ONTARIO WATER RESOURCES COMMISSION

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RESEARCH
PUBLICATION
NO. 16

SUPPLEMENTARY AERATION OF WASTE STABILIZATION PONDS FOR THE TREATMENT OF INDUSTRIAL WASTES

THE ONTARIO WATER RESOURCES COMMISSION

SUPPLEMENTARY AERATION

OF

WASTE STABILIZATION PONDS

FOR THE

TREATMENT OF INDUSTRIAL WASTES

By:

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Publication No. 16

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INTRODUCTION

General Description

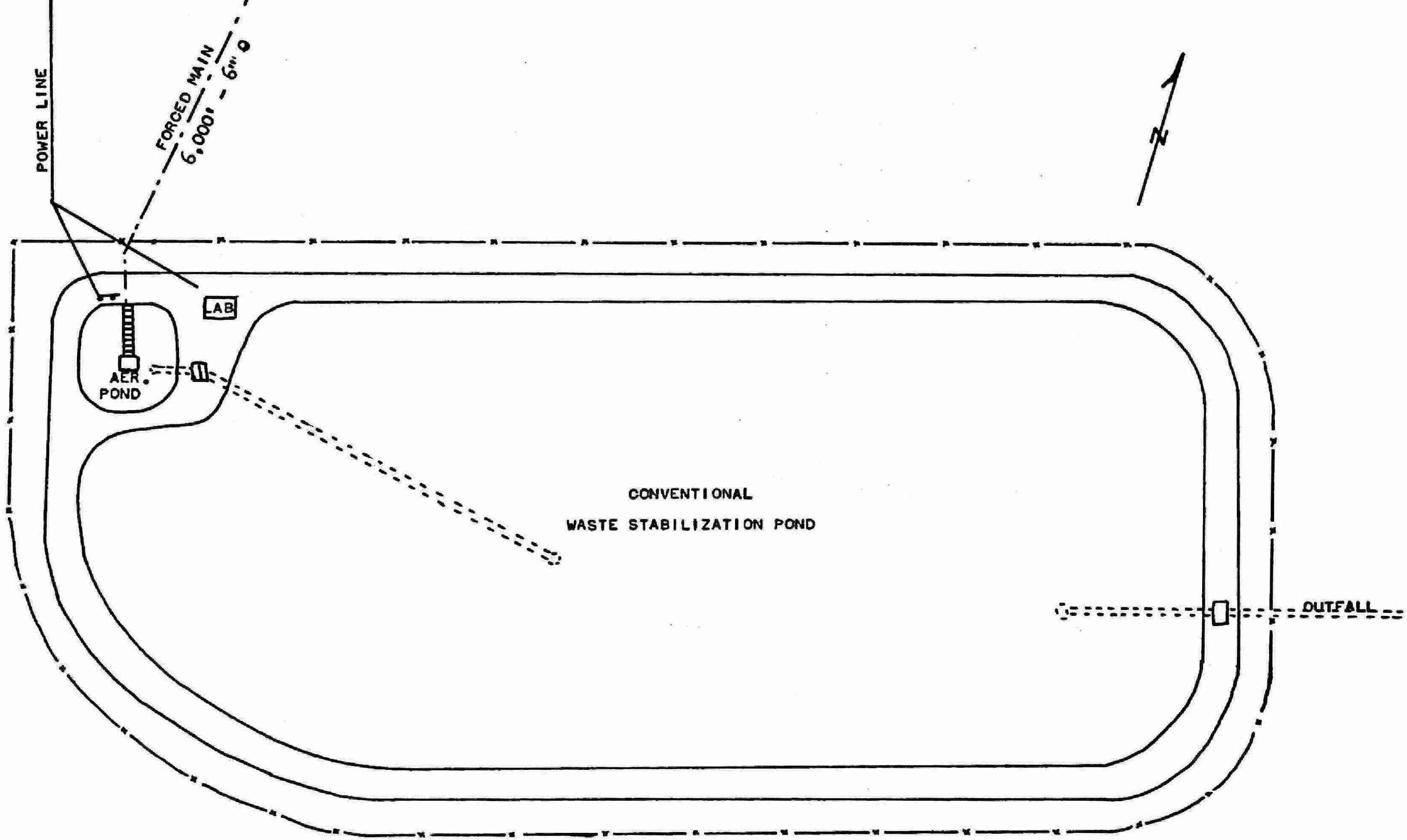
Waste water from an industrial subdivision of Sandwich West Township is collected at a common pump house on Ambassador Road and pumped to a waste stabilization system for treatment. The system consists of an aeration basin* of approximately 2-½ days detention followed by a conventional waste stabilization pond (wsp)** of three months detention. The effluent from the wsp is discharged to Youngstown Drain and eventually finds its way to the Detroit River. Figure 1 gives a plan view of the system.

Raw Waste

The raw waste consists of industrial and domestic wastes from the several small industries within the subdivision, the chief contributor being a dairy, supplying approximately 80% of the flow. The biochemical oxygen demand (BOD) and suspended solids (SS) range from 1,137 to 49 parts per million (ppm) and 403 to 7 ppm respectively, of 24-hr composite samples. The total daily flow averages 84,000 Imp gal/day.

* In this report, the term "aeration basin" will be used to designate a basin of significant depth (4-10 ft) in which oxygenation of organic matter is accomplished by a supplemental aeration unit and from induced aeration.

** The most commonly accepted term, "waste stabilization pond" will be used to denote a pond, 3-6 ft in depth, constructed with dykes, into which either raw sewage or, in this case aeration basin effluent, is discharged. The abbreviated form wsp will be used frequently for brevity.



SCALE - 1" = 120'

FIGURE 1 - SANDWICH WEST INDUSTRIAL LAGOON

Aeration Basin

The aeration basin consists of a single cell of 221,000 gallons capacity, with 1:3 slopes and an 8 foot depth. The corners are filleted in such a manner that the pond is virtually round at the bottom and the entire soil surface has been stabilized with cement to prevent erosion. Aeration is provided by a 7-½ foot diameter Simcar aerator, centrally located on wooden posts and powered by a 20 HP motor through a gear reducer. Liquid depth is controlled by stop logs in the overflow weir box. Daily flows are highly variable and tended to increase throughout the study period. Figure 2 presents a view of the aerator installation.

Conventional Waste Stabilization pond

The conventional wsp of 3:1 side slopes, has an area of approximately 6.8 acres and a liquid depth of 4 feet. The inlet structure is centrally located and the outlet structure has been constructed to allow effluent withdrawal from below the liquid surface. Liquid depth is controlled by stop logs in the outlet weir box.

