FKP 159

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ICE CREAM WASTEWATER CHARACTERIZATION AND TREATABILITY

by

E. F. DUL*

INTRODUCTION

The purpose of this paper is to present the results of a wastewater characterization and treatability study performed on an ice cream processing plant effluent. Particular items of interest are:

- an identification of wastewater sources and characteristics attendant to ice cream processing;
- a description of techniques implemented at the plant to reduce wastes generation;
- a description of the techniques used in waste loading projections and the projections developed for the plant; and,
- the results of alternative aerobic biological treatability studies performed on the wastewater at varying treatment rates and wastes temperature.

PLANT/PRODUCTION INFORMATION

The plant under investigation is located in the Northeast and operates eight hours per day, five days per week. Soft ice cream is the chief production item, with a small quantity of frozen pies also being produced. Ice cream and frozen pie production operations are shown in schematic in Figures 1 and 2.

Ice Cream Processing

The manufacture of ice cream incorporates two basic steps:

- preparation of the ice cream base in vanilla and chocolate flavors; and,
- addition of appropriate ingredients (i.e., fruits, nuts, flavor extracts) to produce a variety of other ice cream types beyond chocolate and vanilla.

Ice cream base is produced by formulating a blend of cream, water, sugar, and additives. The resultant mixture is then pasteurized, homogenized, chilled, and put into interim, refrigerated storage.

Base is withdrawn from storage, as production demands, and is conveyed

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*H. F. Ludwig & Associates/Engineering-Science, Inc., Washington, D.C., Great Neck, New York

Figure 1

SCHEMATIC OF ICE CREAM MANUFACTURE UNIT OPERATIONS & PROCESSES

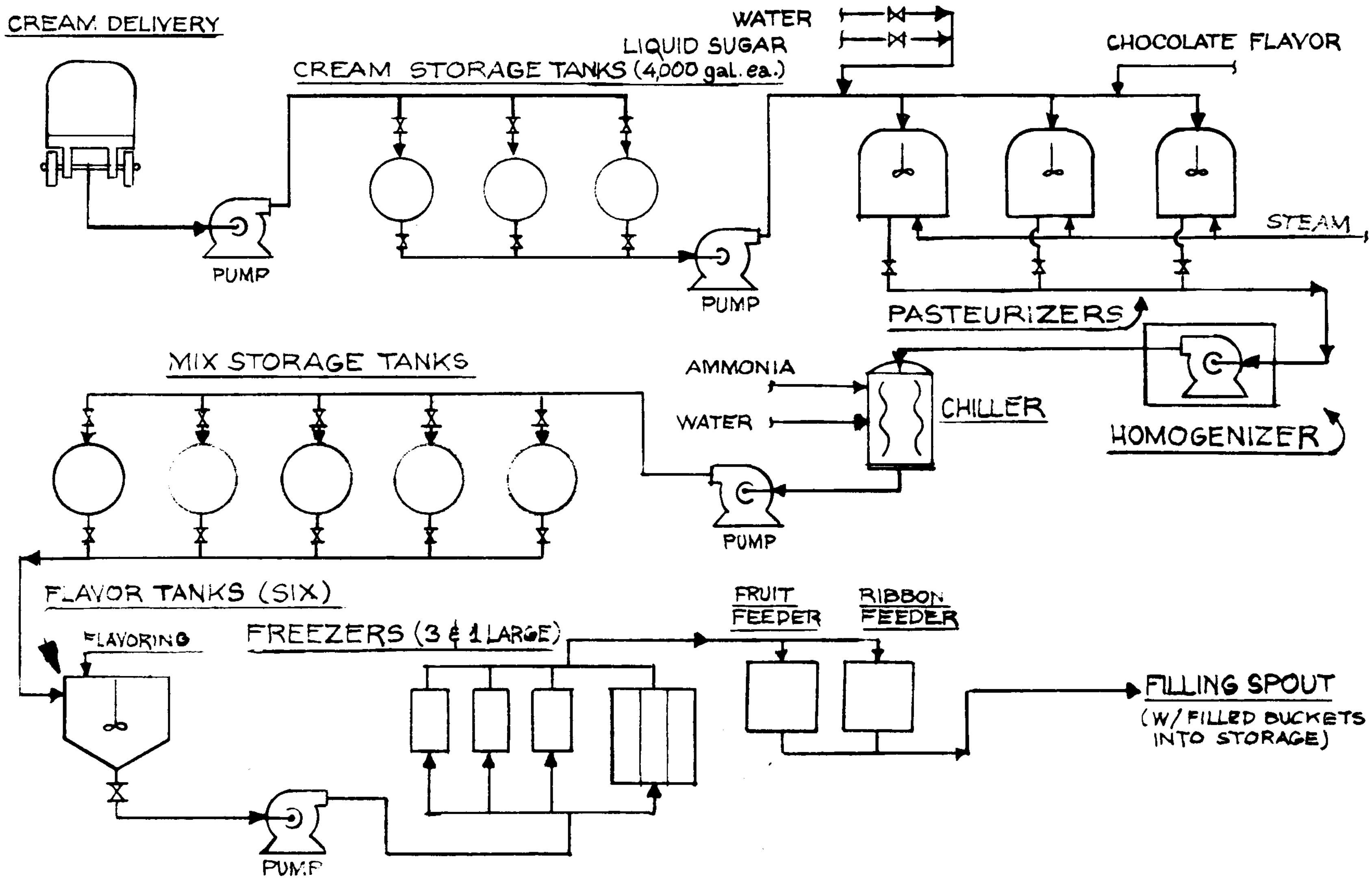
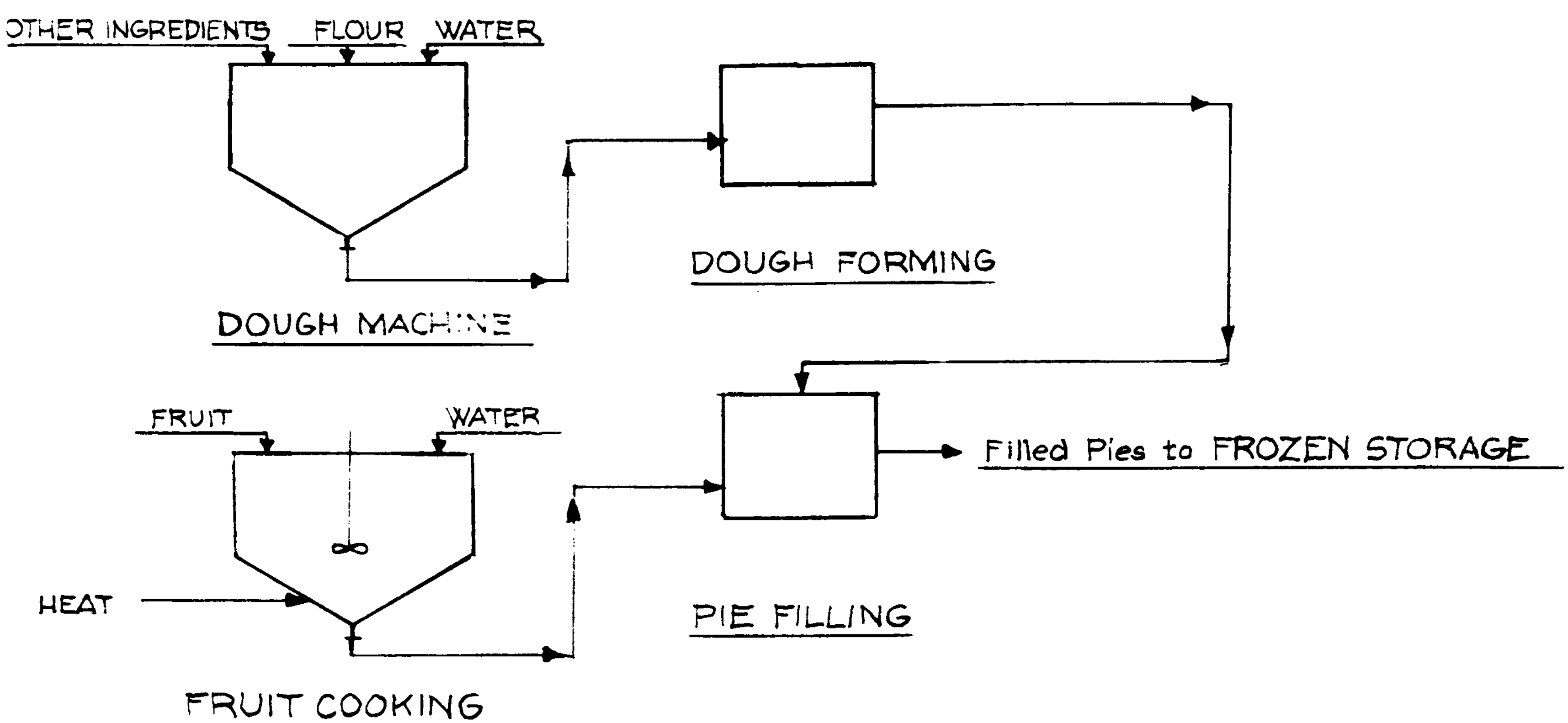


