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Pollution Abatement in Industry - A case study

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ABSTRACT: *An in-plant survey followed by flow measurement was carried out in a typical factory producing about 3200 tonnes rubber latex concentrate and 200 tonnes of skill crepe rubber per year .The characteristics of wastewater from different sections as well as of combined waste water were studied on different occasions. The combined effluent had a BOD varying from 5240 to 6100 mg/l and ammonia nitrogen content varying from 630-750 mg/l. Raising the pH to 11.0 and aerating for 1 hour reduce the ammonia content by 83.1 %. The BOD is reduced to 480 mg/l by treating the combined wastewater after aeration for ammonia removal in an aerobic lagoon with a detention time of 30 days and a BOD loading rate of 0.14 kg/cu.m/day . By aerating the effluent from an aerobic lagoon for 24 hours at a MLSS concentration of 4000 mg/l and BOD loading rate of 0.09 kg/ kg MLSS , the BOD and COD were reduced to 32 mg/l and 280 mg/l respectively. The BOD of the wastewater could be reduced below 40 mg/l by treating anaerobic lagoon effluent in an aerated lagoon with 7 days detention. Based on these studies treatment method is suggested.*

Keywords: *anaerobic lagoon, BOD ,COD, detention time, effluent.*

I. INTRODUCTION

One of the important industrial wastewater from the point of view of pollution of water courses in Kerala and Tamilnadu is the wastewater producing natural rubber latex concentrate and skim crepe. While considerable amount of work has been carried out on the treatment of wastewater in countries like Malaysia [1-3], no work has been done in India on similar Wastewater. A survey [4] of the chemical characteristics of waste water discharged from rubber/latex factories in Malaysia showed that the waste water from latex concentrate factories were the most polluting. High ammionification of field latex and subsequent auto and/or acid coagulation of skim latex were found to be responsible for the high concentration of pollutants in the wastewater from rubber latex concentrate factories.

Moleworth [5] studied the treatment of acidified skim serum by a pilot plant scale tricking filter and obtained a BOD removal of 80 per cent while the nitrogen and sulphate removals were poor..Gale [6] indicated based on design calculations that treatment in trickling filters is expensive. Using a laboratory scale oxidation ditch, Ponniah [7] reported that acidified skim serum may be effectively treated in this system after initial pH adjustment to bring down the BOD values below 100mg/l.Various others [3,4,] have shown that where space is not a limitation, an anaerobid pond system is a simple, economic and effective method for the treatment of effluent from factories producing block rubber.Chick [8]. Reported that the application this ponding method with a detention time of 30 days in the anaerobic and facultative systems reduced the BOD of the wastewater from factories manufacturing rubber latex concentrates to 100mg/l. Laboratory studies carried out by Ponniah et al. [9] have shown that an anaerobic three stage facultative system is capable of effectively treating wastewaters from latex concentrate factories.

With the background in view, the laboratory studies reported in this communication were undertaken.In–plant survey was carried out in a typical factory producing 3200 tonnes of rubber latex oncentrate on wet weight basis and 200 tonnes of skim crepe rubber per year-Characteristics of individual sectional wastes and combined wastes were studied.Laboratory experiments are carried out

on treatment of these wastewaters using different biological methods.Results obtained are presented in this communication.

II. MATERIALS AND METHODS

The raw materials,fresh natural rubber latex containing 30 to 40 percent rubber is received from different parts of Kerala State in closed drums.During Transportation from these estate to the factory the natural rubber latex is preserved by bubbling ammonia gas through minute holes to give a concentration of 0.5 to 0.7 per cent ammonia in the latex.The latex received at the factory is first settled in settling tanks for 24 hours to remove magnesium ammonium phosphate sludge formed.The settled natural rubber latex is subjected to centrifugal force in centrifugal seperators operating at 14,000 rpm for three hours .The centrifugal action separates the latex rubber in two fractions. The cream with a dry rubber content of 70 percent and the skim with a rubber content ranging from 5 to 10 per cent.

The cream after adjustment of dry rubber and ammonia content to the desired level, is packed as natural rubber latex concentrate and dispatched.Wastewater in this operation originates from washings of the centrifuge at the end of each operation and spill-over from tanks and floor washings.The skim fraction containing a dry rubber content of 5 to 10 per cent is coagulated by action of sulphuric acid and the rubber obtained in creped by milling and skim crepe so obtained is marked.The left over serum from the coagulation, the washings from the tanks,separators etc. from the effluent.The serum from the above operation contains proteins,sugars,lipids,inorganic and organic compounds.

