Assessment of Aeration System Performance Efficiency: Frequent Sampling for Damage Detection

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ABSTRACT: A study of oxygen transfer efficiency (OTE) in aeration basins, using measurements of oxygen depletion in offgas collected from them, was carried out over a period of several years by collaborations between the University of California, Los Angeles and the Bureau of Sanitation Research Group of the City of Los Angeles. Measurements were taken of dissolved oxygen (DO), water temperature, oxygen depletion, and air flux at each sampling location as part of the process to obtain standardized OTE. Field instruments, permanently located near the tanks and galleries, are connected to the control room that automatically records return activated-sludge flow, influent flow, tank DO sensor readings, and air flow. Data from the control room and field instruments were collected for the times of the samples to provide context and some degree of quality control for the samples obtained by the measurement team.

The combined air flux and OTE measurements not only agree with the familiar inverse relationship between OTE and air flux but have allowed detection of strong evidence that serious leakage has developed in a few weeks in the air distribution systems of tanks 4 and 5, which was indirectly confirmed by observation of water ejection from the air release valves on the tanks. However, the detail provided by OTE measurements allows more specific understanding of the magnitude of the problem and its significance for the operation of these tanks. Analysis of the OTE measurements made at the site since 1991 also indicates that the diffusers in some of the tanks may now be in need of cleaning or replacement. *Water Environ. Res.,* **72,** 363 (2000).

KEYWORDS: aeration, oxygen transfer efficiency, diffuser maintenance, sampling.

Introduction

Since 1991, the Research Group of the Bureau of Sanitation of the City of Los Angeles (BOS) and the University of California, Los Angeles (UCLA) have collaborated on studies of oxygen transfer efficiency (OTE) at wastewater treatment plants operated by BOS (Iranpour et al., 1997a, 1997b, 1997c, 1998a, 1998b, 1998c, and 1999b, and Stenstrom et al., 1991, 1992, 1993, and 1994). These studies have assessed air flow and diffuser performance to gain insight to power consumption and the relative value of differing types of diffusers and cleaning methods, with the goal of eventually reducing costs of secondary treatment.

Measurements are made using the offgas method (Campbell, 1982; Ewing, 1993; Redmon and Boyle, 1981; Redmon et al., 1983; and U.S. EPA, 1989), which in recent years has been the preferred method for measuring OTE in operating aeration basins because of its combination of reliability and convenience. Nevertheless, because most of a working day is typically required for a crew of two or three to sample the offgas at enough locations in a large basin to obtain a good estimate of average basin efficiency and also because commercially available offgas analyzers have been relatively bulky and expensive, such measurement sessions have been carried out infrequently at the plants where they were performed.

However, it has long been recognized (Huibregtse et al., 1983, and U.S. EPA, 1989) that OTE has great potential economic significance because in a typical activated-sludge plant a large fraction of the electrical load is provided by the blowers for the aeration basins, costing hundreds of thousands of dollars per year at large treatment plants. Hence, improved aeration efficiencies have the potential to save millions of dollars nationwide.

There would be a further benefit if cleaning, replacement, and repair decisions for aeration systems were systematized. For example, an OTE study by Stenstrom and Masutani (1989) found that broken diffusers, blown gaskets, and loose pipes were quite widespread in a dewatered basin, although there was no way to know about this damage during normal operation. Thus, in the past few years there has been increased attention to the potential payoff of additional efforts to monitor tank performance and improve efficiency. Moreover, offgas measurements of OTE are preferable in terms of reliability or cost to possibly competing methods of assessing tank performance (such as attempting to compare the biochemical oxygen demand [BOD] of water samples taken at the influent and effluent ends of an aeration basin).

The bulk of this report is devoted to describing OTE results obtained at the Tillman Wastewater Reclamation Plant (TWRP) in the San Fernando Valley, California. Many other large municipal wastewater treatment plants have equipment similar to TWRP; so results are relevant beyond the boundaries of the Los Angeles sewer system, and the present successful OTE measurements may be a prototype of programs that could be used elsewhere.

Recent work at TWRP has been done with some innovations in sampling (Iranpour et al., 1997a, 1997b, 1997c, 1998a, 1998b, 1998c, 1999a, 1999b, and 1999c). More closely spaced and comprehensive sampling has permitted observations of aspects of aeration system performance that were not evident in previous research with more widely spaced samples (Redmon et al., 1983, and Stenstrom et al., 1991, 1992, 1993, and 1994). In particular, substantial decreases in local OTEs and increases in air fluxes in two tanks over a period of a few weeks, resulting in serious reductions of the overall efficiencies of these tanks were observed. These results seem to justify making an effort to soon repair these aeration systems and are the clearest evidence to date of the potential value of more intense monitoring of oxygen transfer in present and future types of aeration basins.

Methodology

Setup. The TWRP is located in the San Fernando Valley and provides primary, secondary, and tertiary treatment to approximately 157 708 L/min (60 mgd) of wastewater, with a design capacity of 210 000 L/min (80 mgd). It is upstream of the city's main wastewater facility, the Hyperion Treatment Plant, to reduce the load on Hyperion and was built in two phases. Phase I began operation in 1984 with a design capacity of 105 000 L/min (40 mgd) and nine aeration basins. Phase II began operation in 1991 and added another 105 000 L/min (40 mgd) of capacity with another nine basins.

The basins are rectangular, 9.144 m (30 ft) wide, 91.440 m (300 ft) long, and 4.572 m (15 ft) deep. In each basin, air is distributed by three grids of diffusers, designated grids A, B, and C, located in succession from the influent to the effluent end. Aeration is tapered by having the highest density of diffusers and largest total number of them in grid A, with successively lower densities and numbers in grids B and C.

The secondary treatment systems of phases I and II operate almost independently. They receive primary effluent from a common distribution channel from primary treatment, but the clarifiers and return activated-sludge (RAS) systems for the two phases are separate, resulting in the two secondary systems being biologically isolated from each other. Thus, one phase sometimes suffers foaming or some other result of an unfavorable bacterial population that does not occur in the other phase. Also, because the two phases were built at different times, phase I was equipped with Sanitaire ceramic disk diffusers (ITT Industries, Brown Deer, Wisconsin) nominally 230 mm (9 in.) in diameter, and phase II was equipped with Aercor ceramic dome diffusers nominally 180 mm (7 in.) in diameter.

At any given time, some of the 18 aeration basins are out of service. The air control systems in these basins differ from each other because in basins 15 and 16 the valve on the downcomer to each grid is controlled by feedback from a dissolved oxygen (DO) probe in that grid. All other tanks have less detailed control because they are operated in pairs with the valves for all six grids in a pair controlled according to the readings from a DO probe in grid B of one tank of the pair. For example, the control DO probe for tanks 13 and 14 is in tank 14.

The instruments used in the measurements made from 1991 to 1994 were owned by UCLA. Since the autumn of 1997, the measurements have been made with analyzers built by the Research Group of the BOS. The 1998 model was an improvement over the 1997 version because it could measure local air flux as well as local OTE. These instruments use the same principles as the commercially available Ewing (Milwaukee, Wisconsin) Mark V analyzer but are specialized for convenient offgas measurements from aeration basins. Figure 1a is a schematic diagram of the analyzer structure, and Figure 1b shows basin details, including field instruments.

Procedure. Offgas measurements were performed in the conventional manner (Campbell, 1982; Ewing, 1993; Redmon and Boyle, 1981; Redmon et al., 1983; and U.S. EPA, 1989); offgas is collected by a hood floating on the surface of the tank, and after removal of CO_2 and water vapor from the sample stream, the O_2 partial pressure is measured by a fuel cell. The operation of the instrument produces a number of other parameters that are recorded as the fundamental data from which later results are derived. These include sensor pressure, hood pressure, sensor voltage, gas flow rate, and others.

The depletion of O_2 relative to the ambient air is then computed, from which the raw OTE is derived, as described in the references cited. Hence, air contamination leads to underestimation of depletion and of OTE; thus, an important limitation on the speed of offgas measurements is the need for waiting after the hood has been moved until sample contamination by ambient air has decreased to a negligible level.

A DO meter attached to the hood, measurements of ambient air pressure from the instrument, and a mercury thermometer dipped into the tank by the measurement team allowed correcting for departures from the standard atmospheric pressure and temperature (APHA et al., 1992) and for nonzero DO in the wastewater to compute the standardized clean water OTE.

It is also valuable to compute the a parameter, $a = a\text{SOTE}/\text{SOTE}$, estimated from a formula fitted to laboratory measurements in clean water; a measures the reduction in SOTE under process conditions. This aSOTE standardized parameter provides the most uniform basis for comparing aeration efficiencies observed at different times and places. For the Sanitaire disk diffusers, SOTE values were obtained from linear regressions, with slightly differing parameters in each grid: $\text{SOTE} = 32.4 - 2.43QD$ for grid A, $\text{SOTE} = 33.25 - 2.56QD$ for grid B, and $\text{SOTE} = 31.89 - 2.71QD$ for grid C, where QD is the air flow per diffuser in sm^3/min (scfm). For the Aercor dome diffusers, $\text{SOTE} = 45.346 - 22.005QD + 5.903QD^2$. Over the modest range of feasible QD values, this quadratic formula for SOTE also decreases with increasing QD. The slight differences in parameters for disk diffusers in grids A, B, and C represent better SOTE statistics and more thorough testing procedures of the Sanitaire manufacturer. However, it is expected to have differences in SOTEs in different grids with different densities assuming similar air flow per diffuser because of hydrodynamic effects caused by bubble streams.

Results

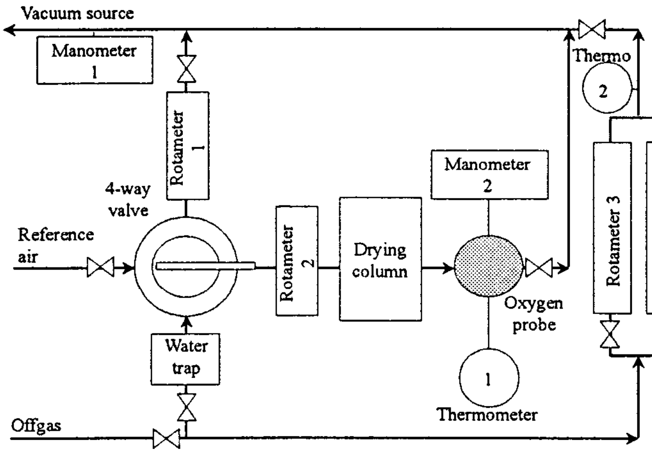
Observations. Figures 2 and 3 present condensed measurements made on tanks 6 and 7 from 1992 to 1994. All of these measurements were made at corresponding positions in the various tanks, selected to be in the interiors of the grids longitudinally, but not near the main manifold pipes at the midlines of the grids, with samples taken near the walls and in the center of the tanks.

