



Title	Odour control & legislation for the large offensive smell facilities in Hong Kong
Author(s)	Kwan, Yiu-keung, John.; 關耀強.
Citation	
Issued Date	1996
URL	http://hdl.handle.net/10722/36808
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The University of Hong Kong

**Master of Science
in
Environmental Management**

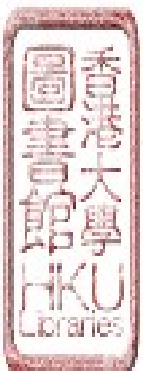
Dissertation Title: Odour Control & Legislation for the Large
Offensive Smell Facilities in Hong Kong

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Date: September 1996



DISCLOSURE STATEMENT

This dissertation is submitted in partial fulfillment of the requirements for the Master of Science Degree in Environmental Management from The University of Hong Kong.

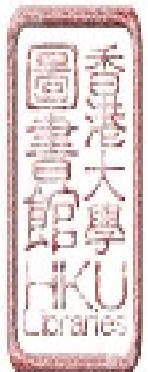
This dissertation represents the author's own work conducted for the purposes of this programme. All significant data or analysis used in this dissertation which draws extensively on other sources -- including work the author has carried-out for purposes other than for this programme -- has clearly been identified as such.

Signed:



Printed Name:

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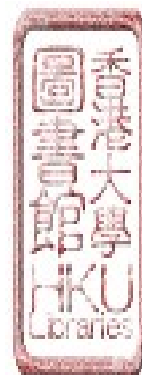


ACKNOWLEDGMENT

I gratefully acknowledge the inspiration given by the many authors from whose publications materials provide for me with the sources of reference.

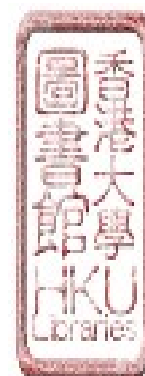
I am also deeply indebted to the many interviewees who had offered me their invaluable views and advice on the topic through the many encounters and conversation.

In particular, I wish to express my most sincere and profound gratitude to my adviser, Dr. D.Y.C. Leung, to whom I owe an inestimable debt for his inspirations, insights and perspicacity comments given to my preparation of this report.

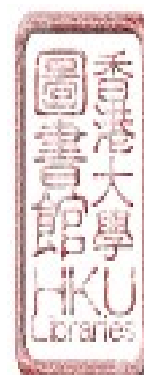


CONTENT

Abstract	1
1. Introduction	2
2. <u>Background</u>	4
2.1 Odour and its Measurement	4
2.11 Human Olfactory System	7
2.12 Odour Threshold	9
2.13 Measurement of Odour	10
2.14 Problem of Odour Nuisance	12
2.15 The effect of odour on health	14
2.2 Principle of Deodourization	15
2.21 Adsorption: Activated Carbon	18
2.22 Absorption: Scrubber	23
2.23 Incineration	25
2.24 Masking	28
2.25 Ozone	29
2.26 Biofiltration	31
3. Objective & Methodology	37
4. <u>A Review of Odour Problems</u>	37
4.1 Odour Problems and its Control in Overseas Countries	37
4.2 Odour Problems and its Control in Hong Kong	49
4.2.1 Abattoir	52
4.2.2 Sewage Works	52
4.2.3 Refuse Transfer Stations	54



4.2.4 Refuse Collection Point	56
4.2.5 Composting Plant	57
5. <u>Legal Aspects</u>	58
5.1 The related legislation and regulations in Hong Kong	58
5.2 The qualitative approach policy	60
5.3 The quantitative approach policy	63
5.4 Requirements to implement the quantitative approach policy	66
6. . Recommendations	68
7 Conclusions	70
8. References	74
9. Appendices	80

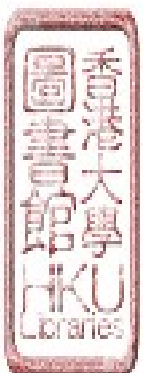


Abstract

The objectives of the work are to identify the odour problem caused by the large offensive smell facilities such as sewage treatment plants, refuse transfer stations, refuse collection points, abattoirs, composting plants and pumping stations; and to review the development of deodourization measures and legislation in the overseas countries. This is also to compare with the ones in Hong Kong.

The approach to the problem is by conducting a survey to collect the data. Questionnaires have been sent to 59 relevant organisations and authorities of overseas countries, and the relevant departments in Hong Kong to gather information on odour control and legislation by them. The main themes of the questionnaire were to: (i) identify the odour problem and the seriousness in different facilities; (ii) find out what kind of measures are being used for odour control; and (iii) obtain information on the legislation related to the control of odour.

