

# **EcoTAGZ-SRORS – A Solids Removal, Oil Recovery And COD-BOD Reduction System For Raw Sludge**

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## **ABSTRACT**

*Nowadays many mills pressed Empty Fruit Bunches (EFB) to recover oil. EFB pressed liquor is discharged to effluent pond together with decanter heavy phase and steriliser condensate after oil is recovered. Although EFB liquor contribute only 5-10% of raw sludge volume produced, it can increased Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) of raw sludge from 50,000mg/l to 100,000mg/l and 25,000mg/l BOD to 50,000mg/l, respectively. Effluent ponds will be overloaded immediately because they are mostly designed to take in 50,000mg/l COD and 25,000mg/l BOD. Consequently, effluent ponds sludged up in about a year instead of three years. Mills are using various systems to desludge effluent ponds, and tertiary plants at the end of the ponding system to bring down BOD to meet Department of Environment given standard for discharge. A technology breakthrough, which has been patented, has been developed to process raw sludge of palm oil mill before it is discharged to effluent ponds for treatment. All suspended solids are removed using our system process, producing a clear tea colour solution with dissolved solids of less than 300mg/l suspended solids for discharge to effluent ponds for treatment. Residue oil of 8,000-15,000mg/l in raw sludge is recovered and channelled into oil tank of the mill, as oil recovered is crude palm oil. Oil residue left in filtrate is consistently less than 50mg/l. With suspended solids and oil removed, COD and BOD of the clear filtrate discharged to effluent ponds for treatment can be reduced by about 70% of original input COD and BOD. This allows for easy treatment of effluent BOD to below 20mg/l for discharge as ponds retention time is maintained. Mills will also reduce greenhouse gases production by about 70% since COD of discharge is reduced by about 70%. This will be good for oil sold to European market. As oil is recovered, this becomes a revenue generating system that will pay for itself, while solving the perpetual sludge problem in the ponds. There will also be saving on desludging and polymers.*

## INTRODUCTION

Since the beginning of the oil palm industry in this country, equipment in oil room for palm oil has not changed much. After oil has been squeezed out from the fruitlets in the screw press, it goes into the clarifier where oil, and some solid derived from fruit pulp or mesocarp, is diluted with hot water, or in some cases, steriliser condensate. The oil floats up and is skimmed off. Clarifier underflow consisting normally of organic solid (6-8%) and oil (about 5-7%) are sent to the decanter system to recover oil and remove suspended solid (Lu, 2012). Due to squeezing, blending, stirring, spinning during the process to extract oil from mesocarp in screw press to decanter system for oil recovery, some of the oil that is in the water gets emulsified. This portion of oil that is emulsified cannot be recovered by existing equipment used in the mill. Acceptable oil loss in raw sludge by the industry is any value below 1%. Mill effluent that is discharged into the pond usually consists of 0.8-1.2% oil, and 2.5-3.5% solid (Lu, 2012).

### **Solid in Effluent**

A three phase decanter system is usually used to recover oil and remove solid in oil palm mill. The decanter system can be adjusted to remove more solid but with higher moisture, or drier solid but less solid removal (Alfa Laval, 2007). Usually solid of about 2.5-3.5% still remains in the decanter heavy phase and is discharged into the pond together with the steriliser condensate and washings. However, in mills that do not use decanter system but just oil separators to recover oil, the quantity of solid in the effluent that is discharged to the pond is about 4-5% (Ma and Ong, 1985).

Solid in effluent is causing a lot of problem in the treatment of effluent to below 20ppm BOD and 200ppm suspended solids for discharge as required by Department of Environment Standard A (DOE, 1979). Many mills have constructed tertiary plant before the final discharge point to bring BOD to below 20ppm for discharge, however, the problem is in the upstream ponds where effluent with high load of solids and BOD is going into the pond for treatment. The ponds usually get sludge up within 2-3 years. Many mills have installed empty fruit bunches press to recover some of the residue oil. Although empty fruit bunches liquor contributes only 5-10% of total volume effluent discharged, it can increase COD from 50,000mg/l to 100,000mg/l, and BOD from 25,000mg/l to 50,000mg/l (Yeoh, 2004). Effluent ponds become overloaded as they were designed for input with 50,000mg/l COD and 25,000mg/l BOD. Effluent ponds get sludged up faster and retention time reduced drastically. The whole system including the tertiary plant gets 'short circuited'. To overcome this problem frequent desludging of effluent ponds and maintenance of tertiary plant is required.

