Anaerobic Treatment of Waste Water - SPB's Experience

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ABSTRACT

Anaerobic treatment for waste water is becoming increasingly popular due to low energy requirement and high reduction in pollution load even though it has few drawbacks such as slow reaction, high sensitivity to operating parameters etc. In our company, M/s Seshasayee Paper and Boards Limited (SPB), the high BOD/COD waste water stream has been isolated and based on extensive laboratory trials, an anaerobic biological system has been installed to treat the same separately. Presently, about 90-95% reduction in BOD and COD load is being achieved by this anaerobic process. This paper deals with our experience on laboratory scale studies and installation of anaerobic system to treat the waste water from bagasse preparation system in plant scale.

INTRODUCTION

SPB is an integrated pulp and paper mill situated on the banks of river Cauvery in Tamil Nadu. The mill till recently was producing around 60,000 tonnes per annum of various grades of cultural and industrial varieties of papers from four paper machines using bagasse and tropical hardwood as primary raw materials. The mill has recently commissioned paper machine # 5 with a capacity to produce an additional 55,000 tonnes per annum of coated and uncoated papers and the pulp for the additional production will be primarily from secondary raw materials such as waste paper and purchased pulp.

AN OVERVIEW OF EFFLUENT GENERATION

The mill generates about 40,000 m^3 of waste water from its operations which after treatment is used for irrigating about 1 500 acres of land for cultivating sugar cane. A typical block diagram indicating the key operations of waste water system before expansion is given in figure 1. The quality of waste water at different stages is given in Table-1. The total mill effluent is catagorized into three streams: Stream -1: Low BOD effluent generated from all the paper machines and part of bleach plant. Stream -2: Medium BOD effluent from all the other sections of the mill, i.e., bleaching (part) and screening, digester, power house, recovery etc. Stream -3: High BOD effluent generated from bagasse preparation system. The waste water in stream -1 is taken to a clarifier and the clarified water is pumped back to pulp mill and paper machines for reuse.

BAGASSE PREPARATION SYSTEM

The mill uses about 500-600 t/day of moist depithed bagasse with 50% moisture. A typical block diagram showing the bagasse preparation system and the waste water generation points is given as figure 2. As could been seen, the waste water from the dewatering screw is taken to a screw press or belt press, the filtrate

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FIG.-1

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SCHEMATIC DIAGRAM OF WASTE WATER TREATMENT PLANT (BEFORE EXPANSION)

