A major problem in palm oil mill effluent engineering essay

In Malaysia, for example, 9. 9 million tons of solids wastes consisting of empty fruit bunch , fibre and fruit shell and approximately 20 million tons of palm oil mill effluent (POME) are generated every year. In response to this, there has been increasing efforts to manage the wastes generated from mills. A major problem in Palm Oil Mill Effluent is their Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) characteristic in final discharge (waste water). BOD is a chemical procedure for determining how fast biological organisms use up oxygen (through degradation of organic material) in a body of water. COD is to determine the amount of organic pollutants found in surface water. The purpose of this study was to minimize the BOD and COD level in waste water treatment plant using the Sequencing Batch Reactor Process (SBR) system. The capability of treatment efficiency was proven during the system is widely used in other industry.

As Malaysia forges ahead with its plan to become a fully developed nation, palm oil mills will have to adapt to various new challenges, including more stringent environmental regulation, labor shortage and competition from other lower cost palm oil producing countries. Basically milling technology has not changed in terms of developing a new sustainable and economics process to extract more oil and kernel. This may sound odd with so many new mills built and best time to incorporate new technology being to start on a green field.

Anyway new technology has developed with concentrated on better mechanical handing, higher throughput, and more durable and reliable equipment with longer intervals between failure and renewal.

The extraction of palm oil and kernel from the palm fruit is a commonly known in palm oil process. But this extraction process also produces a brown effluent which can devastate any aquatic life if dumped directly into our river. It is estimated that for every tone of palm oil produced, 2. 5 tons of wastewater is generated. Thus, with Malaysia's palm oil production is standing close to 8 million tons per annum , the amount of palm oil mill effluent (POME) generated would be equivalent to that of sewage discharged by a population of 22 million people

Palm oil mill effluents are high volume liquid wastes which are non toxic but have an unpleasant odor. They are highly polluting. The Biological and Chemical Oxygen Demand (BOD & COD)

of this effluent is very high and goes for the Total Nitrogen, Ammonia Nitrogen and Oil & Grease. The effluent also acidic. The nature of raw effluent, it is hot, has a bad aroma and brown in color. An effluent with its quality and quantity were to be discharged into river, all aquatic life will perish.

At present there are many methods to treat this raw effluent. The most common method of treatment being employed is the biological treatment. This method of treatment is by using a combine effect of the aerobic, anaerobic and facultative ponds; where at the end of the treated effluent is dumped into a river.

Alternatives treatment methods have propped up in the recent past. In this case, proposed a method which involved Sequencing Batch reactor (SBR) Technology with aerated oxygen enriched air. The sequencing batch reactor

(SBR) is a batch process for treating wastewater. This process is capable to minimized BOD and COD in a reactor.

2. 0 LITERATURE REVIEW

2. 1 Typical Flow Charts

Typical Palm Oil Mill Schematic Flow Diagram

As the palm oil industry grows rapidly, the number of palm oil mills also increases significantly especially in Malaysia. Therefore, one of the major problems arises from this industry is the large amount of wastes generated during the processes. Generally, operation of the palm oil mill generates many by-product and liquid waste which may pose a significant impact on the environment if they are not dealt with properly. The most common method is biological effluent treatment system (ponds).

2. 2 Effluent Treatment Plant

The function of the biological effluent treatment plant is to treat the mill liquid waste to levels within the prescribed limits set by the Department of Environment (D. O. E).

The method of biological treatment in the mill is the anaerobic process. This process comprises three stages:

The anaerobic digestion in the acidification phase

The anaerobic digestion in the methanogenic phase

The quiescent facultative stage of aerobic digestion.

The complete anaerobic digestion or bio-degradation of the mill effluent is a complex operation as this process requires the acid forming organisms to grow in harmony with the methanogenic formers. Any imbalance of activities of these two organisms would upset the digestion process.

The acid producing bacteria and their associated enzymes degrade most type of organic material into fatty acids. The methanogenic bacteria convert the soluble products of the acid produces into methane and carbon dioxide.

The acidification stage is controlled to promote the growth of the acid formers. While in the second stage i. e. the methanogenic phase, the environment is optimum to form the methane formers. The biological effluent treatment plant in the mill comprises of the following:

De-oiling tank

2 Acidification ponds

1 primary anaerobic pond

2 anaerobic maturation ponds

2 facultative ponds

De- sludging facilities

De-oiling tank/ sludge pit

Sludge waste from this mill is pumped into the tank.