In summary of the study, it was learnt that there are various kind of air pollution control equipment (e.g. activated carbon, scrubber, biofilter, and ozone etc.) used for the treatment of odorous gases generated from the offensive smell facilities. The most commonly used equipment in Hong Kong are activated carbon and scrubbers. However, biofilter and ozone are increasingly accepted by many overseas countries. Although biofilter has many advantages such as the low running cost and high odour removal efficiency, more work is still required to reduce the large surface of the biofilter especially for accommodation in the plants of Hong Kong.

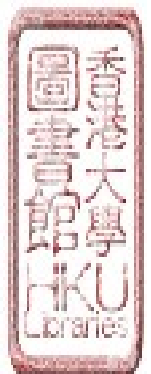


1. Introduction

There are many large offensive smell facilities, such as sewage treatment plants, refuse transfer stations, refuse collection points, abattoirs, composting plants and pumping stations in Hong Kong, which generate odorous gases and cause nuisance to the public. It was shown in the Environmental Hong Kong 1991 that complaining about odour problems constituted over 28% of the total air pollution complaint cases in Hong Kong in 1991. Although not all of these complaints were raised from the large offensive smell facilities, they will highly affect the neighbouring residents as they are proximate to each others.

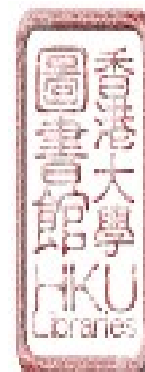
These facilities are usually located in the densely populated areas. For instance the Kennedy Town Abattoir and the Kwai Chung Abattoir are only a few hundred meters apart from the residential areas. It is not an adequate separation, therefore many complaints against odour nuisance were lodged by the public. The odour problem has been long existing and some measures had been adopted to abate the odour nuisance. Scrubber had been fixed to the Kennedy Town Abattoir. Another odour control equipment such as ozonator has been proposed to install in the new abattoir in Sheung Shui.

Although there are deodourization techniques in literature such as ozonation and biofilter, it is not widely used in Hong Kong. There are many kinds of odour control equipment which are claimed to have high odour removal efficiency, however there has not a complete solution to get rid of the annoyance to the public. Once the



offensive facility is there and the odorous nuisance is established, it is not easy to solve the problem by simply retrofit the facilities with the air pollution control equipment. It is because the short distance between the offensive smell facility and the residential area and the increasing environmental awareness of the community. In addition, the complexity of odours' constituents makes it difficult to be treated by air pollution control equipment. Therefore a well planned land uses and proper designed odour control system is recommended. And in the following chapters, a probe into the nature of the odour is needed.

The odour problem can be solved in the planning stage. However, many existing problems can only be solved by retrospective measures. The method for determining or establishing odour nuisance is very controversial. It is because the scent of odour by human beings is subjective. This study shows that the odour problems can be tackled by either qualitative approach or quantitative approach. The qualitative one requires less manpower and straight forward method and without any limitation set by the authority but it is very subjective in performing the assessment of nuisance. Hence in the European countries, it is trying to adopt the quantitative approach policy in abating the odour nuisance. Although it requires sophisticated instrument, accredited laboratory to give reliable measurement of odorous gas, it is still worth for giving a clear picture for the authority and the industries to follow when designing the air pollution standard . This study will also examine the advantages and disadvantages of these two approaches and its feasibility of applying in Hong Kong.



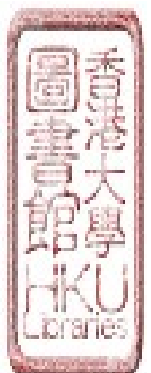
2. Background:

2.1 Odour and its Measurement

In order to have a general idea of the odorous gases, it is to investigate the most commonly known and prevalent odorous gas hydrogen sulfide, H₂S. This gas normally associated with domestic wastewater collection, treatment systems and other offensive smell facilities. It has a characteristic rotten egg odour, and toxic.

The condition leading to H₂S formation generally favour the production of other malodours organic compounds. Investigations of the conditions favouring H₂S formation can also help to quantify the potential for odour generation from other compounds. Thus, solving H₂S odour problems can often solve other odour problems as well.

