Control of Trihalomethanes (THM's) In Wastewater

By

Philip S. Bober,
Operations Superintendent,
Wayne Township

A viable solution exists for wastewater treatment plants using sodium hypochlorite to decrease or eliminate the formation of THM's, without losing any disinfection potential. This is accomplished by simply controlling the amount of Ammonia-N in the effluent.

Wayne Township Process Description

The Mountain View STP is owned and operated by the Township of Wayne, New Jersey. This plant is designed as a 13.5-mgd plug flow system and consists of primary treatment, equalization, surface aerators which provide a complete mix within each of four basins, lime addition, secondary settling, chlorination/dechlorination and post aeration. Currently, the daily flow ranges between 6.5 and 9.5 mgd with a yearly average of 8.5 mgd.

The aeration system has been altered to operate as a modified step aeration facility. In that mode and with additional alterations made to the secondary clarifier tanks, the facility has performed consistently well. It has produced an effluent with a CBOD5 and TSS in the 1-3 mg/l range and Ammonia-N in the 0.1 to 0.2 mg/l range for the last 15 years.

The facility discharges to the Singac Brook, which directly feeds the Passaic River just below the joining of the Passaic and Pompton Rivers at Two Bridges. This entry point in the Passaic is between the two drinking water intakes of the Passaic Valley Water Company.

Definition of Trihalomethanes (THM's):

A THM is simply any single carbon atom containing any three halides. Halides are any elements from group VII of the periodic table. Common halides found in wastewater are chlorine, bromine and sometimes iodine. Hence, there can be many different THM's. However, for the purposes of this paper, THM will be used to describe only the following four: Chloroform, Dichlorobromomethane (DCBM), Dibromochloromethane (DBCM) and Bromoform.

Importance of THM's in Wastewater:

Both EPA and DEP have determined that prolonged exposure to the above four THM's has been known to cause several types of cancers in humans. For this reason, Surface Water Quality Standards have been developed and regulated at the discharge point of wastewater plants for all of them. In New Jersey, these standards are some of the most stringent in the world. Hence, DEP will be requiring the removal of THM's to meet these standards for any wastewater plant producing them. Several plants (including Wayne Township) have already received limits on THM's.

Conventional Control of THM's:

While this paper will not delve into detail on them, the conventional methods for THM removal revolve around the replacement of sodium hypochlorite. Methods which will not produce THM's include: Granular Activated Carbon, Chlorine Dioxide, Ozonation, Ultraviolet and Chloramination. Except for the latter; chloramination, all the other methods will have a high capital and operating costs and/or create other byproducts which may simply trade one problem for another in the future.

Chloramination has a different problem. The process is defined as the total replacement of free chlorine with monochloroamine by reacting HOCl with ammonia. This yields a disinfectant which needs more time to disinfect than most treatment plants can provide within their chlorine contact tanks. This extra time is needed due to monochloroamine being a poorer disinfectant than free chlorine. Hence, the procedure as defined will usually produce permit problems with fecal coliform counts.

Experimental Method of THM Control:

In a strategy session with Somerset Raritan, a facility which also has THM removal requirements, Wayne Township was told that their THM concentrations would drop or disappear as their effluent Ammonia-N levels varied.

When Ammonia-N concentrations are very low (0.1 range), THM formation will occur and may be a future permit problem. Hence, to control Ammonia-N in a facility that is performing excellently for Ammonia-N removal, Wayne decided to incorporate a small feed of Ammonia-N at the secondary settled effluent point to control this ion in the needed ranges. The key for this success is NOT to remove all the free chlorine!

Progress at Wayne Township:

At first, a bench scale test simulating our disinfection system was duplicated in the laboratory. Using the operational parameters found in the plant, a series of tests were conducted with this laboratory vessel. A typical result is shown below:

Table 1: Typical Laboratory Results

	mpn	Ug/l	Ug/l	Ug/l	Ug/l	Mg/l
	F. Coliform	Chloroform	DCBM	DBCM	Bromoform	Ammonia-N after Dechlorination
Effluent Before Chlorination	5200	<0.25	<0.34	<0.32	<0.81	n/a
1.0 ppm Total Chlorine	6	**4.6**	**2.2**	**0.78**	<0.81	0.12
0.5 ppm Ammonia-N + 1.0 ppm T. Chlorine	0	**0.71**	**<0.34**	**<0.32**	<0.81	0.58

The above table shows that a normal dosage of 1.0 ppm Total Chlorine will produce three of the four THM's of concern at Wayne Township while producing a satisfactory Fecal Coliform kill. The amount of Ammonia-N found in this trial was in the low range where THM's certainly form. However, adding 0.5 ppm Ammonia-N to produce a T. Chlorine : Ammonia-N ratio of 1 : 0.5, gave a better Fecal Coliform kill, reduced the chloroform by almost an order of magnitude and eliminated the bromonated THM's originally formed down to wastewater detection limits. Bromoform had not formed at Wayne Township in any testing performed.