III. CHARACTERISTICS OF WASTEWATER

Raw water required is drawn from a nearby river and is used in the process directly without treatment. The quantity of water used in the process is found to be about 100 cu m/day. Water is used for washing the centrifuges, for coagulation, in milling section and for floor washings. The quantities of wastewater of letout from the different sections were determined .The characteristics of the composited wastewater from different sections were studies and the results obtained are presented in Table 1.The flow measurements were carried out along with sample collection. Samples were collected at every hour or two hours for eight hours and composited proportional to flow. The operations are carried out in batch process. The wastewater is let out from different sections after the completion of an operation which normally took one to two hours. From table-1 it can be seen that the effluent after coagulation (i.e scrum) is highly concentrated with variation in BOD and COD value. The waste is acidic with a pH ranging from 3.3 to 3.7.

Table 1: Characteristics of Wastewater from the various Sections from the Factory
(All parameters except pH and flow expressed as mg/l)

Parameters	Washing from centrifugal machine		Serum (effluent after coagulation)			Milling Section	
	1	2	1	2	3	1	2
Flow (cu m/day)	10	0	30	30	30	30	30
pH	7.2	1	3.7	3.4	3.3	5.3	5.5
Acidity ($CaCo_3$)	-	-	-	2800	3200	-	-
Alkalinity ($CaCo_3$)	150	30	-	-	-	-	-
COD	13500	4200	13200	12800	13200	2650	3860
BOD	6800	160	6400	6080	6850	1160	1880
Total Solids	32600	2260	39390	42240	44660	5920	6380

Dissolved Solids	4200	660	37670	39020	40420	5680	5980
Suspended Solids	28400	6600	2320	3220	4240	240	400
BOD load (kg/day)	68	1.6	190	182.4	205.5	34.8	56.4

IV. CHARACTERISTICS OF COMPOSITE WASTEWATER

The combined waste water was collected every hour for 8 hours and composited proportional to flow. The characteristics of composited wastewater let out from the factory was studied on a number of occasions. The results obtained are presented in Table 2.

Table 2: Characteristics of Composite Wastewater let-out from the Factory
(All results except pH and flow expressed as mg/l)

Parameters	1	2	3	4
Flow (cu m/day)	70	0	80	80
pH	4.2	4.1	4.2	4.0
Acidity (CaCo3)	400	80	390	370
COD	10600	1200	10800	11000
BOD	6100	800	5240	5800
Total Solids	28800	2200	29660	32440
Suspended Solids	5440	660	3360	3220
Dissolved Solids	23360	7540	26300	23220
Total Nitrogen (N)	1500	880	1560	1560
Ammonia(N)	630	50	710	650
Phosphate (P)	30	5	40	40
BOD load (kg/day)	427.0	64.0	419.2	464.0

V. STUDIES ON REMOVAL OF AMMONIA

Since the wastewater had a pH about 4.0 and contained ammonia, studies were carried out on removal of ammonia by addition of lime and aeration. About 2 liters of wastewater was taken in beaker and lime suspension was added to raise the pH to 9.0, 10.0 and 11.0. The mixed suspension was aerated for 1 hr and settled for 1 hr. Supernatants were drawn and analysed . The results obtained are presented in Table 3.

From Table 3, it can be seen that rising the pH to 10.0, ammonia content was reduced to 320 mg/l, and COD to 8240 mg/l and BOD to 4210 mg/l. The percentage reductions were 50.8, 22.9 & 19.2 respectively. At pH 11.0 the ammonia removal by the same method was 83.1%. The quantity of sludge produced when lime is added to raise pH to 11.0 is 30% volume by volume.Another set of experiment was carried out by addition of lime suspension to the wastewater to raise the pH above 10.1 and keeping the same sample exposed to atmosphere for different days. The results obtained are presented in Table 4.

