TECHNICAL REPORT

by **Groupe Céres** and **Nutrition Athéna**

WATER QUALITY IN SWINE PRODUCTION

Dan Bussières, B.Sc., agr., Jean-Philippe Martineau, M.Sc., agr. & Marc-Olivier Laprise, B.Sc., agr.
Swine Nutrition Specialists for Nutrition Athéna inc.

WATER QUALITY

Water quality is an important aspect in swine production and it becomes a problem, when its contamination level is likely to cause health and/or productivity problems for pigs. There are three main criteria that are used to assess the quality of water which are the physical, chemical and microbiological characteristics. There are guides for interpreting water analysis results, but the standards are difficult to determine due to the different factors that influence the response of a group of animals when they have access to the same source of water. Caution should be exercised when interpreting water test results.

PHYSICAL CHARACTERISTICS

Standards for the physical properties of water are more often related to aesthetics rather than to health or safety, but there are some physical criteria that can still reflect water quality. The color itself isn't much of an issue, but it can indicate some level of contamination if the water doesn't look quite clear. Turbidity, which results from colloidal solids suspended as particles in the water, may indicate that the water is not safe to drink, especially if it is caused by humans, animals or industrial waste material. The smell and taste of the water means that there is some level of contamination, as pure water has no taste or smell. Finally, water temperature can amplify or mask flavors and odors and can accelerate the rate at which certain unwanted chemical reactions can occur.

CHEMICAL CHARACTERISTICS

In terms of chemical standards, there are several tests and analyzes that can be done to determine the chemical properties of water. On the other hand, in the process of evaluating the quality of water in a farm, it is necessary to start with the standard analyzes (pH, hardness, total dissolved solids, alkalinity, iron, sodium and sulphates). Other basic tests like nitrates, nitrites, calcium and magnesium can be done routinely. If the results seem to be satisfactory compared to the standards, there is no need for further testing. As mentioned earlier, it is not easy to establish definitive standards for the various components that can influence water quality. The following is a table of standards drawn from a review of several published tables.

Table 1. Acceptable standards for water analysis in mg/l (ppm)

	Objectives	Maximum
Total dissolved solids	<1000	7000
Toughness	<110	180
Alkalinity	<500	1000
pH	6.5-8.5	-
Sulphate	<200	1000
Sodium	<100	500
Calcium	<250	1000
Magnesium	<50	150
Iron	<0.3	0.5
Chlorides	<200	500
Nitrites	<4	4
Nitrates	<100	300
Manganese	<0.03	0.6
Potassium	<300	300

*These standards should not be considered definitive.

See next page

TOTAL DISSOLVED SOLIDS

Total Dissolved Solids (TDS) is the sum of the dissolved inorganic matter in a volume of water. The mineral salts most likely to be found in water with a high TDS level are calcium, magnesium and sodium in the form of bicarbonate, chloride or sulphate (Thulin and Brumm, 1991). At levels below 1000 ppm the water is considered safe. If the level exceeds 7000 ppm, this water should not be served to pigs. Between these two values we find ourselves in a gray area. Some have observed significant economic losses with levels below 7000 ppm, while others have found little drawbacks at such levels. Some of the observed variation is likely due to the wide variety of minerals that can contribute to increasing the amount of total dissolved solids in the water and the variability in the physiological effects that different minerals can have on pigs. This highlights the importance of further testing if the STD level is above 1000 ppm to determine if the minerals present may pose a health risk to the animal. Table 2 can still be used as a guide to interpret the analysis results. Conductivity (the ability of water to conduct electrical current) is used in some cases to estimate STDs by multiplying the obtained conductivity value by a constant. However, the value of this constant differs depending on the type of water, but a common conversion factor of 1.55 can be used.

Table 2. Water quality assessment for pigs based on total dissolved solids (Adapted from N.R.C. 1974)

Total dissolved solids (ppm)	Ranking	Comments
<1000	Very good	No risk for pigs
1000-2000	Satisfying	Slight diarrhea for unaccustomed pigs
3000-5000	Satisfying	May cause temporary refusal of water consumption
5000-7000	Acceptable	Avoid higher levels for breeding animals
7000 et +	Unacceptable	Very risky for breeding animals and for pigs under stress

Hardness

Water hardness is associated with the presence of calcium and magnesium salts in water. Water is considered soft if the hardness is less than 60 ppm, hard between 120 and 180 ppm, and very hard at levels above 180 ppm (Durfor and Becker, 1964). Water hardness is not serious or harmful to pigs. On the other hand, salt deposits can interfere with the proper functioning of the heating elements, thus reducing the heating capacity. They can also affect the flow rates of sucker-type drinkers and thus predispose to hypo-drinking conditions. Hard water also loses its ability to lather some soaps, which can affect the effectiveness of some detergents and disinfectants. Finally, the effectiveness of some antibiotics, such as tetracyclines, is reduced in the presence of hard water.

pH

In general, pH is not an issue in terms of water quality, as the vast majority of samples will have a pH between 6.5 and 8.5 (Fraser *et al.*, 1993). However, a very high pH renders chlorination ineffective and a low pH can cause precipitation of some antibacterial agents when administered via water. Sulphonamides are particularly at risk because they can lead to contamination of carcasses, if after precipitation, the drug is still present in the lines after the treatment has been completed. Water acidification can sometimes improve growth performance, especially in piglets.

