Performance Evaluation of an Integrated Waste Water Treatment System for Ribbed Smoked Sheet Processing Waste Water with and Without Bio-dek in the Aeration Unit

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***Abstract*— Rubber processing is considered to be one of the major sources of income to our country. Out of five hundred thousand hectares of rubber plantation in India, Kerala state alone has 75.3 per cent. Rubber processing industry is considered to be one among the major industries that contributes major water pollution. Waste water is an unavoidable by product of rubber processing. About 60 percent of the latex exuded by a rubber tree is water. Waste water generated during the processing of natural rubber latex into Ribbed Smoked Sheets (RSS) contains substantial amount of organic compounds leads to environmental pollution when disposed untreated. Treatment of waste water to bring down the excess pollution parameter to the tolerance limit is mandatory for the disposal to the environment .In view of this, integrated waste water treatment system(IWWTS) was designed, installed and evaluated in an RSS group processing centre. Treatment system consists of primary, secondary and tertiary treatment system. Primary treatment include floor wash collection and coagulation, filtration and equalization tanks. The secondary biological treatment system includes High-rate Anaerobic Methanogenic Reactor (HRMR) and a diffused aeration system. Pressure sand is the tertiary treatment system. The main aim of this study is to evaluate the performance of all the treatment units and the diffused aeration unit is redesigned with attached growth Bio-Dek medium. At the end the comparative study is made with the characteristics of the effluent from the diffused aerator with and without attached growth medium.**

Keywords-Rubber industry,Ribbed smoked sheet, effluent , waste water treatment and reuse , Bio-Dek

1. INTRODUCTION

Wastewater is an unavoidable by-product of rubber processing; whatever processing procedures are used for preparing products from latex, there will always be an aqueous liquid as a by-product (Rungruang and Babel, 2008). If the wastewater is put straight into surface waters wells, streams, lakes or even the sea without any treatment, it will inevitably pollute that water. The disposal of these effluents into public water bodies can give rise to serious depletion of dissolved oxygen, thus affecting the normal environment supporting the aquatic system(Mohammadi et al., 2010).

Rubber processing effluent consists of large number of contaminants, thus makes it difficult to recycle. Proteins, sugars, lipids, carotenoids, inorganic and organic solids of latex, various chemicals added for processing and water used for processing constitute the effluent from natural rubber processing factories. Wastewater from the natural rubber latex processing is heavily polluted; pollution is expressed in high suspended solids (from the remaining latex), high organic matter and nitrogen-containing pollutants (N-organic, N-NH3), high acidity and strong smell. The present studies reveals that the latex concentrate effluent contained more suspended solids, dissolved solids, total solids (TS) and volatile solids (VS) which resulted in substantial growth of microorganisms resulting in high Biochemical oxygen demand (BOD) and Chemical oxygen demand (COD). Studies show that the amount of solids plays a significant role in the salinity of effluent. High BOD and COD value of the rubber processing effluent indicate that the TS in the effluents are mainly organic, especially fine particles of rubber hydrocarbon, with high oxygen requirements for their oxidation.

Regarding the treatment methods for rubber processing waste water, the greatest difficulty is the low efficiency of treatment. For example, the technologies including UASB, activated sludge, oxidation ditches etc. do not have enough ability to remove completely of Nitrogen containing pollutants(Daisuke Tanikawa et al, 2012).

Anaerobic digestion and activated sludge processes are widely applied in factories because of their high efficiency in treating organic matter and the low operation cost. This method is suitable for waste water from rubber sheet processing as well as smoked rubber sheet waste. Anaerobic sequencing batch reactors using effective micro organisms were also used for the treatment of rubber processing effluent which offered a 60% removal of COD, 62% removal of BOD_5, 62% removal of turbidity, and 84% removal of Total suspended solids (TSS)(Nurul Zaizuliana Rois Anwar et al, 2013).

