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Project Summary

Treatability of RCRA Compounds in a BOD/Nitrification Wastewater Treatment System with Dual Media Filtration

Steven I. Safferman and Sanjoy K. Bhattacharya

The discharge of nitrogen and potentially toxic or hazardous organic compounds to the environment from wastewater treatment plants has come under scrutiny in recent years. Of specific concern are the many organic compounds excluded from Resource Conservation and Recovery Act (RCRA) regulations if they are discharged into a wastewater treatment plant. This study investigated the treatability and fate of 28 organic RCRA compounds in a combined organic removal and nitrification process and secondary effluent gravity filtration. A 3.8 L/min pilot-scale extended aeration wastewater treatment system with dual media effluent filter was used for the study. With a total concentration of approximately 1.5 mg/L organics (sum of the concentration of all 28 RCRA compounds) in the aeration basin, most of the compounds were removed to below detectable limits by secondary treatment under either acclimated or unacclimated conditions. The effectiveness of the effluent filter to remove organic compounds could not be assessed as most of the compounds entering the filter were already reduced to below detectable levels. Ammonia removal was significantly impaired at a total concentration of 19.2 mg/L organics in the aeration basin. COD reduction was apparently not inhibited at any of the spike concentrations tested.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, 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 effects of discharging hazardous wastes into the environment without adequate treatment have become of increasing concern to regulatory agencies and the scientific community. Some of the compounds associated with hazardous waste can accumulate in the environment and are mutagenic, teratogenic, or carcinogenic. They can also volatilize into the atmosphere, cause ground water contamination, and inhibit wastewater treatment processes.

Under the domestic sewage exclusion statement, certain RCRA-regulated compounds are exempt from RCRA regulations if discharged into wastewater treatment plants. Such compounds are assumed to be treated adequately by the facility and to cause no process interference.

The treatability of these compounds must be assessed and their effect on the treatment process understood. The specific objective of this study was to investigate the treatability and fate of selected organic RCRA compounds in a combination BOD/nitrification process. The importance of this objective is realized when the recent changes in regulations to require reduced ammonia discharge are considered. Many wastewater treatment plants that previously did not stabilize nitrogen may now be required to do so.

One common means of achieving both nitrification and carbonaceous BOD removal is with an extended aeration sys-

tem. In this study, 28 RCRA compounds with a broad range of properties were spiked into a pilot-scale extended aeration system with dual media secondary effluent filters to achieve the following goals:

- investigate the treatability and fate of the selected RCRA toxics in the nitrification process for both acclimated and unacclimated conditions and
- determine the effectiveness of effluent dual media filtration to remove the composite RCRA toxics.

Procedure

To carry out the objectives of this project, two 3.78 L/min pilot-scale extended aeration wastewater treatment plants with dual media secondary effluent filters were constructed and operated at the U.S. Environmental Protection Agency (EPA) Test and Evaluation Facility (T&E) in Cincinnati, Ohio. The hydraulic retention time of each system was 16.8 hr and the average solids retention time was 21 days.

The influent was primary effluent from the Mill Creek Wastewater Treatment Plant in Cincinnati, Ohio; primary effluent from one of two pilot-scale conventional activated sludge systems at the T&E facility; or a combination of both. Because the conventional pilot systems were being spiked with the RCRA compounds, this design allowed spiking of the extended aeration systems continuously or intermittently at various toxics concentrations.

The 28 RCRA compounds were spiked into the conventional pilot systems at several different concentrations ranging from 0.25 to 1.0 mg/L of each organic. These compounds were selected to ensure a good representation of RCRA compounds with a wide range of properties. The resulting ranges were Henry's coefficient: 0.0000 to 0.944; and log octanol/water coefficient: 0.07 to 8.69.

The three phased project studied (1) process interference caused by organic RCRA compounds, (2) treatability and fate of organic RCRA compounds, and (3) removal of organic RCRA compounds by dual media effluent filtration. A description of the procedures for each phase follows.