For the recent experiments, the lengths of the tanks were subdivided into a larger number of partitions, and measurement stations across the tanks were defined within these partitions. However, the time available for the measurements required skipping some of the measurement stations, particularly because measurements at some stations were repeated to check reliability of the instrument readings and to gain experience with the equipment. Thus, the recent measurements are more comprehensive but less uniform than those taken from 1992 to 1994.

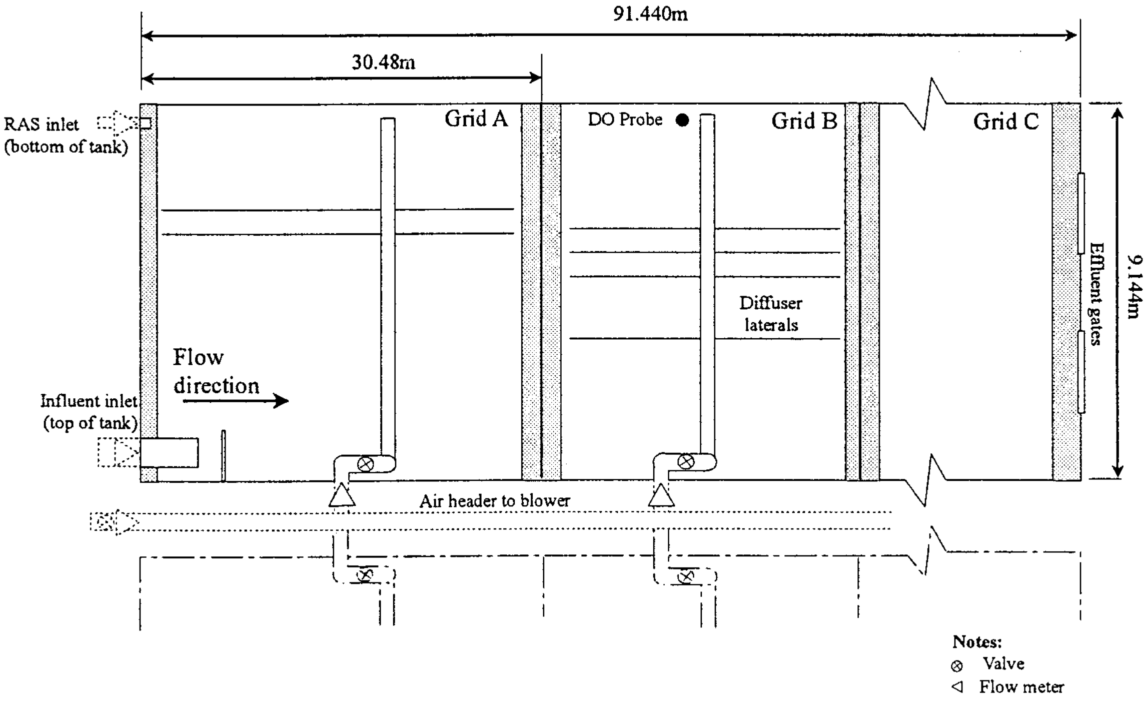
A total of six measurement sessions were conducted on tanks 4 and 5 at TWRP in February, March, and April 1998, and measurements were also taken from tanks 11, 15, and 16 in February and March.

Figure 4a presents aSOTE and a and Figure 4b shows DO and air flux for tank 4 on February 12, 1998. Figures 5a and 5b show the corresponding data for the same tank for April 13, 1998, and Figures 6a and 6b show the data for April 27, 1998. Similarly, Figures 7 and 8 show these parameters for tank 5 on March 27 and April 27, 1998, respectively.

Parameters from the control room at corresponding times include RAS flow rates, wastewater flow rates to the tanks, air flow



a) OTE analyzer structure

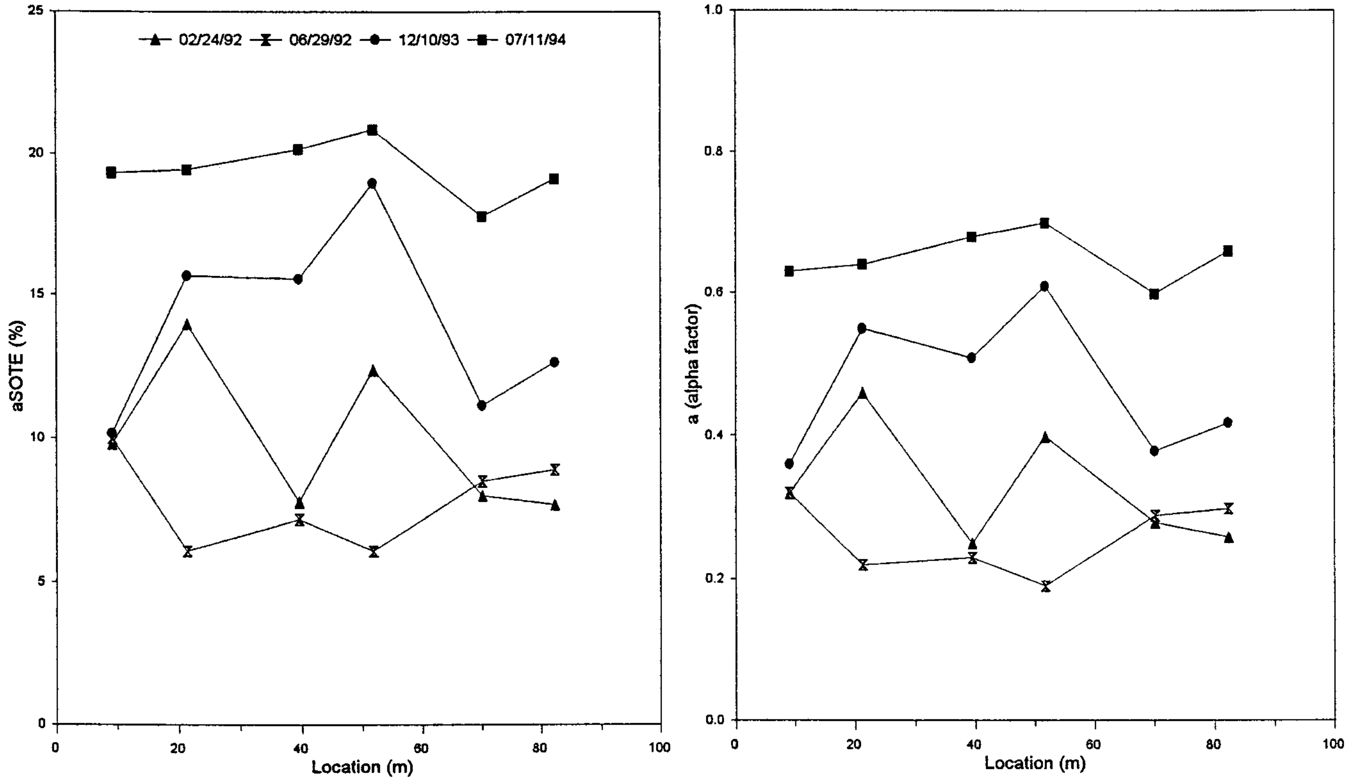


b) Tank structure at TWRP

Figure 1—Plan views of (a) analyzer structure and (b) basin design.

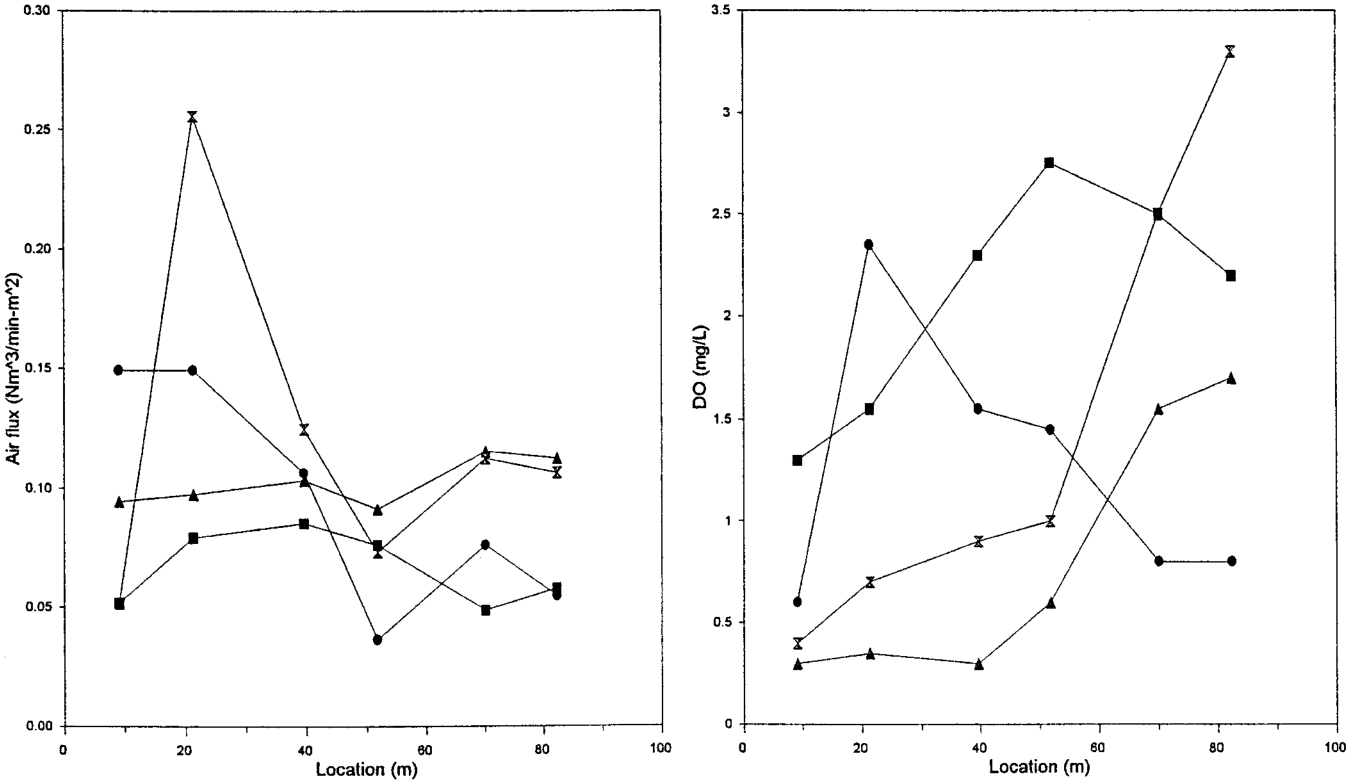
rates to each grid, and DO readings from the oxygen sensors mounted in the tanks. Because these readings are reported every 6 minutes but the offgas measurements were made at more widely spaced time intervals, only the control room values closest in time to the offgas measurements have been plotted. Also, because each offgas measurement was made in one grid, the analysis has concentrated on DO and air flow in the grid where a particular offgas measurement was made. Thus, the comparison was always between each offgas measurement and the control room data closest in time and, when relevant, in position to that offgas measurement. Examples of control room data are given in Figures 9a and 9b. Figures corresponding to data for other sessions, because of space limitations, are not shown here but summarized by averaging data in Table 1.

