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Treatment of Packinghouse Wastes By Anaerobic Lagoons and Plastic Media Filters

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April 1974

TREATMENT OF PACKINGHOUSE WASTES BY ANAEROBIC LAGOONS AND PLASTIC MEDIA FILTERS

by

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Program Element 1BB037

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ABSTRACT

Studies were conducted to demonstrate the efficiency and suitability of using dissolved air flotation, anaerobic lagoons, plastic media trickling filters and chlorination as a system for treating 1 mgd of wastewater from a meat packing plant.

The overall reduction of 5-day Biochemical Oxygen Demand (BOD_5) through the system averaged 98.5% over the ten month evaluation period leaving a discharge concentration of 61 mg/l. Suspended solids were reduced 95.4% through the entire system, leaving an effluent concentration of 90 mg/l after chlorination. The BOD_5 reduction in the anaerobic lagoons averaged 82% and accounted for the majority of BOD_5 removed in the system. The BOD_5 reduction through the plastic media trickling filters averaged 74% of the applied loading which was below the 91% efficiency expected during design. Hydraulic overload, organic overload, and possibly grease concentrations contributed to the lower-than-expected performance.

The cost of the treatment system was calculated to be $0.079 per hog killed or $0.344 per 1000 lb live weight killed.

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ACKNOWLEDGEMENTS

This study was conducted by Farmland Foods, Inc., at Denison, Iowa under the direction of Darrell A. Baker, Chemist-In-Charge for Farmland Foods, Inc. Burns and McDonnel Engineering Company, Kansas City, Mo. designed the trickling filter, clarifier and chlorination system. Other technical personnel involved in the project were Janet Bachmann, and Albert Roundy, of Farmland Foods, Inc., Denison, who assisted with the analytical work.

This report was submitted in fulfillment of Grant No. 12060DFF (formerly WRPD241-01-68). Dr. James C. Young, a consultant to Farmland Foods during the report preparation phase, assisted with the data analysis and report writing. Mr. Otmar O. Olson was the project officer during the construction and operational phase of the study while Dr. William Garner was project officer during the data analysis and write-up phase. Special recognition is made of the efforts of Mr. Jack L. Witherow of the National Environmental Research Center at Corvallis, Oregon.

SECTION I

CONCLUSIONS

Anaerobic lagoons provide high rates of removal of organic materials from packinghouse wastes. The units used in this study removed 82% of the applied BOD_5 at an average loading of 24.7 lb BOD_5/day/1000 ft.^{3}

Plastic media trickling filters followed by clarifiers used to treat anaerobic lagoon effluent removed 74% of the BOD_5 at an average applied loading of 70 lb BOD_5/day/1000 ft^3. However, removal efficiencies were lower than anticipated during design because of both hydraulic and organic overloading throughout most of the operating period, leaving an average effluent suspended solids concentration of 108 mg/l and BOD_5 concentration of 124 mg/l in the effluent from the final clarifiers. As a result of hydraulic overload, suspended solids removal in the final clarifier was not as high as expected.

The performance of the trickling filters, taking into account the increased BOD_5 loading, agreed reasonably well with calculations made using designs established by the manufacturers of the plastic media.

The chlorine contact basin, with an average dosage of 7.7 mg/l of chlorine, resulted in reduction of coliform counts from 10^7/100 ml to 10^3/100 ml.

Dissolved air flotation applied to the raw waste stream removed 33% of the BOD_5 and 62% of the grease from the packinghouse waste. However, this unit was considered to be an in-plant recovery process.

Cost of the treatment system, excluding air flotation, was calculated to be \$0.079 per hog killed or \$0.344 per 1,000 lb live weight killed when amortizing the capital costs over a 30 year period at 6.5% interest.

SECTION II

RECOMMENDATIONS

During the course of the study, it was found that the flows fluctuated widely, due largely to the type of waste and the character of the packing plant involved. It is recommended that treatment facilities be designed to buffer these fluctuations; i.e., larger lagoons to accommodate a 10-12 day flow, larger clarifiers to provide better solids separation, and chemical flocculation in the air flotation unit to improve grease recovery.

It is further recommended that recycling options to the trickling filter should be included to allow the operator to compensate for variable flow rates, slug waste discharges, and other operational problems.

Additional studies are recommended to determine performance characteristics of plastic-media trickling filters for a wider range of controlled hydraulic and organic loadings when operating during both winter and summer temperature extremes. Further investigation needs to be made to more clearly distinguish the advantages and disadvantabes of series operation of the trickling filters as compared to parallel operation with and without effluent recirculation to control the hydraulic loading.

SECTION III

INTRODUCTION

GENERAL

The need for a high degree of treatment for packinghouse wastes is well documented. These wastes generally have high BOD and suspended solids concentrations. A typical packinghouse slaughtering hogs has a population equivalent of 15 to 30 per hog depending on the various processes conducted within the production facilities. These wastes usually are warmer than domestic wastewater and contain a high concentration of animal blood and fat unless these components are removed in the slaughtering and processing plant.

PROJECT DEVELOPMENT

In the Summer of 1968, Farmland Foods, a subsidiary of Farmland Industries, Inc., Kansas City, Missouri, a farmer-owned cooperative, initiated the design of a waste treatment plant for the Denison, Iowa, pork operation. Several limitations affected the design of this plant, but foremost was the limited land available. Therefore, consideration was given to construction of a treatment plant system not requiring extensive aerobic lagoons for effluent polishing. Shortly after the inception of the plan, the U. S. Environmental Protection Agency, then FWPCA, was approached for possible funding of a demonstration project involving the use of plastic-media trickling filters for treating the effluent from anaerobic lagoons. The construction of the project began in April 1969 with FWPCA participating through a Research, Development and Demonstration grant.

HISTORICAL BACKGROUND

The use of anaerobic lagoons for treating packinghouse wastes is well documented [1 - 4]. Experience has shown that anaerobic lagoons will remove 70 to 90 percent of the applied 5-day, $20^{o}C$ biochemical oxygen demand (BOD_5) loading, with loading rates varying from 10 to 30 pounds BOD_5 per 1,000 ft^3 of lagoon volume. Normally, these anaerobic lagoons are followed by a series of aerated and unaerated lagoons to provide additional treatment and to make the wastewater suitable for discharge to natural watercourses. The primary objective of this project was to determine the feasibility of substituting a plastic media trickling filter system for any or all of the aerobic lagoons.

The use of plastic media in trickling filters is relatively new. Plastic media offer distinct advantages over rock media in that plastic media can be loaded at higher organic and hydraulic loadings and the media can be stacked up to 30 feet without intermediate supports. These advantages can contribute to significant economic savings in land and capital costs over rock media filters.

There are three major manufacturers of plastic media: The Dow Chemical Company, B. F. Goodrich Company, and the Ethyl Corporation. Table 1 gives pertinent data for the three plastic media.

Table 1. BULK PROPERTIES OF PLASTIC MEDIA

Manufacturer	Material	Surface area, ft^2/ft^3	Void space, %	Unit wt., lbs/ft^3
Dow Chemical Company	PVC	27	94	2.6
B. F. Goodrich Company	PVC	37	97	2.74-4.13
Ethyl Corporation	PVC	29	97	2.44

Each of these manufacturers has a basic design equation for designing the filter towers.

Dow Chemical Company

The basic equation expressing the BOD fraction remaining at any media depth follows (5):

$$\frac{L_e}{L_o} = e^{-KD/Q^{\frac{1}{2}}} \quad (1)$$

where: L_o = BOD_5 of waste fed to filter (recirculation not included)

L_e = BOD_5 remaining

K = Rate coefficient, treatability factor (0.088 for domestic sewage)

D = Depth of filter media, ft

Q = Hydraulic dosing rate, gpm/ft^2 (recirculation not included)

In determining the volume of filter media required for a particular project, the value of L_e/L_o is know, D is assumed for the particular project, and K is obtained from the Dow Chemical Company for values for wastes other than domestic sewage. Thus, the hydraulic dosing rate, Q, is the unknown to be determined. Then, knowing the hydraulic dosing rate, the influent flow rate and the depth, one can calculate the volume of filter media required.

Research by Germain[5] indicated that when using media manufactured by Dow Chemical Company recirculation did not cause a statistically significant effect of BOD removal. Consequently, recirculation was not considered in the development of Equation 1.

B. F. Goodrich

B. F. Goodrich uses the basic equation developed by Schulze[6] in the design of their facilities. The equation is expressed as follows:

$$\frac{L_e}{L_o} = e^{-K\theta D/Q^n} \qquad (2)$$

Where: L_o = BOD_5 of waste fed to filter

L_e = BOD_5 remaining

K = Treatability factor

θ = Temperature factor, $(1.035)^{T-20^\circ C}$

D = Depth of filter media, ft

Q = Hydraulic loading, gpm/ft^2

n = Media factor

T = Temperature, $^\circ C$

This equation is very similar to Germain's[5] with the exception that a temperature correction factor is included in the Schulze equation. The coefficients used for design and those calculated from treatment performance will be compared later in this report.

Ethyl Corporation

Ethyl Corporation[7] has developed curves for the removal of BOD for several types of wastes. The data from which the curves were developed were obtained from actual pilot and commercial installations. Copies of these BOD reduction curves are available from the manufacturer.

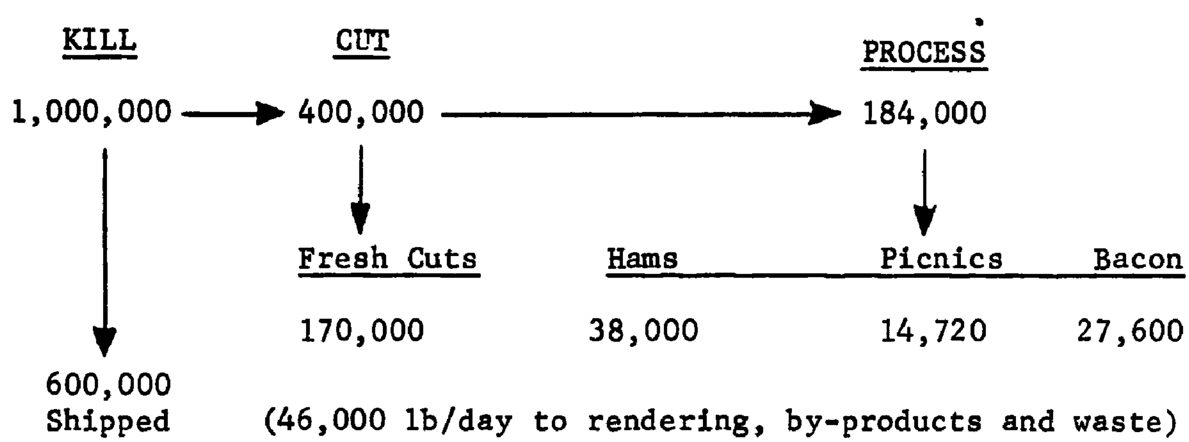
SECTION IV

PLANT DESCRIPTION

SOURCE OF WASTES

The packing-slaughterhouse plant at which this study was conducted is located northwest of Denison, Iowa, and has the capacity to kill and dress 5,000 hogs per day. Typical live weight of hogs killed was about 230 lbs. The hog cutting and processing operation generally accounted for about 40 percent of the kill including two or three hundred head per day shipped to the Denison plant from a plant at Iowa Falls, Iowa. The overall processing schedule is summarized as follows:

BREAKDOWN OF HOG PROCESSING, lb/day



Wastes from the plant were typical of most packinghouse operations, having high BOD, grease and solids content, with variable pH and temperature. The waste from the slaughter-packing plant was collected in two interceptors. Interceptor No. 1 received all wastes from the kill floor area except the scald tank; and Interceptor No. 2 received wastes from the hog pens, scald tank, rendering, blood drying operation, and the domestic waste. There was no cooling water entry into either line. Figure 1 gives a schematic diagram of the entire treatment system.

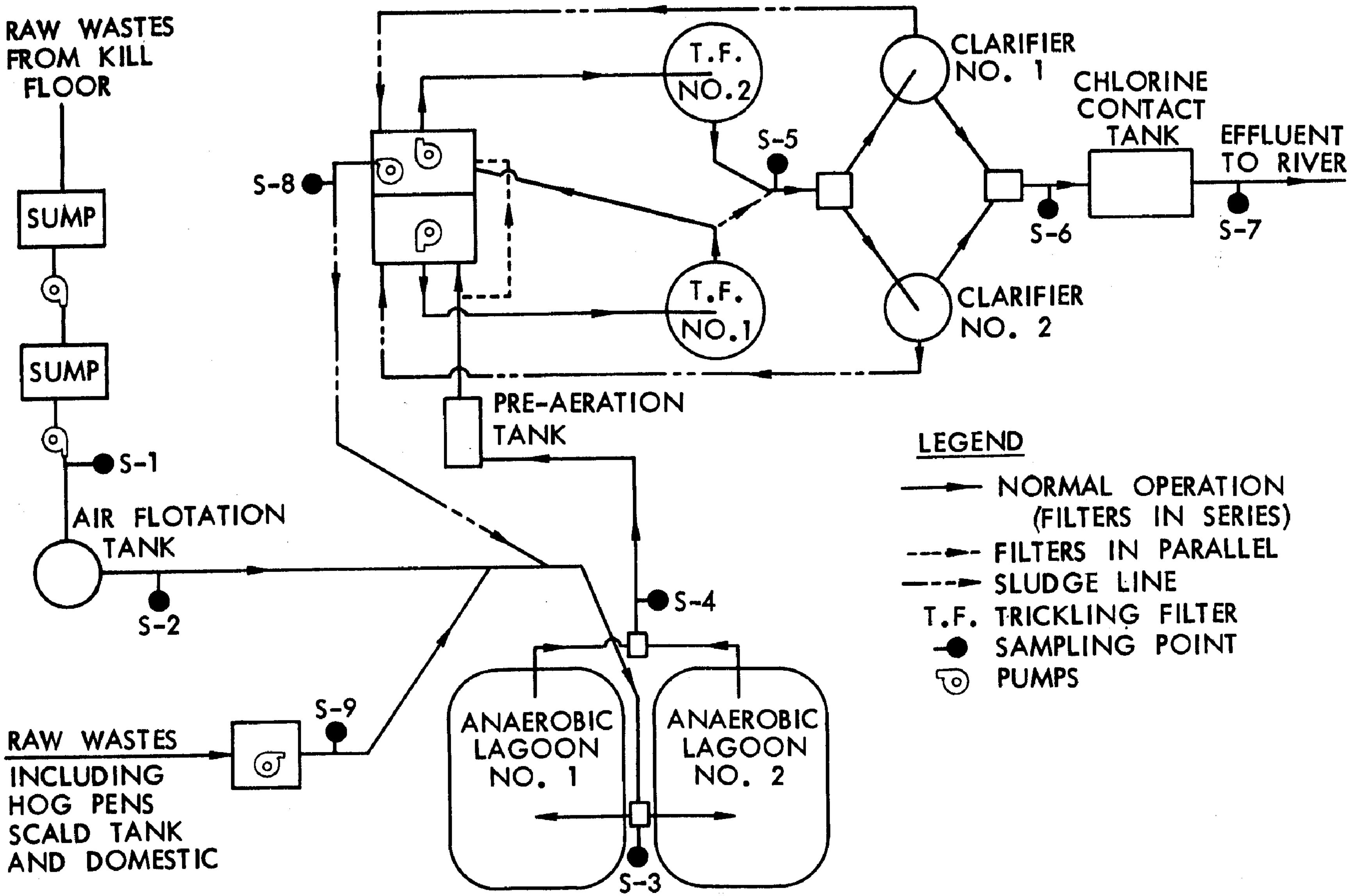


Figure 1. Schematic diagram of the Denison, Iowa, anaerobic lagoon - trickling filter system

PLANT UNITS

Wastes from the Interceptor No. 1 were pumped into a dissolved air flotation cell for pretreatment before discharge into two anaerobic lagoons (Figure 1). Grease removed from the flotation cell was rendered and sold as brown house grease.

