A NOVEL TREATMENT PROCESS FOR PALM OIL MILL EFFLUENT

by: MA AH NGAN

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INTRODUCTION

Over the last two decades, treatment and disposal methods have been successfully developed and employed by the palm oil mills to treat their palm oil mill effluents (POME). Conventional biological system consisting anaerobic and aerobic or facultative processes are used. If well operated and maintained, these processes are able to treat POME to the discharge standards stipulated by the Department of Environment (DOE) (*Table 1*).

TABLE 1. PARAMETER LIMITS FOR WATERCOURSE DISCHARGE FOR PALM OIL MILL EFFLUENT

Biochemical Oxygen Demand (BOD_3 mg/L)	100
Suspended Solid (mg/L)	400
Oil and Grease (mg/L)	50
Ammoniacal Nitrogen (mg/L)	150
Total Nitrogen (mg/L)	200
pH	5 - 9

*BOD_3 - Sample incubated for 3 days at 30°C

Due to the increasing environmental awareness and the deteriorating receiving (river) water quality, especially in catchment areas, DOE is compelled to impose more stringent discharge standards to the palm oil mills and other industries. Zero discharge is imposed in certain areas.

Over the last 10 years, the concept of management of palm oil mill wastes has changed from treatment and disposal to beneficial utilization. POME has been found to contain valuable plant nutrients in substantial amount (*Table 2*). When applied to the plantations in a controlled manner, it can replace the normal fertilizer to a large extent. It can also improve crop yield. Land application of POME has become a standard practice in mills where plantations are located nearby. This has resulted in substantial saving in fertilizer bills and increased income due to higher crop yield.

However, such practice is only viable to the plantation groups where there are enough hectarage of oil palm in the vicinity of their palm oil mills. This accounts for about 30% of the 272 palm oil mills in the country. The rest of the mills are still relying on the treatment and disposal methods. Not all these palm oil mills are able to meet the discharge standards all the time.

TABLE 2. CHARACTERISTICS OF PALM OIL MILL EFFLUENT

Parameters*		Metal	
pH	4.7	Phosphorous	180
O & G	4,000	Potassium	2 270
BOD_3	25,000	Magnesium	615
COD	50,000	Calcium	439
TS	40,500	Boron	7.6
SS	18,000	Iron	46.5
TVS	34,000	Manganese	2.0
AN	35	Copper	0.89
TN	750	Zinc	2.3

All parameters in mg/L except pH
O & G - Oil and Grease; BOD - Biochemical Oxygen Demand
TS - Total Solid; COD - Chemical Oxygen Demand
SS - Suspended Solid; TVS - Total Volatile Solid
AN - Ammoniacal Nitrogen; TN - Total Nitrogen

Biological treatment system needs proper maintenance and monitoring. Biological processes rely solely on the microorganisms to breakdown the pollutants. These microorganisms are very sensitive to the environment. Thus great care has to be taken to ensure that a conducive environment is maintained for the microorganisms to thrive. It requires skillful operators' attention and management's commitment. Sad to say, this is much lacking in the industry. Furthermore, wastewater treatment has always been considered a burden to the industry. Worst still, it is not considered as part of the production process not to mention a profit centre. Undoubtedly it is of the lowest priority as far as maintenance budget is concerned.

Growing awareness of the need to prevent pollution has required the palm oil producers to take a closer look at their plant operations. Process solutions that meet cost and performance requirements and minimize environmental impact are high on their waiting list.

Evaporation is one of the most widely used unit operations in the chemical process industries. It is generally applied to remove water from aqueous solutions in a broad range of processing applications:

Palm Oil Research Institute of Malaysia, Ministry of Primary Industries, Malaysia
P. O. Box 10620, 50720 Kuala Lumpur, Malaysia. Tel: 03-8259155, 8259775. Telex: MA31609. Telefax: 03-8259446

- Concentration of products – glycerine from sweetwater, sugar concentrate (syrup) in sugar refinery, dairy industry.
- Recovery of chemicals.
- Concentration of residues for incineration and heat recovery.
- Desalination of brackish or seawaters.
- Production of natural rubber serum concentrate.

POME is made up of about 95% - 96% water, 0.6% - 0.7% oil and 4% - 5% total solid including 2% - 4% suspended solids which are mainly debris from palm mesocarp.

Elaborate treatment system is required to reduce the BOD to an acceptable level for discharge. Due to one reason or another not many palm oil mills can meet the DOE's discharge standards. The palm oil industry is interested in finding an affordable alternative to solve the problem. If the water and the solid can be reclaimed from the POME, and made into saleable products, this will create a business opportunity for the industry or venture capitalists.

WATER REQUIREMENT AND WATER TREATMENT

Large quantities of water are required in the palm oil milling process. It is estimated that 1 - 1.5 tonnes of water are required to process one tonne of FFB of which about 0.5 tonne is used as boiler feed water. The remaining is used as process water like dilution water, wash water, *etc.* About half of the water used ends up as palm oil mill effluent. The other half is lost as steam (vapour) through mainly sterilizer exhausts, leakages, *etc.*

Most palm oil mills extract the water from natural water systems like rivers and tube wells. These waters normally contain high dissolved solids and suspended solids and require elaborate chemical treatment and purification. Depending on the quality of the water, the cost for chemical treatment varies from RM0.30 to RM0.50 per tonne of FFB.