Many of the substances result from the anaerobic decomposition of organic matter containing sulfur and nitrogen(USEPA, 1985). Inorganic gases produced from decomposition of domestic wastewater commonly include hydrogen sulfide, ammonia, carbon dioxide and methane, of which only hydrogen sulfide and ammonia are malodours. Odour-producing substances include organic vapours such as indoles; skatoles, mercaptans and nitrogen-bearing organics, can also be found in other offensive smell facilities.

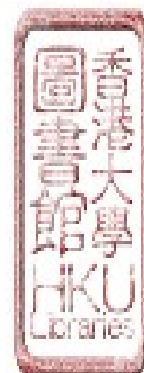


Many of the odours detected in wastewater collection and treatment systems result from the presence of sulfur-bearing compounds. A list of common malodorous sulfur-bearing compounds is shown in Table 2-1. The lower the molecular weight of a compound, the higher the volatility and potential for emission to the atmosphere. Substances of large molecular weight are usually not perceptible and are neither volatile nor soluble. Mercaptans are commonly found in wastewater and are analogous to alcohol with a substitution of sulfur for oxygen in the OH radical. Mercaptans are a reduced form of organic sulfur compounds. They are malodorous and can contribute to odour problems due to their extremely low threshold odour concentration as shown in the table.

Substance	Formula	Characteristic Odor	Odor Threshold ppm	Molecular Weight
Allyl Mercaptan	$\text{CH}_2=\text{CH}-\text{CH}_2-\text{SH}$	Strong garlic-coffee	0.00005	74.15
Amyl Mercaptan	$\text{CH}_3-(\text{CH}_2)_3-\text{CH}_2-\text{SH}$	Unpleasant-putrid	0.0003	104.22
Benzyl Mercaptan	$\text{C}_6\text{H}_5\text{CH}_2-\text{SH}$	Unpleasant-strong	0.00019	124.21
Crotyl Mercaptan	$\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_2-\text{SH}$	Skunk-like	0.000029	90.19
Dimethyl Sulfide	$\text{CH}_3-\text{S}-\text{CH}_3$	Decayed vegetables	0.0001	62.13
Ethyl Mercaptan	$\text{CH}_3\text{CH}_2-\text{SH}$	Decayed cabbage	0.00019	62.10
Hydrogen Sulfide	H_2S	Rotten eggs	0.00047	34.10
Methyl Mercaptan	CH_3SH	Decayed cabbage	0.0011	48.10
Propyl Mercaptan	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{SH}$	Unpleasant	0.000075	76.16
Sulfur Dioxide	SO_2	Pungent, irritating	0.009	64.07
Tert-butyl Mercaptan	$(\text{CH}_3)_3\text{C}-\text{SH}$	Skunk, unpleasant	0.00008	90.10
Thiocresol	$\text{CH}_3-\text{C}_6\text{H}_4-\text{SH}$	Skunk, rancid	0.000062	124.21
Thiophenol	$\text{C}_6\text{H}_5\text{SH}$	Putrid, garlic-like	0.000062	110.18

Table 2.1 Odorous Sulfur Compounds in Wastewater

(Source: USEPA 1985)



Toxicity and Odorous of Hydrogen Sulfide

Besides the characteristic of rotten egg smell even at low concentration, H₂S is an acutely toxic gas which is heavier than air. But as the levels of H₂S increase, workers are generally unaware of its presence. The physiological effects of H₂S are summarized in Fig 2.1. Very low concentrations of this gas can cause serious health hazards and concentrations of 300 ppm (by volume in air) can cause death.