### **Oil Loss Areas**

Oil loss varies from mill to mill. Each mill will have to carry out their own analysis to determine the oil loss from the various areas which also fluctuate over time. Areas of oil loss are shown in *Table 1*.

**TABLE 1. AREAS OF OIL LOSS**

		Volume in Kg	Oil in Sample %	Oil Loss on FFB %	Range of Oil Loss on FFB %
1	<b>Steriliser Condensate</b>	<b>16</b>	<b>1.0</b>	<b>0.16</b>	<b>0.12-0.64</b>
2	Oil in Empty Bunches	23	1.8	-0.41	0.35-0.51
3	Fruit Trapped in Empty Bunches	23	0.1	0.02	0.01-0.04
4	Unstripped Bunches	-	-	0.03	0.02-0.60
5	Mesocarp fibre	12	4.0	0.48	0.45-0.76
6	Nut	13	0.5	0.07	0.05-0.09
7	<b>Sludge</b>	<b>45</b>	<b>1.0</b>	<b>0.45</b>	<b>0.40-0.60</b>
8	Washing & Spillage	20	0.8	0.14	0.13-0.26
	Total oil loss/FFB			1.76	1.53-3.50
	Oil recovered/FFB (OER)			20.0	20.0
	Total oil in FFB/Total losses + OER			21.76	21.53-23.50
	Efficiency			91.90	92.89-85.11

Source: Ng Say Bock

Total amount of effluent from steriliser condensate and decanter heavy phase is 61kg, and oil loss in these areas is 1.0%. Thus oil loss on FFB is 0.16% and 0.45%, respectively, giving a total of 0.61%. If oil loss from washing and spillage, which will varies in mills, is added to the total oil loss in effluent, the value can go as high as 0.75%. This shows that oil loss in effluent is the highest. Second area of oil loss is from mesocarp fibre at 0.48%.

A 60mt/hr mill processing 324,000mt FFB per year and discharging 210,600mt effluent (65%) with 1.0% oil will loss 2,106mt oil, or RM4,633,200 per year with crude palm oil (CPO) price at RM2,200/mt.

