Chapter IV

PRESENTATION AND DISCUSSION OF RESULTS

In - Plant Study

There are two kinds of soya - bean cake, hard soya - bean cake and soft soya - bean cake. In the production process, the quantity and strength of waste water from soft soya - bean cake production is lower than waste water from hard soya - bean cake production. In this research, only hard soya - bean cake waste water was studied.

The processing line of hard soya - bean cake is illustrated in Fig 3. Soya - bean is washed and submerged in water at least four hours. Later, washed soya - bean is milled, soy milk is separated by screen with centrifugal force. Solid waste is used as animal food, soy milk is boiled and poured to coagulating tank. $MgSO_4$ is used as coagulant to separate waste water from bean slurry. The bean slurry is passed to cake making part, water separated from this part by compressive force is one of sources of waste water. Bean cakes are submerged in sodium chloride solution for a while, and then boiled with yellow liquid in producing the yellow bean cake.

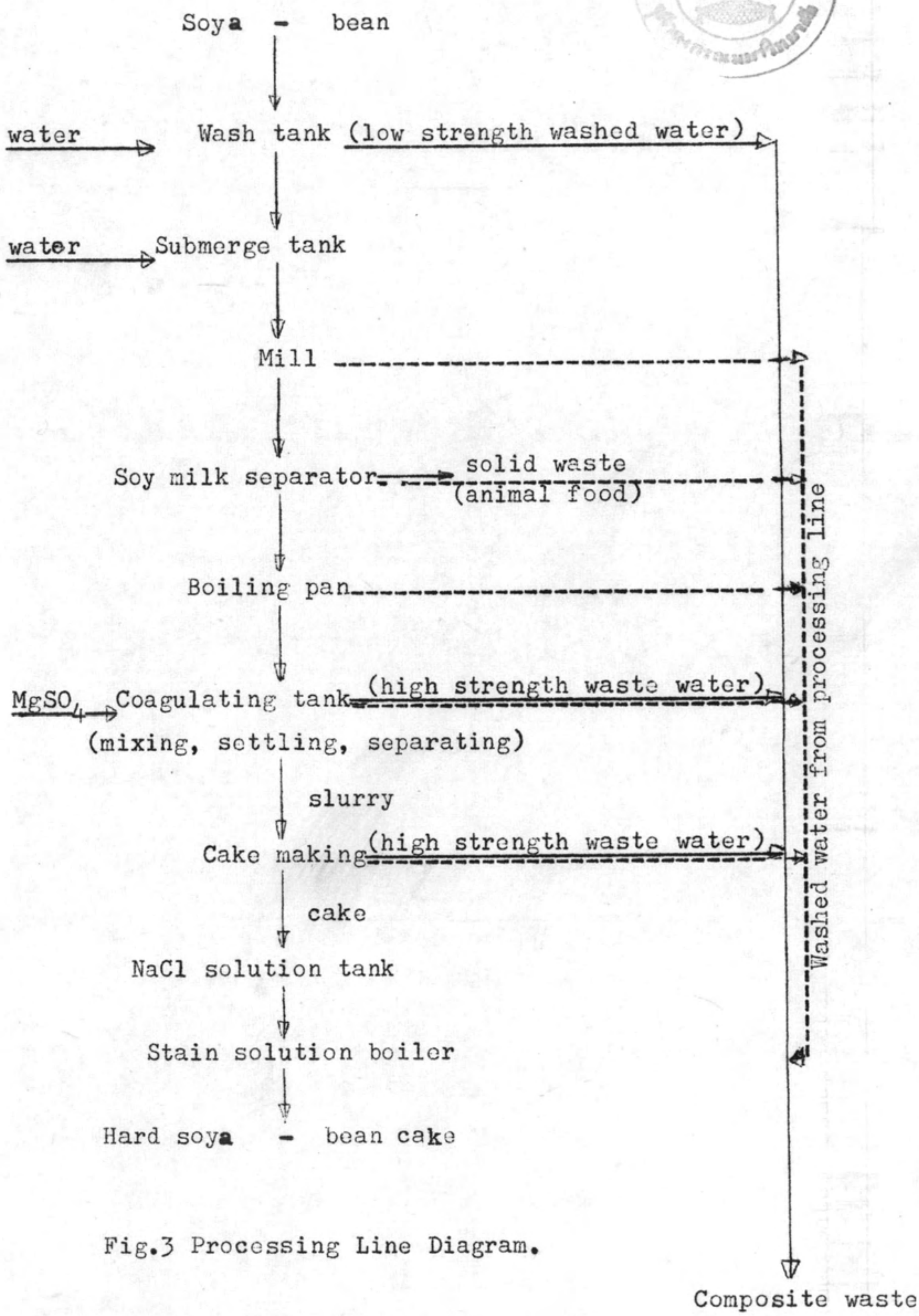


Fig.3 Processing Line Diagram.

Main sources of waste water are as following.

1. Washed water from wash tank is very low in organic matters and high in grit, sand and soil.
2. Waste waters from coagulating and cake making part are concentrated wastes with high in organic substances.
3. Washed water from processing line which is in a large quantity is low in organic matters and is used to dilute the high strength waste water.

Waste waters and washed waters were mixed in a channel as composite waste

Due to batch production process, waste flow in channel was not measured.

It is estimated that the water use is about 190 - 210 l per 10kg of soya - bean used and waste generation is about 180 - 200 l per 10 kg of soya - bean used.

The frequency of washing equipments and machines is directly related to the variety of waste water volume and characteristics and is related to volume of water use. So the volume of water use can be reduced if there is good order of work. In order to reduce the waste water volume to be treated, washed water from wash tank should be passed through coarse solid separator and then be discharged directly to stream.

Waste Water Analysis

The results of raw characteristics analyzed are shown in Table 1.

COD and BOD_5 The variation of COD of waste water during the six hour operation is shown in Fig 4. The variation in COD and BOD_5 depends on the work order and the processing method. The average COD ranges from 3631.4 - 6621.6 mg/l. The difference between maximum COD, 10798 mg/l and minimum COD, 1052 mg/l is very high, indicating that the strength of waste discharged is very fluctuate. This fluctuation is due to management of workers and work order. The ratio of BOD_5 to COD is 0.65 to 0.96, the average ratio is 0.82, indicating the high biodegradability properties of this waste.

Probability curve for COD has been done and shown in Table 2 and Fig 5 . The COD of waste water used as design criteria is 6000 mg/l, with 60 per cent of chance that the waste will have a COD content lower than 6000 mg/l. Compared this value to average value, it is higher providing safety factor for design purpose. More than 60 per cent probability can be used but it is not economic in construction of treatment plant. At 60 per cent certainty, COD discharged is 1.14 kg per 10 kg soya - bean used.

Table 1. Raw characteristics of soya- bean cake waste waste water.

Date, time	COD mg/l	BOD_5 mg/l	TS mg/l	SS mg/l	Settleable Solids ml/l	NH_3-N mg/l	Org-N mg/l	P mg/l	pH
12th Nov.74									
8 AM	6,3[illegible]	5250	-	-	-	-	-	-	-
9 AM	5,353.7	3800	9,852	-	-	134.08	948.06	-	-
10 AM	10,097.5	-	13,504	-	-	51.74	-	-	-
11 AM	6,118.5	-	6,360	-	-	79.66	1047.43	-	-
12 AM	5,506.7	-	7,048	-	-	-	-	-	-
14th Nov.74									
8 AM	2,737.6	-	4,456	1,952	-	97.80	678.30	-	-
9 AM	9,733.8	-	15,380	7,600	-	-	-	-	-
10 AM	3,954.4	-	8,172	960	-	-	-	-	-
11 AM	6,387.8	-	8,526	2,250	-	56.79	1,293.52	-	-

Table 1. (continue) Raw characteristics of soya - bean cake waste water.

