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Cleaning Up Mixed Waste Streams- The Tank Truck Washing Example

THE INDUSTRY/ENVIRONMENT R&D DECISION SERIES

This volume is part of the Industry/Environment R&D Decision Series. The series presents the findings of EPA's Office of Research and Development (ORD) on a number of key issues in the Industry/Environment R&D Program in a format conducive to effective information transfer. The volumes are of three types: summaries—short synopses of larger research reports; issue papers—concise discussions of major industry/environment technical issues; and executive reports—in-depth discussions of an entire programmatic or technical area.

The Division of Industrial and Extractive Processes within ORD's Office of Energy, Minerals, and Industry is charged with planning and coordination of the Industry/Environmental R&D Program. Areas of research include the entire materials processing and production cycle from extraction through production, with emphasis on the assessment of pollution from industrial processes and the development of effective control technologies.

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STATEMENT OF PROBLEM

Pollution threats posed by chemicals manufacturing and transportation involve toxic and highly variable discharges requiring nontraditional clean-up technologies. As in chemical manufacturing where discharges vary greatly with different production operations, transportation of the chemicals results in a highly variable waste discharge. Chemical tankers carry wide varieties of products and must be drained and cleaned between trips. Wastewaters from tanker cleaning, exceeding 50-million gallons per year, now go to municipal waste streams. Chemically burdened wastewaters from tanker cleaning operations profile comparable but higher volume conditions that prevail throughout the chemical manufacturing industry. Demonstration of new and effective technologies for tanker wastes and wastewater treatment as described in this report portend widespread application in a broad range of chemicals manufacturing industries.

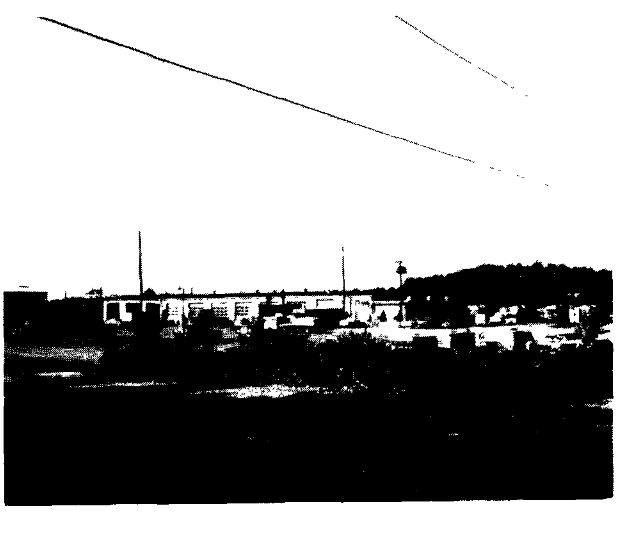
OVERVIEW

One of the most difficult environmental problems the transportation industry faces is the treatment of wastewaters from tank truck interior washing operations.

The root of the problem is lack of proven treatment technologies which embody economic feasibility. Because hauled materials vary widely in character, washing operation wastes reflecting these cargoes are also variable and difficult to treat. The wastestreams primarily contain oil and organic materials, many of which, because of high concentrations or toxicity, may upset municipal waste treatment plants or physical/chemical treatment methods.

In 1974 EPA prepared a *Development Document* for proposed effluent guidelines and standards for these wastewaters. EPA based some of the proposed standards on treatment techniques which were available but not demonstrated specifically for the tank truck industry. The tank truck carriers requested demonstration of a technically and economically viable process for treating the wastewaters before promulgation of the effluent guidelines and standards.

Matlack Corp., one of the nations largest tank truck operators, has long recognized the need for treatment alternatives and has investigated a number of techniques since 1966. Last year Matlack approached EPA's Office of Energy, Minerals and Industry, resulting in a joint venture into construction and demonstration of a full-scale plant to determine technical and economic viability of a treatment system.



TANK TRUCK TERMINAL

The system under demonstration involves an integration of new and state-of-the-art physical, chemical and biological waste treatment unit operations into a unique and promising hybrid system. Matlack's Swedesboro, N.J. terminal cleaning facilities, which produce some 15,000 gal/day of interior tank wash wastewater, was chosen as the test site.

