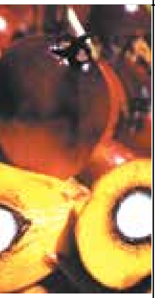

Palm Oil Mill Odour Emission

Andrew Yap Kian Chung*

ABSTRACT

Anaerobic treatment of palm oil mill effluent (POME) emits various odorous chemicals. Thus, Department of Environment under the jurisdiction of the Air Division has proposed odour limit of 12 000 OU m^{-3} for palm oil mills in the draft odour regulation recently. Three mills with differing effluent treatment systems were selected to carry out the odour study in order to validate the proposal. Field survey results showed that the odour emission sources in all mills exceeded the proposed odour limits However, in-field odour concentrations in treatment plant areas are well below the limit. Mill with digester tank has lowest in-field odour concentrations in treatment plant areas compared to mill with covered lagoon while open ponding has the highest readings.

INTRODUCTION

Palm oil mills effluent (POME) has high biological oxygen demand and need to be treated *via* fermentation processes before the POME is allowed to be discharged according to the environmental regulations (Ma, 2000). The fermentation processes especially anaerobic fermentation that interacts to produce unpleasant smell involve many complexes psychological and socio-economic factors. The odour exposure can lead to adverse matter as shown in *Figure 1* (IAQM, 2014).

Thus, regulation to address the industrial odour emission issue is inevitable. Department of Environment under the jurisdiction of the Air Division has proposed odour limit of 12 000 OU m^{-3} for palm oil mills in the draft odour regulation recently. Nurashikin *et al*. (2015) found that the ambient sources emit 7500 OU m^{-3} at sludge storage area, 3330 OU m^{-3} to 7500 OU m^{-3} at the processing area and 600 OU m^{-3} at the mill boundary during their preliminary study using an in-field olfactometer at a palm oil mill located in Penang. In order to validate the proposal, three mills with different effluent treatment systems which are open ponding, covered lagoon and digester tank were selected to carry out the odour study involving laboratory analysis

* *Malaysian Palm Oil Board (MPOB),*
6, Persiaran Institusi, Bandar Baru Bangi,
43000 Kajang, Selangor, Malaysia.
E-mail: andrew@mpob.gov.my

