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Use of Natural Bacteria to Accelerate the Extended Aeration Treatment of Processed Latex Effluent

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Processed latex effluent normally contains high biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen (AN) and suspended solids (SS). The efficiency of coupling bioaugmentation and extended aeration methods in reducing the BOD, COD and SS in processed latex effluent was investigated. The coupled methods were run at two hydraulic retention time (HRT), i.e. *20 h and 24 h using 22 mg/l of microorganism that specifically feeds on hydrocarbon which succeeded in significantly reducing the pollutant load of latex. Analysis after treatment revealed a high percentage removal of the three parameters exceeding 90% under both HRTs. Extended aeration alone in the absence of specific exogenous bacteria could only reduce the BOD from 679 ± 0.5 to 132 ± 0.5. Likewise the COD was assuaged from 1359 ± 9 to 23.8 ± 2.2 and 1355.3 ± 2.9 to 35.2 ± 1.6 at 24 h and 20 h HRTs, respectively using the coupled treatment. Without bioaugmentation process, the COD was only reduced from 1359 ± 1 to 288 ± 0.7. At 24 h HRT, the SS was lowered from 251 ± 1.5 to 10.5 ± 1.5, slightly better than the reduction achieved at 20 h HRT which was reduced from 245.2 ± 2.2 to 14.4 ± 0.4. Without addition of the specific bacteria, the SS was only successfully reduced from 247 ± 0.3 to 54 ± 0.9. Bioaugmentation and extended aeration working simultaneously proved to be more than 17% ± 2.6% efficient for SS, BOD and COD removal.*

Latex effluent is derived from the process of making latex concentrate which involves washing, centrifugation and de-ammoniation process. The waste-water stream consists of excess field latex effluent, stabilisers such as ammonia, sodium sulphite or formaldehyde added to prevent premature coagulation of the field latex. Skim latex is a by-product in the processing of latex to produce latex concentrate after centrifugation. The skim latex serum contains high ammonia, sulphate, organic and inorganic substrates and is the major source of pollutants in latex concentrate factory. The most widely used treatment of latex effluent in Malaysia is lagooning (anaerobic and aerobic). Common biological systems used to treat rubber processing effluents are waste stabilisation ponds and oxidation ditches[1].

The uses of microbes have been seen in the bioremediation schemes in the clean-up of toxic dumps, aquifers and oil spills. Such schemes

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are affected through the natural selection of microbes from an indigenous source[2]. A lot of bioremediation techniques have been proven successful in treating soil, ground-water contamination or waste-water pollution either by organic, inorganic or heavy metals. Many cultures of microorganisms have been found to be able to carry out the reduction of Cr(VI) to Cr(III)[3]. Available carbon is the energy source for the synthesis of new cells.

A bacteria known as *Pertobac-S* consumes aromatic and paraffin fraction of crude oil as carbon sources under aerobic condition[4]. The bacteria belonging to the genus *Lampropedia* isolated from enhanced biological phosphorus removal (EBPR) activated sludge has been studied for its capacity to perform enhanced biological phosphate removal[5]. Another study stated that an odour problem at an industrial waste-water treatment plant was controlled within 14 h with the addition of denitrifying organisms to a biological lagoon[6].

The objective of the study is to see the efficiency removal of biochemical oxygen demand at 3 days incubation (BOD_3), chemical oxygen demand (COD) and suspended solids (SS) of the coupled system at different hydraulic retention time (HRT). This study only focuses on organic pollutans such as BOD_3, COD and SS even though it is known that AN (ammoniacal nitrogen) was also a major pollutant in the latex concentrate effluent.

MATERIALS AND METHODS

The Treatment System

Aerobic pilot scale system was constructed using fibre glass materials. The system comprises 0.5 m diameter cylindrical tank separated into two parts: the equalisation tank (EQT) (0.7 m long) and extended aeration tank (EAT) (0.5 m long). Both ends are capped with 0.1 m cover and the clarifier is a hopper type with dimensions of 0.45 m diameter and 0.6 m high. The 24–20 h retention time in clarifier allowed suspended solids to settle later. Schematic diagram of the reactor is shown in *Figure 1*.

