

NOCARDIOFORM FOAM CONTROL IN A BNR PLANT

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ABSTRACT

For several years, the San Jose/Santa Clara Water Pollution Control Plant has conducted full-scale testing of various nocardioform foam control methods. First, chlorine solution was sprayed over the nocardioform foam area at a dose of 0.5 – 1 mg/L based on wastewater flow. Operation of the chlorine spray system over a one-year period showed that this method controlled, but did not completely eliminate the nocardioform foam. The second method was the addition of cationic polymer to the return activated sludge wet well. The optimum polymer dosage was 0.4-0.5 mg/L based on wastewater flow. Polymer addition completely eliminated foam for several weeks. Finally, the plant implemented automatic control of solids retention time based on continuous instrumental in-situ measurements of mixed liquor and return activated sludge suspended solids concentrations. Since its implementation, no nocardioform foam has been observed.

KEYWORDS

Nocardia foam, automatic waste control, activated sludge, MCRT.

INTRODUCTION

The San Jose/Santa Clara Water Pollution Control Plant (SJ/SC WPCP) is currently in the process of converting its existing activated sludge system from a two-stage, in-series carbonaceous-then-nitrification plant to a single stage parallel BNR plant. This conversion will increase the biological capacity of the plant from 7.3 m³/sec (167 MGD) to 9.6 m³/sec (220 MGD) without additional major construction. The plant conversion was based on data collected during a 4-year long 0.88 m³/sec (20 MGD) "pilot plant" study (Ekster and Jenkins, 1996). The nocardioform organism control methods employed during the pilot plant study will be discussed in this paper.

METHODS AND MATERIALS

The nocardioform organism control methods used were (1) sodium hypochlorite (NaOCl) solution mist spray on the mixed liquor surface (Jenkins *et.al.*, 1993), (2) high-charge-density cationic, polyacrylamide-based polymer addition to the RAS (Shao *et.al.*, 1997) and (3) automatic waste activated sludge (WAS)

flow rate control based on instrumental analysis of mixed liquor suspended solids (MLSS) and return activated sludge (RAS) SS.

The BNR pilot plant consisted of two adjacent aeration basins and three secondary clarifiers in (but isolated from) the secondary activated sludge system. Each aeration basin was a 10,410 m³ (2.75 MG) rectangular tank divided by baffles into four equal-sized compartments (quads). The inter-quad transfers and the basin inlets and outlets were subsurface so that foam was trapped in the aeration basins. Both Quads 1 and 3 could be fed with primary effluent; RAS could be fed to Quad 1. Aeration was by coarse-bubble diffusers. Two of the secondary clarifiers were 29.9 m (98 ft) diameter, 3.6 m (12 ft) deep, peripheral feed and overflow, and one was 42.7 m (140 ft) diameter, 3.8 m (12.5 ft) deep, peripheral feed and overflow.

During the pilot plant study nocardioform foaming became problematic with foam overflowing the aeration basin freeboards and accumulating in the secondary clarifier peripheral feed channels. Odors and dangerous working conditions resulted. The first response to this foaming was to install a system for delivering a fine mist spray of 12.5% NaOCl solution to the surface of Quad 2 of the aeration basin (Jenkins *et.al.*, 1993).

The NaOCl solution surface spray consisted of a 1.89 m³ (500 gal) storage tank for 12.5% NaOCl solution, a metering pump, a mixing manifold, an eductor and valving for dilution of the NaOCl solution to 3 g NaOCl/L with No. 3 water (chlorinated filter effluent) and spray bars (connected to the mixing manifold with hoses) to distribute a fine mist spray on a 7.6 m (24.8 ft) long section of the surface across the width of the aeration basin (Figure 2). The spray bar was installed in a rigid frame that positioned it precisely and provided a structure on which to hang a Hypalon® shroud that trapped the foam beneath the sprays, directed the spray down on to the foam and prevented overspray.

The second nocardioform foaming control method involved the installation of a polymer dosing system (Figure 3) for adding a high-charge-density polyacrylamide-based cationic polymer to the mixed liquor

(Shao *et.al.*, 1997; Shao and Kaporis, 1997). The polymer dosing system consisted of a 18.9 m³ (5000 gal) storage tank for neat polymer solution, a gear pump and mixing manifold to dilute the neat polymer with No.3 water, a 0.945 m³ (250 gal) day tank for diluted polymer solution, and a pump to feed the dilute polymer solution to the RAS lines between the RAS pump and the aeration basins.

