A. No. 332

Research Article

Journal of Plantation Crops, 2008, 36 (3): 491-495

A novel approach for abatement of pollution, reuse of treated water and utilization of bioenergy in rubber sheet processing

Jacob Mathew, P. Doraisamy *, S. Kamaraj*, Eapen Kuruvilla** and C. Kuruvilla Jacob

Rubber Research Institute of India, Rubber Board, Kottayam 686 009

* *Tamil Nadu Agricultural University, Coimbatore - 3*

** *Department of Processing and Product Development, Rubber Board, Kottayam 686009*

Abstract

Processing of RSS generate around 12 L of waste water per kg of dry rubber as serum and floor wash. An attempt was made to treat the waste water to avoid pollution. The floor wash was collected in a collection tank and the rubber (2.3%) contained was recovered by coagulation. The sheet serum and floor wash (after removal of rubber content) were passed through a filter bed and pumped into an overhead tank, from when it was fed to anaerobically erected cylindrical anaerobic high-rate reactor through its bottom. The inlet was controlled by a valve. The organic matter content in the waste water was digested in the reactor by microbial degradation. The biogas generated in the process was separated with the help of a gas liquid separator and collected in a gas holder. The treated water removed from the top of the reactor was oxygenated by diffused air pumped in through diffusers in an aeration system to remove the remaining pollutants by aerobic microbial degradation. After aeration the water was directed to a sedimentation tank, where the sludge was separated by sedimentation. The overflow from the sedimentation tank was further passed through a filter bed. The clear water was collected for reuse in sheet processing. The aerobic treatment generated 3 to 5 L biogas containing methane per litre of effluent and could reduce its BOD and COD by 80 to 90%. The aerobic treatment could further reduce the pollution pavements to safe limit prescribed for disposal. The advantage of this sytem was the reduction in the time required for treatment of waste water from 10 days (using anaerobic immobilized growth digesters) to 24 hours, thus reducing the requirement of waste water holding capacity and consequently the land requirement in group processing centers.

Keywords: bio energy, polution, rubber sheet processing treated water

Introduction

Natural rubber (NR) latex contains around 30-45% rubber and the rest is water containing sugar, protein and other organic and inorganic materials. Conversion of fresh NR latex into ribbed smoked sheet (RSS) is the oldest and most widely practiced method of primary processing in India (Kuriakose and Thomas, 2000). While processing the latex an equal quantity of water is added to the latex and diluted organic acids like formic or acetic acid is mixed with it to coagulate the rubber in aluminium dishes. While forming the coagulum, a part of the non-rubber constituents along with water and the acid gets separated in the dishes. The other part which remains within the coagulum is squeezed out while pressing the coagulum between the rollers to make sheets. This is the main source of waste water in sheet processing. Latex gets spilled on the floor of the processing room while handling it in the group processing centres. The spilt latex along with the water used for the washing of latex carrying and collecting utensils forms the floor wash, which is another source of effluent from the processing centre. As the sheet processing waste water contains organic materials microorganisms proliferate in it and emit foul smell thus deteriorating the quality of the environment. The waste water cannot be directly discharged into water body or to the soil as it causes pollution. The pollutants need to be eliminated before disposal.

In order to improve the quality of RSS, Group Processing Centers (GPC) under Rubber Producing Societies (RPS) are being promoted by Rubber Board where latex from small holdings are collected and processed. Consequently the quantity of waste water *vis-à-vis* extent of pollution are high in this GPCs. Hence waste water treatment using Anaerobic Immobilized Growth Digester (AIGD) followed by aerobic pond was recommended earlier (Mathew *et al.*, 2005). The

Hydraulic Retention Time (HRT), the time required for the proper treatment in this system was about 10 days.

The treatment efficiency of AIGD depends on the flow rate of effluent to the treatment system. The flow rate is fixed based on the capacity of the plant and the HRT required so that the effluent is fed uniformly round the clock. An increase in the flow rate or the lowering the HRT could lead to the improper and insufficient treatment.