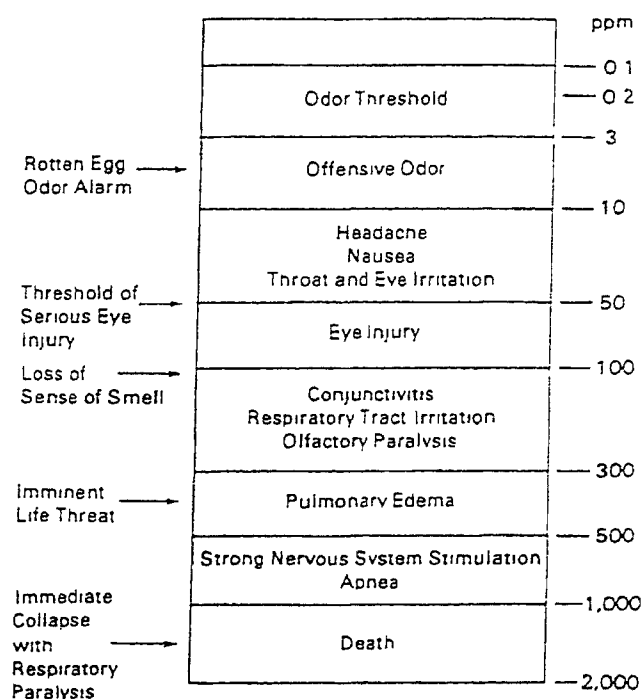


Fig. 2.1 Hydrogen sulfide toxicity spectrum



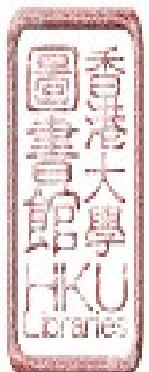
There are several ways to express the concentration limits of toxic gases that a person can be exposed (USEPA,1985):

1. Eight-Hour Time Weighted Average (TWWA): The maximum average concentration to which a worker can be exposed for 8 hours a day, 40 hours a week. This is normally called the threshold limit value (TLV).
2. Ceiling Value: A limit generally not to be exceeded.
3. Acceptable Maximum Peak concentration limit which is not acceptable for specified maximum duration.

2.11 Human Olfactory System

The odour reception system of human is more sensitive in detecting odours than any known instrumental technique (Punter, 1986), and is capable of discriminating among many thousands of odorous substances. The response to an odour is instantaneous, disappearing immediately when the odorant is removed.

The mechanism of the odour reception occurs when air carrying the odorous material travels through the nostrils, along the air passages up into the olfactory cleft (Fig 2.2) where the odour receptors are situated. The olfactory cells, are long and narrow with their length perpendicular to the plane of the nasal cavity and attached to each with olfactory hairs, or flagella, which are believed to be affected by odorous materials, setting off a chain of events which results in the odour being perceived.. The flagella are kept moist normally but when we have a cold or catarrh or due to



changes in humidity or temperature, they are incapacitated and our sense of smell impaired.

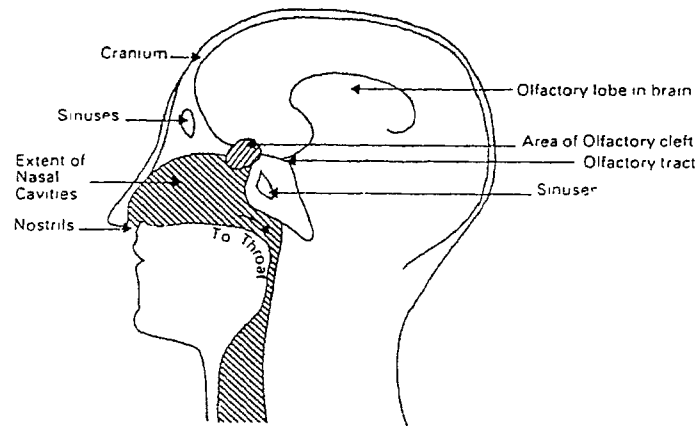
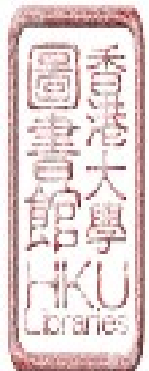


Fig. 2.2 The Human Olfactory System

The olfactory nerves will become fatigue if a person continually inhales odorous air, this is due to the adaptation of the nervous responses to the stimuli. The more concentration the odour, the more quickly fatigue becomes complete, resulting in temporary amnesia.

Moncrieff identified some pre-requisites necessary for the perception of an odour. Firstly, the substance to be odorous must have a measure of volatility, so that it constantly loses molecule. The substance which are non-volatile in room temperature, such as metal, glass are non-odorous. Secondly, it must be capable of being adsorbed, that is the molecules be attached to the surface of the olfactory receptors. Mercaptans and amines are readily adsorbed hence tend to odorous however, the gases methane, carbon monoxide are not therefore they are non-odorous. Incapable of detecting odour can be detrimental, as the human nose is unable to provide a warning of the present of the toxic gas.

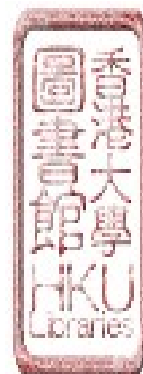


2.12 Odour Threshold

The threshold of odour is the minimum quantity of energy required to cause stimulation in a receptor system (Summer, 1971). Each quality of odour has its own specific threshold. The odour threshold is the level at which the odour panel response of 50% is obtained. Odour is measured in odour unit. Odour unit is not expressed as concentrations (ppm, or mg/m^3) but as having an odour intensity level which is defined in ASTM method of test D1292. For example the odour unit is the value representing the number of times the odour needed to be diluted to 1/32 nd of its concentration ($32 = 2^5$) to reach its threshold, then the odour intensity index OIL equals to 5.

