Pergamon

Wat. Sci. Tech. Vol. 29, No. 5-6, pp. 391–397, 1994.

0273–1223/94 $7·00 + 0·00

0273-1223(94)00140-5

FEASIBILITY OF ANAEROBIC PRE-TREATMENT FOR THE EFFLUENTS FROM HARDBOARD AND LAMINATED BOARD INDUSTRY

V. Eroglu, I. Oztürk, G. Ubay, I. Demir and E. N. Korkurt

Istanbul Technical University, Faculty of Civil Engineering., Environmental Engineering Department, Maslak 80626, Istanbul, Turkey

ABSTRACT

This paper presents results of a comparative evaluation of the feasibility of anaerobic pre-treatment for the effluents from a hardboard and laminated board industry.

The problems associated with the treatment of hardboard mill wastewaters using activated sludge process have been observed as relatively low COD removal, high energy cost and high amounts of excess biological sludge production. The purpose of the study is to evaluate the effectiveness and feasibility of the anaerobic pre-treatment to reduce the excess biological sludge production and energy consumption in the aerobic stage. Anaerobic treatability studies were carried out by a lab-scale upflow anaerobic sludge blanket reactor (UASBR) with an effective volume of 10 litres. The UASBR was operated for a wide range of organic and hydraulic loadings during the experimental studies of more than 4 months. Anaerobic treatability studies have shown that a COD removal of 60% is possible at organic loading rates of 5-11 kg COD/m^3.d. Anaerobic treatability study results have shown that 70 percent reduction both in the excess sludge production and in energy for aeration are possible by applying anaerobic pre-treatment. Considering these findings, it was demonstrated that anaerobic pre-treatment is a feasible option for waste management of the hardboard mill effluents.

KEYWORDS

Hardboard and laminated board industry effluents; sludge treatment; anaerobic pre-treatment; bioenergy recovery; sludge reduction; upflow anaerobic sludge blanket reactor.

INTRODUCTION

Wastewaters from the hardboard industry contain slowly biodegredable matters due to the fact that the main raw material is wood. The main source of COD and BOD_5 are these wood constituents. Substantial amounts of oxygen demanding organics and suspended solids are produced at the hardboard mills. The discharge of these highly polluted wastes into relatively small streams causes unacceptable environmental pollution problems.

The investigated industry is SEKA Bolu Hardboard and Formica mill in Bolu province on the northwestern part of Anatolia in Turkey. This mill is a potential source of pollution due to high amounts of water consumption and high pollution load. The problems associated with the treatment of hardboard mill

wastewaters in the activated sludge process have been observed to be relatively low COD removals, high energy costs and high amounts of excess biological sludge production. The aim of this study was to evaluate the effectiveness of the anaerobic pre-treatment to reduce the quantity of excess biological sludge and to lower the high energy cost in the existing activated sludge treatment system.

MILL DESCRIPTION

Hardboard is produced by the "wet process" in the investigated industry. Production of hardboard by the wet process method is usually accomplished by thermomechanical fiberization of the raw wood material.
Dilution of the wood fiber with water is followed by formation of a wet mat of a desired thickness on a forming machine. This wet mat is then pressed either wet or dried. Several chemicals are added to improve the overall strength, stiffness, hardness, finishing properties, resistance to abrasion and moisture, durability and uniformity. There are two different ways in hardboard manufacturing depending on the method in which the fibers are carried and formed into the mat, and subsequently board. One is the wet process where water is used as the carrying medium. The other one is the dry process in which air serves the same task. Hardboard which is pressed wet immediately following forming of the wet lap is called wet-wet or smooth-one-side (S1S) hardboard. If the wet lap is pressed after drying then the process is called wet-dry and the hardboard is smooth-two-side (S2S).

The basis of decorative laminated board (formica) production is to press some kind of resin absorbing paper under high pressure and temperature by impregnating it with thermo-setting polymer materials. More information about hardboard and formica production processes can be found elsewhere (Eroglu *et al*, 1989).

SEKA Bolu Hardboard and Formica Mill produces annually 14,000 metric ton of hardboard, 2 million m^2 of laminated board (formica) and 2,000 metric ton of decorative paper using 24,000 metric ton raw wood. The mass balance of the raw materials and products is illustrated in Fig. 1.