Increase in the quantity of latex processed than originally planned led to increase in quantity of effluent generated and has rendered the treatment system in many GPCs inefficient. Since the rubber processing period in the GPC is only for a few hours in the morning, the whole waste water is fed at a time. Sudden feeding of the effluent disturbs the functioning of the system and results in the improper treatment.

The aerobic ponds work on the principle of natural diffusion of atmospheric oxygen. The partially treated waste water from the AIGD is fed to the aerobic pond. Due to the small and disproportionate size of the ponds, this treatment was also found insufficient and ineffective to treat the large quantity of waste water and bring down the pollution parameters to the safe limit.

Scarcity of space is a constrain to install another digester or increase the volume of the aeration tank to contain the excess waste water in most GPCs. This situation warrants the design and development of a highly efficient, quick treatment system that require minimum space for the treatment of waste water generated in the RSS Processing in GPCs.

Materials and Methods

1. Quantification of waste water

a. Sheet serum

The serum removed from the coagulum while it was passed through the sheeting battery, the wash water formed in the process and the left over serum in the coagulation dish were bulked and the pooled serum was measured. The quantity of serum generated was expressed as volume per kilogram of processed dry rubber.

b. Floor wash

The floor wash containing the spill over latex, wash water from latex carrying and collecting containers and hand washing of the handling persons were pooled and measured. The quantity of floor wash generated was expressed as volume per kg of dry rubber processed

Fortnightly measurement of both sheet serum and floor wash was done for six months and the mean value calculated.

2. Primary treatment (Physical)

a. Collection of floor wash and recovery of rubber

The floor wash containing latex was collected every day in a 1.5 m x 1.5 m x 1 m tank having an outlet at the bottom with a control valve. Formic acid was added to floor wash (60 ml /L), mixed thoroughly and retained over night. The rubber particles get coagulated and floats on the surface. The bottom fraction is disposed off from the bottom before collecting the floor wash on the next day. The rubber recovered is removed once in three days.

b. Filter bed

The sheet serum and the floor wash after recovery of rubber was passed through a filter unit with a down flow followed by an up flow water movement. The down flow filter bed was filled with 6 mm broken stone at the bottom (75 cm) over which 20 mm broken stone was filled (75 cm), over this layer a coir fibre layer (45 cm) was placed. In the upflow filter bed, the bottom layer was filled with 20 mm broken stone (75 cm) over which 6 mm broken stone was filled (75 cm). The waste water after passing through the filter bed was collected in a collection tank of 2 m x 1 m x 1.5 m size.

c. Overhead tank

Waste water in the collection tank was pumped to an over head tank of 2 m^3 capacity. The high rate anaerobic reactor was fed from the over head tank through a pipe with a control valve with the flow adjusted to 60 L/h.

3. Secondary treatment (Biological)

a. Design and development of high rate reactor

The reactor (Fig. 1 a, b) was fabricated with mild steel sheet and coated with Fibre Reinforced Plastic (FRP) based on the