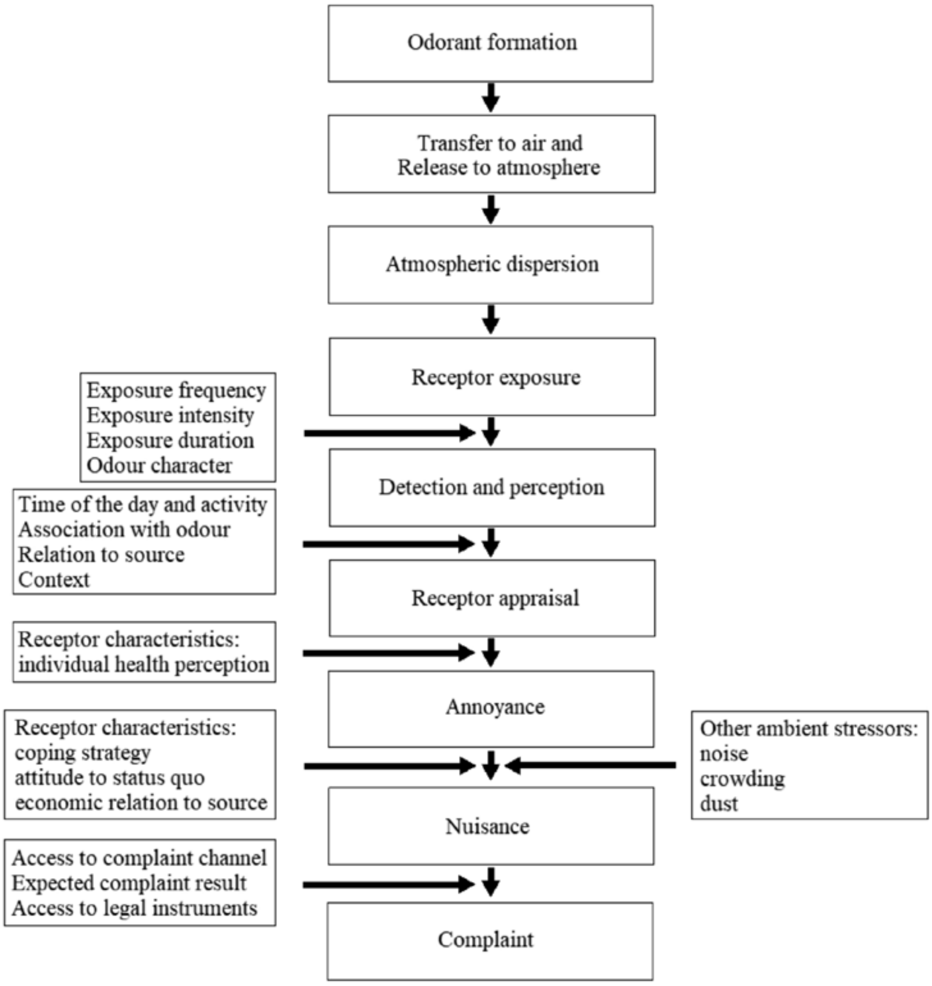

Figure 1. Common human reaction against odour disturbance.

of samples collected at the cooling ponds and ambient odour assessment within the effluent treatment plant.

Odour unit is amount of odourant(s) when evaporated into 1 m^3 of neutral gas at standard conditions, elicits a physiological response equivalent to that elicited by one European Reference Odour Mass (EROM) which is equivalent to 123 μg *n*-butanol, evaporated in one cubic meter of neutral gas at standard conditions as defined in EN 13725:2003.

Effluent ponds are the odour source in palm oil mill. The odour strength is attributed to the micro-organisms' activity to reduce the BOD level. Thus the odorous chemical compounds generation is uncontrollable. Effort is required to prevent such odorant to reach public sensory and stimulates the human olfactory system to perceive the odour. The objective of this study is to identify feasible preliminary effort to address the odour issue in palm oil mills.

ODOUR DISPERSION MODEL

Odourous chemical compounds generated from odour source such as hydrogen sulfide (H_2S), ammonia (NH_3), *etc*. need to be dispersed into atmosphere before they could be detected by human olfactory receptor. Odour emission sources can be classified into point sources such as stack, vent or exhaust; surface sources originated from extended solid or liquid surfaces; and volume sources typically from building ventilation ducts, doors, windows or other opening (Capelli *et al*., 2013).

Meteorological situations are classified in individual wind directions, the corresponding wind speed and dispersion classes. All odour dispersion models are based on Navier-Stokes equation as shown in equation (1) where *u* is the fluid velocity vector, *P* is the fluid pressure, *ρ* is the fluid density, *v* is the kinematics viscosity, ∇ is gradient differential operator and ∇^2 is the Laplacian operator (William Hosch, 2016).

$$\frac{\delta u}{\delta t} + u \bullet \nabla u = -\frac{\nabla P}{p} + v \nabla^{2} u$$

The model equation solution provides a generally valid description of the flow either under radically simplified boundary condition such as Gauss models or using numerical method such as Euler models and Lagrange models (Peter Boeker *et al*., 2000).

Odour dispersion modeling is a computer simulation used to calculate the odour dispersion in the atmosphere and predict the odour concentration at ground level based on the inputs of emission rates for point sources [OU s^{-1}] and area sources [OU $s^{-1}m^{-2}$], source characteristics, land topography, meteorological data and background odours. Steady state Gaussian plume model is the most common model used to describe a simplistic dispersion process. Advanced models take into account diffusion and dispersion using fundamental properties of the atmosphere to suit difficult situations such as long-distance transport. However, community reports usually outweigh the model.

METHODOLOGY

The odour sampling and assessment was performed according to MS 1963: 2007: Air Quality – determination of odor concentration by dynamic olfactometry. The odour samples at the cooling pond are collected into 10 litre Nalophan bag using flux hood and vacuum chamber then sent to the odor for dynamic olfactometry analysis within 30 hr after collection as shown in *Figure 2*.

The in-field odour assessment followed that of Andrew Balch *et al*. (2015) and Ardevan Bakhtari and Medina (2016) which were enhanced procedures adapted from the VDI3940 Grid Method (2006). The assessment involved the determination of odour intensity, odour concentration and odour characters (descriptors).

Odour intensity was recorded every 10 s for 10 min to a scale of 0 to 6 following UK Environment Agency (2007) guideline as described in *Table 1*. Predominant odour characters and source of emission were also noted for each location when odour intensity of 2 (weak) and above was observed. The odour descriptor of UK Environment Agency (2007) was referred to as a guide. The *in-situ* odour concentration was determined using an in-field olfactometer (SM 100 Scentroid Olfactometer, Canada), with detection limit of 3.5 OU m^{-3} – 11, 355 OU m^{-3} as shown in *Figure 3*.