Infact, the ‘trickling filter’ and ‘activated sludge’ process of wastewater treatment employ micro-organisms immobilized by natural means. Microbial cells naturally adhere to colonize on any solid surface immersed in an aquatic environment, forming a bio-film (Characklis Q c;l,l983). Immobilized cells have a major role to play in the removal of organic pollutants from industrial effluent or from partially treated sewage effluent. Immobilization of microbial cells and their use in wastewater treatment has been extensively reviewed (Cheetham and Bucke, 1984). The scientific and technical aspects of using immobilized microbial cells for environmental

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application were also investigated (Cassidy G ;l,1996). The formation of immobilized biomass offer many advantages for the proper operation of wastewater systems. By immobilizing the biomass, the liquid retention time can be uncoupled from the biomass retention time which enables higher rate conversion of organic and inorganic compounds in relatively small bioreactor. In addition, biomass is easily separated from the purified wastewater by settling (Alfons and Stephanie, 1997).

Tampion and Tampion (1987) stated that almost any type of support materials could be empirically tried ranging from natural crushed rocks, porous solid wastes, ceramics and other heat treated inorganics to natural organic materials and synthetic plastics in almost every conceivable physical shape and in the whole spectrum of reactor designs.

2. EXPERIMENTAL WORK

Waste water generated during the processing of natural rubber latex into ribbed smoked sheets(RSS) contains substantial amount of organic compounds, leads to Environmental pollution when disposed untreated. In view of this, integrated waste water treatment system was designed, installed and evaluated in a Rubber Producers Society, Pariyaram, Chalakkudy. The treatment system consists of primary, secondary and tertiary treatment system. Samples were collected from each units at an interval of 15 days for three months and parameters considered are COD and BOD. After analyzing the removal efficiency of present units , an attached growth Bio-Dek was designed and installed in the aeration tank. Then the analysis for the same is done for COD and BOD removal efficiency at an interval of 15 days for another 3 months.

3. TREATMENT UNITS

1) The primary treatment includes floor wash collection and coagulation, Filtration, and equalization tank.

a) Floor wash collection and coagulation tank

-Rectangular coagulation tank is designed to hold floor wash produced in a day for 24 hrs.

b) Initial filtration unit

-This rectangular tank have down flow and upflow water movement.The tank is packed with broken stones and coir fibre.

c) Equalization tank

-The unit is rectangular in shape, which holds both filtered serum and floor wash after coagulation together.

2) The secondary biological treatment system has got a specially designed High rate Methanogenic Reactor (HRMR),a diffused aeration system and a sedimentation system.

a) High rate Methanogenic Reactor(HRMR)

High rate Methanogenic Reactor is a hybrid methanogenic reactor which utilizes the dual advantage of both immobilized microbial digestion and suspended agglomerated granular bacterial digestion as in UASB reactors.

The HRMR is a modified anaerobic immobilized growth digestor (AIGD) with its upper $2/3^{rd}$ portion is thickly packed with a media of PVC having a plurality of surfaces for the bacterial attachment. The bottom of the apparatus ($1/3^{rd}$)is funnel shaped without any media packed inside.

The waste water to be treated is introduced into the bottom of the reactor at a controlled rate to maintain a retention period(HRT) of 24 hrs. As the waste water gushes upwards, in due course of time agglomerated granular bacteria develops and remains as a suspended blanket. As the effluent moves upwards it passes through the void spaces of the packing media. As the effluent come into contact with bacterial suspended bacterial sludge and the attached microbial films on the packing media, the microbes digests the biologically degradable matter in the effluent to methane, carbon dioxide and little sludge. The gas produced during anaerobic digestion in the reactor bubbles out and is collected in a vertically movable gas holder which rests in a water jacket made inside the reactor.

b) Diffused aeration system

The system is designed for effective aerobic digestion of the partially digested effluent from HRMR. The system consists of a rectangular tank having 5 disc type diffusers placed at the bottom of the tank having a spacing of 60cm between each diffusers. Fine bubbles of air are generated from the discs with the aid of 1 HP blower.

c) Clarification /Sedimentation system

The system is designed for efficient settling of settleable solids in the effluent after aerobic treatment .The tank is rectangular in shape with hopper bottom. A part of the sediments has to be recycled back to the aeration tank to maintain the sufficient mixed liquid.