This report presents a perspective on the problem posed by the tank wash waters and presents preliminary data on the treatment system under demonstration.

THE POLLUTION THREAT

Tank truck carriers operate more than 90,000 tank trucks in the U.S. About one-third of these are part of the private fleets such as those operated by major petroleum and chemical companies. These fleets haul products of the parent company, and are generally dedicated to haul specific products. The interiors of these dedicated tankers seldom require washing.

The remaining 60,000 or so tankers constitute the industry common carrier fleet and are "for public hire". Some of these tankers are also "dedicated" to carry specific products, and don't require frequent washing.

But most of the 60,000 tankers are not dedicated and their cargoes can vary from highly toxic materials to innocuous materials such as fish oil.

THE VARIABILITY PROBLEM

The cargoes can be chemicals, petroleum, or other products. Table I shows, through cargoes hauled, the variability of experience in one month. In another month 550 tank interiors containing 47 different chemicals were cleaned at the same facility.

Roy F. Weston, Inc., has studied the variability of wastes for the National Tank Truck Carriers Association. The high degree of variability in "pollutional content" of these wastewaters is indicated by the ratio of probable occurrence of high to low values for the parameters listed in Table II.

Variability of volume and characteristics of wastewater from the cleaning of tankers can be attributed to:

- the product hauled,
- the amount of undelivered product (heel),
- the cleaning procedure used, and
- the number of tank trucks cleaned daily.

These wastes contain materials which range from high biodegradable materials, such as sugars, to phenols, plasticizers, oil and acids.

TABLE I
COMMON CARRIER TANKER CARGO VARIABILITY

CARGO	NUMBER OF UNITS CLEANED	POTENTIAL IMPACT ON BIOLOGICAL SYSTEM
Cutting Oil	1	Low
Lube Oil	366	Low
Toluene	71	High
Unidentified Product	8	—
Fuel Oil Additives	2	High
Carbon Black Oil	9	Low
Acetic Anhydride	1	Medium
Ammonium Thiosulfate	22	Medium
Naphthalene	18	Medium
Wax	62	Low
Tall Oil	1	Medium
Phenol	18	High
Fish Oil	1	Low
Sodium Nitrite	44	High
Latex	66	High
Resin	76	Medium
Plasticizer	348	High
Caustic Soda (Liquid)	19	High
Lard	13	Low
Hydrochloric Acid	1	High
Fatty Acid	5	Low
Liquid Sugar	32	—
	1,184	

TABLE II
TANK TRUCK RAW WASTEWATER POLLUTIONAL CHARACTERISTICS

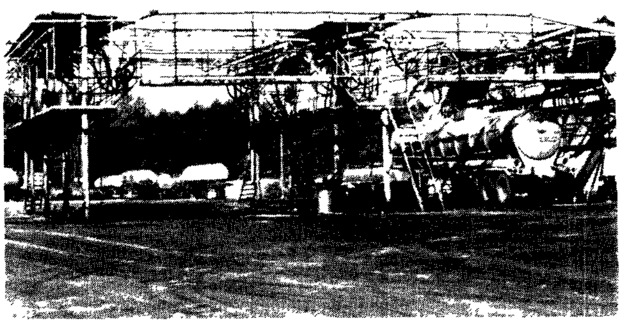
	MEAN	*VARIABILITY RATIO
Flow, Gals/tanker washed	1390	5
BOD_5, Mg/l	2800	5
COD, Mg/l	12000	3
SS, Mg/l	4035	19
Phenols, Mg/l	29	12

*Ratio is generated using monthly average values at 5 terminals. Each value is an average of 3-6 daily composite values taken that month. Values at 90 percent level of occurrence are divided by those at 10 percent level of occurrence to produce the variability ratio.

WHY WASTEWATERS VARY

Heels are the portions of the product not delivered, but returned to the terminal for disposal. Whenever feasible, heels are segregated from the wash water stream and sent to approved disposal sites or, if feasible, returned to the sender. However, heels may be inadvertently flushed to the treatment system or sewer when a washing operation is initiated. Heel volumes range from 10-500 gallons, and if discharges reach downstream physical/biological treatment systems they can exert significant shock load or toxic impact, thus reducing or completely eliminating the system's functional capability.

