United States
Environmental Protection
Agency

Robert S. Kerr Environmental
Research Laboratory
Ada OK 74820

Research and Development

EPA-600/S2-82-075 Nov. 1982

EPA

Project Summary

Treatment Compatibility of Municipal Waste and Biologically Hazardous Industrial Compounds

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The overall objective of this research was to gain information on the effect of organic priority pollutants on the performance of activated sludge units at publicly owned treatment works. The study was designed to gain information on the effects of a wide array of compounds and to determine the most useful study procedures to be used in assessing effects related to the need for pretreatment of industrial wastes.

Batch and continuous flow bench-scale activated sludge pilot plants were fed settled municipal sewage. The general approach was to compare the performance of control systems with that of comparable systems dosed with various concentrations of priority pollutants. Twenty-four compounds were studied in batch pilot plants; eight of these were also studied in continuous flow pilot plants operated at a sludge age of 5 days. Four of the eight were also studied in extended aeration pilot plants. Each compound was studied for a period of six months under each mode of operation.

In batch operations, only pentachlorophenol and 2-chlorophenol caused increases in soluble residual chemical oxygen demand (COD) at feed concentrations of 5 mg/l. None of the eight compounds tested in continuous flow at a sludge age of 5 days showed increased effluent soluble COD at the 5 mg/l dosage. However, the effluent of the units dosed with phenol and methylene chloride did show increased suspended solids concentrations. Higher dosage levels of several compounds led to higher soluble COD and suspended solids concentrations in the effluent. Effluents from the extended aeration process were better than from comparable systems at lower sludge age. From the analyses made for specific compounds, there was no evidence for excessive pass-through of priority pollutants on publicly owned treatment works.

This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, 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

The magnitude of the information base required for formation of regulatory policy to protect the public health and the public investment in biological treatment facilities is best realized by considering the engineered natural process employed for treatment. The microbial population involved in the biological waste treatment is very diverse and the species making up the sludge may change due to interspecies interactions alone without change in the environmental conditions. So the task of determining whether a particular

chemical at low concentrations is responsible for an observed malfunction of an activated sludge process requires considerable data collection.

This 2-year study was undertaken to evaluate as many compounds as possible but for a sufficient time and with sufficient depth of investigation to provide reliable and useful information. The most critical need is to assess the effect and magnitude of effect rather than the mechanism involved. The major effect would be the leakage of soluble organics and solids in the effluent. The fate of the priority pollutant is also of concern.

Some compounds were studied concurrently in extended aeration, activated sludge, and batch systems. This enables one to assess the usefulness of batch systems as well as the effect of sludge age in accommodating the priority pollutant. Also, auxiliary short-term batch studies were made to assess the rate of purification under various dosages of toxic compounds and to determine the degree to which the priority pollutants can be stripped under conditions of aeration in the pilot plant. In addition to determining the biological effects of specific compounds on activated sludge, this study was designed to evaluate methods which can be employed to obtain data for the formulation of pretreatment policy.

Conclusions

Based on the results of pilot plant studies, the following conclusions were made. Of the 24 compounds studied in batch systems, only pentachlorophenol and 2-chlorophenol gave evidence of causing metabolic stress to the system at a feed concentration of 5 mg/l. At a feed concentration of 25 mg/l and higher, 4-chloro, 3-methyl phenol showed metabolic disturbance. In the continuous flow activated sludge unit, none of the compounds tested showed leakage of soluble organics at a dosage level of 5 mg/l. Leakage of soluble organics and effluent suspended solids at higher dosage levels was observed for phenol and methylene chloride. Trichloroethylene showed metabolic disturbances and increased effluent solids concentrations when subjected to cyclic loading with alternating concentration.

In the case of the extended aeration systems, there was evidence for increased soluble COD in the effluent only from the unit dosed with phenol at the 5 mg/l dosage level. There was no increase in effluent suspend ed solids for any of the four compounds at this dosage level. At the higher levels of dosage (25 mg/l and 50 mg/l), there was evidence of increased soluble COD and suspended solids only in the units dosed with phenol. Also, only in the units dosed with phenol was there evidence of disturbance of effluent quality when the dosage was changed on alternate days. From the results of this study, there was evidence that the effluents of the extended aeration pilot plants were lower in soluble COD and particularly in suspended solids concentrations. Any assessment of the effects of priority pollutants on activated sludge should include ecological considerations such as effluent clarity and sludge species diversity.

In regard to study techniques for assessment of effects of priority pollutants on publicly owned treatment works, it is concluded that batch pilot plant operations, although more easily facilitated, cannot be used in place of continuous flow pilot plant studies as a means of gaining information on which to base pretreatment policy regulations.

The analysis made for specific test compounds gave indication of the fate of the compound. With exception of nitrobenzene and 2-chlorophenol, most of the other compounds studied were present in the effluent only at very low concentrations. Most of the test compounds were removed by either stripping biodegradation, or attachment to the surface of the microorganisms.

Recommendations

In future assessments of the effect of priority pollutants on the activated sludge process, a study period of about 6 months should be sufficient for each compound. Batch pilot studies should be abandoned as a basis for formulation of regulatory policy because, as observed in the current investigation, operation environment, e.g., different sludge ages, effected changes in the ecology of the sludge which translated to changes in effluent quality in the presence of various toxicants.

