DEALING WITH WATER CONCERNS FOR PORK PRODUCTION

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INTRODUCTION

Water is a key input for profitable pork production. Pigs require water to perform various important body functions, including growth and production. Water is also an important factor that determines the amount of feed consumed by swine. To optimize pig performance, pigs should be supplied with adequate amounts of good quality water. Any factors that influence the supply or the quality of drinking water will certainly impact on pig performance. Equally important with respect to water is the need to know the factors that influence water consumption by swine. As an important resource, it is essential that water supply is carefully managed. This is particularly important because access to good quality water is becoming increasingly limited in many pork-producing areas. Furthermore, poor quality water will not only compromise pig performance but will also encourage excessive water usage, which in turn creates manure handling and disposal problems as a result of increased slurry volume. This review discusses water concerns that are routinely encountered on swine farms and highlights possible strategies that can be put in place to deal with such concerns.

THE NEED FOR WATER IN PIGS

Pigs require water for various important body functions such as body temperature regulation, nutrient digestion and absorption, and elimination of waste products of digestion and metabolism. Water is also a major component of secretions made by the pig such as milk and saliva. In general, the actual amount of water required by pigs is not known because of the difficulties involved in quantifying requirements. However, the amount of water required by pigs is mainly determined by the amount required to maintain the body water pool, which tends to remain constant at any one stage of growth (Thacker, 2001). Pigs lose body water through a number of avenues including respiration, evaporation, urination and feces. Although the amount lost through each of these avenues varies considerably, urination is a major route for water loss (NRC, 1998).

WATER CONSUMPTION BY DIFFERENT CLASSES OF PIGS

Water consumption by different classes of pigs has been discussed in details elsewhere (NRC 1998; Thacker, 2001) and therefore is only briefly covered in the current review. Estimates of water consumed by different classes of pigs are given in Table 1.
**Gestating Sows**

In addition to satisfying physiological needs, water consumption by gestating sows is also influenced by behavioral characteristics. Because, gestating sows are limit fed, they consume additional water so as to feel satiated. If individually housed, gestating sows may also experience some degree of boredom, which they often try to offset by excessive drinking. Despite these problems, gestating sows should be provided with water for ad libitum intake as this may play an important role in fulfilling welfare requirements of these pigs (Mroz et al., 1995).

**Lactating Sows**

Daily water consumption by lactating sows provided with free access to drinking water varies widely among individual sows. Consequently, it has been recommended that lactating sows should be allowed between 15 and 20 litters per day of drinking water, depending on size and milk production levels (NRC, 1988; Fraser et al., 1990). Adequate water intake is required for optimal milk production, which in turn impacts on litter performance. In addition to milk production levels, lactating sow water intake is influenced by dietary factors such as salt content. For instance in a study with lactating sows, Seynaeve et al. (1996) found that feeding a diet containing 0.4% salt over a 4-week lactation period, led to significantly more water consumption than those fed a low salt water containing 0.1% salt (13.9 vs. 12.4 litter). However, production parameters like milk composition, sow body weight loss during lactation and piglet performance were not affected by water intake levels. This observation suggests that any impact on litter performance as result of inadequate water intake by lactating sows is likely due to reduced milk yield as opposed to altered nutritional quality of milk. From practical pork production standpoint, reduced water consumption by sows is important as it relates to urine production and the associated environmental challenges.

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**Table 1. Estimated water consumption levels of different classes of pigs**

<table>
<thead>
<tr>
<th>Class of Pigs</th>
<th>Water Consumption (kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestating sows</td>
<td>11.5 – 20</td>
</tr>
<tr>
<td>Lactating sows</td>
<td>12 - 40</td>
</tr>
<tr>
<td>Suckling pigs</td>
<td>0 – 0.2</td>
</tr>
<tr>
<td>Weaned pigs</td>
<td>0.5 – 1.5</td>
</tr>
<tr>
<td>Growing finishing pigs</td>
<td></td>
</tr>
<tr>
<td>(fed ad libitum)</td>
<td>5 - 7.5</td>
</tr>
<tr>
<td>Growing finishing pigs (restricted feed)</td>
<td>6 - 9</td>
</tr>
</tbody>
</table>

*Source: Estimated from values NRC, 1998.*
**Suckling Pigs**
As discussed by Thacker (2001), water consumption by suckling pigs is critical for optimal performance and therefore it is important to ensure that they have access to good quality drinking water. Water consumption at this stage is closely related to milk consumption, effective environmental conditions in the creep area, and creep feed intake. High water intake may encourage creep feed consumption, but this may negatively impact on milk intake levels (Mroz et al., 1995; Thacker, 2001). In general, suckling pigs should be provided water for *ad libitum* intake. This is particularly critical if milk intake is limited, in which case water intake may help prevent dehydration and increase survival rate of piglets with low milk intake (Fraser et al., 1988).