The flotation cell effluent and the flow from Interceptor No. 2 were combined shortly before discharging into the two anaerobic lagoons which were operated in parallel. The combined flow, including sludge recirculation from the final clarifiers, was measured at the anaerobic lagoon inlet with a V-notch weir meter. The anaerobic lagoons served two important functions; that of providing biological treatment of the wastes and equalizing the flow to the trickling filter plant evenly throughout the work week.

Effluent from the anaerobic lagoons flowed through a control valve which could be operated manually or automatically; then through a preaeration tank which was designed for two purposes: to control odors emanating from the anaerobic effluent by releasing them at a designated location where they possibly could be treated and to supply a limited amount of oxygen to the wastewater before treatment by the trickling filters. Occasionally, a masking agent was used to control odors in the anaerobic effluent.

The preaeration tank effluent was then pumped to two trickling filters normally operated in series; the plastic media in each unit was manufactured by B. F. Goodrich. The filter effluent was discharged to two final clarifiers and then to a chlorine contact basin for disinfection. Sludge removed from the final clarifiers was recycled to the anaerobic lagoons using a positive-displacement pumped operated on a pre-set schedule.

DESIGN CRITERIA

Design criteria and unit sizes for the treatment facilities are summarized as follows:

Raw Waste Characteristics

Hogs killed per day	5,000
BOD loading:	
5,000 hogs killed(4.3 lbs/hog)	21,500 lbs/day
Average waste flow (operating days)	
Gallons per hog	170 gal/hog
Gallons per day	850,000 gpd
Maximum daily flow	1,000,000 gpd
Peak hourly flow	1,500,000 gpd

Air Flotation Tank

Diameter	22'-6"
Water depth	12'-0"
Hydraulic rate	1000 gpm
BOD removal, percent	40
Grease removal, percent	85

Anaerobic Lagoon

Number of cells	2
BOD applied, lbs/day	12,900
Design loading, lbs BOD per day/ 1,000 ft^3	15
Water depth, ft	14
Water surface area, acres	1.64
BOD removal, percent	80
Total Lagoon area, acres	1.97
Lagoon volume, 1000 ft^3	900

Preaeration Tank

Detention, minutes	30
Volume of air, cfm	100

Trickling Filter

Number of filters	2
Diameter, ft	39
Media depth, ft	22
Media volume, 1000 ft^3	52.56

BOD loading, lbs per day/1,000 ft^3	
First stage	98
Second stage	31
Total trickling filter	49
Hydraulic loading, gpm/ft^2 surface area	0.5
Recirculation	None
BOD removal, percent (includes final clarifiers)	91

<u>Final Clarifier</u> (In Parallel)

Number of clarifiers	2
Diameter, ft	26
Water depth, ft	7
Surface settling rate, gpd/ft^2 (average)	800
Weir overflow rate, gpd/lin.ft (average)	6,800

<u>Chlorine Contact</u>

Detention, at avg. daily flow, minutes	49
Max. chlorine dosage capacity, lbs Cl_2/day	100
Chlorine dosage rate, mg/l	10

<u>Treatment Plant Pumping Facilities</u>

Trickling filter pumps - variable speed	
Filter No. 1:	
Number of pumps	2
Rated capacity, gpm	700
Filter No. 2:	
Number of pumps	2
Rated capacity, gpm	700
Final clarifier sludge pumps	
Number of pumps	2
Rated capacity, gpm	85

SECTION V

SAMPLING AND ANALYSES

Originally, the primary purpose of the evaluation program was to study the performance of the trickling filter system. However, after the program was begun, sampling stations were added so that the dissolved air flotation tank and the anaerobic lagoons could be included in the analysis of the treatment plant performance. The location of all sampling stations is shown in Figure 1. Table 2 shows the location of sampling stations set up for composite and grab samples.

Table 2. SAMPLING STATIONS AND PROCEDURE

Sampling station	Type of sampling
S-1, Air flotation tank influent	Composite
S-2, Air flotation tank effluent	Composite
S-3, Anaerobic lagoon influent	Composite
S-4, Anaerobic lagoon effluent	Grab
S-5, Trickling filter effluent	Grab
S-6, Final clarifier effluent	Grab
S-7, Chlorine contact tank effluent	Grab
S-8, Final clarifier sludge	Composite
S-9, Domestic, hog pens, scald tank	Composite

The final clairfier sludge was sampled by hand several times throughout the pumping cycle. These samples were then mixed together to form a composite.

Three types of automatic samplers were used throughout the program. They included, (1) a suction-type sampler with 24 bottles for compositing, (2) a dip-type sampler which dipped a 10-15 ml sample at a set interval and (3) a rotating disc-type suction sampler. None of the samplers worked satisfactorily on the air flotation tank influent because of the extremely high grease content which continually caused clogging and the high moisture content in the atmosphere which shorted-out the motors. This problem was eventually solved by providing a siphon off the flotation tank influent line which discharged into a 55-gallon barrel. The sample for analysis was then taken from the barrel after the solution was properly mixed.

All laboratory procedures and analyses were conducted in accordance with Standard Methods[8]. The following analyses were made during the program:

- Dissolved Oxygen
- Biochemical Oxygen Demand
- Chemical Oxygen Demand
- pH
- Temperature
- Alkalinity
- Total Kjeldhal Nitrogen
- Ammonia Nitrogen
- Nitrite Nitrogen
- Nitrate Nitrogen
- Total Solids
- Fixed Solids
- Volatile Solids
- Chlorine Residual
- Grease
- Coliform
- Phosphate
- Sulfate
- Hydrogen Sulfide

SECTION VI
RESULTS

The trickling filter plant was designed to be operated at a constant flow rate with the anaerobic lagoons acting as equalizing ponds so that the flow discharged to the trickling filters would be relatively constant seven days a week. The average daily flow discharged to the trickling filters during each month is designated as anaerobic lagoon effluent in Table 3.

From January through July, the flow rate to the trickling filters was controlled to distribute the flow over a seven day week. In general, this was done satisfactorily, except on some Sundays when the flow decreased substantially.

From August through December, a major operational change was made. It was decided not to have treatment plant personnel present on weekends. Therefore, the anaerobic lagoon was not used for flow equalization and the major part of the flow to the trickling filters was treated as it came in. Thus, only a minor flow was discharged to the filters during the weekends. Table 4 shows the daily average flow to the filters during these two different operational procedures as compared to the design flow.

Table 4. TRICKLING FILTER FLOWS

Months	Design flow[a]	Actual Average daily flow
January - July	607,000 gpd	782,050 gpd[b]
August - December	607,000 gpd	1,142,880 gpd[c]

[a] Based on the 5-day working week flow being discharged to the filters over a 7-day period (without sludge recirculation)

[b] Based on raw wastewater flow measurement x 5/7 plus sludge recirculation

[c] Based on flow during working days only including sludge recirculation

Table 3. PLANT FLOWS
(gpd)

Month	Raw wastes to anaerobic lagoon			Final clarifier sludge return	Anaerobic lagoon influent [a]			Anaerobic lagoon effluent [b]		
	High	Low	Average		High	Low	Average	High	Low	Average
Feb.	1,085,000	855,000	925,000	108,000	1,193,000	963,00	1,033,000	1,066,000	541,000	783,000
Mar.	1,047,000	835,000	960,000	108,000	1,155,000	943,000	1,068,000	1,025,000	601,000	778,000
Apr.	1,067,000	813,000	927,000	108,000	1,175,000	921,000	1,035,000	1,031,000	522,000	830,000
May	1,121,000	812,000	972,000	108,000	1,229,000	920,000	1,080,000	1,148,000	696,000	880,000
June	1,099,000	728,000	961,000	108,000	1,207,000	836,000	1,069,000	1,219,000	950,000	1,100,000
July	1,023,000	842,000	917,000	108,000	1,131,000	950,000	1,025,000	---	---	---
Feb.-July Average[c]			943,670				1,052,670			874,200
Aug.	1,128,000	976,000	1,028,000	108,000	1,236,000	1,084,000	1,136,000	1,510,000	764,000	1,253,000
Sept.	1,094,000	1,007,000	1,035,000	108,000	1,202,000	1,115,000	1,143,000	1,406,000	852,000	1,278,000
Oct.	1,091,000	1,017,000	1,054,000	108,000	1,199,000	1,125,000	1,162,000	1,642,000	1,077,000	1,361,000
Nov.	1,103,000	966,000	1,014,000	108,000	1,211,000	1,074,000	1,122,000	1,796,000	866,000	1,296,000
Dec.	1,139,000	931,000	1,043,000	108,000	1,247,000	1,039,000	1,151,000	1,796,000	681,000	1,382,000
Aug.-Dec. Average[d]			1,034,800				1,142,800			1,314,000
Average			985,000				1,093,000			1,094,000

[a] Flow on working days only (includes recirculation) measured by V-notch weir at station S-3

[b] Flow, including recirculation, measured by Parshall flume ahead of the pre-aeration tank

[c] Anaerobic lagoons were used to equalize 5 day industrial flow over 7-day period Feb.-July.

[d] No flow equalization in anaerobic lagoons Aug.-Dec.

RAW WASTE ORGANIC LOAD

Initially, sampling of the dissolved air flotation tank influent was not a part of the evaluation program. After the program was begun, EPA requested that this waste stream be sampled so that the dissolved air flotation tank could be evaluated. Therefore, data for this waste stream and the domestic waste stream (Interceptor No. 2) are available for only the last seven months of the evaluation program.

Table 5 shows the monthly average BOD_5 load in the two raw waste streams. It is evident that the waste characteristics vary considerably from month to month. Approximately 80 percent of the organic wastes was discharged to the dissolved air flotation tank while the remaining 20 percent (from Interceptor No. 2) was discharged directly to the anaerobic lagoons.

OPERATIONAL DATA SUMMARY

Table 6 summarizes the basic operational data for the year. The production facilities were operated at an average daily kill rate of 3,458 hogs per day, approximately 69 percent of maximum production rate. The actual waste flow per hog averaged 278 gallons. Table 7 compares the design criteria with the actual 1970 operational data. Monthly averages of all analytical measurements are given in Appendix Tables A-1 through A-18.

Table 7. SUMMARY OF RAW WASTES

Parameter	Design	Average of 1970 data
BOD_5		
lbs/day	21,500	17,716[a]
lbs/hog	4.3	4.8[a]
Waste Flows		
Gallons per day	850,000	985,000
Gallons per hog	170	278

[a] June - December only

Table 5. RAW WASTES BOD_5

Month	Domestic (Interceptor no. 2) High, mg/l	Low, mg/l	Average, mg/l	Average, lbs/day	Dissolved air flotation tank influent (Interceptor no. 1) High, mg/l	Low, mg/l	Average, mg/l	Average, lbs/day	Total BOD_5 lbs /day
Jan.	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	---	---	---
Mar.	---	---	---	---	---	---	---	---	---
Apr.	---	---	---	---	---	---	---	---	---
May	---	---	---	---	---	---	---	---	---
June	1,224	369	769	2,609	6,795	1,134	3,194	15,945	18,554
July	1,449	112	655	2,818	2,944	943	1,771	8,377	11,195
Aug.	3,240	411	1,260	4,489	3,720	2,484	3,178	16,592	21,081
Sept.	5,133	317	2,058	6,949	6,336	1,407	3,515	20,165	27,114
Oct.	3,004	378	1,402	4,841	4,301	971	1,768	9,297	14,138
Nov.	2,197	308	1,362	4,240	2,290	1,206	1,621	8,315	12,555
Dec.	1,052	369	639	2,095	7,558	1,125	3,325	17,282	19,377
Monthly average				4,006				13,710	17,716

Table 6. OPERATIONAL DATA

Month	Hogs killed/day		Gallons of waste flow		BOD_5, lb	
	Head	pounds live weight	Per head	per 1000 lb live weight	per head	per 1000 lb live weight
Jan. 1970	3,015	692,000	---	---	---	---
Feb. 1970	3,366	765,000	275	1,209	---	---
Mar. 1970	3,216	731,000	299	1,311	---	---
Apr. 1970	3,340	763,000	278	1,215	---	---
May 1970	3,386	784,000	287	1,240	---	---
June 1970	3,382	774,000	284	1,241	5.5	24.0
July 1970	3,031	674,000	303	1,364	3.7	16.6
Aug. 1970	3,519	772,000	292	1,331	6.0	27.3
Sept. 1970	3,876	869,000	267	1,191	7.0	31.2
Oct. 1970	3,743	865,000	282	1,220	3.8	16.3
Nov. 1970	4,241	947,000	235	1,070	3.0	13.3
Dec. 1970	4,149	960,000	251	1,086	4.7	20.2
Monthly average	3,458	800,000	278	1,224	4.8[a]	21.3[a]

[a] June-December only

PERFORMANCE DATA

DISSOLVED AIR FLOTATION TANK

This treatment unit is generally considered to be an in-plant recovery unit. However, analyses were run on the unit from June through December to determine the performance of the unit. Since it was extremely difficult to obtain a representative sample of the flotation tank influent, the results are somewhat limited in value. The main constituents removed in the flotation tank are BOD, COD, grease, and solids. The average performance is summarized in Table 8.