RESULTS

Field evaluation showed that the odour source emission in all project sites exceeded the proposed odour limit as shown in *Figure 4a*. The in-field odour assessment showed that the odour is pungent like urine and rotten egg. The digester tank treatment site with odour intensity level 1 to 2 recorded the lowest odour concentrations below 10 OU m^{-3}, followed by covered lagoon treatment site and open ponding site with odour intensity level 3 to 4 having highest odour concentration below 5000 OU m^{-3}, (Figure 4b).

Odour strength difference between the emission source and in-field inspection is due to the transmission losses. The low in-field odour concentrations in treatment plant areas compared to the odour concentration of samples collected from cooling ponds shows that those odorous gases are heavy and unable to travel far in the air. Theoretically, the in-field odour strength should proportional to the source odour strength. The low correlation between the source and in-field odour measurements as shown in *Figure 5* is due to various factors

Figure 2. Site odour sampling and SS400 scentroid dynamic olfactometer.

TABLE 1. DESCRIPTIONS OF THE ODOUR INTENSITY LEVELS AND ITS CORRESPONDING STRENGTH

Intensity level	Odour strength	Description
0	No odour	No odour
1	Very weak	There is probably some doubt as to whether the odour is actually present
2	Weak	The odour is present but cannot be described using precise words or terms
3	Distinct	The odour character is barely recognisable
4	Strong	The odour character is easily recognisable
5	Very strong	The odour is offensive. Exposure to this level would be considered undesirable
6	Extremely strong	The odour is offensive. An instinctive reaction would be to mitigate against further exposure

such as wind blow and the POME treatment plant design. Mill with digester tank has lowest in-field odour concentrations in treatment plant areas compared to mill with covered lagoon while open ponding has the highest readings.

DISCUSSION

Odour measurement is essential for odour regulation and control (Ueno *et al*., 2009) but technical odour measurement instrument is still unavailable at present. Odour inspection is determined by panelists using olfactometer where the odour samples are diluted systematically and the perceptibility threshold is established.

The nature of odour is complex. In a multi components mixture, individual odour components can mutually reinforce, weaken or mask each other. Thus, compounds combination creates different odours than the individual odours at the similar concentration and superpose the odour strength of several components with known odour strength.

There are four common methods to overcome the odour problem. Masking involves the use of high intensity pleasant scent vapour whereas neutralisation involves the use of suitable chemical to react with the odorous gases. Elimination removes the odorous gases source and quarantine collects the odorous gases into container. Masking and neutralisation method are suitable for small enclosed area but impractical for wide open palm oil mills. Biogas capture practice *via* covered lagoon and digester tank could solve the odour matter *via* quarantine. Research effort

Figure 3. In-situ odour assessment using SM 100 scentroid olfactometer.