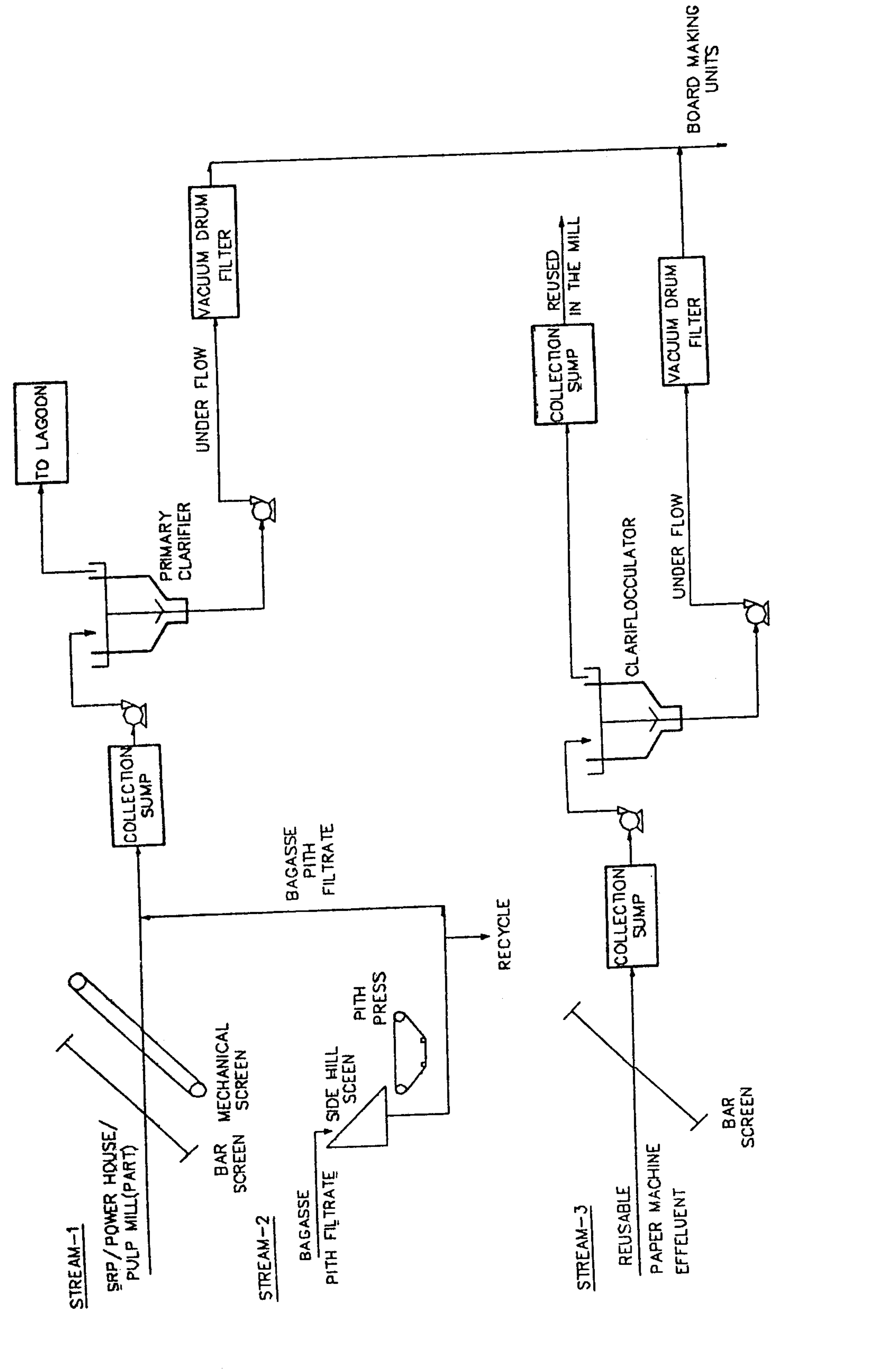
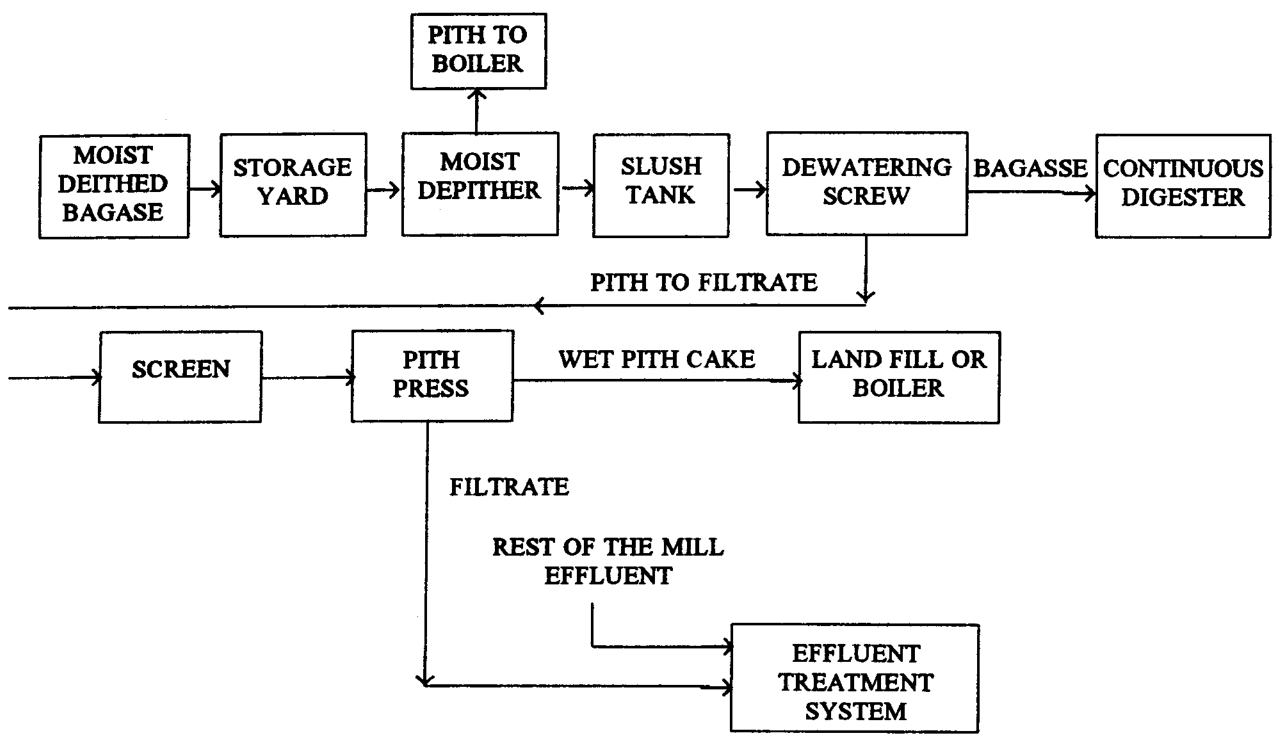