Table 8. DISSOLVED AIR FLOTATION TANK PERFORMANCE

Analysis	Influent, mg/l	Effluent, mg/l	Removal, %
BOD_5	2,624	1,762	33
COD	4,591	4,106	11
Grease	1,484	559	62
Total suspended solids	2,223	1,507	32

ANAEROBIC LAGOONS

The anaerobic lagoons performed well during the test period. Averages of the data for the more important parameters are shown in Tables 9 and 10. The performance of the lagoons was probably enhanced by the thick grease cover which acted as an insulator. The minimum temperature of $60^{o}F$ in the lagoon contents occurred in December and summer temperatures varied between $70\text{-}75^{o}F$ (Figure 2). Average influent wastewater temperature over the test period was 82.9^{o} F and average lagoon effluent temperature was $69^{o}F$.

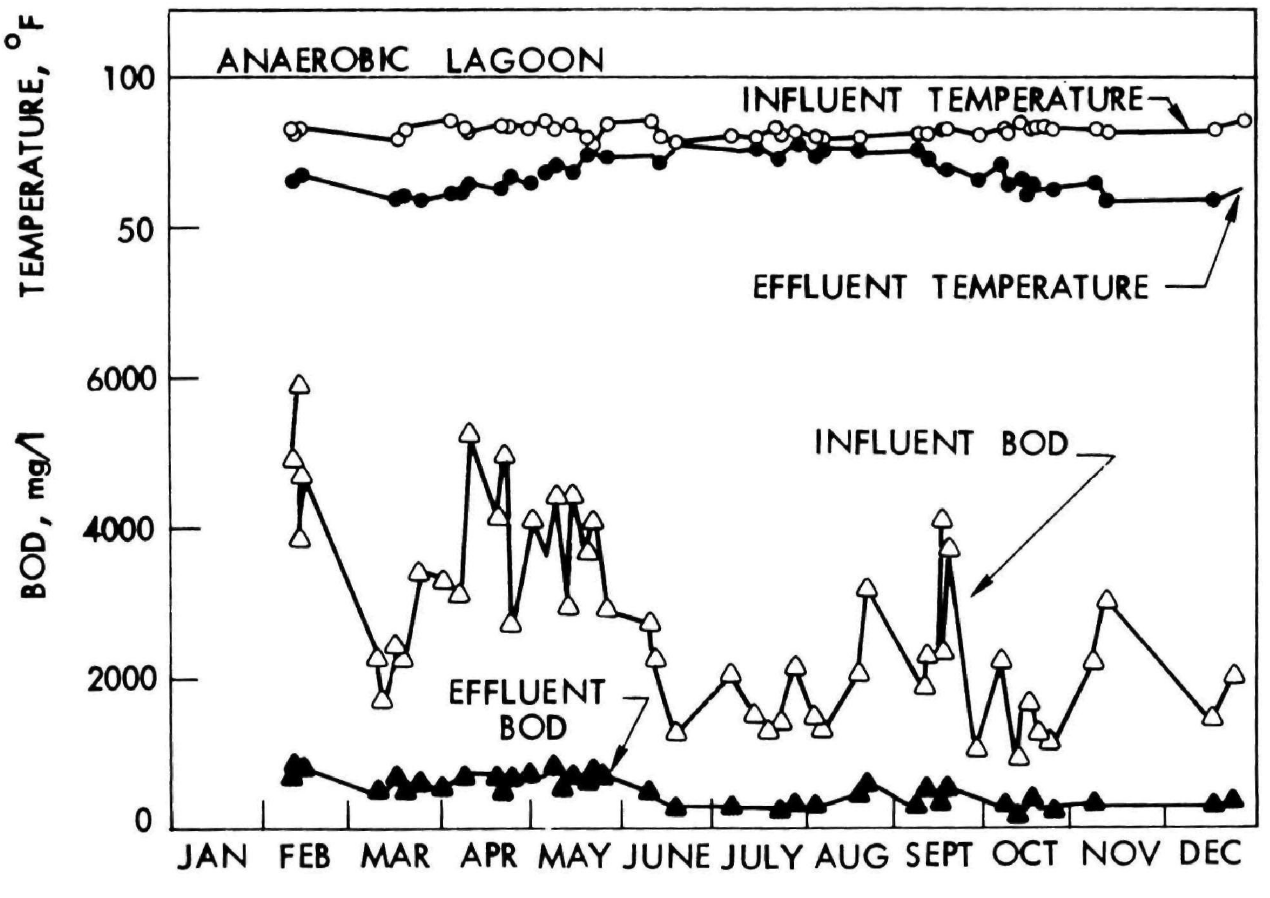


Figure 2. Monthly pattern of BOD_5 removal through the anaerobic lagoon system

Table 9. ANAEROBIC LAGOON PERFORMANCE

Analysis	Influent, mg/l	Effluent, mg/l	Removal, %
BOD	2,635	477	82
COD	4,396	1,403	68
Grease	485	106	78
Total solids	4,094	1,955	52
Volatile solids	2,112	663	69
Total suspended solids	1,402	579	59
Organic nitrogen (N)	95.9	42.1	--
Ammonia nitrogen (N)	67.8	121.6	--
Sulfates	332.0	38.8	88
Hydrogen sulfide	0.0	4.6	--
pH (units)	6.6	7.0	

The lagoons performed as expected, removing an average of 82 percent of the applied BOD_5 even though the lagoons were loaded much heavier than design loading. The total applied organic loading averaged 22,186 pounds of BOD_5 per day (Table 10). Thus the lagoon loading rate averaged 24.7 pounds of BOD_5 per 1,000 ft^3 of lagoon volume. Figures 3 and 4 show the overall performance of the anaerobic lagoon system in terms of removal of both BOD_5 concentration and load. The reduction in effluent BOD_5 after June was associated with a corresponding reduction in influent BOD_5 concentration and load (Figures 3 and 4). It can not be determined from the data available whether this reduced effluent BOD_5 concentration was a result of the higher temperature in the lagoons or the reduced BOD_5 load to the lagoons. The total suspended solids removal of 59 percent was uncommonly low. However, the actual lagoon detention during the evaluation program was five days as compared to an expected detention of 7.5 days, based on design hydraulic flows; and this may have resulted in the lower removal of suspended solids. As expected, much of the organic nitrogen was converted to ammonia nitrogen in the lagoons. The pH remained relatively constant during the year, averaging 7.0.

Table 10. ANAEROBIC LAGOON INFLUENT BOD_5

Month	Domestic + air flotation tank effluent				Final clarifier sludge return,	Average anaerobic lagoon influent,
	High, mg/l	Low, mg/l	Average, mg/l	Average, lb/day	lb/day	lb/day
Feb.	5,960	3,836	4,868	37,554	770	38,324
Mar.	3,406	1,648	2,392	19,151	770	18,921
Apr.	5,265	2,760	3,940	30,460	770	31,230
May	4,645	2,986	3,830	31,048	770	31,818
June	2,780	1,295	2,102	16,847	770	17,617
July	2,130	1,260	1,672	12,787	770	13,557
Aug.	3,521	1,370	2,176	18,656	770	19,426
Sept.	4,149	1,013	2,440	21,062	770	21,832
Oct.	2,265	818	1,453	12,772	770	13,542
Nov.	2,520	2,521	2,386	20,178	770	20,948
Dec.	2,041	1,421	1,731	15,057	770	15,827
Average			2,635	21,416	770	22,186

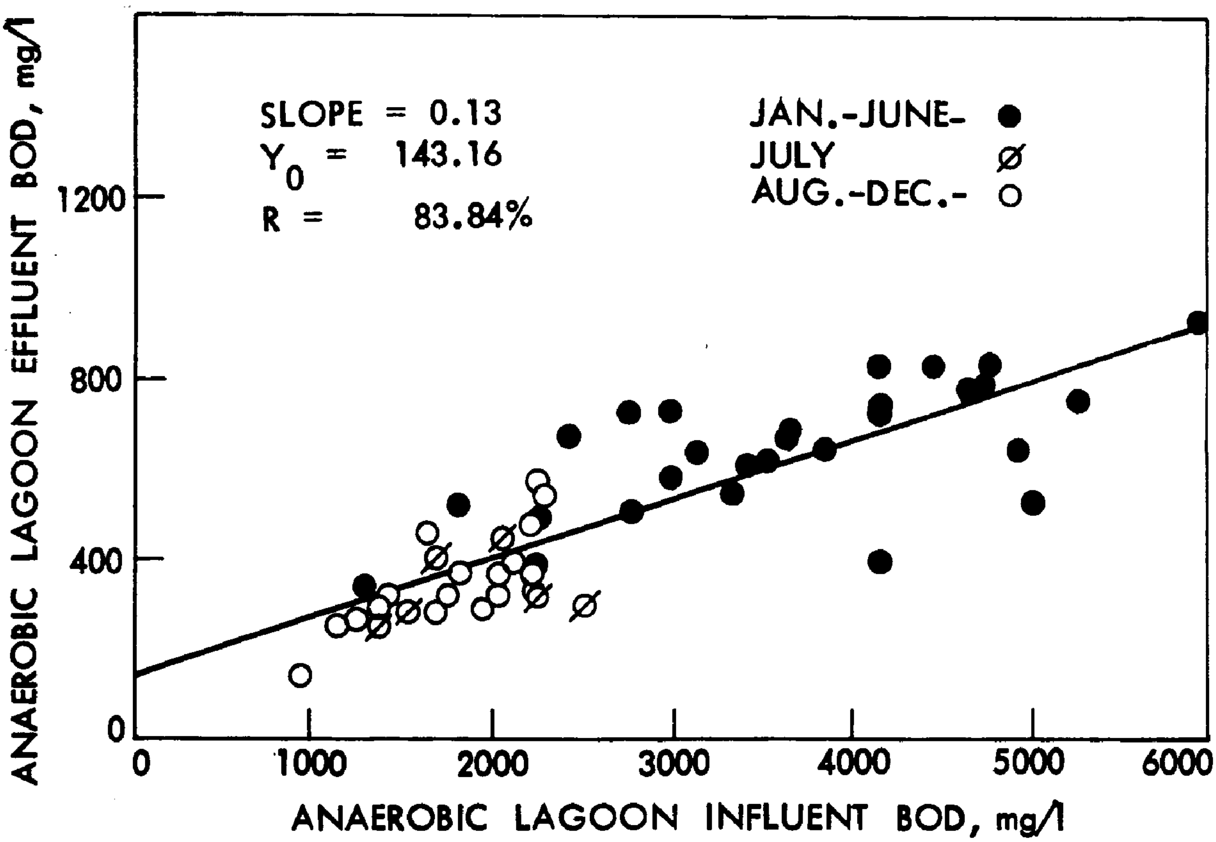


Figure 3. BOD_5 concentration removal characteristics of the anaerobic lagoon system

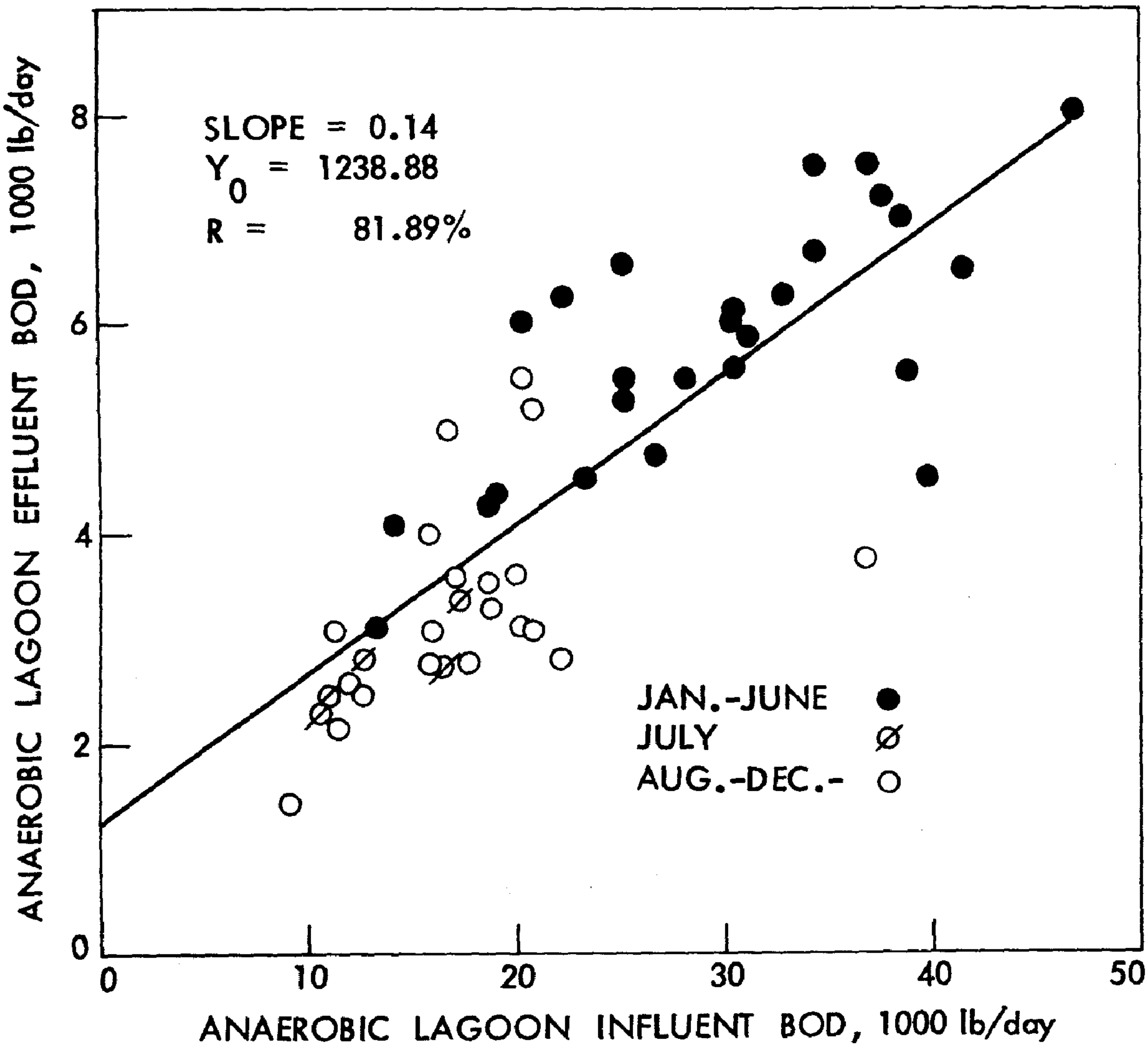


Figure 4. BOD_5 load removal characteristics of the anaerobic lagoon system

Farmland Foods receives its water from the city of Denison, Iowa. This well water supply contains from 344 to 461 mg/l of sulfate. Most of this sulfate was reduced to sulfide in the anaerobic lagoons and sulfide odors were detected at the lagoon overflow weir and the preaeration tank. A masking agent injected into the anaerobic effluent stream for odor control worked well. Sanfac DX-85 was found to be suitable, but this does not mean that other masking agents would not have performed as well.