Date, time	COD mg/l	BOD_5 mg/l	TS mg/l	SS mg/l	Settleable Solids ml/l	NH_3-N mg/l	Org-N mg/l	P mg/l	pH
12 AM	10,798.5	-	10,984	3,150	-	88.34	1,533.29	-	-
1 PM	1,795.0	-	5,788	2,020	-	86.80	669.76	-	-
8th Jan.75									
8 AM	3,595.1	3,262.5	5,996	1,640	65	83.44	1,352.96	56	4.63
9 AM	6,753.0	5,487.5	11,336	1,190	35	49.50	2,166.08	512	4.21
10 AM	7,578.9	6,557.1	13,034	7,050	350	89.60	2,714.88	123	4.65
11 AM	1,052.6	1,013.0	2,154	630	32	42.65	468.16	39	5.20
12 AM	4,404.9	3,241.6	6,098	1,520	100	98.90	1,428.00	140	4.87
1 PM	5,860.0	-	12,542	2,700	-	-	1,581.44	415	4.28
10th Jan75									
8 AM	6,630.0	3,720	11,670	972	12	57.4	1,129.8	-	4.05

Table 1. (continue) Raw characteristics of soya - bean cake waste water.

Date, time	COD mg/l	BOD_5 mg/l	TS mg/l	SS mg/l	Settleable Solids ml/l	NH_3-N mg/l	Org-N mg/l	P mg/l	pH
9 AM	2,672.4	2,400	14,352	1,788	30	5.6	543.9	90	4.70
10 AM	2,960.0	2,700	5,388	2,501	118	12.6	721.0	52	4.80
11 AM	1,121.0	-	2,960	973	30	9.8	358.4	29	4.60
12 AM	1,675.0	-	2,874	1,313	45	2.1	317.8	10	6.05
1 PM	6,730.0	4,400	12,728	2,300	70	34.30	1,468.6	-	4.30
12th Jan.75									
8 AM	7,063.6	-	23,318	2,273	-	78.4	1,691.0	415	3.8
9 AM	5,010.2	-	9,906	1,830	-	41.44	1,272.32	245	4.1
10 AM	8,357.3	-	14,788	2,340	-	45.92	1,937.60	355	4.1
11 AM	5,770.0	-	11,398	1,570	-	60.48	1,346.24	305	4.1
12 AM	4,928.1	-	9,244	1,260	-	36.96	1,041.60	260	4.1

Table 1. (continue) Raw characteristics of soya - bean cake waste water.

Date, time	COD mg/l	BOD_5 mg/l	TS mg/l	SS mg/l	Settleable Solids ml/l	NH_3-N mg/l	Org-N mg/l	P mg/l	pH
1 PM	7,412.7	-	13,562	750	-	-	1,307.40	510	4.5
16th Jan. 75									
8 AM	6,050.	-	12,658	2,410	60	125.62	1,848.0	490	4.12
9 AM	5,552.	-	12,342	2,700	70	154.56	1,736.0	525	4.05
10 AM	4,550.	-	10,964	1,100	20	86.24	1,292.48	470	4.12
11 AM	4,250.	-	9,624	960	24	126.56	1,197.28	360	4.15
12 AM	1,598.	-	5,412	540	-	179.2	644.0	180	4.18
1 PM	3,190.	2,337	3,206	312	-	72.8	296.8	25	4.78

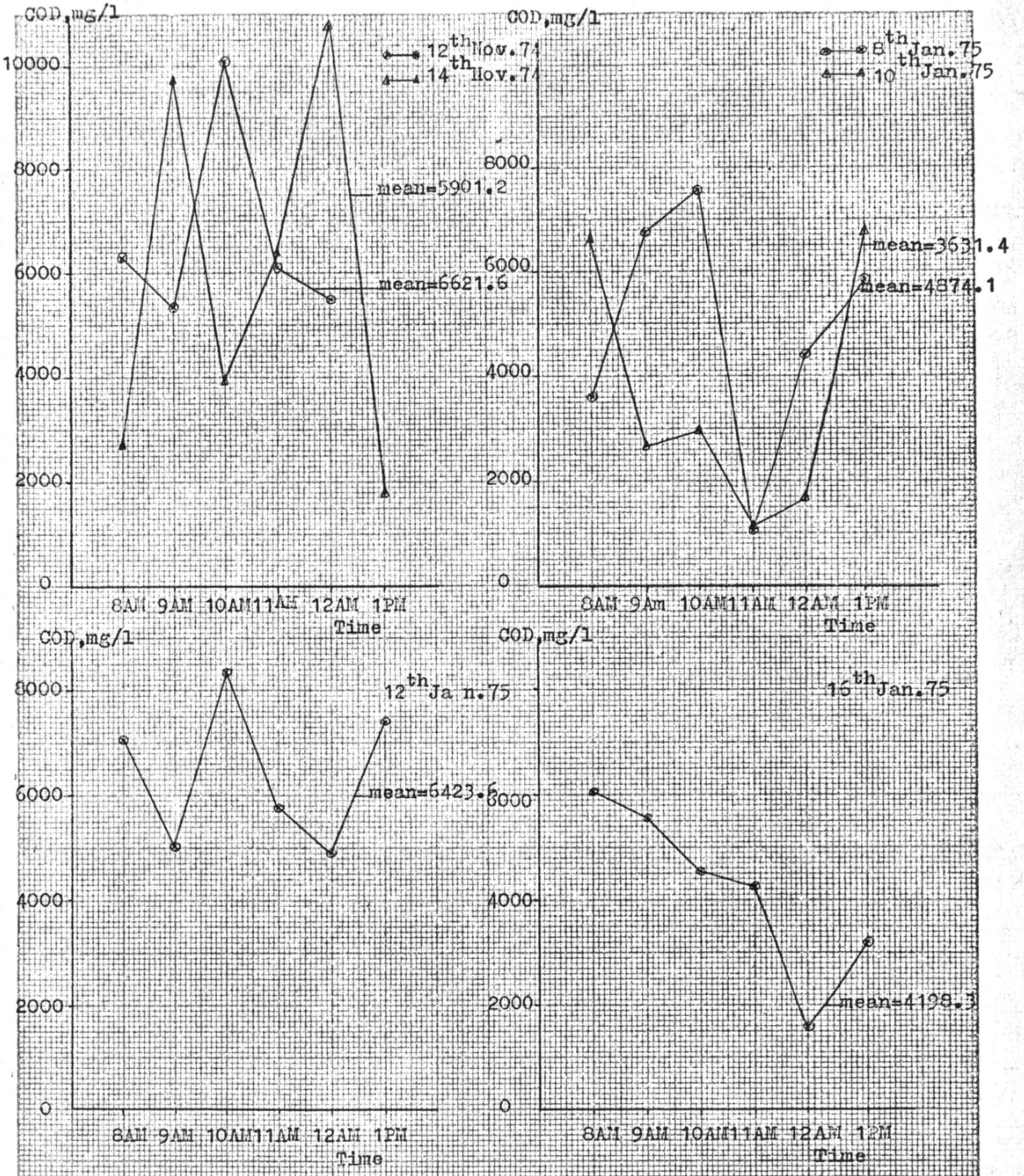


Fig.4 COD Variation of Raw Waste Water

Table 2. Probability of COD in raw waste.

