Ozone for the Purification of Poultry Drinking Water

Technical Report

Ozone for the Purification of Poultry Drinking Water

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REPORT SUMMARY

Like any livestock industry, chickens require a clean and uncontaminated source of drinking water to make maximum daily gains and maintain flock health. This study demonstrated the feasibility of using ozone and filtration to treat well water for a typical broiler unit in Neshoba County, Mississippi.

Background

Broiler production in Mississippi began in the late 1940s and early 1950s. Today Mississippi is the fourth largest broiler producing state in the United States. According to the U.S. Department of Agriculture-National Agricultural Statistics Service, Mississippi production in 2002 was 769,500,000 birds producing over four billion pounds of products valued at slightly over 1.2 billion dollars. Poultry is the largest agricultural commodity in the state.

Once a farmer contracts with a processor and builds his buildings he can expect to be paid 18-24 cents for each bird that is accepted and processed. From this payment the farmer must pay all fixed and variable production costs while the broilers are on his farm. All of the farmer's costs should be minimized while a high quality product is produced. Minimizing water costs is one mechanism that can save a considerable dollar amount per year without impacting product quality. The amount of water utilized by a flock of broilers is dependent on bird size and the evaporative cooling needs to keep the house at a temperature for optimum growth and production. Most poultry integrators require a dependable and clean water supply that provides at least 15 gallons of water per minute for a 25,000-bird broiler house. Many growers have six broiler houses on their farm. The needed water for a six-house production unit is a minimum of 130,000 gallons per day. Utilizing municipal water supplies to satisfy these water needs costs approximately $1,800/month. Drilling and maintaining a 90-gallon per minute well and providing water treatment is much less expensive.

Objectives

To demonstrate the feasibility of using ozone and filtration to treat well water for a six-house broiler unit in Neshoba County, Mississippi; to determine the feasibility of installing additional wells and water treatment for broiler production.

Approach

Steve Cumberland operates six broiler houses at his farm in Neshoba County, Mississippi, using water from a well outfitted with a two-horsepower pump capable of providing 30 gallons of water per minute. Before this study, the well water contained iron, manganese, and sulfides at levels higher than those recommended for safe drinking water. The research team installed a 32-gram per hour ozone generator with three filtration tanks at the farm with filtration tanks timed to expel precipated iron, manganese, and sulfur compounds at night. The team compared the performance of the Cumberland system before and after ozonation, including data on mortality

percentages, average weight of finished broilers, pounds of feed per pound of gain, average daily gain, and total condemned birds at processing. Results were also compared with average data from other local farms working with the same integrator, Peco Farms, LLC.

Results

Key results of this study include:

- The ozonation of the well water did not greatly change the production data for the Cumberland Farms operation.
- Feed conversion was constant over the study and consistent with the feed conversion for all farmers producing for Peco Farms, LLC.
- Total condemned birds dropped slightly.
- Emitter fouling due to precipitants decreased.
- Variable costs for water decreased by nearly $20,000 for the six houses.

Based on this study, Steve Cumberland indicated he would drill an additional well or wells and use ozonation to treat the water for the poultry houses.

EPRI Perspective

EPRI Global is a leader in the application of ozone in agriculture and food processing. The treatment of well water for use as drinking water for livestock and poultry is one of many ozone demonstration programs conducted by the EPRI Global Team in conjunction with their utility partners. Other demonstrations include using ozone in flour milling, ozone treatments in aquaculture tanks, ozone treatment of poultry chiller water, ozone in drip irrigation systems, and ozone applications in catfish processing.

Keywords

Broiler production
Manganese removal
Ozone
Poultry mortality
Sulfide removal
Well water
Iron removal
Mississippi water sources
Poultry feed conversion
Poultry production
Water treatment

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INTRODUCTION

Objective of the Study

The objective of this study was to demonstrate the feasibility of using ozone and filtration to treat well water for a six house broiler unit in Neshoba County, Mississippi. Additionally, in this study flock characteristics and water costs were tracked to determine the feasibility of installing additional wells and water treatment for broiler production.

Introduction

Broiler production in Mississippi began in the late 1940s and early 1950s. Today Mississippi is the fourth largest broiler producing state in the U.S., and poultry production is the largest agricultural commodity in the state. According to USDA-NASS[1], 2002 Mississippi production was 769,500,000 birds producing over four billion pounds of products valued at slightly over 1.2 billion dollars.