Sampling and Waste Water Compositions

Latex effluent samples were collected from a local rubber company. The latex spills and washings from tankers, platform areas and centrifugation system enter the drain to sump A as shown in *Figure 2*. The sample is categorised as processed latex effluent. The latex effluent was analysed for various parameters, *viz.* BOD_3, COD and suspended solids using the APHA techniques[7] and *Manual of Laboratory Methods for Chemical Analysis of Rubber Effluent*[8]. The range of the concentrations for each parameter is presented in *Table 1*.

Inoculum

The heterogeneous culture of *Bacillus sp.*[9] was used in this study. The inoculum was kept in the refrigerator at 4°C until ready for use. The concentrated inoculum was diluted with water to 22 mg/l (w/v) prior to application.

Treatment Process

The effluent was diluted with distilled water to the required concentrations of BOD_3, COD and SS which were allowed to homogenise in a standard FRP tank. The dilution aids in maintaining consistent values of the BOD, COD and SS for the influent. The sample was pumped into the EAT using a masterflex pump (Model no. 7568-10) at a flow-rate of 1 litre/h and 1.2 litre/h. The EAT chamber was aerated for 24 h and 20 h HRTs. Air was supplied using air diffuser (Model no. SA 130 EX; Lot no. 905, National

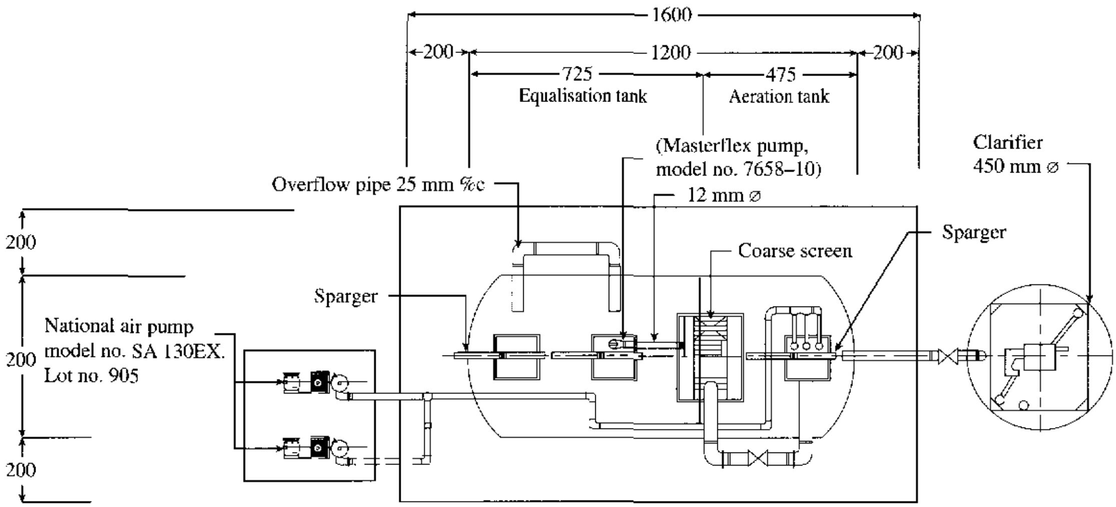

Figure 1. Plan of bioaugmented reactor.

air pump) at a rate 1.5–3.0 mg/l per min. Two sets of fine bubble spargers were used to aerate the extended aeration tank. There was no recycled sludge and the system was operated for a month in order to achieve the required mixed liquor suspended solids (MLSS) of 3000 ± 500 mg/l.

The experiments were run at an average daily temperature of 29 ± 1°C. There was no oxygen supplied in the equalisation tank. The diluted inoculum (22 mg/l) was filled up in a ten-litre aspirator bottle and placed above the EAT. The drips of the specific exogenous bacteria was controlled by a tap and set at six seconds interval per drip (1 ml) for each of the experiment. The slow addition of the specific exogenous bacteria at 1 ml/ 6 s was meant to control the growth of the bacteria. Controls were run only under extended aeration without addition of specific exogenous bacteria. The treated MLSS from EAT tank was passed through the pipe to the clarifier. Sample was collected every day for each experiment which was carried out in triplicates. The collected samples were immediately preserved in refrigerator at 4°C before being analysed for the BOD_3, COD and SS values.