The plots and averages in Table 1 show that wastewater and RAS flows were relatively stable during the period of offgas



(a) Efficiency

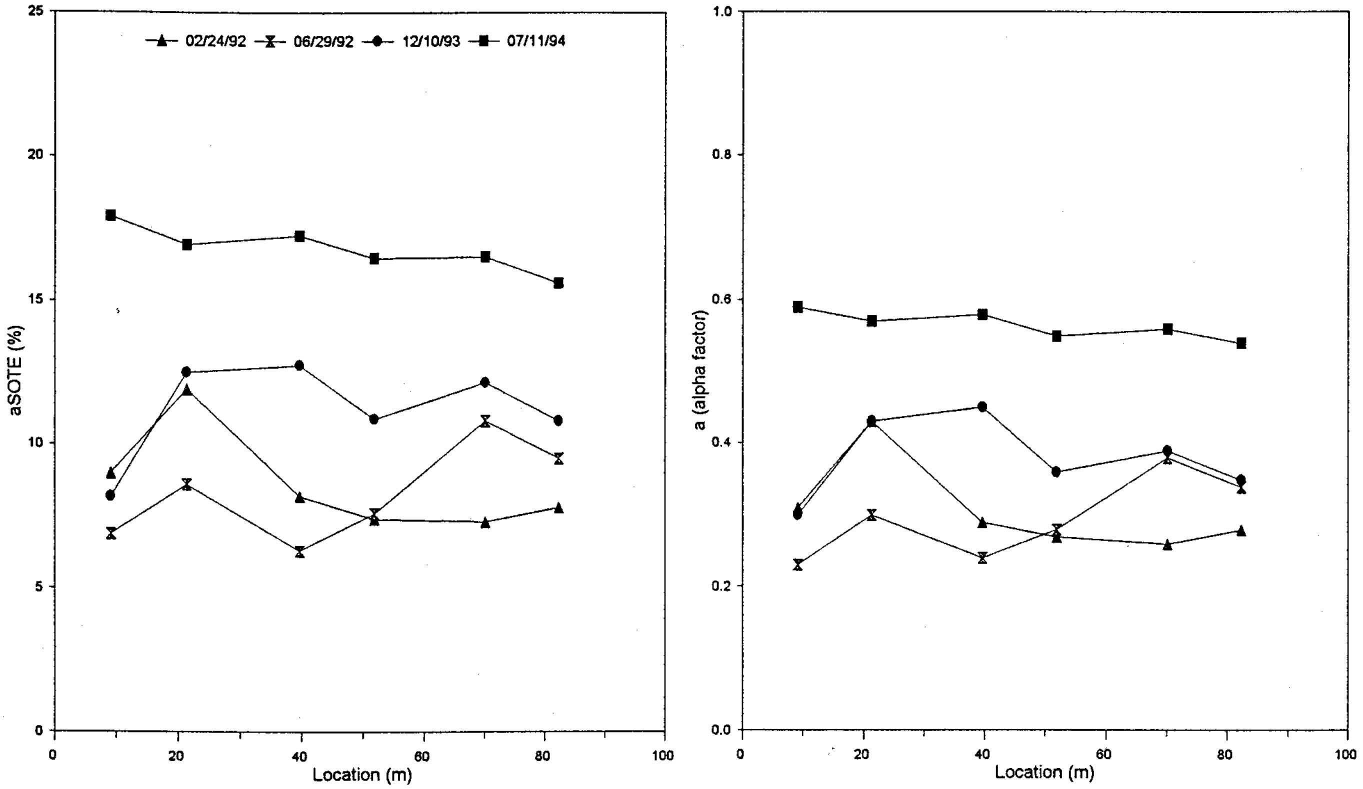
(b) Alpha factor



(c) Air flux

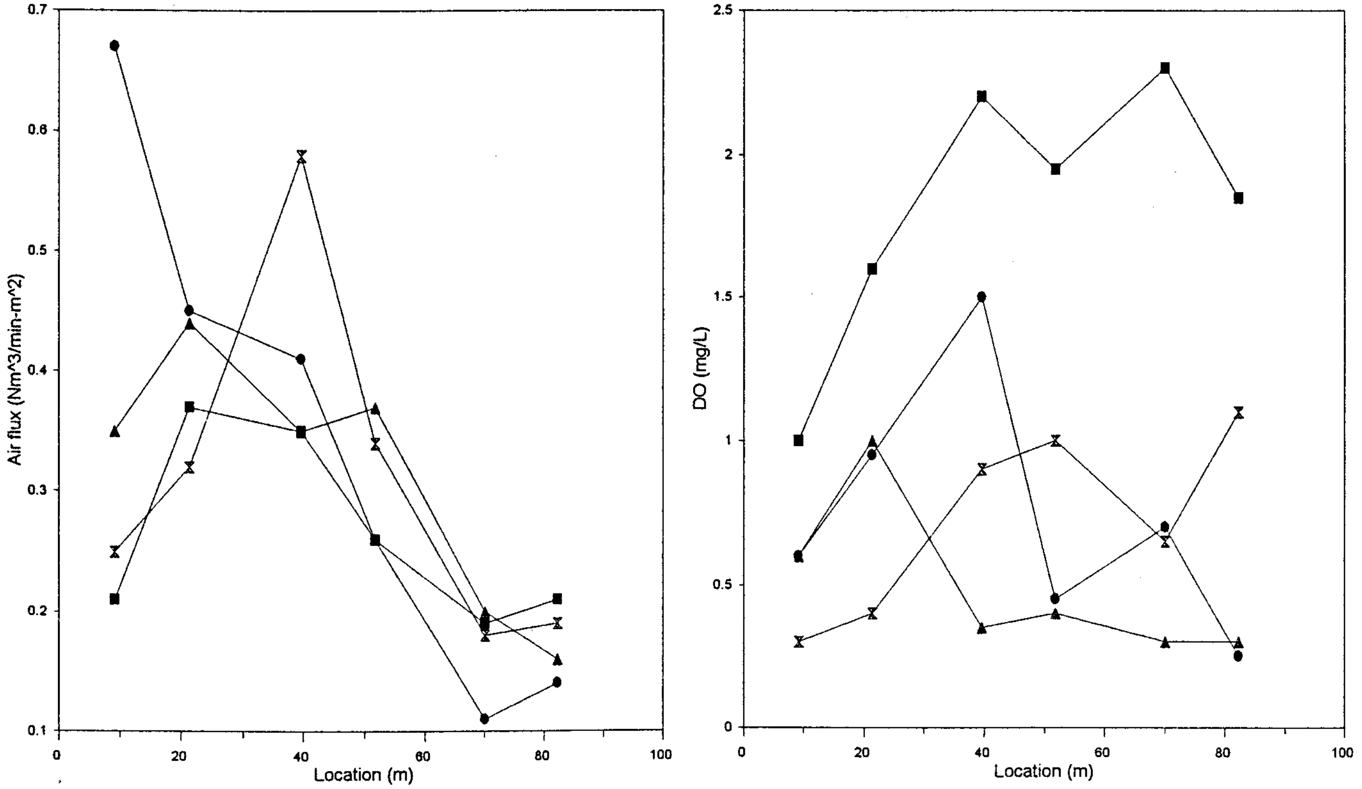
(d) Dissolved oxygen

Figure 2—Offgas analysis of tank 6 at TWRP, 1992 to 1994.