3) Tertiary treatment system consists of pressure sand filtration.

-Pressure filters are similar to gravity filters in that they include filter media, supporting bed and control devices. However, the system is enclosed and water to be treated is fed to the treatment vessel at high pressure, therefore high speed filtration is possible.

4. TREATMENT METHODOLOGY

The serum from sheet processing and floor wash (after acid coagulation for one day) was filtered through filtration unit to remove the coarse particles in the waste water. The filtered effluent was collected in an equalization tank. This was fed into the hybrid reactor (High rate methanogenic reactor) through bottom of the reactor either directly or through an overhead tank by gravitational flow. The flow rate was controlled by a valve. The partially treated water is removed from the top of the reactor to diffused aeration tank, where the effluent is oxygenated through the diffused air pumped in through diffusers. The aerated effluent is retained in a sedimentation tank, where the sludge gets sediment at the bottom of the tank. The overflow from the sedimentation tank is subjected to filtration through sand filter and is collected. Attached growth Bio-Dek medium is installed in the aeration tank and then same treatment procedure is repeated.

5.PERFORMANCE EVALUATION OF THE INTEGRATED WASTE WATER TREATMENT SYSTEM (IWWTS)

The integrated waste water treatment system is shown in Fig 1.Samples were collected from each units with respect to various pollution parameters as per the standard methods(APHA 1992).and checked the removal efficiency of parameters from each units. The parameters considered are :- COD and BOD.

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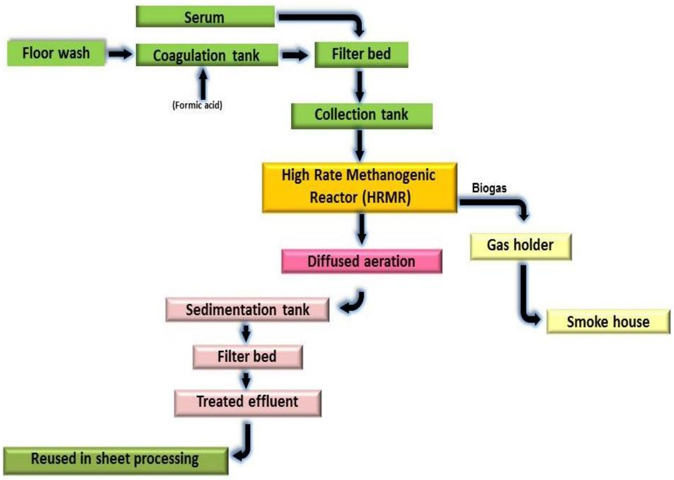

Fig 1. Integrated waste water treatment system

6. ATTACHED GROWTH MEDIA (BIO-DEK)

- It is a PVC media
- 2 m3 media installed in the aeration unit.
- 30cm gap is made between bio-dek and diffuser.

  The chart showing the Bio-Dek specifications are shown in Table 1.

Table 1. Biodek specifications

`Bio-Dek Model	FB 10.27
Standard Dimensions	l-1200mm h-600mm
Maximum Width of Support	100mm
Dry Weight	30kg/m^3
Material	PVC

Bio-Dek is a fixed film medium that is kept submerged in water so as to facilitate treatment of waste water..With the development of plastic structured Bio-Dek medium that has a void age of 95% and more and had regular cross flow pattern. Specific non-clogging media configuration with large flute size (gaps) and large void age (>95%) are available. A slime layer develops over the media and contains the micro-organisms for biodegradation of the substrates to be removed from the liquid flowing through it .Purification performance is shown in Fig.2.