**Weaned Pigs**
During the first few days following weaning, water intake is reduced as piglets learn to seek and drink water. This is undesirable as it might compromise the process of digestion and absorption thus leading to increased incidences of diarrhea (Stockill, 1990). However, because feed intake is also low soon after weaning, piglets tend to increase water intake so as to achieve the feeling of being satisfied (McLeese et al., 1992). Weaned pigs should be encouraged to drink because this is an important factor determining feed intake levels (Brooks et al., 1984).

**Growing-Finishing Pigs**
Water intake in growing finishing pigs is essential for lean muscle growth as lean meat is 72% water (Kober, 1993). The amount of water consumed per day by a growing finishing pig will depend largely on the feeding program. If pigs are allowed *ad libitum* feed intake their water consumption will be around 2.5 kg per kg of feed whereas pigs with restricted feed intake may consume up to 3.7 kg of water per kg of feed (NRC, 1998). The variation in water intake is most likely due to the feeling of satiation of the pigs as was stated previously for gestating sows. The water should therefore be available *ad libitum* for pigs given *ad libitum* access to feed. The pigs receiving restricted feed intake should also have access to water *ad libitum* as their welfare may be impaired with restricted water intake.

**MAIN WATER CONCERNS**
Water consumption by pigs is influenced by several factors. These factors often contribute to the main water concerns encountered on swine farms. Key among these factors are the quality of the water provided, diet composition, physiological status of the pig, environmental conditions, social factors, and equipment design and placement. Table 2 provides a summary of those factors that increase or decrease water consumption by pigs.

**Water Quality**
The levels of two main components namely chemical elements and composition and level of bacteria characterize the quality of water. Chemical elements
dissolved in water have a significant influence on the quality of water for swine depending on their concentration. The maximum recommended limits for chemical contaminants in water for livestock and poultry have been suggested by the Canadian Task Force on Water Quality (1987). However, results of surveys in Saskatchewan (McLeese et al., 1991), Manitoba (Plaizier et al., 2003) and Quebec (Flipot and Ouellet, 1988) show a wide variation in mineral content in well water and that for some wells, these are present in levels that exceed the maximum recommendations.

Table 2. Some factors that influence water consumption by pigs

<table>
<thead>
<tr>
<th>Increase water consumption</th>
<th>Decrease water consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunger</td>
<td>Cold stress</td>
</tr>
<tr>
<td>Boredom</td>
<td>Warm water temperature</td>
</tr>
<tr>
<td>Heat stress</td>
<td>High mineral levels in water</td>
</tr>
<tr>
<td>Increased dietary minerals</td>
<td></td>
</tr>
<tr>
<td>Moderate mineral levels in water</td>
<td></td>
</tr>
<tr>
<td>Pelted feed</td>
<td></td>
</tr>
</tbody>
</table>

1 Adapted from Patience et al., 1995

In general, poor quality water is a major concern that relates to such issues as health, nutrition, animal management and most critically, profitability. Pigs should be provided with good quality water for optimal performance. When given poor quality water, pigs tend to have excessive water usage, which in turn increases the volume of slurry (McLeese et al., 1992). This is undesirable because it adds to the growing concern of manure disposal within the swine industry (Mroz et al, 1995). Furthermore, because pigs must eliminate from their bodies any excess water consumed, this can negatively impact on their performance as energy, which could otherwise be used for growth or production, is expended on water excretion (Mroz et al., 1995). Inadequate water intake as a result of poor quality is equally undesirable as it can impede on feed intake and pigs can easily become dehydrated, with the overall effect being poor performance.

For detailed discussion of the effect of different minerals on pig performance, please see a recent review by Nyachoti and Patience (2003). Of the chemical elements dissolved in water for swine, sulfates cause most water quality problems with respect to pig production in North America (NRC, 1998). At high
levels, sulfates give water a “rotten egg” smell. Although the effects of water sulfate levels on pig performance have been inconsistent among studies, there is enough evidence to suggest that at high levels, sulfates induce diarrhea in young pigs (e.g. Figure 1). This is because sulfates have a laxative effect at high levels of intake (i.e. 1500 – 2500 ppm) (Kober, 1993), which results from the accumulation of salts in the gut causing an osmotic disturbance. Another potential effect of high water sulfate levels is water refusal, especially with high levels of magnesium sulfate (Epsom salt) and sodium sulfate (Glaubers salt), as these sulfates make the water distasteful (Kober, 1993). In general, water with 3500 ppm of sulfate is unfit for sows and generally water with more than 4500 ppm should not be used for any livestock (Kober, 1993).