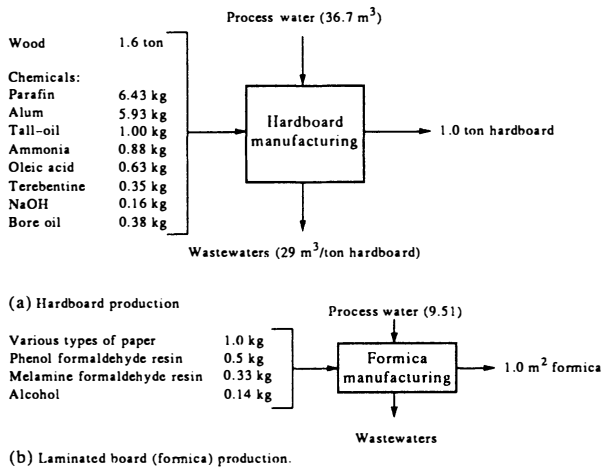

Fig. 1. Process Mass Balance For SEKA Bolu Mill (Eroglu *et al.*, 1990).

EXISTING WASTEWATER TREATMENT PLANT

The existing external wastewater treatment plant of the mill was put into operation in January 1989. The plant consists of an equalization basin, a rapid mixing tank, flocculation and primary sedimentation tanks and two-stage activated sludge units. The excessive quantity of the sludge and high energy costs are among the problems of the existing plant. The flow diagram of the existing wastewater treatment plant is shown in Fig. 2. The yearly average flow of the mill is about 1815 m^3/d. The wastewater is poor in terms of nitrogen and phosphorus concentration. Therefore, ammonia and phosphoric acid are added in order to have BOD_5:N:P ratios of about 100:5:1. Design parameters for the treatment plant are summarized in Table 1.

Table 1. Design Parameters For The Existing Treatment System

Parameter	Equalizat. Tank	Rapid Mixing	Floccul .Tank	Primary Settler	First Stage AS		Second Stage AS	
					Aeration Basin	Settling Tank	Aeration Basin	Settling Tank
Flow (m^3/d)	1815	1815						1815
Volume (m^3)	140	2x4.6	2x17.6	227	2x230	227	4x436	478
Water depth (m)	-	-	-	3.6	3.6	3.6	3.6	2.5
COD (t/d)	11.8	11.8	-	-	8.3		4.7	
MLVSS (mg/l)					3000		3500	
F/M (gVSS/gCOD-d)					2		0.18	
COD removal (%)				30	-	30	-	75

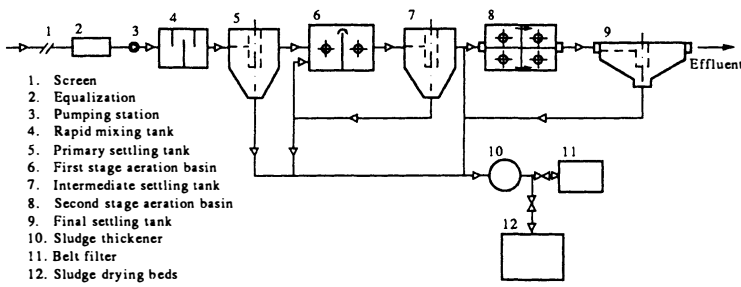

Fig. 2. Schematic of SEKA Bolu mill wastewater plant.

MATERIAL AND METHODS

Composite samples from the effluent of the primary settling tank in SEKA Bolu mill, were used for the anaerobic treatability studies. Wastewater samples were analyzed for suspended solids (SS), COD, pH, alkalinity, temperature, TKN and P using APHA Standard Methods (1990). Biogas flowrates were measured by a wet type gas meter. CO_2 content of the biogas was determined by Orsat apparatus. Reactor temperatures, pH, feed and biogas flowrates were continuously monitored. Alkalinity measurements were performed on a daily basis. COD and SS analyses were made three times per week while TKN and P parameters were analyzed once in two weeks.

RESULTS AND DISCUSSION

Evaluation of Full-Scale Treatment Plant Performances

The treatment plant has been carefully operated since January 1989. The average flow, pH, temperature, SS, BOD_5 and COD values measured in 1990 are given in Table 2. Following the evaluation of the treatment plant performance data for 1990, it is found that the annual average BOD_5 removal efficiency is 81%. Annual average COD and SS removal efficiencies are 78% and 58%, respectively. Low SS removal efficiency is a common problem also observed at the other wet process hardboard mills (Eroglu and Sarikaya, 1992).

TABLE 2 Average Performance Data for SEKA Bolu Wastewater Treatment Plant in 1990

Parameters	Influent	Primary Settler Effluent	Final Settler Effluent	Overall Efficiency, %
Flow, l/s	21 ± 2	-	-	-
pH	5.8 ± 0.7	7 ± 0.5	7.4 ± 0.3	-
Temperature,°C	21 ± 3		12 ± 8	-
SS, mg/l	380 ± 170		160 ± 60	58
BOD_5, mg/l	2 880 ± 720		537 ± 110	81
COD, mg/l	6 500 ± 1 400		1 365 ± 383	78

Discharge standards for COD and SS are 1500 and 200 mg/l, respectively, in Mudurnu river. The COD limits have been met by the existing treatment system but there are some difficulties in achieving the discharge limits of SS.