Waste treatment procedures vary with size of trucking operations, type of cargo hauled and cleaning agent. The interior tank washes are usually performed at terminals equipped with wash racks and lightweight, high-velocity, omnidirectional spray nozzles. Matlack, for example, operates 2800 tankers and 52 terminals, 22 of which are equipped for interior tank wash operations. (External truck washes are performed at all 52 terminals.) Several other large tank carriers operate in this mode, but more than 5000 carriers operate fleets of 5 trucks or less.



EXTERIOR WASH STATIONS

These smaller companies cannot operate such cleaning terminals and some of them discharge their wastes to sewers. Also, the tank cleaning methods vary with the type of cargo hauled. The principal cleaning agents are water, steam, detergents, caustics, and other specific solvents. Use of these agents, sprayed into the tanks under high nozzle pressure and subsequent physical mixing results in highly emulsified waste streams, rich in organics, suspended solids and oils.

WASTEWATER VOLUME AND FATE

The wastewater discharged from interior tank washing ranges between 600-900 gal/tanker, but can reach much higher volumes. EPA estimated that less than 10 percent of the terminals surveyed generate more than 15,000 gal/day of wastewater. These wastewaters are relatively limited in quantity but their environmental impact can be both highly visible and very significant. Table III shows some typical flow rates and pollutional characteristics that could impose significant environmental impacts.

EPA estimates that two-thirds of the tank truck industry discharges wastes to municipal systems, with little or no pretreatment. Where it has been provided, treat-

TABLE III
TYPICAL FLOW RATES AND POLLUTIONAL CHARACTERISTICS

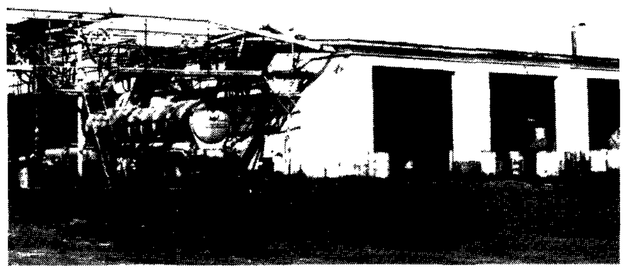
WASHWATER EFFLUENT CHARACTERISTICS	ESTIMATED RAW WASTELOAD
Typical Flow	900 gal/unit washed
High pH (alkaline)	10-12
High in Organic Chemicals, toxic to biological systems	
High BOD	1465 mg/l 11 lb/unit washed
High COD	14,920 mg/l 112 lb/unit washed
High in Solids Content (suspended solids)	1,000 mg/l 7.5 lb/unit washed
High in oils and grease content	1,000 mg/l 7.5 lb/unit washed
High in specific toxic material content	
Phenols	67 mg/l 0.05 lb/unit washed
Chromium	5.3 mg/l 0.04 lb/unit washed
Cyanide	0.93 mg/l 0.007 lb/unit washed

ment has generally been limited to: sedimentation, neutralization, evaporation ponds and lagoons and other relatively unsophisticated techniques. The prevailing treatment practices observed in the EPA survey for their development document are summarized in Table IV.

HOPE FOR FUTURE WASTE TREATMENT

Industry practices and problems in treatment of tank interior wastewater can be summarized as follows:

- The tank interior wash operation has been identified as a major source, and as one of the industry's waste streams that is most difficult to treat.
- While wastewater volumes are relatively small, the potential impact of the materials in the waste stream is significant—both to the environment and to conventional treatment systems.
- State regulatory agencies such as those in California, New Jersey, Connecticut, Louisiana, Kentucky, Texas and other states, requiring compliance with effluent limits issued with their own discharge permits, are creating impetus for new treatment technology.