Figure 2

SCHEMATIC OF FROZEN PIE PREPARATION



to flavor tanks where the appropriate flavor extract is added. The blend is then passed through freezers to be converted to a semi-solid form and then put into three gallon containers for shipment. Fruits, nuts or a "ribbon" are added to the ice cream, as required, just after freezing and prior to container filling.

Frozen Pie Preparation

As seen in Figure 2, batch fruit preparation (cooking and cooling), dough preparation and forming, pie filling and final product freezing and storage are the unit operations attendant to pie preparation.

WASTEWATER SOURCES

The chief wastewater sources at the plant are as follows:

- Process Wastewater;
- Domestic Wastewater; and,
- Utility Wastewater (i.e., cooling water, boiler blowdown)

The latter two forms of wastewater are segregated from process wastewater and are disposed of separately in a manner that is satisfactory to the controlling regulatory agency. Thus, only process wastewater is discussed in this paper.

Ice Cream Process Wastewater

Wastewater generation in ice cream processing results from cleanup operations which can be divided into two general types:

- General plant cleanup which occurs at the end of the production day. All equipment from the "mix" storage tank discharge pumps to the filling spout is "broken down" and cleaned.
- Sporadic cleanup includes:
  - Tank Truck Cleanup - Whenever a cream tank truck is emptied, it must be hosed clean before leaving the plant.
  - Pasteurizer, Homogenizer, Chiller Flushout - Whenever a run of mix is completed, this equipment must be flushed out. The operation is performed by hosing down each pasteurizer vessel and then pumping the resultant wastewater through the homogenizer and chiller and out to waste.
  - Pasteurizer, Homogenizer, Chiller Rinseout - This operation is performed similarly to a flushout except that it is performed only one time per day regardless of the volume or types of mixes prepared. In this operation, water, detergent and a sanitizer are used to prevent a film buildup in the equipment. No contact with raw ice cream ingredients is made in this operation.

- • Mix Storage Tank Cleanup - Whenever a mix storage tank is completely emptied, the tank is hosed down and rinsed with clean water.

- • Small Backflush - Whenever a change is to be made in the type of fruit (or nuts) or ribbon to be added to a given flavor ice cream, the fruit or ribbon feeder and the piping from this unit to the filling spout is flushed so that no intermixing of product types is realized.

- • Complete Backflush - Whenever a significant change in flavor types is to be made (as for example from vanilla to chocolate), all the piping and equipment between the flavor tank and the filling spout must be cleaned. First a small backflush as described above is performed and then the water hose is fed into the filling spout to pass water through the piping back to the flavor tank discharge valve.

From the foregoing, it should be noted that the number and frequency of the six sporadic type cleanups in an ice cream plant are a function of:

- volume of product handled (i.e., this affects the number of tank truck cleanups and mix storage tank cleanups),

- variations in flavors produced (i.e., this affects the number and frequency of complete backflushes),

- variations in ingredients added to a given flavor ice cream (i.e., this affects the number of small backflushes),

- the type and volume of base mix (vanilla, chocolate or ice) produced (i.e., this affects the number of Pasteurizer, Homogenizer and Chiller Flushouts).

Pie Plant Process Wastewater

Four types of cleanups are performed in the pie plant; slop sink cleanup of utensils, cleanup of fruit cooking vats, general floor cleanup (performed at the end of the day's pie production and subsequent to a dry cleanup of the floor), and pan cleaning performed in the dishwasher. The most significant of these operations in terms of wastewater quantity and strength is the general cleanup.

