

JOURNAL OF ENVIRONMENTAL ENGINEERING

AUG. 1997 VOL. 123 NO. 8

ISSN 0733-9372

CODEN: JOEEDU

EDITOR

Byung R. Kim
Ford Motor Company

ASSOCIATE EDITORS

Robert G. Arnold, *University of Arizona*
Oliver J. Hao, *University of Maryland*
Hilary I. Inyang, *University of Massachusetts*
Wu-Seng Lung, *University of Virginia*
Edward A. McBean, *Conestoga-Rovers & Associates*
J. B. Neethling, *HDR Engineering*
Susan E. Powers, *Clarkson University*
Lewis Rossman, *U.S. Environmental Protection Agency*
Makram T. Suidan, *University of Cincinnati*
Mark A. Tumeo, *University of Alaska*
Mark R. Wiesner, *Rice University*
Mark E. Zappi, *Mississippi State University*

CONTRIBUTING EDITOR

J. David Betsill, *Sandia National Laboratories*

PAST EDITOR

Thomas L. Theis, *Clarkson University*

AMERICAN SOCIETY OF CIVIL ENGINEERS

Environmental Engineering Division Executive Committee

David W. Bouck, Chair
Frederick W. Boecher
Joseph F. Malina Jr.
Thomas M. Rachford
Udai P. Singh
Carol J. Whitlock

Board Publications Committee

Larry R. Wade, P.E., Chair
William A. Welsh, P.E., Vice Chair
Arthur J. Greengard Jr., P.E.
Edward E. Rinne, P.E.
Warren W. Sadler, P.E.
Vernon B. Watwood Jr., P.E.

Publications

David R. Dresia, Managing Director

Production Department

Bruce Gossett, Director,
Publications Production
Tony Powell, Manager, Journals
Ajani Malik, Production Coordinator
Carol Reese, Manager,
Information Products
Ellie Marabello,
Copyright and Permissions
Barbara Greene, Reprints
Dina Mukhamedzhanova,
Manuscript Database Coordinator
Kristine Torgersen-Murray,
Discussions and Closures

Editorial Department

Farah Ameen, Senior Copy Editor
Chris Ralston, Senior Copy Editor
Arthur Hughes, Copy Editor
Claudia Isler, Copy Editor
Kristin Jannacone, Copy Editor
Andrew Mathis, Copy Editor
Rebecca Wipfler, Copy Editor

VOCS IN FIXED FILM PROCESSES. I: PILOT STUDIES^a

Discussion by Reza Iranpour⁴ and
Ken Ludwig,⁵ Members, ASCE

This paper, building on the authors' previous work (Melcer et al. 1994; Monteith et al. 1995; Bell et al. 1993), reports a very well conducted experiment with a well-chosen combination of volatile organic compounds (VOCs) of different types, studied in two types of fixed film bioreactors. Although suspended-growth activated sludge systems have received much more attention in research on VOC biodegradation and gas-phase emissions, fixed film bioreactors are also widely used, and provide much higher biomass concentrations than typical activated sludge processes (Reardon 1995). Thus, a study such as this provides timely information for comparison with other systems, especially since the authors demonstrated substantial biodegradation of almost all of the tested VOCs under most operating conditions in both trickling filters and rotating biological contactors (RBCs).

This study raises the following questions that may be useful for other wastewater researchers. We would appreciate any remarks they would like to make about these subjects.

First, if one wishes to increase the biomass concentration in an activated sludge system without major rebuilding, is it preferable to just change the operating parameters of the plant to increase mixed-liquor suspended solids in the aeration tanks (Straub 1995), or should surfaces be introduced for immobilized cell growth, such as by using plastic sheets or ropes suspended in the tanks (Reardon 1995)? A system with the latter approach could be considered intermediate between present fixed film and suspended-growth treatment methods.

Second, how much of a contribution to biodegradation of VOCs could be provided by using respirometric monitoring to improve plant control and the health of a plant's bacterial population as recommended in Kloppe (1991), Jarrel (1991), Manning (1991), and Belles and Lyons (1991)?

Third, have the authors considered applying the work of Naziruddin et al. (1995) by attempting to enhance the degradation of selected VOCs (in either suspended-growth or fixed film systems) by seeding the influent with cultures of bacteria acclimated to metabolize selected VOCs?

The discussers note that the last question involves an idea that is highly speculative now, but there is no obvious barrier to following Naziruddin et al.'s procedure of acclimating the bacteria to a concentration of 20 mg/L of a VOC so that one could then add aliquots of the culture to a wastewater stream containing a lower concentration of the same VOC. Other related studies (Schraa et al. 1986; Wertheim 1996; Hodge and Devinny 1995) could provide some valuable information.

Fourth, is there any reliable way known for assessing the trade-offs in choosing

2. The ventilation rate in a trickling filter
3. The rotation rate in an RBC

since these are corresponding ways of influencing both the oxygen supply of the bacteria culture and the stripping rate of VOCs?

Additional experimental studies will undoubtedly need to resolve some of these questions. The thoroughness displayed by the authors in measuring the fate of the VOCs, including testing for absorption into the disks of the RBCs, is a good example for other wastewater researchers to follow.