Trickling Filter and Final Clarifier

At the beginning of the study it was determined that both parallel and series operation would be used to study the effect of both types of operation on filter performance. However, the trickling filters were operated in series for most of the study program.

During series operation, the hydraulic loading rate averaged 0.64 gpm/ft^2 of surface area on a raw-flow basis, whereas the design hydraulic loading was 0.5 gpm/ft^2. The annual average performance of the trickling filter and final clarifier is given in Table 11 while the month-to-month performance is summarized in Table 12. Figures 5 and 6 are plots of the BOD_5 data from all samples collected throughout the test period. A comparison of effluent vs influent BOD_5 concentration and load shows considerable scattering of data (Figures 7-10). Much of the BOD removal occurred in the final clarifiers. The filters provided enough aeration of the wastewater that the dissolved oxygen in the final clarifier effluent averaged 3.9 mg/l (Table 11).

The correlations shown in Figures 7-10 are not sufficiently accurate for designing plastic-media trickling filter systems to treat anaerobic lagoon effluent. They do give evidence of the effect of some of the problems associated with this study such as highly variable flows and loads, inconsistent flow to the trickling filters, and sampling and analytical problems. Additional studies are needed to define more accurately the treatment characteristics and to develop more accurate design data for these systems.

The data from the limited nitrate analysis were quite variable; but, as indicated in Table 11, some nitrification appeared to occur in the filters. Some denitrification also occurred in the final clarifier and may have contributed to problems experienced with floating sludge. The preaeration-filter-settling system removed 100 percent of the hydrogen sulfide present but did not remove any phosphates, with approximately 47 mg/l being discharged in the final clarifier effluent (Table 11).

Table 11. TRICKLING FILTER PERFORMANCE

Analysis	Trickling filter influent, mg/l	Trickling filter effluent, mg/l	Final clarifier effluent, mg/l	Total removal, %
Dissolved Oxygen	0	2.3	3.9	--
BOD	477	296	124	74
COD	1,403	1,010	372	73
Grease	106	73	33	69
Volatile Solids	663	706	354	47
Volatile Suspended Solids	418	443	83	80
Total Suspended Solids	579	602	108	80
Organic Nitrogen (N)	42.1	41.1	21.3	49
Ammonia Nitrogen (N)	121.6	103.2	100.0	18
Nitrate Nitrogen (N)	9.3	25.2	15.1	--
Sulfates	38.8	64.3	63.7	--
Hydrogen Sulfide	4.6	0.2	0	100
Total Phosphates	47	47	42	11

The 74% BOD_5 removal in the trickling filter system was lower than the anticipated removal of approximately 90% of the applied organic loading. The design organic loading was 2,580 pounds BOD_5 per day, whereas the actual average organic loading was 3,637 pounds BOD_5 per day of operation during the test year. This resulted in an overall loading rate of 70 pounds of BOD_5 per day per 1,000 ft^3 of filter media as compared to the 49 pounds per day per 1,000 ft^3 used for design.

Table 12. BOD_5 CHANGES THROUGH TRICKLING FILTER SYSTEM

Month	Flow rate,[b] mg/l	Trickling filter influent BOD, mg/l	Trickling filter influent BOD, lb/day[a]	Trickling filter effluent BOD, mg/l	Trickling filter effluent BOD, lb/day[a]	Final clarifier effluent BOD, mg/l	Final clarifier effluent BOD, lb/day[a]	Chlorine contact effluent BOD, mg/l	Chlorine contact effluent BOD, lb/day[a]
Jan.	--	--	--	120	--	108	--	44	--
Feb.	0.769	765	4906	150	962	133	733	44	243
Mar.	0.794	543	3596	506	3351	129	738	76	435
Apr.	0.770	604	3879	506	3249	152	839	61	337
May	0.802	732	4896	461	3084	129	747	87	504
June	0.794	407	2695	329	2179	160	915	41	235
July	0.763	305	1941	327	2081	115	732	74	404
Aug.	1.136	424	4017	476	4510	113	969	78	669
Sept.	1.143	502	4781	398	3794	125	1079	81	699
Oct.	1.162	284	2752	286	2772	86	756	29	255
Nov.	1.122	343	3210	298	2789	124	1049	30	254
Dec.	1.151	347	3331	318	3053	89	774	81	705
Average		477	3637	296	2893	124	848	61	431

[a] Loading on days having flow to trickling filters

[b] Adjusted flow for operating days only including sludge recirculation of 0.108 mgd

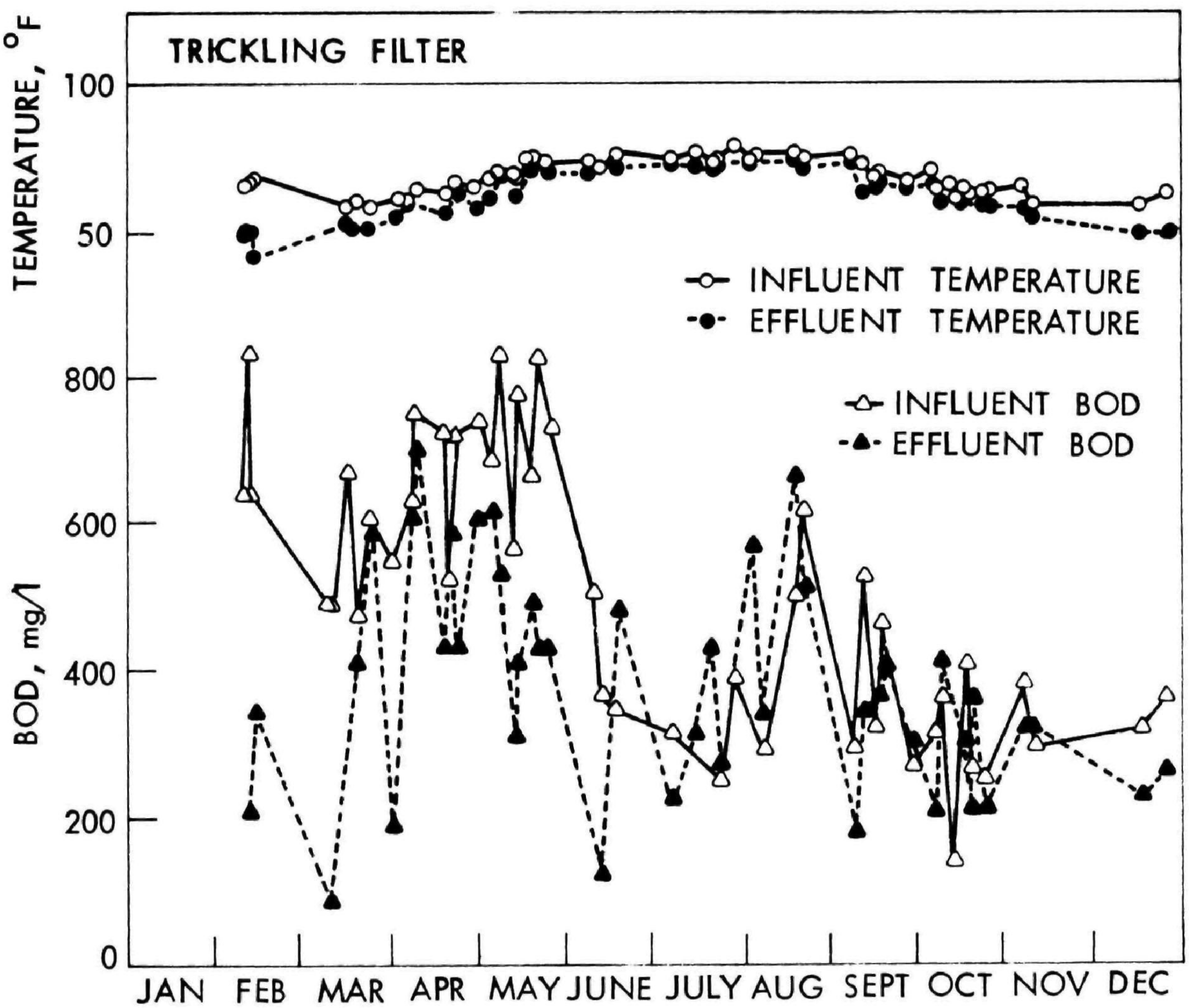


Figure 5. Monthly pattern of BOD_5 removal through the plastic media trickling filters (without final settling)

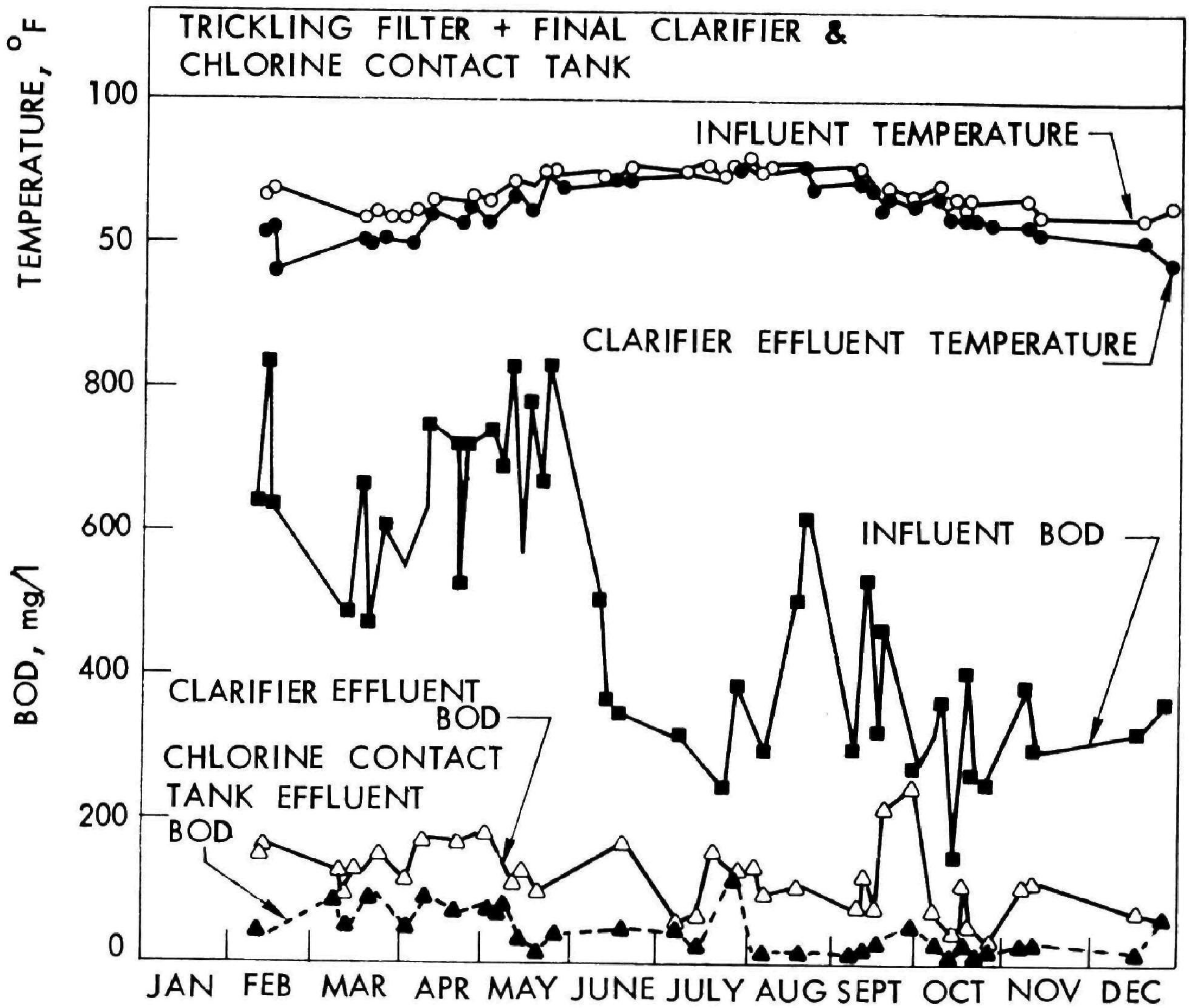


Figure 6. Monthly pattern of BOD_5 removal through the plastic media trickling filter and final clarifier and after chlorination