WASTEWATER CHARACTERISTICS

Source Wastewater Characteristics

Source wastewater characteristics were determined from analysis of waste samples collected on a daily basis from each waste source whenever the operation occurred. The sampling program spanned 2-1/2 months so that all flavor type/ingredient effects could be accounted for. The results of this program in terms of mass emission rates for BOD and Flow are presented in Table 1. As can be seen in Table 1, the general plant cleanup yields the highest unit BOD load as well as a

TABLE 1

ICE CREAM PROCESSING WASTEWATER CHARACTERISTICS

Average Unit Waste Generation

Unit Operation	Unit BOD Load (lbs)	Unit Flow (gals)	Comments
General Plant Cleanup (Major Cleanup)	50	1,000	Occurs one time per day at end of production day.
Tank Truck Wash	1	35	Occurs on receipt of each 4,000 gal. tanker.
Cream Storage Tank Rinse	0	0	Rinsewater conveyed to pasteurizer as part of mix.
Pasteurizer, Homogenizer, Chiller Flushout	18	50	Occurs at end of base flavor run. Maximum number of occurrences equals 3 per day.
Pasteurizer, Homogenizer Chiller Rinseout	0	50	Occurs once per day
Mix Storage Tank Wash	12	50	May occur up to 5 times per day.
Small Backflush	13	650	Occurs up to 6 times per day.
Complete Backflush	25	1,300	Occurs up to 3 times per day.
Pie Shop Cleanup	15	400	Occurs 1 time per day. (Covers approx. 660 ft^2 of production area).
Pan Wash Discharge	1	250	Occurs 1 time per day.

high unit flow. However, more important in terms of their effect on the overall plant wastewater character, are the unit operations that can occur more than one time per day. These operations are:

- Pasteurizer, Homogenizer, Chiller Flushout;
- Mix Storage Tank Wash;
- Small Backflush; and,
- Complete Backflush.

The least significant operations in terms of their impact on overall wastewater character are:

- Tank Truck Wash;
- Pasteurizer, Homogenizer, Chiller Rinseout; and,
- Pan Wash Discharge.

Overall Wastewater Character

Table 2 presents the maxima, minima and average characteristics of the overall process waste stream. The data were acquired over the same 2-1/2 month period utilized to characterize waste source characteristics. Composite samples were obtained by collecting the total daily wastewater volume in the existing, aerated equalization tank. The wide range in data sets shown in Table 2 is caused by the day-to-day variations in the number of small backflushes, complete backflushes, and mix storage tank cleanups that are performed.

An alternative method of presenting the total daily BOD_5 load data [that is later (see WASTEWATER CHARACTERISTICS FORECAST, Method II) shown to be utile in projecting waste loads] is by use of statistical analysis. Figure 3 presents the results of such an analysis. As seen in this Figure, total daily BOD loads, at present, at the plant should not be expected to exceed 400 lbs and 340 lbs more than, respectively, five and ten percent of the time.

Four recommendations were made for improving the wastestream:

- Convey pasteurizer, homogenizer, chiller flushout wastewater (see the earlier section entitled CLEANUP OPERATIONS for description of this operation) to the mix storage tanks rather than to waste.
- Empty the mix storage tanks more completely of their contents before cleanup is initiated.
- Closer mix formulation control should be initiated so that a minimal residual in the flavor tanks remains after production is completed.