Phase 1, Process Interference

In this phase, the effect of the 28 RCRA compounds on the ability of a pilot-scale extended aeration wastewater treatment plant to adequately treat the wastewater was investigated. Chemical oxygen demand (COD), nitrate, ammonia, and total Kjeldahl nitrogen (TKN) were the primary process control variables used to evaluate the system's performance.

The performance was compared under five different spike conditions:

- baseline, system performance before any spike had been added;
- total spike concentration of 1.8 mg/L, which was calculated by summing the amount of each compound found from each event and taking the average of the three events;
- total spike concentration of 4.8 mg/L, which were similarly calculated as above;
- total spike concentration of 19.2 mg/L, which was calculated based on the spike pump's setting; and
- discontinuation of spike.

Phase 2, Treatability and Fate

In this phase of the project, the concentration of the 28 compounds at different stages of the treatment process were studied. The influent spike concentration was about 0.1 mg/L for each compound, assuming minimal removal by the primary clarifier. From the literature and from preliminary operations, this initial concentration was selected so as not to cause any process interference to the system.

To investigate the removal and fate of the compounds under both acclimated and unacclimated conditions, one of the extended aeration systems was spiked continuously with the RCRA compounds to allow the microorganisms to become acclimated to the toxics. The other system was spiked only during sampling events so that the microorganisms would not become acclimated.

Data were obtained from three sampling events, each consisting of a 48-hr time period. For the first 24 hr of each event, the unacclimated system was spiked with the RCRA compounds. For each event, samples were taken every 4 hr and composited for analysis of the RCRA compounds.

Phase 3, Removal by Filtration

In this phase, the efficiency of dual media effluent filtration to remove organic RCRA compounds was investigated. To assess the effectiveness, the concentration of each compound was measured in the secondary effluent (before entering the filter) and then in the filter effluent. Data were obtained for two secondary effluents:

- secondary effluent obtained from the acclimated extended aeration system, which was being spiked at a total toxics concentration into the aeration basin of 1 mg/L and
- secondary effluent obtained from the a climated conventional system at the T& facility, which was being spiked at a tot toxics concentration into the aeratic basin of 4.8 mg/L.

Samples were collected for RCRA con pound analysis 11 times: 3 for the extende aeration system's secondary effluent and for the conventional secondary effluent.

Results and Discussion

Phase 1, Process Interference

The process control parameters of COI ammonia, and nitrate were used to gaug the process interference caused by th spiked RCRA compounds during Phase 1 c this study. Four spike concentrations wer tested. Figure 1 shows the percent remov of TKN and ammonia and the increase i nitrate resulting from secondary treatmer for each spike concentration. The trends i the figure seem to indicate that nitrificatio was inhibited even at a low spike concentra tion, although ammonia reduction by secor dary treatment was not inhibited until spik concentrations between 4.8 and 19.2 mg/ were reached. After spiking ceasec nitrification returned to its pre-spiking lev within a few days. COD removal did nc seem to be adversely affected by the spik even at the highest composite concentratio tested, 19.2 mg/L.

To assess the interference of the RCR compounds on an unacclimated system, parallel system was intermittently spikec The average total spike concentration (tot concentration of 28 compounds) was 1. mg/L for three shock loadings, which ap parently caused no inhibition of COD or am monia reduction.

Phase 2, Treatability and Fate

The treatability and fate of the 28 organi RCRA compounds spiked in Phase 1 at total concentration of 1.8 mg/L was inves tigated in Phase 2 for acclimated and unac climated conditions. Composite samples c aeration basin influent, secondary clarifie effluent, and recycled activated sludge wer collected three times for analysis of the com pounds.