TABLE 1. THE CONCENTRATION RANGE FOR THE TESTED PARAMETERS

Parameter	Conc. before dilution (mg/l)	Conc. after dilution (mg/l)
BOD	5100.0	677.6 – 679.4
COD	10 240.0	1355.3 – 1359.0
SS	883.0	245.2 – 251.5

Operational Problems

During the operational periods, the two sets of spargers in the EAT and masterflex transferring the waste flow must be cleared every month in order to prevent the sludge clogging. Flow-rate of the system was checked every two days to ensure constant flow-rate of 1.0 litre per hour and 1.2 litre per hour. MLSS was measured everyday for sludge settleability determination and maintaining the required MLSS. The MLSS was maintained in aeration tank thorough the continuous addition of the exogenous bacteria and the MLSS was wasting directly from EAT in order to maintain the MLSS range. Besides that the (SVI_{30}) (Slude volume index at 30 min) was done every three hour intervals to ensure that the MLSS was in the range.

Analytical Method

Unless indicated in the text all analyses were made according to APHA Standard Methods[7]. The pH was constantly monitored using Orion Research, Model SA 210 pH meter. Filtered samples were prepared using Whatman filter paper; GF/C 25 mm Ø for MLSS and suspended solids analysis. For BOD_3, incubation was done for three days at 30°C.

RESULTS AND DISCUSSION

Processed latex effluent originates from the washings of field latex and latex concentrate and it has a pH 7–8 due to the ammonia added to the field latex for preservation. Samples for this experiment were collected at point A after the sump, as indicated in *Figure 2*.

Based on the findings depicted in *Figures 3–5*, processed latex effluent treated at 20 h and 24 h HRT in the presence of 22 mg/L specific exogenous bacteria showed a significant reduction in the levels of BOD_3, COD and SS. Using the exogenous bacteria, the resultant BOD_3, COD and SS at 24 HRTs were 12.3 ± 0.2, 23.8 ± 2.2 and 10.5 ± 1.5 mg/L, respectively and BOD_3, COD and SS levels at 20 HRTs were 18.5 ± 0.9, 35.2 ± 1.6 and 14.4 ± 0.4 mg/l, respectively.

BOD_3 values in samples treated with specific exogenous bacteria and extended aeration technique were successfully reduced from 678 ± 1.2 to 12.3 ± 0.2 mg/l for 24 h HRT and from 679 ± 0.4 to 18.5 ± 0.9 mg/l for 20 h HRT. Extended aeration treatment alone (control) can reduce the BOD_3 only from 679 ± 0.5 to 132 ± 0.5 mg/l. The disintegration of SS *via* extended aeration treatment was only assuaged from 247 ± 0.3 to 54 ± 0.9 mg/l. Thus the exogenous bacteria improved the degradation of BOD_3, COD and SS by 17% ± 2.6 mg/l and the enhancement in the breakdown of BOD_3, COD and SS was galvanised by the presence of this specific exogenous bacteria.

Figure 5 depicts the amount of reduction of SS under the 24 h, 20 h HRTs and 24 h treatment without specific exogenous bacteria. Starting with similar levels of SS, the removal efficiency drops to 78.1% when specific exogenous bacteria was not added. The processed latex effluent cannot achieve high pollutant removal efficiency with only the extended aeration system. The values of BOD_3, COD and SS for control at 24 h HRTs were 132.0 ± 0.5, 288.8 ± 0.7 and 54.0 ± 0.3 mg/L, respectively. The specific exogenous bacteria has a capability of enhancing the reduction of the pollutants in the processed latex effluent by more than 17% ± 2.6 for all the parameters.