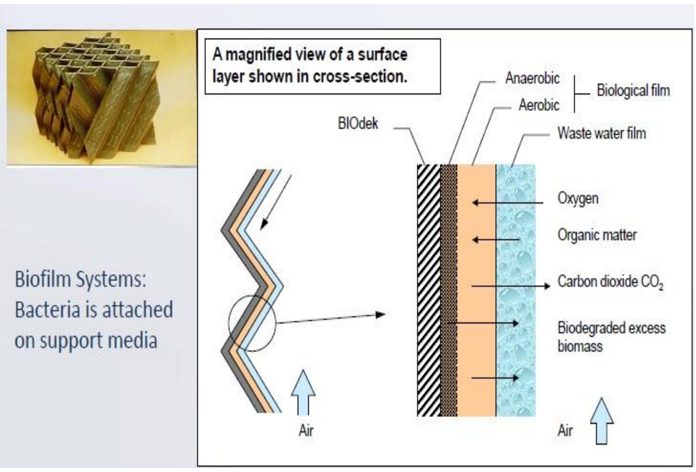

Fig.2 Purification performance by a biofilm

7. PROCEDURE FOR INSTALLING BIO-DEK IN THE AERATION TANK

a) Stacking the Bio-Dek sheets together by using cyclo-hexanol + PVC powder as glue.(Fig 3)
b) Laying and installing the Bio-Dek stack in proper position in the aeration tank
c) Seeding is done using cow-dung

Fig.3 Stack of Bio-Dek sheets

8. SEEDING PROCEDURE

- The start-up process includes , aeration of the effluent in the aeration tank and seeding with cow-dung.
- Cow-dung is the starter for development of MLSS in aeration tank.
- Take fresh cow dung.
- Remove grasses or any other foreign material.
- Prepare slurry in the separate tank.
- Add cow dung into aeration tank filled with effluent.
- Quantity of cow dung is around 3kg/m3
- Keep the aeration on for 24 hr.
- Add urea and DAP(di ammonium phosphate) (4:1); support the growth.(as nutrients)
- Slowly take effluent into aeration tank after 5-7 days.
- It takes 15-30 days for acclimatization.

9. RESULTS AND DISCUSSION

1) Analysis of effluent before installing Bio-Dek

effluent samples were collected before installing the Bio-Dek in the aeration tank from the inlet and outlet of all the units such as after initial filtration, equalization tank, HRMR , aeration unit, sedimentation tank, final filtration unit. it is collected at an interval of 15 days for three months (march -may) and analyzed for various parameters (COD and BOD). the average value of the characteristics from this obtained result is tabulated in table 2.

Table 2. Average value of characteristics from different units during the study(Without Bio-Dek)

Parameter	Filtered Effluent	Discharge from hybrid reactor	After diffused aeration and sedimentation	Final (After filtration)
COD	2882	302	72	39
BOD	1629	94	26	17

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The graph showing the Month-wise variation in COD and BOD from different treatment units(before installing Bio-Dek) are shown in Fig 4 and Fig 5 respectively.

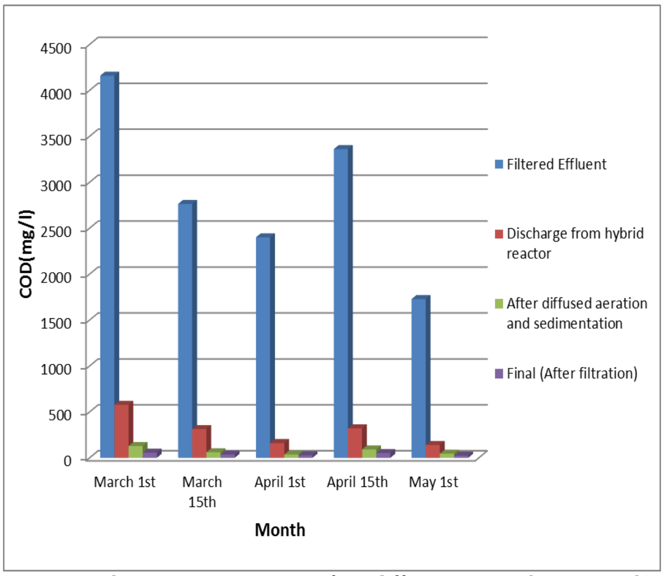

Fig .4 Month-wise variation in COD from different units(without Bio-Dek)

