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Odour Assessment Decision Tree for Odour Sampling and Measurement

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Abstract— There are various method in the world to sample and analyze odour. No matter what method or technique that is used, it should be accordingly to the standard. For the new researcher or people involved in order management, they might lack in knowledge on how to use a proper or a suitable technique to assess odour. In Malaysia, there is no specific method of handling the odour problem. Currently in this country is following the European standard, which using the Olfactometer to analyze odour. Since the Olfactometer is expensive for the first time of installation, a cost effective Odour Threshold Test has been developed from Japan was trying to introduce. A new method from Canada called SM100 Olfactometer was also available in the laboratory. Comparisons between those methods are studied and suitability for use are presented. For odour sampling, there are three types of source that need to be considered; point, area and volume. Proper techniques should be done in order to sample at various sources. This paper would guide on sampling method, test procedure and data analysis of some method. This would make sense as the newer can choose their technique based on available instrument and environment condition.

Index Terms— Guideline, Odour Sampling, Odour Measurement

I INTRODUCTION

Each country has their own legislation and regulation on odour emission and permissible standards [1] and [2]. Review paper of odour legislation by [2] had summarized the legislation in Canada, United States, Australia, New Zealand, Europe and Asia. There have been various different legislative responses to the need to protect air quality from being affected by industrial odour emission in industrialized nations [3]. The legislation is important for each country to make sure the citizens are free from unpleasant odour and each industry, farm or factory could control their emission limit.

To fulfill the legislative, odour emission that produced from each source must be measured to ensure it is within the limit. An agreement in techniques for measurement of odour in each country should be achieved before implementation of legislation. Until now, there are no specific guidelines on equipment and techniques used for odour sampling as mentioned by [4]. However, all sampling and measurement of odour would be referred to the European Standard EN 13725:2003, Air quality – Determination of odour concentration by Dynamic Olfactometry [5], the Offensive Odour Control Law Japan [6] or the VDI guideline from Germany [7] as those standards provide information about the odour sampling. The standards describe on dealing with sampling materials and possible sampling method with sampling procedure in order to maintain olfactometry characteristic of the sample as constant as possible from moment of sampling to analysis. The given indications are not enough, thus, leaving much argument on choice of sampling procedure and equipment [4]. In this country, Malaysian Standard MS 1963 [8] that simulates to European Standard EN 13725 is used for the determination of odour concentration.

Odours are a common problem around the world. Therefore, it is not surprising that there are a lot of techniques that used to measure the odour. The purpose of sampling odour is to get information on the typical characteristics of the sources of odour by collecting a suitable volume fraction of the effluent [4]. Before sampling the odour, several characteristics of odour source need to consider. There are geometrical configuration, either point, area or volume source, suitable equipment for that source and duration of sampling storage before analysis. The aim of this study is to provide some information about the technique of odour sampling and measurement, which is illustrated by the decision tree. The decision tree can be used by the engineers, researchers and also interested individuals towards the study.

II. STATIC AND DYNAMIC ODOUR SAMPLING

There are two types of sampling methods, which is static and dynamic [4]. Static sampling provides sample to be in an enclosed suitable container (either canister or a sampling bag) which is connected to the measurement device in a second moment. Example of static sampling is when the odour needs to sample on site and bring to the laboratory for analysis. Usually, the odour sample will be drawn inside a con-

tainer for example Eco-drum and bring to the laboratory and analyze the samples using the Olfactometer [1] or Triangular Odour Bag method [9].

Some technique would directly measure the odour straightly from the emission without collecting the sample. Usually, the technique is implemented by the in-field olfactometer. The in-field olfactometer is an example of dynamic sampling, as the preparation of odour threshold is determined by dilution which directly done by the equipment. Example of in-field olfactometer is the nasal ranger [10] and scentroid, SM 100 [11], which is a new developed in-field olfactometer from Canada. Dynamic sampling has advantages of minimizing the possibility of sample modifications due to adsorption on sampling equipment or chemical reaction between the compounds contained inside the sampling bag. This method provides an air flow to be analyzed and deducted directly from the source to the measurement device.

III. SAMPLING TECHNIQUE

A study by Jiang and Kaye [12] mentioned that there are two different types of emission, which are emitted from point sources and area source. The authors have stated that the emissions of point source are typically from a stack with a know flow rate from a vent of processing building [12]. Meanwhile, the emission from area source is typically a liquid or solid surface of a large area. Another sampling source has discussed by Zara [4], which called a volume source. The volume source is a typically building from which odours come out, through naturally ventilated ducts, as well as throughout windows, doors or other opening [4].