Range of COD mg/l	frequency ,f	% of time valve equal or less than
1000 - 2000	5	14.28
2000 - 3000	3	22.86
3000 - 4000	3	31.48
4000 - 5000	4	42.86
5000 - 6000	5	60.00
6000 - 7000	7	80.00
7000 - 8000	3	88.57
8000 - 9000	1	91.43
9000 - 10000	1	94.29
10000 - 11000	2	100.00
	$\Sigma f=35$	

% of time value equal or less than $= \frac{\text{accum.f}}{\Sigma f} \neq 100$

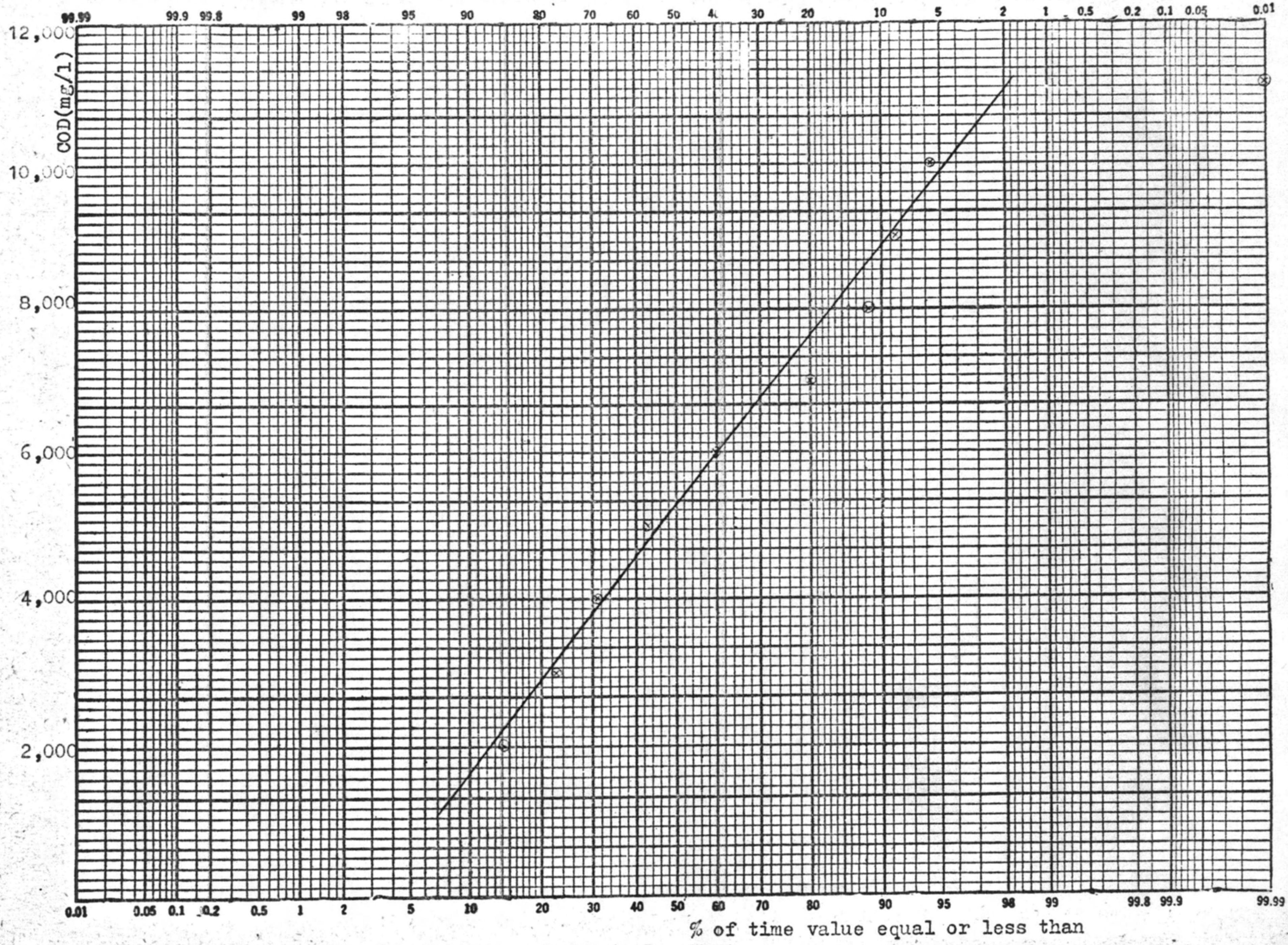


Fig.5Probability of COD in Raw Waste

Solids The variation of suspended solids, total solids, and settleable solids of waste is shown in Fig 6 . Suspended solids of waste water vary from 312 to 7600 mg/l. The volume of settleable solids ranges from 12 to 350 ml/l indicating that a large portion of the solids present in the waste water can be removed by plain sedimentation. The total solids values are 2154 to 23,318 mg/l (0.215 - 2.332 per cent), indicating the highly polluting character of waste water. The high variation in suspended solids, settleable solids and total solids depends on the sources of waste waters discharged. If it is discharged from coagulating tank and cake making part, the total solids will be high but suspended solid and settleable solid will be low. Washed water from processing line will be high in suspended solids and settleable solids but low in total solids.

Nitrogen Nitrogen is one of the essential nutrients required for efficient stabilization of an organic waste and nitrogen deficiency retards the rate of biological reactions Sorab. J. Arceivala (1973) stated that the minimum nitrogen required per BOD removed for conventional activated sludge is 1 : 20. The results of nitrogen analysis are shown in Table 1 . The COD : N ratios for these raw waste samples are from 100:11.58 to 100:51.5, the average ratio is 100:28.1 which is sufficient for biological stabilization.