Plan of Study

The study was designed to obtain performance data on this particular installation and to give general operational data on this type of mechanical surface aerator. The efficiency of the aerator was determined from dissolved oxygen (DO) content, oxygen transfer rate, power consumption and mixing measurements. The sampling procedure was such as to allow performance determinations of each section of the system as separate units or as a combined unit.

Continuous monitoring of organic loadings was accomplished through flow recordings and determinations of BOD, chemical oxygen demand (COD) and SS content of composite samples of raw sewage and aeration basin effluent and of grab samples of wsp effluent. A complete

Figure 2

Aeration basin showing the aerator installation.
Waste stabilization pond is shown in background.

chemical analysis was made on each stage of the treatment as frequently as possible. Grab samples were used for DO, coliform and algae concentration determinations.

The study was carried out in three Parts. A five week field investigation in August and a two week one in October comprised the first Part. Part 2 consisted of periodic checks carried out throughout the winter season, and another four week field investigation in April, 1966 comprised Part 3.

PART I

Part I of this report deals with a continuous field investigation performed during the five week period from August 1 to September 4, 1965 and a repeated two week investigation from October 11 to October 25,1965.

1.1 Program of Data Collection

The sampling procedure and the tests performed were set up to obtain a maximum of information with the time and materials available. Sampling was such as to allow determinations on the aeration basin as a unit, the wsp as a unit, and stabilization system as a whole.

Twenty four hour composite samples of raw sewage and aeration basin effluent were collected, while grab samples of wsp effluent were taken. Because of the varying waste strength, the sample of raw sewage was collected in proportion to the waste flow. The collected samples were used to determine COD, BOD, DO, pH and solids content of the waste. These determinations were all performed at the lagoon site on the same day as the samples were collected.

Several oxygen uptake rate determinations were made throughout the test period as well as dissolved oxygen concentration levels at various depths in the wsp and aeration basin.

Samples were collected each week from the three sources and returned to the OWRC Laboratories for an extensive chemical analysis. Daily samples were collected and sent to the Windsor Health Dept. for coliform and fecal coliform counts. Weekly samples were collected for algae counts.

1.2 Procedure and Equipment

a) Composite Samples

Twenty-four hour samples were taken of the raw sewage and aeration basin effluent. Specially constructed samplers were used. All depth samples were collected with a Kemmerer depth sampler.

b) Biochemical Oxygen Demand (BOD)

The procedure set forth for sewage in Standard Methods for the Examination of Water and Waste-water was used to determine 5-day BOD.

c) Chemical Oxygen Demand (COD)

The dichromate reflux method set forth for industrial wastes in Standard Methods was used to determine COD.

d) Dissolved Oxygen (DO)

The Alsterberg modification of the Winkler Method as set forth in Standard Methods was used to determine DO.

e) pH

All pH determinations were made with a Beckman, model N, pH meter.

f) Suspended Solids (SS)

Suspended solids were determined from the difference between filterable and non-filterable residues. A glass fibre filter was used for all filtered samples.

g) Flow Measurement

A 60° V-notch weir was set up in the aeration basin outlet weir box and a Stevens Recorder was used to continuously record head over the weir.

h) Temperature

Temperature measurements of raw sewage were made on grab samples with a centigrade thermometer. Those of the aeration basin and wsp effluents were recorded daily from max-min thermometers.

i) Coliform Determinations

Coliform determinations were made according to the MPN procedure set forth in Standard Methods.

1.3 Interpretation of Results

The long detention periods and the variable daily flows and waste strengths involved, necessitated the use of as long a study period as possible. For the same reasons, most calculations were based on a mass balance rather than concentrations and the data from each investigation was averaged to a single set of results. The two test periods had to be treated independently because of the aeration basin efficiency differences between the two. In all efficiency calculations, allowances were made for changes in concentrations within the aeration basin.

The intermittent chemical analyses carried out at the laboratories could not fully represent an extensive nutrient study and any data so obtained must not be treated as conclusive.

The original data and calculations have been omitted from this report but are available through the Division of Research.

The results and conclusions presented in Part I of the report are based on the results of the August and October studies only and are not necessarily representative of the full year's operation or treatment.

1.4 Raw Waste

Tables 1 and 2 present the more important properties of the raw waste for each period. It is noted that significant variation in raw waste characteristics of the two test periods occurred in temperature and pH only. Laboratory analyses indicate adequate nutrients for bacterial growth, the BOD:N:P ratio being approximately 100:10:10. Chloride and sulphate concentrations averaged 34 and 27 ppm, respectively. Iron and anionic detergent as ABS were present in very small concentrations. No trace of chrome was found at any time.

Daily flows are shown in Figure 3, the average flow rate being 84,642 gpd.

Table 1

Raw Waste Analysis for August Study

	BOD lb/day	COD lb/day	SS lb/day	DO ppm	pH	Temp °C
Max	1137	1628	403	7.0	10.6	25
Min	68	95	7	0.4	5.1	19
Avg	374	459	196	4.5	7.6	22.5

Table 2

Raw Waste Analysis for October Study

	BOD lb/day	COD lb/day	SS lb/day	DO ppm	pH	Temp °C
Max	760	1062	338	7.5	8.5	20
Min	49	65	15	2.0	2.6	14
Avg	369	485	171	5.0	6.3	16.4