There is no direct relationship between the odour concentration and the odour annoyance. Also, there is a great difference between the detection and recognition thresholds (Hesketh, 1989). For example in low concentration of hydrogen sulfide, say at threshold level of 0.00047 ppm, a sensitive nose can detect the presence of an odour but does not recognize it. It may be described as smelling like chocolate.

Appendix 1 lists typical odour recognition thresholds and odour descriptions at the recognition levels.

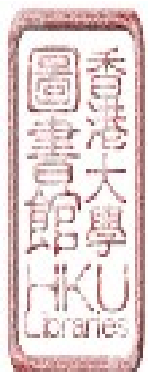


2.13 Measurement of Odour

The human sense of smell, cannot be matched by any presently known instruments as far as sensitivity to most malodours is concerned. Nor can instruments measure the degree of unpleasantness of an individual compound. Therefore people describe the degree of unpleasantness in a very subjective way and is difficult to compare. The measurement of odour is by olfactometer and odour panel. (EPA Victoria)

The odour panel

The basic principle of this method of odour assessment is that a sample of odorous gas is diluted with odour-free air in various concentrations until the number of dilutions required for the odour to be just perceptible by half the members of an odour panel is determined. The sample is diluted by either the static or dynamic dilution method. The odour assessment by an individual is a purely subjective matter. In order to achieve the necessary objective it is usual to employ an odour panel of four to six persons.



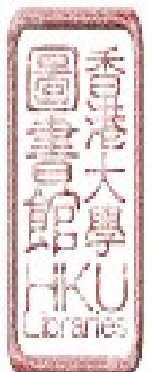
Static Dilution

In static dilution, the panel enter a room with introduction of odour and dilution of concentration. This method is the least subject to error but is very slow, because purging is needed every time prior to introduce a diluted odour into the room.

Dynamic Dilution

Controlled flows of sample gas and odour-free air are combined to achieve dynamic dilution of the odour. Numerous types of apparatus have been developed and tested and vary from those which introduce the diluted malodorant to an individual, to that which introduces it to several members of a panel simultaneously. Several olfactometers have been found to give inaccurate and inconsistent results due to factors such as low flow rate allowing dilution at the panelist's nose and the use of materials that allow adsorption losses.

In order to overcome the various shortcomings of olfactometers on the market, some portable olfactometer has been developed, which is known as Dynamic Dilution Apparatus. The instrument, developed by Warren Spring Laboratory (Bedborough, 1979), is capable of measuring dilutions from 25-250,000.



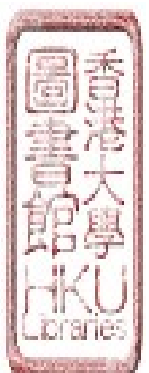
In the process of samples collection a large Tedlar bag, made of polyvinyl chloride film and having a low adsorption tendency, is used. It is then placed in a rigid container in which vacuum is created and causing the inner bag to inflate and the sample is collected through a sample line of PTEE materials. Hot wet samples may cause condensation in the bag, therefore pre-filling the bag with clean dry air is sometimes necessary.

The odour level is defined as the ratio of the volume which the sample would occupy when diluted to the odour threshold to the volume of the sample. The odour level is expressed in odour unit and is analogous to concentration (EPA, Victoria). Sampling apparatus, dilution system and the testing panel are shown in the Appendix 2.

2.14 Problem of Odour Nuisance

Nuisance is a word used casually in many ways, but in the legal sense it has a definite meanings i.e. infringement of the right to use and enjoy land by a party against another party (Punter, 1986). However, nuisance by odour or annoyance cannot be easily quantified.

In the section of the Technical Memorandum of Air Pollution Control Ordinance, nuisance can be assessed under some criteria or guidelines. When determining whether the emission of any air pollutant from the source has cause a



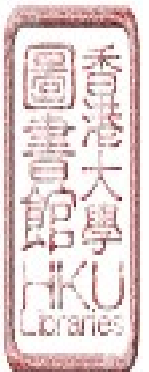
nuisance, the authority is based on the duration, frequency of emission, the relative location etc. The details on the policy of the odour nuisance will be discussed in later chapter.