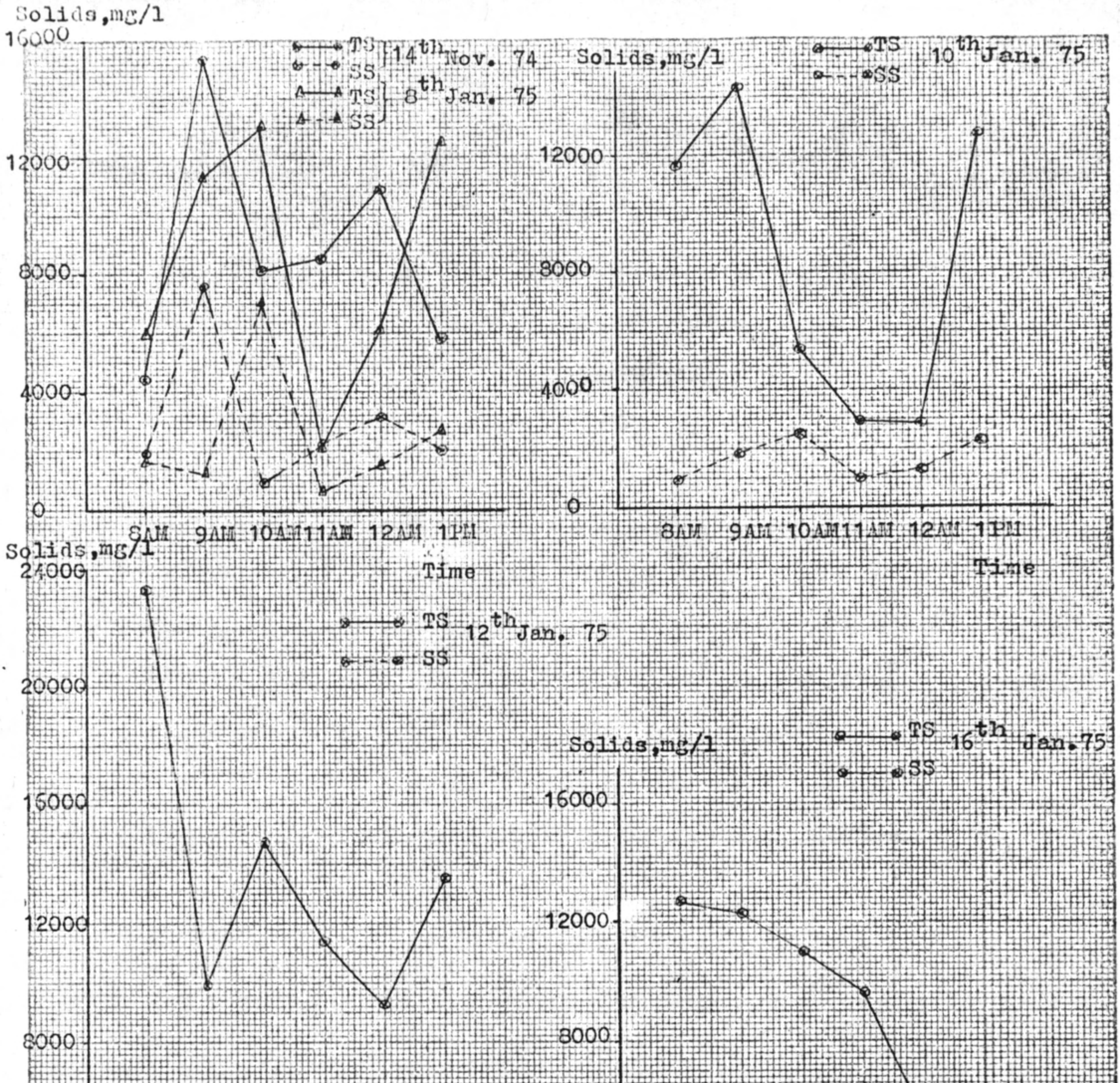


Fig.6 Total Solids and Suspended Solids Variation of Raw Waste Water

Phosphorus Phosphorus is another one of the essential nutrients required for efficient stabilization. The minimum phosphorus required per BOD removed for conventional activated sludge is 1:100. From the results of analysis of waste samples, Table 1 , COD : P ratios are from 100 : 0.60 to 100 : 11.26, average ratio is 100 : 5.06 which is sufficient for biological stabilization.

pH The variations of pH of waste waters are shown in Table 1 . The pH of waste water from coagulating and cake making is low but the pH of washed water is higher. The pH of composite waste is in the range of 3.8 - 6.05. Most organisms can not tolerate pH levels above 9.5 or below 4.0 generally, the optimum pH for growth lies between 6.5 and 7.5 If the pH drops to lower than 6.5 fungi will grow, the optimum pH of fungi growth is 5.6 . So neutralization and buffer solution is required to control pH of the treatment system for this waste.

It can be seen from Table 1 that the characteristics of wastes are continually variable. The pattern of variation cannot be predicted. These phenomena depend on the work order and the frequency of machine and tool washing. This will cause problems in biological waste treatment methods. Shock loading may occur, so equalization basin is needed before waste water is fed into biological treatment plant.

Analysis of Treatment Alternative

From waste water characteristics, solid separation, equalization,neutralization and biological treatment process are necessary because of high suspended solids and settleable solids, high variation of waste characteristies, low pH value and high ratio of BOD_5 to COD, **high dissolved solids, respectively.**

Plain sedimentation is often the most economical method of solid separation for waste water of high suspended solids and high settleable solids. Chemical coagulation process which can be used to reduce suspended and colloidal substances of waste water has been considered as an uneconomical method for this waste because of high cost of chemical used. $MgSO_4$ in the process of coagulation of bean slurry is high enough to remain in waste water so only plain sedimentation is necessary for solid separation.

The variation of waste characteristics will cause the problem of shock loading in biological treatment methods. So equalization basin is needed.

In the experiment, K_2HPO_4 was used to rise pH of waste water to neutrality and phosphate b.ffer was used to control pH to neutrality.

Biological Treatment Process

The effluent from plain sedimentation still contains relatively high concentration of BOD_5, COD, **SS, and dissolved solid.** Its direct discharge to a stream will certainly give pollution problems, so some process of secondary treatment of this waste is desirable. High ratio of BOD_5 to COD indicates that the waste contains high biodegradable organic matters. Biological treatment process should be used.

Biological Treatment Methods Consideration

Both aerobic and anaerobic process are biological treatment process. The selection of method depends primary on the characteristics of wastes, geographical location, and effluent requirements of regulatory agency.

Anaerobic process should not be used for food industry because it will cause obnoxious smell. Anaerobic pond requires much land space. Waste water of high sulphate is not suitable for anaerobic process because it will obstruct the activity of anaerobic microorganisms. Compared with aerobic decomposition, anaerobic treatment has the great disadvantage that the effluent almost invariably contains hydrogen sulphide, and is therefore foul - smelling and also appears black or dark in color. Even if the organic matter is largely decomposed, such effluents exert a large direct oxygen demand and consequently are unsuitable in many cases for direct disposal into natural waters or on to land. Such disposal may give rise to odor nuisance.

Many types of aerobic process, namely, activated sludge, oxidation pond, aerated pond, trickling filters, and bio-discs are considered to be used for treatment of waste water. Compare with activated sludge, trickling filters require more land space, are more dificulty to install, and mostly effect a lower degree of purification, while also cause odors, flies and worm nuisances.

Bio-discs, like trickling filter, may cause odors, flies and worm nuisances.

Oxidation pond is the cheapest method but requires much land space. Unbalance between aerobic and anaerobic in facultative pond causes obnoxious odors.

Aerated pond requires less land space than oxidation pond and low operating cost. Aerated pond should be a process suitable for this waste but this research excludes this process.

Activated sludge process, requires less land but high operating cost, does not cause unesthetic problems. Activated sludge is the process to be considered in this study even it is more sensitive to changes in composition of the incoming wastes, its operation is less simple and it produces more sludge to be disposed of.

Laboratory Evaluation

Plain Sedimentation

One principle commonly applied in waste treatment is separation of solids from the liquid phase to reduce the load on subsequent treatment units, to prevent the formation of sludge banks, to reduce oxygen demand in recieving streams and to offer the possibility of recovering a saleable product. Plain sedimentation is often most economical method of solid separation.

Investigation were also made to determine the pattern of suspended solids, total solids, BOD_5, COD and organic nitrogen removals over an extended period of sedimentation and the results obtained for a typical sample of setteld wasteare shown in Fig 7 . It can be deduced that the percentage removals of COD, BOD_5, total solids, suspended solids or organic nitrogen over 15, 30, 60 and 120 min. of quiescent sedimentation are almost the same. The longer period of quiescent sedimentation which gives the lighter weight of sediment indicates that septic action is taking place and in practice, the sludge should be removed more promptly. The results of experiment are presented in Table 3 . These data show that, for samples tested, suspended solids, total solids, BOD_5, COD and organic nitrogen removals are 51.75 -

