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Livestock Water Quality*

The purpose of this report is to discuss what is involved in livestock water quality and how one goes about getting an analysis that will help in determining this quality, and to assist in the interpretation of such an analysis.

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A successful livestock enterprise requires a good water supply, both in terms of quantity and quality. While shortage is obvious to the stockowner, he sometimes needs the help of a laboratory in evaluating the quality of a supply. The purpose of this report is to discuss what is involved in livestock water quality and how one goes about getting an analysis that will help in determining this quality, and to assist in the interpretation of such an analysis.

Water Consumption

Before beginning the discussion of quality, it may be well to consider briefly how much water animals consume. This information might be of some assistance in planning livestock water systems. Water consumption varies over a rather wide range, depending upon a number of physiological and environmental conditions, so that estimates are subject to considerable error. These conditions include the kind and size of animal, whether or not it is lactating, how active it is, the kind and amount of diet it consumes, climatic conditions, and other factors. The usual ranges for water consumption of adult animals has been summarized in Water Quality Criteria, published by the FWPCA in 1968, as follows:

Water Consumption gallons per day	
Beef Cattle	7-12 per head
Dairy Cattle	10-16 per head
Horses	8-12 per head
Swine	3-5 per head
Sheep and Goats	1-4 per head
Chickens	8-10 per 100 birds
Turkeys	10-15 per 100 birds

Factors in Water Quality

Most ground or surface waters are satisfactory for livestock. Some are not, however, resulting in poor performance or even death in animals confined to them.

What makes waters unsatisfactory for livestock? Very often it is excessive salinity--too high a concentration of dissolved salts of various kinds. Of lesser importance is nitrate content, and on rare occasions alkalinity or other factors may become involved.

Salinity. Water is a very good solvent, and all natural waters contain dissolved substances. Most of these are inorganic salts, the calcium, magnesium and sodium chlorides, sulfates, and bicarbonates predominating. Occasionally these are present in such high concentrations that they cause harmful osmotic effects resulting in poor performance, illness or even death in animals confined to them. The various salts have slightly different effects. but these differences are of no practical significance. Thus, while sulfates are laxative and may cause some diarrhea, their damage to the animal seems no greater than that of chlorides, and magnesium salts seem no more of a problem than calcium or sodium salts. Further, the effects of the various salts seem additive, which means that a mixture of them seems to cause the same degree of harm that a single salt does at the same total concentration.

A number of observations have been made relative to saline livestock waters, some of them verified by experimental findings. At high salt concentrations that are somewhat less than toxic, increasing salinity may actually cause an increased water consumption, even when the animals refuse to drink for a short period of time at first. On the other hand, at very high salinities animals may refuse to drink for many days, followed by a period where they drink a large amount at one time and become suddenly sick or die. Older animals are more resistant to harm from salinity than are the young. Anything causing an increase in water consumption such as lactation, high air temperatures, or exertion also increases the danger of harm from saline waters. Animals seem to have the ability to adapt to saline water quite well, but abrupt changes from waters of low to waters of high salts concentrations may cause harm while gradual changes do not. Whenever an alternate source is available to them, even every two or three days, livestock will avoid excessively saline waters. And finally, when animals suffering from the effects of saline water are allowed water from a source of low salts content they make a rapid and complete recovery.

Salt is sometimes used in feeds to regulate their intake. Special care to supply a drinking water of low salt content should be taken in these instances.

Nitrates. The poisoning of cattle by nitrates was first observed prior to 1900, and there have been many cases since then. As a rule, it results from their eating forages of high nitrate content. The nitrates are not very toxic themselves, but in the rumen the bacteria reduce them to nitrites which then get into the blood stream. There the nitrites convert the red pigment, hemoglobin, which is responsible for carrying oxygen from the lungs to the tissues, to a dark brown pigment, methemoglobin, which will not carry oxygen. When this conversion is about 50% complete the animal shows signs of distress suggesting a shortage of breath, and at 80% or more conversion the animal usually dies from suffocation.