The third, and finally-adopted, nocardioform foaming control method was to operate the BNR activated sludge system at a constant MCRT using automatic sludge wasting based on in-situ instrumental analyses of TSS in the mixed liquor and in the RAS using suspended solids meters, a controller (Fischer-Porter System 6.0) and a flow loop with motorized valve (Figure 4).

The MLSS and RAS meters sent signals to the PID controller that calculated the MCRT, compared it with a set point MCRT and then the WAS flow rate was adjusted. Proportional gain and reset time for the PID controller were calculated based on computer analysis of the dynamic characteristics of the SJ/SC WPCP activated sludge system (Ekster *et.al.*, 1997).

RESULTS AND DISCUSSION

Satisfactory nocardioform foam control was obtained at NaOCl doses of 0.5-1.0 mg Cl₂/L based on the wastewater flow. Figure 5 shows that whenever the NaOCl surface spray was turned off, the foam coverage of the aeration basins increased. While the NaOCl surface spray was operating, the aeration basin surface foam coverage remained below 20%. In spite of this, there did not seem to be a direct relationship either between surface foam coverage and mixed liquor nocardioform counts or between the surface NaOCl dose and mixed liquor nocardioform counts. This could mean that the nocardioform organisms killed by the NaOCl spray were limited to those present in the foam layer and possibly those present in the liquid layer at the very surface of the mixed liquor. It is quite likely that the chlorine demand is so rapid in mixed liquor that very little penetration of chlorine species into the bulk mixed liquor occurs. This observation is consistent with the experiences derived from the use of chlorine for bulking control. With good mixing at the chlorine dose point it is impossible to measure a chlorine residual even at very short distances from the dose point. The observation is further supported by the data on effluent

dissolved copper (Cu) concentrations presented in Figure 5. Note that the BNR effluent almost always has somewhat a lower dissolved Cu concentration than the secondary effluent. This shows that the NaOCl surface spray did not adversely affect dissolved Cu removal. Recent work at the SJ/SC WPCP (Ekster and Jenkins, 1996) showed that small doses of chlorine to activated sludge effluent instantaneously increased dissolved Cu concentrations by solubilizing Cu from the activated sludge TSS present in the effluent. That no such effect was seen from the use of the NaOCl surface spray is further evidence that the NaOCl exerts its influence only at the very surface of the mixed liquor.

Dosing of the high-charge-density cationic, polyacryamide-based polymer (Polydyne Clarifloc® C-331) for periods of 3-10 days was used to control nocardioform foam on three occasions. During the first test period (July 1996) aeration basin foam and scum levels in the secondary clarifier feed channels were noticeably reduced after one day of intermittent polymer dosing at 0.5 mg/L based on wastewater flow. After 2-3 days of continuous polymer dosing at 0.5 mg/L the foam and scum had virtually disappeared. During the second test period (January-March 1997) a polymer dose of 0.2 mg/L controlled foaming most of the time but did not completely eliminate it. Increasing the polymer dose to 0.4-0.5 mg/L controlled the foam. During the third test period (April 1997) foam and scum were controlled within 5 days using a polymer dose of 0.35 mg/L.

Besides being economically more attractive (Table 1) and safer (it did not involve spraying a dangerous and corrosive mist) the polymer addition method was favored over the NaOCl surface spray system.

Following the installation of automated sludge wasting based on a constant MCRT and continuous in-situ measurements of MLSS and RAS TSS, no incidents of nocardioform foaming have occurred. It is suggested that the reason for the absence of nocardioform foaming is that MCRT control with automatic sludge wasting allows for much less variation in discrete MCRT values than does manually-controlled wasting based on laboratory TSS analyses. This point is illustrated by the MCRT data in Figure 6. During manually controlled sludge wasting based on daily laboratory TSS analyses (1995-1996 data) there are many incidents of very high MCRT. These may have been caused by errors in analyses or

operation because of the relatively infrequent data collection and waste flow adjustments. With continuous TSS measurements and automatic sludge wasting control, there were no incidents of very high MCRT. The automatic sludge wasting system was very robust due to built-in automatic fault/error detection functions. It is our hypothesis that the periods of very high MCRT encountered during manual sludge wasting control based on daily laboratory TSS analyses encouraged the growth of nocardioforms that float or foam. These organisms concentrate in the foam layer and are retained in the activated sludge system by the surface-foam-trapping features of the aeration basin even when the MCRT is lowered. Also note that with automatic MCRT control it was possible to operate in a nocardioform foam-free condition with a higher average MCRT (6.3 days) than with manual activated sludge wasting based on daily laboratory TSS analyses (5.1 days).

