WHAT CAN WE DO ABOUT WATER QUALITY?[a]

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TAKE HOME MESSAGES

1. Abundant, high quality drinking water is the most important essential nutrient for dairy cattle. If water nutrition [quality (and) or quantity] is a problem then dairy nutritionists have big problems delivering services and expertise to their clients, and dairy farmers and their cattle have big problems too!

2. Is water nutrition and quality a major bottleneck to maximum health and performance? A major challenge is that most dairy nutritionists and farmers rarely know or understand the two major considerations for initial assessment of adequacy of water nutrition in any dairy farm.
   a. How much are cattle in particular management groups drinking?
   b. What is the quality of that water?

3. Based on one large (greater than 3,600 samples) survey of water quality in livestock farms, between 15 to 30% of total samples exceeded the upper level for calcium, sodium and sulfate as defined by Socha et al. (2003; Table 1). And, iron and manganese concentrations in individual samples exceeded desired levels in more than 40% of the total samples.

4. Based on analyses of over 200 'suspect' drinking water samples from across the U.S. in the last 10 years the most common water quality problems were high iron and high anion (sulfate and chloride) concentrations that are thought to affect cow health and performance (Beede, 2009).

5. The only way to know for sure if drinking water in a particular dairy farm has excess concentrations of iron or anions (sulfate + chloride; greater than 500 ppm) is to have water samples analyzed periodically by a reputable laboratory.

6. Procedures for sampling and a few certified laboratories are listed at: http://www.msu.edu/~beede/; click on Extension and then "Taking a Water Sample" (Table 2).

7. Water treatment methods are available to remove iron, sulfate and chloride: chlorination with filtration; ion exchange; ozonation; reverse osmosis; and/or, oxidizing filters are appropriate although costs vary widely (Table 3).

8. If water quality problems are identified then the challenge is to either find an alternate water source (e.g., drill a new well or hook into another source) or employ some sort of effective water treatment system. Water treatment to oxidize and

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[a]Adapted from an article in Proc. of TriState Dairy Nutrition Conference, April 2012, Ft. Wayne, IN.

remove (mechanical filtration) iron need not be very expensive in small- to medium-sized herds. Hydrogen peroxide or chlorination treatment can be effective to oxidize ferrous iron and manganese before filtration. In larger herds more sophisticated (but more expensive) systems may be preferred. Table 4 lists some questions and recommendations to address with vendors of potential water treatment systems.

9. A key point is to be sure the vendors understand how much water will need to be treated ---- 50 gallons/ cow per day of drinking water is a reasonable estimate to cover the high and low points in the daily routine. If the treated water is used from other purposes in the dairy this must be factored into daily water needs.

10. When water quality *per se* is not an issue, the most common water nutrition problems in most dairies are not providing enough watering stations, enough space at watering stations, and (or) water receptacles that do not fill quickly enough while animals are drinking, and thus, not enough uninhibited drinking opportunities for each cow during her normal daily routine where she lives and is milked.

11. Often lack of adequate water supply is related to over-stocking in management group-housing areas, and lack of enough time and space allocation for every cow in the group whether in free stalls barns or loose housing.

12. Doubtless, current and future dairy farmers will want to improve management and efficiency of use of potable water by carefully using and conserving as much available clean water as possible for their cattle. The future viability of dairy production systems will depend upon much more efficient use of water to maximize cattle performance and health, while simultaneously optimizing on-farm use (from irrigation for feed production, for drinking water, through recycling and conservation) to reduce each farm's water footprint (Beede, 2012).

Table 1. General guidelines for assessing drinking water quality for humans and livestock.