PROCESSING OF POME BY EVAPORATION TECHNOLOGY

The palm oil mill effluent (POME) used is collected directly from the effluent pit in the palm oil mill. Fresh POME is a thick brownish colloidal slurry of water, oil and fine cellulosic fruit debris. It is hot (80°C - 90°C) and acidic (pH 4 - 5). The characteristics of a typical POME are shown in *Table 2*. It is characterised by high biochemical oxygen demand (BOD) and total dissolved solids. It is non-toxic as no chemical was added to the oil extraction process. However, it contains appreciable amount of metals which are the essential nutrient elements for plant growth. Samples of POME are taken daily for analysis on pH, total solid and oil and grease.

A pilot plant was provided by Yokohama Rubber Co. of Japan and installed at one palm oil mill for evaluation (*Figure 1*). It consists of a single effect evaporator of 200 litre capacity. The vacuum (600 mmHg) required was created by water jet. The corresponding boiling point of water is about 60°C.

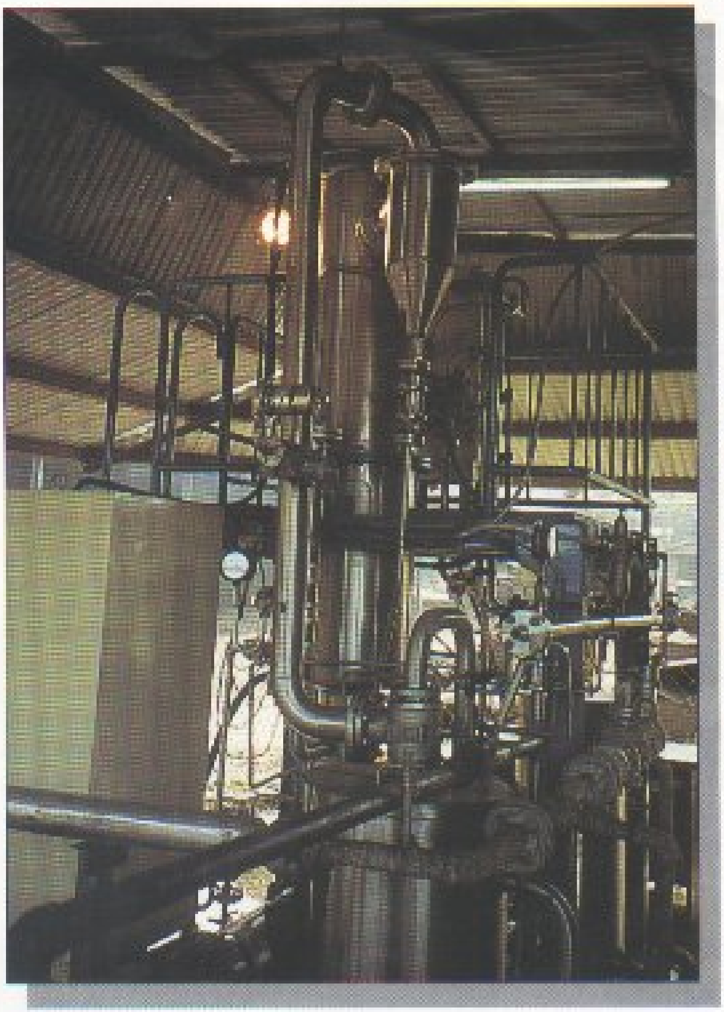

Figure 1.

POME is collected in a holding tank. It enters the evaporator system (by suction) through a plate heat exchanger which is heated by steam from the palm oil mill. The temperature of the feed is maintained at 80°C.

The process was operated batchwise. The evaporation process is controlled by two level sensors at 60 litre and 30 litre level. At the commencement of the batch, when the vacuum and feed temperature had reached 600 mmHg and 80°C respectively, 60 litres of the POME entered the evaporator via a plate heat exchanger. Due to the big temperature gradient, vaporization took place immediately. The liquor in the evaporator is recirculated continuously via the same heat exchanger.

When the liquor in the evaporator dropped to the 30 litre level, fresh POME was admitted. This was effected through the level sensors. This process was repeated until the solid concentration of the liquor in the evaporator had reached a pre-set level, *e.g.* 30%. The solid concentrate was then discharged. A new cycle would begin.

Quality of Distillate

The POME used for the pilot plant trial contained about 3.3% total solids. The solid concentrate produced contained about 20% 30% solid. In other words about 85% of the water has to be distilled off. At the pilot plant, the distillate is recovered for reuse. Excess distillate is drained off.

The quality of the distillate collected at the end of the run is shown in *Table 3*. It can be seen that it is of high quality. Certainly it can be reused as process water or boiler feedwater with minimum chemical treatment.