Table : 1 Quality of waste different stages

Particulars	pH (range)	Suspended solids, ppm (range)	COD, ppm (range)
Digester	7.8-8.5	200-300	190-400
Thickener seal pit	7.4-8.3	350-500	280-400
Bleaching & screeening	6.8-7.2	500-600	360-430
Soda Recovery Plant	7.8-8.6	180-250	150-330
Bagasse pith filtrate	3.5-4.2	1000-3000	3000-6000
Paper machine back Water and rag plant	7.0-8.0	800-1100	80-100

FIG.-2

WASTE WATER GENERATION - BAGASSE PREPARATION PLANT



screw is taken to a screw press or belt press, the filtrate of which is then taken to primary clarifier after recycling as much as possible. The volume of bagasse pith filtrate is about 1000m^3/day.

ABOUT ANAEROBIC SYSTEM

Anaerobic biological treatment process decompose organic matter in a controlled oxygen free environment (anaerobic) since oxygen is not required for decomposition. This process is suitable for the treatment of highly polluted organic waste waters having limited concentration of recalcitrant (toxicants) compounds such as resin, chlorinated phenols and inorganic sulphur compounds which make these water toxic to microflora. Anaerobic lagoons are different from the other stabilization ponds, the main difference being depth.

Normally, three identifiable zones are observed in lagoons:

- The scum layer: This insulates the lagoon and prevents heat loss, suppress odour and maintains anaerobic condition by eliminating oxygen mass transfer between the air and water interface.
- The supernatent layer that contains 0.1% volatile solids
- The sludge layer with 3-4% volatile solids.

The anaerobic metabolism of complex substrate including suspended organic matter can be regarded as a three step process:

Step-1: Hydrolysis of suspended and soluble organic of high molecular weight

Step-2: Degraded small organic molecules are acidified by acidogenic bacteria forming volatile fatty acids (VFA), which are then further converted into acetate and CO_2/H_2 by acetogenic bacteria and finally acetic acid.

Step-3: Production of methane, primarily from acetic acid but also from hydrogen and carbon-dioxide

BENCH SCALE STUDIES

As menioned earlier, among three streams of effluent in mill, effluent of stream-3 coming from the bagasse preparation system contains highest BOD and COD load. Analysis of bagasse pith filtrate being generated from bagasse preparation system is presented in Table-2. It was therefore decided to study this particular waste water for a separate treatment system so that the characteristics of final mill effluent can be improved. Hence, a detailed laboratory work was undertaken to treat the bagasse pith filtrate both by aerobic and anaerobic methods separately. Prior to taking bench scale trials on aerobic and anaerobic treatment of bagasse pith filtrate, some preliminary studies were conducted to ascertain:

Table : 2 Analysis of bagasse pith filtrate

Particulars		Test results (range)
pH		3.5-4.2
Total suspended solids,	ppm	1000-3000
BOD,	ppm	2000-3200
COD,	ppm	3000-6000

- the settling rate of suspended solids as this effluent contains high quantity of total solid content.
- the effect of suspended solid content on chemical oxygen demand value.
- a suitable chemical from economic point of view to increase the pH of pith filtrate to the level of 7.0.