Results depicted from *Figures 3–5* show that at 24 h HRTs, the amount of reduction in BOD_3, COD and SS are only slightly higher than at 20 h HRTs using the same amount of bacteria at 22 mg/L. The percent reductions at 20 h

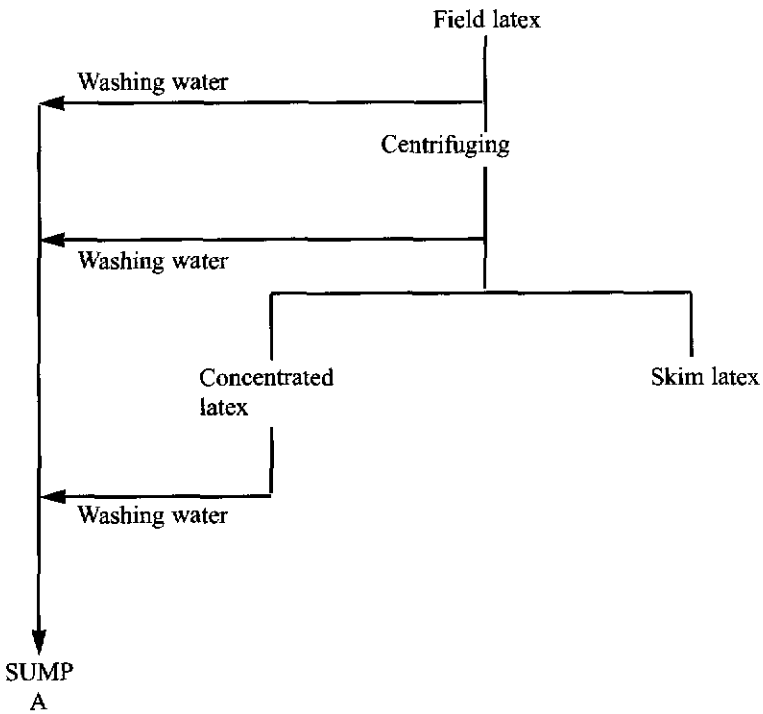

Figure 2. Flow chart showing the sample collection point (Sump A) for processed latex effluent.

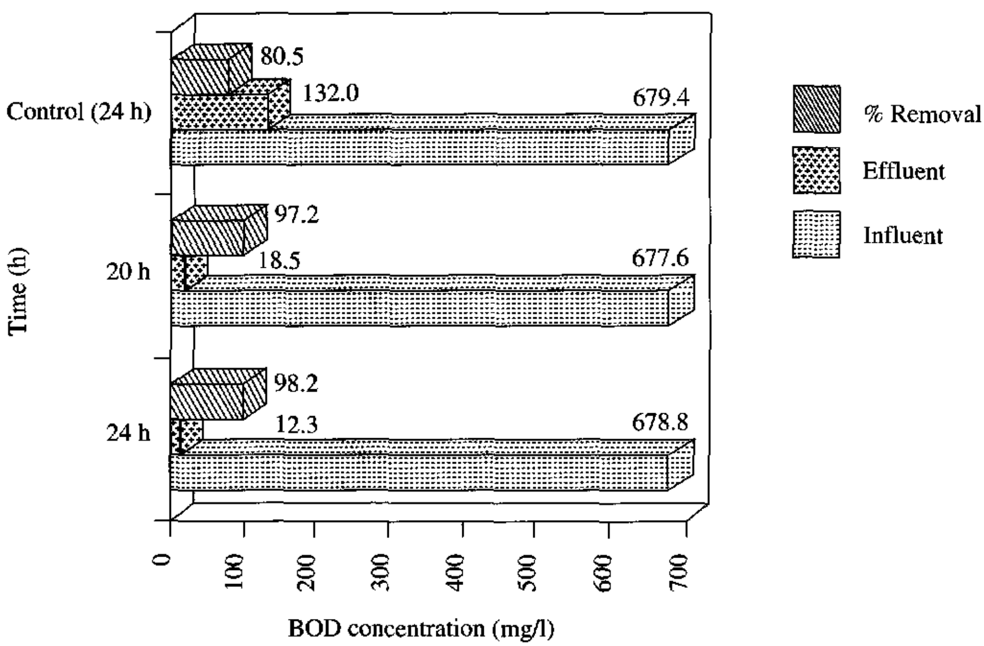

Figure 3. BOD levels before and after treatment at 20 h and 24 h HRTs and 22 mg/l exogenous bacteria for diluted initial latex effluent. The control was performed under extended aeration along at 20 h.