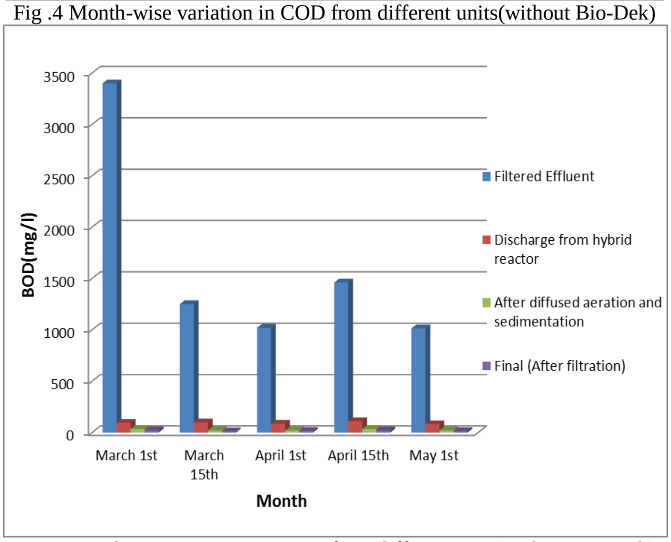

Fig .5 Month-wise variation in BOD from different units(without Bio-Dek)

2) Analysis of effluent after installing Bio-Dek

Effluent samples were collected after installing the Bio-Dek in the aeration tank from the inlet and outlet of all the units. It is collected at an interval of 15 days for three months (June-August) and analysed for various parameters(BOD and COD).The average value of the characteristics from this obtained result is tabulated in table 7.

Table Average value of characteristics from different sources during the study (With Bio-Dek)

Parameter	Filtered Effluent	Discharge from hybrid reactor	After diffused aeration and sedimentation	Final (After filtration)
COD	2326	205	197	151
BOD	1269	70	82	59

The graph showing the Month-wise variation in COD and BOD from different treatment units (after installing Bio-Dek) are shown in Fig 6 and Fig 7 respectively.

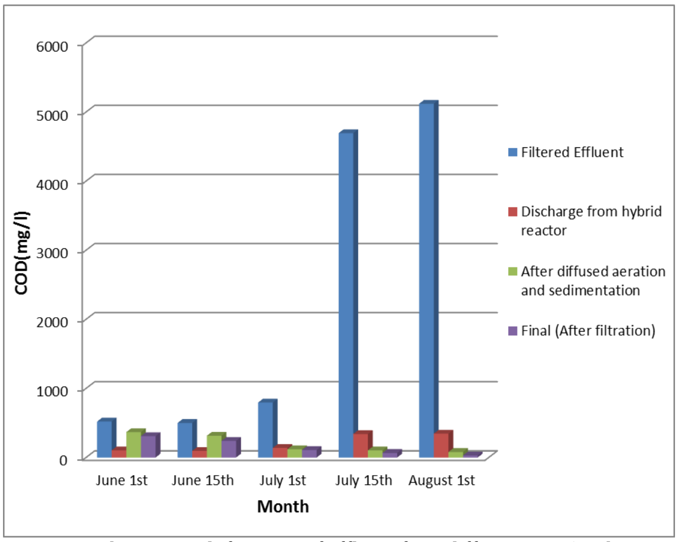

Fig .6 Month-wise result for COD of effluent from different units(With Bio-Dek)