The following economic analysis shows that automatic MCRT control is the most favorable nocardioform control method. Thus the NaOCl surface spray capital cost is \$800,000 – \$1,000,000 and its operating cost is \$15,000 – \$20,000, resulting in a present worth cost of \$1,050,00. For polymer addition these costs are: capital, \$100,000; operating, \$50,000 – \$70,000 and present worth, \$600,000. The capital cost for eight MCRT control systems is \$96,000. The license fee for use of this method is not known and not included (Table 1). Implementation of the automatic sludge wasting MCRT control system is estimated to save \$18,400 annually because even though its annual operating cost is \$21,600, it allows the elimination of laboratory TSS tests costing \$40,000/year. Thus the present worth savings for the automatic MCRT control system are estimated at \$95,000.

CONCLUSIONS

1. Nocardioform foaming in a BNR activated sludge plant was controlled by a surface spray of a 3 g NaOCl/L solution at a dose of 0.5-1.0 mg Cl_2 /L (based on wastewater flow).
2. Nocardioform foaming in a BNR activated sludge plant was controlled by the addition of 0.4-0.5 mg/L (based on wastewater flow) of a high-charge-density cationic polyacrylamide-based polymer.

3. Nocardioform growth and foaming in a BNR plant was controlled at an MCRT of 6.3 days by automatic sludge wasting based on continuous in-situ instrumental analysis of MLSS and RAS SS. With manual control of activated sludge wasting based on daily, laboratory TSS measurements it was impossible to control nocardioform growth or foaming at an average MCRT of 5.1 days. This was attributed to the trapping of nocardioform organisms that grew during the periods of high MCRT that were encountered with manual sludge wasting and infrequent laboratory TSS analyses.
4. Automatic sludge wasting based on in-situ TSS analyses was the most economical nocardioform foam control method.

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Table 1. Capital, Annual Operation and Maintenance Costs and Present Worth of the NaOCl Surface Spray, Polymer Addition, and MCRT Control Systems.

Costs	NaOCl Surface Spray, \$	Polymer Addition, \$ ¹	MCRT Control, \$
Capital	800,000 - 1,000,000	100,000	96,000
O & M	15,000 - 20,000	50,000 - 70,000	- 18,400 ³
Present Worth ²	1,050,000	600,000	- 95,000 ³

1. Does not include license fee
2. Net worth calculations assume 5% interest and 15-year life
3. Negative sign represents savings

Figure 1. Aeration basin schematic showing flow pattern, NaOCl spray point, cationic polymer addition point, and location of TSS meters.

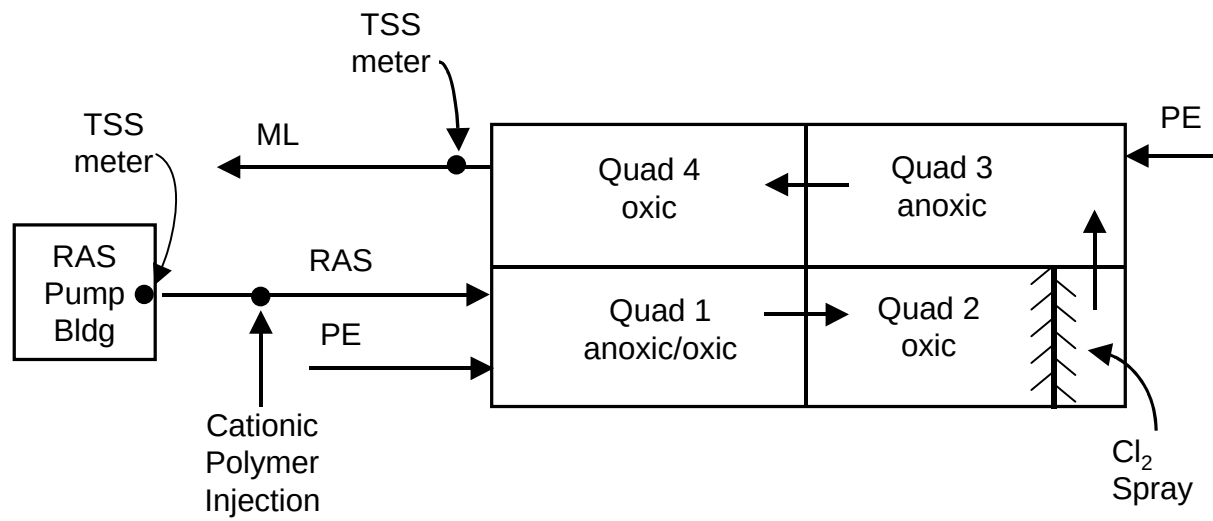


Figure 2. Surface mist spray chlorination system for nocardioform foam suppression.