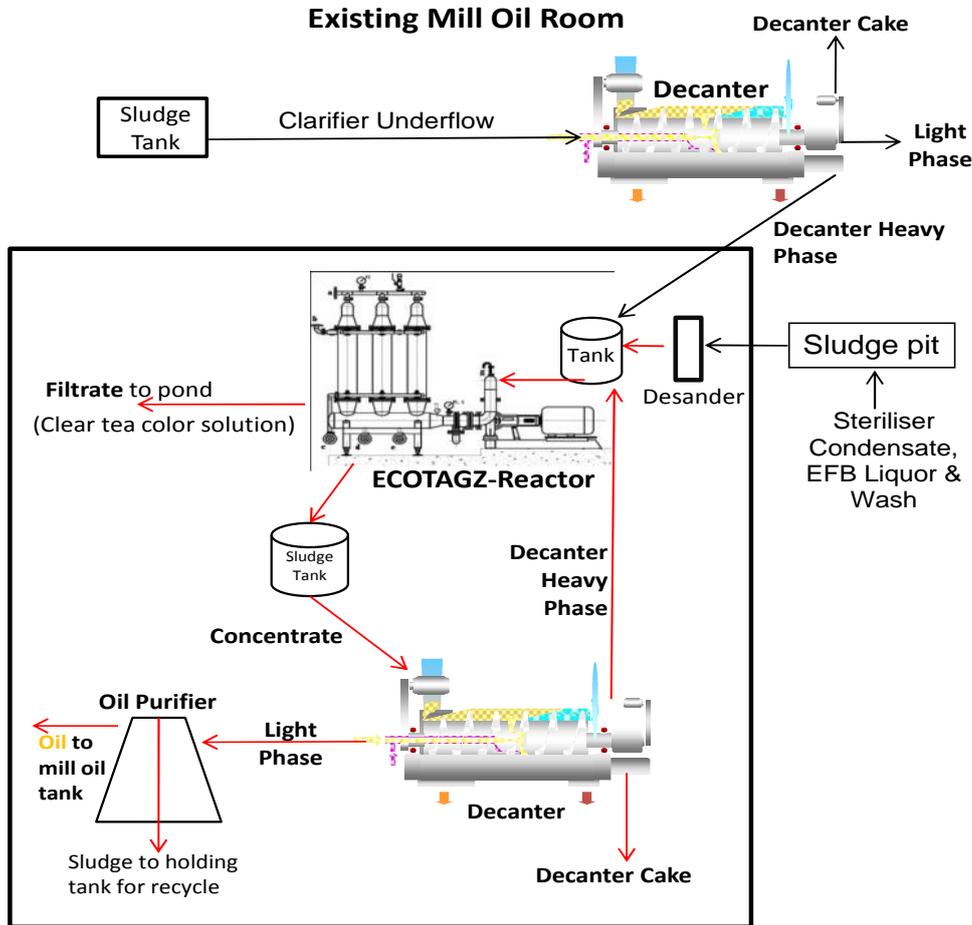
### ECOTAGZ-SRORS Plant

EcoTAGZ has designed and multi patented a system for the palm oil mills, where it has the capability to recover all oil and remove all suspended solids from raw sludge before it is discharged to the effluent ponds for treatment. EcoTagz-SRORS plant will separate raw sludge into its 3 components – oil, decanter cake (suspended solids) and filtrate (water with dissolve organic solids).



EcoTAGZ-SRORS plant, a solid removal oil recovery system main equipment consists of a series of tanks, EcoTAGZ Reactor, 3 phase decanter and centrifugal disc stack (oil purifier), as shown in *Diagram 1*.

**Diagram.1** ECOTAGZ-SRORS Plant



**ECOTAGZ PLANT – An Oil Recovery & Solid Removal Plant**

EcoTAGZ-SRORS is a filtration system which is able to concentrate raw sludge by removing water, separating the emulsified oil and suspended solids from the water part. It produces two products – Concentrate and Filtrate. The Concentrate consists of: oil of about 2-5.0%, solid of 6-8% and the remaining, water. Quantity of oil in Concentrate will depend on amount of oil residue in raw sludge. Filtrate is a clear tea-like solution with negligible oil and suspended solid. BOD of Filtrate is about 30% of raw sludge input BOD. When the Concentrate has reached a certain concentration during process in the system, it is pumped to a 3 phase decanter system to recover oil in the light phase, and remove suspended solids as decanter cake. Light phase is pumped to an oil purifier to recover oil. Decanter heavy phase produced is channelled back to holding tank to be processed. Whole process is repeated again until all oil is recovered, suspended solids removed and water discharged to effluent ponds for treatment.

A full scale plant has been set up in a 45mt/hr mill about one and half year ago. Raw sludge consisting of steriliser condensate, decanter heavy phase and EFB liquor from sludge pit was processed by 2 units of Series M6000 EcoTAGZ Reactor. Unfortunately, oil recovered cannot be quantified as Concentrate is pumped back into the mill's sludge tank and processed together with the mill's clarifier underflow. However, batch processing of EcoTAGZ concentrate has shown the oil recovered to be about 0.5% of OER. At the time of writing this paper another system is to be commissioned in a 30mt/hr mill. This system has its own 3 phase decanter and oil purifier. Oil recovered will be quantified.

Filtrate analysis has consistently show oil of less than 10mg/l, suspended solids of 100mg/l and BOD of about 7,000-8000mg/l without EFB Liquor, and 15,000-18,000mg/l with EFB Liquor. Filtrate tea like colour is due to high dissolved organic solids in it. The colour will varies from brownish to reddish colour, depending on quality of fruits and process in the mill, such as whether hot water or steriliser condensate is used for vertical clarifier dilution. This clear filtrate is discharged to the effluent pond for treatment.

The system comes in modular form, and EcoTagz Reactor comes in 2 models, series M6000 and M8000, with capacity of 18mt/hr and 24mt/hr, respectively. System will be sized according to mill capacity and amount of raw sludge produced. For example, a mill processing 60mt FFB/hr, producing 70% raw sludge will require 2 units of M8000 EcoTagz Reactor, whereas the same mill producing 50% raw sludge will require 2 units of M6000 EcoTagz Reactor.

Flow rate of filtration is maintained through regular backwash which is automated by use of hot water, and low concentration of sodium hydroxide solution once or twice a week. Maintenance cost for Ecotagz-SRORS system is minimal. Cost incurred is mostly on the decanter.

