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Changes at an activated sludge sewage treatment plant alter the numbers of airborne aerobic microorganisms

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Abstract

In 1976, the activated sludge sewage treatment plant in Edmonton, Canada, was surveyed to determine the numbers of culturable airborne microorganisms. Many changes have been made at the plant to reduce odors and improve treatment efficiency, so in 2004 another survey was done to determine if these changes had reduced the bioaerosols. Covering the grit tanks and primary settling tanks greatly reduced the numbers of airborne microbes. Changing the design and operation of indoor automated sampling taps and sinks also reduced bioaerosols. The secondary was expanded and converted from a conventional activated sludge process using coarse bubble aeration to a biological nutrient removal system using fine bubble aeration. Although the surface area of the secondary more than doubled, the average number of airborne microorganisms in this part of the plant in 2004 was about 1% of that in 1976.

Keywords: Bioaerosol; Sewage; Aeration; Outdoors; Indoors

1. Introduction

Wastewater that reaches a sewage treatment plant is teeming with microorganisms. In domestic wastewaters, microorganisms originate from human excreta in household, commercial and hospital sewage. Combined sewage contains street and storm runoff, and these carry microorganisms from soils and animal droppings. Each of these sources contains a vast number and variety of microorganisms, including pathogens. The potential health risks to workers exposed to sewage and aerosols from sewage have been the topic of many studies (Clark et al., 1976; Friis et al., 1999; Rylander, 1999; Thorn and Kerekes, 2001; Hansen et al., 2003; Jeggli et al., 2004). The three major routes of exposure to airborne particles are dermal contact, ingestion and inhalation (Pillai and Ricke, 2002).

In 1976, a research group from the Department of Microbiology at the University of Alberta sampled airborne microorganisms from various indoor and outdoor locations at the Gold Bar Wastewater Treatment Plant in Edmonton, Canada (Fedorak and Westlake, 1980). Splashing and bubble bursting that occur as a result of forced aeration in activated sludge processes are notorious for producing large bioaerosols (Sawyer et al., 1996; Bauer et al., 2002; Prazmo et al., 2003; Pascual et al., 2003). Fedorak and Westlake (1980) reported that the activated sludge tanks typically produced the largest numbers of airborne microorganisms, and that the highest counts among these tanks were observed at night, when the rate of aeration was highest. Similarly, at other outdoor plant locations where aeration is used (such as in the influent to the primary and final settling tanks, and in the grit tanks),

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the numbers of airborne microbes were elevated. Surprisingly, some very high numbers of airborne microorganisms were observed at indoor locations, near sewage sampling sinks (Fedorak and Westlake, 1980).

The Gold Bar Wastewater Treatment Plant has undergone many changes since 1976. Table 1 provides a summary of some of the operations at Gold Bar in 1976 and 2004. The plant has expanded in size and capacity, and new buildings are now on site. Many of the primary tanks are now covered to control odors, and the secondary has fine bubble aeration. Although these changes were not specifically made to reduce the numbers of airborne microorganisms, it was hypothesized that many of the changes would reduce the production of microbial aerosols at the plant.

The objective of this study was to repeat the survey that was done in 1976 to determine whether the changes at the Gold Bar plant reduced the numbers of airborne microorganisms. In addition, some new outdoor and indoor locations were sampled for the first time to assess the numbers of airborne microorganisms at these locations.

2. Materials and methods

2.1. Sampling locations

Most of the locations sampled were the same as those reported in Fedorak and Westlake (1980). The outdoor locations included primary and secondary treatment areas. The indoor locations were near mixed liquor sampling sinks. New locations included a site in the new secondary aeration, a pilot membrane ultrafiltration plant and a building housing dissolved air floatation units for the recovery of waste-activated sludge. Sampling locations are shown in Fig. 1 and described in Table 2. A total of 10 outdoor and eight indoor locations were sampled between August 17, 2004 and January 6, 2005.

Raw sewage enters the grit tanks (locations Bc and Bo) and the wastewater is aerated with coarse bubbles to keep organic matter suspended so that it will flow into the primary settling tanks. In 1976, the three grit tanks were not covered. By 2004, all of the grit tanks were covered to control odors, and air samples (Bc) were taken while the tanks were covered. Then the hinged covers on all of the grit tanks were opened and approximately 1 h later, the second samples (Bo) were taken to test the extent of aerosol suppression by the covers.

2.2. Aerosol sampling and incubation of plates

The sampling methods used in these study were the same as those reported by Fedorak and Westlake (1980), thus the current results could be compared with the data collected in 1976. Most of the air samples were collected 1.74 m above walking surfaces, although on two occasions, samples were collected at 0.44 m at location F. Air samples were taken using slit to agar samplers (STA-203 Microbiological Air Samplers, New Brunswick Scientific) operating at an air flow rate of 50 L min^{-1} for 40 min. Airborne particles of size equal

Table 1
Changes at the Gold Bar Wastewater Treatment Plant during the period 1976–2004

Plant process	1976	2004
Typical volume of wastewater treated	200 ML d^{-1}	260 ML d^{-1}
Number of inhabitants served	460,000	700,000
Secondary process used	Conventional activated sludge	Biological nutrient removal
Aeration used in the secondary	Coarse bubbling	Fine bubbling
Number of tanks in the secondary process	5	10
Grit tanks and primary settling tanks covered for odor control	No	Yes
Number of grit tanks and screening units	3	7
Waste-activated sludge thickened by air floatation	No	Yes
Sampling sinks for mixed liquor in secondary section	Five sets of uncovered sinks with 2–5 continuously running taps into each sink. Splashing occurred as wastewater fell into sinks	Two sets of sinks. One set for all samples for bioreactors 1–5 and the other for bioreactors 6–10. Flow through taps is intermittent, only when samples are automatically collected. No splashing occurs