TABLE 2

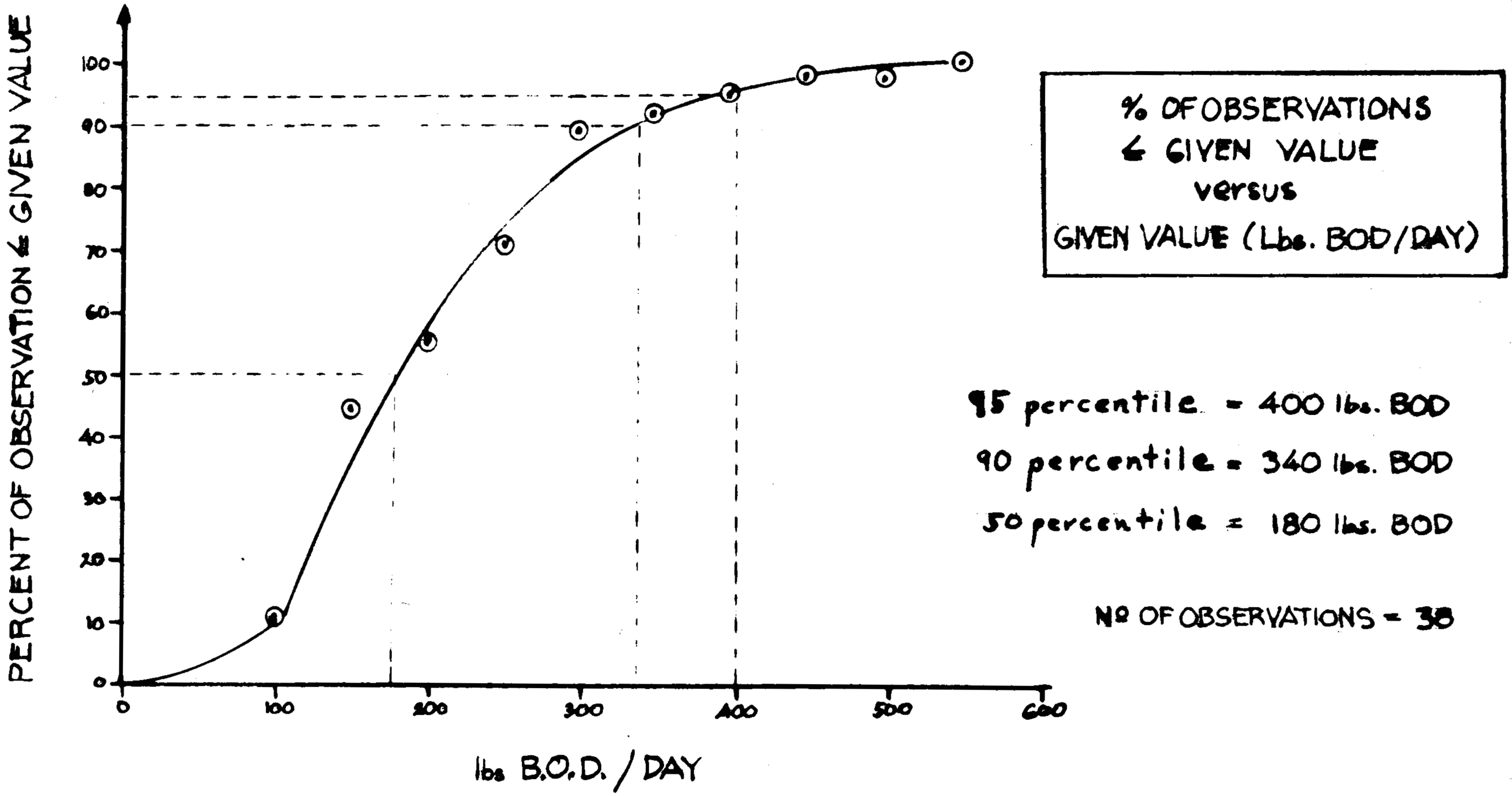
ICE CREAM PROCESSING WASTEWATER CHARACTERISTICS

OVERALL EFFLUENT DATA SUMMARY

Item	Average	Maximum	Minimum	Ratio $\frac{Max.}{Min.}$
Total Daily Flow gpd	4,000	5,400	1,950	2.8
BOD (5da.-20°C) (mg/ℓ)	6,200	13,600	2,540	5.3
COD (mg/ℓ)	7,800	17,000	3,220	5.3
BOD (5da.-20°C) lbs/day	207	540	90	6.0
Suspended Solids (mg/ℓ)	1,170	4,820	140	35
Settleable Solids (mg/ℓ)	11	100	0	≃ 100
pH	--	10.6	4.2	2.5

Figure 3

STATISTICAL ANALYSIS OF BOD_5 DATA FOR TOTAL PLANT EFFLUENT



- Automatic steam/water mixing valves should be installed on the hoses which presently do not have them to reduce water wasting when a hose is dropped and left to run.

PRODUCTION AND UNIT OPERATIONS FREQUENCY VS. WASTEWATER CHARACTERISTICS FORECAST TECHNIQUE

In order to develop scale-up data for future wastewater flow and strength, two alternative approaches were employed. The first was to review wastewater generation in terms of the units of production (i.e., determine the unit flow and BOD per unit of finished product). The second approach was to relate wastewater generation to unit operations of production.

Ice Cream Operations

Present production of ice cream is 32,000 gallons per week or approximately 2,000 units per day. Ultimate plant production capacity is expected to be reached in 1975 or 1976 when daily production will be approximately 6,000 units per day (unit equals one 3 gallon ice cream container). Note, however, that it is the cleanup operations which directly affect wastewater volume and strength and these are related to changes in production items and not directly to the volume of production. Thus it was decided that investigation of the frequency of unit production operations was a more precise method of forecasting wastewater characteristics.

Pie Plant Operations

The only significant wastewater source in pie plant operations was found to be the floor cleanup performed at the end of the day's production. Just as in the case of ice cream preparation, the volume and strength of waste is independent of the number of pies produced but is a function of whether or not any pies are made. Although plans exist to expand the pie plant in the future, no expansion of the processing area is intened (Note: Expanding the processing floor area would mean more floor to clean and thus a greater wastewater volume and strength). The expansion will incorporate new office and freezer facilities and a more intensive use of the production area.

WASTEWATER CHARACTERISTICS FORECAST

The previous section defined the type of data to be utilized for forecasting (i.e., waste generated per unit operation). This section describes the data analysis methods used in developing the forecast of wastewater characteristics.

Method I - Unit Process Effects

Using the unit wastes data presented in Table 1 in conjunction with forecasts regarding the frequency of unit operation occurrence in the future, estimates of future waste loads were made. These estimates are shown in Tables 3 and 4. Note that, because of the addition of a new freezer and attendant piping, the unit BOD and flow factors for

TABLE 3

BOD_5 FORECAST
(Based on Unit Operation Waste Data)

Unit Operation	Unit Waste Load (lbs BOD/day)	Future Unit Operation Frequency*	Future Ultimate Waste Load (lbs BOD/day)
Tank Truck Wash	1# BOD/receipt	1 tanker per day	1
Cream Storage Tank	Zero	Zero	Zero
Pasteurization Homogenization Chilling Flushout	18# BOD/flushout	Assume 3 flushouts per day	54
Mix Storage Tank Wash	12# BOD/washout	Assume all 5 tanks washed per day	60
Small Backflush	13# BOD/backflush	Assume 6 per day	78
Complete Backflush	25# BOD/backflush but 2 parallel systems exist ∴ Use: 50# BOD/backflush	Assume 3 per day	150
Major Cleanup	50# BOD/operation	1 per day	50
Pie Shop Cleanup	Use 15#/cleanup for 660 ft^2	Future = same as today	15
		Total	408 lbs BOD per day

*Per analysis with plant manager.

TABLE 4

WASTEWATER FLOW FORECAST

(Based on Unit Operation Waste Data)

Unit Operation	Unit Flow (gals.)	Future Unit Operation Frequency*	Future Ultimate Wastewater Volume (gals/day)
Tank Truck Wash	35 gals/receipt	1 tanker per day	35
Cream Storage Tank	Zero	Zero	Zero
Pasteurization Homogenization Chilling Flushout	50 gals/flushout	Assume 3 flushouts per day	150
Mix Storage Tank Wash	50 gals/washout	Assume all 5 tanks washed per day	250
Small Backflush	650 gals/backflush	Assume 6 per day	3,900
Complete Backflush	1,560 gals/backflush**	Assume 3 per day	4,700
Major Cleanup	1,000 gals/operation	1 per day	1,000
Pie Shop Cleanup	400 gals/cleanup	Future = same as today (1 operation per day)	400
			Total 10,400 gpd

*Per analysis with plant manager.

**Increased from 1300 gals by 20% to account for the extra piping length added by the new freezer.

the complete backflush were adjusted upwards. Using this technique, the projected ultimate BOD_5 and flow were 408 lbs. per day and 10,400 gallons per day, respectively.

Method II - Analyze Total Plant Effluent

BOD

It was felt that a better account of the effects of "accidents" in the plant (which would definitely and most importantly affect wastewater BOD) might be made via a statistical analysis. A statistical analysis was performed on all the raw sampling and analysis data. Additionally, the sampling program was modified so that concentrated wastes generated in the small and complete backflushes and mix storage tank washouts could be collected separately over the day in one separate vessel (an abandoned flavor tank) and sampled separately. Alternately, all other plant wastewaters (called dilute wastewater) were also sampled and analyzed separately. The results of the statistical analyses are shown in Figures 4 and 5. Figure 4 indicates 90 and 95 percentile values of concentrated wastewater BOD per day of 212 lbs. and 220 lbs., respectively. Figure 5 indicates 90 and 95 percentile values of dilute wastewater BOD per day of 139 lbs. and 147 lbs. BOD, respectively.