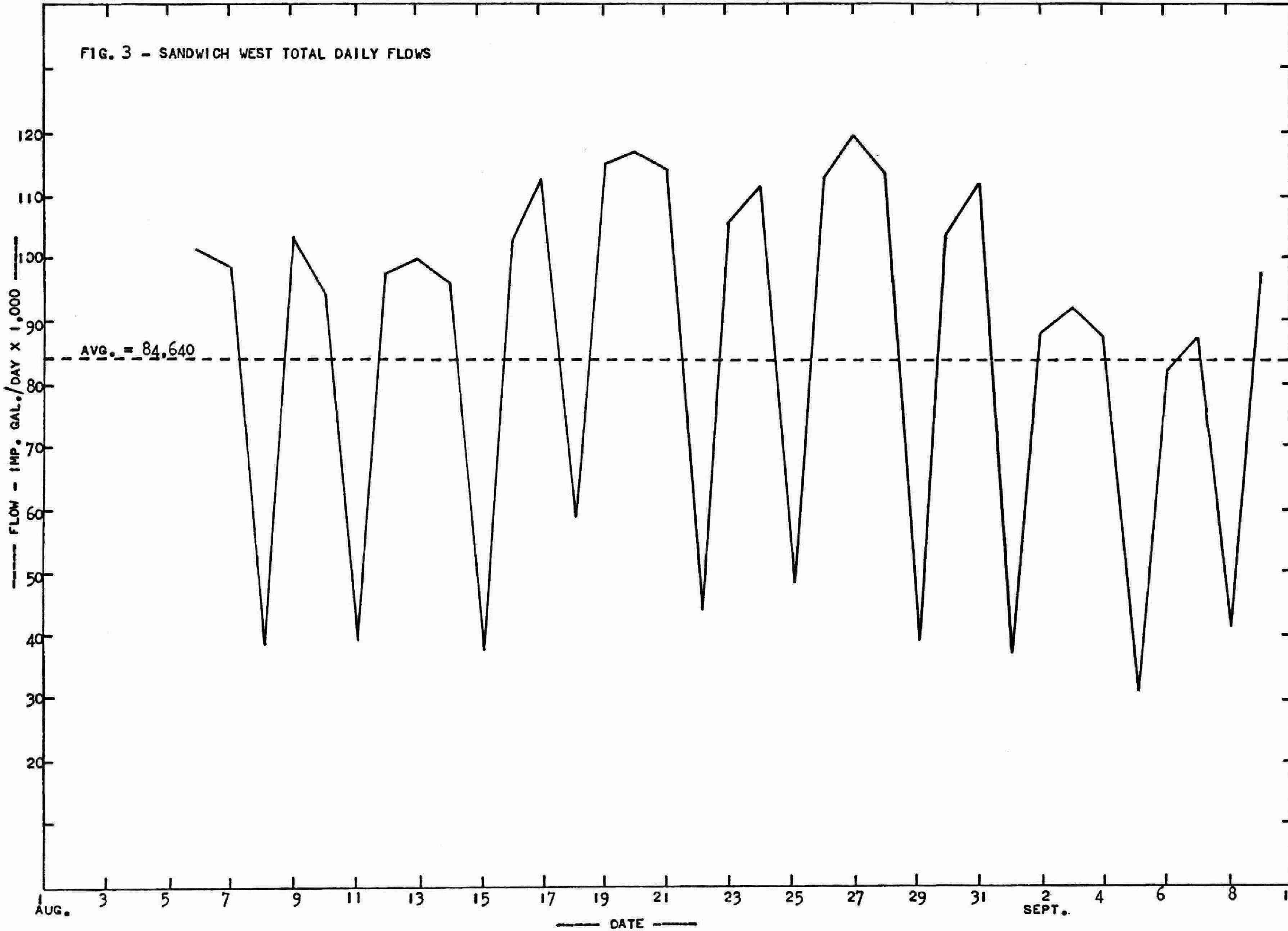


FIG. 3 - SANDWICH WEST TOTAL DAILY FLOWS
AVG. = 84.640
FLOW - IMP. GAL./DAY X 1,000
120
110
100
90
80
70
60
50
40
30
20
1
AUG.
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
2
SEPT.
4
6
8
10
DATE

1.5 Aeration Basin Loading

The loading to the aeration basin varied both in strength and quantity from day to day. Storm drainage entered the system and the dairy was closed on Sundays and Wednesdays. The BOD loading varied between 1,137 and 49 lb/day, average 370, giving an average organic loading of 10.5 lb BOD/1,000 cu ft/day. This is a relatively high loading for this method of treatment. COD and SS loadings averaged 500 and 180 lb/day respectively.

1.6 Mechanical Aerator Performance

The mechanical aerator kept the contents of the aeration basin well aerated and well mixed. Although it temporarily approached zero at times, the DO content of the aeration basin averaged above 50% saturation throughout the two test periods. DO determinations at various depths indicated a gradient of less than 2 ppm (Figure 4) and at no time were settled sludge deposits found on the basin bottom.

The oxygen utilization rate of the mixed liquor is largely dependent upon the BOD concentration, time of aeration and temperature. However, since this is a completely mixed and continuous feed system, the time of aeration may be considered as constant, and the oxygen (O_2) utilization rate is then dependent upon BOD concentration and temperature only.

Figure 5 presents a graph of mixed liquor BOD plotted against O_2 utilization rate. The results of eight rate determinations have been used, but confidence limits of $\pm$ 10 to 15% must be applied, therefore a wide plot has been used for the graph.