The average MLVSS concentrations in the first and second aeration basins are 300 and 3500 mg/l, respectively. The amount of primary and biological sludges average about 2 t/day and 2.8 t/day, respectively. Primary sludges contain about 65 percent chemical sludges (alum and lime). Average chemical consumption for SEKA Bolu treatment plant is about 1.6 t/day. COD and sludge mass balances are presented in Fig. 3.

Anaerobic Pre-Treatment As an Alternative For Energy and Biological Reduction

The average excess biological sludge from SEKA Bolu mill wastewater treatment plant is about 235 m^3 per day with 1.2 percent DS content at design loading conditions. This corresponds to about 2.8 t DS per day. The daily energy requirement for the two stage activated sludge treatment system is about 2000 kWh, corresponding to 1.1 m^3 per wastewater treated, at the current operating conditions. Anaerobic pre-treatment is a feasible alternative for various purposes, including excess biological sludge reduction, saving of aeration energy and bioenergy production from the biogas, in the hardboard and formica industries. In this section, the effects of anaerobic pre-treatment on the excess biological sludge production and the energy requirement for the activated sludge aeration are investigated.

Anaerobic-Treatability Studies

Anaerobic treatability studies were conducted in a lab-scale upflow anaerobic sludge blanket reactor (UASBR) which was a 120 mm diameter plexiglass column with a volume of 10.35 litres at mesophilic conditions.

The reactor had been used in another treatability study and the biomass concentration in the sludge blanket was about 30 g VS/litre which was averaging about 20 g VS/litre considering the total liquid volume of the UASBR. The reactor was fed with the 24 h composite effluent from the full-scale primary sedimentation tank of the SEKA Bolu wastewater treatment plant. The feed was supplemented with urea and H_3PO_4 for providing nutrient balance in accordance with COD:N:P ratios 250:5:1 for anaerobic treatment.

Operating parameters including pH, temperature, alkalinity, COD and gas flowrates were measured daily for the UASBR influent CODs and CO_2 content of the gas were analyzed three times per week. Laboratory scale UASBR treatment results presented in this paper have covered about 130 days of operating period.

Evaluation of the Treatability Results

Table 3 summarizes steady state averages of major operating parameters for three different hydraulic retention times (HRT). Figs. 4 and 5 show the observed COD and biogas flowrates against time during the anaerobic treatability studies. Low COD removals and biogas production yields in Run I reflect the effect of start-up on the UASBR. Considering these findings, it can be concluded that UASBR treatment of settled primary effluent from the SEKA Bolu mill provides a COD removal of about 60 percent at 12 h of retention. Biogas production yields of about 0.25 m^3 per kg COD removed can be achieved and this corresponds to about 0.20 m^3 methane per kg COD removed. Sixty percent reduction in COD means about 70-75 percent removal of the easily biodegradable portion of the influent COD (i.e. BOD_5) Oztürk et al (1992), Eroglu et al (1992). Seventy percent reduction of the BOD load in the existing full-scale activated sludge system will result in 70 percent reduction of the energy requirement for aeration and in the excess biological sludge production. The mass balance for COD and SS in the case of anaerobic pre-treatment for the SEKA Bolu mill are shown in Fig.6. The net energy equivalent of the biogas from the anaerobic reactor will be about 7690 kWh, per day for average design conditions and this corresponds to a bioenergy recovery of 280,000 US Dollars per year.

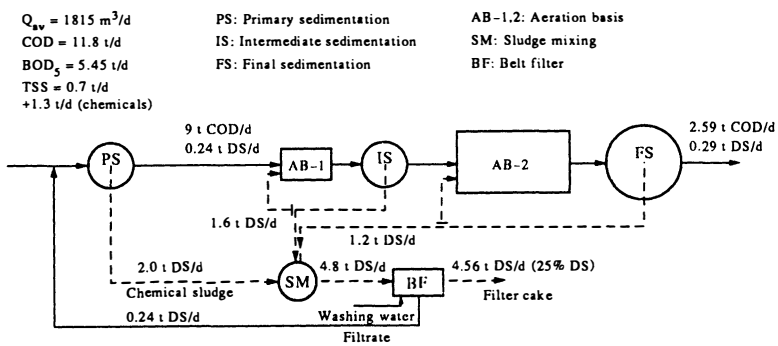

Fig 3. COD and Sludge Mass Balance For The SEKA Bolu Wastewater Treatment Plant

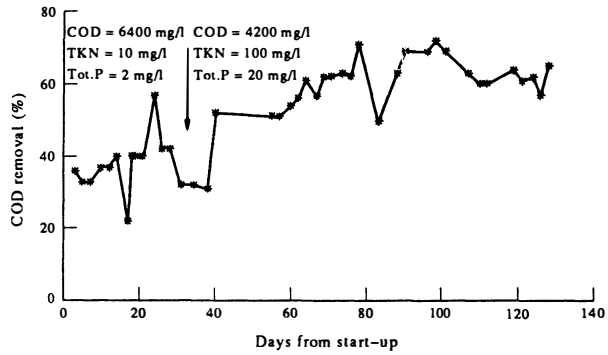

Fig. 4. COD removals(%) vs time graphs for the anaerobic treatability studies.

