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Animal Health Fact Sheet

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.

A. 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 3/5 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 (TDS) for a few days, without harm, if they are then given water of low salinity (TDS). 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 four 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.

The following tables give guidelines on potential uses of waters of various salinity:

Table 1: TDS and Species Variation(1)

Species	Total Dissolved Solids (ppm)				
	Excellent	**Good**	**Fair**	**Poor**	**Limit**
Humans	0-800	800-1600	1600-2500	2500-4000	5000*
Horses,Working	0-1000	1000-2000	2000-3000	3000-5000	6000
Horses, Others	0-1000	1000-2000	2000-4000	4000-6000	10000
Cattle	0-1000	1000-2000	2000-4000	4000-6000	10000
Sheep	0-1000	1000-3000	3000-6000	6000-10000	15000
Chickens & Poultry	0-1000	1000-2000	2000-3000	3000-5000	6000
Swine	(Young pigs and market pigs appear to tolerate less than cattle)				

*The limit for drinking water in Utah is 2,000 ppm.

Table 2. A Guide to the Use of Saline Waters for Livestock and Poultry(2)

Total Soluble Salts Content of Waters (mg/L or ppm)	**Comment**
Less than 1,000 ppm (1670 umhos/cm)	These waters have a relatively low level of salinity and should present no serious burden to any livestock or poultry.
1,000-2,999 ppm (1670-5008 umhos/cm)	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.
3,000-4,999 ppm (5010-8348 umhos/cm)	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.
5,000-6,999 ppm (8350-11688 umhos/cm)	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.

Total Soluble Salts Content of Waters (mg/L or ppm)	Comment
7,000-10,000 ppm (11,690-16,700 umhos/cm)	These waters are unfit for poultry and probably for swine. Con 7,000-10,000 ppm (11,690-16,700 umhos/cm 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 ppm (16,700 umhos/cm)	The risks with these highly saline waters are so great that they cannot be recommended for use under any conditions.
35,000 ppm (58,450 umhos/cm)	Brine

B. 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 which 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	0-60
Moderate	61-120
Hard	121-180
Very Hard	>180

Hardness does not cause urinary calculi

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

C. 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.

D. 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. The maximum recommended levels are:

Table 3. Maximum Recommended Levels of Sulfate

Animals	ppm Sulfate (SO4) ppm	Sulfate as Sulfur (SO4-S)
Calves	< 500	< 167
Adult Cattle	< 1,000	< 333

Magnesium sulfate (Epsom salt) and sodium sulfate (Glauber salt) tend to make water taste objectionable. Sulfate levels up to 1500 ppm produce slight effects on livestock and levels of 1500 to 2500 produce temporary diarrhea. When the sulfate level reaches 3500 ppm, it is unfit for sows. Water with levels above 4500 ppm should not be used.(3)

E. NITRATE

Nitrate toxicity is seldom caused by a water source alone, but it may contribute to a problem feed source. The nitrate ion (NO3-) itself is not especially toxic. However, nitrite (NO2-) 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.

The following table can be used as a guide for nitrate in water, but must be considered along with the forage level.

Table 4. Nitrate Content (ppm)(1)

	Nitrate-N (NO3-N	Nitrate (NO3)	Potassium Nitrate (KNO3)	Interpretation
A. Water: (ppm)	0-100 100-300 Over 300	0-440 440-1300 Over 1300	0-720 720-2100 Over 2100	Considered safe. Exercise caution. Consider additive effect of nitrate in feed. Potentially toxic.
B. Forages: (%)	0-.15% 0.15-0.45% Over .45%	0-0.65% 0.65-2% Over 2%	0-1% 1-3% Over 3%	Considered safe. Exercise caution. May need to dilute or limit feed forages Potentially toxic.
C: Other elements	Several other elements can contaminate water under special circumstances. These will require special tests and are usually not performed unless there are indications of a problem. Questions of cost, accuracy and range of detection must be evaluated. Then a request should be made for the specific elements desired.			

Table 5. Recommended 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	—		—
Arsenic (b)	0.05	5.0	0.2
Barium (c)	1.0	0.2	NE*
Berylium (c)	—	—	—
Boron	—	NE*	—
Cadmium	0.01	5.0	0.05
Chromium	0.05	0.05	1.0
Cobalt	—	1.0	1.0
Copper (c)	1.0	1.0	0.05
Fluoride	4.0/2.0 (e)	0.5	2.0
Iron (e)	0.3	2.0	NE*
Lead (a) (b)	.005	No limit	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 (NO3-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.

G. Conversion Factors and Tables

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 7: Nitrate and Nitrite Expressions and Conversion Factors for Converting from One Form of Expression to Another

	FORM A		FORM B		
	Nitrogen (N)	Nitrite (NO2)	Nitrate (NO3)	Potassium Nitrate (KNO3)	Sodium Nitrate (NaNO3)
Nitrate-Nitrogen (N)	1.0	3.3	4.4	7.2	6.1
Nitrate (NO3)	0.23	0.74	1.0	1.63	1.37
Nitrite (NO2)	0.3	1.0	1.34	2.2	1.85
Potassium Nitrate(KNO3)	0.14	0.64	0.61	1.0	.84
Sodium Nitrate (NaNO3)	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 (NO3)
2. 1.0% nitrate (NO3) X 0.23 = 0.23% nitrate-nitrogen (N)
3. 1.0% KNO3 X 0.61 = 0.61% nitrate (NO3)
4. 1.0% KNO3 X 0.14 = 0.14% nitrate-nitrogen (N)

Table 8. Conversions, Equivalents and Abbreviations

To convert Ca to CaCO3 multiply by 2.50
To convert SO4 to S multiply by 0.333
One U.S. gallon of water weighs 8.345 lbs.
One cubic foot of water weighs 62.43 lbs.
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 10000 parts per million

H. REFERENCES

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