INTERIOR WASH STATIONS

TABLE IV
EPA'S 1974 SURVEY OF PREVAILING TREATMENTS

TREATMENT AFFORDED THIS WASTE STREAM

Terminal Surveyed by EPA	Principal Type of Materials Handled[1]	Sump	Sedimentation	Equilization	Gravity Oil Separation	Neutralization	Chemical Coagulation	Air Flotation	Filtration Media Screen	Extraction	Clarifier	Biological System Pond/ Lagoon +/or Aeration	No Tankers Washed per Day	H_2O Used per Tanker–Gal
A	C, D	X			X	X					X	X	30	1200+
B	C	X	X in pond									X (spray)	10–25	500–800
C	Asphalt											X (spray)	N D	N D
D	C		X										18	N D
E	C		X										N D	N D
F	C					X	X	X					35	570
G	C, D		X	X			X		X			X holding	30	N D
H	D		X		X								80–90	N D
I	D, P		X		X								30–40	100–300
J	B (3)								X				50–60	N D
K	F (4)		X		X				X				80–90	200+

(1) C=Chemicals
P=Petroleum
D=Dry bulk
CG=Compressed Gases

(2) N D = no data
(3) *B=beef/animal carcasses*
(4) F=foodstuffs (dairy-vegetables)

- The EPA program to define effluent limitations for the tank interior wash wastes was delayed by lack of data on the industry and the applicable control technologies. The variable nature of the waste stream and the absence of a demonstrated control technique were the main hurdles.
- Several attempts are being made to develop technically and economically feasible methods to treat tank interior wash wastewaters. Table IV lists the prevailing treatment techniques used in this industry. They include:
  - (a) A sequential air flotation and biological system in Downington, Pa. (Chemical Leaman Corp.)
  - (b) A sequential physical/chemical system in Louisville, Ky. (Liquid Transporter Corp.)
  - (c) A modified (bleed in) biological system in Deer Park, Texas. (Robertson Tank Lines)
  - (d) The joint EPA/Matlack hybrid system involving physical, chemical and biological methods in Swedesboro, N.J.

THE EPA/MATLACK SYSTEM

The hybrid system under test by Matlack involves a combination of these seven specific unit operations:

1. Oil separation: to remove oil/grease
2. Air flotation: break emusion and remove oil/grease/suspended solids
3. Chemical coagulation and pH adjustment: to aid in removal of suspended solids
4. Equilibration/sedimentation: allow separation of solids and prepare waste for further treatment
5. Mixed media filtration (MMF): to further remove solids/color
6. Carbon adsorption: remove organics which may be toxic to biological systems
7. Rotating filter-biofiltration system: to remove degradable organics

The treatment system is operated on a 5-day week. It consists of the above unit operations as shown in Figure 1. Gravity oil separation, pH adjustment, cationic and