## RESULTS

*Table 2* shows the analysis result of heavy phase, and filtrate, where heavy phase is directly from the decanter system.

**TABLE 2. ANALYSIS RESULTS OF DECANTER HEAVY PHASE, AND FILTRATE -Mill A**

No.	Parameter	Heavy Phase	Filtrate
1	BOD <sub>3</sub> mg/L	47,000	16,000
2	COD mg/L	103,000	31,000
3	Suspended Solids mg/L	24,000	<b>180</b>
4	Total Solids mg/L	37,000	33,000
5	Ammonical N mg/L	330	260
6	Total N mg/L	810	560
7	Oil & Grease mg/L	16,000	<b>15</b>

In Mill A, heavy phase COD, and BOD are high. This is due to the used of steriliser condensate for dilution in vertical clarifier.

Analysis result shows that there is 15mg/l oil left in the filtrate. This means 99.9% oil in raw sludge is recovered before discharge to effluent pond. Suspended solid is 180mg/L, which is more than 99.25% removed.

Table 3 shows the analysis result of raw effluent from sludge pit, and filtrate, where raw sludge is a combination of steriliser condensate, EFB Liquor, decanter heavy phase, oil separator and wash water.

**TABLE 3. ANALYSIS RESULT OF RAW EFFLUENT, AND FILTRATE -Mill B**

**Results:**

Type of Test <sup>A</sup>	Test Methods <sup>B</sup>	Results	
		Filtrate	POME
pH Value	APHA 4500-H <sup>+</sup> B	4.69@25.6°C	4.73@25.6°C
Biochemical Oxygen Demand (3 Days @ 30°C), mg/L	DL-LAB-TM01 (based on MN Method 8-22)	13,410	48,100
Chemical Oxygen Demand, mg/L	DL-LAB-TM02 (based on MN Method 0-26; 0-28; 0-29)	19,500	78,000
Ammonical Nitrogen (NH <sub>3</sub> -N), mg/L	DL-LAB-TM03 (based on MN Method 1-05)	12	70
Total Nitrogen, mg/L	DL-LAB-TM04 (based on MN Method 0-88)	28	590
Oil and Grease, mg/L	DOE (M) Reference Method	3	13,812
Suspended Solids, mg/L	DOE (M) Alternative Method	31	24,600
Total Solids, mg/L	APHA 2540 B	20,760	49,750

Mill B use hot water for dilution and is pressing EFB partially to recover oil. COD and BOD of raw sludge is 78,000 mg/l and 48,100mg/l. It can be seen that oil content is only 3mg/l, and suspended solids is 31mg/l in the filtrate as compared to the raw sludge of 13,812mg/l and 24,600mg/l. This is 99.98% and 99.87% recovered, respectively.

Table 4 shows analysis results of filtrate only. It shows that the oil is only 2mg/l in the filtrate whereas suspended solid is about 34mg/l.

**TABLE 4. FILTRATE ANALYSIS RESULT – Mill A**

No.	Parameter	Filtrate
1	BOD <sub>3</sub> mg/L	25,040
2	COD mg/L	37,000
3	Suspended Solids mg/L	<b>34</b>
4	Total Solids mg/L	39,580
5	Oil & Grease mg/	<b>2</b>

## MASS BALANCE

Mass balance of the whole process will show how much oil is recovered regardless of whether the concentrate is diverged back to mill sludge tank and mix with clarifier underflow to recover oil and suspended solids remove by mill decanter, or by a separate decanter and oil purifier system for oil recovery and suspended solids removal. Mass balance of process is shown in Diagram 2.

Amount of oil recovered can be quantified by measuring:-

- volume of raw sludge produced with a flowmeter,
- oil in raw sludge through laboratory analysis
- quantity of decanter cake produced by weigh bridge.
- oil loss in decanter cake by laboratory analysis

Since oil content in filtrate is less than 50mg/l, it indicates that oil residue in raw sludge is 99.5% recovered. About 20% of oil recovered is lost via the decanter cake, which has an oil residue of about 3.5% (wet basis).