(a) Efficiency

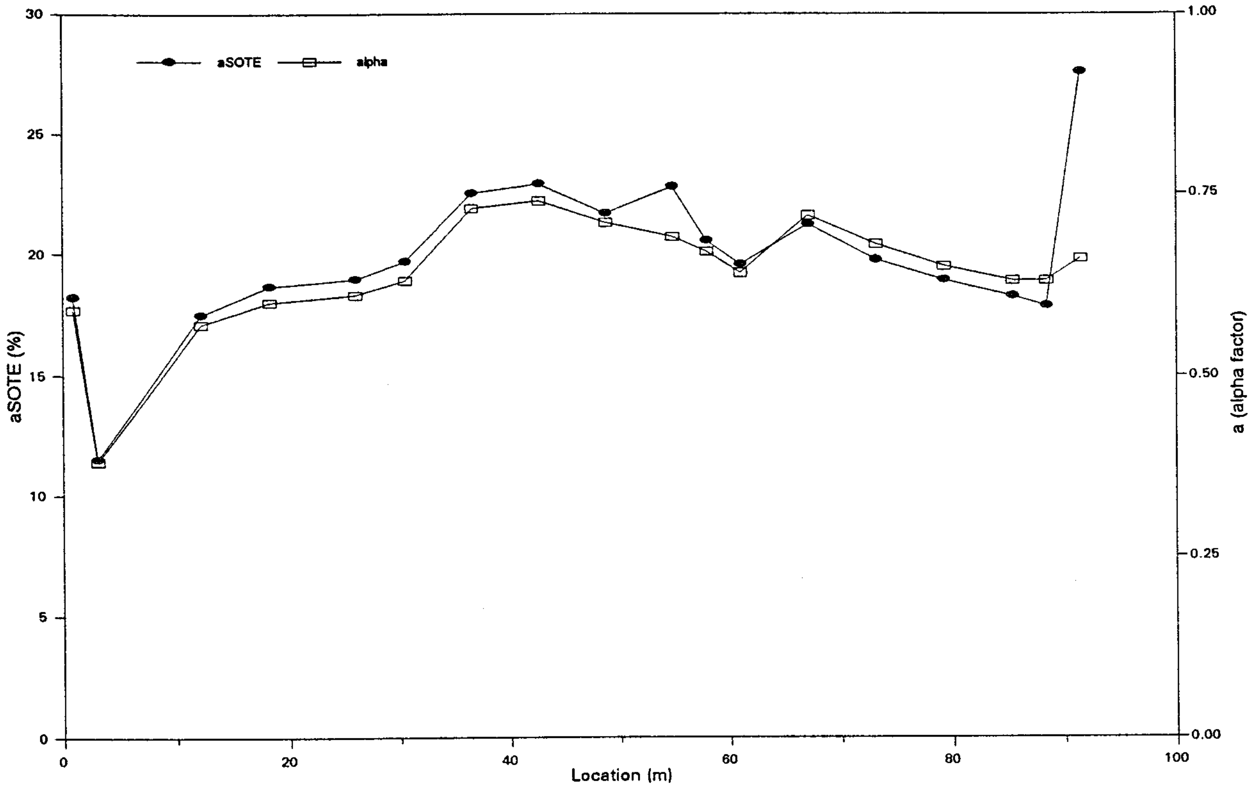
(b) Alpha factor



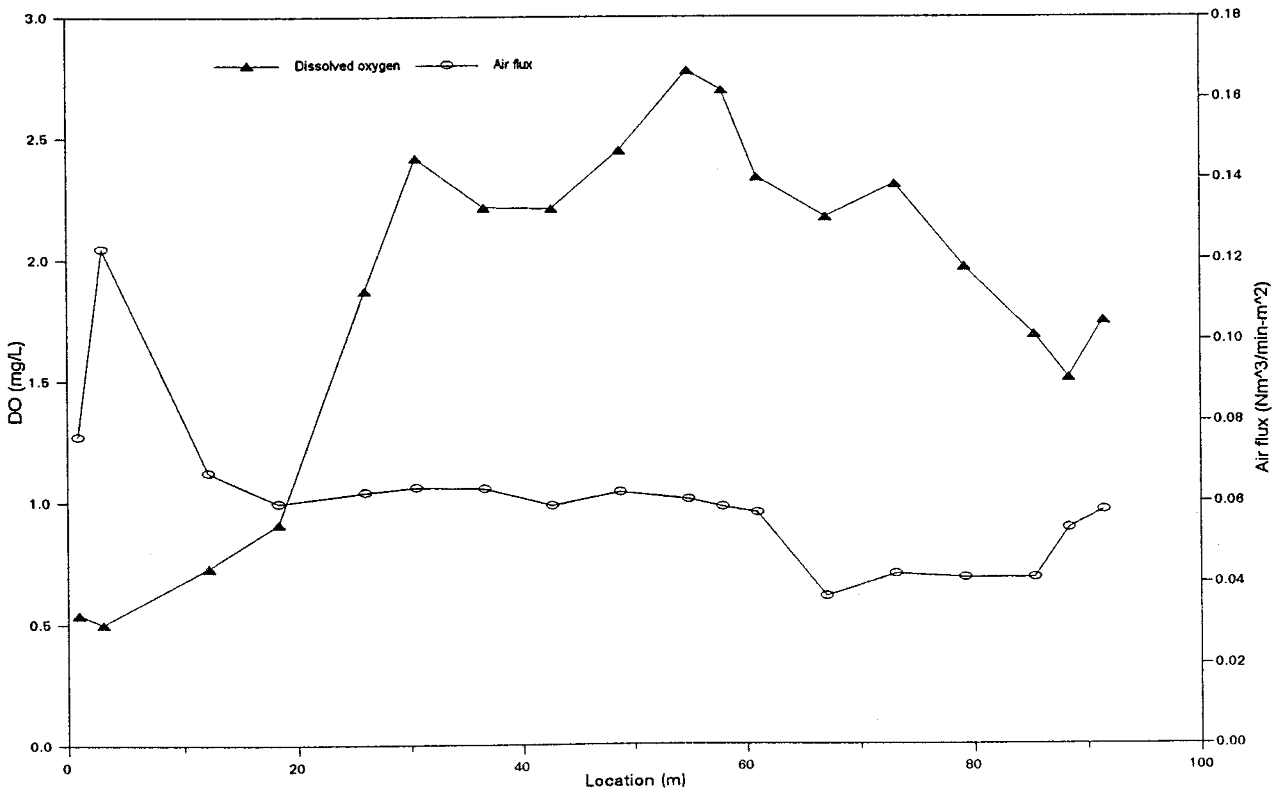
(c) Air flux

(d) Dissolved oxygen

Figure 3—Offgas analysis of tank 7 at TWRP, 1992 to 1994.

