SECTION H:

ENVIRONMENTAL

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SECTION H: Environmental Section

Environmental TOC 112
Environmental Assessment 112
References 120

Environmental Assessment

The proposed action requested in this notification is the establishment of a clearance to permit the use of monochloramine (NH_2Cl) as an antimicrobial agent in water used in immersion chillers during poultry processing at levels not to exceed 50 ppm. Monochloramine will be added to the immersion chiller water, into which poultry carcasses will be submerged to control the growth of pathogens and to minimize the probability of cross contamination during the chilling process.

The monochloramine used in this process will be generated on site at the poultry processing plant *via* an automated, controlled process, which meters in food-grade starting materials (hypochlorous acid and ammonia) to chiller in-flow lines containing potable water. In this process, monochloramine is formed from the almost instantaneous reaction of hypochlorous acid and ammonia, which results in a continual supply of monochloramine in the immersion chiller water. After its use in poultry processing, the monochloramine-treated chiller water is discharged into the viscera flume and becomes part of the total process water effluent to be treated by an on-site wastewater treatment plant or local publicly owned treatment works (POTW) as illustrated below.

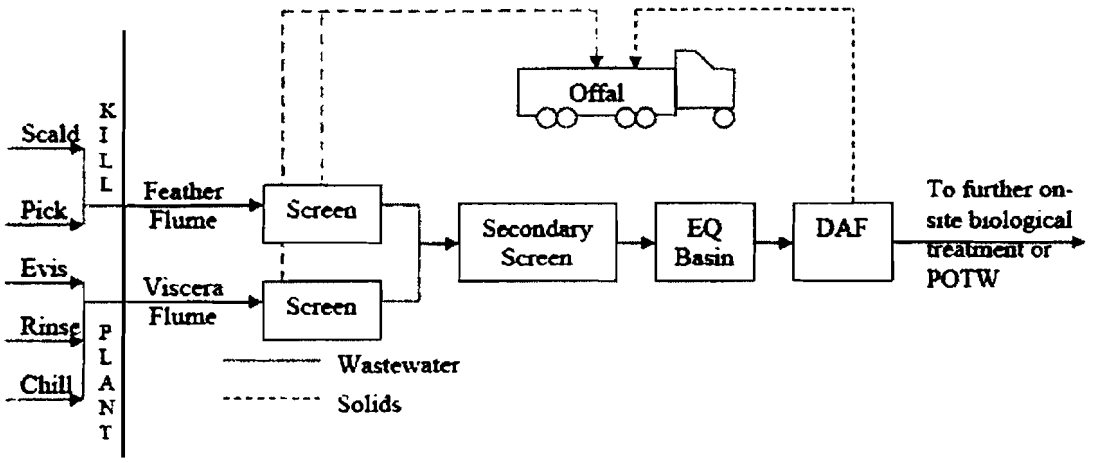

Figure H1. Typical poultry plant process water flow

The used immersion chiller water will only represent a small *percentage* of the total process water effluent that will be treated by the on-site wastewater treatment plant or the local POTW. During the wastewater treatment process, the process water effluent is dechlorinated if necessary, nitrified and denitrified, which reduces the monochloramine present to the chloride ion and nitrogen gas. Approval of this action as described will improve the efficacy of chiller water antimicrobial treatments, reduce the quantities of chlorination chemicals currently used, and will not adversely effect the environment.

The substance that is the subject of the proposed action is monochloramine (CAS Number 10599-90-3). Monochloramine is a colorless to yellow liquid and has a molar mass of 51.48 g/mol. It is formed by the combination of ammonia and hypochlorous acid as illustrated below:

$$NH_3 + HOCl \rightarrow NH_2Cl \text{ (monochloramine)} + H_2O$$

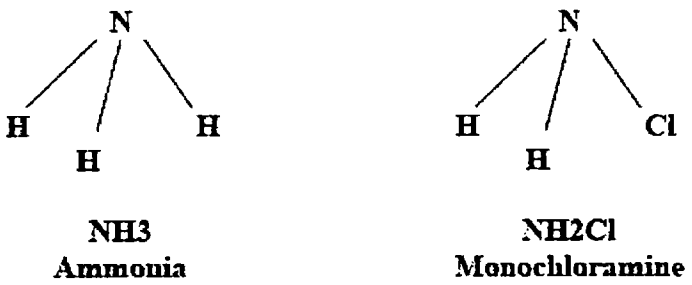

Figure H2. Chemical structure of ammonia and monochloramine

Monochloramine has also been granted prior approval for use as an antimicrobial by the U.S. EPA for use in potable water and by the FDA for use in bottled water at levels up to 4 ppm.

Monochloramine is manufactured on site by the controlled addition of an approved NSF chlorine source (such as sodium hypochlorite, calcium hypochlorite, or gaseous chlorine) and ammonia source (such as ammonium chloride, liquid ammonium sulfate, or ammonium hydroxide) into a fresh water stream at ratios commonly used in POTW. Both ammonia and chlorine are readily soluble in water and are considered to be completely dissolved in the water stream during the monochloramine manufacturing and treatment process. This process leaves no outlet for discharge of monochloramine or its components to the environment as a result of manufacture.