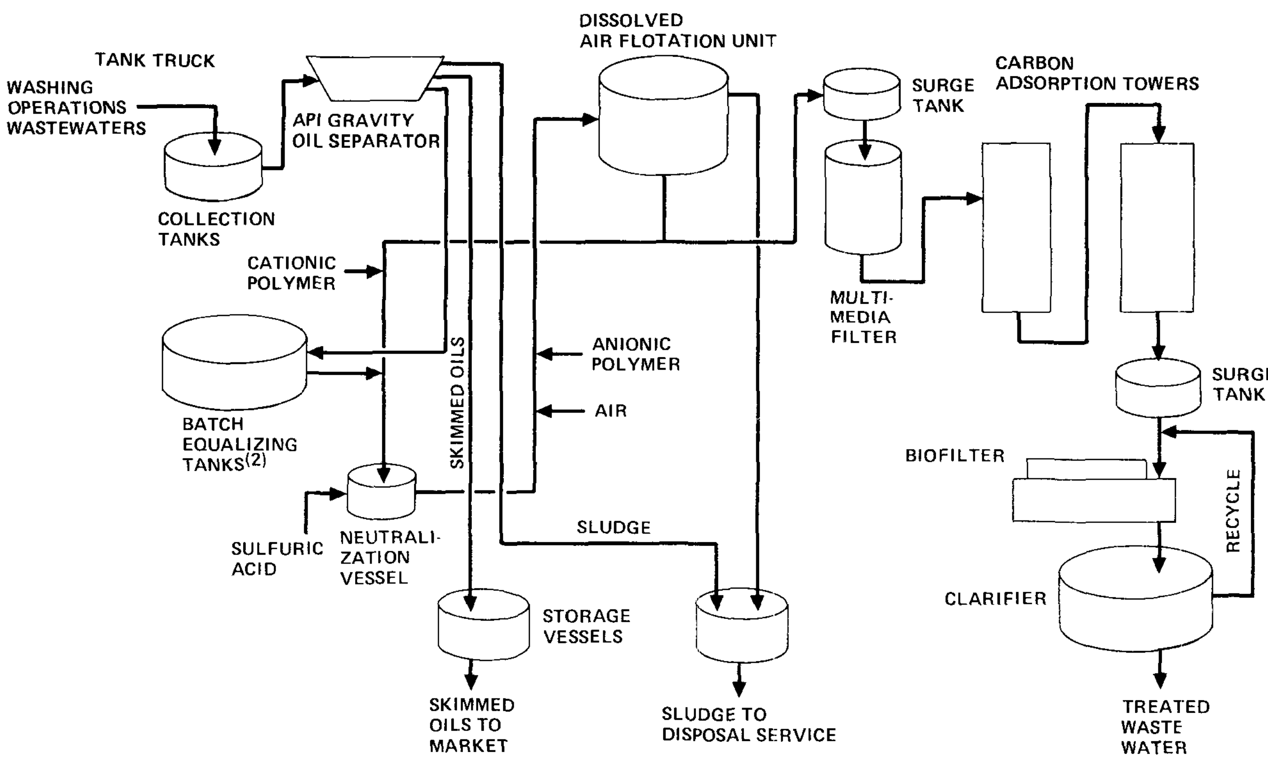


FIGURE 1
EPA/MATLACK TANK TRUCK WASTEWATER TREATMENT SYSTEM

anionic flocculant addition and air flotation operations constitute the "basic" or primary portion of the system. In addition to these operations, multi-media filtration, carbon adsorption and rotating biofiltration units are used for final wastewater treatment. The system operates eight hours/day. The biofiltration unit operates continuously.

The test system configuration affords maximum flexibility with respect to the sequence of unit operations used, flow capability and evaluation of alternative methods. The Swedesboro facility has been in operation since January 1976. Thus, the results presented here are "preliminary" and will be reaffirmed and elaborated as the project proceeds.

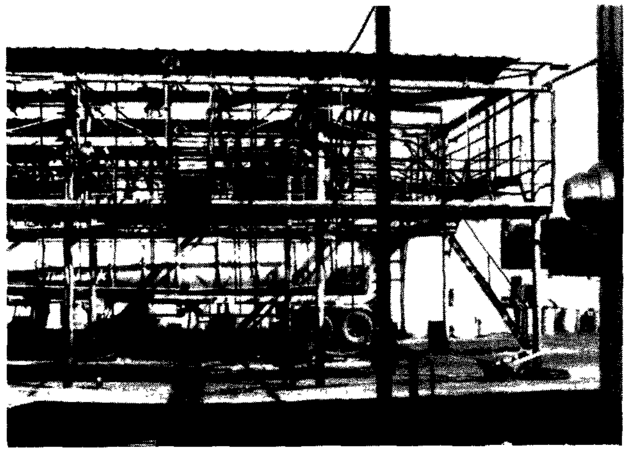
THE TERMINAL OPERATIONS

The Swedesboro Terminal is approximately two miles east of the Delaware River in Gloucester County, New Jersey. Effluents from the plant are regulated under a New Jersey discharge permit issued for the duration of the demonstration project. The tankers using this terminal primarily haul organic chemicals and products, such as those listed in Table I. Heavy metals are rarely a part of the cargoes at this terminal and consequently are seldom a problem in the wastewater to be treated by the test system, but they are an industry problem.

WASH FACILITIES AND SYSTEM

Roofed and exposed wash facilities are provided at this terminal. The wash area is paved and sloped to maximize wash water collection but minimize rain fall collection. Lightweight, omnidirectional, high intensity nozzles are used to direct steam or hot caustic solution and fresh water rinses into the tanks while valves are in the open position. Any solvents used for cleaning and product heels are segregated whenever possible. A central drain carries the wastewater from interior and exterior washes to two collection tanks.