To develop a scaled-up ultimate design BOD load, the following were noted:

- For dilute washwater the conservative 95 percentile value of BOD of approximately 150 lbs. per day would be recommended for use for ultimate design. This is based on the fact that dilute washwater sources will not significantly change with time (i.e., pie plant cleanup, general plant cleanup, tank truck wash).
- For concentrated wastewater, at present, a 95 percentile BOD of 220 lbs. per day is noted. To account for an increase in the number of small backflushes per day (from five performed on 31 March 1971 when the 95 percentile was exceeded) to an ultimate of six (forecasted by the plant) a scale-up factor of (6/5 =) 1.2 should be used. To account for using all the existing and new freezer capacity at the plant (this affects complete backflushes) rather than only two small freezers and two barrels of the new large freezer (Note: This has been the maximum freezer usage to date) a factor of $\left(\frac{\text{6 freezers total}}{\text{4 freezers presently in use}} =\right)$ 1.5 should be used. Thus, concentrated waste BOD is projected to reach a 95 percentile value of (220 lbs/day x 1.2 x 1.5 =) 400 lbs/day.

The projected ultimate 95 percentile of total plant BOD was thus estimated to be:

Figure 4

STATISTICAL ANALYSIS OF BOD_5 DATA FOR CONCENTRATED WASTEWATERS

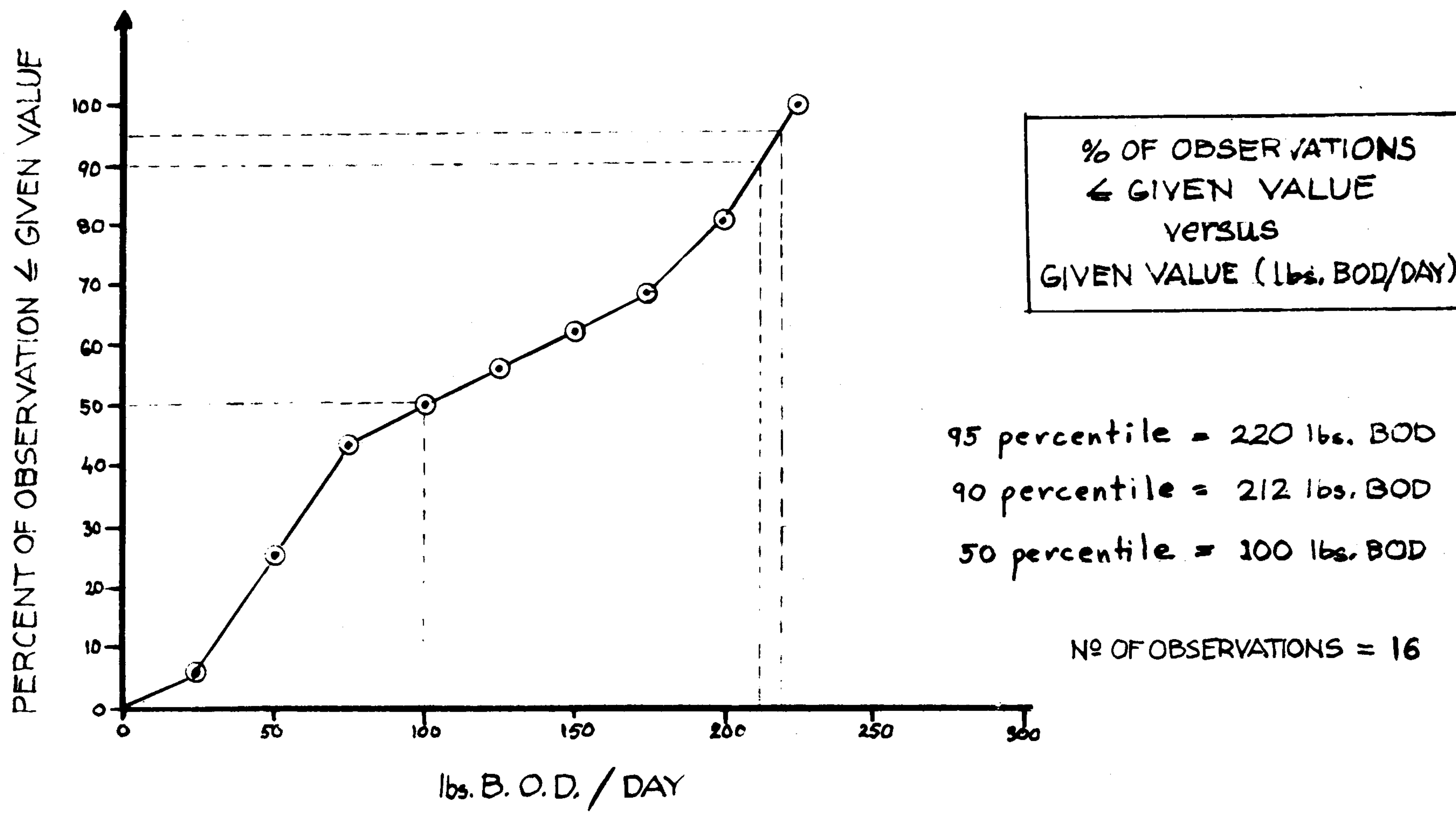
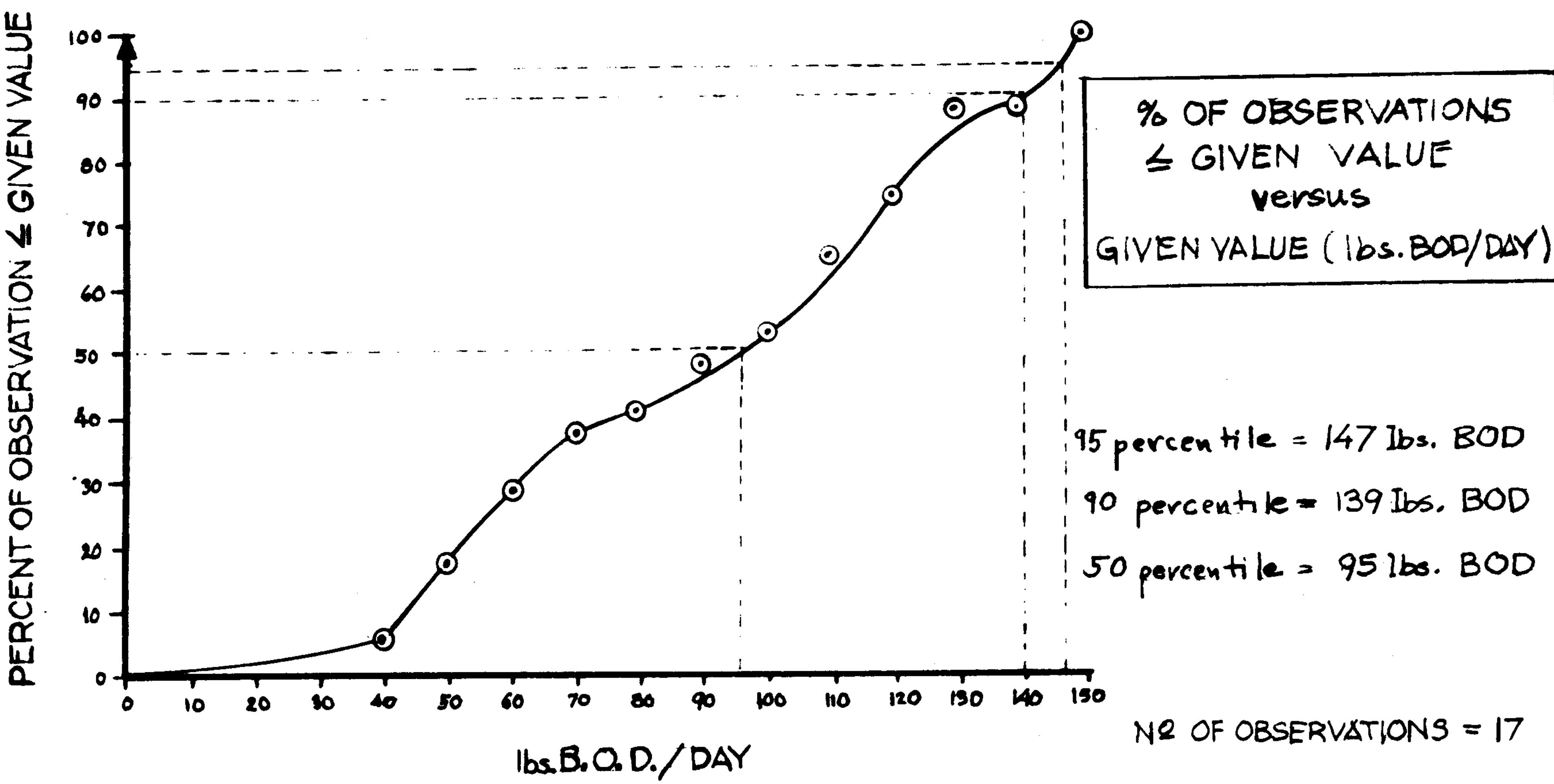