A Odour Sampling at Point Source

During odour sampling at hot emission sources, condensation might occur inside the sampling bag if the odour sample, and the sampling container are at different temperatures [13]. The occurrence of condensation process will affect the odour concentration, by reducing the odour concentration value [13]. This phenomenon usually occurs at the stack of the factories, where the sample emission is hot (> 50^{o}C). To avoid the condensation process, proper sampling equipment should be used, for example the dilution sampler [13]. The dilution sampler operates dynamically, by diluting the odour concentration using odourless gas upon sampling [14].

B Odour Sampling at Area Source

The sampling of odour usually conducted by using the eco-drum [8] or any other sampling equipment for example, vacuum bottle, handy pump or diaphragm pump [6]. Sampling bag, for example the Nalophan bag is inserted inside eco-drum prior start to collect the sample. Nalophan bag is recommended as satisfactory storage material [5] and sample loss during storage is also minimal [12]. After sampling the odour, the sample must be analyzed within 12hours and analyzing more than 30hours should be avoided [15].

C Odour Sampling at Volume Source

Odour sampling of volume sources is typically sampled from odour emitted from the building. The characteristic of the odour emission is challenging as it is difficult to measure a representative of odour concentration. Sampling of ambient odour inside the building can be done by using depression pump or any other equipment that is used to sample at the point source [16]. If the odour emission is collected at the boundary or at environmental, the same odour sampling procedure is conducted which by using the eco-drum or any other odour sampling equipment.

D Problems Related to Odour Sampling

Researchers [15], [17] and [4] have found that there is an effect of using different odour bag materials with respect to the storage time. Bokowa [13] had also advised to evaluate samples as soon as possible, especially for sample collected from sources where hydrogen sulphide is expected to be present. The age of odorous storage inside the sampling bag will affect the odour concentrations as reported by van Harreveld [15]. He had reported that the odour concentration in Nalophan bag remains unchanged 4 to 12 hours after sampling [15]. However, after 30 hours, the odour concentration decays about half of the value at age 4. The researcher also conducted studies of bag material between metal and Nalophan bag. Result shows that odour concentration in metal bag at age 4 hour is significantly lower than Nalophan bag by a factor of 6. The decay in metal bag seems to occur shortly after sampling, approximately between ages 0 to 4 hours. Van Harreveld [15] had also measured the effect of different neutral gas types used for pre-dilution and there is no significant effect on the odour concentration or decay characteristics.

Iwasaki [17] had investigated about the stability of samples (fish meal plant, chocolate plant, incinerator and printing) taken from the site. Six panels were used to examine the samples. From the study, result shows that the odour concentration remains almost the same within 10 days. After that, the odour concentration value starts to decrease. Unfortunately, proper procedure of the study is not available in the paper [17]. In the study conducted by Zarra [4], the results obtained show that the odour concentration determined by dynamic olfactometry in air samples from odorous compound significant decrease in time elapsed especially after having elapsed 30 hours, as required by European standard [5]. The European standard [5] had concluded that storage in Teflon bags is the most stable, while Nalophan bags are less reliable. The highest repeatability and accuracy of the sensors measure was found in that study is when using Teflon bags and carrying out the analysis always at the same elapsed time after the sampling phase and specifically within

14 hours [4].

There is also the possibility of adsorption phenomena during sample storage. Therefore, specific sampling materials are encouraged to be used; for example, using an odourless sampling container and reduce the sampling storage time [4]. This will minimize any interaction between sample gas and the sampling container.

IV. ODOUR MESUREMENT METHOD

There are two types of odour measurement method, which is using sensory (the human nose) or by equipment such as the electronic nose, gas chromatograph and diffusion tube [10]. The sensory method uses numbers of panel in order to obtain the odour concentration value. On the other hand, the equipment odour measurement type requires column or standard in order to get the chemical composition inside the odorous compound. This study is focused about the sensory method because the method is user friendly and sensitivity due to using the human nose.

A Olfactometer

A sensorial technique that used dilution instrument is called the Olfactometer, which presenting the odour at different concentration level. Nowadays the dynamic Olfactometer is widely used and following the European Standard [4] and [5]. It is called dynamic since the sample is diluted and mixing automatically inside the Olfactometer before flowing out through the sniffing port [4]. Generally, the Olfactometer has two standard methods which are "Yes/No method" and "Force-choice" [4],[18] and [19]. For the first method, the panels are required to sniff from a single port and communicate if an odour is detected or not. The odour sample that has been diluted with odourless air or only contains the odourless air will randomly exit from the sniffing port. On the other hand, for the second method, two or more sniffing ports are used. The odour sample is presented at one of the sniffing port and the odourless air at the other port. Therefore, the panel has to compare different samples and choose the port which the odour exist. The differentials of two types of Olfactometers are illustrated in Figure 1 (a) and (b).