The purpose of this tank is to trap remnants of free oil and permit solids to settle out. Solids settled here should be removed on a regular basis in order that working levels be maintained. Regular checks should be made and any trace of oil here must be removed.

Acidification ponds

There are 2 ponds and these are operated in parallel. The acidification stage is a very rapid process converting the organic components of the waste water into volatile fatty acids (vfa) and depresses the pH of the system. However recycling of the anaerobic liquor is done here for buffering i. e.

Obtaining the desirable pH level

Cooling to obtain the desired temperature

Seeding i. e. introducing active organisms population

The above is practiced at this stage to prepare the feed before entering into the anaerobic ponds.

Hydraulic Retention Time (HRT) here in each pond is 2 days

Temperature: 35Ëšc – 45Ëšc

PH: 4. 0 to 5. 5

Vfa: 5000 mg/l

Primary anaerobic

In this stage the strictly anaerobic bacteria called methanogen converts the volatile acids to methane, CO2 and other trace gases. Destruction efficiencies are high here wherein from a high B. O. D. of 24, 000mg/l B. O. D. levels of the supernatant at the pond outlet are reduced to 300mg/l.

Temperature at Anaerobic 2 outlet is approx. 30-35Ëšc with a pH in the region of 5. 5 to 6. 5. Vfa= 1000 to 2000 mg/l. Alkalinity = 1500 to 2000 mg/l.

Anaerobic Maturation Pond

This is a final step of the methanogenic anaerobic stage where further reduction of BOD is made possible. BOD at this stage is down to about 200mg/l . Temperature at the outlet end is 20 to 30Ëšc with a pH in the region of 7. 0. Vfa is approximately 700mg/l and alkalinity above 1500mg/l.

Facultative Ponds

The use of anaerobic digestion alone would not be sufficient to meet the standards stipulated by DOE hence further treatment of effluent is necessary in the facultative. These facultative ponds are for quiescent aerobic respiration of the aerobically treated waste water. These 3 ponds are in series and in these ponds sufficient oxygenation to the waste water is introduced. The effluents after sedimentation in these ponds are allowed to discharge into the water course, with BOD levels below 110 ppm as required by the Dept. of Environment.

Temperature at the outlet of the Facultative is 25 to 30Ëšc with a pH of 7. 0 – 9. 0. Vfa less than 100. Alkalinity in the region of 1000mg/l.

De-sludging of the ponds

The ponding system is operated at low rate with organic loading ranging from 0. 2 to 0. 35 kg BOD/cu. m/day. Because of the size and configuration of the ponds mixing is hardly adequate. Also the rising biogas will bring along with them fine suspend solids and therefore it is common to find islands of solids floating in the anaerobic pond. This often results in dead spots which will lead to short circuiting in the ponds. Undoubtedly it is very labor intensive to maintain the ponds in satisfactory condition at all times. It is also imperative to ensure that as little oil as possible be allowed into the ponds as the oil will agglomerate with the rising solids brought up by the biogas and from a scum which is difficult to remove.

Due to the inadequate mixing by biogas, solids build up at the bottom of the ponds, especially the anaerobic ones. Excessive solids built up at the bottom of the ponds will reduce the effective design capacity and consequently shorten the hydraulic retention time. This will adversely affect the treatment efficiency of the system.

In view of the above regular desludging of the ponds is a must. A de-sludging pond is made available for this purpose. Solids from the ponds are pumped using submersible pumps into this desludging pond and water liquid recycled while solids are left to dry out and subsequently removed.

2. 3 Operation procedures

Sludge pits / Fluming tank

Supervisors / operators are to visually check the pit on a regular basis throughout processing and ensure that a trace of oil is recovered soonest possible.

Also when excessive trace of oil is sighted, immediate measures must be taken to trace and arrest the source of this excessive oil loss.

Schedule cleaning of the sludge pit and tanks must be instituted to remove solids / sands and any debris on a scheduled basis.

Pumps in this area must be checked to be in good operating condition. Any faults or malfunction noticed must be reported for immediate repair.

Buffering Ponds

Ensure that recycling of anaerobic liquor is carried out as per instruction.