Figure 1-1
Typical Broiler House Setting

[1] USDA-NASS (2003)

Most broilers are produced in flocks of 25,000 birds in houses similar to the one pictured in Figure 1-1. These houses are usually constructed at a cost of approximately $6.50/sq. ft. The density of birds placed in a poultry house varies depending on the final market weight desired. As a rule of thumb, each bird usually occupies three quarters of a square foot of house space. This translates into an initial capital cost of $5 dollars per bird or $125,000 per poultry house. As the industry moves to heavier chickens at processing, the space required per chicken will increase to 0.80-0.85 square foot of space per chicken. This increase in space requirement per chicken will be reflected in the amount of fixed costs needed to produce a flock. These costs can be calculated when the needed broiler size of bird is determined.

The industry consists of farmers working with broiler integrators. The farmers own the land and broiler houses and provide labor for care of the chickens. The broiler companies or integrators usually furnish the chicks, the feed and serve as a market for chickens ready for processing. The integrators also usually provide technology and advice on production methods, lighting, heating and cooling of the poultry houses and safeguards to prevent diseases. The farmers and the integrators have a mutual relationship and each depends on the other for their inputs to the poultry production system. The integrators need the farmers' land and labor for production and the farmers need the technology, production inputs and markets provided by the integrator. To foster the mutual relationship between the farmer and the integrator, both must be satisfied that the other will meet expectations so that a trusting but legal business relationship can develop. Once a farmer contracts with a processor and builds his buildings he can expect to be paid 18-24 cents for each bird that is accepted and processed. From this payment the farmer must pay labor costs, house cleaning, bedding, maintenance, electrical costs, water costs, taxes and amortize building costs over the projected life of the building. To cover these costs, it is mandatory all costs be minimized while ensuring that a stellar product is produced. Minimizing water costs is one mechanism that can save dollars per year without impacting product quality.

Poultry Water Requirements

Like any livestock industry, chickens require a clean and uncontaminated source of drinking water to make maximum daily gains and maintain flock health. Water sources high in minerals such as calcium and magnesium can cause problems simply through calcification of equipment and emitters. Plugged emitters reduce water intake and feed conversion as well as being a nuisance to keep clean and in working condition. High calcium and magnesium in the evaporative cooling systems reduce the usable life of the systems and increase maintenance costs. High microbe levels lead to diseases and mortality in the most severe cases and poor flock performance at lower levels of contamination. The removal of microbes through chlorination of the drinking water is not always a satisfactory solution as most types of poultry do not react well to high chlorine levels. The chlorine in the intestines of poultry is thought to reduces beneficial microorganisms and thus reduce feed conversion and possibly immunity to diseases.

Chemical contaminants such as iron, sulfur and manganese can reduce water quality to the level that the chickens limit water intake and feed conversion and weight gains are reduced. In high enough concentrations, mortality rates increase and profits are decreased. To overcome the problems of poor quality water, some producers are installing water purification systems that provide poultry water to the level of national drinking water standards. The purification technology utilized is ozone and filtration. Ozone has the capability of purifying the water by removing microbes and pesticides and neutralizing the harmful effects of iron, manganese and sulfur through precipitation. Once the iron, manganese and sulfur compounds have been precipitated, they can be removed by filtration. Because ozone has a very short life, it does not leave residuals in the water; thus, treated water can be recontaminated with microbes.

The amount of water utilized by a flock of broilers is dependent on bird size and the evaporative cooling requirements to keep the house at a temperature for optimum growth and production. Most producers calculate that they need a gallon of water per bird per day for a flock that is nearing maturity during the summer months. Using this thumb rule, water systems are sized to meet this need. Again using the six house example, a producer with six producing houses will need a water supply capable of supplying 150,000 gallons of water per day for full production. Most integrators will require a dependable water supply that provides at least 15 gallons of water per minute per house. Utilizing these requirements, the needed water for a six-house production unit would be a minimum of 130,000 gallons of water per day. Regardless of rather one uses the grower's thumb rule of one gallon per day per bird or the integrator's requirement of 15 gallons per minute per house, the needed water per day for six houses is 130,000 to 150,000 gallons per day. To achieve this water capacity a farmer must have a minimum sustained well pumping capacity of 90 gallons per minute. One well with this capacity is risky because power outages and breakdowns could limit water supplies to the flock or cause disasters whereby flocks are lost. For this reason most farmers have either standby wells and generators or have access to a municipal water source for emergencies.

The Water Dilemma—Mississippi

Poultry producers in Mississippi can use water from wells, surface sources or utilize water from county and/or municipal water systems. The cost associated with utilizing water from these municipal supplies is variable and depends on the supplier and its rate. Because both drinking water and water for evaporative cooling is necessary, summer costs are usually much higher than the cool season costs. From very limited survey data in this study, it was found that municipal or county water cost could average $300 per month per poultry house. For producers with six or more poultry houses water costs can be over $20,000 per year.

