PALM OIL AGROINDUSTRY

ZERO DISCHARGE MILLING: A NECESSARY STEP FOR SUSTAINABILITY AND A BUSINESS OPPORTUNITY State of the Art

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ABSTRACT

In Malaysia, stringent environmental control about POME (Palm Oil Mills Effluents), from DOE (Dept of Environment), MPOB (Malaysian Palm Oil Board) and clients (market) increases substantially the investment and O&M costs of the palm oil industry and by the way the oil production costs. Biogas generation is a possible income to transform the ETP (Effluent Treatment Plant) into a profit center. Nevertheless, for most of the mills, gas value is very low (no need). Additionally, biogas plants only provide part of the environmental solution: this technological solution is not sufficient to meet DOE's requirements on final discharge which are increasing year after year due to national (communities, policies) and international (market) requests.

On another side, POME are nutrients-rich, have a fertilizer value between 4 and 5 US$/T FFB (Fresh Fruit Bunches) and are an opportunity to restore the soil fertility.

This article presents two technologies, among others, for a ZERO DISCHARGE MILLING, to reduce the costs of chemical fertilization, boost FFB and oil yields per hectare and improve business sustainability.

- *Option 1: Dosed and monitored liquid organic fertilization*
- *Option 2: Biodigested POME evapo-drying (Bio-evapo-drying) up to powdered fertilizer*

In other article, they will be complemented with other options, like Raw POME evapo-drying (POME to animal feed) and co-composting / evapo-composting.

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INTRODUCTION

A few years ago, POME were considered as a polluting effluent, a headache and a cost center. With biogas technology development, POME became progressively a possibility of profit center. Nevertheless, even though Renewable Energy (RE) is on the top of all national and international policies, the proportion of palm oil mills which can take advantage of this RE is very limited:

- Most of the mills are energy self-sufficient with their fibers and shells. Using biogas for shell savings in biomass boilers generates limited incomes (shell sales)
- Few mills have refinery and/or palm kernel crushing plant with energy consumption
- Few mills are connected to the grid and, when they are connected, the electricity sales can be disallowed (no feed-in-tariff), complicated (administrative red tape) and/or not profitable (too low tariff)
- Therefore, in West as well East Malaysia, there is not real incentive to generate biogas and to use it.

On another hand:

- Due to a national commitment for palm oil sustainability, MPOB and the Government drove millers to capture their greenhouse gases emissions and, at least, to flare it. For a typical 60 T/h mill, this is an investment between 1,2 and 2,4 M US$ in function of the quality and reliability of the biogas plant (market prices in Malaysia).
- Effluents discharge standards are stringent (BOD 100 ppm or BOD 20 ppm in function of the region). Compliance implies the construction of facultative and aerobic open ponds (around 1 M US$) + a sophisticated aeration and polishing plant (around 1 M US$).
- Environmental constraints can only increase, year after year, when Malaysia will meet international environmental practices, as:
  - Open lagoons (as well as lagoon-based biodigesters) must be 100% lined to avoid water table contamination (= additional investment of 1 M US$ + sometimes the necessity to rebuild the ponds)
  - Biological sludge must be carefully managed to avoid soils, watershed or water table contamination (= additional investment of 250.000 US$ for a dehydration unit)
  - Nitrogen (N) and Phosphorus (P) must be removed before river discharge (= additional investment of 1 M US$ + additional O&M costs)
  - Color must be removed

All these (future) constraints will not only require new investment but will still increase O&M costs, without any income, except if some use of the biogas can be found. This environmental care, normal for any business in the world, implies higher sales prices or reduces the profit. This is an issue when other countries have not the same environmental constraints and can therefore sell at lower prices. The absence of compliance can generate illegality as well as palm oil marketing limitations.

It means that the environmental constraints of the POME discharge are far more important for the palm oil business than the energy (biogas / electricity) opportunities.
Still more important for the business sustainability is the soil fertility improvement as well as the FFB (Fresh Fruit Bunches) and oil yields per hectare. POME and EFB are part of the solution.

DISCUSSION
Presentation of two options for zero liquid discharge to the environment

Fundamentals: The nutrients cycle:

POME has a high nutrient content, around 50% of the fruit's nutrients content. It represents around 5 US$/T FFB, including its organic matter. It means around 1,5 M US$/year for a 60 T/h mill (300.000 T/year mill). This high value cannot be a surprise: fruits are nutrients-rich while mills only export oil (carbon, hydrogen and oxygen). Where are the nutrients going? Obviously in the by-products and effluents.

The standard POME management practice is the discharge of treated POME (=nutrients) to the watershed (river) or to a limited area for land application (LA). Does it have some environmental or business logic?