Remove any solids scum / oil traces on a daily basis.

Ensure free flow into and out of the ponds.

Anaerobic ponds

Monitor visually ponds bacteria for any signs of fouling.

Solids removal should be carried on a regular basis.

Ensure stirrer / mixers are operated as per instructions.

Ensure that in flow and outlet discharge is proper and feed to downstream ponds is regulated as required.

Facultative ponds

Regulate final discharge as necessary.

Ensure solids recycling where necessary.

Desludging ponds

Ensure that pumping of solids into the pond is monitored.

Ensure that excessive liquid is recycled to the anaerobic ponds.

3. 0 METHODOLOGY

3. 2 Sequencing Batch Reactor (SBR) Technology

Sequencing Batch Reactor (SBR) is an activated sludge biological treatment process. The process uses natural bacteria and when the bacteria are aerated, they grow and multiply using the organics or " pollution" as food. This purifies the wastewater before it is discharged to the environment.

The process is managed in a fill and draw, or batch fashion. This process allows for exceptional flexibility and controls which results in a highly treated effluent that will not harm the environment when it is discharged. Generally the SBR process can be conveniently described in five distinct steps:

Step 1: Fill/React

The treatment Reactor contains bacteria or biomass that processes the wastewater. The cycle starts with the Reactor at least half full of activated sludge. When the wastewater enters the Reactor, air is intermittently supplied by a blower, to maintain an aerobic (air enriched) environment. The pollution in the wastewater is consumed by the biomass as food. The biomass grows and multiplies during this treatment process assuring the system is sustained for further treatment. This cycle of filling and intermittent aeration continues until the Reactor has filled.

Step 2: React only

During this step incoming wastewater is diverted to a second Reactor or is stored. The full Reactor is aerated or mixed continuously during this step. The React only step provides time for additional treatment or “ polishing” of the wastewater to meet required discharged consents. The duration of the react only step is easily adjusted at the computerized control panel.

Step 3: Settle

The biomass in the Reactor must be separated from the treated liquid or supernatant, so there will be sufficient biomass remaining for treatment of the next batch of wastewater. In the SBR system the Reactor becomes the settling device or clarifier when all the pumps and blowers are turned off. This creates quiescent settling conditions to allow the biomass and the treated liquid to separate. After settling, the treated clarified liquid is discharged or decanted from the Reactor.

Step 4: Decant

The treated clarified liquid is discharged or decanted using pumps which have their intake located at the midpoint of the Reactor depth. This assures that any floating debris or settled biomass is not discharged from the

Reactor. A non-return valve on the pump intake prevents the entry of solids into the Decant pump and piping during the aerated treatment steps.

Step 5: Idle

When the Reactor has decanted, and there is no wastewater waiting to be pumped to the Reactor enters an idle or waiting phase. In idle, with no wastewater load, it is not necessary to run the blowers at the same rate as during the filling stage. The blowers automatically reduce the volume of air at idle, saving energy. When the Reactor receives more wastewater, it automatically switches back to the Fill/React step, and the entire cycle repeats.

Sludge waste

Since the biomass continues to grow or increase in volume during each treatment cycle it is necessary to remove excess biomass from the Reactor on a regular basis. The biomass volume is always maintained below the pump intake and at the proper level by means of automatic sludge waste pumps. The excess biomass is pumped to the Trash Tank at the end head end of the plant where it is anaerobically (without air) decomposed. Regular sludge wasting ensures that enough biomass remains in the Reactor to treat the next batch of wastewater, but does not increase to the point where it would be pumped out of the reactor during the Decant cycle.

3. 3 FLOCCULATION TREATMENT

Raw effluent from facultative pond (last pond) is pump into vertical steel clarifier. Flocculation agent and pH correction agent is dose into the pipe line before entering clarifier to ease coagulation process.

PRE – AERATION

The clarified raw effluent will over flow into the 1st holding tank. Filling is estimated for 3 hours.

While in the holding tank, the raw effluent is subjected to pre – aeration for 2 hours before transfer to the reactor tank.

Pre-aeration is done through fine air bubbles passes through an array of disc type diffuser at tank base.

SBR PROCESS

The pre-aeration effluent from holding tank is transferred into the reactor tank via transfer pump.

