THE ESTABLISHMENT OF SETBACK DISTANCE FOR MALODOUR MITIGATION FROM PALM OIL MILL

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by

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TABLE OF CONTENTS

CHAPTER THREE: METHODOLOGY

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

UOP	United Oil Palm
USM	Universiti Sains Malaysia
POME	Palm Oil Mill Effluent
FFB	Fresh Fruit Bunch
DOE	Department of Environmental
ODT	Odour Detection Threshold
FIDOL	Frequency, Intensity, Duration, Offensiveness, Location
TLV	Threshold Limit Value
SRB	Sulphate Reducing Bacteria
PPM	Particle Particulate Matter
LRT	Long Range Transport
CALPUFF	California Puff Model
EPA	Environmental Protection Agency
MM5	Mesoscale Model
INT	Internal
EXT	External
OU	Odour Unit

LIST OF SYMBOLS

Q	Pollutant mass emission rate
U	Speed
x,y,z	Axis along wind, crosswind, vertical distance
H_e	Effective stack height
σ_y	Horizontal dispersion coefficient
σ_z	Vertical dispersion coefficient
Δh	Plume rise
E	Specific odour emission rate
C	Odour concentration
f	Volume of carrier gas per unit time
A	Cross sectional area of flux hood

PENENTUAN JARAK SELAMAT YANG BAGI MENGURANGKAN BAU BUSUK DARI KILANG KELAPA SAWIT

ABSTRAK

Malaysia merupakan antara pengeluar terbesar minyak kelapa sawit. Semasa proses pengeluaran minyak kelapa sawit dijalankan, ianya akan mengeluarkan banyak efluen kilang minyak sawit yang menyumbang kepada masalah bau. Terdapat pelbagai kaedah dalam menguruskan bau busuk antaranya ialah penapis bio tetapi, kos bagi kaedah ini adalah tinggi dan proses penyelenggaraan yang mahal. Oleh kerana itu, salah satu kaedah yang lebih jimat tetapi berkesan ialah menggunakan kaedah jarak selamat. Kajian ini dijalankan bagi menguji keberkesanan tiga kaedah dalam mewujudkan jarak selamat: 1) pemantauan kawasan lapangan dengan menggunakan Olfaktometer, 2) model CALPUFF dan 3) pengiraan model penyebaran Gaussian. Oleh kerana tiada perbandingan penyelidikan yang telah dibuat dalam menggunakan ketiga-tiga kaedah sekali gus, pada akhir kajian ini perbandingan di antara kaedah-kaedah ini dari segi kesesuaian di Malaysia dan juga keberkesanan kaedah tersebut akan dibandingkan. Keputusan menunjukkan bahawa jarak selamat yang sesuai adalah pada 1.3 km dengan menggunakan pemantauan dalam lapangan, 1.2 km dengan menggunakan CALPUFF dan 0.5 km dengan menggunakan pengiraan model penyebaran Gaussian. Daripada ketiga-tiga kaedah, kajian menunjukkan terdapat perbezaan yang besar pada nilai kepekatan bau di kawasan sekeliling dengan nilai tertinggi 385 OU m^{-3} bagi kaedah pemantauan kawasan lapangan, 6.1 OU m^{-3} bagi model penyebaran dan 81 OU m^{-3} bagi pengiraan model penyebaran Gaussian. Perbezaan tersebut adalah disebabkan

kepelbagaian di dalam cara mengendalikan kaedah-kaedah tersebut dan maklumat yang digunakan. Kajian ini boleh membantu di dalam kawalan bau di sekitar kilang kelapa sawit dengan menggunakan kaedah yang paling sesuai dan jarak selamat yang sesuai.