The amount of Ammonia-N remaining in the effluent after dechlorination appeared to come close to a total of the ammonia present before addition and that of the addition itself. It was assumed that one would get back for discharge then, a total amount equaling the two values.

To prove that free chlorine exists throughout the contact tank during the testing, another run, with a different T. Chlorine to Ammonia-N ratio, was checked for free chlorine. The results are listed in table 2.

Table 2: Free chlorine measurements using a T. Chlor : NH3-N Ratio of 1 : 1

30 sec.	1 min.	5 min.	15 min.	30 min.
0.76	0.5	0.23	0.18	0.12

Initial plant trials showed that twice as much Ammonia-N was needed than in laboratory trials. In the initial plant trials, the Township used a metered solution to add the Ammonia-N which was probably giving mixing problems. Hence, an increase to a T. Chlorine : Ammonia-N ratio of 1 : 1 was used to achieve the same level of performance found in the laboratory. Table 3 shows a typical result on a plant scale.

Table 3: Plant Scale Results – T. Chlor. : NH3-N = 1 : 1

Dosage	Chloroform ug/l	DCBM ug/l	DBCM Ug/l	Bromoform ug/l	Ammonia-N mg/l
Chlorination with 1.0 ppm T. Chlorine	5.7	4.3	1.8	<0.81	0.2
1.0 ppm Ammonia-N plus 1.0 ppm T. Chlorine	0.81	<0.34	<0.32	<0.81	0.6

While the ratio of T. Chlorine to Ammonia-N had to be increased in the plant, a phenomenon probably due to mixing, the results are the same. Chloroform is again dropped almost an order of magnitude and the two bromonated THM's produced disappear below wastewater detection limits. However, we have only received about one half the Ammonia-N back that was expected!

Because of this Ammonia-N result, a plant scale test was conducted that varied the T. Chlorine : Ammonia-N ratios for 1 : 0 to 1 : 1 in 0.25 increments in order to determine how the effluent Ammonia-N levels were varying with the anticipated amounts to be found.

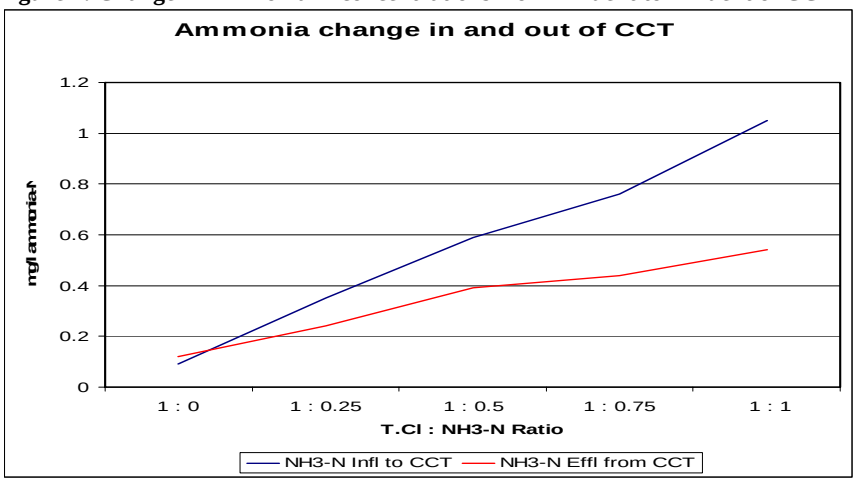
In addition, a powder feeder was substituted for the solution feeder originally used. This allowed the addition of much greater amounts of dilution water (5 gpm rather than 0.5 gpm) in a hope of obtaining better mixing. The results are shown in the following tables and figures.

Table 4: Ammonia-N variation in effluent sampling

Desired T.Cl : NH3-N ratio	NH3-N Infl to CCT	NH3-N Effl from CCT
1 : 0	0.09	0.12
1 : 0.25	0.35	0.24
1 : 0.5	0.59	0.39
1 : 0.75	0.76	0.44
1 : 1	1.05	0.54

A graphical representation of the above is shown in figure 1 below.