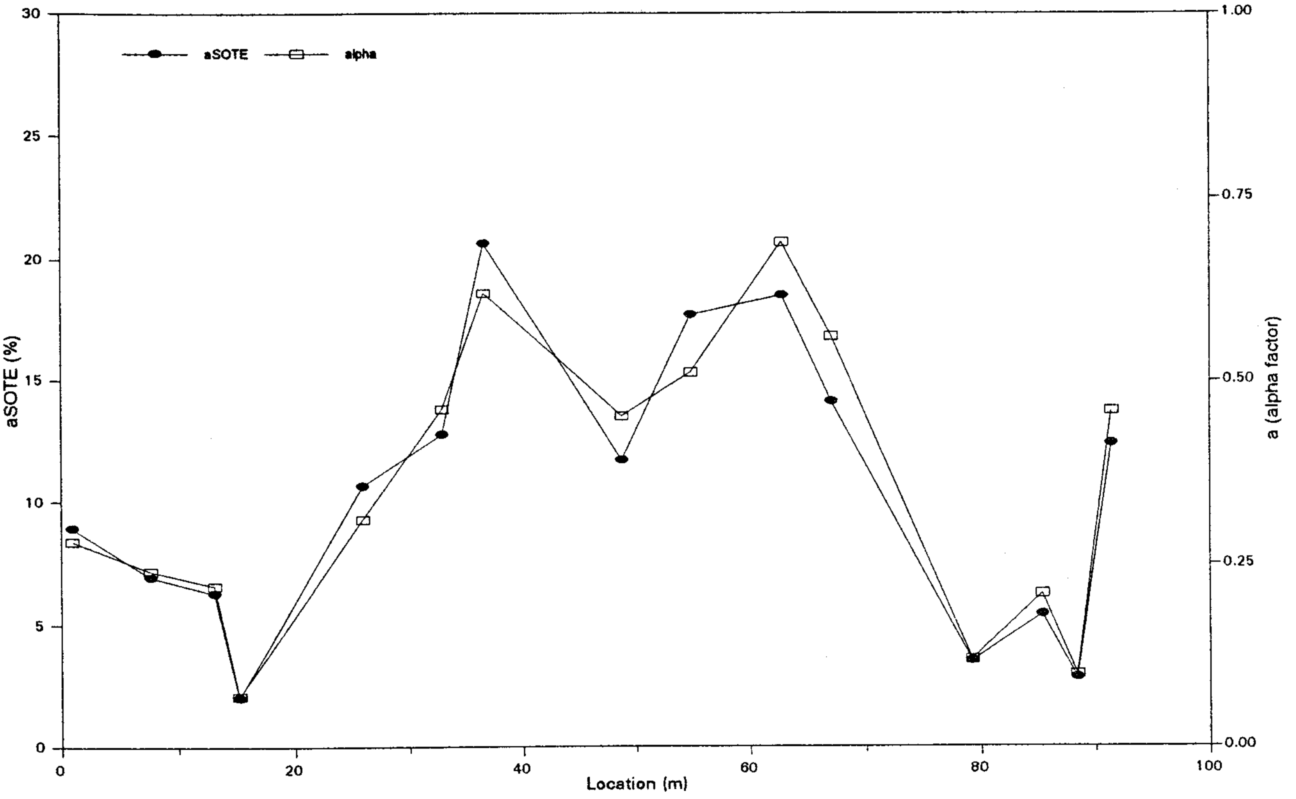


(a) Efficiency and alpha factor

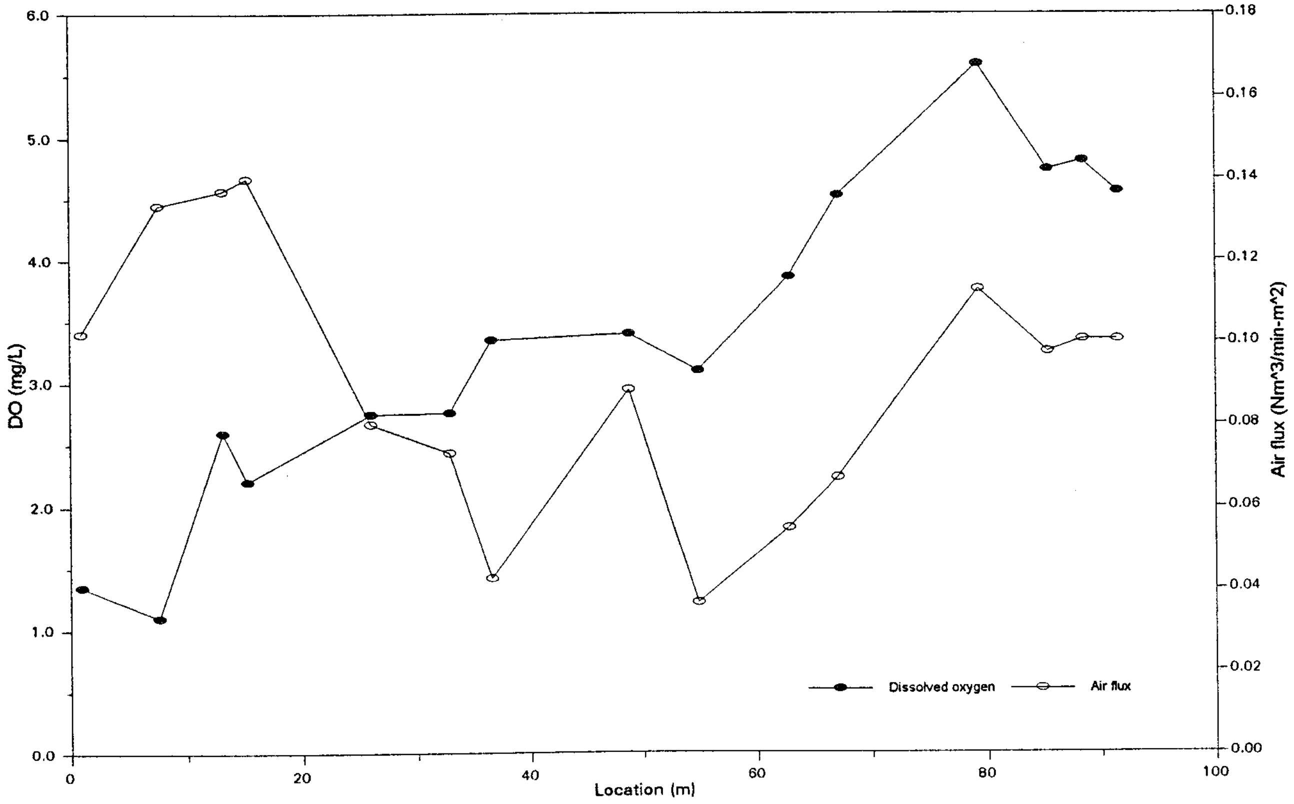


(b) Dissolved oxygen and air flux

Figure 4—Offgas analysis of tank 4 at TWRP, February 12, 1998.

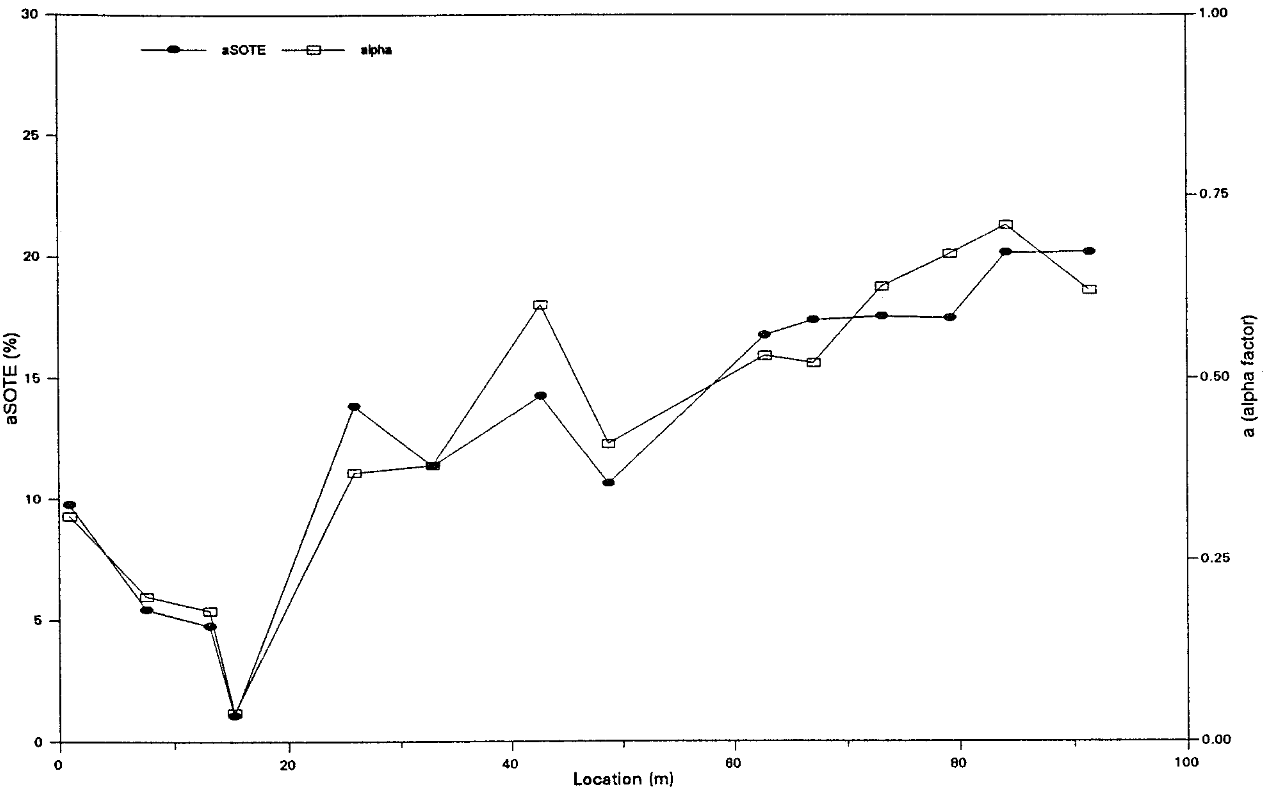


(a) Efficiency and alpha factor

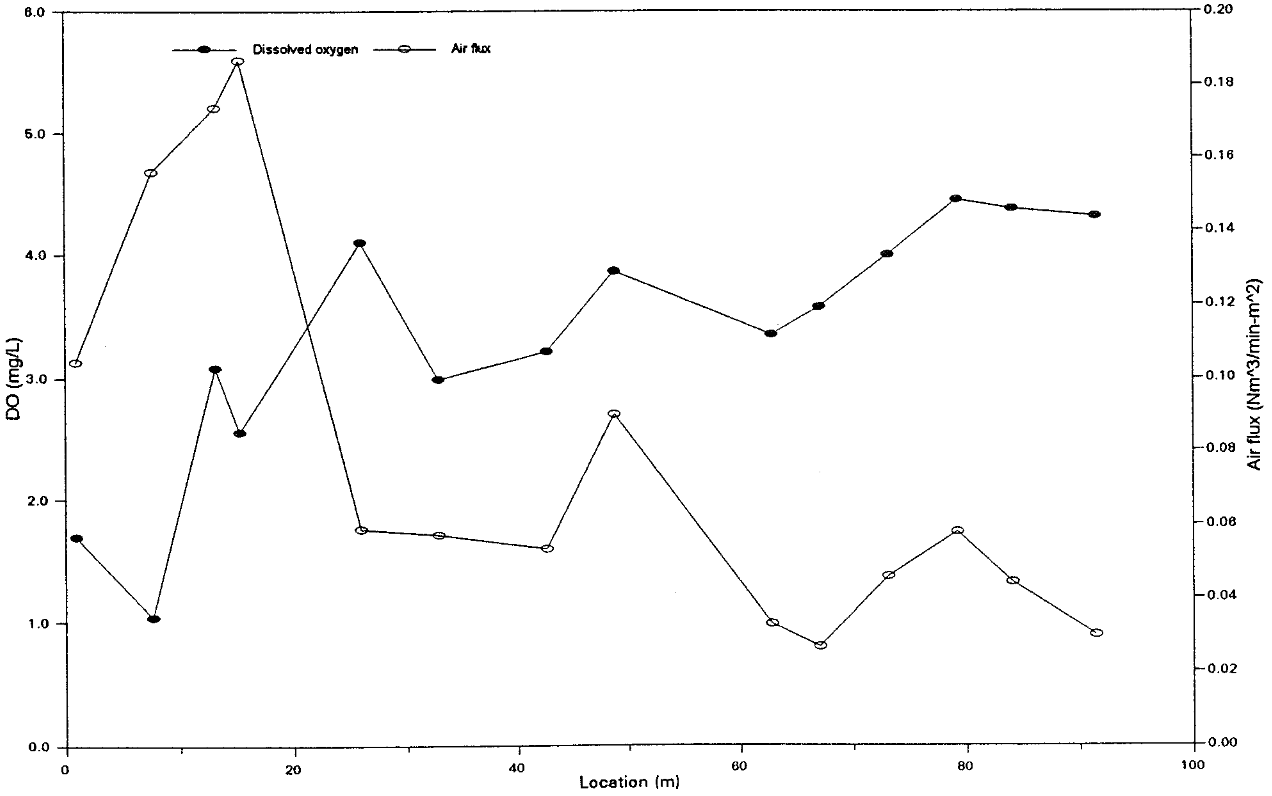


(b) Dissolved oxygen and air flux

Figure 5—Offgas analysis of tank 4 at TWRP, April 13, 1998.