A mill generates, through its POME, around between 0,75 and 1 kg N per ton of FFB. It means a 60 T/h mill (300.000 T/year mill) generates enough Nitrogen in its POME to fertilize between 1.500 and 2.000 hectares of plantation. The traditional "100 hectares land application" (furrow system) is not a POME valorization system but a way to avoid open discharge after due ponding. With the current BOD restrictions for land application in Malaysia (DOE regulations) and the limited (and low value) energy valorization options, mills are simultaneously losing the POME energy value (around 5 US$/T FFB) (due to the absence of energy demand) and the fertilizer value (around 5 US$/T FFB) (due to the BOD restriction for LA) while investing in (and operating on a daily basis) biodigesters, open ponds and polishing plants, what means having O&M costs without incomes to compensate them.

The difficulty of nutrients recovery and application lies in finding the appropriate tool (technologies), considering application efficiency, investment cost and O&M cost.

Mills can use different options for POME nutrients (and organic value) recovery:

- Liquid fertilization (usually through a centralized piping distribution)
- Biodigested POME evapo-drying up to powder (and using or marketing as a nutrients-rich biofertilizer)
- Raw POME evapo-drying up to powder (and marketing as animal feed)
- Co-composting (POME + EFB (Empty Fruit Bunches) with/without evaporation.

The traditional "land application" (LA) is an intermediate solution. It is considered as a method to get rid of the POME rather than to take advantage of its organic and nutrients value.

Option 1: The liquid fertilization

Liquid fertilization, through a monitored and dosed centralized piping distribution system, is one way to distribute treated POME (after ponds or after biodigesters) to the plantations to take advantage of their nutrient values. A 60 T/h mill can fertilize around 2,000 hectares with treated POME plus biological sludge (purged sludge). Nevertheless, the Department of Environment (DOE) has not yet regulated (neither accepted the principle of) the liquid fertilization concept and technologies, probably due to a confusion with the conventional, more well-known, “land application” (that often leads to over-fertilization of only a small portion of the plantation and to an impact on the watershed). Additionally, most of Peninsular Malaysia and Borneo plantations are on hilly areas, so that the homogenous distribution of treated POME on each palm is difficult to implement.

This dosed and monitored liquid fertilization systems are still a disruptive concept for Malaysia that allow mills to reach zero discharge + both energy (if there is a demand) and fertilizer valorization of the POME. Investment in the infrastructure is around 1.500 US$/hectare, including the SCADA monitoring which data can possibly be shared with the environmental authority (DOE). But this concept and related technologies are not already validated by DOE in Malaysia. Additionally, in many cases the plantation location or the topography does not allow a smooth implementation of liquid fertilization through buried and mobile pipes.

Two mills in Latin America have been pioneers in (treated POME) fertilization: PALMAR SANTA ELENA (Tumaco, Colombia) in 1992 and EXPORTADORA DEL ATLANTICO (Aguan, Honduras) in 2010. Agronomical results have been impressive with a 95 to 100% chemical fertilizers substitution and 10 to 25% yield increases compared with the nearby lots with traditional chemical fertilization.

Nevertheless, the feasibility of these “logical” POME management technique for nutrients and organic matter recycling is limited by the availability of the land around the plantation, by the topography and by the local environmental regulations and DOE must define its position on this monitored & dosed organic liquid fertilization.

The amount of nutrients recovered is maximum when the mill has a biodigester (avoiding nutrients evaporation) while it is reduced when the mill still uses the traditional “ponding” system. The inclusion of a ferti-irrigation system, to replace open ponds and polishing ponds (for more or less the same price), has an excellent profitability (due to chemical fertilizer substitution and yield increases, plus biogas use) if the mill can use both the treated effluent for organic fertilization and the biogas for energy purposes. But in many cases, there are too little options of biogas valorization and the only income is coming from the fertilizer. The return on investment (ROI) of the liquid fertilization is usually between 3 and 4 years.

Option 2: The bio-evapo-drying

2.1 The concept:

Bio-evapo-drying is another disruptive technology allowing zero discharge and fertilizer valorization and is also an alternative to high O&M costs of the “traditional” treatment solutions (ETPs) which do not generate incomes.

The BIO-EVAPO-DRYING is a combination of a methanization process (=biogas plant, which volatilizes the carbon, hydrogen and oxygen, generates Renewable Energy (RE)), and “concentrates” the nutrients in the liquid) with an evaporation and a drying process.

The bio-evapo-drying generates a nutrients-rich powder or granule (5% moisture), easy to stock, transport and apply on the plantations. It is also marketable in the country and exportable. It is particularly adapted to mills surrounded by a reduced area of own plantations (less than 1.000 hectares) or by very hilly plantations.

As an option, a BIO-EVAPO-DRYING plant can produce two separated products:

- A high-value soluble organic fertilizer (to sell on the national or international market for crops using fertigation)
- A lower-value insoluble organic fertilizer (to use locally on the plantation)

2.2. The bio-evapo-drying background:

The effluents bio-evapo-drying story started in the bioethanol industry in India. Bioethanol distilleries' vinasses (waste) are the headache of all the distilleries in the world, due to their high COD, except when DOE allows to spread them to the nearby sugarcane plantations (like in Brazil).