Fig. 1a. Anaerobic high rate reactor

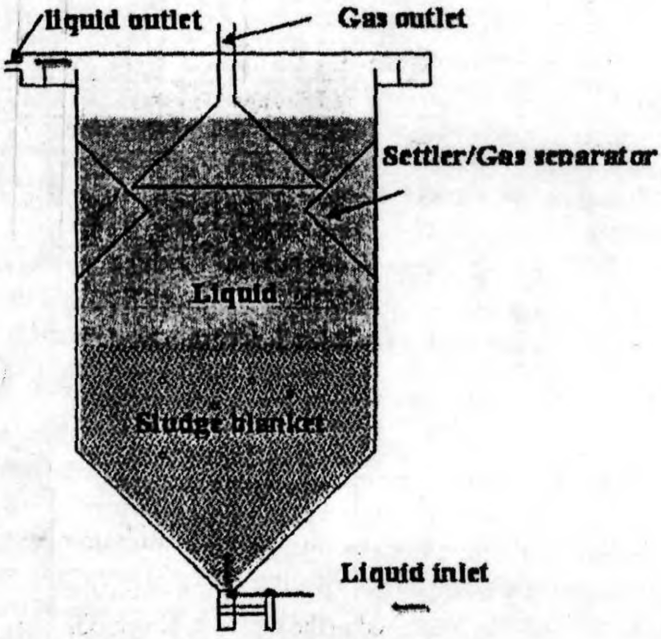

Fig. 1b. Schematic diagram of anaerobic high rate reactor

earlier studies using bench scale models (Duraisamy *et al.*, 2005). The design parameters of the high rate reactor are given in the Table 1. The total reactor volume includes the effective reactor volume and the volume occupied by the gas liquid separator (GLS). The effective reactor volume was calculated based on the formula p/4 x d^2H and found to be 1.44 m^3. The reactor was installed in the RSS processing GPC at Elavampadom RPS, Palakkad. After proper seeding the plant was loaded daily with the effluent. The HRT maintained was 24 h. Effluent samples from the inlet and out let of the high rate reactor were drawn fortnightly intervals for 3 months and analyzed and estimated the per cent reduction in pollution paprameters. Daily production of biogas and its methane content were also estimated.

Table 1. Design parameters of the high rate reactor

Effective reactor vol.	1.44 m^3
Daily loading	1.44 m^3/day
Diameter of the reactor	0.75 m
Effective reactor height	3.27 m
HRT	24 h

b. Design and development of diffused aeration system

Diffused aeration system was developed on the basis of the bench scale studies. This was used for aerobic treatment. A 2.2 m x 2.2 m x 1.2 m tank was constructed and nine disc type diffusers of 30 cm diameter each were placed at a distance of 60 cm from each other and placed at the bottom of the tank. Effluent from the high rate reactor was fed to the aerobic treatment system at the rate of 60 L/h. Fine bubbles of air were generated from the discs with the help of 2 HP blower. An HRT of 24 h was maintained in this system.

c. Sedimentation tank

The outflow from the aeration tank was retained for two days in a sedimentation tank of 2 m depth and 3 m diameter. A part of the sludge was pumped into the aeration tank to maintain the Mixed Liquid Suspended Solid (MLSS) with active bacteria.

4. Tertiary treatment (Filtration)

The over flow from the sedimentation tank was fed to a two stage filtration unit having a down flow and up flow movement. The down flow system consisted of 6 mm and 20 mm broken stone in the bottom and top layer (75 cm) respectively. The up flow system was arranged with 20 mm broken stone at the bottom and 6 mm at the top layers (75 cm). The filtered water from the filter bed was collected in a 2.2 m x2.2 m x1.2 m tank and recycled for the processing.

5. **Characterization of the waste water**

Combined initial effluent, and after primary, secondary and tertiary treatments were collected and analyzed for various physical and chemical properties using standard methods (Trivedi and Goel, 1986). Rubber content in sheet serum and floor wash was also estimated separately.

6. **Recycling of treated water**

The treated water was used for the dilution of latex for sheet making and for the various washing purpose. Ten sheets were made daily using the reused water for one month and graded as per the standards given in the green book (IRQPC, 1979).

7. **Collection of biogas and utilization**

Gas generated during the anaerobic process was measured using a gas flow meter and average daily production was calculated. The gas was stored in a 15m³ FRP gas holder of a conventional biogas plant and used for burning in the smoke house to generate heat for drying the sheets. The average daily burning time of the gas and the temperature buildup in the smokehouse were also estimated. The quantity of firewood replaced by utilizing the biogas in the smoke house was also estimated.