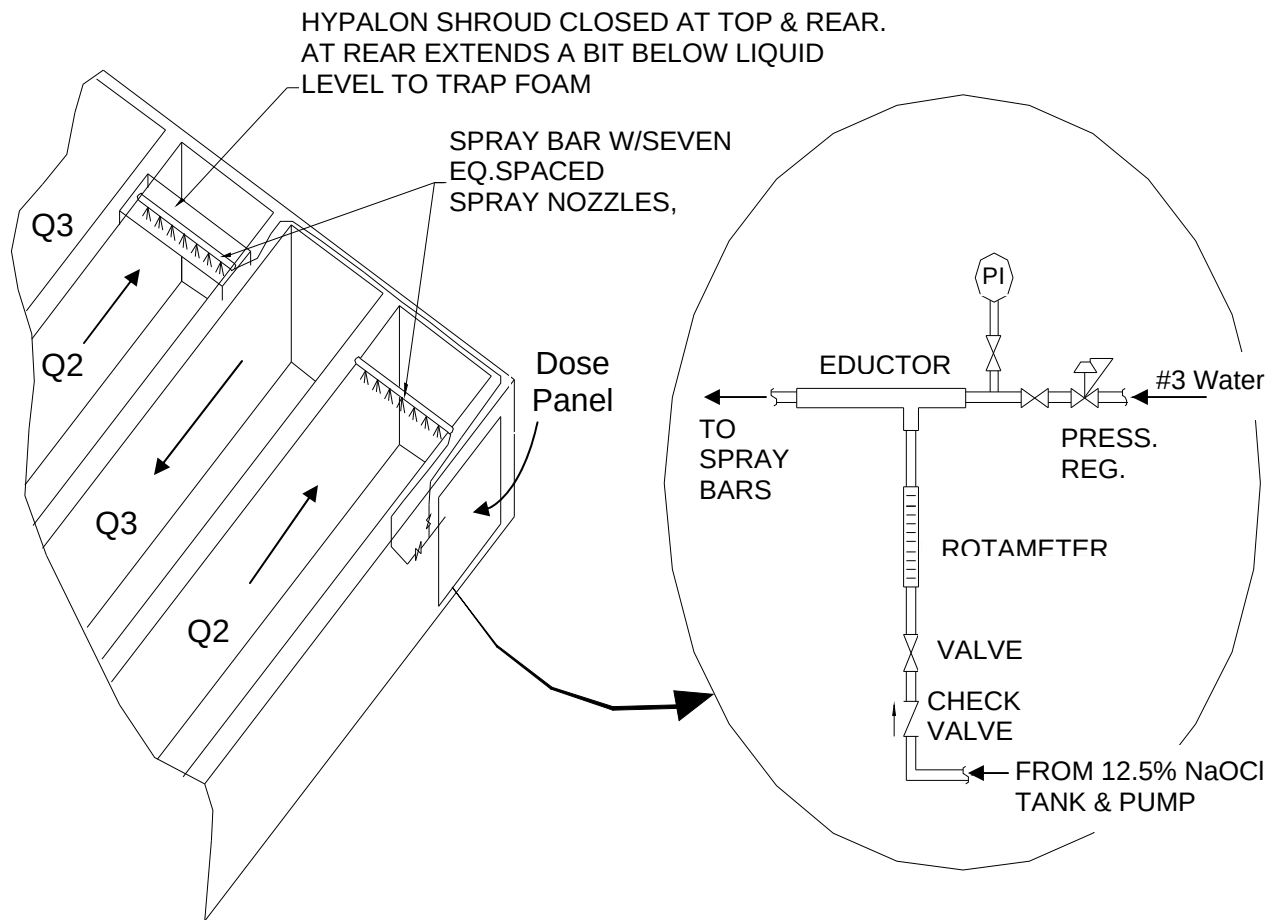


Figure 3. Polymer dosing system for nocardioform foaming control.