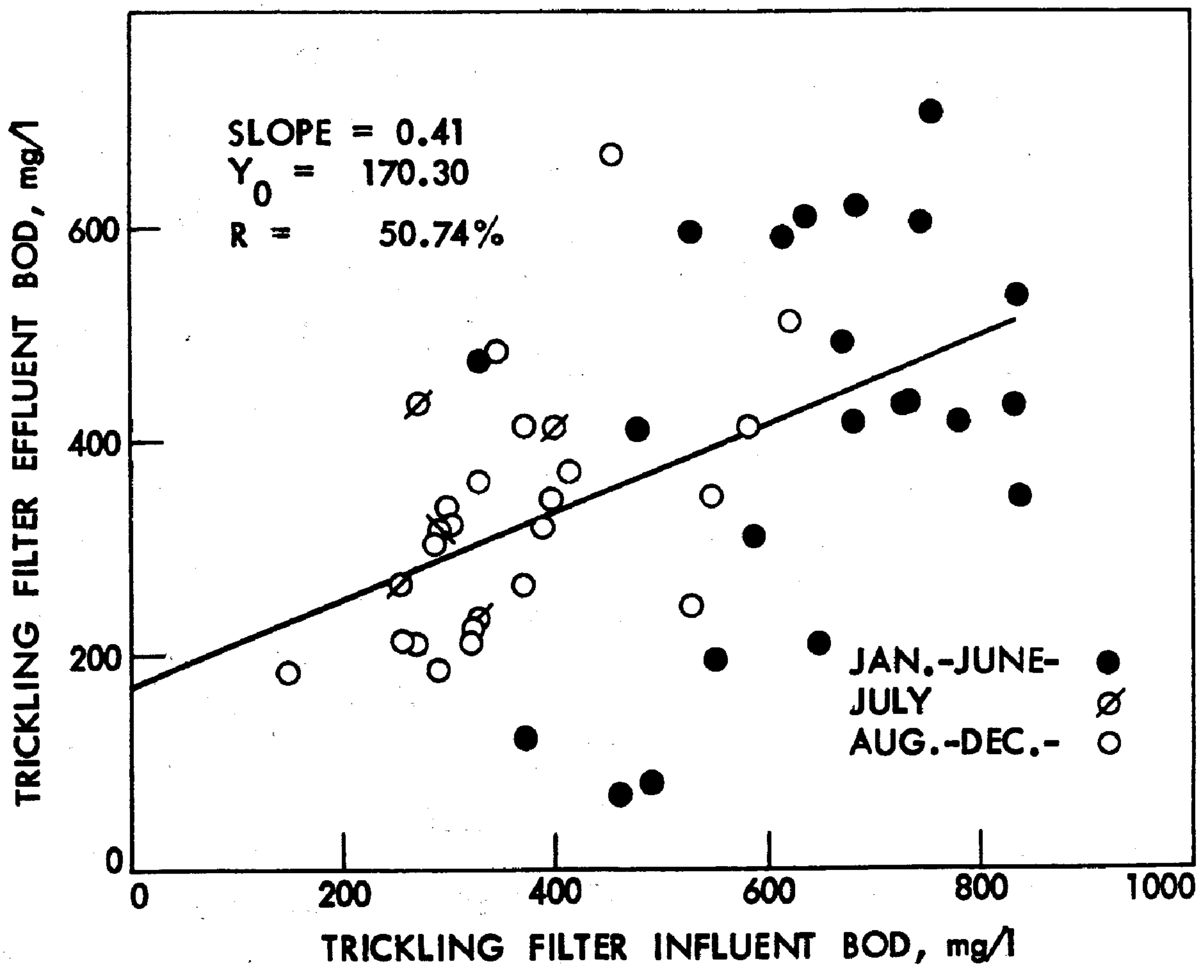


Figure 7. BOD_5 concentration removal characteristics of the plastic media trickling filters (without final settling)

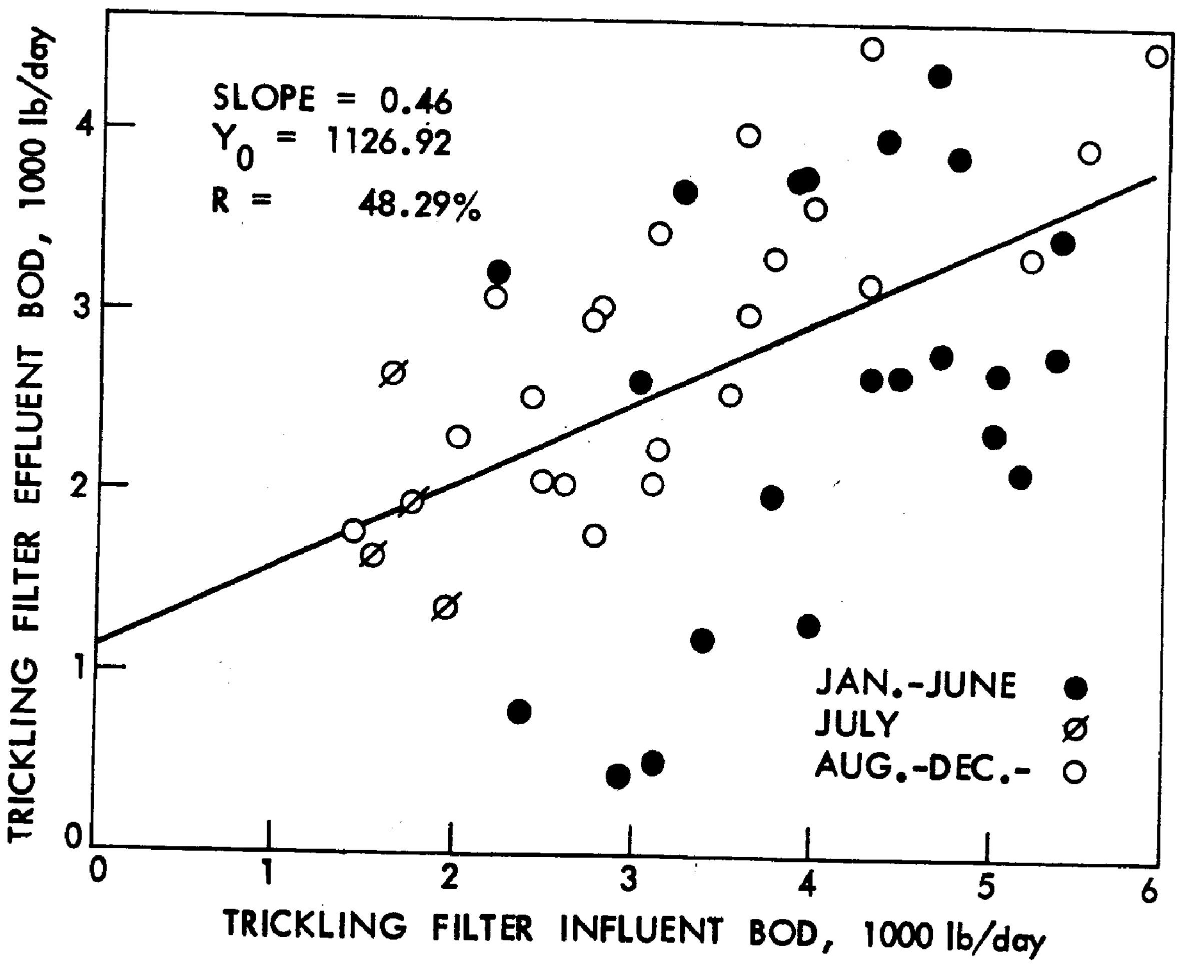


Figure 8. BOD_5 load removal characteristics of the plastic media trickling filters (without final settling)

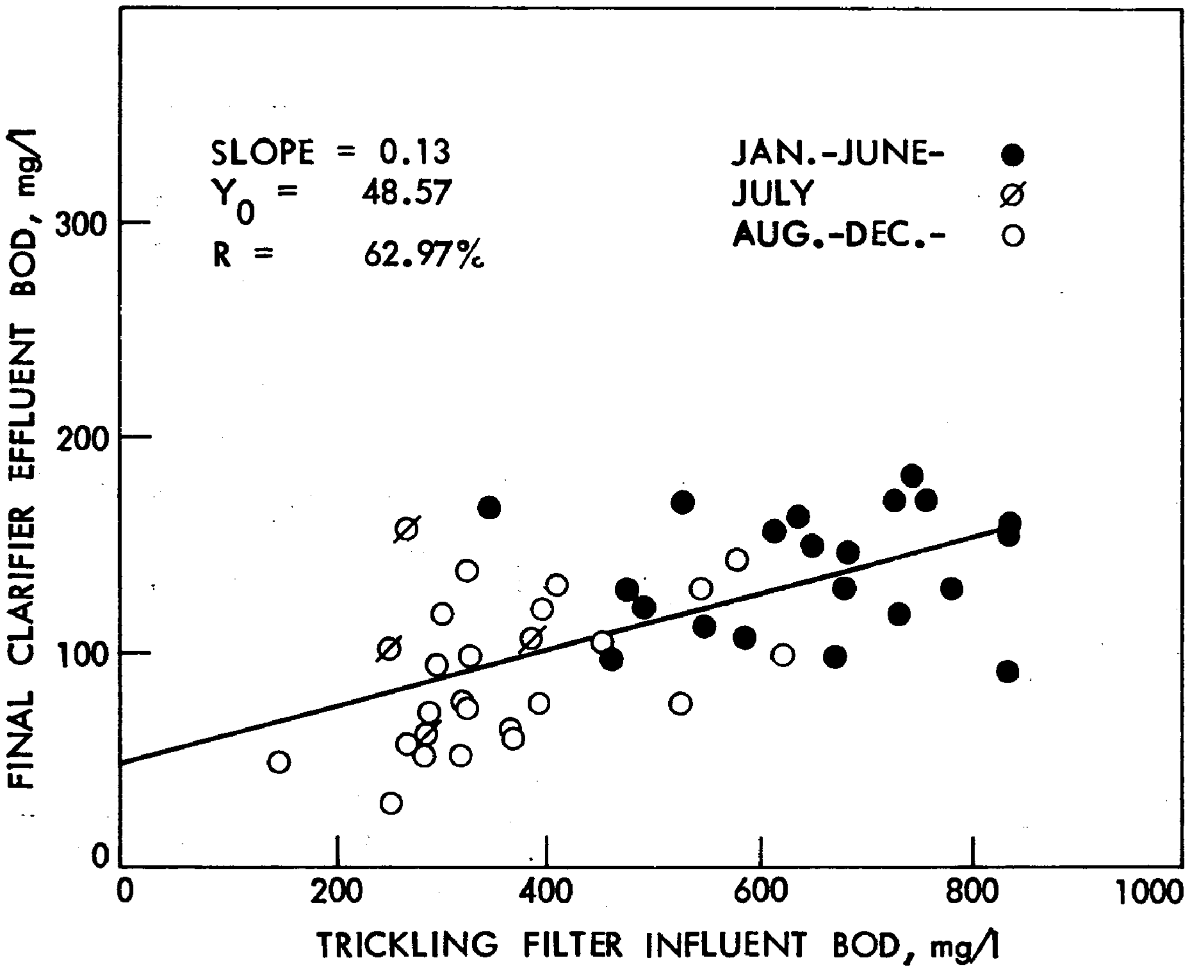


Figure 9. BOD_5 concentration removal characteristics of the plastic media trickling filter - final clarifier system

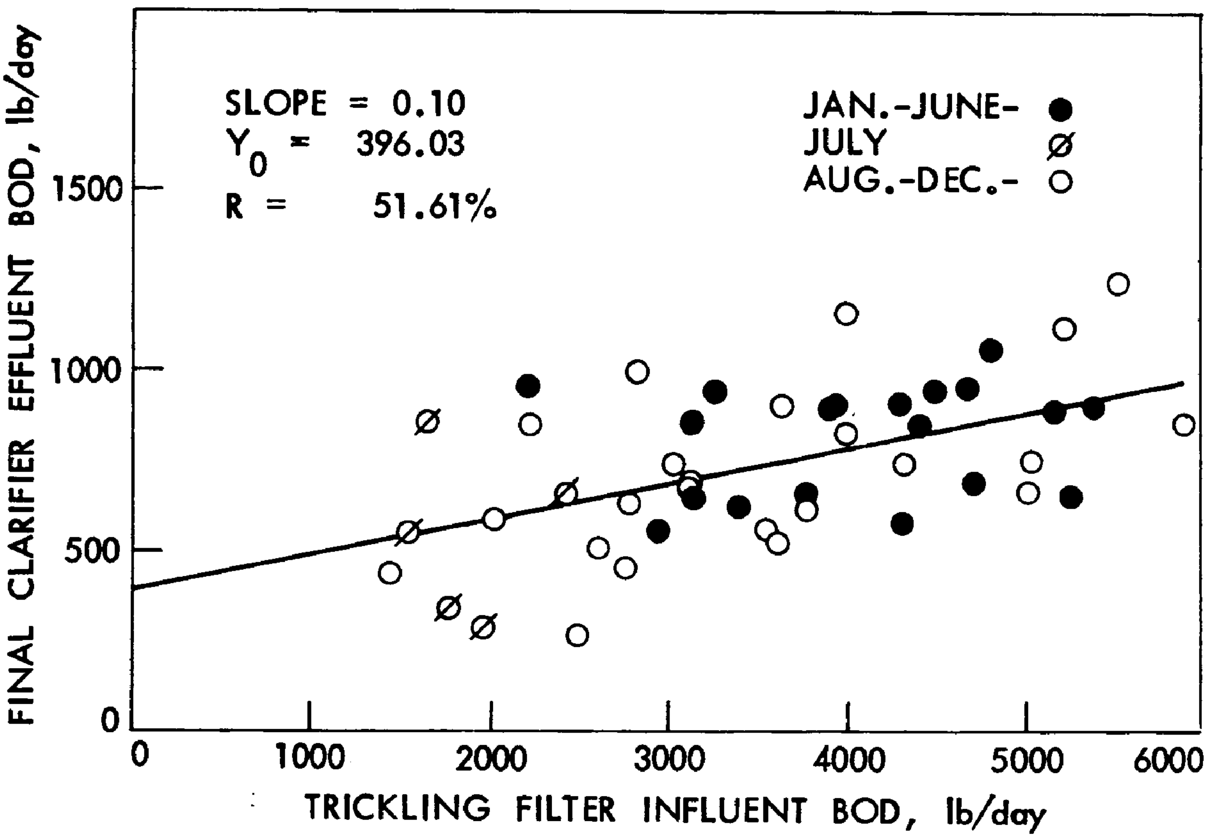


Figure 10. BOD_5 load removal characteristics of the plastic media trickling filter -final clarifier system

This trickling filter performance agreed fairly close with the theoretical efficiencies derived by the equations presented in section III when using the following average annual design factors:

K = 0.04 (assumed in plant design stage)
D = 22.0 ft.
Q = 0.56 gpm/ft^2 (based on average flow rate of 985,000 gpd)
n = 1/2 (assumed in plant design stage)
T = 16°C (Average annual trickling filter effluent temperature)

Based on these criteria, the trickling filter BOD removal was determined to be 69 percent by the Dow Chemical Company equation, 64 percent by the B. F. Goodrich equation, and 75 percent by the standard curves developed by Ethyl Corporation.

These comparisons indicate that the treatability factor, K, is slightly greater than the 0.04 used in the original design. Rearranging the Germain[5] and the Schulze[6] equations and solving for K, gives averages of 0.046 and 0.053 respectively.

The suspended solids concentration in the final clarifier effluent averaged 108 mg/l during the evaluation program. Further reduction of suspended solids and BOD within the clarifiers would be extremely difficult to obtain at such high hydraulic loading rates unless chemical coagulation facilities were added ahead of the clarifiers. Another factor which may have affected the settling characteristics of the solids was the grease concentration in the trickling filter effluent. The filter effluent averaged 73 mg/l of grease. It is possible that the grease adhered to the solids and changed their specific gravity creating a light sludge with poor sludge settling characteristics. Flotation of solids and grease was apparent in the basins. Although skimming was provided on the final clarifiers, considerable solids were discharged in the effluent.

Table 13 shows the average pounds of suspended solids per day in the trickling filter and final clarifier influent and effluent streams.