The SBR process inside the reactor tank will be control through a present time for 24 hours operation based on the following activity:

Filling – 3 hours

Slow aeration – 4 hours

Fast aeration – 10 hours

Settling – 2 hours

Discharge – 2 hours

Filling

Pre-aerated anaerobic liquid is pump from holding tank. During start up, seeding of bacteria is carried out. The quantity from of seeding is depending on the MLSS concentration in the reactor.

Slow aeration

While filling up of the pre-aerated anaerobic liquid half of the diffuser inside the reactor tank will activate, via control valve install at the distribution header.

Fast aeration

Filling completed and full aeration processes activate.

Settling

To allow solids and liquids are separated under true quiescent conditions.

Discharge

The treated or clarified supernatant is pump into a final treated effluent tank for storage. The excess sludge will settle and remain in the reactor tank. Desludging will depend on the MLSS concentration, not to exceed 20-30 % by ratio of the pre-aerated anaerobic liquid. This can be done by taking sample and allow to settle naturally.

Standby

The reactor tank is ready for the next batch.

The treated water will overflow through a constant level flexible outlet into a transfer (clarified) water tank. The clarified water enters an activated carbon filter via booster pump, which act to polish the water before discharge out to river. At this stage the BOD level should be â‰¤ 20 ppm. A reject line is installed to return treated effluent into anaerobic pond if the BOD level exceeds 20 ppm.

3. 4 NOPOL- diffuser

The NOPOL system has a suitable diffuser for any wastewater application.

Reliable construction

The main component of the system is the NOPOL dual layer polyethylene disc. This has a thin fine top for maximum oxygen transfer efficiency. All deposits are easily removed by the formic acid.

The NOPOL disc aeration system is ideal for all biological processes. An aeration system covering the entire bottom of the basin gives the desired oxygen content throughout. Mixing energy is evenly distributed throughout the basin. Uniform mixing prevents any sludge sedimentation. Adjustment range-volume of air per diffuser is wide enough for any load variation. The disc aeration system does not cool down the activated sludge or produce any harmful aerosols.

3. 5 SBR system tank and pipe layout

4. 0 ANALYSIS

4. 1 A BASIC DESIGN OF SBR SYSTEM

Capacity : 1080 m^3 / day

Influent BOD: 200 ppm

Discharge BOD: 20 ppm

Basic design data

Actual waste water quantity discharged from plant : 1080 m^3 / day (max)

Design waste water quantity : 1080 m^3 / day or 45 m^3 / hour

BOD : 200 mg / l

COD (assume) : 300 mg / l

PH : 7. 2

Temperature : 26 Ëšc

Suspended solids (assume) : 300 mg / l

Oil & grease (assume) : 20 mg / l

Sequence of operation of SBR reactor tank No. 1 or 2

Filling and slow aeration time : 8 hours

Fast aeration time : 12 hours

Settling time : 2 hours

Discharge of treated effluent : 2 hours

Sizing of tanks

Based on the above operation sequence and the two trains of SBR tank operating alternatively, the sizes of the holding tank and reactor tanks are as follows:

Holding tank

Tank required : 1 unit

Waste water flow rate : 45 m^3 / hour

The retention time for the holding tank : 6 hours

Volume of tank required : 270 m^3

Selected holding tank size is 8700 m Ø Ã- 7. 62 m height

Capacity : 400 m^3

Reactor tanks

Wastewater flow rate : 45 m^3 / hour

No of tanks required : 2 units

Retention required for reactor vessel : 12 hour

Volume of waste water in each reactor tank : 540 m^3

Volume of activated sludge to be retained in reactor tank : 20 % of the waste water

Therefore required volume of reactor tank : 648 m^3

Selected reactor tank size is 11650 mm Ø Ã- 7. 62 m height

Capacity : 800 m^3

Calculation of air required for aeration at reactor tank

Process utilized : Palm Oil Mill Effluent

Type of waste : Industrial

Design flow : 1080 m^3 / day

BOD5 : design 200 mg / l = 216 kg / day

Temperature of waste : 26 Ëšc

Dissolved oxygen to be maintained in waste water (CÎ») : 2. 0 mg / l

Oxygen to BOD5 ratio : 1. 5 (assume)

Oxygen required per hour : (216 Ã- 1. 5) / 12 = 27 kg / hour

Oxygenation capacity required per hour = 02 required per hour / correction factor