Non-ruminants may convert small amounts of ingested nitrate to nitrite in their intestines, but the amount so converted is not harmful. Nitrates in the diet may interfere in the conversion of carotene to vitamin A under some circumstances, but an impressive amount of experimental data shows this to be of no practical significance. Further, the experimental evidence suggests that chronic nitrate poisoning does not occur in livestock and that the young are no more susceptible to the acute type than are older animals. Nitrates are occasionally found at toxic levels in water. Nitrites are also found in water on many occasions, but not at levels dangerous to livestock. As a rule, reports of water analyses include nitrites with the nitrates.

Sulfates. Experimental data on effects of high sulfate in livestock water are limited. Both sodium and magnesium sulfates are well known laxatives. For humans, a sulfate content of over 250-600 ppm may cause a temporary laxative effect while over 700 ppm may cause a consistent laxative effect. South Dakota work with swine showed no harmful effect in rate or efficiency of gain or fecal consistency where water contained up to 3000 ppm sulfates for gestating or lactating sows or their litters up to 28 days of age.

In weanling pigs, 3,000 ppm added sulfates in the water did cause some scouring and less firm fecal condition than in pigs receiving water without added sulfates, but rate and efficiency of gain was essentially the same.

From the recommendations for human consumption and the swine work quoted, it would appear that sulfates should seldom be a problem in livestock water if rations are adequately formulated. Copper is one of the most likely deficiencies that might be a problem with high sulfate levels in the drinking water.

Alkalinity. Many and perhaps most waters are alkaline. This is fortunate since if they were acid they would corrode pipes and plumbing. Only in a very few instances have they been found too alkaline for livestock. Alkalinity is expressed either as pH or as titratable alkalinity in the form of bicarbonates and carbonates. A pH of 7.0 is neutral, below that is acid, and above that is alkaline. Most of our waters have pH values between 7.0 and 8.0, which means that they are very mildly alkaline, and this further means that they contain only bicarbonates and no carbonates. As the pH goes up, the waters become more alkaline, and at values of around 10, waters are very highly alkaline and contain carbonates. Most waters have alkalinities of less than 500 parts per million, and these are not harmful.

Excessive alkalinity in water can cause physiological and digestive upset in livestock. The level of alkalinity at which it begins to become troublesome and its precise effects have not been thoroughly studied. Therefore, the establishment of guidelines to the suitability of alkaline waters for livestock is difficult.

Bacterial Contamination. Bacterial contamination of water for livestock does not usually cause apparent production problems. Most water consumed has varying degrees of contamination from dirty waterers, or from being impounded in small depressions, tracks, dugouts or ponds. However, producers should be concerned when the farm water supply system becomes contaminated by bacteria. The source of contamination should be determined and eliminated, particularly if there is opportunity for humans to consume water from the system.

While we have no meaningful laboratory methods to measure it, filth in livestock waters must obviously be avoided. A reasonable effort should always be made to provide animals a clean and sanitary water supply.

Other Factors. On rare occasions, natural waters may contain or become contaminated with certain toxic elements such as arsenic, mercury, selenium, cadmium, etc., or with radioactive substances. While

these may harm animals that drink these waters, our major concern is that they do not accumulate in the meat, milk or eggs making them unsafe for human consumption. Analyses need to be made for these when there is good reason to suspect their presence at excessive levels.

Persistent organic pesticides have been found as contaminants in most surface waters. However, their concentration is so small in these waters (because of their low solubility in water) that they have been found to be no problem to livestock.

Occasionally, heavy algal growths occur in stagnant or slowflowing bodies of water. A few species of these can, under some circumstances, be toxic. We have no tests for these toxins, and at present we can only recommend avoiding using any stagnant source of water for livestock.

Interpreting A Water Analysis

Salinity. A guide to the use of saline waters for livestock is presented in *Table I*. Considerable judgment should be exercised in using this guide. It has reasonable margins of safety built into it, and adherence to it should prevent deaths or economic losses with rare exceptions.

Nitrates. Comments relating to the use of waters containing nitrates are shown in *Table II*. In using this table, it is important to take into account the way in which the nitrate content is expressed on the report of analysis. Some express it in parts per million (ppm) of nitrate nitrogen (NO_3N). Others express it as parts per million of nitrate (NO_3) or of sodium nitrate ($NaNO_3$). The relationship between these various methods of expressing it are as follows:

1 ppm of nitrate nitrogen = 4.43 ppm of nitrate or 6.07 ppm of sodium nitrate. With livestock waters having a total dissolved solids content of less than 1,000 ppm or a conductivity of less than 1,400 micromhos/cm at 25°C, there is no need to make a nitrate determination.