Figure 1. Effect of high water sulfate levels on incidences of diarrhea in piglets (After Veenhuizen et al., 1992).

**Bacterial Contamination and Water Quality**

Bacterial contamination of water is currently viewed as a serious problem relative to the quality of water for both human and livestock use. The main types of bacteria that have been associated with water quality problems include Cryptosporidium, enterotoxigenic *E. coli*, Salmonella, and Leptospira (Meek, 1996; NRC, 1998; Thacker, 2001). Other microorganisms such as Protozoa as well as eggs and cysts of intestinal worms might affect water quality for pigs. The degree of water pollution by bacteria is traditionally estimated by measuring the level of coliforms, which represents a group of generally pathogenic bacteria, as an indicator (Meek, 1996). A count of 5000 total coliform per 100 milliliters is normally used as a guideline for maximal levels in water for pig production (NRC, 1998; Meek, 1996). It must be emphasized, however, that the actual level that can impact on water quality will vary depending on the virulence of specific bacteria present.
**Diet Composition**

Various dietary factors including dry matter content and concentrations of salt, crude protein and fibre levels are known to influence water intake in pigs. A study by Greary et al. (1996) suggests that when weaner pigs are fed diets with low dry matter content their water consumption increases dramatically. In this study water intake of piglets fed the low dry matter diet was almost 1000 ml/pig/day more than for those piglets consuming a high dry matter diet. Similarly, McLeese et al. (1992) reported that during the first week post weaning piglets tend to have high water intake. Furthermore, Yang et al. (1984) reported excessive water drinking in growing-finishing pigs consuming less than 30 g of dry matter per kg body weight. Results of these studies can be explained by the fact that pigs consume excessive water to feel satiated when feed (dry matter) intake is low.

The form in which feed is offered might also influence the amount of water consumed by pigs. Although not consistently observed in all three trials performed by Laitat et al. (1999), there was some suggestion that pigs fed mash diets might have a higher need for water than those fed pelleted diets.

The crude protein and mineral content in swine diets have a major impact on water intake levels (Thulin and Brumm, 1991; Mroz et al., 1995; NRC, 1998). When pigs are fed diets with a protein concentration that exceeds their requirements for maintenance and growth or production purposes, the excess protein is broken down and excreted as urea (NRC, 1998). This process exerts an additional need for water to help in the excretion of the excess nitrogen, which explains why pigs consuming high protein diets have high water intake levels (NRC, 1998; Figure 2). From the data summarized by Mroz et al. (1995) and the study by Seynaeve et al. (1996), it is evident that high salt (NaCl) intake result in increased water consumption in all classes of pigs and that this is associated with increased urine output. Again, this is undesirable as it adds to current challenges associated with manure handling and disposal in the swine industry.

![Graph showing water intake and output in growing and weaned pigs](image-url)
Figure 2. The effect of dietary crude protein on water intake in growing pigs (Shaw et al. 2003) and water usage in weaned pigs (Nyachoti et al. 2003, unpublished data).

Physiological Status of the Pig
The physiological status of the pig is clearly an important determinant of water consumption. This is particularly the case in sows as they move from gestation to lactation periods. For instance, various studies have shown that water consumption by sows increase before parturition and then drop to very low levels after parturition. This is then followed by an increase in water consumption reaching maximum levels 10 to 14 days after parturition (Friend et al., 1971; Fraser and Phillips, 1989; Seynaeve et al., 1990). The increased lactation water intake is closely related to increasing feed intake during this period. Lactating sows not only consume more water but also retain more of the water consumed than do dry sows perhaps because of milk synthesis and production.

Environmental Factors
In general, any factor that creates stress in pigs can have an impact on water consumption. Pigs kept in hot environment, for instance, tend to have higher water consumption in part as a mechanism for body temperature control (Mount et al., 1971; Nienaber and Hahn, 1984). Health status of the pig is equally important; pigs with diarrhea problems tend to have poor water intake levels (Thacker, 2001). Social factors such as the number of pigs per pen do not seem to influence the total amount of water consumed but may affect water intake patterns (Turner et al., 1999). It can be concluded from these studies that stress factors in hog barns should be carefully controlled to optimize water intake and therefore overall pig performance.