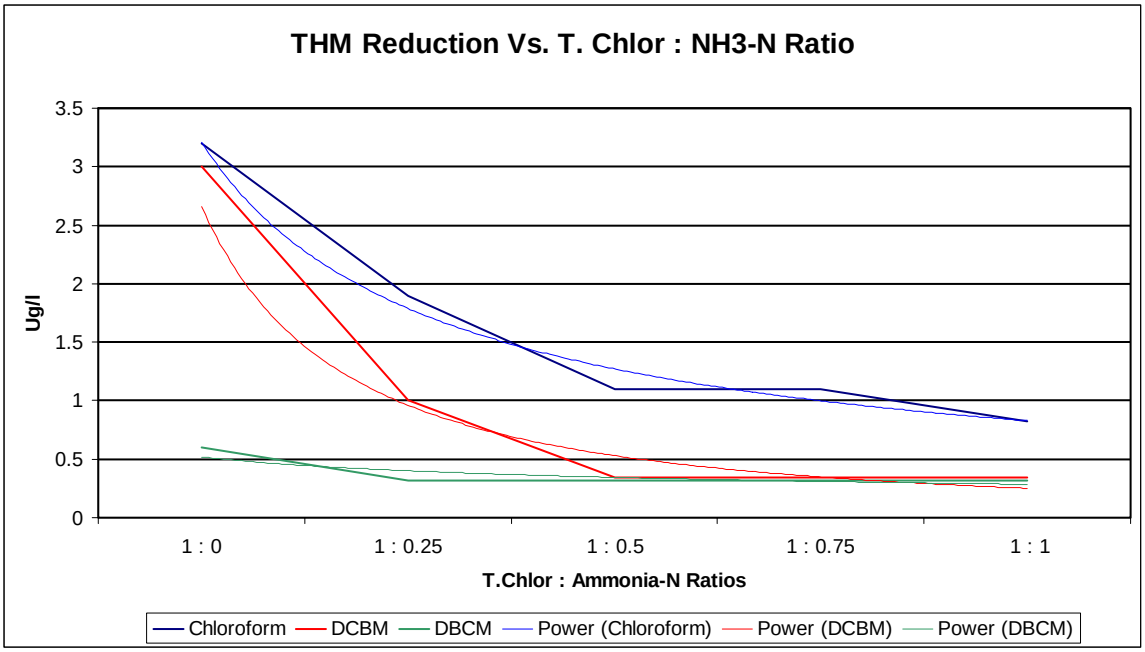
Figure 1: Change in Ammonia-N concentrations from Influent to Effluent of CCT



The two lines have a correlation coefficient of 0.99 showing there is a divergence of Ammonia-N concentrations between what has been added to what is found and the plant discharge after dechlorination as the T. Chlorine : Ammonia-N ratios increase toward 1 : 1.

The above test was also conducted for the THM's formed. The degree of THM formation vs. T. Chlorine to Ammonia-N ratios is given in Figure 2.

Figure 2: Reduction of THM's with Changing T. Chlorine : Ammonia-N Ratios



It is now evident that switching to a powder feeder for Ammonia-N addition and being able to add higher amounts of dilution water for better mixing will allow plant dosages close to that being achieved in the laboratory.

Sources of Ammonia-N:

Almost any source supplying the ammonium ion can be used. Originally, Wayne Township used Ammonium Bicarbonate due to its chemical identity to the bicarbonate

buffer system the nitrification process produces. It worked well, but had cost and odor problems due to its stability. Currently, Wayne Township is using Ammonium Sulfate as its source. It is inexpensive, stores well, has a proven safety track record with the water companies and gives two moles of Ammonia-N for every mole of Ammonium Sulfate used, $(NH_3)_2SO_4$.

Cost Savings Over Other THM Reduction Methods:

Below is a table summarizing the cost of several methods and comparing it to the Ammonia-N addition method with Wayne Township had accumulated during its study of the problem.

Table 5: Cost Comparison of THM Removal Methods

THM Removal Method	Capital Cost	Operation/Maintenance	Total Cost After 20 Years (Capital + O&M)
Granular Activated Carbon	**$2,200,000**	**$110,000**	**$4,400,000**
Ozone	**$2,500,000**	**Investigation Cancelled**	**$4,500,000**
Ultraviolet	**$4,500,000**	**$201,000**	**$8,500,000**
Ammonia-N Addition	**< $50,000***	**$13,200**	**$314,000**

*** Ammonia-N analyzer cost is $30,000 of total. Less expensive analyzers exist.**

Conclusions:

1.) It appears that a facility, disinfecting with any type of chlorine and experiencing THM formation, may have an option of exploring slight amounts of ammonia addition to prohibit their formation. This small amount of Ammonia-N addition should be well within state permit limits. The Ammonia-N addition must be careful not to destroy all of the free chlorine produced, but is set such that a blend of monochloroamine and free chlorine exist simultaneously throughout the contact tank. In accomplishing such, one will also receive a better disinfection than using free chlorine alone!

2,) Since we are only adding a slight amount more Ammonia-N than what is already present, the chances of producing any other byproducts should be extremely slim. Indeed, many other facilities are producing effluent Ammonia-N concentrations in the amounts proposed here simply due to the type of processes they are running.

3.) Checking with toxicity professionals it has also been learned that placing this additional 0.5+ ppm Ammonia-N into the effluent should not have any detrimental effect on cWET toxicity.

Recommendations:

If one desires to study the above process on their system, it is recommended to work in the laboratory first. If success is achieved, seek engineering advice. If a process can be technically achieved, seek legal advice. If, through discussion with all parties mentioned, a formal submission can be written which had preliminary budgeting, then seek to discuss this with the DEP. The Department is very interested in the progress of this method. If your proposal looks promising and there is a commitment by the plant to implement this, an Upset Defense Letter may by issued.