# DISCUSSION

Of: **Polymer addition as a solution to *Nocardia* foaming problems.** Y.J. Shao, M. Starr, K. Kaporis, H.S. Kim, D. Jenkins, **69,** 25 (1997).

Gerald N. McDermott

I would not discourage wastewater treatment plant managers from trying to solve *Nocardia* problems by adding polymer; however, I would have more confidence in its success if the results of additional trials were reported. Operators report that *Nocardia* incidences come and go for unexplained reasons, so, at a minimum, the observations would benefit from having included observations for a period after discontinuing addition of the polymer. If troublesome concentrations appear following termination of polymer addition, cause and effect would be more firmly established.

As an engineer, I also find the absence of economic information inconvenient. Is comparison of the economics of various alternatives of interest? Additional sludge wasting, that is, shorter solids retention time, has been reported as controlling the problem to manageable levels.

Unfortunately, the authors continue to repeat the misobservation that high *Nocardia* populations are associated with the presence of fats, oil, and grease in the influent. As a representative of an industry with high concentrations of dispersed animal and vegetable oils in process wastewater, my work has included responding to operators experiencing *Nocardia* problems. One source of information found in searching for causes of the problem was a compilation of information from the, at the time, Breidenbach Water Pollution Research Laboratory of the U.S. Environmental Protection Agency in Cincinnati, Ohio. According to the search, a measurement was made of the fats, oil, and grease in a sample of the scum collected from an aeration tank experiencing *Nocardia* excesses. The value was high. Of course it was high because the phenomena that cause the *Nocardia* population to be higher in the foam than in the mixed liquor are the same phenomena that lift particulate fats, oil, and grease into the scum layer. This is witnessed by the use of dissolved air flotation to remove particulate fats, oil, and grease from wastewater. The researcher did not report on the quality of the wastewater being treated or the high-oil-content industrial wastewater present at the treatment plant involved. Interestingly, Shao *et al.* did not bother to report on the fats, oil, and grease concentrations at the plant where their field observations were made. Why repeat the gross error of this statement without any data to support it?

Data available from a number of industrial and municipal plants that receive wastewater from the animal and vegetable oil refining industry indicated that the level in domestic wastewater with limited industrial contribution averaged 25 to 30 mg/L. Municipal plants with significant percentages of industrial wastewater, particularly from the processes of interest, had fats, oil, and grease concentrations averaging, at the extreme, just more than 100 mg/L. The captive industrial plants (there were three of them) treated wastewater by the activated-sludge or aerated stabilization basin processes containing up to an average of more than 500 mg/L of fats, oil, and grease. Such materials constituted the majority of the biochemical oxygen demand of the wastewater. Neither the captive industrial plants nor the municipal plants involved reported experiencing a *Nocardia* foaming problem.

Dispersed animal and vegetable oils are as biologically treatable as is the other conglomerate collection of organic matter in domestic wastewater. In fact, animal and vegetable fats, oil, and grease are natural constituents of domestic wastewater, universally constituting a significant percent of the organic matter.

### Acknowledgments

**Author.** Gerald N. McDermott is a retired engineer. Correspondence should be addressed to Gerald N. McDermott, 267 Lookout Drive, Sedona, AZ 86351.

Of: **Polymer addition as a solution to *Nocardia* foaming problems.** Y.J. Shao, M. Starr, K. Kaporis, H.S. Kim, D. Jenkins, **69,** 25 (1997).

Reza Iranpour, Sonia Alvarez

This study suggests that a "customized" polymer coagulant such as Clarifloc LA-2691 may be a valuable option for reducing *Nocardia* foaming. The work provides an example of an unanticipated benefit of polymer addition with respect to the control of *Nocardia* foams, and it should provide impetus for additional investigation by the legions of other publicly owned treatment works (POTWs) that have experienced excessive *Nocardia* foaming. The conclusion states that more testing is needed before polymer application can be recommended as a routine response to foaming incidents and describes desirable additional work, but we believe that other considerations argue for some studies that were not mentioned. We invite the authors' responses to the following comments and questions about their findings.

1. *Nocardia* growth is known to be influenced by a number of conditions, including both those mentioned by the authors and concentrations of oxygen and dissolved nutrients (Pennsylvania State University, 1994). Operation with an anoxic region was established at Terminal Island Treatment Plant for several reasons, including that facultative metabolism by other microbes would suppress *Nocardia* growth by reducing the dissolved nutrient concentrations under conditions where the oxygen-dependent *Nocardia* cannot grow. Conversely, excessive aeration

tends to promote *Nocardia* growth. This discussion might give more consideration to the role of these and other known factors in the initiation of foaming incidents. Also, these considerations imply that overall system planning to prevent foaming probably should consider the potential role of improved process monitoring instrumentation and process control, such as using on-line biochemical oxygen demand (BOD) monitoring or dissolved oxygen sensors.