Equipment Design and Placement
Nipples drinkers are commonly used to supply water to all classes of swine although bowl drinkers are preferred for delivering water to weanling pigs (Fraser et al., 1996). The effect of the number of waterers on water intake by pigs is not consistent. For instance, water intake was similar in pigs housed in groups of 20 with 1 or 2 waters or 60 with 3 or 6 waterers (Turner et al., 1999). On the contrary, Brumm and Shelton (1986) reported that the number of waterers per pen was an important factor determining water intake in pigs. The flow rate of water does not seem to influence pig performance although it impacts water consumption patterns (Nienaber and Hahn, 1984; Barber et al., 1988; Ogunbameru et al., 1991). Finally, installation of nipple drinkers should be carefully considered because nipple position and/or angle can influence water consumption by pigs (Carlson and Peo, 1982). Generally, poorly positioned (too high, too low or incorrect angle) drinkers create difficulties in drinking and increases water wastage.
DEALING WITH WATER CONCERNS

Access to good quality water will continue to be an important issue as the swine industry in Western Canada develops. It is, therefore, critical to monitor the quality of the available water as regularly as possible but certainly not less than once a year. Such a test should always include measurement of bacterial (coliform) contamination (Kober, 1993). Also, swine nutritionists should have the results of water quality tests so that they can formulate rations accordingly to compensate for any excessive amounts of minerals supplied by the water (Flipot and Ouellet, 1988). That way nutritional disorders brought on by certain mineral excesses can be prevented, enabling one to continue using the same water source whilst improving production in the swine unit.

Clearly, the level of each water contaminant at which pig performance is adversely affected varies widely. This means that water analysis results alone will not be sufficient to justify changes in the production system. However, once it has been determined that the quality of water is a production problem, dealing with the problem has no straightforward solution. One should first determine whether or not the analyzed water quality is sufficient to create a substantial health and performance problem (Veenhuizen, 1993). This is because in some cases the quality of water may be poor enough to fail certain quality tests, but if the performance of the animals is not significantly reduced, it might not be economical to install an expensive water purification system. However, if water quality is found to be inadequate for supporting optimal pig performance, then a means to improve quality must be identified.

Water Treatment Techniques Available to the Swine Industry

The swine industry spends considerable resource on water treatment, particularly in the nursery. Although in some cases pigs may be able to acclimatize to water of poor quality (Veenhuizen, 1993), there are situations that the quality of the water is so poor to be utilized economically for swine production and therefore either an alternative source of water has to be found or the water has to be treated before use (Meek, 1996). A major challenge with respect to water treatment is to identify a suitable treatment system that is not only effective but also affordable. Various water treatment methods (e.g. chlorination, coagulation, filtration, and pH adjustment; Table 3) are available to the pork industry, but their impact on pig performance is largely unknown. The following is a brief description of these methods.

Chlorination

Chlorination is now an accepted practice within the swine industry, at least as it relates to nursery pigs. What is not well understood, however, is the impact of different levels of chlorination on water intake and pig performance. The amount of chlorine required to effectively disinfect water varies depending on the quality of the water. In general, more chlorine will be required to effectively disinfect water with high levels of contaminants (e.g. nitrite, iron, organic matter, etc.) or high pH because these are known to reduce the efficacy of chlorine. The
effectiveness of chlorine is also dependent on the length of the contact time and
the type of bacterial contaminant; protozoa and enteroviuses are more resistant
to chlorination than bacteria (Patience et al., 1995). Although chlorination could
be used effectively to disinfect water with a high coliform count, the goal should
be to identify and eliminate the source of the contamination (Blind, 2001).
Shock chlorination (use of a large amount of chlorine at once) only offers
temporary benefits.

Table 3. Suggested water treatments for specific water quality problems.

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>SOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coliform count</td>
<td>Chlorinate water</td>
</tr>
<tr>
<td>Water hardness</td>
<td>Install a softener</td>
</tr>
<tr>
<td>High nitrates or other minerals</td>
<td>Ion exchange or reverse osmosis treatment systems</td>
</tr>
<tr>
<td>Iron</td>
<td>Filtration</td>
</tr>
<tr>
<td>High water pH</td>
<td>Acidification</td>
</tr>
</tbody>
</table>

Acidification
Many of the sources of water available are slightly basic (i.e. alkaline) with a pH
value between 7 and 8. As the pH increases the level of carbonates compared to
bicarbonates also increases. Physiological and digestive upsets can occur with
high alkalinity, especially in younger pigs. Acidification of the water supply has
been used to increase piglet performance, by decreasing the pH of the water
down to neutral pH.