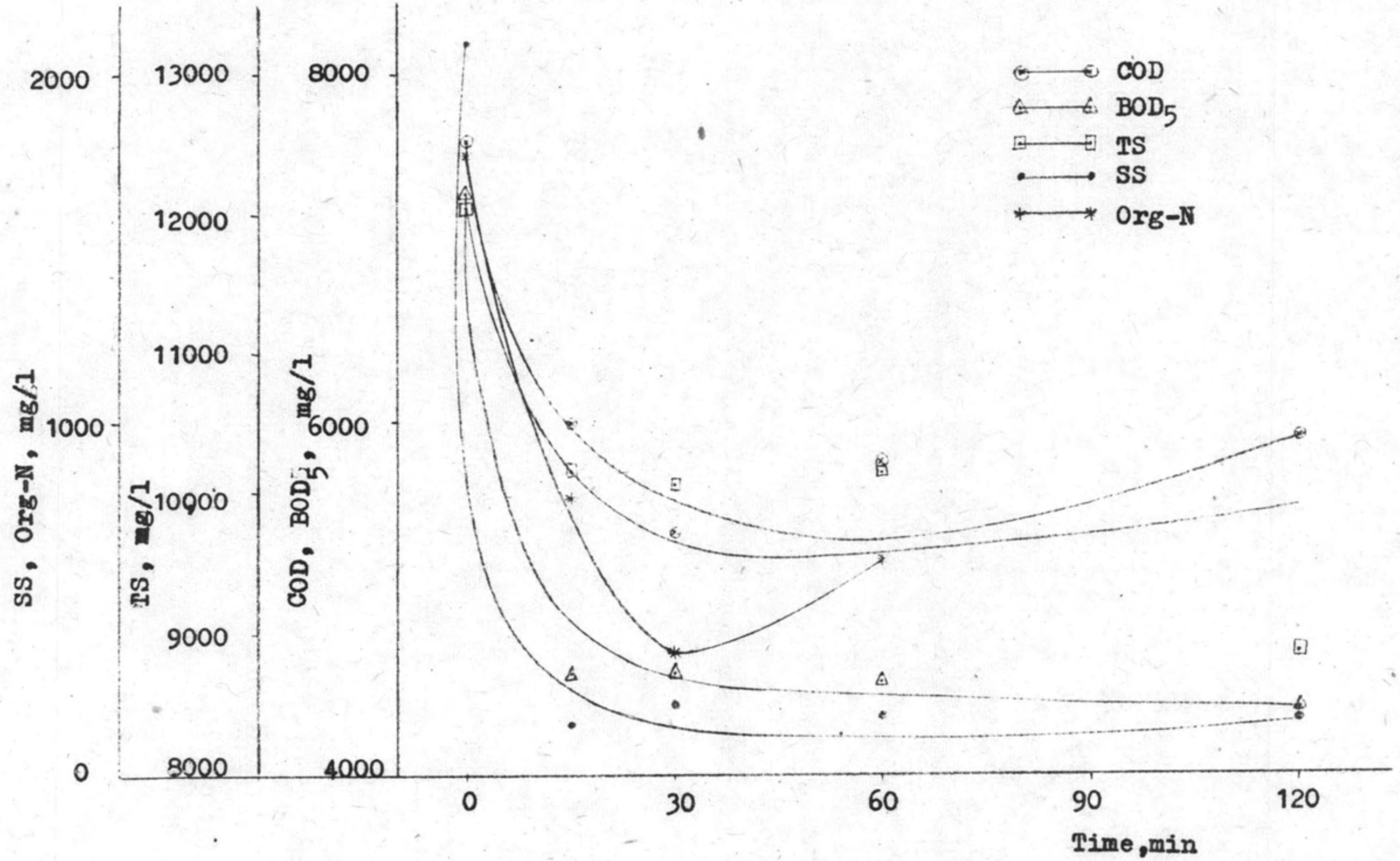


Fig.7 Effect of Plain Sedimentation on a typical sample

Table 3. Results of plain sedimentation study.

Date, Detention time, min	COD mg/l	%COD removal	BOD_5 mg/l	$\%BOD_5$ removal	TS mg/l	%TS removal	SS mg/l	%SS removal	Org-N mg/l	%Org-N removal	NH_3-N mg/l	P mg/l	pH
17th Nov.74													
0	7615.4		7320		12,058		2,096		1772.12		40.80	-	-
15	6000.0	8.80	4580	37.42	10,188	15.50	144	93.2	788.48	55.5	40.60	-	-
30	5384.6	16.28	4580	37.42	10,050	16.63	204	90.3	341.04	80.7	32.20	-	-
60	5784.6	10.92	4520	38.00	10,150	15.81	168	92.0	610.48	65.5	43.96	-	-
120	5846.2	10.11	4380	40.20	8,704	27.80	156	92.5	-	-	-	-	-
19th Nov.74													
0	7593.8		7480		9,816		1096		-	-	-	-	-
15	6281.3	17.3	6100	18.44	9,532	2.90	528	51.75	-	-	-	-	-
30	6812.5	10.3	5720	23.50	9,514	3.08	456	58.30	-	-	-	-	-
60	-	-	6420	14.16	9,466	3.56	216	80.02	-	-	-	-	-
120	7187.5	6.06	5500	26.45	9,192	7.37	220	79.80	-	-	-	-	-

Table 3. (continue) Results of plain sedimentation study.

Date, Detention time, min	COD mg/l	%COD removal	BOD_5 mg/l	%BOD_5 removal	TS mg/l	%TS removal	SS mg/l	% SS removal	Org-N mg/l	%Org-N removal	NH_3-N mg/l	P mg/l	pH
23th Nov.74													
0	2114.9		1450		3,466		1212		-	-	-	-	-
15	1042.1	50.7	900	37.9	2,354	32.1	80	93.3	-	-	-	-	-
30	1164.7	45.0	-	-	2,152	37.9	52	95.6	-	-	-	-	-
60	1195.4	43.5	-	-	2,216	32.8	-	-	-	-	-	-	-
120	1118.8	47.1	975	32.8	2,160	39.2	40	96.5	-	-	-	-	-
24th Nov.74													
0	6293.4		-		9,674		1432						
15	4749.0	24.55	-	-	8,844	8.54	328	77.1					
30	4749.0	24.55	-	-	-	-							
60	4749.0	24.55	-	-	-	-							
120	4440.2	29.46	-	-	-	-							

Table 3. (continue) Results of plain sedimentation study.

Date, Detention tim, min	COD mg/l	% COD remo-val	BOD_5 mg/l	$\%BOD_5$ remo-val	TS mg/l	%TS remo-val	SS mg/l	%SS remo-val	Org-N mg/l	%Org-N remo-val	NH_3-N mg/l	P mg/l	pH
11th Jan.75													
0	1774.0		-		3,888		1488		470.4		6.72	28	5.0
15	917.0	48.25	-	-	2,736	29.60	172	88.4	237.44	49.5	6.72	22	5.13
30	890.2	49.76	-	-	2,542	34.60	88	94.0	234.08	50.0	6.72	28	5.2
60	823.3	53.50	-	-	2,590	33.35	140	90.6	194.88	58.5	6.72	28	5.25
120	769.7	56.50	-	-	2,710	30.30	156	89.5	238.56	49.3	6.72	21	5.24
13th Jan.75													
0	5892.8		5512		10,518		1330		1153.6		76.16	340	4.31
15	5039.7	14.5	4650	15.64	9,580	8.92	475	64.25	1074.1	6.88	62.72	380	4.31
30	5000.0	15.15	4855	11.92	9,884	6.03	420	68.40	1086.4	5.82	68.32	360	4.35
60	5198.4	11.8	4875	11.56	9,750	7.30	450	66.20	1070.7	7.18	62.72	380	4.32
120	4801.6	18.5	-	-	9,728	7.50	350	73.70	706.7	38.7	-	415	4.32

Table 3. (continue) Results of plain sedimentation study.

Date, Detention time, min	COD mg/l	%COD removal	BOD_5 mg/l	%BOD_5 removal	TS mg/l	%TS removal	SS mg/l	%SS removal	Org-N mg/l	%Org-N removal	NH_3-N mg/l	P mg/l	pH
14[th] Jan.75													
0	5714.3		-		8700		1970		1161.4		65.52	275	4.12
15	4096.9	28.33	-	-	7460	14.26	540	72.6	828.8	28.6	99.68	255	4.15
30	4096.9	28.33	-	-	7490	13.90	540	72.6	688.8	40.7	92.40	235	4.16
60	3809.5	33.35	-	-	7542	13.33	600	69.5	-	-	96.32	210	4.17
120	3727.4	34.80	-	-	7416	14.76	520	73.6	788.5	32.1	82.32	275	4.15

96.50, 219 - 39.2, 11.56 - 40.2, 1.06 - 56.5 and 5.82 - 80.70 per cent, respectively. The ranges of these removals are wide because the variations of concentration, suspended solids and total solids of waste waters. For waste water of low suspended solid, the removals of COD, BOD_5, suspended solids, total solids and organic nitrogen are low and will be lower for waste of higher concentration or soluble solids. For waste water of high suspended solids, the removals of COD, BOD_5, suspended solids, total solids and organic nitrogen are high and will be higher for waste of lower concentration.

To prevent the rising of sludge to the susface caused by septic action, short period of quiescent sedimentation as 30 min. should be suitable. The results of these tests show that plain sedimentation is likely to prove highly efficient as a treatment method for raw waste. If the conditions of the 30 min. laboratory sedimentation test could be accomplished in practice then an average removals of suspended solids, total solids, BOD_5, COD, and organic nitrogen would be approximately, 79.87, 18.69, 24.28, 27.04, and 44.3 per cent, respectively. The average ratios of COD : N and COD : P of settled waste are 100 : 21.55 and 100 : 5.28, respectively.