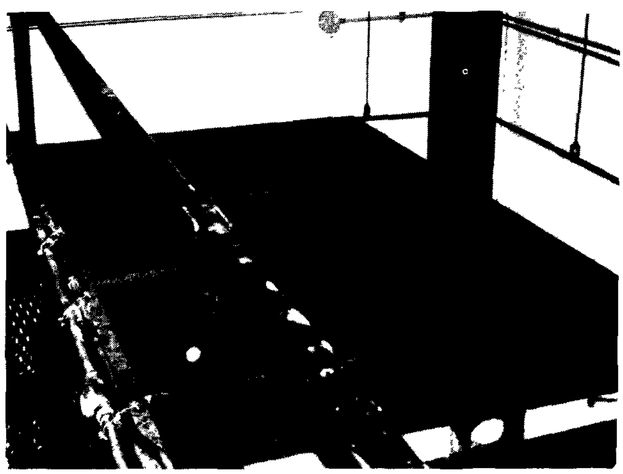
The wastewater produced in the wash operation is an emulsion of oils, organic and some inorganic chemicals. It varies in color from white to various shades of tan and brown reflecting its variable content and potential impacts. Two collection tanks receive the alkaline and emulsified wastewater, which occasionally contains heels despite efforts to segregate them. No sanitary wastes are discharged to the treatment system. Total wastewater to the system is estimated at 12-18,000 gal/day for a 6-day collection week.



SLOPED WASH AREA

OIL REMOVAL

A diaphragm pump moves the wastewater from the sump to a 1,640 gal API separator at an average rate of 16 gal/min. In the API separator, baffled flow patterns and a detention time of about 1-2 hr allow free oils to float to the surface where they are skimmed and collected. About 500-700 gal/week of oil are recovered and stored in underground tanks. The recovered oil is sold for re-refining at a current rate of $0.03/gal. This unit operation also produces approximately 4,000 gal/week of sludge. The 15 gal/min of effluent from this unit, contains large quantities of colloidal and dissolved oils and has a pH of 11. Other characteristics of effluents from this unit operation are shown in Table V.



API SEPARATOR

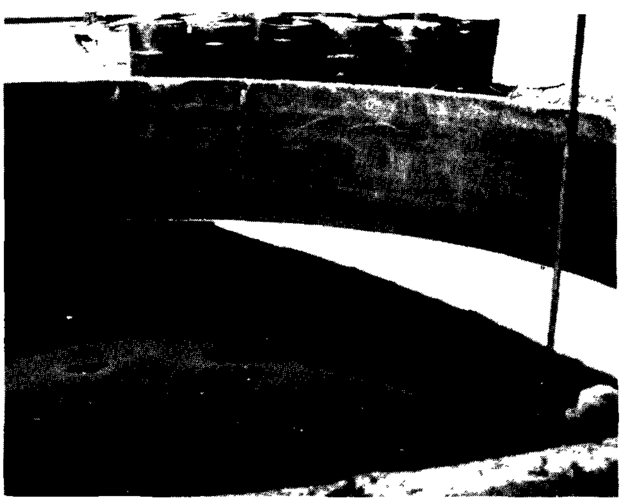
TABLE V
PRELIMINARY EFFLUENT DATA FOR EACH OF THE UNIT OPERATIONS

	OIL SEPARATION	MIXED MEDIA FILTRATION	CARBON ADSORPTION LEAD CARBON	CARBON ADSORPTION POLISH CARBON	BIOFILTRATION
pH	10.5–12.5	6.5–8.0	6.5–8.5	6.5–8.5	6.5–8.5
Color	Over 500	50–100	1–10	1–5	10–50
Turb [a]	Over 500	5–30	5–10	1–5	–
COD	1,800–11,000	1,100–5,500	900–1,900	650–1,800	125–300
BOD_5	600–2,000	–	800–1,500	550–1,300	20–100
O&G [b]	110–350	5–15	–	<1	<1
Phenols	1–250	1–200	–	0.1	0.1
SS [c]	300–1,300	10–20	–	0.1	–

[a] Turbidity (mg/l)
[b] Oil and Grease (mg/l)
[c] Suspended Solids (mg/l)

EQUALIZATION

Effluent from this process is pumped to one of two 20,000 gal batch tanks and allowed to "equalize" for 16-24 hrs. This equalization is essential to the air flotation process downstream. Sedimentation in this tank is limited due to the emulsified nature of the wastewater. Approximately 30 gal/min of "equalized" wastewater plus 70 gal/min of recycle from the flotation unit goes to a mix tank.