The initial set-up for the Olfactometer is approximately $50,000 including all required equipment during the odour assessment [10] and [20]. The maintenance cost also might be expensive because the Olfactometer used other equipments (for example, the flux hood and air supply unit) to be coupled with the Olfactometer upon odour measuring [13].

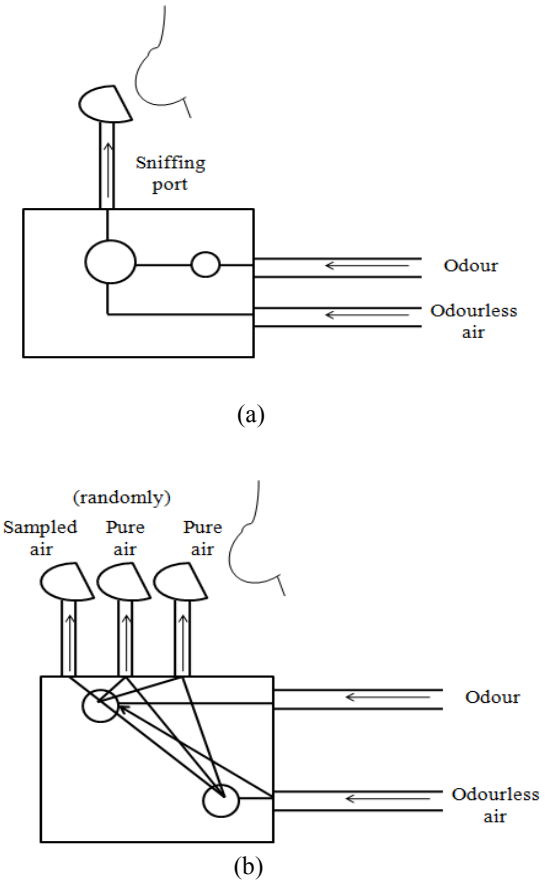

Figure 1: Types of dynamic Olfactometer (a) Yes/No method (b) Force-choice method

B Triangular Odour Bag

In Japan, the Triangular Odour Bag method has been studied and published in 1960 by N.A.Huey [17] using the A.S.T.M syringe method. Unfortunately, at early development, the method had several disadvantages such as small volume of syringe (100 ml), adsorption of odour on syringe surface, long preparation time of the highly diluted sample, occurrence of unnatural feeling when sniffing odour from syringe to nose and influence of preconception of panel members [17]. Therefore, more researched had been done in order to improve the previous method [17] and [21].

In 1972, the Triangular Odour Bag was developed and it was introduced into the Offensive Odour Control Law in 1995 [17], [21] and [22]. To reduce the disadvantages of previous A.S.T.M. syringe method, the Triangular Odour Bag method is introduced by using 3 L of plastic bag instead of using syringe [17]. This method requires three sampling bags per dilution per panels.

Three of the bags are labeled and filled with odourless air. The odour sample is randomly injected into one of the odour bag by using air-tight glass syringe [21].The panels are asked to guess which bags that contained odour. Total of six panels is usually involved in the odour assessment. By this

way, the odour bag eliminates disadvantage of A.S.T.M syringe method of having the bag as the dilution medium and panels are required to choose one out of three bags that contain odour [17].

C Odour Threshold Test

In Malaysia, a new method that simulates to Triangular Odour Bag has been developed as an alternative to the Olfactometer [23]. Odour Threshold Test is an easy and simple odour measurement with lower cost compared to the olfactometer. The difference from previous Triangular Odour Bag method is the material and equipment that available in Malaysia. Panel is selected from local students and technical staff of the university that has difference sensory from Japanese as each person has a different sensory smell. The setup cost of Odour Threshold Test method is approximately $9000 including sampling and odour bags, and equipments that are air-supply unit, air-tight glass syringe and activated carbon. The estimation was based on preliminary experiments [23] in order to develop the odour measurement method.

D In-field Measurement

Field Olfactometer is usually used to determine the odour concentration in the ambient environment. A journal paper conducted by Bokowa [13] mentioned that ambient air odour measurement analysis is not suitable by using dynamic Olfactometer because the presence of a variable odour background in the field may strongly affect panel response. Therefore, field Olfactometer is suitable and effective for the use of an ambient odour. Unfortunately, this method neither has disadvantage because it is often not filled in correctly and the community can easily lose their passion in observing the odour. The cost of the in-field olfactometer is approximately $550 [10].