### Diagram 2. Mass Balance

#### MASS BALANCE OF RAW SLUDGE AFTER PROCESSED BY ECOTAGZ FILTRATION PLANT - A SOLIDS REMOVAL OIL RECOVERY SYSTEM (SRORS)

FFB 1000.0	==>	DHP 450.0	+	SC 150.0	+	EFB LIQUOR 40.250	=	RAW SLUDGE 640.250 mt	Quantity of raw sludge discharged is/can be measured by mill before it is discharged to the effluent ponds
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EFB 230 mt		
Moisture 65%		
After press 50%		
Liquid 15%	34.500 mt	
	5.39%	
Moisture 65%		
After press 45%		
	20%	46.000 mt
		7.18%
Average	40.250 mt	6.29%

Raw Sludge - components				
Oil	+	Total Solids	+	Moisture
1.00%		3.25%		95.75%
6.403 mt		20.808 mt		613.039 mt

Assumptions:				ppm	%	mt
Total Solids in Raw Sludge		36,500	3.65	23.369		
Dissolved Solids in Filtrate		22,000	2.20	14.086		Values Depends on Mill & analysis
Solids removed by ECOTAGZ - SRORS		14,500	1.45	9.284		

Oil Recovered - Net	
4.990 mt	
77.93% to raw sludge	
0.499% to FFB	

Solids Removed - As Decanter Cake After ECOTAGZ SRORS			TOTAL
9.284 mt	Dry basis		
40.364 mt	Wet basis - based on 23% solids		
23.00%	Total solids in decanter cake		
77.00%	Moisture		41.776 mt
Recovered Oil Lost in Decanter Cake			
3.50%	Wet basis. Value from lab analysis		
15.22%	Dry basis - based on 23% solids		
1.413	Quantity of recovered oil lost in decanter cake		

Moisture Discharged - Filtrate				TOTAL
Oil	Solids			Moisture
	Suspended	Dissolved		
50	300	22,000 ppm		
		14.086	579.398	593.484 mt

Check - Mass Balance	
Oil	4.990
Decanter Cake	41.776
Filtrate	593.484
<b>Total - R. Sludge</b>	<b>640.250</b> mt

Through mass balance it was calculated that mills will recover about 0.5% oil to OER based on 1% oil loss in raw sludge, and 65% raw sludge produced to FFB processed. This percentage of oil recovered was confirmed by the mill actual recovering about 0.5% oil to OER when batches of concentrate from EcoTagz-SRORS were processed.

However, if a separate 3 phase decanter and oil purifier is used to process the recovered oil, then the exact amount of oil recovered can be quantified by a totaliser counter.

## ECONOMICS

Ecotagz-SRORS plant is a revenue generating system while providing a solution to solve the effluent problem encountered by most palm oil mills.

A 60mt/hr mill processing 306,000mt FFB annually will recover about RM3,480,000 worth of oil annually, as shown in Diagram 3. This is based on 1% oil residue in raw sludge, price of CPO at RM2250/mt.

Diagram 3.

### ESTIMATE FINANCIAL RETURN FROM OIL RECOVERED FROM RAW SLUDGE USING ECOTAGZ FILTRATION PLANT

Assumptions	Decanter HP	S.Condensate	EFB Liquor	Total	
Liquid per mt FFB	45.0%	15.0%	5.00%		65.0%
Solid in Sludge					3.25%
Oil loss in decanter cake					3.50%
Solid in Decanter cake	23.0%				
Mill Capacity	60				mt/hr
Operating Hours	17				hrs
Oil loss in raw sludge	1.0				%
Sludge Oil Recovery from Pond					mt/yr
Price of CPO	2250				RM/mt
Power Requirement	350				kw/hr
Power cost per kwhr	0				RM/kwhr
Cost of operation	60,000				RM/yr
					FFB Processed per year
					Raw Sludge - % of FFB
					Raw Sludge
					Decanter Cake
					dry basis
					wet basis
					Gross Oil Recovered
					Oil loss in Decanter Cake
					Net Oil Recovered
					Minus sludge Oil Recovered
					Net % oil recovered from Raw Sludge
					% of oil (OER) recovered per mt FFB
					Revenue from Oil Recovered
					Power cost
					Power cost
					Net Revenue from Oil Recovered

Payback period of plant is between 2.5-3 years depending on throughput of the mill and oil loss in raw sludge. Return on investment (ROI) is usually more than 200% over 10 years. Maintenance cost is minimal as consumable used is very minimal. Small amount of chemical is used for backwashing only, which is done one or twice a week.