Table 13. SUSPENDED SOLIDS ANALYSIS THROUGH TRICKLING FILTER SYSTEM

Month	Flow rate[a], mgd	Trickling filter influent SS, mg/l	Trickling filter influent SS, lb/day	Trickling filter effluent SS, mg/l	Trickling filter effluent SS, lb/day	Final clarifier effluent SS, mg/l	Final clarifier effluent SS, lb/day
Jan.	--	399	--	284	--	122	--
Feb.	0.769	326	2091	546	3502	115	634
Mar.	0.794	354	2344	589	3900	116	664
Apr.	0.770	353	2267	386	2479	77	425
May	0.802	434	2903	445	2976	73	423
June	0.794	463	3066	477	3159	57	326
July	0.763	494	3144	433	2755	123	672
Aug.	1.136	691	5763	771	7305	77	660
Sept.	1.143	954	9094	771	7350	102	880
Oct.	1.162	728	7055	794	7695	82	721
Nov.	1.122	837	7832	731	6840	159	1345
Dec.	1.151	911	8745	1008	9676	186	1618
Average		579	4937	602	5240	108	761

[a] Flow adjusted for operating days only including sludge recirculation rate of 0.108 mgd

The average suspended solids loading discharged to the filters was 4,937 pounds per day, whereas the total pounds of suspended solids removed as sludge and discharged in the clarifier effluent averaged 5,240 pounds per day, for a net gain in suspended solids of 303 pounds per day. This increase in solids, no doubt, was a result of bacterial cells synthesized from the soluble BOD and sulfides in the influent to the trickling filter system. This synthesis also would account for the high degree of BOD_5 removal in the final clarifiers, as compared to the trickling filter, where the major biological reaction was synthesis and not oxidation. Lower organic loadings to the trickling filters should have permitted more oxidation in the filters and, therefore, a greater BOD removal efficiency might have occurred.

Parallel operation was tried several times with very poor results. The recommended minimum hydraulic loading to keep solids from accumulating in excessive amounts in the filters was 0.25 gpm/ft^2. The highest loadings that were attained when parallel operation was attempted ranged from 0.16 to 0.19 gpm/ft^2. B. F. Goodrich engineers indicated that this was insufficient hydraulic loading to accomplish the necessary treatment. The overall results when parallel operation was used was a very highly colored brownish effluent to the clarifiers with a high suspended solids content which carried over to the chlorine contact tank.

In theory, series operation would provide better efficiency for a given wastewater since two filters in series would represent essentially a doubling of height on a single filter; and Equation 2 indicates efficiency increases directly with increased height but only by the square root of the fractional decrease in hydraulic loading.

Chlorine Contact Basin

The chlorine contact basin was designed for disinfection of the final effluent. However, the analyses show that some BOD and suspended solids were also removed in the chlorine contact basin (Figure 6, Table 14).

Table 14. CHLORINE CONTACT BASIN PERFORMANCE

Analysis	Basin influent, mg/l[a]	Basin effluent, mg/l[a]	Removal, %
BOD_5	124	61	51
COD	372	371	0
Grease	33	17	49
Volatile Solids	354	348	2
Volatile Suspended Solids	83	68	18
Total Suspended Solids	108	90	17
Chlorine, total	7.7	1.3	--
Coliforms (per 100 ml)	23,800,000	1,276	99.99

[a]Except Coliforms

In studying the BOD_5 and COD data for the chlorine contact basin (Table 14), it appeared that the chlorine affected the BOD test of the final effluent even though the proper procedure for dechlorination was followed in accordance with Standard Methods[8]. Since 7.7 mg/l of chlorine cannot oxidize 63 mg/l of BOD, other biological or physical actions may have been the cause. The volatile suspended solids removal through the chlorine contact tank averaged 15 mg/l. Therefore, since the BOD_5 of volatile suspended solids is normally less than 1.0 mg BOD_5/mg VSS it was calculated that approximately 20 mg/l of BOD was removed by settling in the chlorine contact basin. This was evident by the need to clean the basin periodically.

Table 15 gives the monthly chlorine usage and coliform destruction through the chlorine contact basin. Excellent disinfection was accomplished during the year. With such high ammonia nitrogen concentrations in the waste stream, it is expected that the majority of the chlorine was immediately tied up as combined chlorine.

Summary of Treatment Plant Performance

Table 16 summarizes the average efficiency of each plant unit.

Table 15. CHLORINE USAGE AND COLIFORM REDUCTION

Month	Chlorine contact tank influent		Chlorine contact tank effluent			Coliforms/100ml	
	Chlorine, lbs/day	Chlorine, mg/l	Free chlorine, mg/l	Combined chlorine, mg/l	Total chlorine, mg/l	Chlorine contact tank influent	Chlorine contact tank effluent
Jan.	50	---	0.7	3.2	3.9	22,200,000	65
Feb.	50	9.1	0.5	0.8	1.3	34,000,000	125
Mar.	44	8.0	0.4	0.2	0.6	17,700,00	836
Apr.	50	8.5	0.1	0.3	0.4	35,200,000	4,500
May	50	7.9	0.3	0.6	0.9	12,300,000	767
June	60	7.3	0.1	0.9	1.0	21,200,000	1,360
July	50	---	0.1	0.8	0.9	---	---
Aug.	70	7.5	0.1	0.7	0.8	---	---
Sept.	60	6.3	0.1	0.7	0.8	---	---
Oct.	90	8.7	0.2	0.7	0.9	---	---
Nov.	70	7.2	0.1	2.7	2.8	---	---
Dec.	70	6.7	---	---	---	---	---
Average	60	7.7	0.2	1.1	1.3	23,800,000	1,276

Table 16. SUMMARY OF PROCESS EFFICIENCY

Unit	BOD_5 removal efficiency, %		COD removal efficiency, %		Grease removal efficiency, %		Suspended solids removal efficiency, %		Coliform removal efficiency, %
	Unit	Total	Unit	Total	Unit	Total	Unit	Total	Unit
Dissolved air flotation	33	33	11	11	62	62	32	32	-
Anaerobic lagoon	82	87.9	68	71.5	78	91.6	59	72.1	-
Trickling filters	74	96.9	73	92.3	69	97.4	80	94.4	-
Chlorine contact	51	98.5	0	92.3	49	98.7	17	95.4	99.99

SECTION VII

COSTS

Operating expenses were recorded for all treatment units with the exception of the dissolved air flotation tank. Since the primary purpose of the flotation tank is to recover a saleable product, grease, it is considered to be an in-plant recovery unit and not a treatment unit. Operating expenses include personnel salaries, utilities, chemicals, repairs, and debt service. Table 17 summarizes the annual operating expenses for 1970.

Table 17. ANNUAL OPERATING EXPENSES, 1970

Item	Cost
Salaries	$ 47,893
Utilities	1,443
Operating and maintenance	10,412
Subtotal	$ 59,748
Debt service	50,900
Total	$110,648

The debt service was based on the entire construction cost of $644,000 amortized over a 30-year period at 6 1/2 percent interest.

The daily operating expense was $303 per day. Table 18 shows the total operating expenses based on different parameters.

Table 18. OPERATING EXPENSES, 1970

Item	Cost
Per hog killed (at 900,000 head/yr)	0.123
Per 1,000 lbs live wt.(at 230 lb/head)	0.535
Per lb BOD_5 to treatment(at 3.2 lb BOD_5/head)	0.038
Per 1,000 gallons of raw wastes(at 278 gal/head)	0.442

During the latter part of 1970, Farmland Foods, Inc. reduced their personnel at the treatment facilities. This significantly reduced their annual operating expenses but should not have affected the plant operation. Table 19 shows the operating expenses projected after this change in operation.

Table 19. ESTIMATED ANNUAL OPERATING EXPENSES, 1971

Item	Cost
Salaries	\$ 10,500
Utilities	1,500
Maintenance	300
Operating	8,100
Subtotal	\$ 20,400
Debt service	50,900
Total	\$ 71,300

Table 20 shows the estimated expenses for 1971, based on the same parameters as shown in Table 18. These figures are based on the assumption that the kill rate, waste flow and organic concentration of the waste stream were similar to the 1970 averages.

Table 20. ESTIMATED OPERATING EXPENSES, 1971

Item	Cost
Per hog killed (at 900,000 head/ yr)	\$0.079
Per 1,000 lbs. live wt. (at 230 lb/head)	0.344
Per lb. BOD_5 to treatment (at 3.2 lb BOD_5/head)	0.025
Per 1,000 gallons of raw wastes (at 278 gal./head)	0.285

SECTION IX

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8. Standard Methods for the Examination of Water and Wastewater, Twelfth Edition, American Public Health Association, Inc. New York (1965)

SECTION IX

APPENDIX

Table A-1. DISSOLVED OXYGEN
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	0	0	0	5.6	4.2	4.9	6.0	1.7	3.8	7.7	5.3	6.7
Feb.	0	0	0	6.3	4.5	4.9	5.8	3.1	4.1	8.3	6.9	7.5
Mar.	0	0	0	5.5	3.5	4.1	6.4	3.3	5.0	7.7	6.7	7.3
Apr.	0	0	0	2.0	0	0.3	6.0	0.6	3.7	7.8	5.8	6.8
May	0	0	0	2.4	0.5	1.5	3.9	0.2	2.5	6.9	3.9	5.3
June	0	0	0	2.5	0	1.4	5.3	1.4	3.3	7.4	3.9	5.7
July	0	0	0	2.2	0.2	1.5	3.8	1.5	2.7	7.0	4.9	6.1
Aug.	0	0	0	2.0	0.3	1.6	4.5	2.5	3.9	6.3	2.1	5.6
Sept.	0	0	0	3.6	0.4	1.1	5.2	0.6	3.3	7.2	3.8	5.7
Oct.	0	0	0	3.1	0.3	1.5	5.8	2.9	4.4	7.1	5.0	6.2
Nov.	0	0	0	4.1	1.2	2.2	5.6	1.0	4.4	7.4	4.2	6.3
Dec.	0	0	0	4.4	1.8	2.8	6.3	5.6	5.8	5.7	3.7	4.8
Average			0			2.3			3.9			6.2

Table A-2. BOD_5
(mg/1)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	----	----	----	----	----	----	----	----	----	----	----	----
Feb.	----	----	----	----	----	----	----	----	----	5960	3836	4868
Mar.	----	----	----	----	----	----	----	----	----	3406	1648	2392
Apr.	----	----	----	----	----	----	----	----	----	5265	2760	3940
May	----	----	----	----	----	----	----	----	----	4645	2986	3830
June	6795	1134	3194	4652	1602	2287	1224	369	769	2780	1295	2102
July	2944	943	1771	3933	758	1637	1449	112	655	2130	1260	1672
Aug.	3720	2484	3178	2502	1482	1841	3240	411	1260	3521	1370	2176
Sept.	6336	1407	3515	4248	1018	2224	5133	317	2058	4149	1013	2440
Oct.	4301	971	1768	3493	449	1415	3004	378	1402	2265	818	1453
Nov.	2290	1206	1621	2693	711	1012	2197	308	1362	2520	2251	2386
Dec.	7558	1125	3325	2755	1176	1916	1052	369	639	2041	1421	1731
Average			2624			1762			1164			2635

[a] Interceptor No. 1

[b] Interceptor No. 2

Table A-2 (continued). BOD_5
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	172	85	120	153	71	108	72	29	44
Feb.	930	646	765	210	115	150	161	109	133	52	36	44
Mar.	678	460	543	599	70	506	157	98	129	92	47	76
Apr.	756	414	604	707	196	506	177	113	152	94	28	61
May	834	584	732	537	312	461	183	93	129	181	36	87
June	506	345	407	485	125	329	168	152	160	35	46	41
July	396	253	305	436	223	327	182	53	115	132	30	74
Aug.	621	297	424	514	301	476	139	96	113	121	19	78
Sept.	1092	271	502	703	187	398	249	44	125	213	13	81
Oct.	411	149	284	468	147	286	148	43	86	57	16	29
Nov.	387	300	343	340	158	298	220	83	124	40	17	30
Dec.	368	326	347	361	267	318	152	64	89	104	65	81
Average			477			296			124			61

Table A-3. COD
(mg/1)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	---	---	---	---	---	---
Mar.	---	---	---	---	---	---	---	---	---	---	---	---
Apr.	---	---	---	---	---	---	2473	534	1348	7810	3383	5460
May	---	---	---	---	---	---	5544	167	2077	9501	4446	7625
June	8108	2623	5426	9588	490	5065	3198	328	1863	6271	1745	3903
July	8019	1502	2825	6147	818	3959	1972	283	1160	4535	1000	3169
Aug.	9818	1794	5085	9869	1444	3707	4542	525	1928	7042	1337	3146
Sept.	10,097	1479	6029	7926	1714	3957	9901	476	3616	7162	1281	3898
Oct.	4811	1909	3590	9644	1707	3840	6358	354	2408	6390	1650	3576
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			4591			4106			2057			4396

[a]Interceptor No. 1

[b]Interceptor No. 2

Table A-3 (continued). COD
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	---	---	---	---	---	---
Mar.	---	---	---	---	---	---	---	---	---	---	---	---
Apr.	2765	756	1907	1943	707	1153	896	356	678	885	297	565
May	2500	538	1519	1630	323	1123	978	215	429	669	108	411
June	2623	624	1788	1247	811	938	802	328	602	846	309	588
July	1147	361	846	1080	229	741	472	94	234	318	94	192
Aug.	1488	615	1112	1498	195	943	553	91	285	553	163	282
Sept.	1774	840	1275	1285	360	982	427	80	379	491	40	275
Oct.	1623	981	1374	1448	673	1193	364	158	284	374	119	283
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			1403			1010			372			371

Table A-4. GREASE
(mg/l)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	---	---	---	---	---	---
Mar.	---	---	---	---	---	---	759	54	219	326	132	194
Apr.	---	---	---	---	----	---	213	34	71	521	97	219
May	---	---	---	---	---	---	1146	41	306	675	132	327
June	2623	245	849	1145	192	517	128	25	81	923	122	383
July	7006	221	1455	1456	39	552	596	25	144	3167	26	967
Aug.	1257	203	756	1670	80	447	1193	33	287	825	76	366
Sept.	15924	201	3613	1156	402	812	5540	37	1183	2152	311	920
Oct.	1658	234	746	690	92	469	3818	54	640	1024	82	511
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			1484			559			366			485