APPENDIX. REFERENCES

- Bell, J., Melcer, H., Monteith, H., Osinga, I., and Steel, P. (1993). "Stripping of volatile organic compounds at full scale municipal wastewater treatment plants." *Water Environment Res.*, 65(6), 708-716.
- Belles, D., and Lyons, S. (1991). "Sludge liability and BOD testing with respirometry." *Operations Forum*, 8(11), 12-13.
- Hodge, D. S., and Devinny, J. S. (1995). "Modeling removal of air contaminants by biofiltration." *J. Envir. Engrg., ASCE*, 121(1), 21-32.
- Jarrel, R. (1991). "Multiple uses of respirometry in wastewater treatment." *Operations Forum*, 8(3), 10-11.
- Kloppe, P. H. (1991). "Respirometry and training." *Operations Forum*, 8(4), 12-15.
- Manning, D. P. (1991). "Managing a plant today with 'today's' data." *Operations Forum*, 8(7), 16-17.
- Melcer, H., et al. (1994). "Modeling volatile organic contaminants' fate in wastewater treatment plants." *J. Envir. Engrg., ASCE*, 120(3), 588-609.
- Monteith, H. D., Parker, W. J., Bell, J. P., and Melcer, H. (1995). "Modeling the fate of pesticides in wastewater treatment." *Water Environment Res.*, 67(6), 964-970.
- Naziruddin, M. (1995). "Determination of biodegradation kinetics of volatile organic compounds through the use of respirometry." *Water Environment Res.*, 67(2), 151-158.
- Reardon, R. (1995). "Advanced wastewater treatment." *Water Environment and Technol.*, 66-73.
- Schraa, G., Boone, M. L., Jetten, M. S. M., van Neerven, A. R. W., Colberg, P. J., and Zehnder, A. J. B. (1986). "Degradation of 1,4 dichlorobenzene by *Alcaligenes* sp. strain A175." *Appl. Envir. Microbiol.*, 52, 1374-1381.
- Straub, W. O. (1995). "An assessment of the activated sludge process as a biofilter for the treatment of volatile organic compounds." *LWMD Rep.*, Bureau of Sanitation, City of Los Angeles, Calif.
- Wertheim, M. (1996). "Unnatural appetites: training bacteria to snack on plastic waste." *The Sci.*, (May/June), 15-17.

^aJuly 1996, Vol. 122, No. 7, by Wayne J. Parker, Hugh D. Monteith, and Henryk Melcer (Paper 10487).

⁴Res. Staff, Wastewater Engrg. Services Div., Sanitation, City of Los Angeles, P.O. Box 262, Culver City, CA 90232.

⁵Div. Mgr., Wastewater Engrg. Services Div., Sanitation, City of Los Angeles, P.O. Box 262, Culver City, CA.

1. The aeration rate in a suspended-growth tank

**Closure by Wayne J. Parker,⁶
Hugh D. Monteith,⁷ and Henryk Melcer⁸**

A number of general issues are addressed in the discussion. The difference in response between suspended-growth and biofilm systems will be the potential for diffusive limitations in the latter system. The impact of diffusive limitations on the fate of volatile organic compounds (VOCs) will depend on the degradation mechanisms for the specific compound. If the compound is biodegraded aerobically, then diffusive limitations in a biofilm system may reduce the rate of biodegradation as compared to a suspended-growth system. If a compound is degraded under anaerobic conditions, then diffusion limitations on oxygen in a biofilm system may result in the formation of anaerobic zones that enhance degradation.

The use of respirometric monitoring, as input to a control strategy to ensure a viable biomass, may enhance the biodegradation of VOCs. This might be accomplished by ensuring that the minimal amount of aeration is used to reduce losses to the competing stripping mechanism.

The use of seed reactors for producing acclimated bacteria has been examined by other researchers. At this time, the writers are not aware of the application of this technique in the operation of any full-scale wastewater-treatment processes. It may have application in some industrial processes where only relatively few VOCs are consistently present. In municipal wastewaters there may be 10–20 different VOCs present, and it will be quite difficult to operate a seed reactor with all of these compounds. There is a significant potential for inhibition of biomass when all of these different compounds are being treated at relatively high concentrations in the seed reactor.

At present, there is limited quantitative information describing the relationship between dissolved oxygen concentration and the rate of biodegradation of VOCs. Presumably, at high dissolved oxygen concentrations there will be no inhibition of biodegradation rates; however, this will correspond to situations in which there is high liquid-gas mass transfer and stripping of VOCs. More research is required to determine the minimum dissolved oxygen concentrations that are required to have minimal inhibition of VOC (and biochemical oxygen demand) biodegradation and to incorporate this into models that describe mass transfer. The current study has tried to obtain information on the mass transfer of VOCs from the liquid to the gas phase, and oxygen mass transfer will be correlated to this. The challenge for future research is therefore to determine the relationship between dissolved oxygen concentration and biodegradation kinetics.

⁶Asst. Prof., Dept. of Civ. and Envir. Engrg., Carleton Univ., 1125 Colonel By Drive, Ottawa, Ontario, Canada, K1S 5B6.

⁷Mgr. of Operations, Enviromega Ltd., 7 Innovation Dr., Suite 245, Hamilton, Ontario, Canada, L9J 1K3.

⁸Sr. Process Specialist, Brown and Caldwell Consultants, 100 West Harrison St., Seattle, WA 98119-4186.