For the three sampling events from th acclimated system, all of the compounds for which valid data were collected, wer removed to below detectable limits (Tabl 1). The variations in the aeration basin in fluent were probably caused by differen removal rates of the compounds in the primary clarifier, background concentra

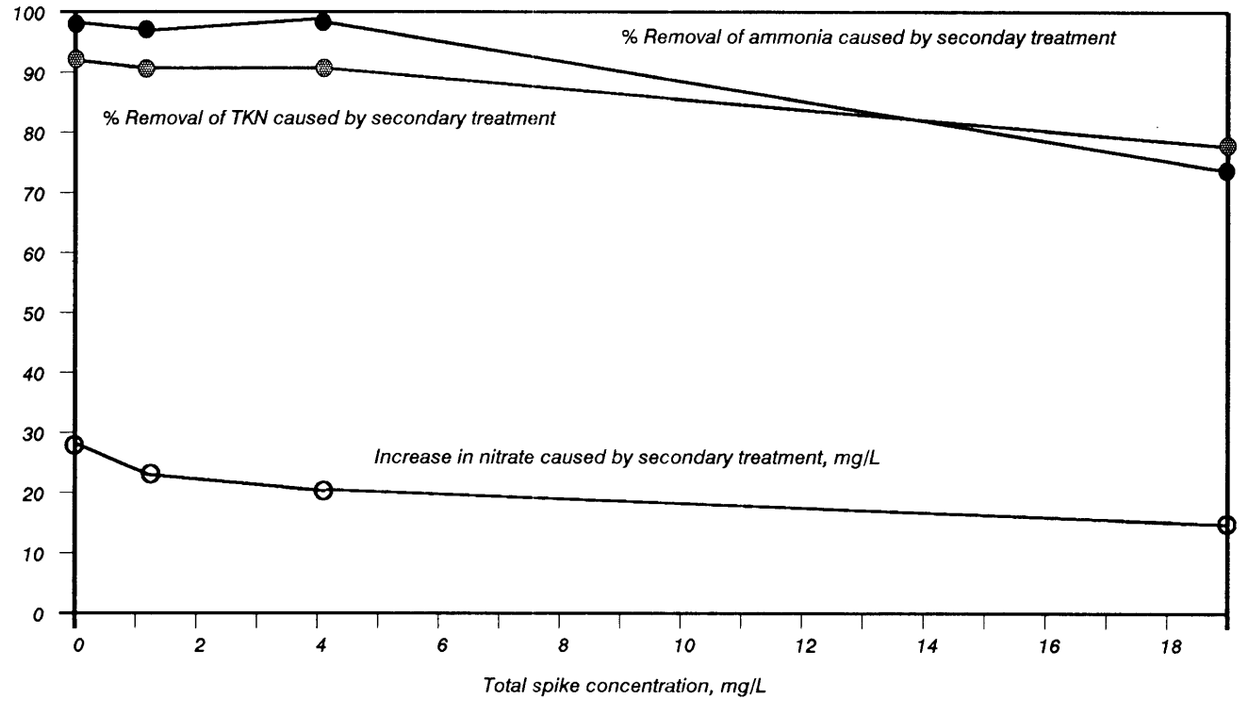

Figure 1. *Acclimated conditions, ammonia, TKN, nitrate vs. concentration of spike.*

ɔns of the compounds in MSD's secondary fluent and analytical errors.

For the three sampling events for the unɔclimated system (spiked intermittently at ɪ average total concentration of 1.3 mg/L), ɲly four compounds had removals below 5%: 1,1,2-trichloroethane, bis(2-ethylhexyl) ɲthalate, toluene, and nitrobenzene (Table . The unacclimated conditions apparently d not result in a significant reduction in ɪmoval efficiency at the RCRA compound's ɔncentration tested.

hase 3, Removal by Filtration

The secondary effluent from both the acimated and unacclimated nitrification sysms were passed through dual media fluent filters for the first 62 days of the oject. The secondary effluent from the ɔnventional system was passed through ɲe of the filters after day 62. Eleven ɲalyses were run for the organic RCRA ɔmpounds going into and coming out of ɪe filter: three for the nitrification secondary fluent and the others for the conventional /stem.