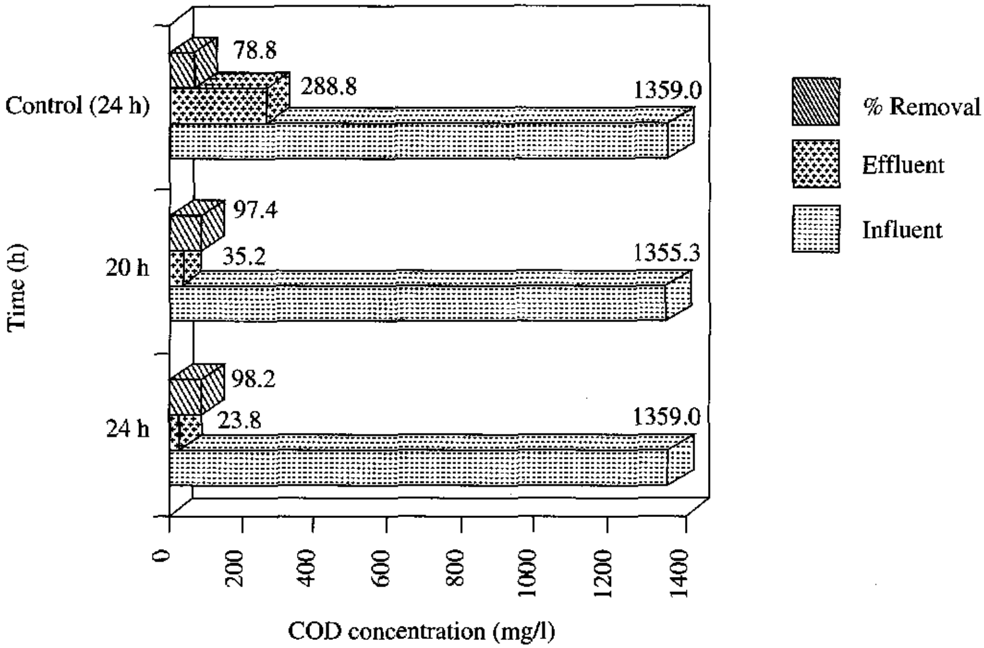

Figure 4. COD levels before and after treatment at 20 h and 24 h HRTs and 22 mg/l exogenous bacteria for diluted initial latex effluent. The control was performed under extended aeration along at 20 h.