These preliminary findings are essential to carry out the aerobic and anaerobic treatment studies effectively. The findings on these preliminary studies are as under:

(i) Within 25 minutes, nearly 90% settling of suspended solids is achieved.

(ii) No significant reduction in COD is observed with the reduction of suspended solids content in the effluent

Suspended solids, ppm	COD, ppm
3100	8480
2312	8160
900	8240
600	8120

(iii) Among several chemicals used, to bring up the pH of pith filtrate to about 7.0, milk of lime addition appears better from the point of improvement in settling rate, clarity of effluent and low cost.

Table : 3 Effect of nutrient on BOD and COD of effluent

Aeration Hr.	WITHOUT NUTRIENTS					WITH NUTRIENTS				
	pH	COD ppm	COD redn.%	BOD ppm	BOD redn.%	pH	COD ppm	COD redn.%	BOD ppm	BOD redn.%
0	7.3	3053	-	1090	-	7.3	3435	-	1251	-
16	7.5	3015	1.2	1010	7.0	7.6	2595	24.5	855	32.0
22	8.2	2252	26.2	856	23.0	8.1	870	74.7	724	42.0
39	8.1	1186	61.2	790	28.0	8.1	508	85.2	494	61.0
44	8.2	931	69.5	751	31.0	8.2	423	88.0	414	67.0

PHASE-1 STUDY:

The objective of this bench scale study was to ascertain the necessity of nutrients (DAP and urea) for the reduction of BOD and COD content in the bagasse pith filtrate under aerobic conditions. In this study, the pH of pith filtrate was adjusted to 7.3 with lime and divided into two portions. One of the portions was aerated without addition of nutrients (termed as control) and the other was treated with nutrient in the proportion of effluent: urea: DAP as 100:5:1 Both the samples were continuously aerated for different time intervals. pH, COD and BOD were determined. The results are presented table-3.

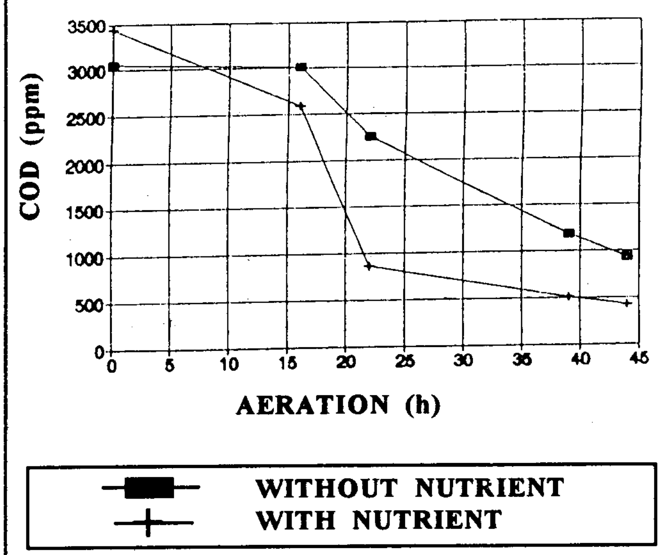
This study clearly revealed that, there is drop in COD and BOD contents, when the effluent (bagasse pith filtrate) is subjected to aerobic condition at near neutral pH irrespective of the addition of nutrients. However, the reduction in COD and BOD is considerably high, when nutrients are added in the effluent compared to control, i.e., without nutrients. This trend can be observed from the figures-3 and 4 which represent the effect of nutrient on COD and BOD respectively.

Therefore, to achieve maximum reduction in BOD and COD load from the effluent in a stipulated time, nutrients like Di-Ammonium Phosphate (DAP) and urea should be added in the effluent.

PHASE-2 STUDY:

The study was conducted in bench scale, to study the reduction of BOD and COD content in the bagasse pith filtrate at different time intervals in both aerobic and anaerobic conditions using nutrients (DAP and urea) at near neutral pH level.