Figure 5

STATISTICAL ANALYSIS OF BOD_5 DATA FOR DILUTE WASTEWATERS



Dilute Washwater		150 lbs. per day
Concentrated Wastewater	=	400 lbs. per day
Total		550 lbs. per day

ALTERNATIVE WASTEWATER TREATMENT AND DISPOSAL TECHNIQUES

Throughout the study period as data accumulation and analysis progressed, alternative wastewater treatment and/or segregation and disposal techniques were reviewed. The chief alternatives that came under review were:

Alternative I - Treatment of the total daily wastewater on-site in an extended aeration type aerobic biological treatment plant.

Alternative II - Treatment of dilute washwaters on-site in an extended aeration type aerobic biological treatment plant while concentrated wastewater is treated on-site in an anaerobic fermentation treatment plant.

Alternative III - Treatment of dilute washwaters on-site in an extended aeration type aerobic biological treatment plant while concentrated wastewater is collected for disposal off-site.

Alternative I was selected as the optimum treatment system for the following reasons:

- Published data (1) indicate that an extended aeration type aerobic biological treatment plant will produce a high quality effluent that will meet the demands of the controlling regulatory agency.

- Annual costs (amortized capital and annual operation and maintenance) for Alternative I would be the least and could be more reliably projected than those for the other alternatives. (Especially as regards Alternative III, off-site disposal costs are subject to increase with time.)

- Alternative I requires the simplest operation and maintenance expenditures and labor talent.

- Alternative I has the highest "shock absorbing" capacity of all the alternative systems studied. The plant will be able to sustain the effects of in-plant accidents (i.e., accidental fruit or mix spills) without requiring the plant personnel to call for outside assistance (i.e., emergency scavenger calls to pump out an overloaded treatment plant).

LABORATORY TREATABILITY STUDIES

General

In order to define the efficiency of the proposed extended aeration system under various operating conditions, a three component treatability study was developed and implemented.

Phase I of the study was designed to operate at a Food: Microorganism (F/M) ratio averaging at 0.07 (Note: From correlations, BOD = 0.8 COD). A five liter aerobic reactor was utilized and reactor contents were maintained at room temperature. In order to simulate field conditions, the total daily feed volume (i.e., 200 mℓ) was fed to the reactor in four equal doses of 50 mℓ each over an eight hour period. No feed was made to the system for the other sixteen hours per day or over the weekend. The system was operated utilizing actual raw plant waste (Note: Concentrated wastes were collected in the field and diluted in the laboratory). The resultant hydraulic retention time was approximately 25 days and nutrient nitrogen was added to the system to maintain a BOD: N ratio of 20:1.

Phase II of the treatability studies was designed to simulate long term shock loading conditions. After operating the Phase I system for approximately one month, the loading was then increased to a total of 500 mℓ per day. All other Phase I conditions were maintained. The average F/M ratio during this period was 0.31 and the hydraulic retention time was reduced to 10 days.

Phase III of the treatability studies was designed to determine the effects of low temperature on the Phase I system. Phase III was implemented by reverting from the Phase II to Phase I loading conditions, equilibrating and then putting the reactor into a refrigerator maintained at 2^{o}-4^{o} C. The results of all the foregoing are presented in the following sections.

