academy of Sciences. 1974. Nutrients and toxic substances in water for livestock and poultry.

Water Quality Criteria. 1972. National Academy of Science—National Academy of Engineering, Environmental Study Board, ad hoc Committee on Water Quality Criteria, U.S. Gov't. Printing Office.



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## Conversion Factors and Tables

**Table 5. Suggested limits of concentration of some potentially toxic substances in drinking water for livestock. Safe upper limit of concentration (mg/L).**

| Element | U.S. EPA (for humans) | U.S. EPA(for livestock) | NAS (for livestock) |
|---|---|---|---|
| Aluminum | -- | 5.0 | -- |
| Arsenic[b] | 0.05 | 0.2 | 0.2 |
| Barium[c] | 1.0 | -- | NE* |
| Berylium[c] | -- | NE* | -- |
| Boron | -- | 5.0 | -- |
| Cadmium | 0.01 | 0.05 | 0.05 |
| Chromium | 0.05 | 1.0 | 1.0 |
| Cobalt | -- | 1.0 | 1.0 |
| Copper[e] | 1.0 | 0.5 | 0.5 |
| Fluoride | 4.0/2.0[e] | 2.0 | 2.0 |
| Iron[e] | 0.3 | no limit | NE* |
| Lead[a,b] | .005 | 0.1 | 0.1 |
| Manganese[e] | 0.05 | no limit | NE* |
| Mercury[c] | 0.002 | 0.001 | 0.01 |
| Molybdenum | -- | no limit | NE* |
| Nickel | -- | -- | 1.0 |
| Nitrate[d] | 10 | 100 | 100 |
| Nitrite[c] | -- | 33 | 33 |
| Selenium[a] | 0.01 | 0.05 | -- |
| Vanadium[a] | -- | 0.1 | 0.1 |
| Zinc[e] | 5.0 | 25.0 | 25.0 |

*Not established. Experimental data available are not sufficient to make definite recommendations.

[a]Lead is cumulative and problems may begin at threshold value (0.05 mg/L).

[b]The safe limit is below the lowest detectable level.

[c]Analyses available only at certain laboratories.

[d]As Nitrate-N ($NO_3$-N).

[e]Secondary standard. Drinking water limits for humans are classed as primary and secondary. Primary limits are health related and are enforced by law. Secondary limits are for aesthetics and are recommendations.

Sources: Carson 1993 and Water Quality Criteria 1972.

**Table 6. Conversion factors for salinity measures.**

ppm to umhos = ppm x 5/3 = ____________ umhos/cm

umhos to ppm = umhos/cm x 3/5 = ____________ ppm

(umhos/cm) to dS/m = (umhos/cm) x 0.001 = ____________ dS/m (or mmhos/cm)

dS/m (or mmhos/cm) to umhos/cm = dS/m ÷ 0.001 = ____________ umhos/cm

ppm to dS/m = ppm x 0.0017 = ____________ dS/m

dS/m to ppm = dS/m ÷ 0.0017 = ____________ ppm

**Table 8. Conversions, equivalents, and abbreviations.**

To convert Ca to $CaCO_3$ multiply by 2.50

To convert $SO_4$ to S multiply by 0.333

One U.S. gallon of water weighs 8.345 pounds

One cubic foot of water weighs 62.43 pounds

One U.S. gallon equals .13368 cubic foot

One kilogram equals 2.2 pounds

One pound equals 454 grams

One ounce equals 28.35 grams

ppm is parts per million

ppb is parts per billion

One part per million is equal to 1 mg/l

One part per million is equal to 1 mg/kg

One part per million is 0.0001 percent

One percent is 10,000 parts per million

**Table 7. Nitrate and nitrite expressions and conversion. Factors for converting from one form of expression to another.**

| | FORM B | | | | |
|---|---|---|---|---|---|
| FORM A | Nitrogen (N) | Nitrite ($NO_2$) | Potassium Nitrate ($NO_3$) | Nitrate ($KNO_3$) | Sodium Nitrate ($NaN_3$) |
| Nitrate-Nitrogen (N) | 1.0 | 3.3 | 4.4 | 7.2 | 6.1 |
| Nitrate ($NO_3$) | 0.23 | 0.74 | 1.0 | 1.63 | 1.37 |
| Nitrite ($NO_2$) | 0.3 | 1.0 | 1.34 | 2.2 | 1.85 |
| Potassium Nitrate ($KNO_3$) | 0.14 | 0.64 | 0.61 | 1.0 | 0.84 |
| Sodium Nitrate ($NaNO_3$) | 0.16 | 0.54 | 0.72 | 1.2 | 1.0 |

To convert Form A to the equivalent amount of Form B, multiply A by the appropriate conversion factor (Form A x Conversion Factor = Form B).

Examples:

1. 1.0% Nitrate-Nitrogen (N) x 4.4 = 4.4% Nitrate ($NO_3$)
2. 1.0% Nitrate ($NO_3$) x 0.23 = 0.23% Nitrate-Nitrogen (N)
3. 1.0% $KNO_3$ x 0.61 = 0.61% Nitrate ($NO_3$)
4. 1.0% $KNO_3$ x 0.14 = 0.14% Nitrate-Nitrogen (N)