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Project Summary

Study of Microbial Aerosols Emitted from a Water Reclamation Plant

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The purpose of this investigation was to determine the occurrence of selected microorganisms in the air in the vicinity of the O'Hare Water Reclamation Plant (OWRP), Des Plaines, Illinois. The contribution of the OWRP to ambient microbial aerosols was determined by comparing baseline, or preoperational, observations during fall and spring/summer months to those made after operation was initiated. Three sampling sites were positioned < 150 m, 150 to 250 m, and > 250 m downwind, while one location was upwind of the center of the two-stage activated sludge aeration tanks. Depending upon the wind direction, the first downwind site was frequently positioned at < 5 m from the edge of the aeration tanks, with the other downwind sites proportionally nearer to this tank boundary.

Air sampling volumes were based upon predetermined sensitivity levels for each group of microorganisms. At each site, multistaged impactor and slit samplers were used to determine total aerobic bacteria-containing particle concentrations and particle size distributions. In addition, "large volume" air samplers, that included electrostatic precipitator and cyclone scrubber samplers, were used to detect aerosols of standard plate count organisms, total coliforms, fecal coliforms, fecal streptococci, *Salmonella* sp., other organisms within the total coliform group, coliphages of *Escherichia coli* C3000, and animal viruses detectable with Buffalo green monkey kidney (BGMK) and WI-38 cell cultures.

Low concentrations of several aerobic bacteria species and of certain coliphages were present in the air surrounding the newly constructed activated sludge plant before operation was initiated. After plant operations began at 21 to 67% of its design capacity of approximately 270,000 m^3/d [72 million gallons per day (MDG)], the frequency of detection of all microorganisms studied increased at the < 150 m downwind locations. The geometric mean total aerobic bacteria-containing particle (TABCP) concentrations, determined with slit samplers, increased from 59 to 218 colony forming units (cfu)/m^3 during the nighttime and from 34 to 57 cfu/m^3 during the daytime. The TABCP concentrations determined with Andersen samplers increased from 125 to 281 cfu/m^3 during the nighttime and from 87 to 234 cfu/m^3 during the daytime.

Using large volume scrubber (LVS) samplers at the first downwind location, standard plate count (SPC) organism geometric mean concentrations during the fall nighttime increased from 55 to 1325 cfu/m^3 and during the fall daytime from 49 to 220 cfu/m^3. Increases from 0.30 to 5.03 cfu/m^3 for total coliforms, 0.12 to 1.02 cfu/m^3 for fecal coliforms, 0.14 to 0.66 cfu/m^3 for fecal streptococcus organisms, and 0.004 to 0.095 most probable number plaque-forming units (mpnpfu)/ m^3 for coliphages were also observed at this first downwind site after operations started. At 150 to 250 m downwind from the center of the aeration tanks aerosol concentrations of total coliforms, fecal

coliforms, fecal streptococci, and coliphages were significantly higher during plant operations than before such operations started. When the aerosol concentrations of these organisms at the >250 m downwind site during plant operations were compared to preoperation concentrations, however, no significant ($p < 0.01$) differences could be detected from any group except for the coliphages.

Microbial aerosol concentrations were generally higher during the nighttime than during the daytime. The total coliform bacteria in aerosols during plant operations were predominantly *Enterobacter* sp., *Escherichia* sp., and *Klebsiella* sp., respectively. Animal viruses were detected at < 150 m downwind from the center of the aeration tanks in BGMK but not in WI-38 cells in two of twelve downwind air samples having total assay volumes of 385 to 428 m^3. Of the three virus isolates, two were identified as coxsackievirus B-1. The other virus was not identified by the antisera pools used.

The low-level concentrations of microbial aerosols observed before plant operations began did not increase beyond the perimeter of the plant on the east, south, and west sides during plant operations. Depending upon the meteorological and diurnal conditions, the concentration of certain microorganisms could occasionally increase beyond the north plant boundary. These concentrations, however, are very low (< 1 cfu or mpnpfu/m^3) and require very sensitive methods for detection.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Population growth within large urban regions necessitates expansion of existing wastewater treatment systems for processing increased volumes of sewage prior to utilization or discharge. Locating new wastewater treatment facilities in densely populated regions, however, requires consideration of the potential environmental and health effects of their operation. Microbial aerosols are emitted by wastewater treatment processes into the surrounding air. Activated sludge treatment, for example, generates small bubbles by diffused air aeration that adsorb and concentrate suspended bacteria and viruses as they rise through the sewage depth in the aeration tank to the surface boundary. At this boundary, a surface film containing microorganisms is disrupted as these rising bubbles burst, releasing tiny aerosol droplets containing the bubble-adsorbed, as well as the surface film-associated microorganisms.

The nearly instantaneous evaporation which may occur as these droplets become suspended in air leaves dried residues referred to as droplet nuclei that are subject to downwind dispersion. The survival and dispersion of the organisms that may be associated with these droplet nuclei are affected by organism characteristics and environmental factors such as relative humidity, temperature, irradiation, wind velocity, atmospheric stability, and atmospheric pollutants.