Correction factor = Î± [(Î²) (CÏƒ) – CÎ»] 1. 024 (Ï„-20)/ CÏƒH20

CÏƒ H20: oxygen solubility factor

Î± = 0. 9

Î² = 0. 95

CÏƒ at 26Ëšc at 200 ft elevation = 8. 1

1. 024 (Ï„-20) at 26Ëšc = 1. 153

CÎ» = 2 ppm

Therefore, oxygenation capacity required per hour = 27 / 0. 7289

= 37. 04 kg / hour

Density of air at 26Ëšc = 1. 18 kg / m^3

Volume of air required taking oxygen content in air is 20% by unit weight = (37. 04Ã-5m^3/hr)/1. 18

= 157 m^3 / hour

Efficiency of aeration by using Nopol diffuser at 4m water dept = 18 % at 4m^3 / hr per unit

Flow rate of air blower required = 157 m^3 / hr / 18 % = 872 m^3 / hr

Use air blower = 900 m^3 / hr

No. of diffuser required = 900 / 4 = 225 pcs

Therefore,

No. of diffuser installed per reactor = 225 (for 1080 m^3/day) operating at 12 hours

Determination of number of diffusers per tank for holding tank

The required aeration for waste water in holding tank is to ensure saturation concentration of oxygen dissolved in water.

Based on temperature of 26Ëšc, the saturation concentration of oxygen in water is = 8. 11 mg/l

With influent flow rate = 45 m^3 / hour

Total oxygen required = 364. 9 g / hour

Allow 20% extra air to ensure saturation, the actual aeration rate = 438 g / hour

No. of diffusers at 1 m^3 / hour per unit at 18 % = 11 nos.

No. of diffusers installed at holding tank for primary aeration and mixing

to saturation point = 30 nos. (At 0. 4 pc/m^2 distribution density)

Total diffuser used for 2 trains system = 510 nos.

Selection of two (2) units of surface aerator

Model = EEE FA- 1010

Specifications are enclosed.

The application of these surface aerations installed at facultative pond is for:

Proper mixing of the effluent before pumping to the effluent treatment plant

To supply some aeration to the facultative pond so as to minimize the inlet BOD to the effluent plant and at the same time to improve the bacteria activity.

Selection of one (1) unit activated carbon filter at treated effluent discharge point

Dimension = 2420 mm Ø Ã- 1828 mm SL

Surface area = 4. 59 m^2

Flow rate = 60 m^3 / hour

Flow velocity = 13. 0 m / hour

Volume of activated carbon = 4. 1 m^3

The activated carbon filter acts as a polishing filter for the final treated effluent.

5. 0 DISCUSSION AND CONCLUSION

A more responsible biological treatment process through a proven automated operation program responding on time every situation and alarm in a reactive way so that the plant performance can be maintained regardless of the operator attendance and equipment failure.

Lower investment and recurrent cost, as secondary settling tanks and sludge return systems are not required.

Lower space requirements.

Better settling, as settling conditions in an SBR are

Ideal while the sludge population changes towards

better settle able micro-organisms.

Improved effluent quality.

Improved operational reliability.

Hardly any or no smell problems.

Better temperature control.

Lower effluent COD and BOD. The batch nature process and high organic concentrations (feast)

during Fill encourages the growth of organisms with high organic uptake rates. The famine period at the end of React encourages the utilization of recalcitrant organics. The combined effect of the feast and famine periods is the optimal removal of BOD and COD.

Better settling sludge. The feast-famine conditions that naturally occur in each cycle promote the growth of floc-forming organisms and disfavor filamentous organisms, thereby eliminating the need for polymers.

In a number of situations the application of an SBR system will thus result in lower investment as well as operational costs. Critical in this respect are the load and concentration of the wastewater, the design and the local situation.

6. 0 SUGGESTION FOR FURTHER WORK

At this study, Sequencing Batch Reactor process, raw effluent from facultative pond (last pond) is pump into clarifier in system. Thereby, the pond still need for this system due to oil recovery in first 2 ponds. In future study, the pond system which consumed a large area needs to remove. The wastewater from the mills, directly pump to SBR system tanks for further treatment. The new method for oil recovery in SBR system will be taken in action. The discharge water which in brownish color need to be analyze due to remove the color.