Water from wells and surface sources is much less expensive but may have several problems associated with using these water sources for poultry drinking water. These problems include:

- Turbidity (shallow wells and surface water sources)
- Microbial contamination (shallow wells and surface water sources)
- Contamination from runoff (shallow wells and surface water sources)
- Nitrates and phosphates (all wells and surface water sources)
- Iron, manganese and sulfur (shallow and deep wells)
- Other contaminants depending on the water source, well construction and geology
- Reliability of the water supply

Generally Mississippi has very adequate ground water supplies but each site must be evaluated separately, and the water quality and quantity must be determined before utilizing a water source for poultry production. Surface and shallow well water sources must be approached with extra caution as they are subject to changes in weather patterns, long-term climatic changes and extraneous factors such as chemical spills and upstream water use patterns. To use shallow groundwater or surface water sources, producers are urged to obtain professional advice or work through their local Soil and Water Conservation District and the National Resources Conservation Service. NRCS can evaluate the reliability of surface water sources and determine the capabilities of water holding structures. They can also provide information on soil permeability and the expected movement of contaminants through the soil.

Mississippi producers wanting to use deeper groundwater sources should contact their local Extension Service office or the Mississippi State University Extension Service[2] as a starting point to collect information on actual well locations, sealing requirements, and water quality testing information. Additionally, all producers are encouraged to contract with a licensed well drilling firm under a legal and binding contract that specifies what is to be delivered and the expected water quantity and quality. If the expected water quality does not meet safe drinking water quality standards[3], the poultry producer should be prepared to investigate costs and methodologies for water treatment to meet such standards.

Technologies for water treatment are readily available for most water sources. The factors limiting the treatment of well water are usually both capital and operating costs. These costs will be dependent on the treatment needed and the materials that need to be removed. In Mississippi the treatment needed for deep well water is usually the removal or iron, manganese and sulfur compounds, particularly sulfides. All three of these contaminants can be precipitated using ozone. To avoid plugging of emitters, water lines and sensitive equipment, the flocculated materials need to be filtered and removed. Once these steps have been taken, much of the well water in Mississippi is very suitable for drinking water. As a side benefit, the ozonation of the well water also acts as an antimicrobial agent and further purifies the water for chick growth early in the production period.

[2] www.msucares.com

[3] www.epa.gov/safewater/mcl.html

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A CASE STUDY—CUMBERLAND FARM DEMONSTRATION

To demonstrate the potential for treatment of well water, TVA's David Salladay, Projects Manager, Public Power Institute and George (Tedd) Battles, Industrial Marketing Manager (Food Processing) spearheaded efforts that led to TVA supporting a demonstration project conducted by EPRI's Global Energy Partners to demonstrate the potential for the treatment of well water for broiler production in Mississippi. The study was conducted on the Steve Cumberland farm in Neshoba County, Mississippi. Mr. Cumberland and his wife operate six broiler houses. Peco Farms, LLC is the integrator that contracts to supply the chicks and process the broilers from the Cumberland Farm. The local processing plant is located in Philadelphia, Mississippi. The ozone generation system and necessary filtration equipment was designed by Mr. Charlie Hayes of the North Carolina-based McNeal Company. Project coordination and report preparation was done by Dr. Charles Sopher for Global Energy Partners, LLC, Lafayette, California.

The situation at start-up consisted of a well outfitted with a two horsepower pump capable of providing 30 gallons of water per minute. The actual capacity of the 365 ft. deep well was estimated by the well driller to be 40 gallons per minute. Based on visual observations of the pump house (Figure 2-1), the iron contents of the water was high and the water smelled of hydrogen sulfide. Sulfide odors were particularly noticeable when water was sprayed at 60 pounds of pressure.

Figure 2-1
Pump House Showing Iron Deposits—Cumberland Farm

To treat the well water, a 32 gram per hour ozone generator was installed along with three filtration tanks. This equipment is shown in Figure 2-2. The filtration tanks are timed to flush at night and expel any precipitated iron, manganese and sulfate compounds. Prior to installation of the ozonation equipment, the well water was sampled by the TVA Central Laboratory Services and analyzed for inorganic contaminants

Figure 2-2
Ozone Generation and Filtration Equipment—Cumberland Farm

These water analyses were used as guides in developing specifications for the needed ozonation and filtration equipment. Water samples were also collected from the municipal water source at the farm. Treated water samples were collected once the ozonation and filtration equipment were installed. Summary data from these water samples are presented in Table 2-1.