Sulfates

Sulfates (SO_4) are the primary source of chemical problems with water quality. The two main compounds are magnesium sulphate (Epsom salt) and sodium sulphate (Glauber salt) which have laxative properties. A report from Western Canada indicated that 25% of wells in that region had very high sulphate levels above 1000 ppm (McLeese *et al.*, 1991). Pigs, especially weaned piglets, are sensitive to high sulphate levels. The problem usually manifests itself in the form of more or less severe diarrhea. Most of the time, the pig is able to adapt to high levels of sulfate in water, but if dehydration is too severe before adaptation, performance can be affected. Weaned piglets appear to be more sensitive due to their low water intake before weaning. The acceptable standard for sulphates is around 1000 ppm. Much higher levels may also be harmless to the animal in some cases, but in the presence of other stressors, levels higher or even lower than 1000 ppm can cause productivity losses and health problems. High sulfate levels are also sometimes characterized by a rotten egg smell, but this is not necessarily an indicator of poor water quality.

Alkalinity

Alkalinity is a measure of the ability of water to absorb hydrogen ions which influence the acidity of water. It therefore represents the power of water to buffer changes in pH. It is not of great importance, except in cases where it is associated with high pH.

Sodium

Sodium is often confused with salt. Salt is indeed sodium chloride (NaCl). Sodium, on the other hand, is a good indicator of the salinity level of water. A high sodium level will increase the animal's need for water so that it can detoxify its system. If water supply is limited or if the level of sodium is such that the animal only worsens its situation by consuming more water, the problem can be partially or totally corrected through feeding by reducing the sodium level in the water. However, it is

See next page

important to ensure to maintain safety margins to compensate for variations. Signs of sodium toxicity manifest as problems with the nervous system that can lead to paralysis and even death. Sodium in the form of sodium sulfate has laxative effects and can cause diarrhea problems. Sodium levels should be below 100 ppm, but levels up to 500 ppm can be tolerated and controlled through diet.

Iron

Iron, as such, has no direct impact on animal performance and health. On the other hand, high levels of iron can be problematic in terms of the appearance and odor of the water. Normally the iron present in well water is in its soluble form (Fe++), but in the presence of oxygen it oxidizes and takes on a much less soluble form (Fe+++). This reaction gives the water a rusty color. The oxidation of ferrous iron to ferric iron is also favored by a pH above 7.5 and by the presence of copper, which acts as a catalyst by accelerating the oxidation reactions. The major consequence of this process is the precipitation of iron when water is pumped from the well, which can lead to blocked drinking systems and lines.

Iron also promotes the growth of certain bacteria if the well has been previously contaminated. These bacteria, when they die and decompose, can give the water a foul odor and in severe cases, cause the lines and even the well to be completely blocked. Direct chlorination of the well and/or lines can help control the problem.

Magnesium

Magnesium is mostly found in the form of magnesium sulphate (Epsom salt) and it is undesirable because it can promote the onset of diarrhea. Typical water tests do not determine Epsom salt levels, but rather the individual amounts of magnesium and sulfate present. Magnesium is also used with calcium to determine water hardness.

Manganese

As for iron, manganese can be oxidized in the presence of oxygen and give water a rusty color. This reaction also promotes precipitation of manganese which can lead to blockage of water systems. Oxidation is favored by a pH above 9.5, which is rather rare. Thus, the oxidation of manganese is less important than that of iron.

Chloride

In general, little chloride is found in well water. However, certain local conditions can favor the accumulation of chloride in the water. If chlorides, in the form of sodium chloride, are high, the salt level in the ration can be adjusted to work around the problem, but this should be done carefully with the help of a nutrition advisor.

Nitrates and nitrites

Many people give great importance to nitrates and nitrites. Nitrates are formed by the decomposition of organic matter. In humans, they can cause serious problems. In animals, ruminants are more sensitive to nitrates than pigs because rumen bacteria convert nitrates to nitrites which are a much more dangerous form. The major concern about nitrites is that they reduce the blood's ability to carry oxygen by reducing hemoglobin to methemoglobin. Nitrates and nitrites have also been identified as having the potential to reduce the availability of vitamin A. The levels at which nitrates and nitrites can cause problems are not well defined, but in general the amounts found in water are well below the problematic doses for pigs. Table 3 summarizes the results of an experiment by Garrison et al. (1966) and shows that nitrate and nitrite levels must be high enough to cause problems. Nitrates and nitrites still require some attention, but they are mainly a human risk.

