Reuse of Wastewater Effluent

in a

USDA Fresh Meat Packing Plant

By

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INTRODUCTION

Carolina Food Processors, a division of Smithfield Foods, Inc., is the world’s largest fresh pork production plant. Located on NC Hwy 87 south of Fayetteville in Bladen county, the plant started production in October 1992. The original design was for a single shift kill rate of 16,000 hogs per day. Since 1993, the plant has experienced a dramatic increase in the demand for its fresh meat products from both domestic and foreign clients. This has resulted in a plant expansion that started in 1994 with the addition of a Japanese product conversion room and blast chiller. Expansion continued in 1995 with the addition of hog coolers and an international product shipping cooler, and will continue into 1997 as the plant proceeds to its design kill of 32,000 head per day with the addition of a second shift.

Water consumption was originally estimated for design at 125 gallons per head, but the inexperienced labor force and rapid plant expansion resulted in an actual usage rate of 175 gallons per head. In 1994, the production water use rate had declined to ~150 gallons per head, or 2,400,000 gallons per day. At this use rate, the groundwater aquifer would be unable to supply the water necessary for full plant production. In addition, the wastewater treatment facilities were designed for a 3.4 mgd daily production flow and a 7 day equalized flow of 3 mgd. The high water use required a design review for the expansion of the wastewater treatment facilities and a permit modification for an increase in the discharge flow. The NPDES permit limits for BOD5 were 5 mg/l monthly average and 7.5 mg/l daily maximum at the permitted flow. Several discussions were held with DEM, but it was apparent that the wasteload allocation would not allow effluent limits much beyond the existing 5 mg/l.

Smithfield Foods began a review of alternate water sources in early 1994. The options were limited to construction of a surface water treatment plant or connection to a regional water utility. Neither option addressed the problem of wastewater disposal. The high operational efficiency of the wastewater treatment plant led to the idea of reusing effluent back in the production plant. Reuse would reduce the demand on the wells and reduce the discharge to the river.
APPROVAL PROCESS

Approval for the reuse of wastewater effluent in the production plant areas falls under the jurisdiction of two regulatory agencies: USDA and EPA/DEM. USDA has the primary authority for all operations in the official premises of the establishment, including livestock, production floors, utilities, and rendering. USDA had previously permitted only one other pork packing plant for water reuse and had done so through a committee that was composed of technical personnel from several divisions within USDA, FDA, EPA, and the academic community. The approval process took over 5 years.

The USDA required a written proposal of the water reuse program that contained at a minimum the following items:

- Management's Commitment and Certification
- Fail Safe System
- Separation of Human Waste from System
- Critical Control Points
- Analytical Limits
- Description of Use Points
- Cross Connection Control

The original Carolina Food Processor's "Reconditioned Water Use Program for Presentation to USDA/FESD" was a detailed, technical document. It summarized the design criteria of the wastewater treatment plant and described anaerobic, activated sludge, nitrification, denitrification and tertiary treatment processes. It also included tables of wastewater plant operational data, equipment brochures, and tables of total and fecal coliform bacteria counts from the wash water used to flush out the hog intestines. The proposal was submitted in mid 1994. After a significant review period, the USDA returned the proposal with a list of comments and questions to be addressed in the revised document. At this point, it became evident that our proposal, written from a water and wastewater perspective, was not well understood by the veterinarians and food inspection professionals who were reviewing it. Dr. Roy Carawon, with NC State, was retained to assist in a rewrite of the proposal. Dr. Carawon was on the original USDA water reuse committee and was intimately familiar with the regulatory approval process. At the same time, USDA reorganized and the water reuse program was shifted to the
Technology Assessment and Research Coordination Division (TARCD). Dr. Carawon provided valuable insight into the necessary format for our proposal. For example, no reference could be made to the use of non-potable water, wastewater, or reuse water in the production plant. USDA regulations delineate only two types of water in a production facility, potable and non-potable. In order to make the proposal acceptable in accordance with the regulations, the reuse water must be referred to as “Reconditioned Process Water” at all times.

The proposal required a detailed list of anticipated use points within the plant. This was easily developed for points such as pretreatment, inedible rendering, and utilities, which use a total of about 500,000 gallons per day. The other use points required a more substantive thought and review. A survey of the larger water use points within the plant became the starting point for that review. Livestock uses an estimated 450,000 gallons per day in overhead sprays for cooling and calming live hogs. The kill floor uses almost 300,000 gallons per day for pre-eviscerate processes such as the carcass prewash, scald tub, dehairer, polishing cabinet, and singer rail cooler. These use points, totaling 1,250,000 gallons per day, were readily acceptable to the USDA for reuse water. The last use points, chitterling and casing production, required a substantially greater degree of treatment for the reuse water, and approval was difficult to achieve. Caroline Food Processors decided to pursue these use points due to their high water consumption, a total of almost 1,000,000 gallons per day. Therefore, to produce enough reuse water for all of these use points, the reuse treatment design was set at 2.1 million gallons per day.