Table 3: Effect of Lime and Aeration on the Removal of Ammonia

Parameters	Raw waste	pH		
		9.0	10.0	11.0
Quantity of lime (mg/l)	-	7000	13500	15000
Ammonia (N) mg/l	650	490	320	110
BOD mg/l	5400	4840	4210	3980
COD mg/l	10200	9660	8240	7880
Sludge Volume (mg/l)	-	300	320	320
% Reduction in Ammonia	-	24.6	50.8	83.1

% Reduction in BOD	-	10.4	22.0	26.3
% Reduction in COD	-	5.3	19.2	22.8

Table 4: Effect of Lime Addition to Wastewater and Exposure to Atmosphere

Parameters	Raw waste	Days of Exposure		
		2	4	6
COD mg/l	10200	9880	8460	7900
BOD mg/l	5400	4820	4450	4100
Ammonia (N) mg/l	650	360	180	100
% Reduction in COD	-	3.1	17.1	22.5
% Reduction in BOD	-	10.7	17.6	24.1
% Reduction in Ammonia	-	44.6	72.3	84.6

VI. BIOLOGICAL TREATMENT

6.1: Studies using anaerobic lagoon:

Experiments were carried out with wastewater after treatment with lime and aeration. Laboratory anaerobic lagoons each with a working capacity of 10 liters of wastewater were seeded with 3.3 liters of seed sludge and made up to 10 liters with the waste and were maintained at room temperature for different days. The lagoons were initially operated at 40 days detention time and the detention time was reduced gradually. The results of the performance data of lagoon is given in Table 5.

From Table 5, it can be seen that the effluent after anaerobic treatment had a pH between 8.1 to 8.8 with variation in detention time, the volatile acid the BOD removal per cent.

Table 5: Performance of Anaerobic Lagoon Experiment
(Influent characteristics: pH 9.8, COD 8000 mg/l, BOD 4200 mg/l)

Parameters	Detention time (days)			
	40	30	20	10
PH	8.8	8.6	8.3	8.1
Volatile acids mg/l (CH_3COOH)	400	460	1290	2200
BOD mg/l	4.4	480	1480	2350
COD mg/l	880	940	2960	48110
% Reduction in BOD	89.5	88.6	64.8	44
% Reduction in COD	89	88.3	63	39.9
Odour	Nil	Nil	Present	Present
BOD load (Kg/cu.m/day)	0.11	0.14	0.21	0.42

6.2: Treatment using extended aeration system or oxidation:

Two sets of experiments were carried out by employing extended aeration system. The effluent after treatment in a lagoon with 30 days detention time was used in one set and the wastewater after treatment with lime to pH 10.0 and aeration was used in other set. Acclimatised activated sludge was used in the system and after acclimation the wastewater was aerated. The mixed liquor suspended solids concentration was maintained at 4000 mg/l. The effluent after different periods of aeration was analysed for COD and BOD. The results are shown in Table 6 and Table 7.

Table 6: Treatment of Anaerobic Lagoon Effluent Using Extended Aeration System
(Raw waste: Effluent from anaerobic lagoon)
MLSS: 4000 mg/l

Aeration Time (hours)	COD	BOD

	mg/l	% red	mg/l	% red
0	900	-	460	-
8	520	42.2	180	60.9
12	420	53.3	80	82.6
24	280	68.9	32	93

Table 7: Treatment of Pre-Aerated wastewater by Extended Aeration System (Wastewater after lime addition and aeration or storage) MLSS: 4000 mg/l

Aeration time (days)	COD mg/l	%red	BOD mg/l	%red
0	8000	-	4200	-
1	5880	26.5	2240	47.7
2	2400	70	960	77.1
3	1880	76.5	480	89
4	1210	84.9	160	96.2
5	820	89.8	72	98.3
6	540	93.3	32	99.2

VII. TREATMENT BY AERATED LAGOON

Experiments were carried out to treat wastewater which was earlier treated in anaerobic lagoon by aerated lagoon. Acclimatised sludge was used in the experiments. Laboratory studies were carried out to determine the optimum detention time required keeping MLSS between 50-500 mg/l. The results obtained are shown in Table 8.

Table 8: Aerated Lagoon Studies

Waste used	Waste after treatment by anaerobic lagoon
BOD mg/l	400
System rate constant 'K'	0.15
Detention time required for 90% BOD removal	6.3 days
Expected final BOD mg/l	40

The result shows that the wastewater after treatment with lime to pH 10.0 or above aeration or storage and anaerobic lagoon treatment can be treated in an aerated lagoon. The final effluent has a BOD of 40 mg/l with detention time of 6.3 days.