The filters removed approximately 50% of ɪe total suspended solids for most operatɪg conditions. Because the secondary efɹent from the nitrification system had very ɔw concentrations of RCRA compounds, ɪe effectiveness of the filters could not be assessed for the first 62 days of the project. Higher concentrations of some of the compounds were present in the secondary effluent from the conventional system. The results indicate acetone, tetrahydrofuran, tetrachloroethylene, and phenol had significant removals by the filters (Table 3). Values for these compounds, however, were found only in Event 9. The remaining compounds, for both Events 4 and 9, had removals under 20%.

Conclusions

The following conclusions were drawn from this study:

- COD removal was not inhibited at the tested composite spike concentrations of 1.8, 4.8 (measured by summing the concentrations of all 28 compounds into the aeration basin), and 19.2 mg/L (estimated based on pump setting).
- Ammonia removal was significantly inhibited at the composite spike concentration of 19.2 mg/L (the sum of the concentrations of all 28 compounds into the aeration basin).
- Almost 100% of the spiked organic RCRA compounds were removed when the spike concentration was at 1.8 mg/L (the sum of the concentrations of all 28 compounds into the aeration basin) for the acclimated condition and 1.3 mg/L for the unacclimated condition.
- Adsorption did not appear to be a principal mechanism for the removal of the RCRA compounds.

Recommendations

This study indicates that an extended aeration wastewater treatment plant can effectively remove low concentrations of organic RCRA compounds without interfering with BOD, ammonia, and suspended solids removal. Because of the many different combinations and concentrations of RCRA compounds that could be expected in the influent to a municipal wastewater treatment plant, a correlation between this study and a real life situation is risky. Further studies and surveys of actual extended aeration wastewater treatment plants are required to confirm these study findings, to determine if or when harmful by-products are produced, and to find the compound's removal mechanism.

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Table 1. *Summary of Sampling Events for Acclimated Conditions*

Compound	Event 1		Event 2		Event 3		AVG. ABI. (µg/L)	AVG. % REDSEC	#
	ABI.	% REDSEC	ABI.	% REDSEC	ABI.	% REDSEC			
Cyclohexanone	210	100	N	NF	N	NF	210	100	1
Methy ethyl ketone	130	100	150	100	148	100	143	100	3
Methyl isobutyl ketone	120	100	N	NF	N	NF	120	100	1
Tetrahydrofuran	130	100	N	NF	63	100	97	100	2
Carbon tetrachloride	79	100	64	100	70	100	71	100	3
Chlorobenzene	190	100	110	100	100	100	133	100	3
Chloroform	100	100	81	100	90	100	90	100	3
1,2-Dichloroethane	110	I	93	100	96	100	95	100	2
1,2-Dichloropropane	99	100	67	100	74	100	80	100	3
Tetrachloroethylene	73	100	64	100	66	100	68	100	3
Trichloroethylene	69	100	62	100	70	100	67	100	3
1,1,1-Trichloroethane	100	100	70	100	77	100	82	100	3
1,1,2-Trichloroethane	91	95	74	100	72	100	79	100	3
Ethylbenzene	75	100	65	100	95	100	78	100	3
Toluene	130	100	110	100	170	100	137	100	3
o-xylene	150	100	21	100	42	100	71	100	3
Bis(2-ethylhexyl)phthalate	40	100	40	85	45	100	42	100	3
Butyl benzyl phthalate	N	NF	13	100	N	NF	13	100	1
1,4-Dichlorobenzene	N	NF	N	NF	42	100	42	100	1
2,4-Dimethylphenol	10	100	N	NF	N	NF	10	100	1
2,4-Dinitrophenol	40	100	N	NF	N	NF	40	100	1
Naphthalene	64	100	77	100	67	100	69	100	3
Nitrobenzene	35	100	N	NF	68	100	52	100	2
4-Nitrophenol	N	NF	N	NF	32	100	32	100	1
Phenol	120	100	N	NF	180	100	150	100	2

ABI.: Concentration into aeration basin, µg/L.
AVG.: Average.
I: Influent concentration less than effluent concentration.
N: None detected.
NF: Compound not found in aeration basin influent.
% REDSEC: Percent of compound reduced by secondary treatment.
#: Number of samples with valid values, out of 3.