Biological Treatability Study

The results of biological treatability study are presented in Table 4 . The average total COD removal is 93.3 per cent for 23 hr. aeration with suitable environmental conditions such as pH, air, and nutrients indicating the high treatability of this waste water.

Batch - fed Activated Sludge Process

The change of COD, MLVSS and MLSS over the aeration time in the system were determined and shown in Table 5 . The relationsphips between COD, MLVSS and dentention time were shown in Fig 8 . The results indicate the effect of detention time and MLVSS on the efficiency of COD removal and the sludge accumulation. For the systems of average MLVSS of 1027.47, 1560.63, 1447.0 and 1621.44 mg/l, the COD removal in 2 hr and 4 hr detention time were 66.1 and 86.7 %, 85.6 and 92.4 %, 84.9 and 95.0 %, and 86.8 and 93.8 %, respectively. It can be deduced that COD removed rapidly in the first 2 hr and for the system of lower average MLVSS, COD removal was lower than the system of higher average MLVSS. The system of lower MLVSS required longer detention time. This concept was applied to extended aeration process.

Table 4. Biological treatability study of soya - bean cake waste water.

Date	MLSS, mg/l at started point	COD, mg/l		% COD removal
		Inf.	Eff.	
25th Nov. 74	2453	996.05	42.80	99.2
26th Nov. 74	2205	844.36	56.69	93.4
27th Nov. 74	2232	1022.83	103.53	90.0
30th Nov. 74	2088	992.00	87.30	90.7
			Average	93.3

Table 5. The change in COD, MLVSS and MLSS on aeration time.

Aeration time, hr	COD, mg/l				MLVSS, mg/l				MLSS, mg/l			
	30th Nov.74	5th Dec.74	7th Dec.74	10th Dec.74	30th Nov.74	5th Dec.74	7th Dec.74	10th Dec.74	30th Nov.74	5th Dec.74	7th Dec.74	10th Dec.74
0	460.00	695.65	765.35	690.60	1136.00	1706.67	1560.0	1584.0	1484.0	2453.3	2232.0	2088.0
0.5	408.88	505.97	519.68	432.00	1084.00	1820.00	1504.0	1496.0	1336.0	2446.7	2072.0	1860.0
1	327.10	320.16	317.32	316.80	-	1720.00	1596.0	1948.0	-	2340.0	-	2452.0
2	218.85	142.29	165.35	130.40	1193.30	1960.00	1571.0	1836.0	1333.3	2340.0	2537.0	2324.0
3	105.14	98.81	82.68	88.00	1227.30	1707.50	1534.0	1756.0	1333.3	2307.5	1984.0	2304.0
4	85.67	75.10	52.76	60.00	1260.00	1697.50	1402.0	1724.0	1313.3	2295.0	1890.0	2308.0
6	66.20	63.24	44.88	40.00	966.63	1488.00	-	1656.0	1253.3	2030.0	-	2360.0
8	46.73	52.96	32.94	32.00	1000.00	1341.67	1379.0	1612.0	1260.0	-	1990.0	2183.0
10	56.22	60.31	42.35	29.76	753.30	1241.00	-	-	993.0	1833.3	-	-
23	64.25	44.75	40.00	33.73	626.70	924.00	1029.0	981.0	800.0	1429.7	1571.0	1373.0

Initial COD (30th Nov. 74) = 646.42 mg/l

(5th Dec. 74) = 996.05 mg/l

(7th Dec. 74) = 1022.86 mg/l

(10th Dec. 74) = 992.00 mg/l

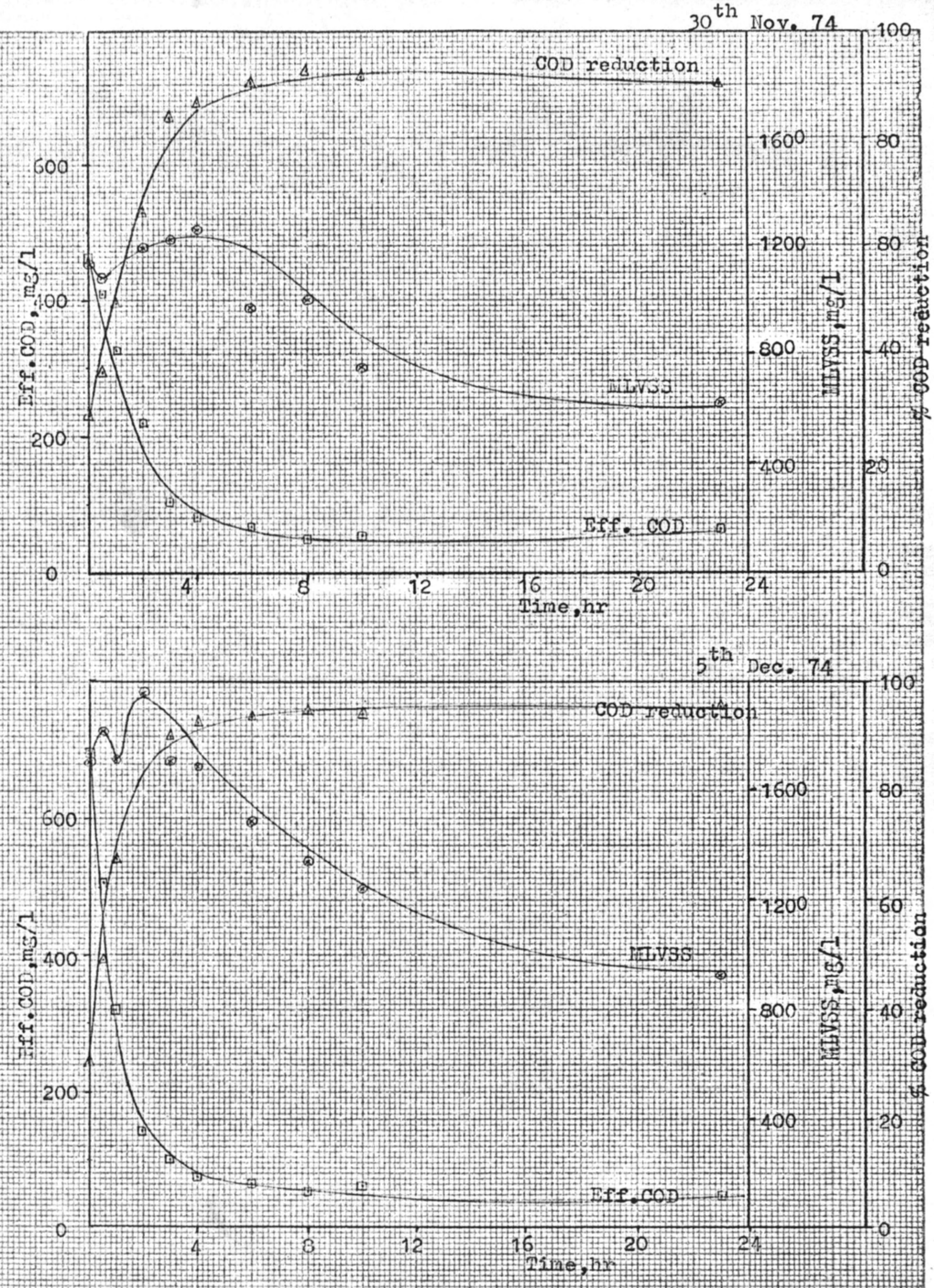
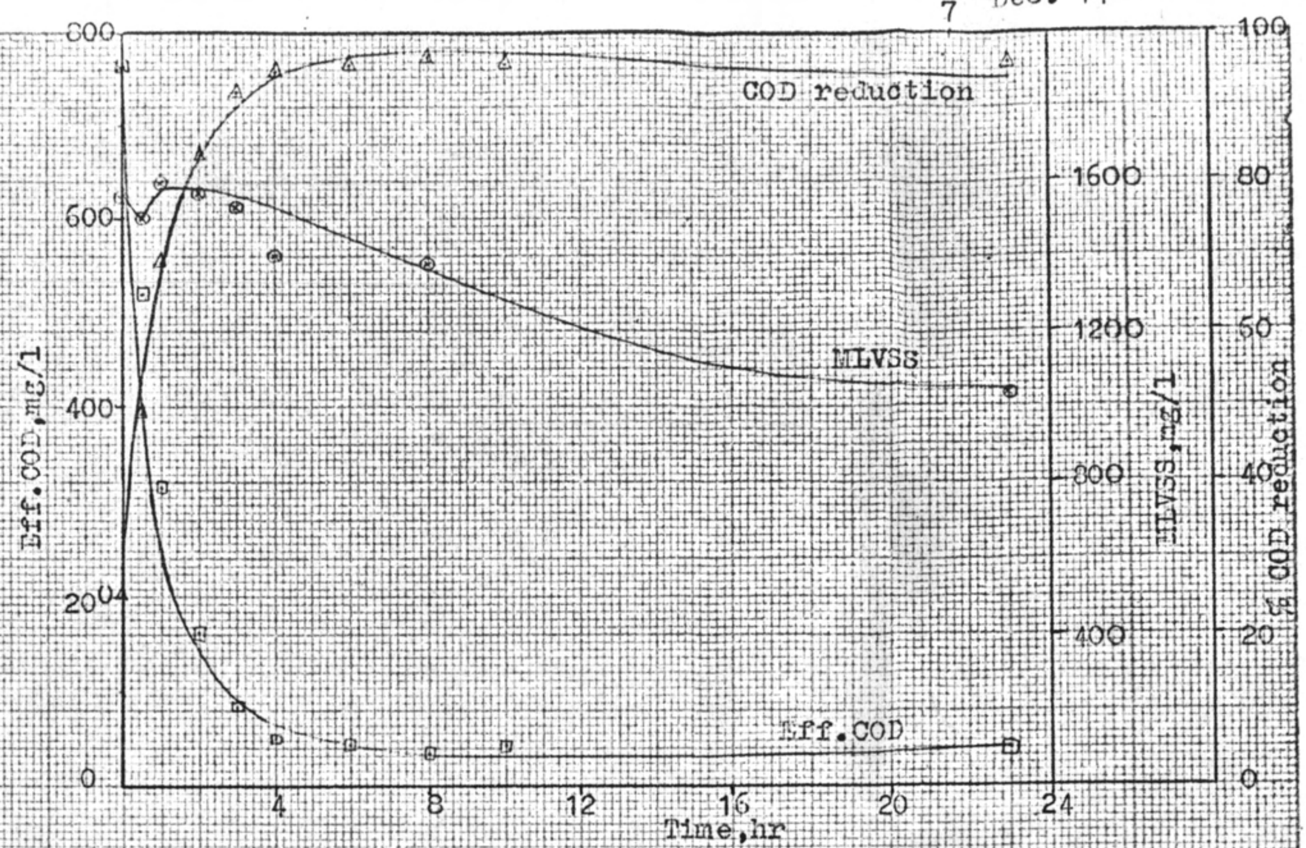