2. The paper describes three periods (4/26/1994 to 4/29/1994; 1/31/1995 to 2/6/1995, and 2/8/1995 to 2/14/1995) when foam reduction following polymer addition was rapid, and one period (1/11/1995 to 1/24/1995) when foam coverage was high and polymer addition made little difference. It is desirable to know whether this means that the polymer effect is not 100% reliable or whether it is ineffective against the most severe foam events, so that other measures, such as removal by a vacuum truck, are needed in such cases.
3. The effect of the polymer would be clearer if additional information about the parameters of the mixed liquor and the operational parameters of the plant such as mean cell residence time (MCRT), aeration rate, and sludge loading rate were available. In particular, it is desirable to know whether these parameters were held steady during the period of polymer application.
4. A clearer chemical and biological examination of the foam would also be desirable in any future effort to follow up on this observation because the relative role of *Nocardia* and other substances in forming the foam is not clear from the available information. The foam was attributed to *Nocardia* because of its brown color, but colloids from various sources may also contribute.
5. As the polymer addition point was the mixed liquor channel to the secondary clarifiers, not all of the polymer was returned to the aeration basins with the return activated sludge. Moreover, most of the active sites on the polymer molecules by then were probably filled by the sludge. Thus, the actual effective polymer concentration in the aeration basins was unknown, but certainly less than the 0.5 mg/L at the original injection point. We agree with the conclusion that there is a need to test other injection points, but we suggest that this should be combined with measurements of active polymer concentrations in the aeration tank. If possible, it seems prudent to seek a correlation between the speed or extent of foam removal and the polymer concentration to optimize polymer use.
6. The rate of change of foam coverage data as summarized in Figure 2 appears to correlate better with polymer dosing than does the *Nocardia* count data. The most important parameter is actually the net rate of foam generation rather than the absolute percentage of foam coverage. This area of coverage is actually the integral over several days or weeks of the difference between the rates of foam generation and foam loss. For the data in this report, the rate of foam growth or shrinkage can be estimated by numerically differentiating the percentage coverage values in Figure 2. The intersection/count method provides a reasonably reliable means for *Nocardia* determination in activated-sludge samples.
7. Because coverage estimation is subjective, the authors should have provided information on how this was conducted during their tests. It is worthwhile raising this matter as an open question to others seeking a relatively simple but reliable way of judging the effectiveness of chemical addition for foaming control. A specific method of judging coverage would improve the reliability at one plant and the comparability of results at different plants. Photographing the foam from a constant position provides both a permanent record and a source for quantitative measurements.
8. While the incidental benefits of polymer addition for foaming control is a potentially valuable observation, the authors might also have noted initial reservations in view of the fact that the MCRT (8 days) was substantially longer than the time required for the foam to disappear (3 days or fewer). This rapid response needs to be verified, if possible, and understood better. As implicitly noted by the authors, the most likely explanation is a chemical effect in which the polymer clumps or dissolves the material so that *Nocardia* are no longer effective in forming the foam. The authors' attempts to formulate a plausible mechanism for foaming control should be taken up by others to assess this potential because this work raises the possibility that "customized" coagulant such as Clarifloc LA-2691 might provide similar benefits for other POTWs.
9. Because the effective polymer concentration is low, the fate of the polymer is probably not an urgent question, but eventually it would be desirable to know the biodegradability, the degradation products, and whether *Nocardia* leave the system in the sludge or the effluent stream. As acrylic plastics are used in many types of paint that may be expected to last for a long time, biodegradability of polyacrylamide may be low.
10. Considering the fate of the polymer raises the question of polymer choice. Many polymer coagulant products are on the market, and it is not obvious that if a polymer is chosen for improving sludge settling then it would be best for foam suppression. Testing some alternatives to Clarifloc LA-2691 seems desirable.

These observations imply that in addition to the laboratory tests recommended in the paper, a number of other bench-scale tests of different polymer types, biodegradability, and causes of foaming incidents probably should be conducted before further full-scale tests on foaming tanks at operating treatment plants. If the causes of *Nocardia* foaming are understood clearly enough to be replicated reliably in laboratory equipment, then pilot-scale tests of foaming control by different methods should also be performed.

There are many well-known tradeoffs in normal operation of secondary treatment, such as between MCRT and BOD of the effluent. The number of parameters is sufficiently large that human judgment is not likely to arrive at an optimal combination in the absence of calculation because the set of possible parameter values is an irregularly shaped solid in a multidimensional space. Another source of complexity is the combination of objectives because one wants to minimize consumption of energy and other expenses while maintaining compliance with discharge regulations. Thus, one has an optimization problem, with some nonlinear aspects, such as the exponential dependence of bacterial growth rate on temperature. From this viewpoint, selecting operating parameters to suppress foaming is just one aspect of the overall problem of process control. A more thorough discussion of these points would be more suited to a paper about plant process control, but the broader topic seems worth mentioning here to avoid an excessively narrow focus on the foaming problem.

As the use of vacuum trucks, monitoring and process control devices, and installation of equipment for polymer application and other ways to suppress *Nocardia* all have significant costs, an economic analysis of the costs of dealing with foaming incidents seems desirable. This should also include the consequences of tolerating a modest amount of foam because circumstances may exist where this is the most optimal course.