BATCH TANK

CHEMICAL TREATMENT/PHYSICAL SEPARATION

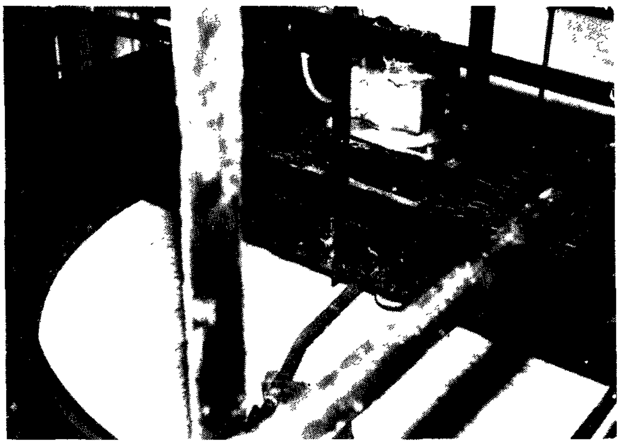
In this tank wastewater pH is adjusted with sulfuric acid to 6.5-7.5, and cationic polymer is added at the rate of 1-20 gal/hr. The polymer is added to promote development of floc (agglomerated particles) which can be more easily removed in the flotation unit.

An air eductor introduces 40 psi air into the wastewater. Anionic polymer is added at the rate of approximately 7 gal/hr to further promote coagulation and the pressurized waste stream is then released to atmospheric pressure in a 2,200 gal dissolved air flotation unit. As the small bubbles of air form and rise, the colloidally suspended materials become attached to the bubbles and rise with it to the tank surface where it is skimmed and stored for collection by a disposal service. Heavier floc, formed by polymer addition, settles to the bottom of the tank.

The sludge produced in this process approximates 5 percent of the wastewater volume, or approximately 700 to 1,000 gal/day. Sludge collected from this unit operation is typically 10 percent solids.

The dissolved air flotation unit operation breaks the emulsion of wastewater with oils and solids, and removes these materials which could interfere with subsequent treatment processes. Operation of dissolved air flotation is still being optimized. It depends heavily on the segregation and removal of heels and solids settled in the API unit. Detergents which tend to sustain emulsions, are counterproductive in this unit and their presence is minimized when possible.

Treated wastewater from the dissolved air flotation unit is fed to a 2,250 gal storage feed tank for distribution to the next operation.



DISSOLVED AIR FLOTATION UNIT

MIXED MEDIA FILTRATION/ DISSOLVED AIR FLOTATION

Effluent from the flotation unit feeds the filtration unit at the rate of 30 gal/min. This unit is filled with a bottom layer of 40 mm mesh sand and 0.5mm mesh, Anthrafilt (coal derivative). The effective bed depth is 18 inches for each media. The pressure drop across the filter under operating condition is 8-15 psi. The filter and dissolved air flotation units reduce the solids level in its effluent to the 10-20 mg/l range. Other effluent characteristics are shown in Table V.

The filter is backwashed when pressure drop across the filters reaches 12-15 psi. Backwash is returned to the batch tanks. The filter is backwashed on the average of once per week under the current operation schedule.

CARBON ADSORPTION UNITS

Effluent from the mixed media filter flows to two activated carbon towers operated in series. These units remove organic chemicals which might be toxic or otherwise deleterious to the biological process that follows. Theoretically, complex organic molecules (typical of "toxic" cargoes), are preferentially adsorbed on the carbon. This allows the less complex "non-toxic" molecules to pass through to the biofilter unit operation which follows.