Table 3. Effect of nitrates and nitrites on pigs

	Nitrates (ppm)			
	0	750	1 500	3 000
ADG. (g/d)	730	748	649	630
TCA	3.56	3.59	3.58	3.82
Vit. A serum (ug/100ml)	39.5	47.1	40.2	22.2
Vit. A liver (ug/g)	21.8	11.8	11.8	5.8

	Nitrites (ppm)			
	0	200	400	800
ADG. (g/d)	730	549	576	499
TCA	3.53	3.43	3.71	3.53
Vit. A serum (ug/100ml)	21.3	21.3	21.3	17.7
Vit. A liver (ug/g)	16.2	16.2	9.6	8.7

Source : Garrison and al. (1966)

These are the main elements of interest concerning the water quality in terms of chemical properties. Other analyzes can also be carried out for other elements of lesser importance, but there is not much information on the subject.

MICROBIOLOGICAL CHARACTERISTICS

Microbiological quality is one of the first factors to consider when talking about water quality. Poor microbiological quality is a risk factor for several pathologies, especially digestive ones, whether in piglets, fattening pigs and breeding animals. The standards used to describe the microbiological quality of water are based on those for human health. Some claim that

See next page

pigs would be more sensitive to water of poor microbiological quality due to the fact that they consume larger volumes of water. However, care must be taken with any extrapolation of standards to another species. Table 4 presents the standards for various parameters of interest for the assessment of the microbiological quality of water:

Table 4. Main microbiological standards for water

Settings	Number/100 ml
Total coliforms	< 10
Faecal coliforms	0
Faecal streptococcus	0

Source : G.P Martineau Pig Breeding Diseases

U.S. environmental protection standards consider that 5000 coliforms per 100 ml of water should be exceeded before considering water unfit for consumption (EPA 19730). There is a lot of room for interpretation of contamination standards. It should be understood that clean water is a very desirable factor, and it is best to take no chances, but that contamination at a certain level is not incompatible with good productivity. Table 5 shows the standards for interpreting the microbiological quality of drinking water for animals:

Table 5. Standards for interpreting the microbiological quality of drinking water

Coliforms per 100 ml	Totals	Comments
Less than 10		• This water is very clean; there is no reason to worry
From 10 to 100		• This water is slightly contaminated • The risk of problems is very low • It is necessary to redo an analysis and do a regular follow-up
From 100 to 1000		• This water is contaminated • Disinfection is necessary if the water is intended for piglets • To be followed on a regular basis
Over 1000		• This water is contaminated and treatment must absolutely be implemented. • A verification of its effectiveness must be done within two weeks

Source : G.P. Martineau Pig Breeding Diseases

The general microbiological standards are established in relation to bacteria, coliforms including *Escherichia coli* and enterococci including *Streptococcus faecalis*. Other contaminants of bacterial and viral origin may be present in the water: *Salmonella spp*, *Vibrio cholera*, *Leptospira spp*. Protozoa and intestinal worm eggs can also be found.

Total coliforms should be interpreted as an indicator of microbial contamination of the water or as a mean of assessing the effectiveness of disinfection. At the level of wells, it indicates surface contamination, either of plant and/or animal origin. For their part, faecal coliforms indicate pollution of faecal origin, most often recent. This type of contamination is found more often in the lines than in the wells. Faecal streptococci signal contamination of animal origin (such as faecal coliforms) but, more often than not, older and therefore deeper in the case of wells.

Ensuring that the water has good microbiological quality is a prerequisite. The most important and probably least implemented intervention is regular disinfection and cleaning of water distribution systems.

There are different type of product and chemical compound that can be used for water line cleaning and disinfection. Chlorine is probably one of the most popular and easy to use products as it can be used in presence of animal. Others products are available and very efficient, but in order to be effective, these disinfections must ideally be done in the absence of animals or by blocking their access to water. It is also important to ensure that water lines are rinsed thoroughly after disinfection. Water wells or water pound can also be a source of contamination for the water, which make it important to look after those water source and take action if water is contaminated. As there are many products available on the market, it is important, it is important to make sure that you are dealing with competent people who are experts in the field.

To ensure reliable and representative test results, follow the laboratory's recommendations for sample collection. It is always recommended to let the water run for a while and to use sterile containers that have an expiration date and are provided by the laboratory. When taking a sample, it is important to clean the area where the sample is to be taken to avoid any contamination that could bias the analysis. It is also recommended to take a sample at the entrance and if possible, at the end of the line. In this way it is possible to identify whether the well or other water sources and/or the water lines are contaminated. The correct identification of the specimens and the method of shipment to the laboratory (temperature, time) are other factors to which special attention must be paid in order to obtain representative results.

In conclusions water remains a very important nutrient for your pigs. Do not underestimate the importance of its quality and the impact it can have on the pig's performance and health.