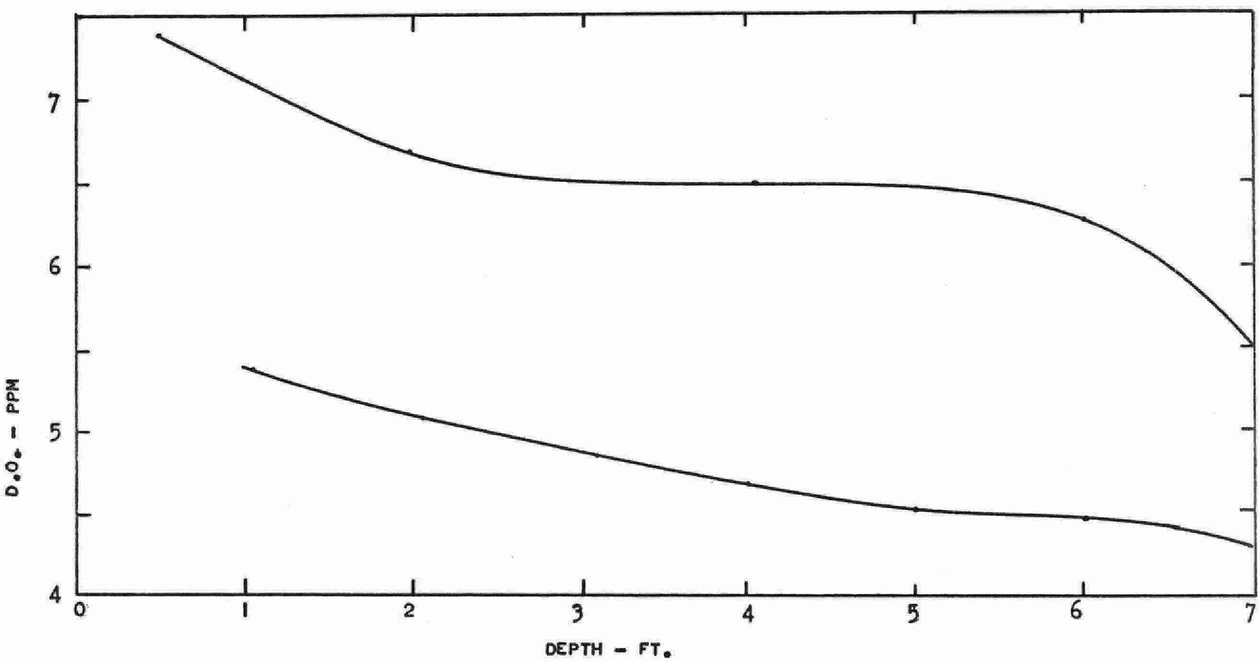


FIGURE 4 - TYPICAL D.O. PROFILES OF AERATION BASIN

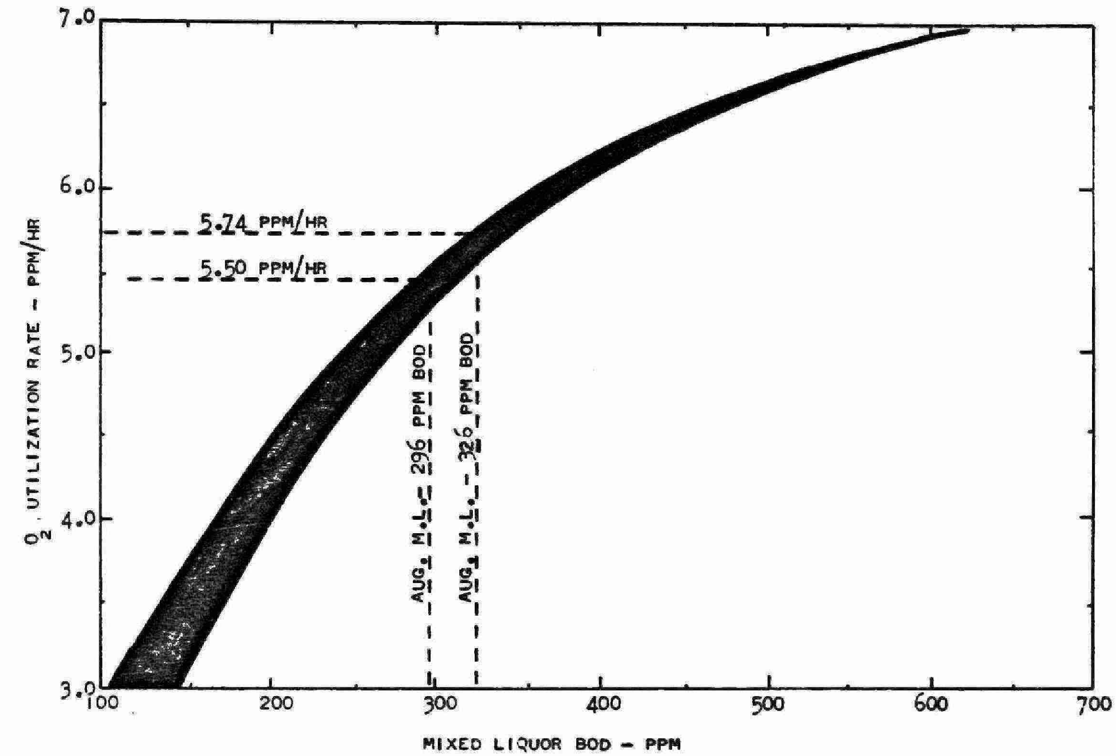


FIGURE 5 – OXYGEN UTILIZATION RATE VS MIXED LIQUOR BOD

The average mixed liquor BOD for August was approximately 330 ppm, corresponding to an O_2 utilization rate of 5.74 ppm/hr. That for October was 295 with a corresponding O_2 utilization rate of 5.50 ppm/hr. An oxygen transfer rate of 24.9 lb/hr. or 2.95 lb O_2/EHP-hr based on zero DO was calculated for each test period.

The pounds oxygen consumed per pound of BOD reduced was 2.5 for August and 1.5 for October. The high value for August may be partially explained in relation to the periodic high pH of the raw waste. The impact of such high pH values on the aeration basin was to temporarily reduce biological activity and to kill off the more sensitive bacteria. This was then followed by a high rate of bacterial growth, but before endogenous respiration could be fully established, high caustic conditions were again experienced. The system was in an interrupted log growth phase resulting in high rates of cell synthesis, but low rates of organic stabilization.

The high pH values in the August period also indicates the possible presence of certain chemical reactions which enter oxygen into a bond to effectively reduce pH to a lower value. The presence of stearates in the August test may also account for the use of some of the oxygen as an oxidation of stearates would not be indicated in the oxygen tests.

1.7 Aeration Basin Performance

In the aeration basin, oxygenation was accomplished by a mechanical aeration unit and resultant induced surface aeration. DO determinations and physical observations indicated that the aeration basin approached complete mixing conditions. The system was therefore, analogous to the activated sludge process. The low biological solids level, however, Indicated that BOD removal was primarily a function of detention time, temperature and the nature of the waste.

If the characteristics of the waste are assumed to follow a first order reaction BOD removal may be formulated according to the relationship:

$$\frac{Le}{Lo} = \frac{1}{1 + Kt}$$

in which "Lo" is the initial 5-day BOD, "Le" is the final 5-day BOD and "t" is the detention period. "K" is constant for a specific waste and depends upon temperature in accordance with the equation:

$$K_t = K_{20^\circ C}\theta^{(T-20)}$$

The value of θ for this waste has been determined to be approximately 1.027. The value of K for October was determined to be 0.346 @ 20°C.

The efficiencies experienced in the two periods indicate that the characteristics of the raw waste are more important than temperature effects. Efficiencies averaged 35.1% and 52.6% respectively, for August and October even though temperatures were 15 to 20 fahrenheit degrees colder during the latter period.

Chemical analyses indicated the presence in the raw sewage of adequate nutrients and the absence of any toxic material such as chrome, cyanide, etc. pH appeared to be the controlling factor. The optimum pH range for this particular type of waste is 6.5 - 7.6, with an effective range of 3.5 - 8.4. Below and above these limits the particles tend to coalesce decreasing the effectiveness of aeration. A rapid change in pH may decrease the respiratory activity by as much as 75%. The periodic high alkaline conditions of the raw waste during August induced poor bacterial growth for varying periods of time, resulting in low efficiencies. The low pH during October appeared to have much less detrimental effects.

1.8 Aeration Basin Effluent

Tables 3 and 4 give the more important properties of the basin effluent. Because of the differences in efficiencies, the effluent quality differed greatly between the two studies. The dissolved oxygen content of the effluent reflected the efficiency of the basin, being much higher in the October study. A high effluent DO is of particular importance to the wsp during the winter season when photosynthetic oxygen production is reduced. Microscopic examination revealed that the effluent quality was primarily related to the excess microbial solids, and 80% of the effluent BOD settled out in less than one hour.