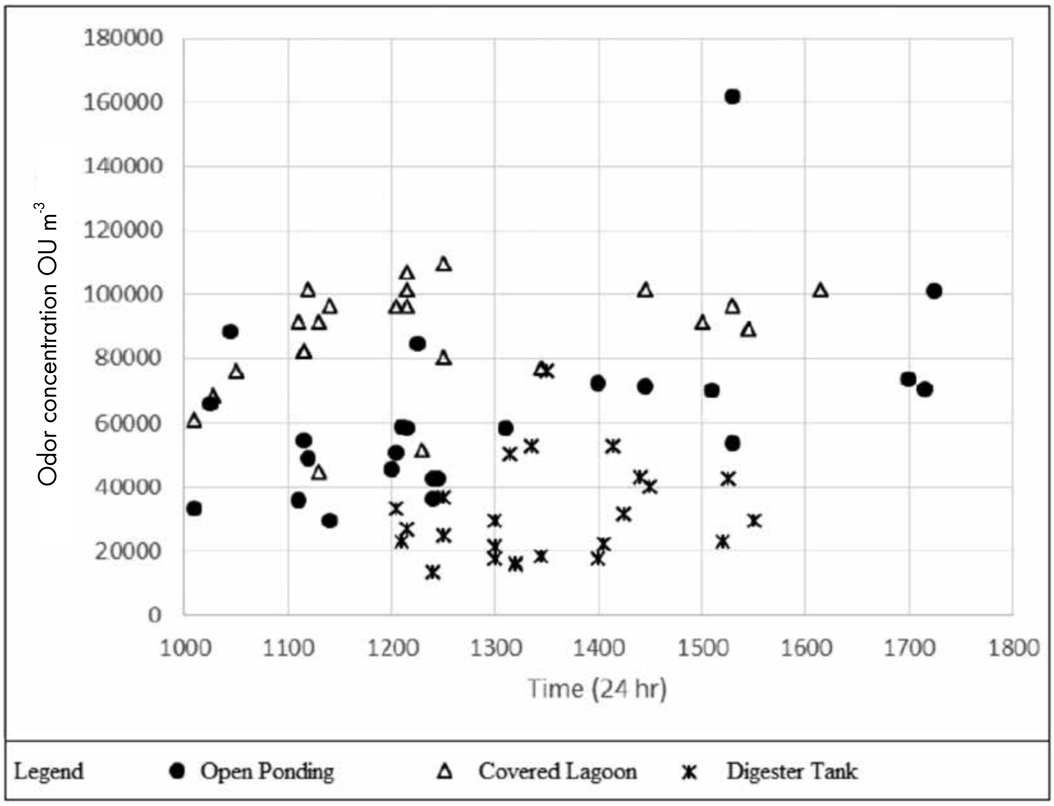

Figure 4a. Odour concentration distribution (at source) for all the project sites.

toward zero discharge milling process would solve the odour matter *via* elimination.

CONCLUSION

The POME treatment plant is the main odour emission source and the odour concentration exceeded 12 000 OU m^{-3} but in-field odour concentration at the treatment plants are well below the proposed limits. Survey results show that biogas capture is able to reduce the community complaint regarding the unpleasant odour issue *via* quarantine.

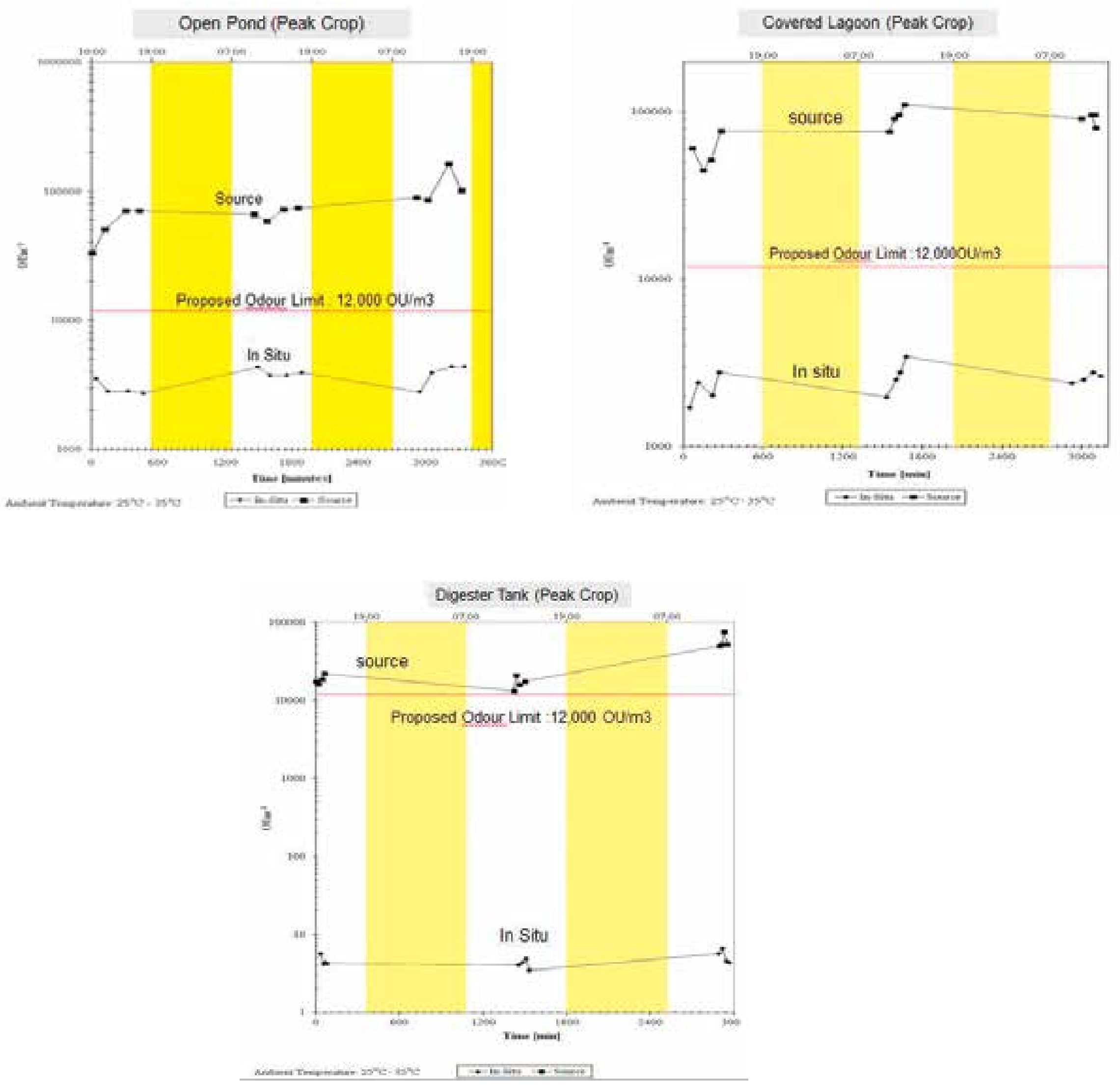

Figure 4b: Odour concentration (at source & in situ*) for all the project sites.*