Phase I Results

Phase I operating results are presented in Table 5. Over the period of 6 May through 9 June, an average mixed liquor volatile suspended solids (MLVSS) of 2,290 mg/ℓ was maintained in the reactor. With an influent COD averaging at approximately 5,050 mg/ℓ (i.e., BOD averaging at 4,050 mg/ℓ) over this same period, the food-to-microorganism (F/M) ratio in the system was:

$$\frac{F}{M} = \frac{\#BOD}{\#MLVSS} = \frac{4050 \text{ mg}/\ell \times 0.2\ell}{2290 \text{ mg}/\ell \times 5\ell} = 0.07$$

COD removals throughout this period ranged from a low of 93.0 percent to a high of 97.7 percent with an average of 95.8 percent. Good settling of the resultant sludge was reported once the system reached equilibrium (starting 21 May) yielding an average Sludge Volume Index (SVI) of approximately 160.

Another important result of the study can be seen by inspecting COD removal efficiency data over weekend periods. The data in Table 5 indicate that insignificant changes in the system efficiency resulted over the weekend periods in spite of the fact that no waste was fed to the system over the weekend in an attempt to simulate actual field conditions.

TABLE 5

ICE CREAM PROCESSING WASTEWATER

EXTENDED AERATION TREATABILITY STUDY RESULTS (F/M = 0.07; 68° F)

DATE	pH	SETTLE-ABILITY mℓ/ℓ	TSS mg/ℓ	VSS mg/ℓ	INFLUENT COD mg/ℓ	EFFLUENT COD mg/ℓ	% COD REMOVAL
5-6	6.1	980	4880	4100	-	-	-
5-7	6.0	980	4380	3700	-	-	-
5-8	-	-	-	-	-	-	-
5-9	-	-	-	-	-	-	-
5-10	5.35	980	4267	3633	5390	167	96.9
5-11	5.6	980	4300	3640	5200	144	97.2
5-12	5.25	985	4400	3600	4960	310	93.7
5-13	5.2	980	4200	3550	4930	188	96.2
5-14	5.2	980	3700	3200	4900	330	93.2
5-15	-	-	-	-	-	-	-
5-16	-	-	-	-	5096	333	93.4
5-17	5.1	970	3200	2600	5350	310	94.2
5-18	5.0	970	3150	2900	5400	312	94.2
5-19	4.9	920	3050	2550	4940	384	92.2
5-20	4.8	920	2860	2400	5300	368	93.0
5-21	4.7	380	2750	2220	5280	220	95.8
5-22	-	-	-	-	-	-	-
5-23	-	-	-	-	-	-	-
5-24	4.6	520	2580	2100	5352	192	96.4
5-25	4.6	760	2430	2020	5450	190	96.5
5-26	4.3	400	2530	2030	4840	120	97.5
5-27	4.6	350	2420	1860	5340	176	96.7
5-28	4.5	320	2150	1780	5300	160	97.0
5-29	-	-	-	-	-	-	-
5-30	-	-	-	-	-	-	-
5-31	4.5	300	1900	1700	5150	120	97.7
6-1	4.9	300	2070	1650	5060	140	97.2
6-2	4.6	290	2150	1820	4940	192	96.1
6-3	4.55	250	1980	1720	5080	176	96.5
6-4	4.75	230	1718	1180	5340	140	97.4
6-5	-	-	-	-	-	-	-
6-6	-	-	-	-	-	-	-
6-7	4.2	240	2010	1490	3240	140	95.7
6-8	4.3	230	1970	1625	4500	150	96.6
6-9	4.3	220	1750	1420	4980	150	97.0
AVG.	-	342	2762	2290	5054	212	95.8

Phase II Results

The results of the Phase II (i.e., shock loading condition) operations are presented in Table 6. Except for the first day of operation wherein the COD removal efficiency dropped to 88.0 percent from 97.0 percent on the previous day, no adverse effects on system operation were noted. For the two-week period following the first increase in loading, the system COD removal efficiency ranged from a low of 91.4 percent to a high of 95.6 percent, with an average of 94.0 percent. System operating parameters were as follows:

Average MLVSS 1038 mg/ℓ

Average Influent COD = 4072 mg/ℓ

Average Influent BOD = 3250 mg/ℓ

$$\text{Average } \frac{F}{M} = \frac{3250 \text{ mg/}\ell \times 0.51}{1038 \text{ mg/}\ell \times 5.01} = 0.31$$

The sludge settleability was found to be very good with an average SVI of 63. Again, no adverse effects were noted as a result of "starving" the system over the weekend.

Phase III Results

The results of the Phase III (i.e., chilled conditions) treatability program are presented in Table 7. Inspection of the data in Table 7 indicates that the COD removal efficiency ranged from a low of 88.9 percent to a high of 95.6 percent and averaged at 93.0 percent. Sludge settleability was again found to be very good with a resultant SVI of 72. Weekend "starving" of the system produced no adverse effects. The system was maintained at an average F/M ratio of approximately 0.14.

The chilling study results were compared with the work of Clark, et al[2]. Clark concluded that, "...several investigations have collected data for aerated lagoon operation performance within the temperature range of 0^{o} C to 10^{o} C...the curves [in Figure 6] demonstrate that there is a high probability for obtaining BOD removal efficiencies greater than 80 percent at detentions less than 15 days with lagoons operating at temperatures less than 5^{o} C." The results of the Phase III program compare favorably with the data/conclusions reported by Clark.

CONCLUSIONS

The most significant conclusions that can be drawn from the foregoing are as follows:

- Ice cream wastewater characteristics are chiefly a function of the type and number of cleanup operations performed.

- Opportunities do exist for wastewater volume and strength reduction in an ice cream processing plant. However, the potential

TABLE 6

ICE CREAM PROCESSING WASTEWATER

HIGH RATE TREATABILITY STUDY RESULTS (F/M = 0.31; 68° F)

DATE	pH	SETTLE-ABILITY (mℓ/ℓ)	TSS mg/ℓ	VSS mg/ℓ	INFLUENT COD mg/ℓ	EFFLUENT COD mg/ℓ	% COD REMOVAL
6-10	4.6	155	1925	1075	5920	712	88.0
6-11	5.1	150	1680	1500	4960	220	95.6
6-12	-	-	-	-	-	-	-
6-13	-	-	-	-	-	-	-
6-14	5.2	80	1220	1020	4720	214	95.5
6-15	-	70	1550	1075	4080	196	95.2
6-16	6.0	70	1400	1200	4000	180	95.5
6-17	-	80	1200	1025	3360	160	95.2
6-18	6.1	70	1130	900	3240	236	92.7
6-19	-	-	-	-	-	-	-
6-20	-	-	-	-	-	-	-
6-21	-	64	1430	1180	3600	192	94.7
6-22	5.0	70	1000	600	3160	148	95.3
6-23	5.0	70	1100	900	3320	170	94.9
6-24	5.75	65	1350	950	4120	352	91.4
AVG.	-	86	1362	1038	4072	244	94.0

