ASSESSMENT OF WATER QUALITY

G. L. Meerdink, DVM

Water quality is a major environmental and political issue. Although the quality of water for livestock is an enigma, few actual toxicoses occur from water-borne contaminants. However, effects on production due to nutrient competition or reduced intake because of poor palatability do occur. "Calves don't care what they drink," was the conclusion of Crawford, U. of MO, from two years of studies on water quality and calf performance. The pond water was above human water standards for iron, sodium and coliforms (not surprising from the defecation in the pond). Pond water intake was similar to well water intake as was weight gain between the study groups. Though "dirty pond water" may not cause a problem; the concentration of specific materials is the defining issue, not water appearance or source.

INTAKE

Water intake is affected by the environment (temperature and humidity), dry matter consumption and animal physiologic demand (e.g., lactation). Also, intake increases with high fiber, salt and protein. An approximate "rule of thumb" for water consumption of mature, non-stressed animals is 1 gallon/100# body weight/day. (For lactating animals, add the water required for milk production to the gallon/cwt. estimate for maintenance).

ASSESSMENT

Other than microbiological testing and pH, most water testing is directed toward element composition. **Salinity** is defined as the total solids (or "salts") in water after all carbonates have been converted to oxides, all bromide and iodide have been replaced by chloride, and all organic matter has been oxidized. It is an expression of the amount of total dissolved salts in a water sample; the ions most commonly involved include Ca, Mg, Na, bicarbonate, Cl and sulfate. (Refer to Table 2) **Hardness** indicates the tendency of water to precipitate soap or form scale on heated surfaces and is expressed as the sum of Ca and Mg and usually reported in equivalents of Ca carbonate. Fe, Al, Zn and Mn also can contribute to hardness and should be considered if present in unusual amounts.

Hardness should not be confused with salinity (water can be very soft with low levels of Ca and Mg, yet have a high salinity value from dissolved Na salts). Most ground waters have hardness values of less than 2000 mg/L (may be higher in arid areas). Occasionally, hardness is reported as grains per gallon (1 grain per gallon is equivalent to 17.1 mg/L). Water hardness has been classified as follows:

Hardness Range (mg/L)	Description
0-60	Soft
61-120	Moderately hard
121-180	Hard
>180	Very hard

Conductivity is a numerical expression of the ability of a water sample to transmit an electric current (which depends on the ionized substances dissolved in the water and temperature). Conductivity is expressed in umhos and is measured across a certain distance such as a centimeter. Fresh distilled water has a conductivity of 0.5 to 2 umhos/cm; conductivity of potable waters in US ranges generally from 50 to 1500 umhos/cm. An estimate of the dissolved ionic matter may be made by multiplying the conductivity (umhos/cm) by an empirical factor of about 0.55 to 0.9 (depends on components in water and temperature).

INTERPRETATION

Total Soluble Salts (Table 2) offers a quick reference to interpretation of overall assessment of hazard of salinity to livestock. A practical limit of 3000 to 7000 mg/liter of dissolved salts in livestock drinking water has been recommended by National Academy of Sciences (NAS). Especially when this overview value is high, individual elements should be examined. A few of the more commonly questioned agents follow.

Nitrates are highly soluble and leach into water supplies from N fertilizer applications and other sources such as, decaying animal or plant protein, animal metabolic waste and soils high in N-fixing bacteria. Ruminants are more sensitive to high nitrates than monogastric animals because of the ability of rumen microbes to reduce nitrate to the more toxic nitrite. Unlike human infants, baby pigs do not lack high stomach acidity (which allows for the presence of nitrate reducing bacteria); thus baby pigs are not more sensitive to nitrates than adults. Actual toxicity of nitrates in ruminants depends on their stage of adaptation; higher concentrations can be tolerated when microbial metabolic processes have had time to adapt. Water nitrate concentrations over 750 ppm nitrates might be hazardous to unadapted ruminants; concentrations over 1500 mg/l nitrates are potentially toxic, even to adapted animals.

The units of expression of nitrate concentration vary and commonly cause confusion. Nitrate concentrations are reported from laboratories as “nitrate-N” (the level of nitrogen in the form of nitrate), “Nitrates” (the level of nitrates-one nitrogen atom and three oxygen atoms) or “K nitrate” (nitrate atoms + potassium). Confusion arises when EPA safe upper limit is listed as 10 mg/L nitrate-N and the water analysis report states (for example) “26 mg/L nitrates.” This water is not above the standard because 26 mg/L (or ppm) nitrates is equivalent to 5.9 mg/L nitrate-N. Proportional equations based on atomic weights can be used in the conversion calculation or the following table can be used:

Nitrate Expressions and Conversion Factors

Form A	Form B		
	N	NO_3	KNO_3
Nitrate-nitrogen (N)	1.0	4.4	7.2
Nitrate (NO_3)	0.23	1.0	1.63
Potassium nitrate (KNO_3)	0.14	0.61	1.0

(*To convert Form of expression A to the equivalent amount of Form B, multiply A by the appropriate conversion factor i.e. Form A X Conversion factor = Form B)*

Sulfates cause health problems via their osmotic effect in the intestine to produce diarrhea (such as Epsom salts-$MgSO_4$) or metabolism to sulfides leading to polioencephalomalacia in ruminants. Sulfate concentrations greater than 750-1000 ppm may produce a transient diarrhea in pigs with initial exposure; levels greater 2000 ppm cause problems across species and ages. (Some feel that >300 ppm can cause a problem in young (pigs) when combined with nitrates or iron excess).