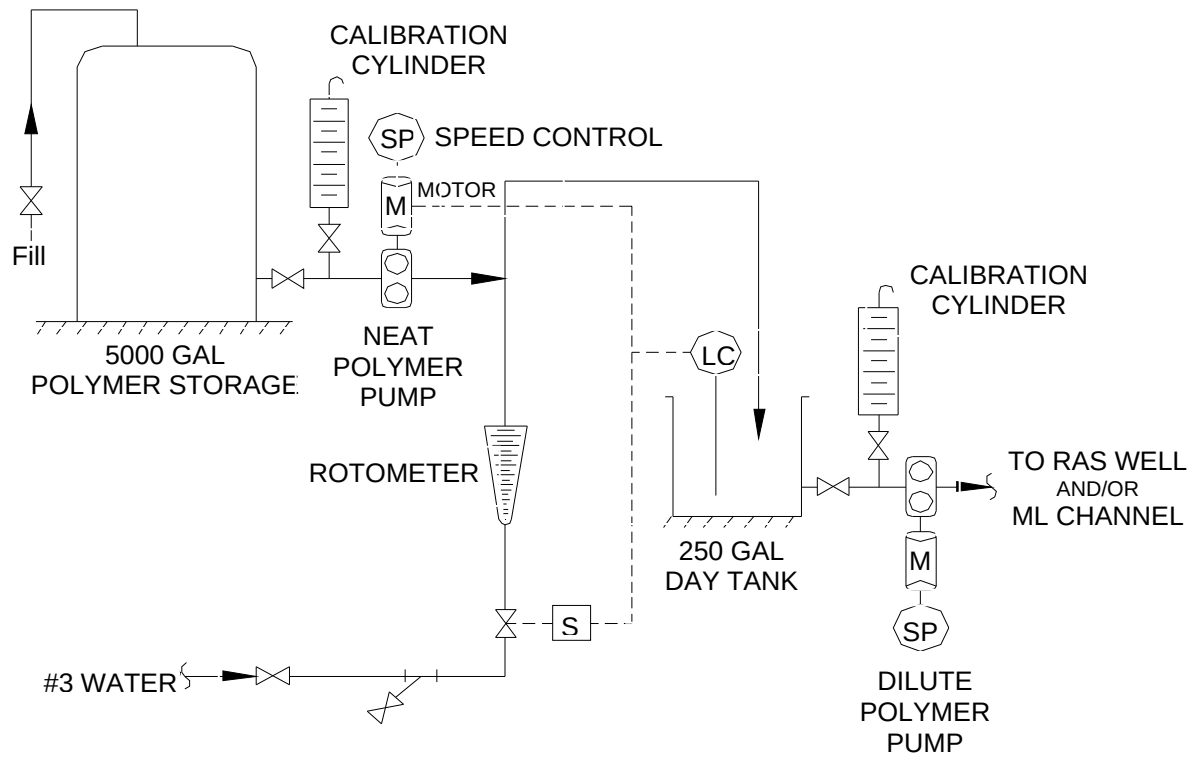


Figure 4. Automatic waste activated sludge control system based on MCRT.

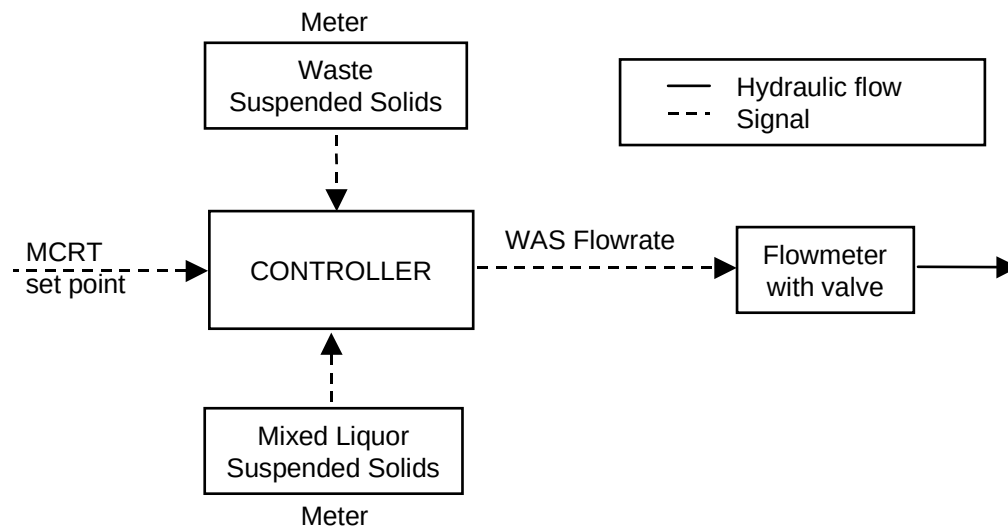


Figure 5. Nocardioform control using chlorine mist surface spray in the BNR pilot plant.