Table 3

Aeration Basin Effluent Analysis for August Study

	BOD lb/day	COD lb/day	SS lb/day	DO ppm	pH	Temp °C
Max	670	974	1,075	7.2	8.6	25
Min	52	131	85	0.0	7.0	16
Avg	253	459	367	2.1	7.5	20

Table 4

Aeration Basin Effluent Analysis
for
October Study

	BOD lb/day	COD lb/day	SS lb/day	DO ppm	pH	Temp °C
Max	268	719	330	7.2	7.7	16
Min	54	145	97	3.0	7.2	8
Avg.	171	383	219	5.0	7.3	14

1.9 Waste Stabilization Pond Loading

The loading on the conventional wsp averaged 37 lb BOD per acre per day for the August study and 25 for the October study. These are within permissible loadings for summer operation but would be high under winter conditions. The nature of the load, however, is quite different than if it were raw sewage with no pretreatment. Thus it may be possible to increase the loading beyond the recommended limits for the ordinary conventional wsp treating raw sewage.

1.10 Waste Stabilization Pond Treatment

The conventional wsp, despite the relatively high DO concentrations throughout the liquid (see Figure 6), is facultative rather than aerobic. Aerobic conditions may well have extended to the sludge layer, but the sludge and settled solids underwent anaerobic decomposition. The ammonia, nitrite, nitrate, and CO_2 produced by aerobic decomposition of the dissolved and suspended organics and the ammonia and CO_2 produced by anaerobic digestion of the settled sludge, combine in the presence of sunlight to form green algae, oxygen and water. The three phases of biological growth in the wsp are then:

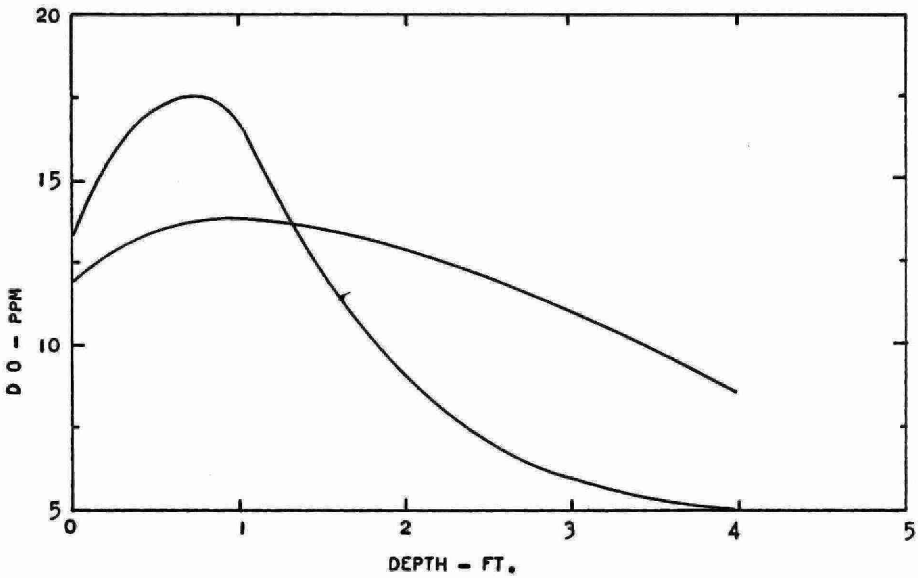


FIGURE 6 - TYPICAL D O PROFILES OF CONVENTIONAL W S P

a) stabilization of organic matter on the pond bottom,
b) stabilization of organic matter by bacteria suspended in the liquid, and
c) algae growth in the part of the liquid penetrated by light.

A disruption in any phase will affect the treatment efficiency.

Tests on the supernatant of the aeration basin effluent showed that 80% of the BOD settled out in one hour, thus the major portion of the organic matter and bacterial solids entering the wsp was subjected to anaerobic digestion.

The efficiency of the wsp differed considerably between the two studies with BOD reductions averaging 87.5% for October but only 79.2% for August. The improved floc and higher effluent DO and BOD reductions in the aeration basin during October are the more important reasons for this difference, although other factors may also have contributed to it.

Suspended solids reductions between influent and effluent, averaged 80% during both studies; that of the effluent consisting mainly of algae. Phosphorus and nitrogen reductions are presented in Table 7.

1.11 Waste Stabilization Pond Effluent

Tables 5 and 6 give the major properties of the wsp effluent. The average BOD and SS contents of the effluent were somewhat above the objectives of the OWRC. The nitrogen and phosphorus contents of the effluent are presented in Table 7, and the algae concentrations in Table 8. A microscopic examination of the wsp effluent indicated that the suspended solids were largely algae cells and not raw sewage solids or activated sludge solids, formed in the aeration basin.

Table 5

WSP Effluent Analysis for August Study

	BOD_5 ppm	Filt. BOD_5 ppm	COD ppm	SS ppm	DO ppm	pH	Temp °C
Max	129	56	322	227	6.7	8.2	27
Min	24	16	110	27	0.0	6.8	15
Avg	62	23	216	97	1.1	7.8	22

Table 6

WSP Effluent Analysis for October Study

	BOD_5 ppm	BOD_5 ppm	COD ppm	SS ppm	DO ppm	pH	Temp °C
Max	38	25	175	64	8.4	7.8	15
Min	9	4	109	13	0.0	7.3	10
Avg	24	10	136	36	4.4	7.6	13

1.12 Nitrogen and Phosphorus

Reductions in total nitrogen and phosphorus obtained throughout the system were very low, being each less than 25%. The negligible concentrations of nitrite and nitrate nitrogen and relatively high concentrations of ammonia throughout, indicate a low level of nitrification in the wsp and aeration basin. A slight increase in ammonia nitrogen appears to have occurred. Ammonia is an intermediate product of aerobic, and a final product of anaerobic decomposition of organic nitrogen and may be lost to the atmosphere as nitrogen gas, or absorbed by algae through photosynthesis.

The reductions in total and in soluble phosphate, being essentially the same, indicate that soluble polyphosphate compounds, utilized by pond biota, were being precipitated in the form of insoluble orthophosphate ion. This was in part due to algal utilization of CO_2 resulting in a raising of the pH level in the wsp.

A thorough understanding of the mechanism of nitrogen and phosphorus reduction in the system would require a much more extensive sampling program. The data obtained from the intermittent sampling can not fully represent an extensive nutrient study and must not be considered as such.