TABLE 3. QUALITY OF DISTILLATE

Appearance	Clear to slight turbid
pH	5 - 6
Chemical Oxygen Demand (mg/L)	100
Biochemical Oxygen Demand (mg/L)	20
Total Solid (mg/L)	150
Suspended Solid (mg/L)	10
Oil and Grease (mg/L)	10
Ammoniacal Nitrogen (mg/L)	6
Total Nitrogen	20
Iron	Not detectable
Phosphorus	Not detectable

For a 30-tonne FFB per hour palm oil mill generating about 19.5 tonnes of POME, a 85% recovery means 16 tonnes of water are recovered for recycle. This will be sufficient to meet the boiler feedwater requirement. This will offset the water intake from the source.

Solid Concentrate

The single effect pilot plant scale evaporator is able to produce a concentrate with 20% – 30% solid content. It is envisaged that a commercial plant using multiple effects evaporator system, a concentrate with 30% solid can be achieved without much difficulty.

Utilization of Solid Concentrate

For a 30 tonnes FFB per hour palm oil mill, the volume of solid concentrate (20% solid content) obtainable amounts to about 3.2 tonnes per hour as compared to 19.5 tonnes of POME. Thus there is a significant reduction (84%) in volume. Of course, a higher solid concentration corresponds to a lower liquid volume. It is much easier and simpler to handle even from the disposal point of view.

Currently all the palm oil mills have constructed their own POME treatment plants. All these treatment plants have ponds for different designed functions. Since there is no more liquid effluent to be treated as before, these ponds can be utilized to contain the solid concentrate and there will be virtually no discharge. The solid can be used later when required as fertilizer which is presently being practised.

The solid concentrate contains high plant nutrients, especially nitrogen (N), phosphorus (P) and potassium (K), as shown in *Tables 2* and *4*. It is a good feed material for fertilizer manufacturing. In fact granular fertilizer has been successfully produced by Yokohama Rubber Co. Ltd. of Japan in small scale experiment. In order to produce a balanced fertilizer, other fertilizer ingredients have to be incorporated. The fertilizer effect on crops will be evaluated. From the experimental trial, it appears that the small amount of oil content in the solid concentrate did not affect the fertilizer making process. The solid concentrate also contains about 13.5% protein and other essential amino acids. Thus it can be used for making other saleable value added products like animal feed or used as a feed stock for fermentation.

TABLE 4. NUTRIENT ANALYSIS PALM OIL MILL EFFLUENT SOLID CONCENTRATE

	Wet Basis (%)	Dry Basis (%)
Total Nitrogen	0.41	2.07
Ammoniacal Nitrogen	0.03	0.15
Total Phosphorus (P_2O_5)	0.19	0.96
Water Soluble (P_2O_5)	0.15	0.76
Total Potassium (K_2O)	1.29	6.51
Total Calcium (CaO)	0.023	0.12
Total Magnesium (MgO)	0.396	2.00
Total Manganese (MnO)	0.003	0.015
Total Iron	0.007	0.035
Total Sodium	0.004	0.020
Moisture	80.0	

ENERGY CONSUMPTION

Energy requirement is the major consideration in the evaporation process. It is envisaged that the heat energy required for the evaporation can be provided by steam and electricity from the palm oil mill. As the fresh POME discharged from the palm oil mill is 80°C – 90°C, little sensible heat is required. However, quite high electrical energy may be required. Under standard conditions, the specific energy consumption is taken as one (*i.e.* one kg of steam per kg water evaporation). In recent years, significant advancement has taken place in evaporation technology to reduce the energy consumption. A modern evaporator design is able to give a specific energy consumption of 0.1. This can be achieved by increasing the number of evaporators and by efficient thermal vapour recompression. Of course, more evaporators means higher investment costs. An evaluation on the cost-effectiveness of an evaporation system for the palm oil mill effluent is being carried out.

ENERGY DEMAND

It is well known that all the palm oil mills are self-sufficient in energy by burning fibre and shell. In fact there is excess of these solid by-products which have to be disposed off separately. This often poses environmental problem. Empty fruit bunch is another solid by-product which has attracted much negative attention due to the emission of "white smoke" by the current incineration process. This white smoke, though consists of mainly water vapour, is aesthetically unacceptable. The Department of Environment discourages the burning of these empty fruit bunches especially for new establishments. These are "free" energy source however. Thus it is envisaged that the energy demand by the evaporation process can be met without much difficulties. For those palm oil mills having excess boiler and electrical energy generating capacities, the additional investment required will be minimal.

CONCLUSION

With the incorporation of the evaporation technology in a palm oil mill to process the palm oil mill effluent, the palm oil mill is able to achieve a closed loop system and there will be no liquid effluent discharged. This innovative process will offer a long term solution and opportunities for solving environmental problems through effective energy management. POME should be considered as a valuable resource and its recovery is a much more desirable alternative from an environmental perspective than the treatment and disposal practice. The distillate can be recycled as boiler feedwater with minimal treatment or as process water with no chemical treatment. The solid concentrate can be used for making fertilizer or other saleable products. More beneficial spin off can be realised when processing POME is considered part of the palm oil production process. This will also create new business opportunities for the industry.

For more information kindly contact:

Director-General
PORIM
P. O. Box 10620
50720 Kuala Lumpur
Malaysia