Results and Discussion

1. **Quantification of waste water**

a. **Sheet serum and floor wash**

The quantity of the two sources of effluents in the RSS processing is given in Table 2. The average volume of sheet serum generated was 4 L/kg DRC. This comprised of the water content in the latex, water added for the dilution of latex during coagulation and the diluted formic acid used for coagulation. Floor wash generated while processing was on an average 8L/ kg dry rubber.

Table 2. Quantity of waste water generated in sheet processing

Source	Quantity generated	Rubber content (g/L)
Serum	4 L/kg DRC	2.5
Floor wash	8 L/kg DRC	23.5
Total	12 L/kg DRC	26.0

Recovery of rubber

The coagulation of the floor wash resulted in recovery 800g of dry rubber per 1000 L of effluent collected daily.

Performance evaluation of the integrated treatment system

The extent of reduction in pollution parameters of effluent at each stage of treatment was estimated and compared with the safe limit (Table 3) (KSPCB, 1997). There was an increase in the pH from 5.5 from the initial to 7.7 at the final stage. The total solid content in the untreated effluent was 14280 mg/L, which was reduced to 420 mg/L, due to treatment. The reduction of total solids in this treatment system was 97% indicating oxidation of the organic constituents in the waste water by the action of microorganisms (Kudalingama and Yapa, 2007). The COD in the untreated effluent was 11944 mg/L, which was reduced to 182 mg/L in the final discharge (98.4%) reduction. BOD also reduced to 48 mg/L from 4065 mg/L. The BOD reduction per cent was 98.8. The significant reduction in both COD is due to the biological oxidation of the organic matter in the processing effluent (Bitton, 1999). Since the final discharge aft the series of treatments was with in the safe limit, tl treated water was found suitable for reuse in the processing.

Table 3. Characteristics of effluent after integrated treatment

Source	Effluent parameter (mg/l)			
	pH	TS	COD	BOD
Raw effluent	5.5	14280	11944	4065
After biomethenation	6.5	1756(87.7)	912(92.3)	204.4(94.9)
After aeration and settling	7.7	880(93.8)	240(97.9)	67(98.3)
Final discharge	7.7	420(97)	182(98.4)	48(98.8)
Safe limit	6-8	2100	250	100

Grading of sheets processed using the treated water

All the sheets made using the treated water were graded consistently as RSS 1. This finding revealed that the treated water could be used for making quality sheets.

Quantity of biogas generated and its utilization

Monthly average biogas production from June to December 2007 is presented in the figure 2. The maximum gas production of 3210 L/day was obtained during November which may be due to the generation of large volume of waste water during the period. The biogas was found to contain upto 67% methane. The gas was burned in a smoke house (250 kg capacity) for 5 hours using biogas stove. The maximum temperature build up in the smoke house was 52°C. The comparative study on the use of firewood alone and in combination with biogas revealed that the heat generated by burning 100 kg of firewood could be attained by initial burning of biogas for 5 hours followed by use of 70 kg firewood (Fig. 3). Hence,

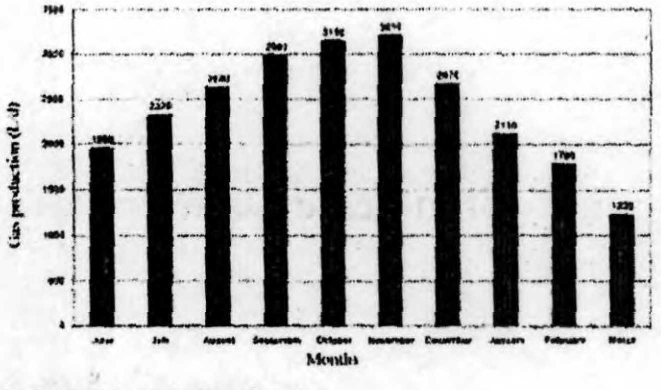

Fig. 2. Monthly production of biogas

firewood saving of 30% could be achieved by the initial burning of biogas in the smoke house.