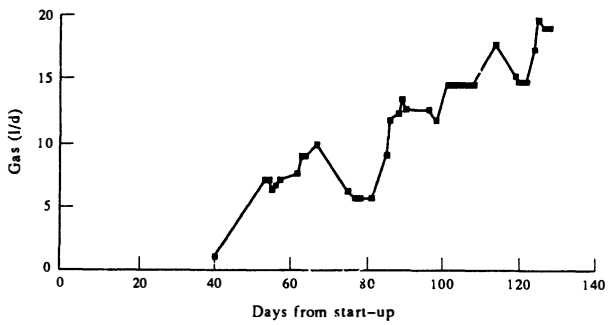

Fig. 5. Biogas production rate vs time graph for the treatability studies.

Table 3 Steady-State Operating Results From The UASBR Treatment of SEKA Bolu Mill Effluents

Parameters	Influent (Feed)	HRT=24h (Run I)		HRT=13h (Run II)		HRT=10h (Run III)	
		Infl.	Effl.	Infl.	Effl.	Infl.	Effl.
pH	6.9±0.6	-	7.6±0.6	-	7.6±0.6	-	7.6±0.6
Temperature (°C)	-	-	33±2	-	33±2	-	33±2
Alkalinity (mg/l)	1040±255	-	1340±360	-	1340±360	-	1340±360
COD_T, (mg/l)	4890±1426	5230±1560	2870±1338	4170±491	1300±170	4710±987	1882±450
Q_{gas},(l,d)	-	-	7.85±2	-	13.56±1	-	16.7±2

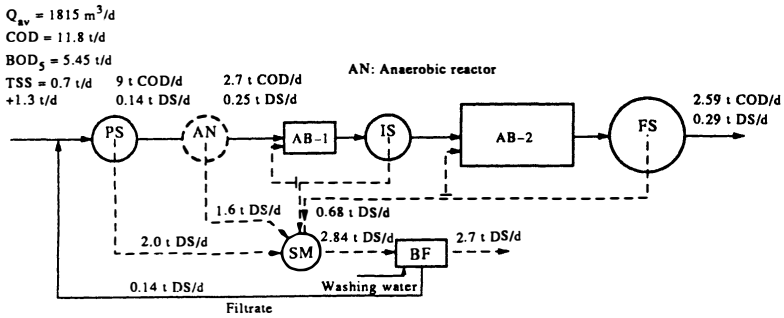

Fig. 6.COD and sludge mass balances in the case of Anaerobic Pretreatment for the SEKA bolu Mill.

CONCLUSION

Anaerobic pre-treatment prior to the existing activated sludge system in the SEKA Bolu Hardboard and Laminated Board (Formica) mill may provide 70 percent reduction both in energy for aeration and in excess biological sludge production from the treatment plant. In addition to these, it is also possible to recover bioenergy of 7690 kWh per day, corresponding to 280,000 US Dollars per year, by adding anaerobic pre-treatment into the existing treatment system. These results have clearly indicated that anaerobic pre-treatment is a very feasible way for energy saving and biological sludge reduction in the agro-industries.

ACKNOWLEDGEMENTS

The authors are grateful to The General Directorate For Turkish Pulp and Paper Association (SEKA) for permission to publish the data used in this study.

REFERENCES

APHA, AWWA and WPCF. (1990). Standard methods for the examination of water and wastewater. 21st edition. Washington, USA

Eroglu, V., Öztürk, and Sarikaya H. Z. (1992). Aerobic and Anaerobic Treatment Studies of Pulp and Paper Industry Wastewaters. *Biowaste'92 Proceedings*. 1st International Conference and Exhibition on Biological Waste Treatment. June 1-4, Denmark.

Eroglu, V., San, H. A. and Sarikaya, H. (1989). Joint Treatment of Liquid Wastes of Wet Process Hardboard and Formica Plant, *Proceedings of 44th Purdue Industrial Waste Conference* , Lewis Publishers, Inc. Michigan, USA, pp.719-725.

Oztürk, I, Eroglu, V. and Basturk, A. (1992). Sludge Utilization and Reduction Experiences in Pulp and Paper Industry. *Water Science and Technology* **26**(9-11), 2105-2108.