While processes of wastewater treatment have shown to generate microbial-laden aerosols that can be carried downwind, the occurrence of potentially infectious microbial aerosols per se does not provide evidence of associated health risks. No conclusive evidence is yet available that demonstrates that persons residing in the vicinity of wastewater treatment facilities are subjected to greater health risks than those who do not dwell in such areas. Placing such facilities in regions of high population densities has, however, initiated concerns regarding the health implication of exposure to microorganism-containing wastewater aerosols.

One such facility, the O'Hare Water Reclamation Plant (OWRP), located in the City of Des Plaines, Illinois, was constructed to be operated as part of the regional Metropolitan Sanitary District of Greater Chicago (MSDGC) system. The proximity of this plant to a residential area has been the subject of concern over the past several years because of the potential for exposure to plant-emitted microbial aerosols. Because no data were available to determine the potential for community exposure to microbial aerosols that might be emitted from this plant, this study was initiated to determine the probability of such exposure over a wide range of environmental and meteorological conditions.

The probability of community exposure was evaluated by comparing the preoperational, or baseline, plant site microbial aerosol contribution to the surrounding environment to that observed after initiation of plant operations. This study was intended to provide data on whether or not significant increases in microbial aerosols could be attributed to facility operations during different seasons and atmospheric conditions.

Conclusions

1. When operating at 21 to 67% of its design capacity, the OWRP is a source of aerosols containing bacteria and viruses.
2. Significant aerosol concentration increases over the baseline at < 150 m downwind from the center (or, depending on the wind direction, to within 5 m from the edge) of the aeration tanks were observed for total aerobic bacteria containing particles, standard plate count organisms, total coliforms, fecal coliforms, fecal streptococci, and coliphages. The total coliform aerosols identified were predominantly *Enterobacter* sp., *Escherichia* sp., and *Klebsiella* sp. Animal viruses from assay volumes ranging from 385 to 428 m^3 in two cell culture lines were detected in two of twelve downwind air samples. Of three virus isolates, two were identified as coxsackievirus B-1 and the third was not identified with the antiserum pool used.
3. At 150 to 250 m downwind from the center of the aeration tanks, no significant increases in microbial aerosol concentrations were observed during the daytime after the plant began operations. When considering both daytime and nighttime samples, however, significant increases were observed for total coliforms, fecal coliforms, fecal streptococci, and coliphages. The concentrations of these organisms at 150 to 250 m downwind sites decreased substantially from those observed at the < 150 m downwind location during plant operations. These concentrations decreased by 85% (5.0 to 0.77 cfu/m^3) for total coliforms, by 76% (1.02 to 0.24 cfu/m^3) for fecal coliforms, by 33% (0.66 to 0.44 cfu/m^3) for fecal streptococci, and by 68% (0.004 to 0.002 mpnpfu) for coliphages.
4. Aerosol concentrations did not significantly increase after the plant began operations for any bacteria studied at sampling distances beyond 250 m downwind from the center of the aeration tanks. The frequency of detection did, however, increase from 38 to 79% for total coliforms, from 0 to 63% for fecal coliforms, and from 69 to 89% for fecal streptococci. Coliphage concentrations were, however, significantly higher and their frequency of detection increased from 22 to 86% after the plant began operations.

5. Bacteria aerosol concentrations were directly related to sewage flow rate within 150 m downwind of the center of the aeration tanks during the fall season of plant operations, but, at downwind locations greater than 150 m downwind, inverse correlations were observed at night.
6. During plant operations, bacteria aerosol concentration was directly related to wind velocity during the spring/summer season at locations ≤250 m downwind of the center of the aeration tanks. Before operations, negative correlations were found at upwind and 150 to 250 m downwind locations.
7. Bacteria aerosol concentrations were directly related to temperature at locations within 150 m downwind of the aeration tanks during plant operations. At nighttime, however, negative correlations were observed at locations > 250 m downwind and upwind.
8. Bacteria aerosol concentrations were generally inversely related to relative humidity.
9. Fecal streptococci and coliphages appear to be more stable in aerosols than the other indicator bacteria studied.
10. Low-level concentrations of bacteria and coliphages were present in the air in the vicinity of the OWRP before the plant began operations. These concentrations did not increase beyond the perimeter of the plant on the east, south, and west sides during plant operations. Depending upon the meteorological and diurnal conditions, the concentration of certain microorganisms could occasionally increase beyond the north plant boundary. These concentrations, however, are low (< 1 cfu or mpnpfu/m^3), and require very sensitive methods for detection.

Recommendations

1. Selected microbial aerosol parameters should be monitored at the OWRP boundary during the nighttime when the plant begins operation at full capacity. These data should then be compared to the baseline observations made in this study to determine whether significant concentration increases occur at higher sewage flow rates.
2. Coliphages and fecal streptococci appear to be stable as aerosols and are recommended as indicators of potential sewage-borne aerosol contaminations.

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The complete report, entitled "Study of Microbial Aerosols Emitted from a Water Reclamation Plant," (Order No. PB 83-234 906; Cost $14.50, subject to change) will be available only from:
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