Monochloramine will be used at levels not to exceed 50 ppm in poultry immersion chiller water.

The literature indicates that during the immersion chilling process monochloramine is not incorporated in the chickens themselves, as it does not tend to react with organics, but remains in the process water providing an antimicrobial residual (Axtell *et al.*, 2006). Monochloramine is similarly not expected to adhere to the offal for the same reasons it does not adhere to the chickens during the chilling process. It is expected that virtually 100% of monochloramine will remain in the chiller water and the wastewater stream.

Over time, however, monochloramine can hydrolyze and dissociate into its component parts as shown below. Should dissociation occur, the mix of products produced will depend on the pH of the solution.

$$NH_2Cl + H_2O \rightarrow HOCl + NH_3$$

and/or

$$NH_2Cl + H_2O \rightarrow OCl^- + NH_4^+$$

A brief discussion of the fate of the dissociation products in the immersion chiller follows. The immersion chiller water carries an exceptionally high organic load such that a free chlorine (HOCl and OCl^-) residual cannot be established even with the addition of up to 400 ppm free chlorine. (Tsai *et al.*, 1992). If monochloramine dissociation were to occur, the free chlorine would immediately react with some constituent of the chiller water en route to its eventual reduction to the chloride ion which would not react further. Due to the high solubility of gaseous ammonia (NH_3), it and the ammonium ion (NH_4^+) would remain in the water and eventually be discharged to the on-site wastewater plant or the POTW as applicable.

All the effluent from a poultry processing plant is either processed by an on-site wastewater treatment plant or is discharged to a POTW for treatment. Potable water containing up to 4 ppm monochloramine can be used and discharged directly to the environment without any treatment whatsoever. Levels of monochloramine and its dissociated components introduced into the environment from use in this application are far less than that introduced into the environment as a result of the use and disposal of monochloramine treated potable water.

The capacity of the immersion chillers in a typical poultry plant will be enough to hold the carcasses from two high speed processing lines (140 birds *per* minute) long enough to reduce the temperature of the carcasses to less than 40° F. Depending on the size of the processed chickens, this could take between one and two hours. Assuming the chiller would be able to hold 1½ gallons of water *per* bird the chiller capacity would be 50,400 gallons (140 birds/min x 2

lines x 120 min x 1.5 gal/bird = 50,400 gallons). In addition to the volume of water in the chillers, USDA has recommended that plants add ½ gallon make-up water *per* bird to the chillers. Following these guidelines a plant processing 200,000 birds *per* day would use a total of about 150,400 gallons of process water in the chillers (200,000 x 0.5 + 50,400 = 150,400). (Kiepper, Brian Harry, 2003).

It has been estimated that a poultry plant uses between 5 and 10 gallons of water *per* processed bird. The concentration of monochloramine in the total effluent process water therefore would range between 3.76 ppm and 7.52 ppm:

50 ppm x 150,400 gal / 2,000,000 gal = 3.76 ppm

50 ppm x 150,400 gal / 1,000,000 gal = 7.52 ppm

These extremes bound the 4 ppm allowable level of monochloramine in potable water supplies. The process water effluent is discharged into the environment *via* either a POTW or an on-site wastewater treatment plant.

If all the chiller and chiller make-up water in the processing plant were treated to the maximum concentration of 50 ppm monochloramine the total amount of monochloramine used in a day would be:

50,400 gal chiller + 200,000 birds/day x 0.5 gal/bird make-up = 150,400 gal/day

150,400 gal/day x 3.785 L/gal = 0.569264 x 10^6 L/day = 0.569264 x 10^6 kg water/day

0.569264 x 10^6 kg water/day x 50 mg MON/kg x 1 kg/10^6 mg = 28.46 kg MON/day

In addition to the worst case monochloramine concentration of 7.52 ppm contributed by the chiller treatment, the effluent process water will also typically contain about 20 ppm of ammonia that it picks up from birds during the slaughter process. Although a 5:1 chlorine (as Cl_2) to ammonia-nitrogen ratio is all that is necessary to produce monochloramine, a slight excess of ammonia-N is typically added to ensure each molecule of hypochlorous acid has the opportunity to combine with a molecule of ammonia. Therefore a 4:1 chlorine to ammonia-N ratio is more frequently used in the manufacturing process. Given a 20 ppm ammonia

concentration in the process water effluent from the slaughter process, the ammonia constituent of monochloramine manufactured at a 4:1 ratio would add about 1.565 ppm (7.52 / 4 = 1.88) to the effluent raising the total to 21.88 ppm, less than a 10% increase.