Bioethanol distilleries' vinasses are very similar to POME (pH 4, COD between 60.000 and 120.000 ppm).

A few years ago, the Indian Environmental Authorities prohibited any discharge of vinasses to water bodies. A few Indian high-tech evaporation and drying companies started R&D on raw vinasses evaporation up to 50 or 60% DM, and finally on drying up to powder form. Energy consumption and low value of the final product (slurry or powder) were the main initial limitations of the concept. The posterior combination of methanization (biodigestion) and evapo-drying overcame these limitations, as some companies could find an equilibrium between methane generation and energy requirement for the evapo-drying process. Evaporation of biodigested (methanized / bio-methanated) effluent has several technological differences with evaporation of crude (raw) organic matter, but these differences could easily be solved. After a few years, more than 100 distilleries have been equipped with effluents evaporation units (MSE = Multi-Stage Evaporators) and more than 20 already with effluents evapo-dryers (usually spray dryers).

A joint R&D between SSP India and BIOTEC adapted the concept and the technology to POME. The immediate market for this solution is therefore Malaysia due to the stringent environmental discharge standards and the compulsory greenhouse gases capture regulations. On the contrary, due to lower environmental requirements for POME discharge and higher market opportunities for the gas (electricity demand), this concept generates less business interest presently in Indonesia or in Latin America.

2.3 The suitability of the bio-drying concept for the palm oil business:

The nutrients content of raw POME is around 1 kg N, 0.5 kg P_2O_5 and 2.2 kg K_2O per ton of FFB. But these nutrients are "diluted" in a large amount of organic matter, making transportation and application costs high, even if it is dried. Additionally, the drying process is energy-consuming, and the mills usually do not have enough steam and electricity for that process.

The biogas produced by the biodigester is enough to fuel the evapo-dryer, if this one is well designed. As the biodigester digests more than 80% of the volatile matter, the (macro and micro) nutrients concentration, expressed in function of the dry matter, is three or four times more concentrated in the final product than in the raw POME. It averages 45% of the dry matter instead of 13%. It means than an hectare can be fertilized with few bags, like with chemical fertilizers.

The condensed water produced by this process is crystal-clear, has a neutral or basic pH and has very low COD and BOD values.

Due to its high concentration of nutrients, this bio-fertilizer (final product) has a value around 300 US$ per ton. A 300,000 T/year mill can produce around 3,000 T/year of this dry bio-fertilizer.

The system implemented allows:

- Zero discharge to the watercourse
- Energy self-sufficiency with the biogas generated
- The production of large amounts of nutrients-concentrated dry bio-fertilizer(5-4-13-3-3-3)

Marketing of this dry bio-fertilizer is an attractive option for mills which have no or little associated plantations. The 50% humus content, basically in the form of fulvic acids, adds value for the bio-fertilizer, especially when used for horticultural and fruit crops. The bio-fertilizer form (powder, pellet) and solubility (yes/no) is a technological choice based on the specific market and end-user.

The bio-fertilizer has also the advantage to be produced with renewable energy, and additionally allows reduction Greenhouse Gases (N_2O) generated by the chemical nitrogen fertilization. This POME management system reduces substantially the carbon footprint of the palm oil business.

Thanks to the market value of the (digested) dry bio-fertilizer, and despite the CIP requirements for the evaporation stage, the return on investment is usually lower than 7 years, with three big added-values:

- no more effluent discharge → no more investments for additional DOE requests in the future
- organic fertilization of the plantation (or high-value organic fertilizer marketing)
- strong reduction of the palm oil business carbon footprint

CONCLUSIONS

Both systems (liquid fertilization and bio-evapo-drying) can replace ETPs and <u>complement</u> the (already traditional) biogas plants to reach GHG capture and zero POME discharge, with the advantage that biofertilizer value exceeds O&M costs and that organic fertilization can restore soil fertility and ensure business sustainability.

> Note: <u>Other</u> two ZERO DISCHARGE solutions have recently been put on the market by SSP and BIOTEC in India and S-E Asia: to evaporate crude POME instead of biodigested POME, producing animal feed or mixing the POME concentrate (slurry) with EFB for co-composting.
> These two other Zero Liquid Discharge options will be debated in another article.

This is a key breakthrough for a sector where average yields (FFB and oil) have been capped for nearly 40 years, despite giant genetic improvements, and which is worldwide (but unfairly) seen for its negative environmental impacts.

Due to its sectorial leadership and its stronger environmental regulations, Malaysia has the opportunity to be the leader of that agricultural revolution. It is definitively a suitable direction for the Malaysian palm oil business. It will require the involvement of DOE, MPOB and Ministry of Agriculture regarding the concept and technologies for organic fertilization (liquid or solid).

The agricultural engineering must definitively be part of the environmental solution for the agroindustry and give tools for business sustainability.

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