## DISCUSSIONS

Although the parameters of raw effluent or heavy phase vary drastically, the two main values that are important is the oil and suspended solid in the filtrate. In all analysis taken, it was seen that there is negligible oil and suspend solids in the filtrate. Basically all oil residue is recovered and suspended solids removed from raw sludge. EcoTagz Reactor in

combination with a 3 phase decanter system recovers the oil, removes the suspended solid to produce a clear solution or filtrate with about 30% of original COD and BOD for discharge to effluent pond for treatment. Although all oil is recovered, about 20% of this oil is lost via the decanter cake, which has residue oil of 3.0-3.5% (wet basis).

In mills where decanter system has been adjusted to recover oil and minimise oil loss in heavy phase, it can be adjusted to recover neat oil and to remove as much suspended solid as possible (Ong, 2015). This is because heavy phase is recycled back to recover oil and remove suspended solids. With EcoTagz-SRORS no oil is lost or discharged to effluent pond.

Mills without three phase decanter system but only oil separators to recover oil will need to install a decanter system before EcoTagz plant to reduce solid in the heavy phase for EcoTAGZ plant to operate optimally.

Filtrate will be easier to treat to bring BOD to below 20ppm for discharge as BOD has reduced to about 30% of original values, and there is no suspended solid to sludge up the ponds. Solid amassed in effluent ponds will be due to microbe biomass. Thus effluent ponds will not sludge up easily and there will be ample savings from desludging and consumable used. Ponds will retain original design retention time to provide good treatment of effluent.

Mills that use steriliser condensate instead of hot water for dilution in its vertical clarifier will find the filtrate without oil and suspended solids to be a better medium for this process.

There will be no more sludge oil in cooling pond for recovery as oil in raw sludge is completely recovered in the mill as crude palm oil with EcoTagz-SRORS plant before it is discharged to the pond.

For mills with biogas or looking into biogas system, the decanter cake and filtrate can be mixed up again to go into biogas plant. It is basically raw sludge without oil. The decanter cake and filtrate can be blended accordingly to cater to the biogas system, with more or less solid. Subsequently, biogas tank can be smaller, or retention time can be longer to provide more efficient digestion of effluent for biogas production.

Raw sludge of mills without EFB pressed liquor has 50,000mg/l COD and 25,000mg/l BOD. After processed by EcoTagz-SRORS plant, filtrate COD and BOD will be about 15,000mg/l and 7,500mg/l, respectively. It is possible for effluent with such low BOD to go straight into aerobic pond with aeration equipment to treat the effluent to prevent biogas production. This will be a biogas avoidance system.

European Union Renewable Energy Directive 2009, Article 17 on sustainability criteria for biofuels and bioliquids requires GHG to be reduced at least 35% by 2015, 50% by 2017, and 60% by 2018 (EU Directive, 2009). As EcoTagz-SRORS system can reduce

COD to more than 60% and thus GHG, the mill will be able to meet this directive requirement up to 2018, after the mill has been certified by a certification body once the system is installed in the mill.

A project is also underway to look into purification of the filtrate into clean water which will be recycled back to the mill for use. This is to ultimately provide the mill zero discharge and biogas avoidance facility. This will also augers well for mills that encounter water problems whether availability or quality.

## **CONCLUSIONS**

EcoTagz plant is a system that will not only recover the +/- 1% residue oil in raw sludge, which is considered as an acceptable loss in the mill, it will also remove suspended solids from raw sludge. No suspended solids will be discharged to effluent ponds. Ponds will not sludge up so easily and will retain their original design retention time for a much longer time for effluent to be properly digested for discharge. EcoTagz plant is not a system to treat BOD to below 20ppm for discharge, however, with the suspended solids removed and BOD reduced to 30%, BOD 20mg/l as required by Department of Environment will be easier to achieve.

EcoTagz plant will generate revenue for the mill as it has been calculated that a 60mt/hr mill operating 18hrs/day and processing 306,000mt FFB with 1% oil loss in raw sludge will recover about RM3.48 million worth of oil per year, after oil loss through decanter cake (3-3.5%) on oil recovered from raw sludge has been factored in, with crude palm oil priced at RM2,250/mt. On top of that there will be ample savings from desludging and polymers consumed.

The mill will also become much greener as the mill will reduce GHG production by about 70%. This claim can be certified as COD of raw sludge before and after process by Ecotagz-SRORS can be analysed and certified. This will auger well for oil that is sold to European market where such requirement is needed.

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