FIGURE-3
EFFECT OF NUTRIENT ON COD



The bagasse pith filtrate after adjusting pH, was treated with nutrient in the proportion as mentioned above. The treated effluent was split into two portions. One portion was kept for simple aeration and the other portion was retained as such on open atmosphere (anaerobic). At different time intervals, samples were drawn and analysed for COD and BOD content and the results are presented in table-4.

The following remarks were drawn from this bench scale study:

By subjecting the bagasse pith filtrate to aerobic and anaerobic treatment with nutrient at near neutral

Table : 4 Reduction of BOD & COD in Aerobic and Anaerobic systems

Time Hr.	AEROBIC TREATMENT				ANAEROBIC TREATMENT			
	COD ppm	COD redn. %	BOD ppm	BOD redn.%	COD pp	COD redn.%	BOD ppm	BOD redn.%
0	3468	-	2361	-	3468	-	2361	-
18	1936	44	1225	48	2464	29	1405	41
24	950	73	620	74	2077	40	1200	49
42	740	79	525	78	1672	52	885	63
48	528	85	337	86	1200	65	608	74
72	-	-	-	-	1110	68	520	78
96	-	-	-	-	970	72	425	82
120	-	-	-	-	830	76	330	86
144	-	-	-	-	660	81	260	89

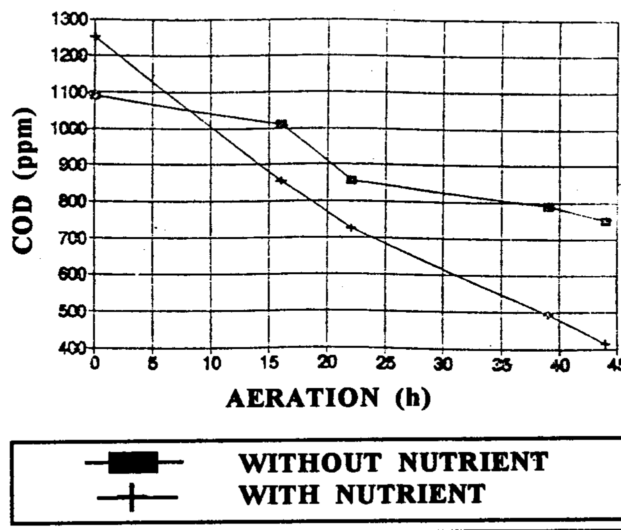
pH level, COD and BOD reduction was experienced linearly with time interval.

The extent of reduction of COD and BOD are high at any particular time interval in the case of aerobic treatment compared to anaerobic treatment.

Since during the laboratory trial the exact flow of air quantity could not be measured, the values obtained by aeration treatment shall not be considered for any design. Moreover, as in the begining of this article it is mentioned that, aeration process will consume enormous quantity of energy anaerobic treatment results were taken for consideration for implementing the same in plant scale. It can be seen from this study results, about 80% COD reduction and about 90% BOD reduction in the bagasse pith filtrate is obtained over a period of 6 days.

After several discussions with specialists and various technical persons and also considering the laboratory scale results, it was decided to install an anaerobic treatment lagoon for bagasse pith filtrate alone having ten days retention time. The volume needed for the same with days retention time is around 10,000 m^3 (1000m^3/day). A study of our lay out indicated that this lagoon can be accommodated inside the mill.

FIGURE-4
EFFECT OF NUTRIENT ON BOD



INSTALLATION OF ANAEROBIC TREATMENT SYSTEM

Based on several laboratory studies as mentioned above, SPB installed an anaerobic lagoon system in September 1998 with a volume of around 10,000 m^3 (10 days retention time). A typical block diagram for the system installed is given in figure-5. Stabilization of this system needed about three months.

Following steps were carried out during the start -up and stabilization period of anaerobic treatment system:

Step-1: Storing acclimatized slurry after procurement separately near to the lagoon.