When breakthrough occurs in the first or lead tower, wastewater flow is directed to the second tower and the exhausted carbon is replaced. The new adsorbent is placed on line in the second or polish tower position. The adsorption carbon and regeneration services are rented from Calgon Corp. The carbon used is a mixture of Filtrasorb 300 and 400. The system currently uses about 2,000 lb. of carbon per month. The carbon units have been performing well.

A mild caustic soda treatment can inhibit inordinate biological degradation activity on the carbon which could interfere with the adsorption process.

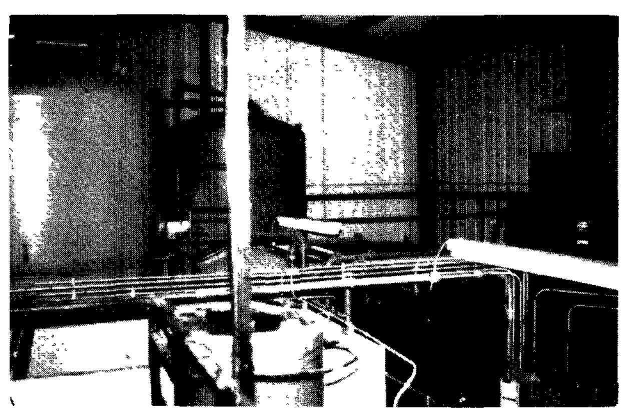
The characteristics of effluent from the carbon unit shown in Table V indicate the applicability of this technique for removal of soluble organics, some of which may be toxic to the biological process.

BIOLOGICAL DEGRADATION

Effluent from the carbon adsorption unit flows to a holding tank and then to the biofilter operation. Wastewater is fed at the rate of 30 gpm. A 40 percent biofilter effluent recycle during wastewater feed and 100 percent recycle at other times maintains the flow into the unit at 50 gpm and allows its continuous operation. Because biotreatment influent is biodegradable, air is introduced by an air eductor to the influent to maintain dissolved oxygen levels.

This unit combines the principle of rotating disc systems and trickle bed biofiltration. A 7.5 ft. long x 6 ft. dia. drum-shaped container formed from perforated steel is mounted horizontally aand filled with 1-1/2 x 2 inch polyethylene raschig rings. This packing provides 35 sq. ft. of surface per cubic foot of packing. As shown in Figure 2, the basket rotates in an open tank partially filled with wastewater.

Preliminary data shown in Table V clearly demonstrates that this unit can reduce influent BOD by as much as 50-90 percent based on current loads.



OVERVIEW OF TREATMENT SYSTEM

PROCESS ECONOMICS

The system at Swedesboro will treat wastewater from tank interior wash at a cost of approximately $50/1000 gal or $750/day. It should be noted that about $30/1000 gal (the largest single cost) is due to equipment rental. This cost could be substantially reduced by equipment purchase and amortization. At Swedesboro some 15,000 gal/day of wastewater are produced from washing 15-20 tank interiors and exteriors per day.

The present costs of rented equipment and laboratory support to optimize operating conditions for the system do not necessarily approximate typical full-scale operating system economics. The analysis of costs to date shown in Table VI is based on 15,000 gal/day six-day work week, with five days for treatment operations.

Similarly this cost is expected to be reduced by equipment purchase and more efficient water use.

TABLE VI
OPERATIONAL ECONOMICS

	(In Dollars)			
	Cost/Day		Cost/1000 Gal.[1]	
OPERATING COSTS—TOTAL		$181.62		$12.11
Labor[2]	$ 73.93		4.93	
Chemicals[3]	57.69		3.85	
Sludge Disposal[4]	38.46		2.56	
Power	11.54		.77	
RENTAL COSTS—TOTAL		496.16		33.08
Activated Carbon[5]	461.54		30.77	
Biofilter[6]	34.62		2.31	
CAPITAL COSTS—TOTAL		72.12		4.81
Depreciation[7]	72.12		4.81	
TOTALS		$749.90		$50.00

Notes:
[1] Per 1000 gallons of treated wastewater
[2] One full time hourly worker, 5-day 9-hour day
[3] Sulfuric acid, cationic, and anionic polymers
[4] 6.25¢/gallon of sludge removed
[5] Rental includes regeneration
[6] RBF rental at $900/month
[7] Over 8½ years, building cost is $42,000+