Table 7

Average Concentrations and Percent Reduction of Phosphorus and Nitrogen Compounds

	Phosphorus as PO_4 (ppm)		Nitrogen as N (ppm)	
	Total	Soluble	Total	Free Ammonia
Raw waste	34	28	44	11.4
WSP Effluent	26	21	33	12.4
% Red.	24	25	25	- 8

1.13 Algae Specie and Concentrations

Blue-green, green, flagellates and some protozoa were present in all samples of wsp effluent. No Diatoms or

Crustacca were found at anytime. According to Eckenfelder, the type of algae found active in oxidation ponds are Chlorella, Scenedesmus, Euglena and Chlamydomonas. All of these species were found in varying concentrations in the wsp. The average concentration of algae in the wsp was 15,702.86 areal standard units/ml. although the species and concentrations present varied greatly from week to week as shown in Table 8. The low algal concentrations of August 25 may have been due to a period of heavy rain and high flows, decreasing greatly the detention time in the wsp.

Table 8

Species and Corresponding Concentrations of Algae (areal standard units/ml and Zooplankton (No. per ml) of WSP Effluent

Date	August 11	August 25	Sept. 1	Sept.5
Blue-green				
Oscillatoria	180.66		3,428.59	
Anacystis		28.39	293.88	3,020.42
Green				
Micractinium	293.57	36.25	5,012.27	8,432.69
Selenastrum		25.83	1,910.21	5,142.88
Ankistrodesmus		45.16	963.27	2,040.83
Chlorella	13.55		710.21	465.31
Franceia			1,387.76	228.57
Planktospheria				2,326.54
Scenedesmus	64.52		204.08	
Lagerheimia		1,316.21	497.96	
Golenkinia	72.91	273.75		
Oocystis	47.10			
Flagellates				
Chlamydomonas	161.56	54.84	2,310.21	1,820.42
Euglena	16,425.50		2,575.53	
Totals	17,259.37	1,780.43	20,293.97	23,811.43
Average	15,702.86			
Protozoa	847	386	1,632	5,713
Average	2,145			

1.14 Coliform Densities and Reductions

The coliform group of organisms are found in large quantities in human excreta, and since human feces are the primary source of pathogenic enteric organisms, the presence in water of coliforms offers significant evidence of the potential presence of such pathogens. However, some members of the coliform group may also be found in soil and plant material. Thus no surface water would be expected to be devoid of this type of organism.

The total coliform reduction, based on logarithmic averages was 95.1%. Fecal coliform reduction determined by the confirmed test was 98.6%. However, in spite of these reductions, effluent concentrations were still high, averaging 50,540 coliforms per 100 ml and 18.5 fecal coliform per 100 ml.

PART II - SANDWICH WEST

Part II of this report is based upon grab samples of raw sewage, aeration basin effluent and wsp effluent taken through November, 1965 to March, 1966.

2.1 Program of Data Collection

Because of the remoteness of the lagoon system from Toronto, grab samples were collected during the first half of this period, whenever Research personnel were in the Windsor Vicinity. Field determinations of pH, DO and temperature were made as well as the routine analyses at the lab.

Following the annexation of Sandwich West Township by Windsor, weekly grab samples were collected and returned to the laboratory by the operators of the Little River STP in Sandwich East. Routine chemical analyses only were done on these samples.

2.2 Interpretation of Results

Table 9 presents the results of the more important chemical analyses and field determinations, when available, of the grab samples for the winter test period.

Since flow measurements were not made throughout this period, calculations and results have been limited to the use of concentration rather than mass values.

Percentage reductions have been calculated for various parameters. The infrequent sampling, and method of sampling, however, limits the validity of any conclusions based on these calculations.

Perhaps the only truly representative samples collected were those of the wsp effluent,which are the most important from the pollution point of view.

2.3 Raw Waste

The strength of raw waste appears to have varied greatly during the winter season, with BOD and SS concentrations ranging between 200 and 2,000 ppm and 107 and 718 ppm respectively. Laboratory analyses indicate adequate nutrients for bacterial growth with no trace of toxic material being found at any time. Field determinations, however, indicated high causticity in the waste at certain times.

2.4 Aeration Basin Loading

Since no flow recordings were made during this period, and since the sampling was very irregular, only an estimation of the loading can be made. Assuming an average flow of 84,600 IGD and a BOD concentration of 500 ppm, the organic loading to the aeration basin averaged 14.9 lb BOD/1,000 cu ft/day. Using the similar values, the SS load averaged 207 lb/day. Both these loadings are considerably above those of the fall period.

2.5 Aeration Basin Performance

BOD reduction within the aeration pond averaged 49% during the winter season. Observations of the basin, however, indicated somewhat lower reductions than this. The floc was much more poorly established than during the fall season and at times, treatment appeared to be very slight. As can be seen from the SS data, sludge growth was much less than during the fall. This was undoubtedly due to the cold weather and to the nature of the wastes, which were still highly caustic at times. This high causticity killed off the sludge and re-establishment of floc was slow due to the cold weather.

2.6 Aeration Basin Effluent

The effluent from the aeration basin was somewhat higher in BOD and lower in SS than during the fall study, averaging 256 and 199 ppm respectively. This is indicative of the poorer treatment during the winter. The DO content of the effluent was quite high (90% saturation) indicating poor sludge growths but good aeration.

2.7 Waste Stabilization Pond Loading

Assuming again an average flow of 84,600 IGD the average organic loading to the wsp was 31.6 lb/acre/day, a value above the recommended 20 lb/acre/day.

The suspended solids content of the influent being somewhat less than in the fall would indicate poorer settling in the wsp.

2.8 Waste Stabilization Pond Treatment

The treatment efficiency of the wsp in respect to BOD reduction was 83.5% which is comparable to that of the fall. Suspended solids reductions between influent and effluent averaged 72%. No appreciable reduction in phosphorus was found but a reduction of 36% total nitrogen occurred. The free ammonia content remained almost constant between influent and effluent indicating a very low rate of nitrification.

No odours were noticed at anytime except for slight odours in the vicinity of the outfall.

2.9 Waste Stabilization Pond Effluent

As can be seen from Table 9, the effluent from the system never met the Commission's objectives of 15 ppm BOD and 15 ppm SS. Effluent concentrations reached as high as 86 ppm BOD and 118 ppm SS. Filtered analyses, however, indicated that approximately 67% of the effluent BOD was due to algal growths.