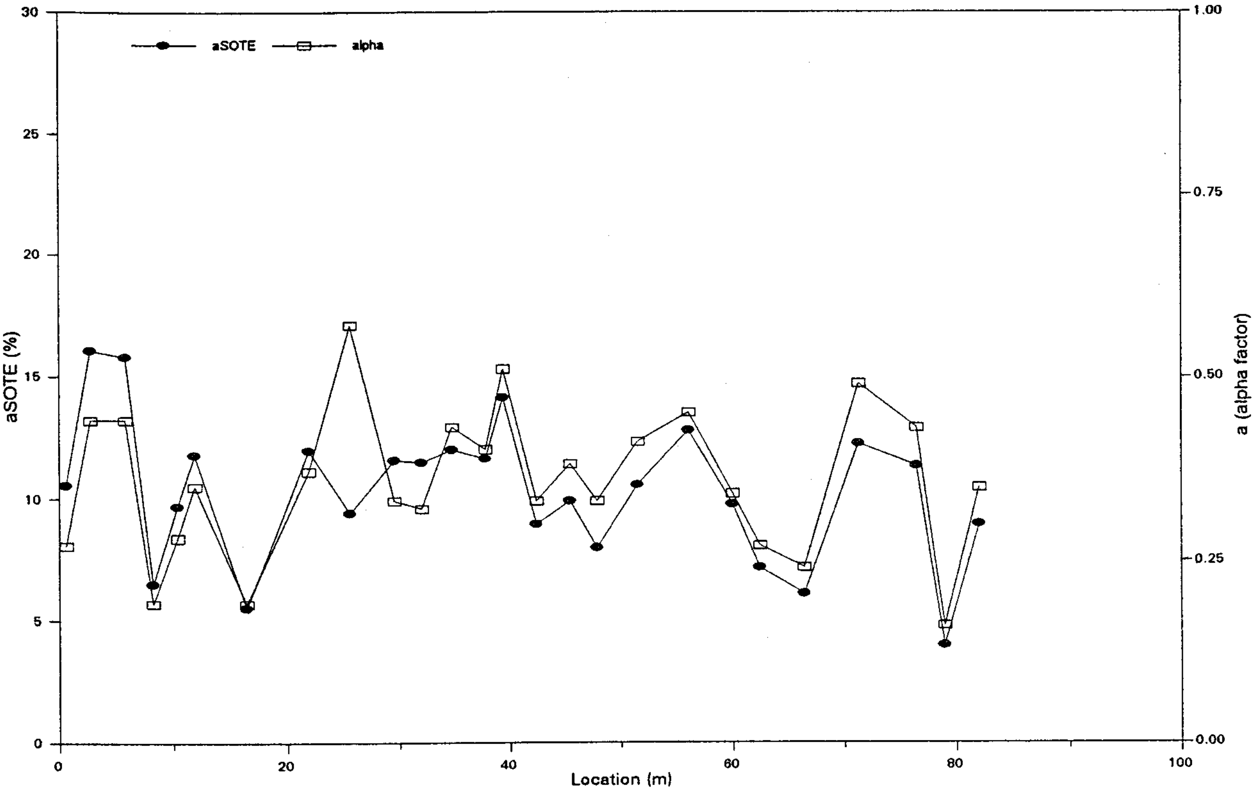


(a) Efficiency and alpha factor

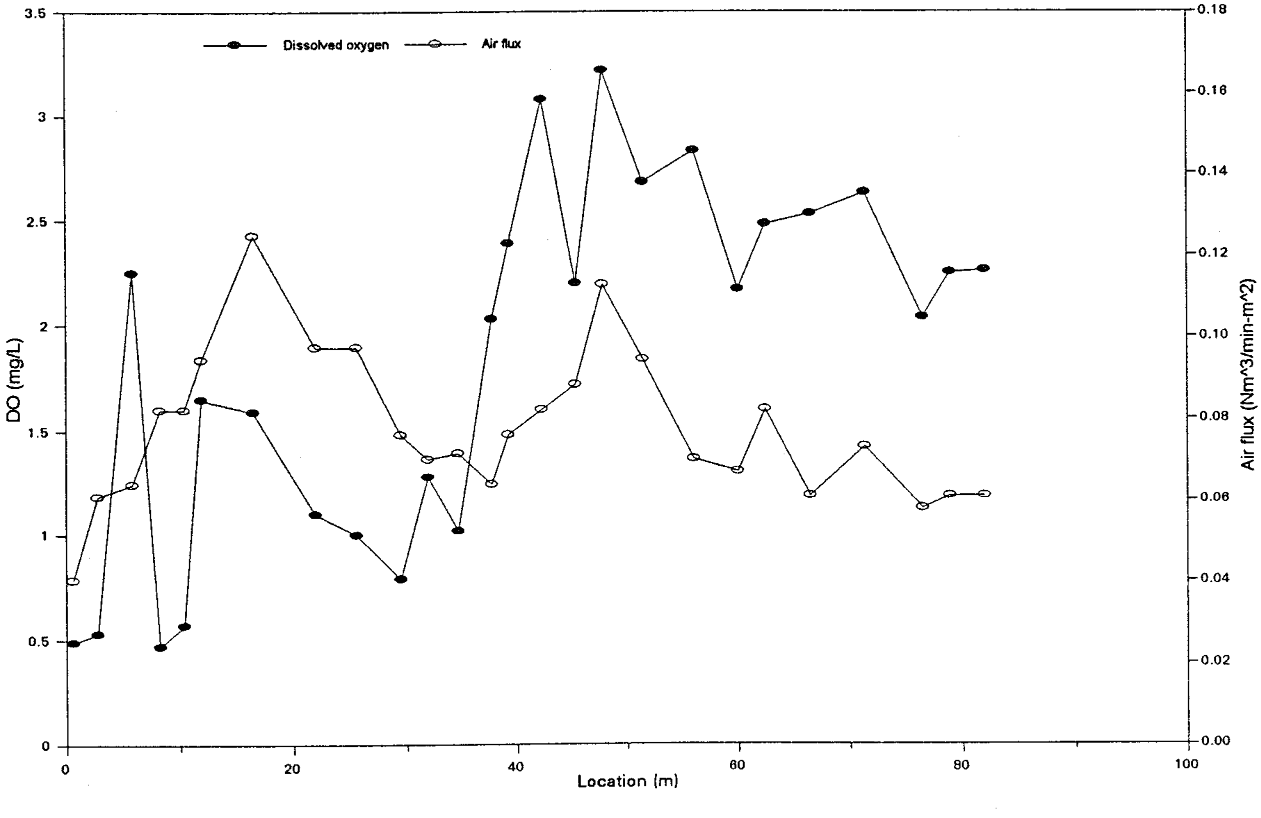


(b) Dissolved oxygen and air flux

Figure 6—Offgas analysis of tank 4 at TWRP, April 27, 1998.