Bench-scale continuous flow pilot plants should be run on municipal wastes relatively devoid of industrial wastes at three or more sludge ages. Variations in dosage and mode of its administration should include steady dosages, variations in mode of dosage including steady concentration levels, and pulsating levels with various time periods of resting between dosages. Combinations of priority pollutants should be run. The analyses should include specific toxicant levels in effluent and sludge, forms of nitrogen, detailed observation of changes in predominant species of microorganisms in the biomass and auxiliary batch growth studies to establish whether the presence of toxicant causes changes in the biokinetic constants used in design and operational models.

Results

Twenty-four compounds on the priority list were studied in batch pilot plants. Eight compounds were studied in continuous flow activated sludge pilot plants, and four were studied in extended aeration systems. The continuous flow units operated were of internal recycle type. A listing of the compounds studied and operational conditions under which they were studied is given in chronological order in Table 1. The feedstock consisted of effluent from the primary clarifier of the Stillwater Treatment Plant supplemented with glucose and ammonium sulfate. To this feedstock various concentrations of the test compound were added during conduct of the experiment. The major analytical techniques employed were COD, suspended solids concentration, and specific compound concentration measured by gas chromatography.

The batch units were operated on a 24-hour fill and draw schedule. The internal recycle continuous flow units were operated at a mean cell residence time of 5 days and hydraulic retention time of 8 hours. The extended aeration activated sludge systems were operated at a hydraulic retention time of 16 hours.

The performance of the batch and continuous flow pilot plants was evaluated based on the statistical analysis of the data along with plotted data for a control and the unit receiving the test compound. Changes in predominant species, presence or absence of protozoa and/or filamentous organisms were also taken into account.

In the batch studies, pentachlorophenol and 2-chlorophenol showed the most adverse effects upon soluble COD removals. These effects were at all concentrations. The other compounds showed very little effect.

For the compounds tested in the continuous flow activated sludge pilot plants, there was no evidence for increased soluble COD in the effluent at the 5 mg/l dosage. At this lower dosage,

Table 1. Compounds Studied and Operational Conditions

Batch	Continuous Flow		Period
	$\mu_n = 0.2$ days^{-1}	Extended Aeration	
Naphthalene	—	—	7/15,
Toluene	—	—	1977
Hexachlorobenzene	—	—	to
Benzene	Benzene	—	1/15,
Phenol	Phenol	Phenol	1978
Pentachlorophenol	—	—	
Nitrobenzene	Nitrobenzene	—	1/15,
2-Chlorophenol	2-Chlorophenol	2-Chlorophenol	1978
Anthracene	—	—	to
2-Nitrophenol	—	—	7/15,
Hexachloroethane	—	—	1978
Fluorene	—	—	
Methylene Chloride	Methylene Chloride	Methylene Chloride	7/15,
Carbon Tetrachloride	—	—	1978
Chloroform	—	—	to
Trichloroethylene	Trichloroethylene	—	1/15,
Chlorobenzene	—	—	1979
Tetrachloroethylene	—	—	
4-Chloro,3-methyl phenol	4-Chloro,3-methyl phenol	4-Chloro,3-methyl phenol	1/15, 1979
Ethylbenzene	—	—	to
1,2-Dichloroethane	1,2-Dichloroethane	—	6/15,
1,1,2-Trichloroethane	—	—	1979
Bromoform	—	—	
Tetrachloroethane	—	—	

there was evidence for increased suspended solids in the effluent of pilot plants dosed with phenol and methylene chloride. At the higher dosage levels, there was evidence for an increase in both soluble COD and suspended solids in the effluent for the pilot plant dosed with phenol. For the units dosed with 2-chlorophenol, methylene chloride, and 1,2-dichloroethane; soluble COD in the effluent was not affected, but there was some disturbance in effluent suspended solids concentration. In addition, cyclic loading of nitrobenzene and trichloroethylene led to increased suspendeds in the effluent.

Based upon the analyses made, there was no evidence of massive passthrough of any of the compounds for which specific analytical determination was made, even at the dosage level of 50 mg/l. However, small quantities of some of the compounds were detected in the effluents.

The results of this study showed that the effluents of the extended aeration pilot plants were lower in soluble COD and suspended solids than effluents from comparable faster growing systems. Among reasons for such results may be lower mass loading rate, i.e., higher biomass concentration and longer mean hydraulic retention time. The reason for the lower suspended solids concentration is probably due to generally greater abundance of protozoa. Generally in the faster growing systems, an increase in dosage of the test compound appeared to cause more serious reduction in protozoan activity than in the extended aeration system. Thus, while the biomass with fewer grazing species could provide nearly equal efficiency with respect to residual soluble COD, it would not provide a low suspended solids concentration in the effluent. Therefore, in designing study procedures to assess effects of priority pollutants on activated sludges, the ecological considerations as reflected in effluent clarity as well as other aspects of ecology, such as limiting effects on species diversity, should be included as parameters for assessment.

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The complete report consists of two volumes, entitled "Treatment Compatibility of Municipal Waste and Biologically Hazardous Industrial Compounds,"
"Volume I,"(Order No. PB 83-105 536; Cost: $19.00, subject to change)
"Volume II. (Appendix)," (Order No. PB 83-105 544; Cost: $23.50, subject to change)
The above reports will be available only from:
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☆ U.S. GOVERNMENT PRINTING OFFICE: 1982—659-017/0859