

Evaluation of Water Quality and Effect on Performance

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Water is a vital nutrient essential to the turkey to soften feed in the crop, aid in digestion, a building block for blood and lymph (immune system) and for evaporative cooling when heat stressed. Although water is essential for the growth and performance of our flocks the quality of it is often overlooked and the effect on performance greatly underestimated. All water except distilled will contain impurities due to the nature of the water cycle. Consequently any factor which might alter water quality (bacterial content, pH, nitrogen levels, hardness, mineral level) might directly impact water consumption or the bird's ability to utilize the consumed water.

Is the quality of your water affecting your flock's performance?

The following may be indicators of unacceptable or inferior water quality:

- Loose droppings and poor gut health
- Higher than normal water consumption
- Wet litter and burned footpads
- Roundheart
- Lack of uniformity within the flock (front to back of building)
- Scale on drinkers
- Repeated E. coli or Bordetella breaks
- Comparative farm performance poor (similar genetics, feed and management)

Although water plays a critical role in the performance of our turkey flocks, we do not spend the same amount of time analyzing it as we do feed samples. We must not lose sight of the facts that 1) turkeys consume two to two and half times as much water as they do feed and 2) feed intake will be determined by water consumption (if they don't drink, they won't eat). The following are some tools which can be used for evaluating water quality. These tools allow you to make the step from thinking or assuming that your water is acceptable to knowing without a doubt that it is.

1. *Water Analysis.*

I recommend sampling water on-farm twice a year. This will account for variations in the water table level which may alter both the chemical and bacterial levels in the water. This should be part of a routine HACCP or Best Management program and not just when there is a suspected problem. Sampling all farms within a short period of time allows us to better analyze the effects of water quality on farms with similar genetics, feed and levels of management. The significance of the results will depend on where the sample is taken and will help pinpoint where contamination is entering the water system i.e. at the well head, as water enters the barn or as water reaches the turkeys. So think about what you

are trying to evaluate. To take a quality water sample sterilize the end of the tap or pipe and/or run water through it for a few minutes. Collect into a sterile container. Keep it cool until delivered to the lab and/or use bottles with sodium thiosulphate added which neutralizes residual chlorine, if that is the class of disinfectant being used for water sanitation. You should request the laboratory analyze for bacterial levels and for chemical content.

Bacterial Culture : the overall bacterial load is determined by doing a total plate count at 37⁰ C (< 10 cfu/ml) and 22⁰ C (<100 cfu/ml). Total counts are not correlated to the presence of pathogens. They are useful as a general indicator of water quality. What is more important is whether fecal indicators (*Coliforms*, *Enterobacter*, *Fecal streptococci*, *E. coli* and *Clostridium perferingins*.) are present .The acceptable level is zero present in a 100 ml (~4 oz) sample of water. If present it may be due to heavy rainfall into shallow wells, dead birds buried too close to the water source or a breach of the well system. If the latter is the case, the well head and casing should be repaired and the well shock chlorinated.

Chemical Content : the laboratory will analyze the sample for the presence of total dissolved solids (TDS) which are a measure of inorganic ions such as calcium, magnesium and sodium salts. These inorganic elements are not directly harmful but do contribute to scale formation resulting in restricted water flow and biofilm build up. High calcium or magnesium is shown by a high pH (alkaline). pH will indirectly affect the flock by influencing the effectiveness of chlorination and the absorption of certain types of antibiotics. Tetracyclines are absorbed best in acidic water (pH < 7) while sulfa's are absorbed best in alkaline water (pH>7).

2. Measuring the Effectiveness of Water Sanitation.

A standard guideline in the poultry industry for water sanitation was 2 to 3 ppm of free chlorine at the end drinker. With time it was discovered that this did not always guarantee clean water because the pH of the water was not being taken into account. When a sanitizer such as liquid chlorine is added to water, the pH of the water determines how much will dissociate into hypochlorous acid (which kills bacteria immediately) and hypochlorite ion (which kills bacteria only after prolonged contact). Consequently, 3 ppm of free chlorine at a pH of 6.8 will sanitize water effectively but as pH increases the effectiveness of the chlorine decreases. So to effectively sanitize water we need to find the correct proportion between the pH and the free chlorine.

The table below shows the dramatic effect of pH on effective chlorination.

pH	FREE CHLORINE	
	Hypochlorous Acid (HOCl) % KILLS IMMEDIATELY	Hypochlorite Ion (OCl) % DELAYED KILL – UP TO 20 MINUTES
5.5	98	2
6.0	96	4
7.0	75	25
7.5	53	47
8.0	22	78
8.5	10	90

Chlorine / pH Test Kits (Pool or Spa type, Strips, Titration Type). It is important that the kit measure free chlorine and that pH level is known. Testing for chlorine and pH is an easy and inexpensive way to ensure that clean water is consistently reaching all birds within the barn. If the front of the house is receiving clean water but the back of the house isn't this tells you that the water lines in between are contaminated with biofilm buildup. When bacteria attach to the biofilm, they begin to excrete a slimy material and also turn on a whole new set of genes making them more difficult to kill. Biofilms will be highest in areas of slow moving water.

Oxidative Reductive Potential (ORP) Meters

Measuring the oxidative reductive potential of the water allows us to find the effective balance between pH and free chlorine. Most importantly, it is a way for us to know immediately whether our flocks are receiving clean sanitized water or not. Today with improved yet inexpensive technology, evaluating the quality of water has advanced from pH and free chlorine measurements to include Oxidative Reductive Potential (ORP).

Oxidation reduction potential (ORP), also known as redox, is the measurement of a solution's oxidizing and reducing activity. Oxidation is any chemical reaction that loses an electron. When enough electrons are lost bacteria and other organic matter is killed and used up. Rust is an example of a slow oxidation/reduction reaction. Oxygen in the air, combines with iron (nail, piece of metal) to form iron oxides. In this process, the iron is oxidized and the oxygen has been reduced. ORP meter readings measure the voltage between the negative and positive poles in the meter, with the water in between.