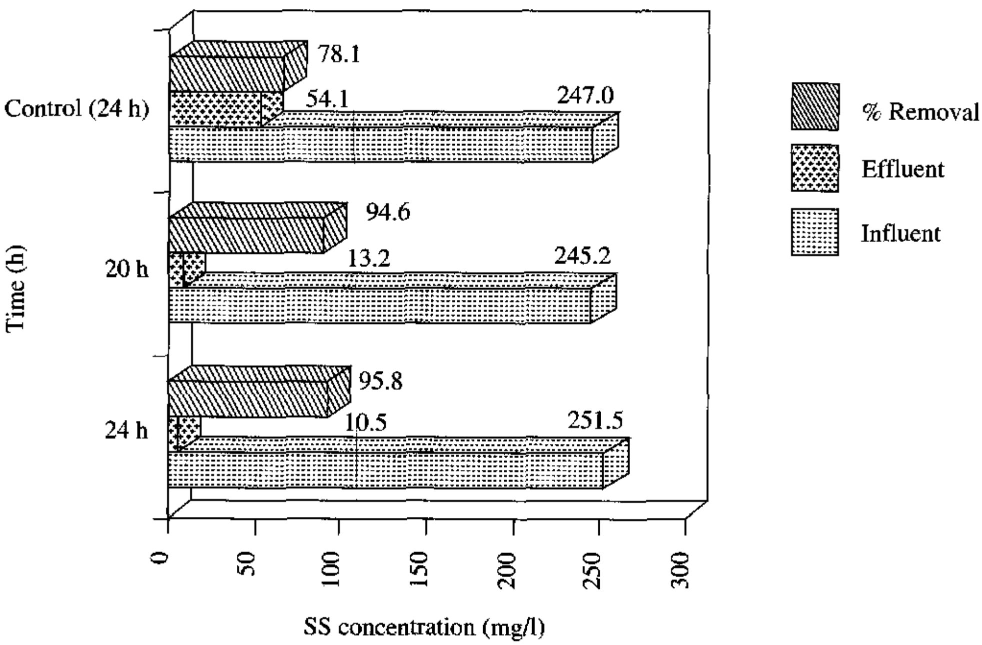

Figure 5. Suspended solids (SS) levels before and after treatment at 20 and 24 HRTs and 22 mg/l exogenous bacteria for diluted initial latex effluent. The control was performed under extended aeration along at 20 h.

HRTs for BOD_3, COD and SS were 97.2, 97.4 and 94.1, respectively with the final levels at 18.5 ± 0.9, 35.2 ± 1.6 and 14.4 ± 0.4 mg/L, respectively. Longer HRT appears to work better in the reduction of the three parameters at shorter hours. The difference in 20 h and 24 h HRTs is less discernible although admittedly the extra four hours deemed more action time for the bacteria to act.

In extended aeration method, factors such as HRT and organic loading are important. A normal plant loading for extended aeration is about 0.25 kg BOD/m^3.d and normal extended aeration at 2 kg O_2 is usually used to treat sewage at influent concentration <250 mg/l and be reduced[10] to about 10 mg/l. The use of specific exogenous bacteria accelerates the degradation of BOD_3.

Although the effluent samples were diluted prior to treatment, the successful reduction of BOD_3, COD and SS by applying the exogenous bacteria paved a possible alternative or a complementary option to treat latex waste water. An added advantage of the technique is the removal of odour, commonly associated with latex processing industries. Normally the source of odour for these industries comes from the use of ammonia to preserve the raw latex and the production of hydrogen sulphide gas due to the use of sulphuric acid for latex coagulation[11]. In this case the odour was removed by the exogenous bacteria through the nitrification process.

The treatment efficiency removal decreased with increasing HRT[12]. In the research on treating domestic waste water using aerobic package treatment system (APTS) it was found that HRTs of aeration basins in APTS should be reduced to approximately one day for a better effluent quality[13]. Longer HRT (up to three days) should be avoided for reasons of cost saving and to gain good results. The laboratory system operating at HRT between 0.5 and 2 days produced high quality effluent with low BOD_3 concentration (averaging 19.4 mg/l)[6] and correspond to our results.

The monitoring study has demonstrated that both the oxidation ditch and the submerged aeration activated sludge (SAAS) systems are capable of efficient removal of organics; BOD_3 was reduced from 1130.0 mg/l to 14.0 mg/l and about 2205 mg/l to 128.0 mg/l for COD within 2.04 day HRT[14]. But this bioremediation system is the package plant system using the fibre glass materials. There is no temperature fluctuation in the system. Furthermore it can operate on its own without combining with another system. It can also be installed in the small area compared to anaerobic-facultative system that require a large area to purify latex concentrate[15], and it is easy to maintain and needs minimum unskilled workers to do cleaning and maintaining the system within 2–3 hours.

CONCLUSIONS

Addition of specific exogenous bacteria in aerobic biological and bioremediation system can enhance the reduction of BOD_3, COD and suspended solids in latex effluent from rubber processing factories by about $17\% \pm 2.6$. This system has an advantage over the ponding system due to the minimal land area that is needed and there is no temperature fluctuation. The system is also considered as a potable sytem as in the case of Lee Latex concentrate factory which has a total flow-rate of 16.6 m^3 /hr. The retention time is short and only a single system is needed which is easy to maintain and operate. The pilot system and the exogenous bacteria provide a potential alternative to treating the latex effluent to achieve acceptable levels.

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