The information in Table 2-1 represents a summary of several water samples taken over time. These samples were taken to check the performance of the installed equipment. The municipal water samples were also checked for chlorine levels because high chlorine can cause growth problems in poultry. The objective of this study was to demonstrate the feasibility of using ozone and filtration to treat well water for a six house broiler unit in Neshoba County, Mississippi. Flock characteristics and water costs were tracked to determine the feasibility of installing additional wells and water treatment for broiler production.

Table 2-1
Water Analyses—Cumberland Farm Well and Municipal Water Supply

Analysis	Units	Raw Well Water	Treated Well Water	Municipal Water
pH		6.86	7.05	6.88
Iron (Total)	mg/L	5.50	0.820	2.50
Manganese (Total)	mg/L	0.15	0.028	0.069
Calcium (Total)	mg/L	30	29	29
Magnesium (Total)	mg/L	12	12	12
Ca & Mg Hardness	$mg/LCaC0^3$	124	122	122
Chlorine (Total)	mg/L	N/A	N/A	8.8
Sulfate (Total)	mg/L	12	12	N/A
Sulfide (Total)	mg/L	12	<0.02	N/A

Based on the water analyses presented in Table 2-1, it was concluded that the well on the Cumberland Farm did have problems with iron, manganese and sulfide contents all being above drinking water standards of 0.3, 0.05 and <0.02, respectively. Although the municipal water meets national drinking water standards for safety, the secondary standard for iron was not really being met and residual chlorine was quite high in some samples. Ozone studies on turkey poults by the AFTA[4] indicate these levels could be dangerous to bird health and increase flock mortality.

To establish the exact amounts of chlorine is the municipal system, it will be necessary to sample the municipal water source over time and establish the chlorine levels and test for any patterns that might emerge due to the timing of chlorine treatments (injections) into the municipal system. Based on economics this testing may not be necessary as Mr. Cumberland is planning on drilling additional well(s) and using the municipal system as a standby source of water.

To compare the Cumberland system before and after ozonation of the water to other farmers involved with Peco LLC, the following data are presented below:

- Flock Sales information for 2002 using raw well water (21 houses)—Table 2.2
- Flock Sales information for 2003 using ozonated water (27 houses)—Table 2.3
- Peco Farms, LLC weekly averages for flock data for the 2003 period—Table 2.4.

[4] *The Effects of High Purity Water on Poult Enteritis and Mortality Syndrome (PEMS) in Turkeys*, EPRI, Palo Alto, CA: 1999. TR-113587.

For comparison purposes the information collected was:

- Mortality percentages over the production period
- Average weight of the finished broiler
- Feed conversion—pounds of feed per pound of gain
- Average daily gain
- Total condemned birds at processing

Table 2-2
Flock Data for Cumberland Farm—2002 (Before Ozonation of Water)

Date	Source	Mortality %	Ave.Wt./lbs.	Feed Conv. lb.feed per lb.gain	Daily Gain/lbs.	Total % Condemnation
3/12/2002	Cumb1	5.83	5.20	1.89	0.1106	1.27
3/11/2002	Cumb2	4.81	5.10	1.90	0.1083	1.39
5/20/2002	Cumb1	4.39	5.65	1.94	0.1089	1.73
5/19/2002	Cumb2	3.37	5.25	1.92	0.1050	1.60
7/30/2002	Cumb1	5.24	5.85	2.04	0.1108	1.78
	Cumb2	NoSales				
10/1/2002	Cumb1	No Sales				
10/1/2002	Cumb2	4.82	5.61	1.99	0.1102	1.73
12/3/2002	Cumb1	2.71	5.99	1.89	0.1193	1.66
	Cumb2	No Sales				
Average	**Cumb1**	**4.54**	**5.67**	**1.94**	**0.1124**	**1.61**
	Cumb2	**4.33**	**5.32**	**1.94**	**0.1078**	**1.57**
2002 Average		**4.44**	**5.50**	**1.94**	**0.1101**	**1.59**

Note: Cumb1 designates Elsie Cumberland flocks; Cumb2 designates Steve Cumberland flocks

Table 2-3
Flock Data for Cumberland Farm—2003 (After Ozonation of Water)