THE ESTABLISHMENT OF SETBACK DISTANCE FOR MALODOUR MITIGATION FROM PALM OIL MILL

ABSTRACT

Malaysia is the largest producer and exporter of palm oil. During the palm oil mill process, it will release an enormous amount of palm oil mill effluent which becomes a major odour problem. There are varieties of methods in managing the malodour such as biofilter, but those methods are expensive and high-maintenance. As the alternative, the setback distance method can be used as this approach is low-cost and effective. This research was carried out to verify the performance of three different setback distance methods: 1) in-field monitoring using Olfactometer, 2) the CALPUFF model and 3) the Gaussian plume model calculation. Since no research has compared the three methods, this study examined the suitability to be used in Malaysia and the effectiveness of the methods. Results show that the proper setback distances were 1.3 km by using in-field monitoring, 1.2 km by using CALPUFF model and 0.5 by using the Gaussian plume model calculation. Research shows that there a huge different in odour concentration value at the surrounding area from those methods with for 385 OU m^{-3} in-field monitoring, 6.1 OU m^{-3} for dispersion model and 81 OU m^{-3} for Gaussian plume model calculation. The differences was cause by the different process in running the method and also the needed data. This research can recommend a proper way to build a setback distance and setback distance value to reduce odour nuisance in the areas around palm oil mills.

CHAPTER ONE

INTRODUCTION

1.1 Odour Nuisance from Palm Oil Mill

Palm oil tree has many uses such as its leaves can be used to make a basket or a roof for a house, but the purpose of palm oil tree is that its fruits can be extracted to produce oil. This palm oil can be used in many ways, for example as frying oil, margarine and cocoa butter. It can also be used to make soap and detergent. Besides Indonesia, Malaysia is one of the world's largest palm oil exporters, amounting to 39 % of world palm oil production and 44 % of world exports (MPOB, 2014). In a global market, palm oil has made an impressive growth over the past four decades (Abdullah and Sulaiman, 2013). Palm oil mills are the industry that has been specified to carry out the palm oil processing where the extracting work of the oil from the fruit bunch was done there.

Despite the positive effect, the palm oil mill industry has always been related to the environmental issues, for example the establishment of the mill is believed to lead to issues of loss of habitats, deforestation, land degradation and also environmental pollution, such as water and air due to the effluent and chemical reaction release from the process (Liew et al., 2015). For example, the mill needs large quantities of water and energy during the production process and released large quantities of the solid waste, wastewater and also air pollution during the manufacturing process (Abdullah and Sulaiman, 2013). Besides that, even the oil palm industry leads to pollution as results from maintaining the plantation by using large quantities of pesticides and herbicides. During oil extraction process, large

quantities of water are used and about 50 % of the water contributes to the palm oil mill effluent (POME) (Abdullah and Sulaiman, 2013). From this, it can be said that the palm oil industry contributes to the environmental degradation both in production and its effluent.

Sterilization and clarification are the two main processes in the palm oil mill. Sterilization is the process used to cook the palm fruit with steam by using sterilizer. The steam will penetrate to the points of attachment of the fruits which is still attached to bunch. While clarification process is the crude oil extracted from palm oil by pressing the palm fruit to remove water and impurities (Rupani and Singh, 2010). These processes generate large amount of steam and hot water which will lead to the polluting of wastewater and also create odour problem to the river pollution, residential area round it and to the passersby (Ehsan and Wahid, 2013). Before it leads to a serious matter, prevention needs to be taken due to these environmental problems that can be caused from the increasing of crude palm oil production.

Over the past 20 years, the techniques that is applied for the POME treatment is mostly biological treatment pond that consists of anaerobic, facultative and aeration pond systems. This type of treatment is usually being called as the pond system or as a stabilization pond. Each of the ponds has its own function and each mill has its own number of ponds according to the design of the mill which the requirement of the waste or wastewater that generate during the process needs to be met. However, since the processes rely solely on microorganisms to break down the pollutants, this biological treatment system needs proper maintenance and monitoring. This is because, the microorganisms need great care to ensure they can do the degradation work effectively, thus suitable environment needs to be conducted in maintaining the microorganism condition (Ahmed et al., 2015).