	BOD (ppm)				SS (ppm)			pH			DO (ppm)			Temp (°C)		
	1*	2	3	3F	1	2	3	1	2	3	1	2	3	1	2	3
Nov. 1	210	145	18	6	296	198	37	6.0	7.5	7.5	-	-	-	-	-	-
Nov.25	580	200	22	8	152	262	26	7.2	7.6	7.9	4	5	10	16	12	8
Dec.14	385	290	20	3	107	218	37	10.0	9.4	7.6	3	5	13	14	8	4
Jan. 4	200	270	27	8	-	166	60	9.8	9.2	7.6	4	8	6	12	6	1
Jan.25	380	390	38	9	114	201	51	10.3	9.2	7.2	3	12	1	10	0	2
Feb. 7	200	360	41	20	272	286	118	-	-	-	-	-	-	-	-	-
Feb.14	2000	170	39	9	718	158	84	-	-	-	-	-	-	-	-	-
Feb.22	-	265	80	52	-	126	64	-	-	-	-	-	-	-	-	-
Feb.25	240	180	51	22	120	138	38	8.3	7.4	7.4	2	8	1	11	4	3
Mar. 8	350	290	86	8	180	238	24	-	-	-	-	-	-	-	-	-
Aug.	504	256	42	14	245	199	54	8.6	8.4	7.5	3.2	7.6	6			

* Numbers refer to location of sample.
1 - raw waste; 2-aeration basin effl.; 3-WSP effluent; 3F-filtered WSP effluent

Table 9. Waste analyses for Winter Study period.

PART III - SANDWICH WEST

Part III of this report deals with a continuous field investigation performed during the period April 4 to April 28, 1966.

3.1 Program of Data Collection

The sampling procedure and the tests performed were similar to those set up for Part I of this study. Difficulties, however, were found in obtaining a 24 hr. composite sample of raw waste during the latter half of the study because of pumping problems. Thus, several grab samples were taken and combined into one composite sample each day.

A greater emphasis was placed on oxygen uptake rate determinations during this study. A total of 12 determinations were made employing a respiration cell, and E.I.L., DO meter and a recorder.

No coliform determinations were made during this study.

3.2 Interpretation of Results

Because of the long detention periods and the variable daily flows and waste strengths involved, most calculations have been based on mass balance values rather than concentrations. In all efficiency calculations, allowances were made for changes in concentrations within the aeration pond.

3.3 Raw Waste

Table IO presents the important properties of the raw waste for this test period. The variable strength of the raw waste may be noted; BOD values ranged between 796 and 158 ppm and SS ranged between 393 and 58 ppm. Daily flows are shown in Fig. 7, the average flow rate being 95,900 gpd.

Again, high fluctuations were observed in pH values and high causticity was observed for varying lengths of time, also peculiar to this study was a strong odour of gasoline in the raw waste, particularly during the first part of the week.

TABLE 10

RAW WASTE ANALYSIS FOR APRIL STUDY

	BOD (ppm)	BOD (lb/day)	SS (ppm)	SS (lb/day)	DO (ppm)	pH	Temp. (°C)
Max.	796	834	393	304	12	10.8	14
Min.	158	154	58	60	1.4	6.4	8
Avg.	437	366	165	154	6.4	8.5	12

3.4 Aeration Basin Performance

The organic loading to the aeration basin varied greatly from day to day, but averaged 12.5 lb BOD/1000 cu.ft/day, a relatively high loading for this type of system. COD and SS loadings averaged 735 and 154 lb/day, respectively. As has already been noted, the raw waste varied considerably in pH also, and resulting high causticity in the aeration basin again upset treatment for short periods of time, although at no time was the floc completely killed off.

BOD removal in the aeration basin averaged approximately 40% during the April study but this efficiency

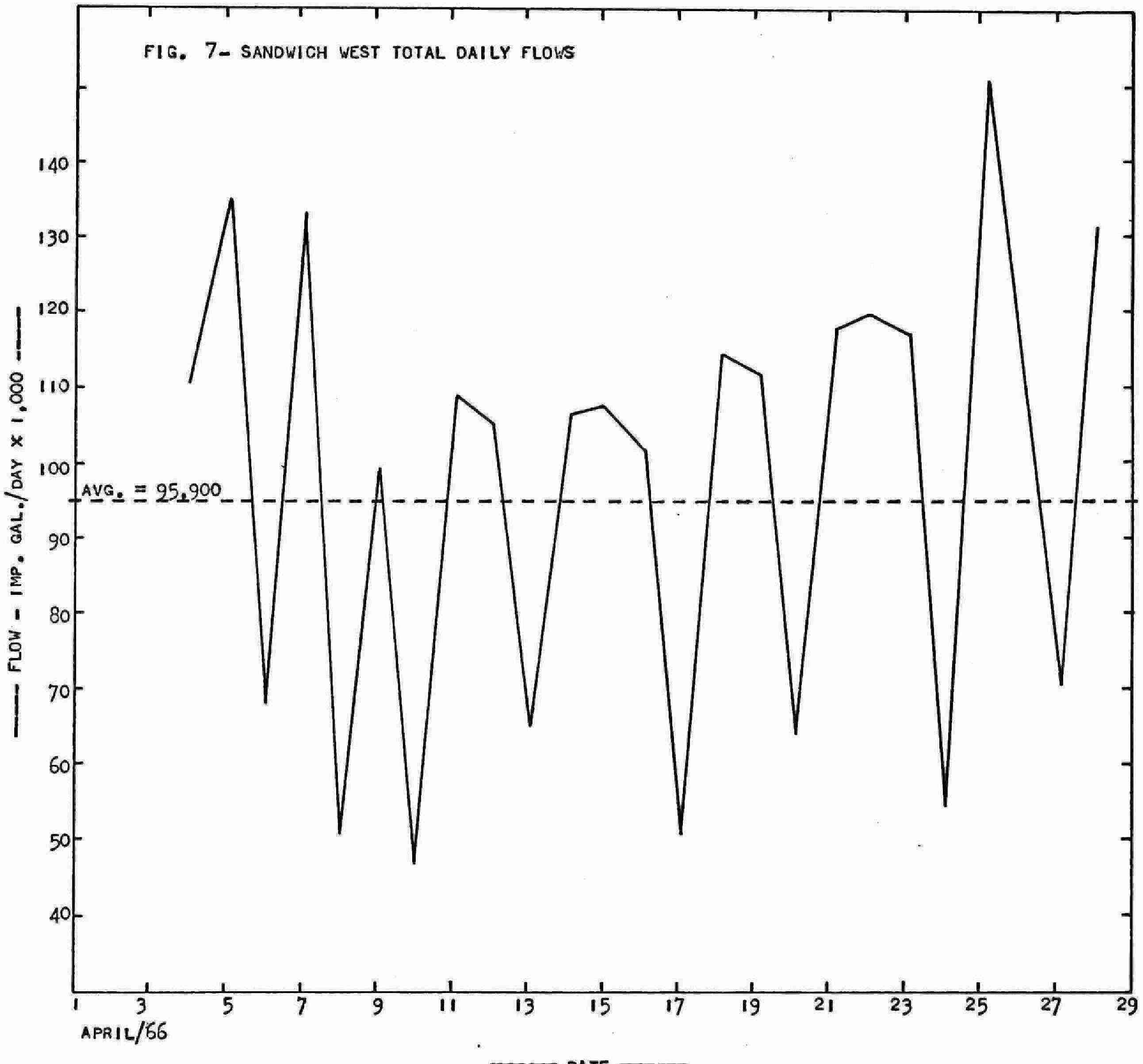


FIG. 7- SANDWICH WEST TOTAL DAILY FLOWS

value fluctuated greatly. DO levels within the aeration basin mixed liquor were maintained at about 60% saturation with no excessively low values being experienced at any time.