Fig.8 Effect of detention time on COD and MLVSS in system



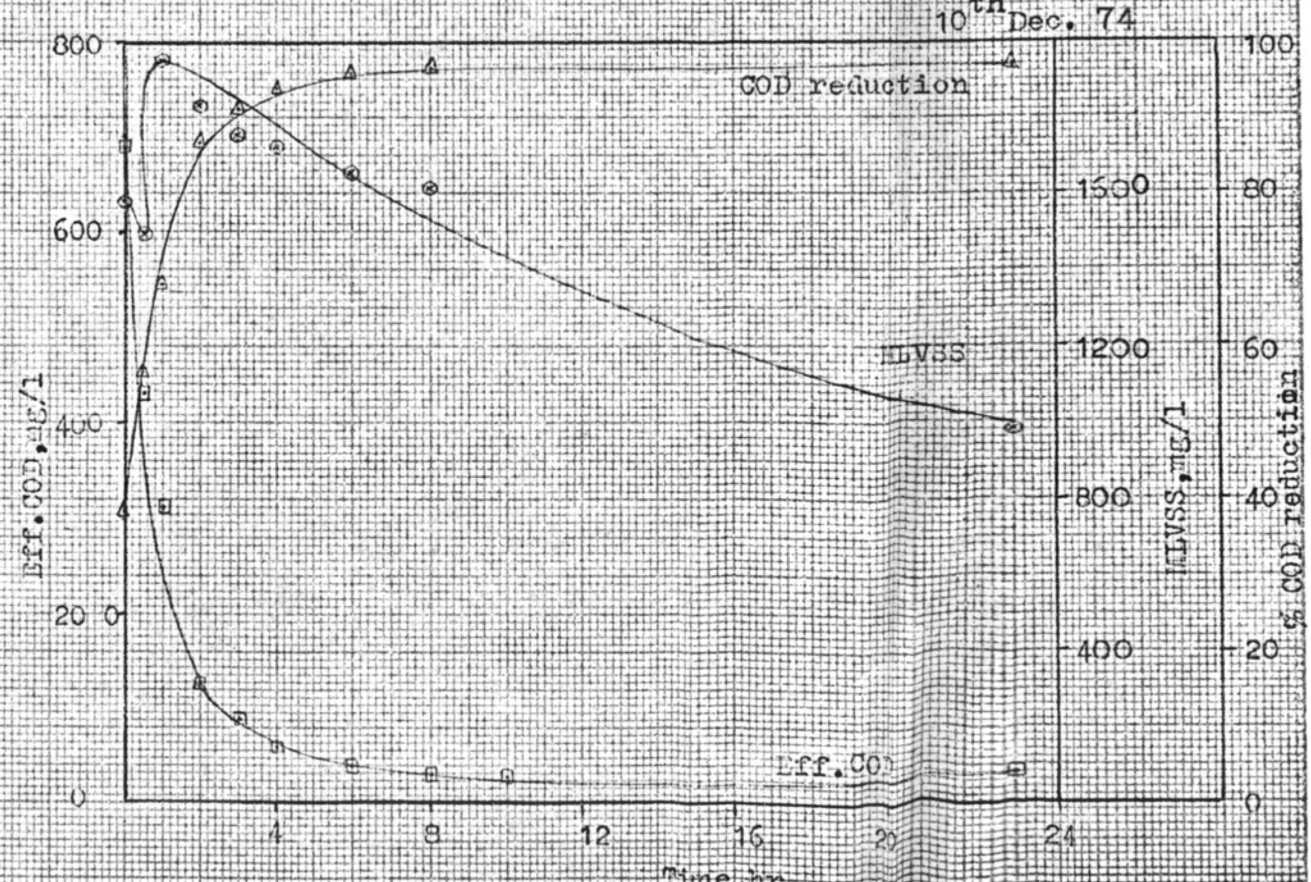


Fig.8(continue) Effect of detention time on COD and MLVSS in system

There were only two phases of bacterial growth, declining growth phase and endogenous phase, lag phase was not appeared because the seed was acclimatized to the waste already. Declining growth phase occured in the first 2 hr of aeration and endogenous phase was started at 2 hr. of aeration. The COD was removed until 8 to 10 hr of aeration, afterward the COD of the system was higher because of low F : M ratio, the dead microorganisms increased COD of the system.

COD removal of the system of about 1500 mg/l average MLVSS and 4 hr detention time was about 93 %. So 4 hr detention time and 1500 mg/l average MLVSS should be used for treatment of this settled waste. The MLVSS and MLSS ratios of the system ranged from 0.65 to 0.96, the average ratio was 0.76. Usually, MLVSS is assumed to be 70 to 80 % of MLSS for conventional activated sludge of domestic waste.