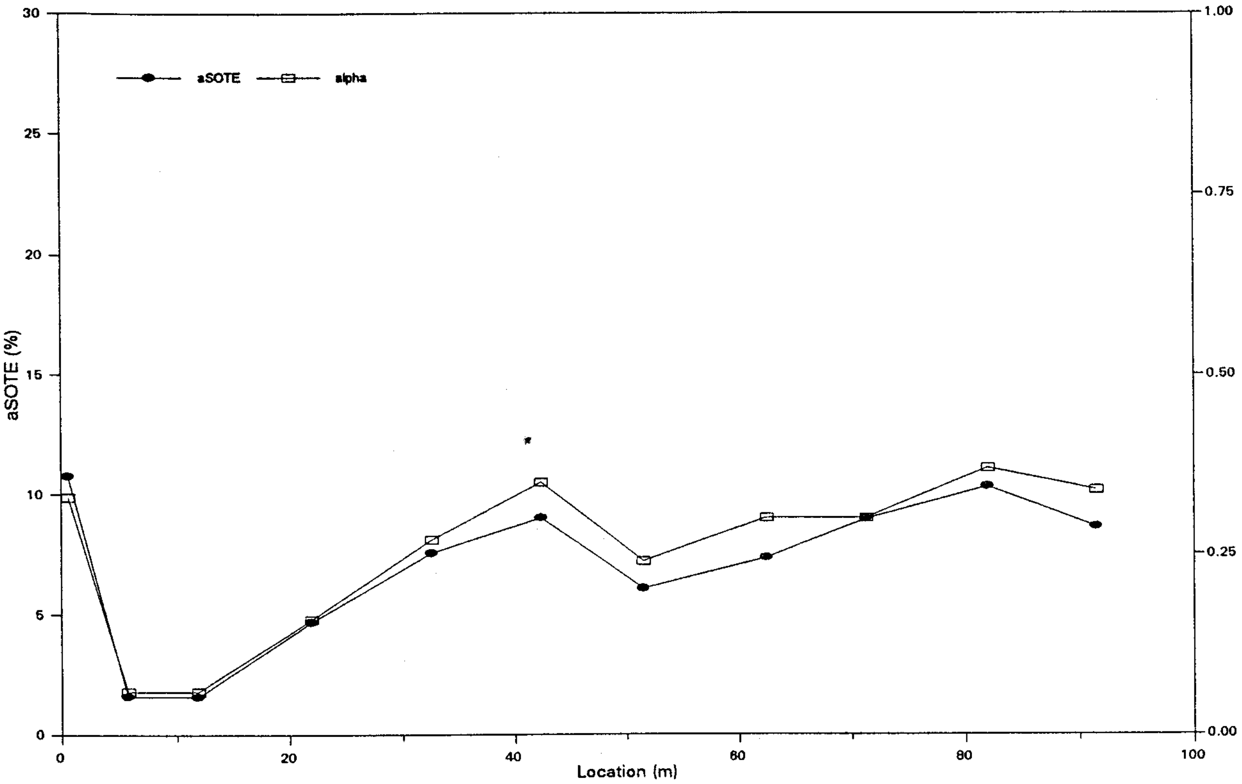


(a) Efficiency and alpha factor

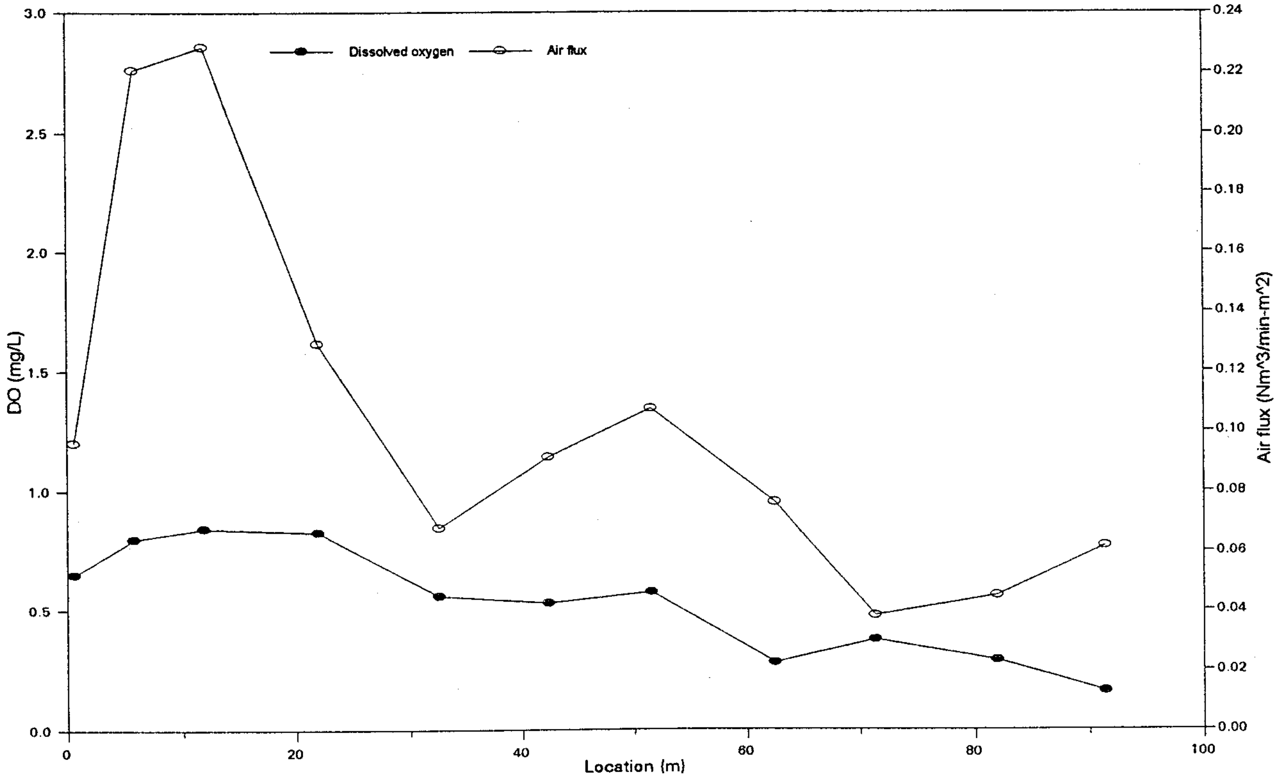


(b) Dissolved oxygen and air flux

Figure 7—Offgas analysis of tank 5 at TWRP, March 27, 1998.

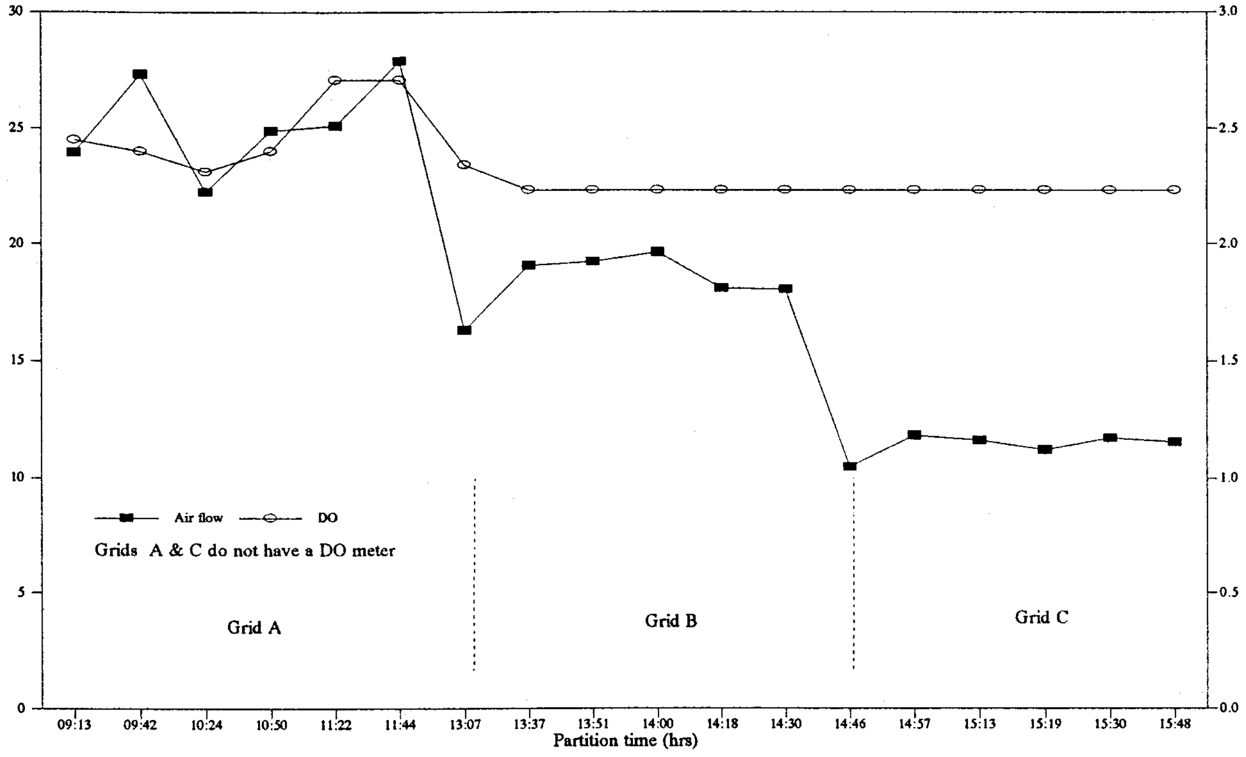


(a) Efficiency and alpha factor

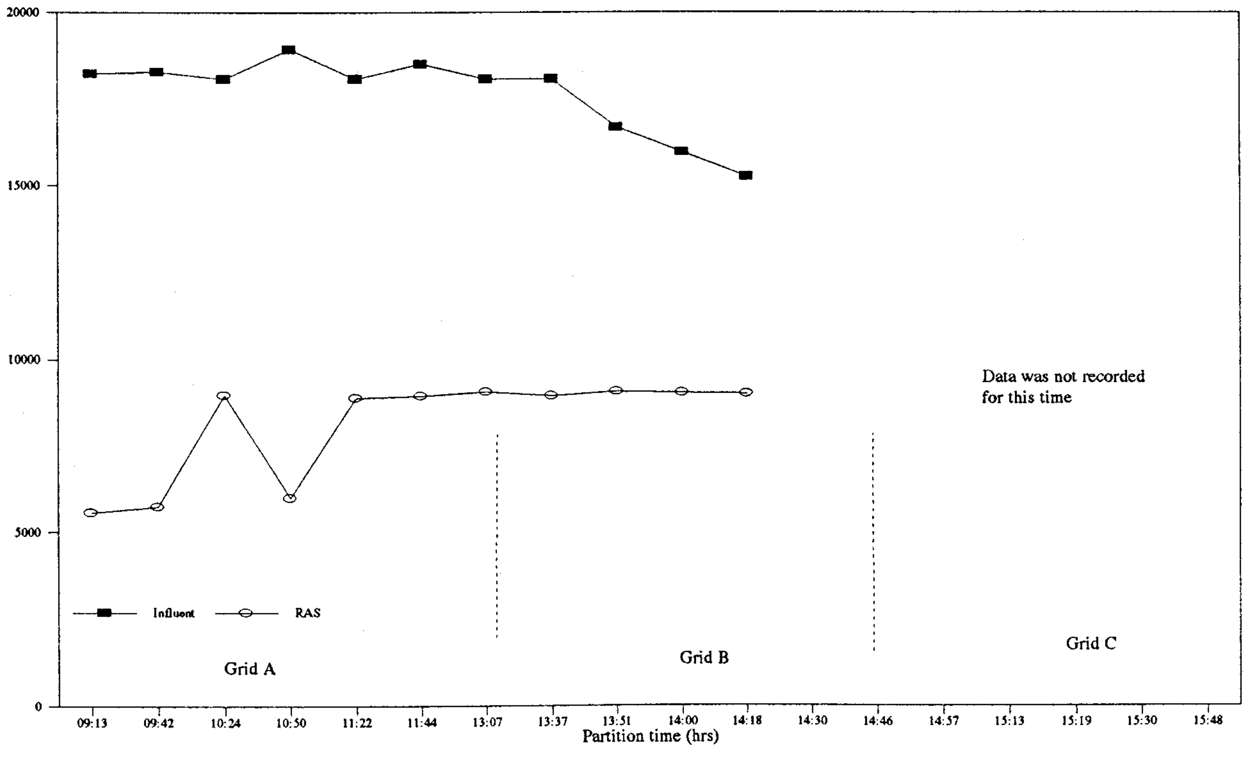


(b) Dissolved oxygen and air flux

Figure 8—Offgas analysis of tank 5 at TWRP, April 27, 1998.



(a) Air flow rate and DO



(b) Influent and RAS flow rate

Figure 9—Offgas analysis of tank 4 at TWRP (control room data), February 12, 1998.

Table 1—Control room data at TWRP, multiple hood positions.[a]

				Air flow			DO
Date	Tank number	RAS, m^3/min	*Q*,[b] m^3/min	Grid A, m^3/min	Grid B, m^3/min	Grid C, m^3/min	Sensor in grid B, mg/L
Feb. 24, 1992	6	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 24, 1992	7	n/a	n/a	n/a	n/a	n/a	n/a
June 29, 1992	6	n/a	n/a	n/a	n/a	n/a	n/a
June 29, 1992	7	n/a	n/a	n/a	n/a	n/a	n/a
Dec. 10, 1993	6	n/a	n/a	n/a	n/a	n/a	n/a
Dec. 10, 1993	7	n/a	n/a	n/a	n/a	n/a	n/a
July 11, 1994	6	n/a	n/a	n/a	n/a	n/a	n/a
July 11, 1994	7	n/a	n/a	n/a	n/a	n/a	n/a
Feb. 12, 1998	4	8.11 ± 1.53	17.66 ± 1.58	29.88 ± 3.74	17.30 ± 2.95	10.11 ± 1.67	2.33 ± 0.16
Mar. 27, 1998	5	8.26 ± 1.68	18.11 ± 1.00	41.72 ± 9.94	24.41 ± 6.00	14.5 ± 6.8	1.80 ± 0.19
Apr. 1, 1998	5	8.79 ± 0.03	22.21 ± 1.08	33.50 ± 2.01	19.00 ± 1.3	13.42 ± 1.36	1.79 ± 0.06
Apr. 13, 1998	4	8.95 ± 0.29	18.71 ± 1.84	51.54 ± 10.11	21.16 ± 5.72	22.06 ± 6.00	2.42 ± 0.43
Apr. 27, 1998	4	9.29 ± 0.18	19.69 ± 1.21	47.63 ± 3.79	21.24 ± 1.84	11.67 ± 1.19	3.20 ± 0.2
Apr. 27, 1998	5	8.76 ± 0.39	17.58 ± 0.87	61.06 ± 1.05	28.86 ± 0.68	16.63 ± 0.42	0.74 ± 0.0

[a] Data presented as average ± standard deviation.
[b] Flow rate.

measurements on each day, but the plots of DO and air flow show that, as expected, these parameters varied somewhat during most of the measurement sessions. The control room data confirm that DO in grid A is typically less than that in grids B and C in the tanks. In most of the 1998 data, air flows were more nearly stable than those recorded during the measurement sessions in the fall of 1997.