REFERENCES

Andrew Balch; Gary Graham and Bianca Knaggs (2015). *FIDOL Factors, Odor Nuisance And Risk: The Adaptation Of Field Based Odor Assessments Using A Field Olfactometer. A Discussion and Case Study. Proc. of CASANZ2015 Conference.* Melbourne, 20-23 September 2015.

Ardevan Bakhtari and Sidarta Medina (2016). *Enhancing VDI3940 Grid Method via In-Field Olfactometry to Obtain Complete Odor Impact Assessment. Chemical Engineering Transactions, Issue 54.*

Capelli, L; Sironi, S and Del Rosso, R (2013). *Review Odor Sampling: Techniques and Strategies for the Estimation of Odor Emission Rates from Different Source Types.* Sensors. *13,* 938-955.

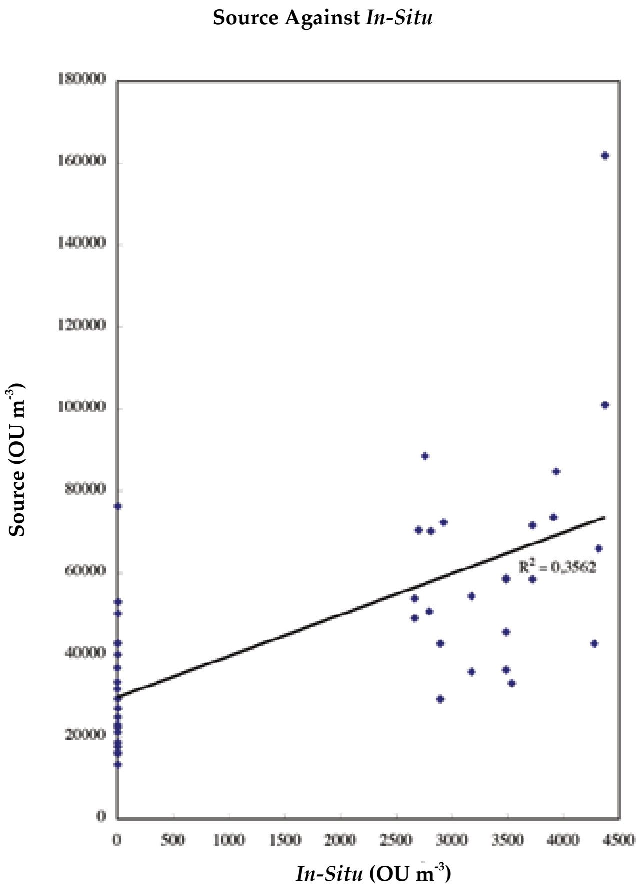

Figure 5. Correlation between Source and in-situ Odour Measurements.

IAQM (2014). *Guidance on the assessment of odour for planning*. London: Institution of Environmental Sciences. http://www.iaqm.co.uk.

Ma Ah Ngan (2000). *Management of Palm Oil Industrial Effluent. Advances in Oil Palm Research. Vol II.* MPOB, Bangi.

Nurashikin Yaacof; Nastaein Qamaruz Zaman and Yusri Yusop (2015). *Odour Intensity Assessment at Different Area of a Palm Oil Mill Using Olfactometry Method. Applied Mechanics and Materials Vol. 802 (2015)* Trans Tech Publications, Switzerland pp 472-477.

Peter Boeker; Oliver Wallenfang; Frank Koster; Roberto Croce; Bernd Diekmann; Michael Griebel and Peter Schulze Lammers (2000). *The Modelling of Odour Dispersion with Time-Resolved Models. Agrartechnische Forschung 6 (2000)* Heft 4, S. E 84-E 89.

Ueno, H; Amano, S; Merecka, B and Kośmider, J (2009). Difference in the odor concentrations measured by the triangle odor bag method and dynamic olfactometry. *Water Science & Technology. 59 (7)*: 1339-1342.

William L Hosch (2016). *Navier-Stokes equation*, Encyclopædia Britannica, Inc, Chicago.