Step -2: Spreading of fresh cowdung or other manure

FIG.-5

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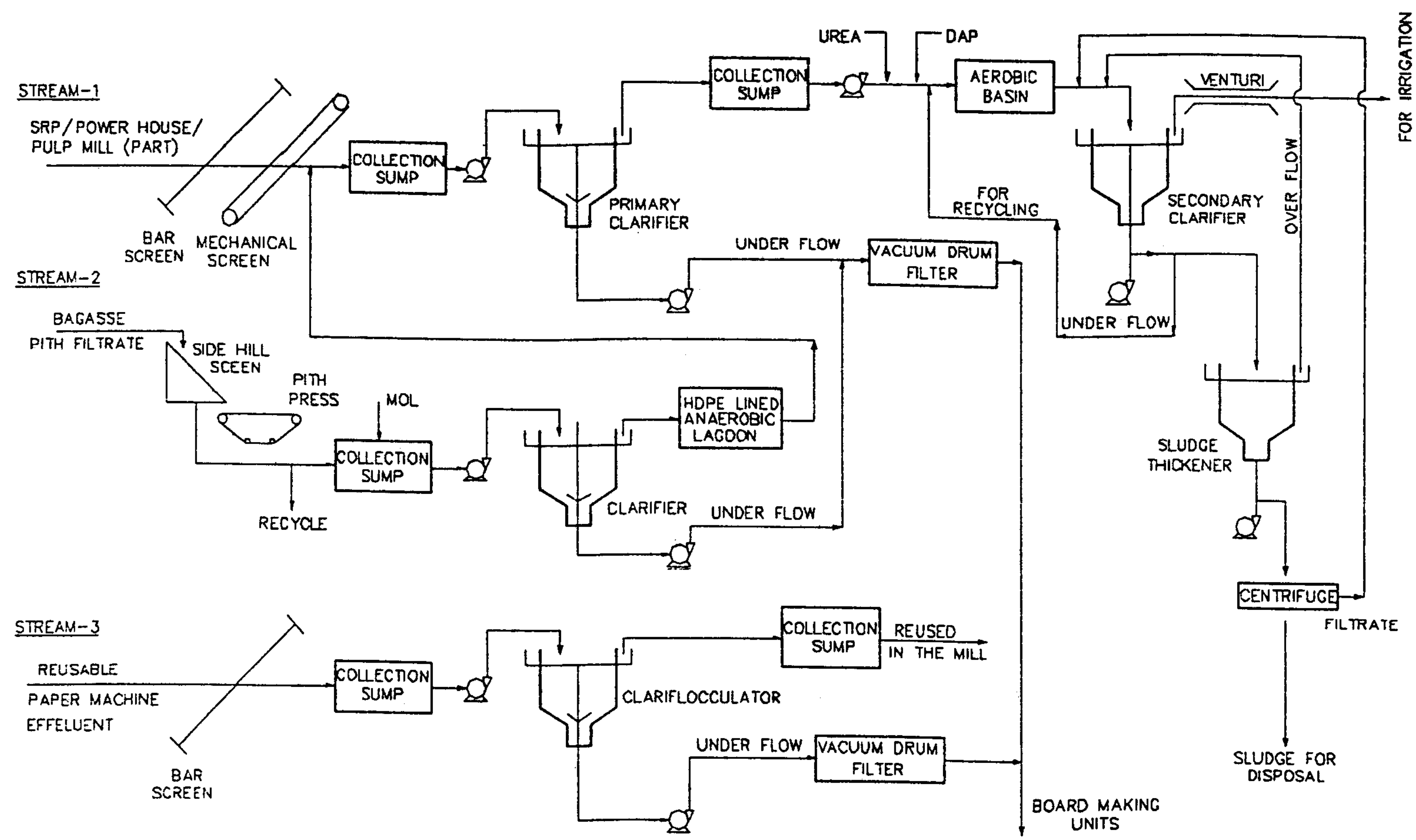
SCHEMATIC DIAGRAM OF WASTE WATER TREATMENT PLANT (AFTER EXPANSION)



as lumps inside the Lagoon area evenly above the sand bed.

Step-3: Pumping of 1000m³ bagasse pith filtrate (10% of lagoon volume) into the lagoon after correction of pH. The influent to lagoon is to be analysed for COD, VFA, TSS and pH.

Inflow is to be added with molasses to curb dissolved oxygen, $FeCl_3$ and ammonium molybdate (sulphate bacteria inhibition).