Note: Acetone, Methylene Chloride, and Furfural were analyzed for but not found in feed or the compound was found in the blank.

Table 2. *Summary of Sampling Events for Unacclimated Conditions*

Compound	Event 1		Event 2		Event 3		AVG. ABI. (μg/L)	AVG. % REDSEC	#
	ABI.	% REDSEC	ABI.	% REDSEC	ABI.	% REDSEC			
Cyclohexanone	180	100	N	NF	N	NF	180	100	1
Methy ethyl ketone	140	100	240	100	330	100	237	100	3
Methyl isobutyl ketone	71	100	N	NF	75	100	73	100	2
Tetrahydrofuran	97	100	N	I	N	NF	97	100	1
Carbon tetrachloride	36	100	N	NF	35	100	36	100	2
Chlorobenzene	65	100	76	100	73	100	71	100	3
Chloroform	72	100	36	100	66	100	58	100	3
1,2-Dichloroethane	N	NF	12	100	N	NF	12	100	1
1,2-Dichloropropane	50	100	31	100	40	100	40	100	3
Tetrachloroethylene	19	100	36	100	32	100	29	100	3
Trichloroethylene	27	100	25	100	46	100	33	100	3
1,1,1-Trichloroethane	64	100	N	NF	50	100	57	100	2
1,1,2-Trichloroethane	61	100	24	88	42	90	42	93	3
Ethylbenzene	17	100	77	99	45	100	46	100	3
Toluene	57	67	96	99	120	100	91	89	3
o-xylene	48	100	130	98	66 B	100	81	99	3
Bis(2-ethylhexyl)phthalate	38	100	22	82	15	100	25	94	3
1,4-Dichlorobenzene	28	100	22	100	24	100	25	100	3
Naphthalene	54	100	50	100	38	100	47	100	3
Nitrobenzene	76	75	32	78	36	81	48	78	3
Phenol	170	100	130	100	220	100	173	100	3

ABI.: Concentration into aeration basin, μg/L.
AVG.: Average.
B: Compound found in blank.
I: Influent concentration less than effluent concentration.
N: None detected.
NF: Compound not found in aeration basin influent.
% REDSEC: Percent of compound reduced by secondary treatment.
#: Number of samples with valid values, out of 3.

Note: Acetone, Furfural, Methylene Chloride, Butyl Benzyl Phthalate, 2,4-Dintrophenol, 2,4-Dimethylphenol and 4-Nitrophenol were analyzed for but not found in feed or the compound was found in the blank.

Table 3. *Summary of Toxic Filter Sampling Events for Acclimated Conditions*

Compound	Event 4		Event 9	
	FILIN.	% RED.	FILIN.	% RED.
Acetone			40	100
Tetrahydrofuran			230	41
Chloroform	30	21	31	15
1,2-Dichloroethane	88	9	100	15
1,2-Dichloropropane	40	6	42	1
Methylene chloride	59	10	63	5
Tetrachloroethylene			9	24
Trichloroethylene	4	13	6	8
1,1,1-Trichloroethane			6	3
1,1,2-Trichloroethane			105	5
Phenol			6	100

FILIN.: Influent to filter.
% RED.: Percent reduction of compound by filter.

Steven I. Safferman and Sanjoy K. Bhattacharya are with the Department of Civil and Environmental Engineering, University of Cincinnati, Cincinnati, OH 45221.

***Sidney A. Hannah** is the Technical Project Monitor (see below)*

The complete report, entitled "Treatability of RCRA Compounds in a BOD/Nitrification Wastewater Treatment System with Dual Media Filtration" (Order No. PB 90-194 705/AS; Cost: $17.00, subject to change), will be available only from:

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