Besides pond system, Malaysia now has been introduced to the digestive tank system to treat highly concentrated POME wastewater. This system is an alternative as it has more advantages such as the minimal formation of sludge, can avoid the unpleasant odour and the methane gas can be collected and be used as the renewable energy source. But the cost of building and maintaining the tank is expensive, which make the pond system is preferable compared to the tank system. Although the POME is organic, but it is still difficult to decompose it in natural ways and most of it converts the waste into a valuable products such as organic fertilizer and also feed stock (Rupani and Singh, 2010).

Besides the oily characteristics that gave a lot of problems in maintaining POME treatment ponds, it is also common for bad odour problem with total amount of hydrogen sulphide which can have detrimental effects on the environment (Chin et al., 2013). The main sources of the odour mainly from the degradation of the wastes and some of it from the chemical reactions, which happen during the process operation. Odour gases are different in each industry and because of the various mixes of chemical, the smell of each odour is unique and sometimes the source of the offensive odour can be detected just by smelling and the odour is identified. The difficulty in maintaining the problem to ensure less complaint and smooth performance over huge areas has not exactly been figured out yet.

As shown by anaerobic digestion of landfill industries, odour is likely to be caused by anaerobic process (Romain et al., 2013) because the anaerobic process emits hydrogen sulphide (H_2S) and ammonia (NH_3) (Zhou et al., 2013), thus the anaerobic process for POME is likely generated from the anaerobic digestion process.

1.2 Introduction to Odour Generation and its Dispersion Mechanism

Odour pollution is widely recognised as the offensive air pollution due to human activity usually in populated areas. Odours that result directly or indirectly from human activities and that cause an adverse effect are often classified as contaminants and are subject to regulation (Nicell, 2009). Even though odorous substances are not directly toxic or harmful to human health, and their concentration in the air is usually far below the threshold limit value (TLV) fixed by health authorities (Sironi et al., 2007), long term exposure to malodour will induce different effects on human beings. Some studies suggest that the exposure to odours may cause emotional stresses such as states of anxiety, unease, headache or depression with physical symptoms (Capelli et al., 2011).

There are a lot of factors that cause odour generation and its dispersion. Temperature is one of the factors that affecting the air dispersion and the air molecules density. Even a small change in temperature will make a huge different in the atmospheric condition (Lecoq et al., 2016). This is necessary in verify the affect of the temperature toward odour dispersion as the night and day time has a huge different in temperature condition. The odour emission distance will be different during day time and night time because of its different mixing condition with the air. The molecules in hot air will adsorbed the energy in the form of heat and it will move faster compare to the molecules in the cold air. The energy that adsorbed by the molecules will make its air density decrease and tend to be further apart. This will make it less in weight and easily rise up to the atmosphere compare to the cold air which is sinking. The air during night time generally calmer and the emission

molecules usually will disperse forward instead of rise up to the atmosphere and therefore create an emission zone greater than usually occur during the day time.

Different approaches can be used in order to evaluate odour impact whether directly from its source or tracing the source. There are on site measurement, dispersion modelling and survey methods to be chosen that can be run simultaneously or independently depending on the odour situation. Some practitioners believe that prediction tools such as dispersion modelling are less effective compared to real-time tools such as direct sensory assessment or retrospective techniques such as complaints (Bokowa, 2010).

1.3 Setback Distance as Odour Control Technique

Odour regulation to mitigate the odour problem can be built in different ways, such as types of substance or pollutant, odour concentration values and also build safe or buffer distance between the source and the receptors (Bokowa, 2010). Setback distance is one of the easy methods to be applied and selection of a setback distance is important to reduce industrial impact towards community. Setback distance is a distance that separates the source of nuisance from the community around it, but this approach needs a good land planning (Nicolas et al., 2008). An appropriate distance need to be measured to avoid the complaints from the resident around the source if the setback distance is insufficient, but over measurement of the setback distance will restrict the development of the industries (Schauberger et al., 2012).

There are two ways of measuring a suitable setback distance, first is by using experience based which is field inspection and second by using dispersion based