USDA, in the development of the guidelines for water reuse, relied upon the EPA manual, “Guidelines for Water Reuse”, EPA document number 625/R-92/004, published in September 1992. The final reconditioned process water criteria are listed in Table I. The criteria for turbidity and coliforms are direct from the Surface Water Treatment Rule and the Total Coliform Rule developed by EPA and implemented as drinking water standards. The selection of the use points for our protocol necessitated the adherence to these drinking water criteria.
**TABLE I**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.5 - 8.5 S.U.</td>
</tr>
<tr>
<td>Turbidity</td>
<td>( \leq 1 ) NTU with no more than 5% of samples ( &gt; 1 ) NTU &amp; with no samples ( &gt; 5 ) NTU</td>
</tr>
<tr>
<td>Fecal Coliform</td>
<td>None</td>
</tr>
<tr>
<td>Total Coliform</td>
<td>&lt; 5% of samples positive</td>
</tr>
<tr>
<td>Total Plate Count</td>
<td>&lt; 500 CFU/ml</td>
</tr>
<tr>
<td>Chlorine Residual</td>
<td>1 - 5 mg/l</td>
</tr>
<tr>
<td>Total Organic Carbon</td>
<td>&lt; 100 mg/l</td>
</tr>
</tbody>
</table>

USDA required that the reconditioned process water program also meet the following criteria:

- The reconditioned process water must also meet EPA *maximum contaminant levels* for heavy metals.

- A potable water rinse on all edible product and equipment that contacts reuse water.

- A "fail-safe" system of critical control points (TABLE II) must be in place that prevents substandard water from entering the end use part of the system that contacts product.

- The reconditioned process water lines will be physically separated from potable water lines with provisions made for potable water availability for standby use.
<table>
<thead>
<tr>
<th>Critical Control Point</th>
<th>Parameter</th>
<th>Acceptable Limit</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarifier Effluent</td>
<td>TSS</td>
<td>≤150 mg/l</td>
<td>Increase sampling and monitoring frequencies to assure that effluent turbidity is ≤1 NTU.</td>
</tr>
<tr>
<td></td>
<td>NH3</td>
<td>≤15 mg/l</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BOD5</td>
<td>≤50 mg/l</td>
<td></td>
</tr>
<tr>
<td></td>
<td>%UV</td>
<td>&lt;30%</td>
<td></td>
</tr>
<tr>
<td>Reconditioned Water</td>
<td>Turbidity</td>
<td>≤1 NTU with no more than 5% of samples &gt; 1 NTU &amp; with no samples &gt; 5 NTU</td>
<td>Divert filter effluent to the wastewater treatment system or shut down reconditioning system.</td>
</tr>
<tr>
<td>Filter Effluent</td>
<td>pH</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOC</td>
<td>≤100 mg/l</td>
<td></td>
</tr>
<tr>
<td>Reconditioned Water</td>
<td>Chlorine</td>
<td>≥1 mg/l</td>
<td>Divert filter effluent to the wastewater treatment system or shut down reconditioning system.</td>
</tr>
<tr>
<td>Chlorine Contact</td>
<td>Residual</td>
<td>≤5 mg/l</td>
<td></td>
</tr>
<tr>
<td>Chamber Effluent</td>
<td>(free)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TPC</td>
<td>≤500 mg/l</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fecal</td>
<td>absent in all samples</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coliform</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>present in ≤5% of the samples per month</td>
<td>Notify USDA, resample immediately, check all control points, adjust chlorine system. If second set of samples are in excess of limits, divert to wastewater plant.</td>
</tr>
<tr>
<td></td>
<td>Coliform</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The reuse water quality criteria dictated a treatment design that afforded operational flexibility and stability. A pilot study using clarifier effluent and direct sand filtration produced water with a turbidity of no less than 2 NTU. Subsequent pilot testing resulted in an equipment and chemical treatment regime similar to that used for potable water treatment. Final reuse facility design (Figures 1-4) included flocculators, parallel plate settlers, continuous backwash sand filters, and chlorination. The chemical treatment that proved effective was the use of a blended polymer/alum product as a coagulant and the application of an anionic polymer as a flocculant.