Date	Source	Mortality %	Ave.Wt./lbs.	Feed Conv.lb.feed per lb.gain	Daily Gain/lbs.	Total % Condemnation
2/8/2003	Cumb1	6.62	4.86	1.82	0.1017	0.79
	Cumb2	6.26	4.86	2.00	0.1017	2.59
4/12/2003	Cumb1	4.97	4.77	1.95	0.0975	0.77
	Cumb2	6.61	4.82	1.96	0.0990	1.01
6/14/2003	Cumb1	No Sales				
	Cumb2	3.42	5.38	1.86	0.1098	1.67
6/21/2003	Cumb1	2.97	5.88	1.93	0.1131	0.81
	Cumb2	No Sales				
8/16/2003	Cumb1	4.20	5.25	1.96	0.1071	1.59
	Cumb2	Disaster Flock				
10/18/2003	Cumb1	2.94	5.53	1.93	0.1145	1.65
	Cumb2	5.38	5.51	1.96	0.1124	1.78
Average	**Cumb1**	**4.34**	**5.26**	**1.92**	**0.1068**	**1.12**
	Cumb2	**5.42**	**5.14**	**1.95**	**0.1057**	**1.76**
2003 Average		**4.88**	**5.20**	**1.94**	**0.1063**	**1.44**

Note: Cumb1 designates Elsie Cumberland flocks; Cumb2 designates Steve Cumberland flocks

Table 2-4
Flock Data Comparisions for Cumberland Farms and Peco Farms, LLC

Date	Source	Mortality %	Ave.Wt./lbs.	Feed Conv.lb.feed per lb.gain	Daily Gain/lbs.
2002	Cumberland Farms/Average	4.44	5.50	1.94	1.59
2003	Cumberland Farms/Average	4.88	5.20	1.94	1.44
2003	Peco Farms/Average	5.37	5.55	1.94	1.19

3
RESULTS AND CONCLUSIONS

Results and Conclusions

The following is an interpretation of the data and trends observed for the Cumberland Farm production. This production data are compared to Peco Farms, LLC production figures for all farms in their operation. The data was not replicated or developed with statistical analyses planned. Thus, all interpretations of the production means are generalized. A larger data base over a longer time period is needed to accurately quantify results.

Based on the production data collected and cost discussions with Steve Cumberland, the following was concluded:

- The ozonation of the well water did not greatly change the production data for the Cumberland Farms operation
- Mortality was close to the Peco Farms, LLC average for all farms
- Feed conversion was constant over the study and consistent with the feed conversion for all farmers producing for Peco Farms, LLC
- Total condemned birds dropped but remained higher than the Peco Farms, LLC average
- Emitter fouling due to precipitants decreased
- Variable costs for water decreased by nearly $20,000 for the six houses. Fixed costs for well drilling and maintenance were not available but were quite low compared to the cost of municipal water.
- Potential chlorine problems were avoided

Based on this study, Steve Cumberland indicated that he will drill an additional well or wells and utilize ozonation to treat the water for the poultry houses.

Recommendations

Based on this study, the following recommendations are being made to farmers considering the utilization of non municipal water for poultry operations:

- Contact your integrator/processor and determine their accepted sources for poultry water
- If an existing well is going to be utilized, test the water for inorganic, organic and microbial contaminants and determine the cost and availability of satisfactory water treatments

- If a new well is going to be drilled, consult your local Agricultural Extension Service for assistance
- If you wish to use a surface water source, consult your local Soil and Water Conservation District Conservationist for advice on soils, impoundments and possible sources of contamination
- Plan on testing your water sources regularly and be prepared to upgrade water treatment methods if the water source doesn't meet local water standards
- Whenever possible avoid the use of chlorinated water
- Be prepared to routinely maintain well pumps and have standby generation available to avoid disaster when the temperature is high and a thunderstorm interrupts your power supply for more than a few minutes
- When ozonation is selected for water treatment, remember there is no residual antimicrobial protection and avoid lines with dead-ends that can provide a place for microbial growth and backward water movement to an emitter

Other Applications of Ozone in Food Processing

With the preparation and acceptance of the Food Additive Petition[5] which requested that FDA and USDA approve the use of ozone as an antimicrobial agent safe to bring into contact with food products, EPRI and Global Energy Partners, LLC have been leaders in the application of ozone in agriculture and food processing. Water treatment for livestock and poultry is only one of many ozone research and demonstration programs ranging from the treatment of processed meat, poultry and fish to numerous fresh agricultural products and treatments for reducing microbial activity in stored food products.

Utility Company Involvement

The Tennessee Valley Authority (TVA) and its electrical distribution partners along with EPRI and Global want to continue to protect the public health and the sustainability of the communities it serves by promoting this technology as a safe, effective way to reduce microorganisms and other forms of contamination in our food supplies.

This successful project came about through the leadership and efforts of TVA's George (Tedd) Battles and David Salladay who gave their combined support to these research efforts to enhance the economics of poultry production in the Tennessee Valley.

[5] *Direct Food Additive Petition: Ozone as an Antimicrobial Agent for the Treatment, Storage and Processing of Foods in Gas and Aqueous Phases*, EPRI, Palo Alto, CA: August 2, 2000.

Program:

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