[a] Interceptor No. 1

[b] Interceptor No. 2

Table A-4 (continued). GREASE
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	152	88	136	72	6	29	87	6	30	58	10	22
Feb.	166	107	136	102	28	51	30	13	20	24	12	16
Mar.	185	106	137	80	32	61	45	3	26	30	3	9
Apr.	138	30	83	93	29	68	28	8	15	30	0	15
May	241	45	111	241	62	104	136	0	30	55	0	15
June	224	53	93	138	41	76	35	7	17	63	7	21
July	400	39	112	107	23	85	321	4	82	81	0	42
Aug.	179	35	87	299	13	93	275	1	50	115	0	41
Sept.	162	59	102	171	31	74	92	0	13	26	0	12
Oct.	168	32	98	180	41	93	92	0	46	58	0	22
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			106			73			33			17

Table A-5. TOTAL SOLIDS
(mg/1)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	2716	1259	1813	6247	2896	3889
Mar.	---	---	---	---	---	---	3515	917	2020	8084	2574	3994
Apr.	---	---	---	---	---	---	5015	883	2346	8909	2484	4855
May	---	---	---	---	---	---	20176	943	1728	46405	2378	9581
June	5933	2204	2862	5901	881	3353	5931	603	1197	4058	1980	3625
July	12107	1421	4389	25488	2778	6355	5860	978	1192	3704	2016	2884
Aug.	6089	2425	3682	23517	2379	5711	3477	864	1864	5986	2329	3280
Sept.	25619	1448	7558	6454	2474	3409	8983	1086	2809	4661	2497	3096
Oct.	9646	1906	3968	10425	2460	4572	4566	952	2578	7669	2280	3611
Nov.	6031	2137	4381	4836	1971	4265	8789	1476	4168	4917	2220	3497
Dec.	9484	3193	5574	17081	2420	5432	1800	1217	1484	3372	2014	2722
Average			4630			4728			1895			4094

[a] Interceptor No. 1

[b] Interceptor No. 2

Table A-5 (continued). TOTAL SOLIDS
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	1711	1223	1580	1564	1162	1486	1424	1011	1342	1386	1004	1335
Feb.	1774	1608	1669	4969	1574	2023	1536	1442	1494	1544	1428	1468
Mar.	1969	1490	1775	5659	1430	1998	1631	1287	1530	1613	1301	1487
Apr.	2096	1723	1820	2024	1542	1857	1669	1441	1544	1707	1155	1543
May	2094	1738	1961	2087	1698	1944	1630	1437	1613	1608	1447	1603
June	2546	1721	2331	2533	1853	2272	2136	1365	1685	2144	1387	1673
July	1879	1609	1748	1966	1688	1776	1594	1388	1466	1503	1394	1429
Aug.	1992	1722	1850	2436	1681	1941	1461	1246	1379	1471	1256	1386
Sept.	2321	1324	2212	2450	1863	2168	1685	1352	1521	1595	1228	1504
Oct.	2552	1347	2101	2587	1922	2259	1637	1426	1552	1630	1473	1557
Nov.	2218	1894	2115	2323	1858	2142	1689	1467	1584	1664	1456	1548
Dec.	2826	1915	2301	3297	1867	2427	1928	1382	1592	1691	1350	1556
Average			1955			2024			1525			1393

Table A-6. TOTAL VOLATILE SOLIDS
(mg/1)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	1534	608	707	3526	1353	2143
Mar.	---	---	---	---	---	---	2266	397	1131	4302	1134	2434
Apr.	---	---	---	---	---	---	3632	359	1406	7287	849	2324
May	---	---	---	---	---	---	1630	477	1204	3749	1527	2287
June	1922	1313	1786	1908	905	1312	879	212	564	2539	987	1638
July	1663	588	2830	23307	986	4900	1375	381	541	2457	1341	1806
Aug.	5599	1641	2711	21451	930	4124	2584	441	1147	4054	1077	2089
Sept.	18870	611	5453	5220	858	1679	6769	543	1449	3327	763	1801
Oct.	3553	753	1616	8672	590	2577	3153	392	1474	6145	740	2272
Nov.	5086	1221	2388	3536	1122	2622	6846	695	2372	3814	1478	2394
Dec.	3027	1762	2942	15340	1166	3851	2835	551	810	2302	973	1553
Average			2818			3009			1164			2112

[a] Interceptor No. 1

[b] Interceptor No. 2

Table A-6 (continued). TOTAL VOLATILE SOLIDS
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	632	442	551	534	225	462	451	242	342	382	94	325
Feb.	557	388	509	3398	327	739	418	284	337	389	244	323
Mar.	618	456	533	4088	370	694	446	252	299	295	191	283
Apr.	666	458	533	666	295	560	343	219	288	392	150	297
May	755	549	627	755	549	610	303	266	321	404	275	316
June	728	544	628	594	485	560	308	285	265	340	230	273
July	640	487	576	734	488	458	505	239	378	427	235	353
Aug.	770	594	682	1056	613	744	438	280	350	477	302	367
Sept.	1585	611	843	1585	789	899	544	330	434	517	321	437
Oct.	1001	214	746	1055	692	885	487	339	390	495	355	402
Nov.	873	679	812	988	680	845	512	373	451	491	265	435
Dec.	1144	678	925	1294	687	1017	675	325	397	479	265	373
Average			663			706			354			348

Table A-7. TOTAL SUSPENDED SOLIDS
(mg/1)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	499	85	270	1148	175	539
Mar.	---	---	---	---	---	---	2571	154	945	5913	440	2115
Apr.	---	---	---	---	---	---	3631	121	819	4007	277	1637
May	---	---	---	---	---	---	19178	162	2402	4022	701	2190
June	3449	195	2051	3590	413	1360	2168	116	613	2168	486	1370
July	8618	347	2055	3080	551	1682	331	205	219	2306	604	1197
Aug.	5133	757	2104	1773	615	1225	2478	189	883	2278	738	1363
Sept.	18305	464	4832	3982	552	1685	4968	294	1351	1953	398	1147
Oct.	2893	434	1037	3053	145	1628	3052	145	1762	3366	912	1425
Nov.	4231	392	1360	2471	485	1282	6456	366	2148	2057	679	1419
Dec.	6920	644	2120	2818	481	1687	805	219	426	1652	454	1019
Average			2223			1507			1076			1402

[a]Interceptor No. 1

[b]Interceptor No. 2

Table A-7 (continued). TOTAL SUSPENDED SOLIDS
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	535	188	399	516	168	284	208	15	122	353	16	103
Feb.	543	181	326	3677	71	546	210	38	155	157	29	75
Mar.	510	198	354	4394	155	589	472	57	116	132	31	85
Apr.	564	219	353	804	105	386	118	44	77	161	34	70
May	1345	379	434	606	124	445	337	20	73	161	22	75
June	611	215	463	661	301	477	126	18	57	326	47	90
July	655	384	494	616	363	433	230	45	123	165	20	81
Aug.	931	564	691	1140	468	771	119	48	77	138	43	80
Sept.	2110	503	954	1184	369	771	244	64	102	256	19	106
Oct.	1079	429	728	1079	547	794	180	21	82	145	24	61
Nov.	1201	666	837	867	646	731	386	98	159	135	41	116
Dec.	1193	591	911	1958	410	1008	691	67	186	286	49	140
Average			579			602			108			90

Table A-8. VOLATILE SUSPENDED SOLIDS
(mg/1)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	570	68	190	1074	91	441
Mar.	---	---	---	---	---	---	1940	111	768	4552	317	1676
Apr.	---	---	---	---	---	---	2869	104	609	2716	300	1364
May	---	---	---	---	---	---	1240	298	729	2853	845	1736
June	1891	658	1121	1103	421	705	294	46	176	1693	450	927
July	5157	363	2258	22708	543	4155	284	105	224	2190	601	1105
Aug.	5159	692	2192	18831	558	3815	2263	142	798	1865	702	1199
Sept.	17901	502	4660	3524	361	926	5861	212	848	1586	313	887
Oct.	2173	369	866	4379	662	1316	2455	761	942	3072	454	1229
Nov.	4179	365	1521	2756	621	1724	6073	207	1273	1962	421	996
Dec.	6847	596	2056	14371	147	3007	1562	147	542	1562	342	729
Average			2096			2235			645			1117

[a]Interceptor No. 1 [b]Interceptor No. 2

Table A-8 (continued). VOLATILE SUSPENDED SOLIDS
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	435	199	315	321	142	252	194	20	149	121	4	76
Feb.	499	89	278	1376	116	328	168	6	99	151	10	66
Mar.	420	217	303	3876	153	512	258	50	90	121	24	75
Apr.	447	216	294	694	59	328	145	18	64	107	8	53
May	426	269	199	417	312	342	92	60	67	127	11	56
June	494	296	398	439	209	347	130	59	22	103	13	57
July	530	320	409	501	263	338	224	18	112	159	6	73
Aug.	605	329	481	756	359	482	95	8	65	105	29	59
Sept.	1349	540	617	852	247	564	171	15	61	190	58	73
Oct.	787	246	452	813	373	564	180	33	83	180	30	42
Nov.	639	456	571	627	442	530	254	63	120	188	13	87
Dec.	940	627	701	956	404	737	503	4	59	198	19	93
Average			418			443			83			68

Table A-9. TOTAL DISSOLVED SOLIDS
(mg/1)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	2737	989	1617	5099	1190	3153
Mar.	---	---	---	---	---	---	1849	763	1052	2911	1417	2083
Apr.	---	---	---	---	---	---	3545	762	1513	8155	1746	3440
May	---	---	---	---	---	---	2140	596	1185	3949	1180	2241
June	3460	1159	2022	4667	1784	2777	2935	1872	2360	2935	1494	2287
July	3489	1178	2008	2717	1494	2077	4639	676	1330	2262	1306	1679
Aug.	2455	956	2262	3820	1042	2179	1137	662	986	3711	1314	1998
Sept.	7254	979	2639	3688	1907	2439	3970	785	1567	2703	1531	1959
Oct.	8807	1407	3042	5804	1288	3169	1642	957	1254	4305	1622	2374
Nov.	8870	1635	2739	3451	1476	2456	3886	924	2191	3240	1255	2397
Dec.	8870	2096	3462	2733	2000	2316	1387	801	1057	1986	1142	1496
Average			2622			2488			1467			2130

Table A-9 (continued). TOTAL DISSOLVED SOLIDS
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	1317	927	1181	1325	766	1202	1342	960	1093	1330	754	1232
Feb.	1449	1188	1343	1492	1292	1392	1463	1342	1379	1457	1163	1393
Mar.	1719	1192	1421	1546	1192	1409	1524	1314	1414	1536	1312	1402
Apr.	1638	1399	1467	1596	1376	1471	1601	1393	1467	1605	1389	1473
May	1615	1374	1527	1574	1292	1499	1655	1329	1540	1609	1346	1528
June	2105	1414	1868	2117	1392	1795	2081	1372	1628	2079	1373	1583
July	1340	1188	1254	1445	1213	1343	1375	1315	1343	1376	1228	1348
Aug.	1287	781	1158	1394	1167	1269	1386	1193	1300	1397	1213	1306
Sept.	1312	1196	1258	1529	1248	1397	1495	1337	1419	1547	1308	1398
Oct.	1480	1297	1373	1548	1375	1465	1593	1376	1496	1570	1398	1496
Nov.	1403	1003	1278	1529	1208	1411	1587	1226	1425	1598	1181	1432
Dec.	1487	1271	1390	1589	1249	1419	1576	1237	1492	1576	1234	1416
Average			1377			1422			1416			1417

Table A-10. ORGANIC NITROGEN
(mg/1)

	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
Month	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	109.2	75.6	110.2	85.4	75.6	80.5
Mar.	---	---	---	---	---	---	952.0	33.6	48.1	125.0	28.0	86.1
Apr.	---	---	---	---	---	---	123.0	44.8	65.5	135.7	77.8	106.8
May	63.0	63.0	63.0	---	---	---	182.0	53.0	147.7	195.0	142.1	159.7
June	151.0	87.0	76.2	151.0	16.0	92.2	199.0	11.0	94.7	162.0	72.8	108.6
July	126.0	15.0	56.0	95.0	20.0	79.0	95.0	64.0	65.0	95.0	35.0	71.6
Aug.	103.0	90.0	96.5	276.0	78.0	177.0	142.0	31.0	71.6	228.0	67.0	147.5
Sept.	47.3	47.3	47.3	---	---	---	80.0	80.0	80.0	---	---	---
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			67.0			117.0			80.8			95.9

[a]Interceptor No. 1

[b]Interceptor No. 2

Table A-10 (continued). ORGANIC NITROGEN
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	50.4	56.0	25.2	39.2	8.4	27.8	58.8	12.6	23.8	50.4	11.2	21.8
Feb.	36.2	25.2	39.9	36.4	19.6	28.5	28.0	14.0	22.8	30.8	19.6	24.4
Mar.	33.6	25.2	30.8	33.6	22.4	34.9	25.9	14.8	21.9	25.2	16.8	20.8
Apr.	38.0	22.4	27.9	70.0	25.2	41.0	37.1	13.6	24.3	25.2	19.6	21.7
May	76.0	34.0	44.9	62.0	31.0	45.0	29.0	9.0	21.7	29.0	5.0	19.4
June	148.0	39.0	63.0	67.0	45.0	54.4	28.0	14.0	24.3	25.0	14.0	22.7
July	159.0	28.0	40.0	45.0	34.0	38.0	22.0	11.0	17.6	17.0	11.0	16.1
Aug.	146.0	39.0	48.6	40.0	26.0	38.6	18.0	17.0	17.0	17.0	12.0	15.3
Sept.	59.0	59.0	59.0	53.0	47.0	62.0	---	---	---	---	---	---
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	----	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			42.1			41.1			21.3			20.2

Table A-11. AMMONIA NITROGEN
(mg/1)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	54.9	29.7	47.4	52.1	51.7	51.9
Mar.	---	---	---	---	---	---	57.7	4.4	25.7	62.4	4.9	29.9
Apr.	---	---	---	---	---	---	38.7	10.7	20.8	45.9	36.4	41.1
May	28.0	28.0	28.0	---	---	---	58.0	13.0	37.2	72.0	42.1	55.5
June	58.0	3.0	20.0	53.0	12.0	29.0	61.0	15.0	36.0	68.0	5.2	44.3
July	80.0	1.0	46.0	100.0	4.0	60.0	114.0	13.0	71.0	110.0	7.2	65.6
Aug.	7.0	2.0	4.0	7.0	2.0	2.3	47.0	33.0	40.3	26.0	16.0	19.0
Sept.	2.0	2.0	2.0	2.0	2.0	2.0	7.0	7.0	7.0	33.0	33.0	33.0
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			20.0			23.3			35.6			42.5