The last item to be addressed prior to the approval of our reuse protocol was the separation of the sanitary or human waste from the process wastewater. USDA regulations require that the sanitary waste piping be separated from the process waste piping within the production plant. The sanitary waste piping for the facility terminated in a lift station outside the building that also collected the wastewater from the livestock pens. From there, it was pumped to the pretreatment facility and combined with the process wastewater. The design for the reuse facility included the erection of a used package wastewater treatment plant that had been purchased from the city of Raleigh, NC. A wall was placed in the existing lift station and the piping was separated, creating two lift stations. The pen waste was still pumped to the pretreatment facilities, but the sanitary waste was now pumped to the package treatment plant.

The reuse protocol was approved by USDA in March 1996 as an in-plant trial. The trial has four phases that must be passed for final approval. Those phases are described as follows:

PHASE I - Initial Start-up

- Lasts for 10 process days.
- No use of reconditioned process water—all discharged back to system.
- Phase I analytical test parameters and frequencies (Table IV).
- Results tabulated and presented to TARCD and IIC.
Phase II - Initial Use of Reconditioned Process Water

- Initiated after review of Phase I and lasts 30 days.
- RPW used for Utility and Inedible Use only.
- Phase II analytical test parameters and frequencies.
- Results tabulated and presented to TARCD and IIC.

Phase III - Full Use of Reconditioned Process Water in Specified Areas

- Initiated after review of Phase II results with IIC and TARCD.
- Lasts for 90 calendar days, RPW used for all specified uses.
- Phase III analytical test parameters and frequencies.
- Results tabulated and presented to TARCD and IIC monthly.

Phase IV - Full Use

- Initiated after review of Phase III results with IIC and TARCD.
- Lasts for one year with automatic one year extensions.
- RPW used for all specified uses. Phase IV analytical test parameters and frequencies.
- Establish a HACCP system to include maintenance testing of physical, chemical, microbiological criteria for long term control and verification of the end use water.
- Results tabulated yearly and presented to TARCD and IIC.

START UP

Construction of the system began in August 1995 and was finished in June 1996. The system was put into operation for testing and operational training. The initial emphasis was placed upon achieving the 1 NTU turbidity required by the protocol. All attempts were unsuccessful, except operating the flocculator as a settling basin. This allowed the protocol to pass from Phase I to Phase II, allowing use of RPW in the utilities and inedible rendering areas. This operational mode would only produce 400,000 gallons per day of reuse water. A detailed analysis of the flocculator design revealed that the unit would produce a well formed floc that readily settled, but the overflow from the floc chamber, a 3 foot drop into the outlet
chamber, and an inadequate head box were shearing the floc. Design modifications were made, eliminating the outlet chamber and enlarging the transition chutes to the headbox of the plate settlers. This allowed the floc adequate formation time and slowed the velocities down so that shearing was minimized.

The original design for the plate settlers called for air diaphragm pumps to remove the settled sludge, but the units were unable to produce a withdrawal velocity adequate to “shake” the sludge loose from the inclined plates. The pumps were removed and air actuated valves were installed with a gravity line to the backwash lift station. This has produced the desired effect.

The sand filters were also having problems meeting the design flow and turbidity requirements. Microscopic examination of the filter media showed the sand to be highly irregular in shape and non-uniform in size. That sand was removed and replaced with a filter media that met the design specifications. The system has been able to consistently meet the turbidity requirement of 1 NTU since these modifications.

Several other start up problems were minor in nature. The chlorine system control was revised to include ORP and chemical feed pump sizes had to be modified. A change from caustic soda to magnesium hydroxide in the wastewater treatment plant created some operational problems that are still being resolved. The most significant operational problem has been the inadequate disinfection causing sporadic high total plate counts and positive total coliform tests. The original design utilized chlorine for disinfection. During Phases I and II, we were unable to consistently meet the protocol requirements despite high chlorine residuals and low turbidities. A chlorine dioxide generator was installed temporarily and the reuse water now meets the protocol standards for bacteria.

SUMMARY

The reuse protocol trial has successfully passed into Phase III with livestock and kill floor use points in the program. The program is scheduled to proceed to the casing use point in mid-December 1996.

The reuse water has created no problems at any of the use points except the evaporative condensers. The process wastewater treatment system maintains an
effluent temperature of ~80 degrees F. The use of this water, 20 degrees warmer than the groundwater previously used, increases the water loss in the condensers through evaporation. This additional flow was not calculated in the original projections and will limit our use points next spring. In addition, the reuse water is very costly to produce just to evaporate into the air. Plans are currently being developed to use wastewater plant effluent at this use point rather than reuse water.

The reuse program has taken a long time and considerable effort to develop, approve, and implement. For Carolina Food Processors, it has been worth the effort. Since September 1996, our groundwater withdrawal has decreased by a 20% reduction, or over 600,000 gallons per day, and our wastewater discharge has decreased by over 30%, or 750,000 gallons per day. Clearly, the water reuse program has accomplished its goals.

**Contributors**

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