Softening
Simply installing a water softener will reduce the hardness of the water. However,
the softening of the water results in a higher level of sodium (i.e. Mg is
exchanged with Ca and Na), which may again produce an intake of salt that is
too high for the pigs thus making their performance deteriorate.

Coagulation and Other Methods
Water with a high turbidity (a measure of fine particles suspended in water) can
be unsuitable for use in swine, particularly because it is difficult to be disinfected
effectively. This is because the suspended particles reduce the effectiveness of
chlorination by preventing accessibility of the microorganisms. Coagulation,
which involves lumping together the fine particles into large particles, which are
in turn settled and then removed from the water, offers a viable means for
treating water with high turbidity (Butler, 2002, personal communication). This
procedure could be particularly useful in treating surface water, as this water is likely to contain high levels of suspended particles resulting from surface runoff.

Other available techniques for water treatment include ion exchange or reverse osmosis treatment systems, and ultraviolet radiation. However, many of these techniques are quite costly and therefore of limited application in commercial pork production. Furthermore, the benefits of feeding treated water may not also result in better pig performance (e.g. Table 4). It has also been suggested that poor water quality may be solved without too much added cost by blending the poor quality water with a supply of water containing low concentration of the contaminant in question (Veenhuisen, 1993). However, this might not be a practical solution for those operations with only one source of water.

Table 4. The effect of reverse osmosis treatment on water quality and piglet performance (After Patience et al., 1997).

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>Treated water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids, ppm</td>
<td>3086</td>
<td>193</td>
</tr>
<tr>
<td>Total sulfates, ppm</td>
<td>1634</td>
<td>15</td>
</tr>
<tr>
<td>Piglet performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average daily gain, g/d</td>
<td>410</td>
<td>410</td>
</tr>
<tr>
<td>Average daily feed intake, g/d</td>
<td>674</td>
<td>656</td>
</tr>
</tbody>
</table>

Management Approaches

Water concerns may be addressed through nutritional means, particularly when high intake of a given nutrient is an issue. However, care should be taken in using this approach to ensure that its impact on pig performance is not worse than that of the original problem. For example, the salt content in the diets fed to pigs drinking poor quality (i.e. high sodium levels) water may be reduced (Patience et al., 1995). This practice appears to reduce the occurrence of scours; however, the impact on performance may be even more than this. Salt contains both sodium and chloride, whereas poor quality water often contains large quantities of sodium with relatively small amount of chloride. Therefore, pigs consuming diets low in salt may become deficient in chloride, which could potentially result in decreased feed intake and poor performance. Considering that mineral content of water vary widely, and that the availability of minerals in water has not been well established, caution should be taken when formulating diets to compensate for poor quality water. This means that it is necessary to know specific mineral profile of a water supply and how it varies over time so as to make the appropriate adjustment in ration formulation.

Another management aspect that can have a significant impact on water usage by swine relates to the water supply system. Maintaining the right water pressure
in the system will ensure that pigs have adequate supply of water. Similarly, it is important to ensure adequate water flow, the right number of drinkers and that the drinkers are easily accessible to staff for ease of checking to ensure functionality.

The quality of water may act synergistically with disease causing factors or inadequate management practices to decrease pig performance. Therefore, stressful factors in the barn should be kept to the mean. This will give the pigs a better chance to deal with any impact related to poor water quality.

**Summary and Conclusions**

- Water should no longer be taken for granted as accessibility to good quality water for swine production is becoming increasingly scarce in western Canada.
- Although surface water is being used in swine production, its quality should be closely monitored because it highly susceptible to contamination.
- Diarrhea in the nursery may be related to poor water quality. Therefore, water-related diarrhea must first be ruled out before treating pigs with antibiotics.
- In many cases, indicators of water quality are poorly related to pig performance. Before investing in costly water treatments systems, swine producers should ensure that it is indeed good for their operation. In other words, it is important to look at pig performance, comfort, and health when a water quality issue is in question to rule out effect of other non-water related problems (e.g. group size uniformity, facility management, identification and treatment of poorly performing animals, etc.).
- The fact that a water-supplying device is provided in the pen, it doesn’t mean that pigs have access to adequate water.
- It is advisable to develop a pro-active protocol for cleaning and maintenance of the water supply system. This will ensure that the system is in working order at all times.
References