To further illustrate the negligible impact this proposed treatment could have on the environment, we will calculate an environmental introduction concentration (EIC) assuming that 100% of the maximum allowable dosed monochloramine remains in tact throughout the on-site treatment process and arrives at a POTW that processes 25 million gallons of water *per* day:

25M gal/day x 3.785 L/gal = 9.46×10^7 L/day

7.52 ppm MON x (7.57×10^6 L/day plant effluent)/(9.46×10^7 L/day) = 0.6 ppm

Under this theoretical scenario, the POTW influent would contain a maximum concentration of 0.6 ppm monochloramine, a fraction of the level the POTW can add to the finished water entering the potable water distribution system.

The ammonia component of the monochloramine is normally removed in either the POTW or the on-site wastewater plant in a biological nitrification-denitrification process. The water supply feeding the biological process is generally dechlorinated first to avoid depleting the population of nitrifying bacteria.

Following is a brief summary of the nitrification-denitrification process used to biologically remove ammonia from waste water. In the nitrification step the oxygen demand is reduced by converting the ammonia to nitrate in a process using *Nitrosomonas* and *Nitrobacter* bacteria. *Nitrosomonas* oxidizes ammonia to nitrite while *Nitrobacter* further oxidizes the nitrite to nitrate. Nitrification involves a complex series of reactions that can be approximated by the following equations: (Metcalf and Eddy, 1991).

For *Nitrosomonas*:

$$55NH_4^+ + 76\ O_2 + 109\ HCO_3^- \rightarrow C_5H_7O_2N + 54\ NO_2^- + 57\ H_2O + 104\ H_2CO_3$$

For *Nitrobacter*:

$$400\ NO_2^- + NH_4^+ + 4\ H_2CO_3 + HCO_3^- + 195\ O_2 \rightarrow C_5H_7O_2N + 3\ H_2O + 400\ NO_3^-$$

After the nitrification step, the nitrate is removed from the wastewater by converting it to gas during the denitrification process. Several genera of bacteria are capable of accomplishing denitrification, including *Achromobacter, Aerobacter, Alcaligenes, Bacillus, Brevibacterium, Flavobacterium, Lactobacillus, Micrococcus, Proteus, Pseudomonas, and Spirillum.* They first convert nitrate to nitrite followed by further reduction nitrite to Nitric oxide, nitrous oxide and nitrogen gas. This process is summarized below:

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

Nitric oxide (NO), Nitrous oxide (N_2O) and nitrogen (N_2) are all gases that can be released to the atmosphere, completing the nitrification-denitrification process used for removing ammonia from a water source. (Metcalf and Eddy, 1991). *Wastewater Engineering, Third Edition*)

As discussed above, monochloramine introduced to treat a poultry processing immersion chiller will likely be entirely consumed or reduced to the end products (chloride ion and nitrogen gas) of its dissociated components (hypochlorous acid and ammonia) in the wastewater treatment process. Nitrogen gas will be released to the atmosphere completing the nitrogen cycle and the chlorides will join the ubiquitous presence of chlorides already existing in naturally occurring waters. (White, 1999). Also, as previously discussed, if the entire concentration of monochloramine introduced at the poultry plant passed through both the on-site and the POTW treatment processes completely intact, the concentration entering the POTW distribution system would be 0.6 ppm. This is nearly seven times less than the EPA established limit on levels of monochloramine that can be added by the POTW to maintain a residual monochloramine concentration of 4 ppm in the potable water distribution system.

Every poultry processing plant sends its effluent water to a wastewater treatment plant where contaminants such as chlorine and ammonia are removed prior to discharge to the environment. All processing plants introduce ammonia into the wastewater stream which is removed by nitrification and denitrification processes at the attendant wastewater treatment plants. Processing plants are likewise required to use chlorine in their process which is also removed prior to discharge to the environment. The addition of monochloramine to the

immersion chilling process has a negligible effect on these existing treatment processes which nitrify, denitrify and dechlorinate to meet existing discharge permits. There are no anticipated environmental effects of released substances (nitrogen gas and chloride ions) due to treating immersion chillers with monochloramine.

The use of monochloramine in poultry immersion chillers will not require additional energy resources for treatment and disposal of waste water since virtually all existing systems currently chlorinate, dechlorinate and operate biological systems to eliminate ammonia through biological nitrification-denitrification processes. Raw materials used for the on-site manufacture of monochloramine are all NSF approved chemicals.

No adverse environmental effects are expected by the intended use of monochloramine in poultry processing plant immersion chillers and therefore no new mitigation measures of any kind are anticipated to be required.

Approval of this FAP would result in no adverse effects on the environment. Alternatives that would be employed should this FAP not be approved are the continued use of existing antimicrobials in the immersion chilling process. The most prolific antimicrobial used in this application is chlorine, which as indicated by the literature requires substantially higher concentrations than that of monochloramine to achieve comparable results in indicator and pathogenic bacteria. (Russell S. M. *et al.*, 2004). Approval of this FAP would potentially reduce the quantity of chlorination chemicals (*i.e.* sodium hypochlorite, calcium hypochlorite, etc.) currently used in plants treating their immersion chillers with free chlorine.

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