Some of the design parameters for settled soya - bean cake waste were determined from this part of study by using Eckenfelder's Mathematical Approach. The substrate removal rates (k) value calculated in Table A_1, A_2, A_3, A_4, B_1, B_2, B_3, B_4 and Fig A_1, A_2, A_3, A_4 in Appendix were equal 0.0252, 0.0278, 0.0329 and 0.0372 day^{-1}, respectively. This value was almost equal to k value of domestic waste. The removal rate constants for domestic were 0.017 - 0.03

day^{-1}, and 0.038 day^{-1} at23 - 28°C. The mass yield rate (a) and the endogenous respiration rate coefficient (b) of the 10th Dec 74 were calculated in Table C_1 and the graph was shown in Fig B_1 in Appendix. Other data were not used for determination of a and b because the sludge accumulation of some data was very low and some data were not complete. The mass yield rate (a) and endogenous respiration rate (b) obtained were 0.85 and 2.6832 day^{-1}, respectively, Both of them were higher than of domestic sewage as mention in LITERATURE REVIEW.

Continuous - Fed Activated sludge Process

The results of study are presented in Table 6. The COD removal efficiency, suspended solids removal efficiency, sludge volume index and sludge production at different loading rates are determined and will be discussed under the following headings.

COD removal efficiency The COD removal efficiency of the waste was high, ranging from 95.27 to 96.92 per cent. The loading rate was slightly effected on the COD removal efficiency. The COD removal efficiency of this study was not lower for some higher loading rate may be due to the difference of influent COD. For the same loading rate as F:M ratio, the system of high influent COD gave higher COD

Table 6. Results from continuous - fed activated sludge.

F:M ratio	COD, mg/l			SS, mg/l			MLSS mg/l	MLVSS mg/l	SVI	sludge produced gm MLSS/ gm COD removed/day
	Inf	Eff	%Removal	Inf	Eff	%Removal				
0.22	1404.5	49.6	96.47	310	14	95.5	1830	1090	123	0.58
0.29	1530.0	48.0	96.86	290	10	96.5	1550	1250	124	0.66
0.34	2232.0	84.0	96.24	390	50	87.1	2640	2140	104	0.61
0.43	2310.7	72.8	96.85	260	38	85.4	2480	1890	110	0.63
0.57	3536.0	108.8	96.92	360	72	80.0	2470	1770	77	0.67
0.70	2757.5	119.0	95.68	216	36	83.3	3180	-	57	0.75
0.75	2883.0	118.5	95.89	188	20	89.4	2230	1680	85	0.59
1.30	3740.0	119.5	96.80	220	29	86.7	3020	2170	66	- *
1.67	3658.5	173.0	95.27	180	24	86.5	2410	2060	56	- *

* foaming

removal efficiency than the system of low influent COD.

The loading rate could be as high as 1.67 gm COD per gm MLSS - day while the efficiency was still high, about 95 %, but the difficulty of foaming occured. When the loading rate was low, foaming occured slightly until the loading rate was higher than 0.75 gm COD/gm MLSS - day, foaming grew rapidly and caused difficulties in operation. Usually, foaming can be removed by using antifoamer or defoamer or by diluting waste water. For proteinaceous materials, triglyceride oils can be used to increase foam suppressing properties. It is not suggested to use antifoamers because they will increase organic loading and operating cost.

Loading rate of this waste should be 0.75 gm COD per gm MLSS - day. Compared with the typical organic loading of domestic sewage for conventional activated sludge as indicated in LITERATURE REVIEW, the loading rate of this waste is slightly higher. It may be deduced that this waste can be stabilized as easy as domestic sewage.

In the system of 0.75 gm COD/ gm MLSS - day loading rate, and 2883 mg/l influent COD, the effluent COD and BOD_5 were 118.5 and 66.7 mg/l, respectively, which were higher than the effluent standards imposed by the Ministry of Industry. If the recieving stream has enough dilution factor, the quality of this effluent is still considered to be acceptable. If the dilution is not enough, the modification of activated sludge should be done by docreasing the F : M ratio or by increasing the mixed liguor suspended solid or incereasing the aeration time.

COD loading rate can be used to dosing aeration basin volume.

$$\text{aeration basin volume} = \frac{\text{COD of raw waste}}{\text{MLSS in the system}} \not\; \frac{\text{Flow rate}}{\text{COD loading rate}}$$

Suspended solid removal efficiency The suspended solid removal efficiency of this waste ranged from 80.0 to 96.5 percent which were in the range of normal suspendend solid removal efficiency of good operational activated sludge. At high loading rate, 1.67 gm COD per gm MLSS - day, the suspended solid removal was 86.5 % indicating that 1.67 gm COD/ gm MLSS - day loading rate should be used if there is no difficulties of foaming.

Sludge velume index Sludge volume index (SVI) is a measure of the settling properties of aclivated sludge and is an extremely useful parameter of the process performance as the success of the process depends not only on the oxidation of the organic matter in the waste but also on the separation of a clear effuent from the sludge. In final sedimentation tank, whatever is not readily settleable is likely to appear in the effluent and spoil quality. In practice it has been found that sludge showing SVI under 50 settle excellently, those under 100 settle quite well, while those upto 150 settle reasonably well. Sludge with higher index does not settle well and may throw out solids in the effluent, a condition known as "sludge bulking".

The SVI determined in this experiment are shown in Table 6 . The SVI of the system of 0.22 to 1.67 gm COD/gm MLSS - day loading rate was lower than 150. Sludge bulking did not occur. The SVI of the system of low COD loading rate was high and decreased as the loading rate increased to 1.67 mg COD/mg MLSS - day. R.P. Logan and W.E. Budd concluded that the sludge volume index increases not only when the system is overloaded but also when underloaded. The poor settleability at the low loading was probably due to unoxidized fragments of the floc being broken up with a consequent reduction in specific gravity, while the very nature of dominant filamentous microbial population was considered responsible for the high load bulking. Based on the results of SVI, it can be deduced that the loading of 1.67 gm COD/gm MLSS - day is not overloaded. If overloading occures, more food is fed, the microorganisms are in the active stage and so they disperse through out the mixed liquor and the SVI will increase. At the loading rate of 0.75 mg COD/gm MLSS - day, SVI is 85 indicating that sludge settles quite well.

Sludge production Sludge will accumulate in the activated sludge process because of the synthesis of new cells and the accumulation of suspended solid present in the influent waste. It is important to know the quantity of sludge to be produced per day, as it will effect the design of sludge handling and disposal facilities. The sludge production coefficient of this experiment is shown in Table 6. The sludge production coefficient ranged from 0.58 to 0.75 gm MLSS/gm COD removed - day which is relatively high and has to be disposed of every day. MLSS in the system has a little effect on sludge production. The sludge production of the high MLSS system is slighly higher than the low MLSS system. Sludge production of the systems of 1.30 and 1.67 gm COD/gm MLSS - day cannot be reported because of throwing out of sludge by foaming.

Sludge yield varies with the amount of agitation provided. Cell yield decreases with increasing turbulence. MD.Rickard and A.F.Gaudy, Jr.(1968) explained that five mechanisms can be advanced to explain the increase in oxygen uptake and decrease in solid yield observed with increasing velocity gradient. These are

1. changes in predominance
2. increased frequency of contact between cell and substrate

3. production of smaller floc particles with resultant improved prenetration of substrate and oxygen
4. increases in the rate of O_2 transfer across the cell liquid interface, and
5. maintenance of a higher DO concentration with increasing turbulence.

Nutrients in effluent was not determined. High nitrogen and phosphorus in effluent will cause algae bloom in recieving water. Phosphorus removal in activated sludge process can be controled by adding a phosphorus precipitant to the aeration chamber. Comparison of the process with and without aluminum supplement to aerator, no supernatant recycle, for conventional activated sludge, the average overall removal of phosphorus is 40 per cent and for the process with 10 mg/l aluminum to aerator the average removal of phosphorus is 94 per cent. (E.F.Barth and M.B.Ettinger,1967). With aluminate, the pH control is automatic, because any exeess hydroxide ions will be converted to bicarbonate during aeration.