Analyte	Maximum Contaminant Level[a]	Upper Levels Livestock[b]	Maximum Upper Levels[c]	Expected[d]	Possible Cattle Problems[e]
Aluminum	(0.05 – 0.2)[f]	5.0	10.0		
Arsenic	0.01	0.2	0.2	< 0.05	> 0.20
Barium	2.0	1.0	1.0	< 1.0	> 10 (health)
Bicarbonate		1,000	1,000		
Boron		5.0	30.0		
Cadmium	0.005	0.01	0.05	< 0.01	> 0.05
Calcium		100	200	< 43	> 500
Chloride	(250)	100	300	< 200	
Chlorine (Cl_2)	4.0[g]				
Chromium	0.1	0.1	1.0	< 0.05	

Copper	1.3 (1.0)	0.2	0.5	< 0.6	> 0.6 to 1.0
Fluoride	4.0 (2.0)	2.0	2.0	< 1.2	> 2.4 (mottling)
Hydrogen sulfide[h]				< 2	> 0.1 (taste)
Iron	(0.3)	0.2	0.4	< 0.3	> 0.30 (taste, veal)
Lead	0.015	0.05	0.1	< 0.05	> 0.10
Magnesium		50	100	< 29	> 125
Manganese	(0.05)	0.05	0.5	< 0.05	> 0.05 (taste)
Mercury	0.002	0.01	0.01	< 0.005	> 0.01
Molybdenum		0.03	0.06	< 0.068	
Nickel		0.25	1.0		
Nitrate	44	89	100	< 44	
pH	6.5 to 8.5 (6.5 – 8.5)	6.0 to 8.5	8.5	< 6.8 – 7.5	< 5.1 to > 9.0[i]
Phosphorus		0.7	0.7	< 1.0	
Potassium		20	20	< 20	
Selenium	0.05	0.05	0.1		
Silica				< 10	
Silver	(0.1)	0.05	0.05		
Sodium		50	300	< 3	> 20 (veal calves)
Sulfate	(250)	50	300	< 250	> 2,000
Total bacteria (cells/100 ml)		1,000	1,000	< 200	> 1,000,000
Total dissolved solids	(500)	960	3,000	< 500	> 3,000
Total hardness				< 180	
Vanadium		0.1	0.1		
Zinc	(5.0)	5.0	25.0	< 5	> 25

[a]Values are parts per million (ppm; which is equal to mg/L) unless otherwise indicated. Adapted from US Environmental Protection Agency (EPA, 2009) as the National Primary Drinking Water Regulations (EPA-regulated concentrations for humans and(or) Treatment Technique action level to require treatment to remove contaminant).

[b]Adapted from Socha et al. (2003) as composite values from several published sources for livestock.

[c]Adapted from Socha et al. (2003) the Upper Maximum Levels are concentrations above which problems could occur in livestock.

[d]Adapted from Adams and Sharpe (1995) based primarily on criteria for water fit for human consumption.

[e]Adapted from Adams and Sharpe (1995) based primarily on research literature and field experiences of the authors.

[f]Values in parenthesis are EPA National Secondary Drinking Water Regulations non-enforceable guideline concentrations for humans that may cause cosmetic effects (e.g., tooth or skin discoloration) or aesthetic effects (e.g., taste, odor, or color) in drinking water.

[g]Maximum Residual Disinfectant Level (MRDL) allowed in drinking water.

[h]Hydrogen sulfide is very volatile; concentrations must be determined on-site with appropriate methodology or values are not accurate. Also, sulfate is converted (reduced) to hydrogen sulfide in warmer waters.

[i]Values for cows listed in table; for veal calves 6.0 to 6.4 is recommended.

Table 2. Whatever the most appropriate treatment method, here are some recommendations on how to proceed to a solution if one suspects drinking water quality problems for dairy cattle.