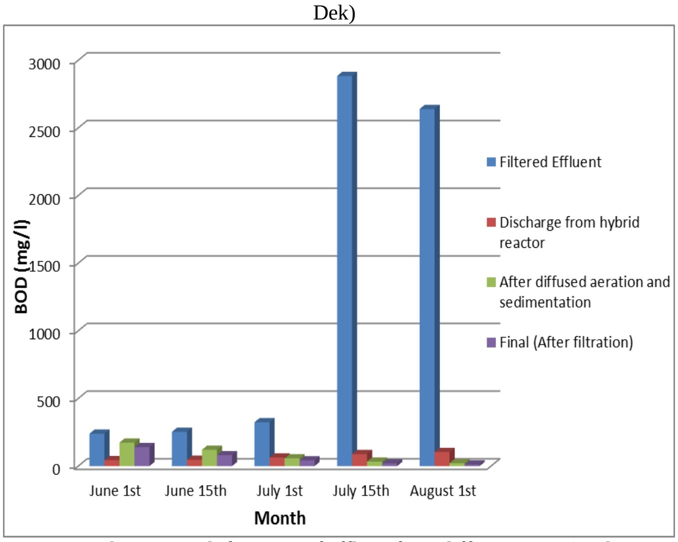

Fig .7 Month-wise result for BOD of effluentfrom different units (With Bio-Dek)

The average COD and BOD before installing the Bio-Dek in the aeration tank was 823.75 mg/l and 441.5 mg/l respectively. And after installing Bio-Dek the obtained COD and BOD values were 719.75mg/l and 370 mg/l respectively. COD and BOD Removal efficiency in the aeration unit without Bio-Dek were 75% and 72% respectively and with Bio-Dek were 73% and 70% respectively during the period of study.

The low value of COD and BOD may be due to the pre-coagulation that has already done in the collection tank before the effluent enters the treatment units ,which reduce the organic matter.Another reason may be the high rate of dilution with fresh water during the processing.

After the final treatment the COD and BOD values obtained were 39 mg/l and 17 mg/l respectively (without Bio-Dek).and 151 mg/l and 59 mg/l respectively (with Bio-Dek).The high value obtained in the 2^{nd} case(i.e,with Bio-Dek) was due to the presence of cow dung and other nutrients that was added to the aeration tank to support the growth of micro-organisms during the seeding period.After three months of study on the removal efficiency in the aeration tank with Bio-Dek, it was able to reach an

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average of 93.5% and 95.4% removal efficiencies for COD and BOD respectively,it was due to the attached growth medium provided where hydraulic retention time and biomass retention time was uncoupled and waste water was in continuous contact with the microbial bio-film and hence efficient treatment is made.In the present study a successful reduction of both BOD and COD of effluent was observed to a level enough to make the effluent ready to be reused in the processing stages or can be discharged to land for irrigation purposes.

10. CONCLUSION

Attached growth medium / Bio-Dek is an efficient method adopted in different treatment units for the treatment of ribbed smoked sheet processing waste water ,where hydraulic retention time is uncoupled with sludge retention time. In this study the Bio-Dek is designed and installed (2 m^3 media) in the aeration unit. The microbial film grows and covers the entire available surface of the Bio-Dek. The film adsorbs the organic pollutants since the media is submerged and a major amount of oxygen transfer occurs due to mechanical aeration system. However, the substrate utilization within the microbial film is a continuous process. The process of 'sloughing' also continues, thus maintaining a constant thickness of the microbial film on the Bio-Dek. Therefore the aeration unit is now a continuous flow aerated fixed film reactor. The effluents from various units were collected before and after installing the Bio-Dek in the aeration unit and were analysed to study the characteristics. The study found that the effluent after coagulation unit was polluted and all the parameters are above the limits prescribed by KSPCB. Study was conducted both with Bio-Dek and without Bio-Dek in the aeration unit. After three months study in both cases, the parameters were within the permissible limits prescribed by KSPCB and can be reused in the processing stages or can be discharged to land for irrigation purpose after all the treatment stages. The average removal efficiency in the aeration unit obtained in the three month study before installing Bio-Dek for COD was 75%, BOD was 72%. Now after installing the Bio-Dek in the aeration unit and analyzing for another three months, the average removal efficiency in the aeration unit obtained for COD was 73%, BOD was 70% .Here the reduction in the removal efficiency was due to the presence of cow dung and other nutrients that was added to the aeration tank to support the growth of micro-organisms during the seeding period and more efficiency is obtained after each month. Hence more removal efficiency will be obtained in the long-run.

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