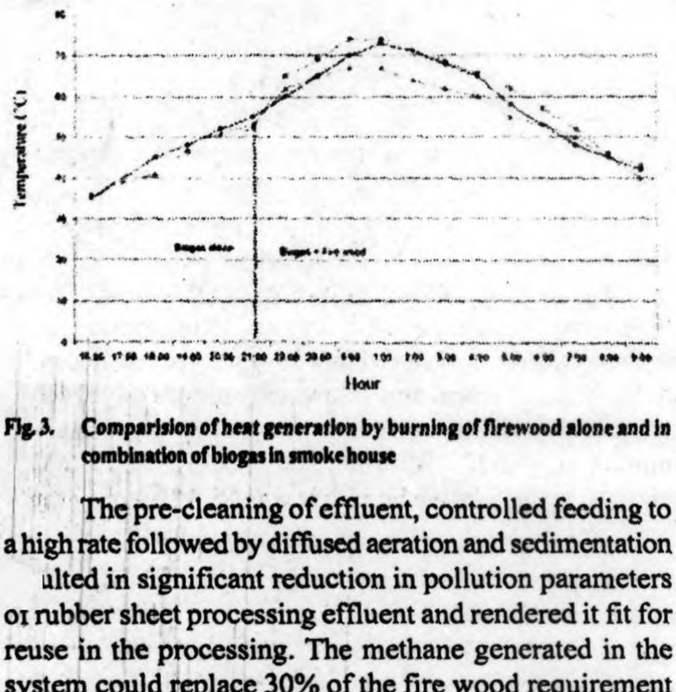

Fig. 3. Comparision of heat generation by burning of firewood alone and in combination of biogas in smoke house

The pre-cleaning of effluent, controlled feeding to a high rate followed by diffused aeration and sedimentation ulted in significant reduction in pollution parameters of rubber sheet processing effluent and rendered it fit for reuse in the processing. The methane generated in the system could replace 30% of the fire wood requirement in the smoke house. The new system thus saves on energy and water input for sheet processing in group processing centers.

Acknowledgement

Authors are thankful to Dr. James Jacob, Director, RRII and Dr. N.M. Mathew, former Director, RRII for the encouragement and valuable suggestion during the study. They are also thankful to the co-operation and help rendered by the President, Board members and workers of the Elavampadom Rubber Producers Society, Palakkad.

References

Bitton G. 1999. Activated sludge process in waste water. *Microbiology*. 2nd edition, John Wiley and Sons Inc. Publication, New York, pp. 181-206.

Doraisamy, P., Kamaraj, S., Senthilkumar, N., Mathew, J. 2005. Energy production from rubber latex processing waste water through biomethanation. pp. 435-441. In : *International Natural Rubber Conference*, India, Preprints Rubber Research Institute of India, Kottayam, India.

IRQPC 1979. International standards of quality and packing for natural rubber grades. The Green Book. International Rubber Quality and Packing Conference. The Rubber manufacturers Association Inc., Washington DC, p. 19.

KSPCB, 1997. Environment, effluent, emission and noise: standards and guidelines. Kerala State Pollution Control Board, Trivandrum, 105 p.

Kudalingama, K.V.V.S. and Thomas, K.T. 2000. Rubber sheets. pp. 386-398. In: Natural Rubber: Agromanagement and crop Processing (Eds.) P.J. George and C.K. Jacob, Rubber Research Institute of India, Kottayam.

Mathew, J., Sanal, K.V., Rameshan, C.K.V., Jessy, M.D. and Jose, G. 2005. Treatment of RSS effluent in Anearobic Immobilized Growth Digesters (AIGD) and its use for irrigation. pp. 426-435. In: *International Natural Rubber Conference*, India, Preprints Rubber Research Institute of India, Kottayam, India,

Trivedi, R.K. and Goel, P.K. 1986. Chemical and biological methods for water pollution studies. Environmental publications, Karad, 252 p.