## Acknowledgments

**Authors.** Reza Iranpour is a research engineer and Sonia Alvarez is Assistant Division Manager at the Research Group in Culver City, California. Correspondence should be addressed to Reza Iranpour, Research Group, P.O. Box 262, Culver City, CA 90232.

## References

Pennsylvania State University (1994) The Microlife: Wastewater Biology Courses. Office Program Plann., Continuing Educ., University Park, Pa.

## Closure

Y.J. Shao, Mark Starr, Kosta Kaporis, Hi Sang Kim, David Jenkins

We are grateful to the discussion authors for raising points that allow us to expand on the material presented in our paper.

McDermott suggests that more and longer duration trials would be useful. How can we disagree with the often-used conclusion that "more research is needed"? Since the publication of our paper, several plants have successfully used polymer addition for *Nocardia* foam control. We refer Dr. McDermott to the Water Environment Federation's Web site, Water Environment WEB (http://www.wef.org), where one of these applications is discussed in the Technical Discussions on Plant Operations/Troubleshooting.

McDermott is concerned that we have wrongly laid the blame for *Nocardia* growth and foaming in activated sludge at the feet of fats, oil, and grease. For this we apologize but wish to point out that our paper did not attempt to explain the cause(s) of *Nocardia* filaments or foaming. The paper acknowledges that "although the specific causes of *Nocardia* growth are not very well defined, high populations have been associated with long mean cell residence time (MCRT), warmer temperatures, and the presence of grease, oil, and fat in the influent." These associations (long MCRT; high temperature; and fats, oil, and grease) are common observations but may not be applicable to *Nocardia* filament growth in all instances. If the causes for *Nocardia* growth and foaming were better understood, *Nocardia* foaming control methods such as polymer addition, return activated sludge (RAS) chlorination, and vacuum removal would not be necessary. Indeed, we probably know more about how to get rid of *Nocardia* than how to prevent it from growing!!

McDermott is correct in pointing out that the paper did not provide a cost analysis for our foam control technique. Costs will depend on polymer price and the amount of additional polymer-dosing equipment required. As stated in our paper, polymer storage, handling, mixing, and dosing facilities were already available, and only a short run of polyvinyl chloride (PVC) piping (90 m) was required to complete the dosing system. Polymer cost for a dose of 0.5 mg/L to a plant flow of 64 ML/d was approximately $1.09/ML.

Iranpour's discussion points are answered individually below.

1. We agree that all possible methods for *Nocardia* control should be considered in design. It is, however, sometimes difficult to avoid the incorporation of design features that encourage *Nocardia* growth and foaming (such as high MCRT required for nitrification and foam-trapping aeration basins required for high-purity-oxygen activated-sludge systems). At the Terminal Island Plant, the use of an anoxic selector (installed 12/21/93) controlled type 021N filamentous bulking but did not control *Nocardia* growth and foaming because of the foam-trapping characteristics of the aeration basins and the need to operate at an MCRT of 8 days so that complete nitrification occurred in the presence of highly fluctuating organic loads.
2. The first documented attempt at foam control by polymer addition (1/11/1995 to 1/24/95) was not as rapid or successful as the later reported attempts (1/31/95 to 2/6/95 and 2/8/95 to 2/14/95) because activated sludge could not be wasted on 1/14/95 to 15/95 and because polymer was not added during high storm flows on 1/23/95.
3. All of the typical activated-sludge operating parameters (such as MCRT, mixed liquor suspended solids, aeration rate, aeration basin configuration, and RAS flow rate) were held constant during the periods over which polymer addition trials were conducted.
4. The foam is routinely examined microscopically. Over many years of such observation, it has been established that the foam contains elevated levels of *Nocardia* and/or *Microthrix parvicella* compared to those in the mixed liquor. This is an indication that the foaming is associated with these organisms.
5. Certainly it would be interesting to conduct optimization studies on factors such as polymer dose and addition point. However, the paper shows that even at what may not be the best polymer addition point, the technique rapidly controls foam.
6. and 7. Foam coverage was assessed by visually estimating the percent surface coverage of the second aeration basin in each three-basin train at the same time each day. The second basin was chosen because it had the most severe foam-trapping features.

   The specific method of assessing foam intensity will vary from plant to plant, depending on specific physical features. In general, the foam coverage assessment should, if possible, be done for the parts of the plant where the foam accumulation produces the most critical problems.

8. The rapid decrease of foam (3 days) compared to the MCRT (8 days) most likely occurs because the control mechanism is predominantly physical/chemical rather than microbiological. Thus, free-floating *Nocardia* filaments (which are the more effective foam producers) are flocculated into the activated-sludge flocs by the polymer and once in the flocs they do not promote foam as effectively.
9. The polymer used was biodegradable under the conditions in the aeration basin.
10. Our choice of Clarifloc LA-2691 was the result of limited polymer testing. We agree that further refinement may be possible.
11. We agree that it is possible to tolerate a certain amount of *Nocardia* or *M. parvicella* foam in aeration basins and secondary clarifiers. However, even at levels that do not cause nuisance foams on aeration basins, these organisms can cause intolerable anaerobic and aerobic digester foaming.