Step -4: Pumping of acclimatized slurry to the lagoon.

Step-5: Pumping of another 2000m³ of corrected, analysed bagasse pith filtrate to lagoon slowly within 7 days

Sample from lagoon is to analysed for VFA, DO, TSS , pH, Eh and COD

Step-6: Lagoon is to be kept under stabilization for another 10 days without any disturbance.

Step-7: Pumping of 3000m³ treated, analysed pith filtrate after 10 days. Wait for another 10 days. During this period, sample from 1 lagoon is to be analysed for VFA pH, Eh, DO, TSS and COD.

Step-8: Pumping of another 1500 m³ treated pith filtrate and to be watched for another 10 days. Say, after 40 days make the lagoon full and overflow at the rate of 50 m³/hr.

Required amount of Urea and DAP were added in the lagoon along with filtrate during this stabilization period.

During this stabilization period, sample from inside the lagoon was analysed from various points for TSS, BOD, COD, VFA, pH and Eh. The results obtained were reviewed with the experts from time to time for doing any modification in the system (if required).

After about three months of close monitoring work, anaerobic lagoon system came to stabilization. Since, then, SPB is successfully operating the anaerobic system by obtaining satisfactory results in the reduction of COD and BOD, thereby reducing the demand for energy and chemicals in the aeration system. Table-5 represents the various analysis data (in range) of bagasse pith filtrate before and after anaeroboic treatment system. This data clearly shows that, the reduction of COD and BOD across the anaerobic system is at a level of 90-95%. The anaerobically treated bagasse pith filtrate joins the rest of the mill effluent and then pumped to the primary treatment system. Table -6 represents the BOD and COD load of treated effluent from primary treatment system before installation of anaerobic system and after stabilization of anaerobic system. The results clearly show the impact of 1000m³ anaerobic treated effluent on total effluent of 40,000m³, in terms of reduction in BOD and COD load.

While the anaerobic lagoon system appears to be simple, the system is sensitive to variations in retention time, pH and overloading of the system. In anaerobic system as stated earlier the complete organic pollutants are anaerobically degraded by basically two groups of bacteria, viz., acid producing and methane producing. In any upset condition, the substrate available for non-methanogenic bacteria is increased resulting in increased production of volatile fatty acid (VFA), carbon di-oxide, hydrogen etc., Such increase in volatile acids reduces the pH and the anaerobic system collapses. The system therefore needs very close monitoring. Since the retention time is around 10 days in the anaerobic lagoon there is a possibility of suspended solids settling in the lagoon. This will need cleaning of the lagoon, may be once in two years. Alternatively, an anaerobic digester system can be considered which is generally

Table : 5 Performance of anaerobic lagoon

Particulars		Inlet	Outlet
pH		7.0-8.0	7.2-7.8
Temperature	°C	37-38	35-36
COD	ppm	5000-7000	270-350
BOD_5 at 25°C	ppm	2000-3200	110-140
TSS	ppm	1000-2000	100-500

Table : 5 BOD & COD values of 180' primary clarifier treated water

Month & Year	COD, ppm	BOD, ppm
Before installation of Anaerobic lagoon		
January '98	308	105
February '98	314	110
March '98	280	96
April '98	250	102
May '98	291	89
June '98	255	97
July '98	286	88
August '98	310	102
After stabilisation of Anaerobic Lagoon		
December '98	209	85
January '99	260	75
February '99	212	80
March '99	242	85
April '99	186	69
May '99	190	72
June '99	215	83
July '99	185	81
August '99	224	90

an upward flow digester and can tolerate suspended solids. This will also help in generation and usage of methane gas.

CONCLUSION:

The anaerobic system at M/s Seshasayee Paper and Boards Limited, installed for handling the waste water from the bagasse preparation section has been operating well with substantial reduction in COD and BOD values without the use of energy. It has considerably reduced the load on the subsequent effluent treatment system. As per SPB's experience, this anaerobic system works very well for the treatment of bagasse pith filtrate having high BOD and COD load. A combination of anaerobic treatment for bagasse waste water along with a secondary treatment including aeration for mill effluent has given good results.