V. DECISION TREE FOR SAMPLING AND MEASURING ODOUR

Sampling and measuring of odour are done to check the concentration of odour from sources. There are so many techniques that are used around the world, either to sample or measure odour. Even some of the techniques are still under development.

Figure 2 shows the decision tree of sampling and current measuring odour tools, especially the tools that has been highlighted in this study.

Generally, there are two types of analysis; either to carry out the odour measurement on site (in-field analysis) or bring the odour sample to the laboratory for odour measurement analysis. If an assessor requires low budget (< $50,000) of in-field analysis, it is suggested to use the Nasal Ranger since the price is in between $5,000 to $6,000. The Triangular Odour Bag or the new developed method, Odour Threshold Test that is introduced in this research could be applied if the assessors wish to analyse the odour concentration at a lower price. These methods require the simple laboratory procedure, such as air-tight syringe and 18 odour bag for each odour assessment session. The sampling apparatus and sample storage technique are decided according to previous researchers [9] and [24] and also from preliminary experiments conducted [23].

VI. CONCLUSION

Odour can be measured using various methods. Each method has different procedure and equipment. This study highlighted about sensory analysis, which using the human nose to measure odour concentration. There are also equipments for odour measurement method available around the world, however, it is not discussed in the present study. Usually, the odour measurement is done by human olfactometry rather than instrument because the nose is sensitive compared to the instrumental technique. The decision tree that provided in this study can be used for the new venture in this field, especially in Malaysia since there is very lack information and knowledge of odour measurement.

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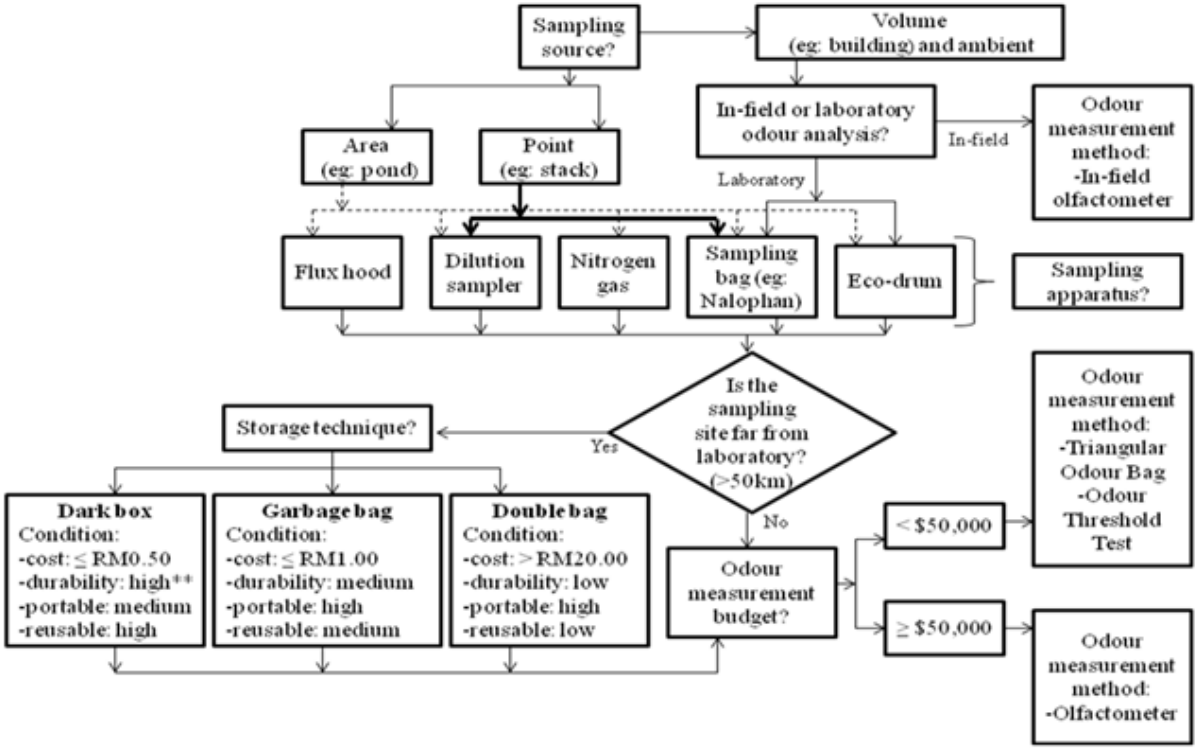

Figure 2: Odour Assessment Decision Tree