An ORP probe is really a millivolt meter, measuring the voltage across a circuit formed by a reference electrode constructed of silver wire (in effect, the negative pole of a circuit), and a measuring electrode constructed of a platinum band (the positive pole), with the water in between. Modern ORP electrodes are almost always combination electrodes, that is, both electrodes are housed in one body – so it appears that it is just one probe. We are reading the very tiny voltage generated when a metal is placed in water in the presence of oxidizing and reducing agents. These voltages give us an indication of the potential of the oxidizers in the water to keep it free from contaminants.

Free chlorine and ORP levels do not increase at the same rate. In general, a ten-fold increase in free chlorine concentrations will not result in a corresponding proportional increase in millivolts. This water quality will likely result in measurements of 650-700 mV ORP if the water pH is 6.5 to 7. Lowering the pH to 6.0 will raise the ORP as more hypochlorous acid becomes available. Raising the pH to 8.0 will lower the ORP value as more hypochlorite ion is present. At ORP levels of 700 to 800 mV, E. coli is killed within seconds. If a water sample is checked and the ORP value is less than this, you should next check the pH and free chlorine to determine which needs to be corrected in order to achieve effective water sanitation.

The table below illustrates the relationship between ORP and bacterial levels measured from commercial spa water .

Free Chlorine (ppm)	pH	ORP (mV)	Total Plate Count	Pseudomonas (cfu)
4.0	5.8	805	0	0
4.4	7.4	730	0	0
4.9	7.9	668	0	0
2.3	7.8	653	0	0
1.2	7.1	618	170	12,400
1.2	7.8	296	640	1,600
0.8	7.8	590	310	2,400
0.7	8.3	480	15,000	2,400

(cfu = colony forming unit)

In 1972, the World Health Organization recognized in its Standards for Drinking Water that, at an ORP level of 650 mV, water is disinfected and viral inactivation is almost instantaneous. Research has shown that at a level of 650 mV ORP, bacteria such as E.coli are killed on contact or within a few seconds. Tougher organisms such as listeria, salmonella, yeasts and molds may require 750 mV or higher in order to be killed.

There are several types of ORP measurement meters that vary depending on the process requirements and design. Measurement is made by simply dipping the electrode in water and observing the display. A stable reading is usually reached within a couple of minutes. Process meters and controllers are useful on large farm complexes where the water is sanitized at a central location. These controllers are units designed to measure, control and regulate the pH, ORP, and Free Residual Chlorine values. They are demand-based units that automatically inject sanitizer or acidifier into the waterline according to preset values. Very close control can be maintained. They provide a reliable method of process control as well as recording for automated record keeping and HACCP programs and verified through continuous recording data loggers.

In conclusion, although water is a critical nutrient it is frequently overlooked as an underlying cause of poor performance in turkey flocks. Consequently, water analysis

must be done regularly so that changes can be made and deficiencies eliminated. Cleaning and disinfection of the water system between flocks in combination with consistent water sanitation throughout the life of the flock is a key component to ensuring a successful flock.

(Although the effects of mineral composition were not covered extensively in this paper the table on Water Quality Standards for Poultry has been included as a reference. *Source: Schwartz, D. L., "Water Quality," VSE, 81c., Penn. State Univ. (mimeographed); and R. Waggoner, R. Good, and R. Good, "Water Quality and Poultry Performance," in Proceedings AVMA Annual Conference, July, 1984. All other references are available upon request*)

TABLE 1 : WATER QUALITY STANDARDS FOR POULTRY

CRITERIA	CONCENTRATION (PPM)	COMMENTS
Total Dissolved Solids (TDS)	0 – 1,000	Good
	1,000 – 3,000	Satisfactory, although wet dropping may result near the upper limit, performance and health should not be affected.
	3,000 – 5,000	Poor, wet droppings, increased mortality.
	> 5,000	Unsatisfactory
Hardness	< 100 (soft)	No problem.
	> 110 (hard)	Interferes with effectiveness of soap, disinfectants and some medications.
	1500	Maximum limit
pH	< 4.0	Decreased water consumption. Corrosion
	> 10.0	Unsuitable
Sulphates	50 – 200	May cause looseness if Na or Mg > 50 ppm.
	200 – 250	Maximum desirable limit.
	250 – 500	Looseness but birds may adjust.
	500 – 1,000	Looseness especially if chlorides high. May interfere with copper absorption.
	> 1,000	Increased water intake. Hazardous for poult.
Sodium	50 – 300	Generally no problems. Looseness if sulphate > 50 ppm or if chloride > 14 ppm.
Chloride	250	Highest desirable level. Levels as low as 14 ppm may cause problems if sodium > 50 ppm.
	500	Maximum permissible level
	> 500	Looseness, reduced feed and increased water intake.
Potassium	< 300	No problem.
	> 300	OK depending on alkalinity and pH Additive with sodium
Magnesium	50 – 125	OK. If sulphate >50ppm then looseness due to formation of magnesium sulfate.
	> 125	Looseness. GIT irritation is sulphate high.
	>350	Maximum
Calcium	600	Maximum. Excess deposit and scale.
Nitrates	10	Maximum level. Under certain conditions, levels as low as 3 mg/l may affect performance
Nitrites	Trace	OK
	>Trace	Health hazard. Indicates fecal contamination
Iron	< 0.3	OK
	> 0.3	Encourages growth of iron bacteria which clogs water systems, causes odours and precipitate.
Fluoride	2	Maximum
	> 40	Causes soft bones.
Zinc	< 1.5	Higher levels are toxic