VIII. TREATMENT SUGGESTION

Based on the Laboratory studies different alternative treatment schemes can be suggested. However, taking into consideration the land availability, the strength of the wastewater and the cheapness of anaerobic lagoon in treating strong industrial wastewater following treatment method is suggested. It can be seen that the wastewater coming out of the factory is acidic in nature and is discharged in batches. The wastewater also contains high concentration of ammonia which will have to be removed before biological treatment. It is therefore , proposed to treat the combined waste water with lime or caustic soda to pH of 10-11 in two reaction or equalisation –cum –settling tanks. Two tanks are provided so that while one tank is being filled up, neutralization with lime or caustic soda followed by settling will be carried in the other tank. The overflow from these tanks will be aerated by bubbling air or exposed to atmosphere in open tanks to remove ammonia. The sludge collected from equalisation –cum –settling tank will be taken to sludge drying beds using non-clogging pump. The effluent after ammonia removal will be fed to an anaerobic lagoon having a detention time of 30-40 days. The effluent from the anaerobic lagoon will be treated in an extended aeration activated sludge

system with an integrated sludge settling compartment. The extended aeration unit will have a food to micro-organism ratio of 0.1 or lower and a mixed liquor suspended solids (MLSS) concentration of 4000-4500 mg/l. The contents of the tank will be aerated by passing through diffuser or by means of mechanical surface aerators. The clear supernatant will be discharged and the excess sludge will be dried on sludge drying beds will be taken to the treatment units described above.

Installation cost excluding land cost for this treatment unit would be about 4,05,000 and annual running cost would be about 40 percent of the capital cost. The total land area required is 0.75 hectares.

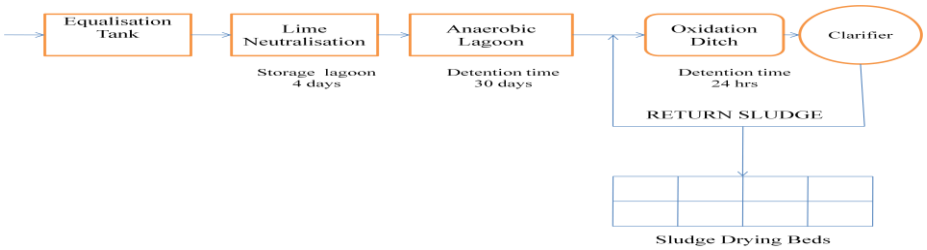

Fig. 2: Treatment Flow sheet

IX. CONCLUSION

1. The factory where studies were carried out manufactures 3200 tonnes of rubber latex concentrate on wet weight basis and 200 tonnes of skim crepe rubber per year. The quantity of water used in this factory is about 100 cu.m/day and quantity of wastewater is discharged about 80 cu.m/day
2. Wastewater discharged includes serum (effluent after coagulation) washings from centrifugal machine and milling section. The BOD of wastewater from centrifugal machine serum and milling section were 6800-8100 mg/l, 6090-6850 mg/l and 1160-1880 mg/l respectively.The BOD load contributed by centrifuges, serum and milling section were 68.0-81.6 kg/day, 182.4 to 205.5 Kg/day and 34.8- 56.4 kg/day respectively.
3.The BOD of the combined wastewater varied from 5240 mg/l to 6100 mg/l while total nitrogen content varied from 1500 mg/l to 1980 mg/l. The pH of the combined wastewater varied from 4.0 to 4.2 while ammonia nitrogen content varied from 630 to 750 mg/l
4. By raising the pH above 10.0 using lime or sodium hydroxide and aerating for one hour or storing for two to four days ammonia nitrogen content was reduced up to 83.1 per cent.
5. The pre-aerated wastewater could further be treated in an anaerobic lagoon of 30 days detention. The removal in anaerobic lagoon varied from 89.5 per cent at a loading of 0.11 kg BOD cu.m/day to 44.0 per cent at a loading of 0.42 kg of BOD/cu.m/day.
6. The wastewater after treatment in anaerobic lagoon could be further treated in an extended aeration system of activated sludge. At a BOD loading 0.09 kg BOD per kg of MLSS and aeration time of 24 hours the BOD of the combined effluent is reduced to 32 mg/l.It was also found that the combined wastewater after lime or sodium hydroxide treatment and aeration could be directly treated in an extended aeration system. By aerating for 6 days at a loading rate of 0.16 BOD per kg MLSS the BOD could be reduced to about 30 mg/l.
7. The combined wastewater treatment with lime aeration and in an anaerobic lagoon could be treated in an aerated lagoon with detention time of sever days. System rate constant value was found to be 0.15.
8. Based on these studies, a treatment flow sheet incorporating equalization-cum-settling tank, pre aeration, anaerobic lagoon and extended aeration unit was suggested.

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