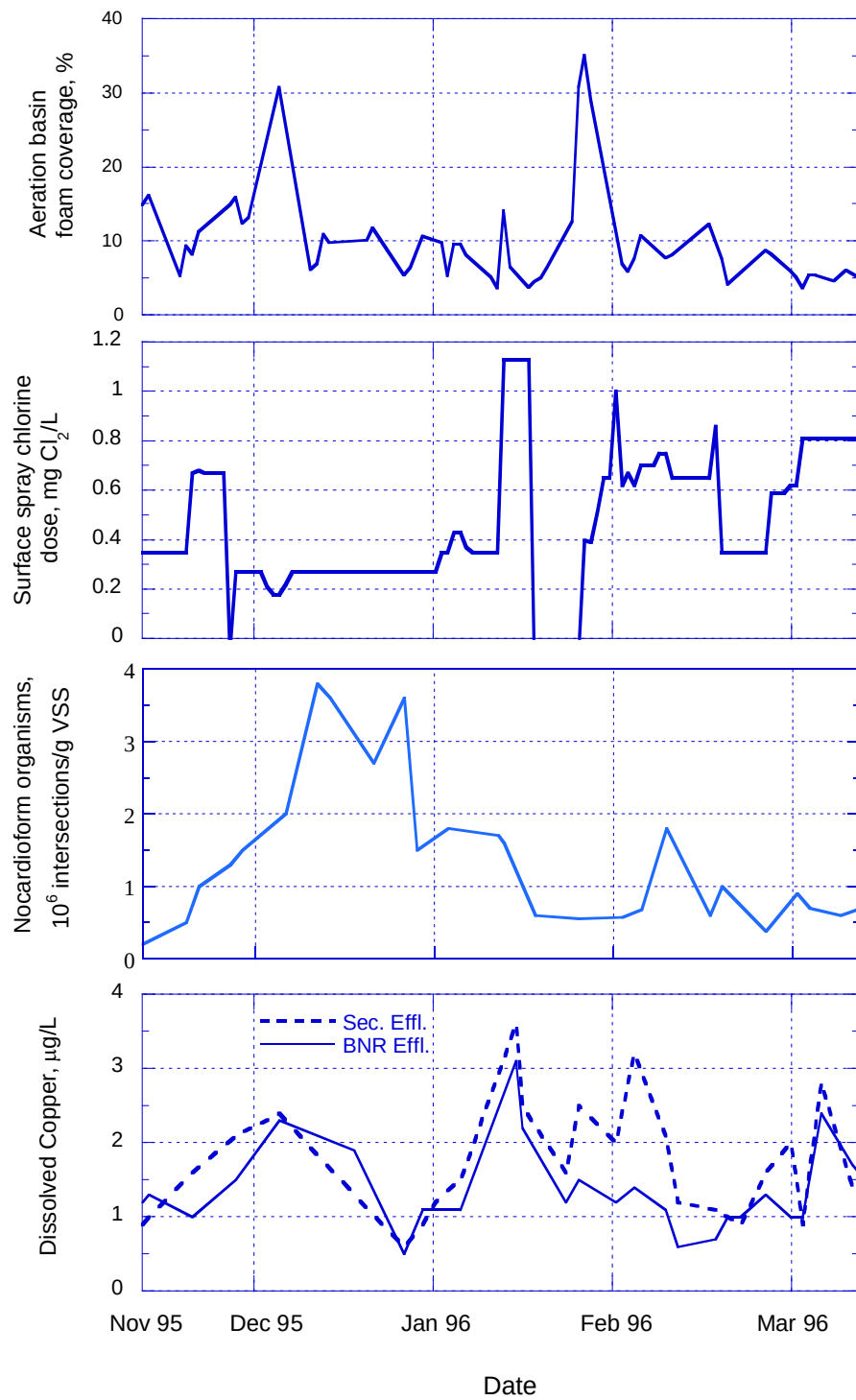


Figure 6. MCRT obtained with manual control (1996) and automatic control (1997) in the BNR pilot plant.