[a] Interceptor No. 1

[b] Interceptor No. 2

Table A-11 (continued). AMMONIA NITROGEN
(mg/l)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	124.9	91.3	113.3	119.2	70.0	97.6	165.2	92.0	101.6	118.0	88.4	96.8
Feb.	122.1	99.0	112.8	127.6	88.0	100.0	119.2	88.4	99.0	102.4	88.0	91.1
Mar.	110.9	94.6	105.8	98.2	91.2	94.4	96.8	88.4	91.7	102.4	88.5	90.5
Apr.	122.1	110.8	120.1	108.0	92.8	100.2	99.6	90.0	96.0	99.6	88.4	93.8
May	136.0	94.0	114.0	133.0	91.0	109.0	133.0	88.0	107.2	142.0	86.0	107.0
June	184.0	53.0	122.0	153.0	104.0	120.0	151.0	113.0	121.0	151.0	104.0	121.0
July	181.0	75.0	130.0	156.0	80.0	118.0	156.0	80.0	110.0	151.0	80.0	108.0
Aug.	131.0	123.0	127.3	98.0	83.3	90.3	94.0	83.0	89.0	91.0	83.0	88.3
Sept.	150.0	150.0	150.0	117.0	83.0	100.0	---	---	83.0	77.0	77.0	77.0
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			121.6			103.2			100.0			97.1

Table A-12. NITRATE NITROGEN
(mg/1)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	40.00	40.00	40.00	---	---	---
Mar.	---	---	---	---	---	---	5.0	4.85	4.93	5.07	1.20	3.42
Apr.	---	---	---	---	---	---	4.99	4.97	2.97	3.25	3.25	3.25
May	3.97	3.97	3.97	---	---	---	3.00	3.00	3.00	---	---	---
June	---	---	---	---	---	---	---	---	---	---	---	---
July	---	---	---	---	---	---	---	---	---	---	---	---
Aug.	---	---	---	---	---	---	---	---	---	---	---	---
Sept.	---	---	---	---	---	---	---	---	---	---	---	---
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			3.97						12.72			3.33

[a]Interceptor No. 1

[b]Interceptor No. 2

Table A-12 (continued). NITRATE NITROGEN
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	30.99	1.70	7.44	20.89	0.99	4.19	39.75	0.99	6.21	1.9	0.7	3.38
Feb.	39.99	3.79	14.43	56.62	3.99	19.47	56.08	2.99	19.03	43.6	2.7	14.45
Mar.	4.2	4.0	4.0	8.62	7.42	8.02	11.01	7.22	9.2	11.6	7.2	9.4
Apr.	24.99	6.99	17.49	109.55	28.98	69.26	32.5	21.98	27.01	51.5	21.9	30.63
May	3.0	3.0	3.0	---	---	---	14.0	14.0	14.0	14.55	14.55	14.55
June	---	---	---	---	---	---	---	---	---	---	---	---
July	---	---	---	---	---	---	---	---	---	---	---	---
Aug.	---	---	---	---	---	---	---	---	---	---	---	---
Sept.	---	---	---	---	---	---	---	---	---	---	---	---
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			9.27			25.23			15.05			14.40

Table A-13. NITRITE NITROGEN (mg/l)

Month	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	0.002	0.002	0.002	0.19	0.19	0.19
Mar.	---	---	---	---	---	---	0.15	0.03	0.075	0.02	0.02	0.02
Apr.	---	---	---	---	---	---	0.03	0.01	0.03	0.03	0.03	0.03
May.	0.03	0.03	0.03	---	---	---	0.005	0.005	0.005	0.08	0.08	0.08
June	---	---	---	---	---	---	---	---	---	---	---	---
July	---	---	---	---	---	---	---	---	---	---	---	---
Aug.	---	---	---	---	---	---	---	---	---	---	---	---
Sept.	---	---	---	---	---	---	---	---	---	---	---	---
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			0.03						0.028			0.008

[a]Interceptor No. 1

[b]Interceptor No. 2

Table A-13 (continued). NITRITE NITROGEN
(mg/l)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	0.008	0.002	0.020	0.110	0.002	0.042	0.110	0.002	0.047	1.000	0.048	0.199
Feb.	0.007	0.001	.004	0.380	0.005	0.150	0.400	0.007	0.226	1.000	0.065	0.230
Mar.	0	0	0	0.400	0.380	0.380	0.450	0.330	0.370	0.450	0.350	0.375
Apr.	0.01	0.005	0.0045	0.460	0.010	0.425	0.500	0.020	0.475	0.520	0.020	0.475
May	---	---	0	0.450	0.450	0.450	0.500	0.500	0.500	0.450	0.450	0.450
June	---	---	---	---	---	---	---	---	---	---	---	---
July	---	---	---	---	---	---	---	---	---	---	---	---
Aug.	---	---	---	---	---	---	---	---	---	---	---	---
Sept.	---	---	---	---	---	---	---	---	---	---	---	---
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			0.009			0.289			0.323			0.345

Table A-14. PHOSPHATES
(mg/1)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	61	12	49	57	8	49	52	9	43	51	15	36
Feb.	61	6	55	58	7	51	55	7	48	58	8	50
Mar.	47	2	45	47	2	45	54	7	47	49	5	44
Apr.	44	4	40	48	4	42	48	21	27	48	9	39
May.	---	---	---	---	---	---	---	---	---	---	---	---
June	---	---	---	---	---	---	---	---	---	---	---	---
July	---	---	---	---	---	---	---	---	---	---	---	---
Aug.	---	---	---	---	---	---	---	---	---	---	---	---
Sept.	---	---	---	---	---	---	---	---	---	---	---	---
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			47			47			42			42

Table A-15. pH

	Flotation cell influent[a]			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
Mongh	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	7.3	6.8	7.0	6.7	6.3	6.6
Mar.	---	---	---	---	---	---	8.4	6.8	7.5	7.3	6.2	6.6
Apr.	---	---	---	---	---	---	10.3	6.9	7.5	6.8	6.3	6.7
May	7.2	5.8	6.5	---	---	---	8.2	6.2	7.3	6.8	6.3	6.6
June	6.4	5.5	5.9	6.9	5.5	5.9	9.4	5.6	6.8	6.8	6.1	6.4
July	7.0	5.6	6.3	7.3	5.4	6.0	8.0	6.9	7.3	6.9	6.2	6.6
Aug.	6.8	5.3	6.2	6.6	5.1	5.9	8.2	6.3	7.3	6.8	6.2	6.4
Sept.	6.8	5.1	6.2	6.9	5.4	6.0	8.6	5.7	7.0	7.5	6.2	6.5
Oct.	7.7	5.5	6.5	6.9	5.3	6.1	8.0	5.7	7.3	7.0	6.2	6.6
Nov.	7.1	5.6	6.3	6.0	5.3	5.5	8.1	5.3	6.9	6.8	6.0	6.6
Dec.	6.6	6.2	6.3	6.2	5.1	5.7	7.9	6.5	7.4	6.8	6.3	6.6
Average			6.3			5.8			7.2			6.6

[a]Interceptor No. 1

[b]Interceptor No. 2

Table A-15 (continued). pH

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	7.2	6.6	6.8	8.1	7.9	8.0	8.1	7.9	7.9	8.0	7.6	7.9
Feb.	7.0	6.6	6.8	8.1	7.8	8.0	8.1	7.9	8.0	8.0	7.9	8.0
Mar.	7.3	6.6	6.9	8.2	7.8	8.0	8.2	7.9	8.0	8.2	7.8	8.0
Apr.	8.1	6.6	7.1	8.2	7.6	8.0	8.4	7.8	8.1	8.5	7.8	8.1
May.	7.9	6.6	7.0	8.2	7.3	7.9	8.1	7.9	8.0	8.0	7.8	7.9
June	7.5	7.0	7.2	8.3	7.9	8.1	8.3	7.9	8.1	8.0	7.7	8.1
July	7.4	7.0	7.1	8.0	7.6	7.8	7.9	7.6	7.8	8.2	7.8	7.8
Aug.	7.4	7.0	7.1	8.0	7.7	7.9	8.0	7.8	7.9	8.0	7.5	7.8
Sept.	7.5	6.8	7.1	8.1	7.3	7.9	8.1	7.4	7.8	7.8	7.2	7.6
Oct.	7.5	7.0	7.3	8.2	7.8	8.0	8.1	7.8	8.0	7.9	7.5	7.8
Nov.	7.4	6.8	7.2	8.2	7.9	8.0	8.0	7.9	8.0	8.0	7.6	7.8
Dec.	7.1	6.3	6.8	8.2	7.9	8.0	8.1	7.9	8.0	8.1	7.9	8.0
Average			7.0			8.0			8.0			7.9

Table A-16. TOTAL ALKALINITY
(mg/1 as $CaCO_3$)

Month	Flotation cell influent			Flotation cell effluent			Domestic[b]			Anaerobic lagoon influent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	---	---	---	---	---	---	---	---	---	---	---	---
Feb.	---	---	---	---	---	---	553	167	350	590	360	438
Mar.	---	---	---	---	---	---	262	60	175	325	282	307
Apr.	---	---	---	---	---	---	362	21	180	461	160	319
May	121	121	121	---	---	---	303	70	174	402	148	314
June	252	121	111	272	80	153	483	80	268	392	148	208
July	111	111	111	221	221	221	302	302	302	---	---	---
Aug.	191	60	104	272	70	147	563	121	280	395	163	241
Sept.	101	101	101	121	121	121	131	131	131	---	---	---
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			109			161			232			316

[a] Interceptor No. 1

[b] Interceptor No. 2

Table A-16 (continued). TOTAL ALKALINITY
(mg/l as $CaCO_3$)

Month	Anaerobic lagoon effluent			Trickling filter effluent			Final clarifier effluent			Chlorine contact tank effluent		
	High	Low	Average	High	Low	Average	High	Low	Average	High	Low	Average
Jan.	653	533	599	603	502	545	603	487	538	614	483	537
Feb.	563	483	537	513	199	453	513	199	442	493	422	452
Mar.	563	372	510	523	453	468	483	443	460	483	443	452
Apr.	583	500	546	533	422	504	503	413	460	473	392	438
May	795	532	641	704	463	537	563	453	511	573	442	490
June	724	554	692	603	553	587	593	543	567	593	493	551
July	493	493	493	483	342	423	463	338	401	443	312	378
Aug.	875	201	782	563	302	415	453	302	380	420	264	353
Sept.	815	815	815	603	301	452	362	362	362	328	328	328
Oct.	---	---	---	---	---	---	---	---	---	---	---	---
Nov.	---	---	---	---	---	---	---	---	---	---	---	---
Dec.	---	---	---	---	---	---	---	---	---	---	---	---
Average			623			487			458			442

Table A-17. SULFATES AND HYDROGEN SULFIDE (mg/1)

Month	Anaerobic lagoon influent		Anaerobic lagoon effluent		Trickling filter effluent		Final clarifier effluent		Chlorine contact tank effluent	
	SO_4*	H_2S	SO_4	H_2S	SO_4	H_2S	SO_4	H_2S	SO_4	H_2S
Jan.	350.0	0.0	40.6	4.4	52.1	0.24	52.1	0.0	52.6	0.0
Feb.	---	---	34.6	4.3	57.5	0.09	63.7	0.0	64.9	0.0
Mar.	381.0	0.0	40.8	5.0	56.3	0.30	63.3	0.0	64.8	0.0
Apr.	293.0	0.0	32.3	---	82.3	---	73.3	---	55.0	0.0
May	305.0	0.0	45.3	---	73.3	---	66.3	---	57.5	0.0
Average	332.0	0.0	38.8	4.6	64.3	0.21	63.7	0.0	58.9	0.0

* Sulfate analyses were made on relatively few samples, however, the range of the analyses shown was from 270 to 400 mg/1 as sulfate. In September of 1970, the water supply of the plant was changed from well water to city water.

Table A-18. CHLORIDES
(mg/1)

Month	Anaerobic lagoon effluent	Trickling filter effluent	Final clarifier effluent	Chlorine contact tank effluent
January	573	528	535	551
February	755	742	737	731
March	803	793	813	779
April	819	816	839	831
August	699	684	684	683
September	735	870	700	860
Average	731	739	718	739

*U.S. GOVERNMENT PRINTING OFFICE: 1974 546-319/417 1-3

SELECTED WATER RESOURCES ABSTRACTS

INPUT TRANSACTION FORM

1. Report No.

2.

3. Accession No.

W

4. Title Treatment of Packinghouse Wastes by Anaerobic Lagoons and Plastic-Media Filters

5. Report Date 4/74

6.

8. Performing Organization Report No.

7. Author(s) Darrell A. Baker, Allen H. Wymore, and James E. White

12060 DFF

12. Sponsoring Organization Environmental Protection Agency

13. Type of Report and Period Covered

15. Supplementary Notes Environmental Protection Agency report number, EPA-660/2-74-027, April 1974

16. Abstract

Studies were conducted to demonstrate the efficiency and suitability of using dissolved air flotation, anaerobic lagoons, plastic media trickling filters and chlorination as a system for treating 1 mgd of wastewater from a meat packing plant. The primary objective of the study was to determine if the plastic media filters could be used to replace the aerobic lagoon system normally used to treat the anaerobic lagoon effluent.

The overall reduction of 5-day Biochemical Oxygen Demand (BOD_5) through the system averaged 98.5% over the ten month evaluation period leaving a discharge concentration of 61 mg/l. Suspended solids were reduced 95.4% through the entire system, leaving an effluent concentration of 90 mg/l after chlorination. The BOD_5 reduction in the anaerobic lagoons averaged 82% and accounted for the majority of BOD_5 removed in the system. The BOD_5 reduction through the plastic media trickling filters averaged 74% of the applied loading which was below the 91% efficiency expected during design. Hydraulic overload, organic overload, and possibly grease concentrations, contributed to the lower-than-expected performance.

The cost of the treatment system was calculated to be $0.079 per hog killed or $0.344 per 1000 lb live weight killed.

17a. Descriptors

*Industrial Wastes, *Packinghouse, *Waste Treatment, *Trickling Filter, *Anaerobic Lagoons, Wastewater treatment, Plastic Media

17b. Identifiers

*Packinghouse Wastes, *Anaerobic Lagoons, *Trickling Filter, Plastic Media, Efficiencies

17c. COWRR Field & Group

18. Availability	19. Security Class. (Report)	21. No. of Pages	Send To:
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