Iron in excess does not generally cause a health problem (especially since it is usually in the nutritionally unavailable oxidized form i.e. rust). However, concentrations over 10 ppm have resulted in reduced water intake, presumably because of palatability. Iron, in excess, is also one of the salts blamed for anti-nutrient competitive effects.

BACTERIOLOGIC ASSESSMENT

Standards for allowable bacteria vary tremendously depending on the recommending agency and intended use of the water. Coliform bacteria indicate general sanitary quality of the water and likelihood of pollution from outside sources. Water is tested for coliform bacteria by culturing 100 ml of water and counting colonies. US Public Health Service bacteriologic standards allow no coliforms in water for human consumption. EPA has set an action limit of 4 coliforms/100 ml for public water; for livestock, EPA suggests water should not exceed 5000 coliforms/100 ml. Other reviews have suggested “no coliform limits” for livestock water in consideration of the amount of waste refeeding (e.g., poultry waste to cattle) that seems to do no harm. (High nitrate levels are often found in conjunction with high coliforms, perhaps because of surface run-off contamination).

Pathogenic bacteria can be removed by filtration, although chlorination is the most common method of decontamination. Chlorine (bleach) is added to provide 0.5 ppm of free chlorine. If ammonia is present, chloramines compounds are formed and effectiveness is reduced. The efficacy of chlorine disinfection is a function of chlorine residual concentration, type of residue (free of chloramines), water temperature (higher the better), pH of the water (better <7) and type of organisms present. Superchlorination is done because farm water treatment systems cannot assure the constant level of residual chlorine or the long contact time. This involves overchlorination (at 5-10 ppm) for short periods (5 minutes). (Animals do not like water with over 5 ppm chlorine.) Chlorination does not reduce the nitrate level in water.

Following are some tables to aid in the assessment of water analytical results. Of the three sources of element standards, one relates to human water quality and the other two relate to animal recommendations. Note that the two later sources were published in 1974 and were based on valid scientific research information available at the time. Some data determined since these published values may refute the recommendations for some species, but the lists, regardless of age, provide some starting point in this difficult-to-interpret area of water quality and animal health.

Water quality standards listing are being changed from a simple listing of concentrations as appear below to TMDL's or Total Maximum Daily Load. These present a dose risk more accurately and prompt the interpreter to also consider the amount of a specific element acquired from other sources, namely the feed. Contact your reference laboratory regarding tests that are recommended and available for assistance with interpretation.

Table 1 Recommended Limits of Concentration of Some Potentially Toxic Substances in Drinking Water For Livestock and Poultry

	Safe Upper Limit of Concentrations (mg/L)		
Substance	EPA[1] (for humans)	NAS[2]	CAST[3]
Arsenic	0.05	0.2	0.5
Barium	1.0	N.E.[4]	
Cadmium	0.01	0.05	0.5
Chloride	250		
Chromium	0.05	1.0	5.0
Cobalt		1.0	1.0
Copper	1.0	2.0	0.5
Fluoride	2.0	2.0	3.0
Iron	0.3	N.E.	No Limit[5]
Lead	0.05	0.1	0.1
Manganese	0.05	N.E.	No Limit
Mercury	0.002	0.01	0.01
Molybdenum		N.E.	No Limit
Nickel		1.0	
Nitrate-N	10.0	100.0	300.0
Nitrite-N		10.0	10.0
Sulfate	250		
Vanadium		0.1	1.0
Zinc	5.0	25.0	25.0
pH	6.5-8.5		

[1] US Environmental Protection Agency, CFR 40 (143) Appendix V p 187 and 40 (265), Appendix V, p 621, 1986.

[2] recommended by National Academy of Sciences publication Nutrients and Toxic Substances in Water for Livestock and Poultry, 1974.

[3] recommended by the Council for Agricultural Science and Technology, Report No. 26, Quality of Water for Livestock, April 19, 1974.

[4] N.E. = Not Established

[5] no limit: experimental data available are not sufficient to make definite recommendations

Table 2   National Academy of Sciences Guide for the Use of Saline Waters in Livestock

Total Soluble Salts (mg/L)	COMMENTS
0-1,000	These waters have a relatively low level of salinity and should present no serious burden to livestock.
1,000-2,999	These waters should be satisfactory for all classes of livestock. They may cause temporary, mild diarrhea in livestock not accustomed to them, but should not affect their health or performance.
3,000-4,999	These waters should be satisfactory for livestock, although they might possibly cause temporary diarrhea or be refused at first by animals not accustomed to them
5,000-6,999	These waters can be used with reasonable safety for dairy and beef cattle, sheep, horses and swine. It may be well to avoid their use in lactating animals or those approaching the later stages of pregnancy.
7,000-10,000	These waters are unfit for swine but swine may subsist on them for long periods of time under conditions of low stress.
>10,000	The risks with these highly saline waters are so great that they cannot be recommended for use under any conditions.

Table 3   Tests for Nuisance Water (Manel, OhSU Extension, 1989)

	Appearance	Test
Stained fixtures and clothes	red or brown	iron
	reddish-brown slime	iron bacteria
	black	manganese
	green or blue	copper
Off-color	cloudy	turbidity
	black	hydrogen sulfide, manganese
	brown or yellow	iron, tannic acid
Unusual taste and color	rotten egg	hydrogen sulfide
	metallic	pH, corrosive index, iron, zinc, copper, lead
	salty	total dissolved solids, chloride
	septic, musty, earthy	total coliform bacteria, methane
	alkali	pH, total dissolved solids
	gasoline or oil	hydrocarbon scan
	soapy	surfactants
Corrosive water	deposits, pitting	corrosion index, pH, copper, lead