TABLE 7

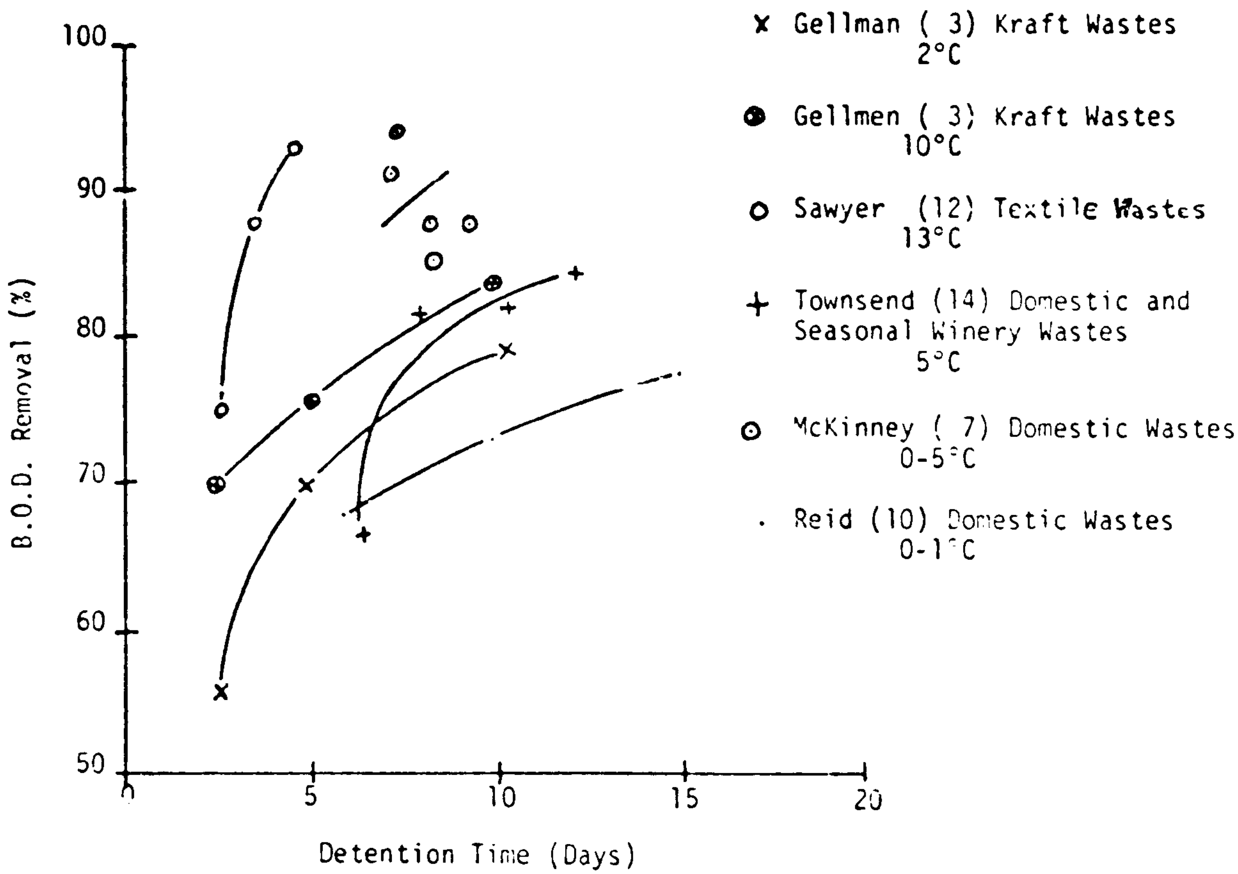
ICE CREAM PROCESSING WASTEWATER

"WINTER" OPERATING RESULTS FOR EXTENDED AERATION (F/M = 0.14; 2°C - 4°C)

DATE	TEMP(°C)	pH	SETTLE-ABILITY mℓ/ℓ	TSS mg/ℓ	VSS mg/ℓ	INFLUENT COD mg/ℓ	EFFLUENT COD mg/ℓ	% COD REMOVAL
7-7	4	7.5	50	-	-	2740	212	92.3
7-8	4	-	60	1010	713	3100	320	89.7
7-9	3	-	-	1215	1000	2760	308	88.9
7-10	-	-	-	-	-	-	-	-
7-11	-	-	-	-	-	-	-	-
7-12	2	-	60	1020	-	2880	216	92.5
7-13	3	-	-	1030	715	3340	210	93.7
7-14	2	-	-	1115	800	3260	204	93.7
7-15	4	-	90	1230	1030	3230	180	94.4
7-16	4	-	80	1280	1040	2680	180	93.3
7-17	-	-	-	-	-	-	-	-
7-18	-	-	-	-	-	-	-	-
7-19	2	6.1	85	1285	865	2960	150	94.9
7-20	4	6.1	70	900	780	5580	428	92.3
7-21	3	5.8	80	910	806	5680	248	95.6
7-22	4	5.6	70	766	613	5120	332	93.5
7-23	4	5.4	90	900	860	4768	384	91.9
7-24	-	-	-	-	-	-	-	-
7-25	-	-	-	-	-	-	-	-
7-26	2	-	-	930	900	5472	338	93.8
7-27	3	5.6	100	1133	1013	5810	296	94.9
AVG.	-	-	76	1051	856	3958	277	93.0

Figure 6

AERATED LAGOONS
PERFORMANCE EFFICIENCIES (2)



for accidental raw/finished product spills should not be underestimated.

- Overall wastewater characteristics in an ice cream plant are highly variable because of day-to-day changeovers in types and quantities of ice cream produced.

- COD removal efficiencies of 94-96 percent can be achieved in aerobic biological treatment units handling ice cream wastewaters at F/M ratios in the range of 0.07 to 0.31.

- No significant change in system operating efficiency resulted when a pilot extended aeration plant (operating an ice cream wastewater) was operated at room (20^{o} C) and subsequently under cold (2^{o}-4^{o} C) temperatures.

LIST OF REFERENCES

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