Table 11 gives the important properties of the basin effluent. Microscopic examination revealed that the effluent quality was primarily related to the excess microbical solids and approximately 80% of the BOD generally settled out in less than 1 hour.

TABLE 11

AERATION BASIN EFFLUENT FOR APRIL STUDY

	BOD (ppm)	BOD (lb/day)	SS (ppm)	SS (lb/day)	DO (ppm)	pH	Temp. (°C)
Max.	308	413	479	505	9.8	9.4	16
Min.	114	89	223	134	4.2	7.4	0
Avg.	228	154	340	340	5.9	7.8	8

3.5 Mechanical Aerator Performance

The mechanical aerator was very effective in keeping the contents of the aeration pond well mixed and well aerated. Very little sludge settling occurred and the D.O. gradient was found to be less than 1.5 ppm throughout the depth of the basin. At no time was the DO measured at less than 4 ppm and it averaged 5.9 ppm during the study.

Oxygen uptake rate determinations indicated an uptake rate averaging 3.7 ppm/hr. yielding an oxygen transfer rate of approximately 2.17 lb/EHP-hr. A reasonably heavy flocc was maintained, except for instances of high causticity, with an overall average of 340 ppm SS.

3.6 Waste Stabilization Pond Treatment

The loading to the WSP during the April study, averaged 33.4 lb/acre/day and ranged anywhere between 61 and 13. Effluent concentrations of BOD and SS averaged 48 and 96 ppm respectively, consisting mainly of algal cells. Filtered effluent BOD averaged 11 ppm.

BOD reduction in the WSP averaged 79% while SS reduction averaged approximately 80%.

Dissolved oxygen levels in the WSP effluent increased with increasing algal production as temperatures warmed up. DO concentrations were as low as 0.5 ppm during the first week in April, but reached as high as 20 ppm towards the end of the month.

No obnoxious odours were noticed throughout the study except for slight odours at times in the over-flow weir structure. No rising sludge was found at any time.

Table 12 gives the important properties of the WSP effluent for the April study.

TABLE 12

WSP ANALYSIS FOR APRIL STUDY

	BOD (ppm)	Filt. BOD (ppm)	SS (ppm)	DO (ppm)	pH	Temp. (°C)
Max.	63	16	249	20	8.8	14
Min.	29	5	8	0.4	7.3	4
Avg.	48	11	96	6.5	8.1	12

SUMMARY

The performance of the Sandwich West industrial lagoon, in respect to BOD and SS reductions, varied considerably throughout the study period (See Table 14). Many factors entered into these variations. The efficiency of the aeration basin and thus upon the entire process appeared to be most highly dependent upon the pH of the raw waste, while that of the lagoon was primarily dependent upon the settleability of the aeration basin effluent and upon the algae content in the lagoon effluent.

The treatment achieved in the October period may be considered as ideal for this method of waste water treatment, and the other periods may be compared to it. During October the raw waste imposed no caustic shock loads to the aeration basin, temperatures were moderate for bacterial activity and, although algal densities were sufficient to supply adequate oxygen to the lagoon contents, no large concentrations appeared in the effluent. As seen from Table 13, overall BOD reductions of 94% were experienced with effluent BOD and SS concentrations averaging 24 and 36 ppm, respectively.

During the August study high causticity shock loads were experienced in the raw waste with resultant BOD reduction in the aeration basin of only 35%. Algal densities were relatively low in the lagoon effluent, but overall BOD and SS reductions were poor because of the poor quality of the aeration basin effluent.

During the Winter Season, treatment was somewhat poorer than during October because of the colder temperatures involved. Because of the decreased algal densities due to ice cover, however, an overall efficiency of BOD removal in the order of 92% was experienced.

During the April study, treatment was again poor because of the caustic shock loads to the aeration basin, the lower temperatures and the high algal densities in the lagoon effluent. Treatment in the spring is generally poor, however, because of the turnover of the lagoon contents.

TABLE 13

TREATMENT EFFICIENCIES OF THE FOUR PERIODS OF STUDY

	% BOD Removal			% SS Removal	Effluent Conc. (ppm)		
	A.B.	WSP	Overall	Overall	BOD	Filt.BOD	SS
Aug. 1-Sept.4	35	79	86	44	62	23	94
Oct.11-Oct.25	53	88	94	75	24	10	36
Nov.-April	49	84	92	78	42	14	54
April 4-Apr.28	40	79	88	42	48	11	96

CONCLUSIONS

From the results of this study, it was seen that the poorest treatment occurred during August when environmental conditions for this type of treatment should have been at their best. Thus, the nature of the waste is more important in determining treatment efficiency than environmental conditions. Wastes of high pH (9-10) are less effectively treated, in this installation, than wastes of low pH (5-6).

The growth of algae in the wsp is also a determining factor in total BOD and SS removal. Under periods of too low algal growth, treatment may be poor because of lack of oxygen in the wsp contents. Under periods of excessive algal growth, the indicated treatment may also be poor because of high algal densities in the effluent yielding high effluent BOD and SS concentrations.

Overall treatment is reduced considerably during low temperatures of the winter season.

RECOMMENDATIONS

In the light of the study completed at Sandwich West the following recommendations are presented for the effective operation of aerated lagoons treating industrial wastes:

1) That some buffering system be employed to control the pH of the raw waste to between 4.0 and 8.5.

2) That a holding tank with gravity sludge return and 2 hour retention be incorporated in the aeration basin effluent system.

3) That the volume of the lagoon be decreased during the spring and summer period to reduce retention time and thus reduce algal densities in the effluent.

4) That the effect of algal populations on the receiving stream be determined and perhaps a different interpretation be made for effluent BOD and SS concentrations if such are largely due to algae.

5) That the retention time in the aeration basin be no less than 2.5 days.

6) That the oxygen transfer rate of the aeration device be such as to maintain a dissolved oxygen content of at least 2 ppm in the aeration basin at all times, and that the turbulence created by the aeration device be such as to maintain settleable solids in suspension.

7) That the wsp be composed of at least two cells in series.

The foregoing is based on the assumption that adequate nutrients are available in the raw waste.