Alkalinity. Waters with alkalinities of less than 1,000 ppm are considered satisfactory for all classes of livestock and poultry. Above that concentration they are probably unsatisfactory, although for adults they may do little harm at concentrations less than about 2,500 ppm unless carbonates are present in excess over bicarbonates.

Miscellaneous

a. Waters may in some instances supply a portion or even all of an animal's requirement for certain minerals. As a general rule, however, their contribution with respect to minerals is of no practical significance.
b. Hard waters have often been suggested as a cause of urinary calculi (kidney stones or water belly). Experimental evidence shows that this is not true, however, and hardness might, in fact, actually contribute to the prevention of certain types of calculi formation.

c. The results of water analyses have been expressed in a number of ways. Some of these ways and their interrelation are shown below:

   One *part* per million (ppm) means one pound per million pounds of water. For all practical purposes, *milligrams per liter* (mg/l), *milligrams per kilogram* (mg/kg), and *parts per million* (ppm) mean the same thing. One *grain per gallon* is equivalent to about 17 *parts per million*.

d. Highly saline waters are often mistakenly referred to as "alkali" waters.They may or may not be highly alkaline, and usually are not. Sometimes they are referred to as hard waters. If most of their salinity is in the form of sodium salts, however, they may actually be soft waters, as hardness is due largely to calcium and magnesium.

Table I. A Guide to the Use of Saline Water for Livestock and Poultry.

Total dissolved solids (parts/million)*	**Comments**
Less than 1,000	From the standpoint of its dissolved solids, this water should be excellent for all classes of livestock.
1,000 to 2,999	This water should be satisfactory for all classes of livestock. Those waters approaching the upper limit may cause some watery droppings in poultry, but they should not adversely affect the health or production of the birds.
3,000 to 4,999	This water should be satisfactory for livestock. If not accustomed to it they may refuse to drink it for a few days, but they will adapt to it in time. If sulfate salts predominate, they may show temporary diarrhea, but this should not harm them. It is, however, a poor to unsatisfactory water for poultry. It may cause watery feces, and particularly near the upper limit, it may cause increased mortality and decreased growth, especially in turkey poults.
5,000 to 6,999	This water can be used for livestock except those that are pregnant or lactating, without seriously affecting their health or productivity. It may have some laxative effects and be refused by the animals until they become accustomed to it. It is unsatisfactory for poultry.
7,000 to 10,000	This is a poor livestock water that should not be used for poultry or swine. It can be used for older, low-producing ruminants or horses that are not pregnant or lactating with reasonable safety.
Over 10.000	This water is considered unsatisfactory for all classes of livestock.

* Electrical conductivity expressed in micromhos per centimeter at 25°C can be substituted for total dissolved solids without introducing a great error in interpretation.

Table II. A Guide to the Use of Waters Containing Nitrate for Livestock and Poultry.

Nitrate content* (ppm nitrate nitrogen)	Comments
Less than 100**	Experimental evidence to date indicates that this water should not harm livestock or poultry.
100 to 300	This water should not by itself harm livestock or poultry. When feeds contain nitrates, this water could add greatly to the nitrate intake to make it dangerous. This could be of some concern in the case of cattle or sheep during drought years and especially with waters containing levels of nitrates that approach the upper limits.
Over 300***	This water could cause typical nitrate poisoning in cattle and sheep, and its use for these animals is not recommended. Because this level of nitrate contributes significantly to salinity and also because experimental work with levels of nitrate nitrogen in excess of this are meager, the use of this water for swine, horses or poultry should also be avoided.

*Includes nitrite nitrogen.
** Less than 443 ppm of nitrate or less than 607 ppm of sodium nitrate.
*** Over 1,329 ppm of nitrate or over 1,821 ppm of sodium nitrate.

**Adapted from GPE-1401, authored by O.E. Olson and D.G. Fox, South Dakota State University.*

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