1. Take a water sample. For guidelines on how to take drinking water samples and standard water analysis refer to: http://www.msu.edu/~beede/, click on Extension and then “Taking a Water Sample”.
2. Have a standard laboratory analysis for “livestock water” done by a certified laboratory.
3. Iron analysis always should be for total recoverable iron ---- after the sample has been acidified at the laboratory. Some laboratories may do a direct analysis (without acidification), which detects only a portion of the total recoverable iron; this is not completely useful information. Contact the laboratory to verify analysis of total recoverable iron before sampling and sending in the sample(s).
4. If the laboratory reports iron concentrations greater than 0.3 ppm or either sulfate or chloride concentrations greater than 250 - 500 ppm, take two more samples and send each to a different certified laboratory for analysis. This may seem like over-kill at the time, but water treatment systems can be a major investment, so it is very important to know absolutely for sure that concentration(s) of a particular analyte(s) is (are) in excess.
5. When collecting samples for laboratory testing, take, label and seal from air (screw-top bottles) two additional samples to save as back-ups and a historical record.
6. If one or more of the analytes in question is in excess of recommendations (e.g., Table 1), contact at least two or three water treatment vendors and ask about their treatment methods, and if and how they remove iron, sulfate, and/or chloride from water. Local or regional companies typically are best to ensure good customer service and maintenance after installation.
7. After a treatment system is installed, take treated water samples at least every month, label and tightly seal them (to stop possible evaporation), and store in a cool place for historical purposes. At least every third month send a sample to a certified laboratory for a standard “livestock” analysis, including iron, sulfate and chloride. Is the water-treatment system removing the constituents as guaranteed?

Table 3. Guide for treatment to remove unwanted constituents (anti-quality factors) from drinking water[a].

	Treatment Method[b]									
Constituent	ACF	AS	C	D	C-A E	MF	RO	UR	O	OF
Chlorine	X[c]									
Coliform bacteria, other microorganisms			X					X	X	
Color	X		X		X				X	
Hydrogen sulfide		X	X[d]						X[d]	X
Inorganics [e.g., some macromineral elements and heavy metals (e.g., lead, mercury, arsenic, cadmium, barium)]	X[e]			X	X[f]		X			
Iron/ manganese –dissolved			X[d]		X[g]				X	X
Iron/ manganese – insoluble						X				X
Nitrate				X	X[h]		X			
Odor and off-taste	X	X	X	X	X		X		X	
Some pesticides	X[i]						X[i]			
Radium				X	X		X			
Radon gas	X	X								
Salt				X			X			
Sand, silt, clay (turbidity)						X				
Volatile organic chemicals	X	X		X[j]			X			
Water Hardness					X					

[a]Adapted from www.midwestlabs.com.
[b]ACF = activated carbon filter; AS = air stripping; C = chlorination; D = distillation; C-A E = cation or anion exchange; MF = mechanical filtration; RO = reverse osmosis; UR = ultraviolet radiation; O = ozonation; and, OF = oxidizing filters.
[c]Within the table “X” indicates method that can be used to remove part or all of the constituent present.
[d]When followed by mechanical filtration or an activated carbon filter.
[e]Mercury only.
[f]Barium only.
[g]When present in low concentrations.
[h]Anion exchange units will remove nitrate; but, cation exchange units will not.
[i]For information on ways to treat water for specific pesticides, obtain local pesticide health advisory summaries.
[j]Works for volatile organic chemicals with high boiling points.

Table 4. Questions to ask prospective water-treatment companies.

1. Do you know how much water this particular dairy uses? Obviously, many times the company representatives will not know the answer, but dairy advisors and producers must know the answer to this question! Most dairies use a lot of water; often much more than companies are accustomed to treating at a single location. What is the treatment rate (volume/time)? Can their system supply enough treated water for all functions on the dairy simultaneously during peak usage (e.g., during milking, parlor cleanup and when cows are drinking)? Will a sizable investment in large long-term storage of treated water be necessary to ensure ample supply during peak usages?

2. Does each company guarantee that their system will remove iron, or sulfate and chloride, depending on the quality problem? Are they willing to provide a written guarantee that their system will remove these unwanted constituents throughout the specified life of the treatment system?

3. How long will each system last and how much maintenance is required? Who does the maintenance? Do they have "service-after-the-sale" and what does that entail? Do they have or can they provide a maintenance contract?

4. Which other anti-quality factors (besides iron, sulfate, and chloride) might their water treatment systems remove? There may be none. But, there also may be additional benefits to one treatment system over another if other constituents are in excess in water samples.

5. What chemicals (e.g., other mineral elements) does their particular treatment method add to the water and what will be their concentrations? There may be nothing added. But, in other cases something may be added, such as significant chlorine addition during chlorination to oxidize ferrous iron.

6. What do the systems cost — installation, and monthly maintenance and operating costs?

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