Analysis. For the assessment of diffuser and air distribution system condition, Table 2 summarizes the results from phase I. Results from 1992 through 1994 were all obtained with the same sampling pattern; so they are easily compared, but the new sampling patterns require a little more consideration. The most direct comparison between the recent results and the earlier ones is provided by calculating area-weighted averages of the recent data that omit samples taken in the partitions between the grids at the leading edges of the grids and at the extreme ends of the tanks and by comparing these with the 1992 through 1994 results.

Table 2—Oxygen transfer efficiencies of phase I aeration tanks at TWRP, multiple hood positions.[a]

		Efficiencies of grid interiors	
Date	Tank number	OTE	*a*SOTE
Feb. 24, 1992	6	9.21 ± 2.73	9.91 ± 2.62
Feb. 24, 1992	7	8.45 ± 1.39	9.01 ± 1.76
June 29, 1992	6	6.29 ± 1.46	7.31 ± 1.41
June 29, 1992	7	7.26 ± 1.36	7.74 ± 1.41
Dec. 10, 1993	6	11.60 ± 2.45	13.40 ± 3.85
Dec. 10, 1993	7	9.95 ± 1.57	10.79 ± 1.96
July 11, 1994	6	15.67 ± 1.97	19.63 ± 2.90
July 11, 1994	7	14.02 ± 1.13	16.87 ± 0.65
Feb. 12, 1998	4	15.37 ± 1.94	18.93 ± 3.31
Mar. 27, 1998	5	7.83 ± 2.16	9.85 ± 2.60
Apr. 1, 1998	5	7.62 ± 2.20	8.70 ± 2.41
Apr. 13, 1998	4	5.04 ± 3.70	7.47 ± 5.47
Apr. 27, 1998	4	5.66 ± 3.36	8.97 ± 6.11
Apr. 27, 1998	5	4.40 ± 3.01	4.66 ± 3.10

[a] Data presented as average ± standard deviation.

The salient results in these tables are the rapid decreases in the efficiencies of tanks 4 and 5. The average *a*SOTE of tank 4 was approximately 19% on February 12, 1998, but only 8 to 9% on April 13 and 27, 1998. Likewise, the average efficiency of tank 5 decreased from approximately 10% on March 27 to approximately 5% on April 27, 1998. Unlike the one percentage point decline in the estimated efficiency of tank 15 from approximately 13% on October 16 to approximately 12% on March 4, the decreases in efficiencies of tanks 4 and 5 are greater than the estimated standard deviations derived from the averaging calculation and thus seem statistically significant.

These conclusions are supported by the detailed measurements. On February 12, 1998, all but one of the *a*SOTE measurements in tank 4 were approximately 20%, and the corresponding air flux measurements were all approximately 0.061 $Nm^3/m^2 \cdot min$ (0.2 scfm/sq ft), except for the point with 11.5%, which had a flux of 0.121 $Nm^3/m^2 \cdot min$ (0.4 scfm/sq ft). On April 13, 1998, most of grids A and C of tank 4 had efficiencies less than 10%, with air fluxes greater than 0.091 $Nm^3/m^2 \cdot min$ (0.3 scfm/sq ft), and grid A had fluxes greater than 0.4 $Nm^3/m^2 \cdot min$. In all three grids, peak fluxes occur at the locations of the primary air pipes [15.24, 45.72, and 76.20 m (50, 150, and 250 ft) from the influent end], suggesting leaks in these pipes. Similar results were obtained on April 27, 1998, with fluxes in grid A peaking at greater than 0.182 $Nm^3/m^2 \cdot min$ (0.6 scfm/sq ft) and corresponding efficiencies of approximately 5%, although the efficiencies in grid C were back to approximately 20%, with fluxes less than 0.061 $Nm^3/m^2 \cdot min$ (0.2 scfm/sq ft).

The tank 5 measurements from March 27, 1998, varied much more along the length of the tank, but only a few were greater than 0.091 $Nm^3/m^2 \cdot min$ (0.3 scfm/sq ft). By April 27, 1998, the fluxes in grid A peaked at greater than 0.213 $Nm^3/m^2 \cdot min$ (0.7 scfm/sq ft), and the corresponding efficiencies were less than 5%. On both days, both grids A and B had flux peaks near the primary air pipe locations.

Evidence of the potential for improvement by cleaning and the performance of new diffusers at this plant are provided in Table 2. Between the second and third testing sessions conducted by the UCLA–BOS collaboration on tanks 6 and 7, diffusers were cleaned in both tanks, and between the third and fourth sessions, the diffusers in tank 6 were replaced, and the diffusers in tank 7 were cleaned with liquid acid. Evidently, the liquid acid cleaning improved the efficiency of tank 7 significantly but not to the level achieved with new diffusers in tank 6.

Recent measurements of tank 15 show only a slight drop in average tank efficiency during the past few months, which is within the uncertainty of the average derived from the local OTE measurements. Hence, it would not justify an expensive effort to clean or repair a diffuser system unless the performance were already so poor that cleaning or repair seemed warranted, as in the situation observed by Stenstrom and Masutani (1989) when dewatering showed serious deterioration in the air distribution system in basin 3 of the Whittier Narrows wastewater treatment plant.

Discussion

Comparison with the work of Newbry (1998) and Iranpour et al. (1999a, 1999c, and 2000) provides a useful perspective on these results. Newbry shows that in clean water performance tests, if bubbles of a uniform diameter, *D*, are rising through a fixed distance, *H*, then R_{O_2}, the rate of oxygen transfer per unit volume of the liquid (in g/m^3•s) is proportional to $D^{-7/4}$ so that the overall OTE is highly sensitive to the size distribution of the bubbles.

This theory is not quantitatively applicable to these measurements in process water. In particular, further analysis of Newbry's development indicates that OTE is likely to decrease rapidly with increasing CO_2 transfer to the bubbles because this reduces the partial pressure of the oxygen that remains in them as they rise, but his formulae are derived for water that contains neither O_2 nor CO_2. (These and other considerations imply that the typically calculated *a* factor may overstate the degree to which oxygen transfer in operating aeration tanks falls short of the performance possible under clean water conditions because the physical conditions typically used by manufacturers in clean water testing are sufficiently unrealistic to overestimate the oxygen transfer that may be feasible; a later publication may consider this point in further detail.) However, the qualitative conclusion of strong OTE sensitivity to bubble size distribution still holds, implying that the kinds of changes seen over the years in tanks 6 and 7 could result from relatively modest shifts to larger numbers of larger bubbles, not from gaping holes in the distribution system.

On the other hand, the magnitude and rapidity of the changes in the efficiencies observed in tanks 4 and 5 imply that the distribution systems in these tanks may have suffered significant losses of integrity. This conclusion was confirmed by briefly opening the air release valves on the air systems in these tanks. Large quantities of water ran out, indicating leakage into the submerged pipes. However, doing this provided little information about where the leak(s) might be, whereas the offgas and air flux measurements showed that much of the leakage in grids A and B of both tanks was occurring along the primary air pipes at 15.24 and 45.72 m (50 and 150 ft) from the influent end.

Repairs of lesser leaks also may help reduce air-side fouling of the diffusers, which is not affected by external cleaning processes. Because the air supply to the diffusers is in part derived from the headworks and other areas that otherwise would produce unacceptable odors, it is filtered before it is distributed to the tanks, and so the air-side fouling may be the result of deposition of substances evaporated from small amounts of process water that have leaked into the air distribution system through such imperfections. (Compression heats the air to 75 °C or more so that both water and volatile organics are rapidly vaporized.) This may occur during normal operation because of the unsteady air flow through leaks, but it is much more likely to occur during power failures, which in recent years have occurred at TWRP approximately once per month. Also, during a power failure, the loss of air pressure allows the external water pressure to drive suspended solids and bacterial slime growth into the surfaces of the diffusers, causing much more rapid fouling than normal operation.

Combining these considerations implies that the OTE of a large aeration system is sufficiently vulnerable to reduction by various disturbing factors that more frequent monitoring may well be justified. Additional economic analysis of the costs of offgas monitoring relative to the costs of operating with seriously reduced efficiency is under investigation.

Conclusions

The OTE measurements at TWRP have shown significant changes of tank performance over time scales of both years and weeks. Two tanks show strong evidence of rapid recent deterioration of their air distribution systems. Air flux measurements indicate that significantly increased leakage is occurring along several of the primary air distribution pipes that are located halfway along each of the diffuser grids. This is much more specific information about the nature and location of the damage than what could be obtained by any other method short of dewatering the tanks and directly inspecting the pipes and diffusers.

Efficiencies in several other tanks are less than the greatest values observed in the past, but it is not yet clear how much of this is irreversible deterioration of the diffusers and how much is fouling that could be removed by suitable cleaning. As might be expected, cleaning, even though it was done with an acid wash, has not been observed to restore performance to levels achieved when new diffusers are used. The economic analysis of whether to clean the diffusers would involve not only assessing the efficiency improvements of cleaning the diffusers themselves, but also assessing the value of repairs that would be possible if the tanks were emptied for cleaning, and the authors plan to address this topic further in the future.

Because only 12 of the 18 tanks at TWRP have been studied so far (10 tanks were measured in late 1997, 1998, and 1999, and two more were measured in studies conducted from 1991 to 1994), it is likely that more remains to be learned about the tanks that will be of local interest. However, the present results are evidence of the potential value of more frequent monitoring of oxygen transfer in aeration basins than what has been typical practice in the past and provide a possible starting point for similar work elsewhere.

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