Experiment has been done (Punter, 1986) on the relationship between the odour concentration and odour annoyance. The results indicated that there was no direct relationship between concentration of an odour and the amount of odour annoyance it caused. However, the human nose responding to the perceived odour intensity can be expressed by Weber-Fechner Law (Bedborough, 1979).

Odour Complaints

Complaints against odour nuisance seems increased steadily (Environment Hong Kong, 1992). There are many reasons for this, for instance, housing is being built much nearer to the plant's boundary than ever before. And above all, public expectations of the environment of the people in Hong Kong have changed when comparing with the one in a decade or even a few years before.

In handling odour nuisance the authority tends to be in an inactive way. They are seldomly controlled in a preventive aspects. The odour problems tend to follow a common pattern: (1) complaints begin, increase in frequency and the local authority becomes involved; (2) environmental officer makes a first inspection; (3) initial measures make the problem go underground for a while; (4) complaints start again; (5) resident association is formed, and complains to the director of the company or



the authority; (6) an abatement notice is issued and (7) remedial works are undertaken in a great hurry and under pressure.

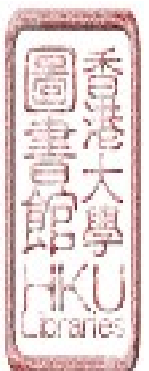
A decade before, the deodourization works seemed to be done retrospectively. They are the results of the odour complaints or the pressure of the community. Nowadays the assessment on the large offensive smell facilities are all involved odour assessments in the Environmental Impact Assessments, EIAs (HKG, DSD, 1992 & HKG EPD, 1994).

2.15 The effect of odour on health

Odours produce a wide variety of emotional and physical effects, unpleasant odours give rise to unfavourable reactions which can, at the very least, cause much unhappiness for the receptors.

There is no doubt that odours do pose a problem for environmental health but to what extent they affect the health of an individual exposed to an odour is difficult to say with precision.

Odours are very subjective in nature and affect people in different ways. Various common reactions which are associated with exposure to odours include physiological, toxic, psychological, annoyance and social reactions, many people experiencing more than one reaction at the same time (Artis, 1984).



The World Health Organisation's viewpoint is that health is more than the absence of disease or infirmity. It is "a state of complete, physical, mental and social well-being" (WHO, 1968). If this is accepted then odours that destroy the enjoyment of food and home, are prejudicial to health thus adequate legal measures have to be made to ensure their control.

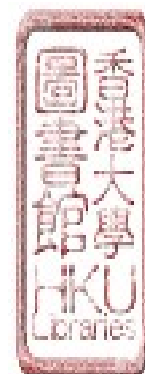
2.2 Principle of Deodourization

Odour Control measures

The successful resolution of odour elimination and complaints requires a careful analysis of the problem. A suggested strategy to control the odour is as follows:

1. Identification of the sources of odour
2. Identification of the chemical composition of the odour
3. Quantification of the intensity and determination of the degree of control that must be achieved to eliminate or reduce complaints
4. Selection of a method of controlling the odours.

Identification of the odour source may be simple in a small plant. A large treatment complex such as the waste water treatment plant may have numerous odour sources. General sources of odours from the odour causing industry are listed in Table 3.1 (Hesketh, 1989).

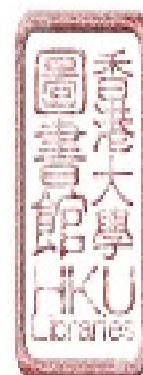


Type of Industry	Principal Type of Odorous Material													
	Hydrogen Sulfide	Mercaptans	Methyl & Dimethyl Sulfide	Ammonia	Sulfur Dioxide	Nitrogen Oxides	Urea	Aldehydes	Fluorides	Phenols	Hydrocarbons	Chlorine Compounds	Acidic Gases	Amines
Kraft Paper Mill	■	■	■											
Petroleum Refinery	■	■		■	■									
Fertilizer				■		■	■	■	■					
Asphalt Saturators					■	■				■	■			
Metal Casting							■			■				
Barrel Mfg/Reconditioning						■					■			
Pesticides										■		■	■	
Print & Varnish											■			
Food & Agriculture	■	■		■				■						■
Landfills & Sewage Treatment	■	■		■										■
Prendering	■	■		■			■				■			■
Transportation					■						■			

Table 3.1 General Sources of Odours from the Odour Causing Industries

(Source: Hesketh 1989)

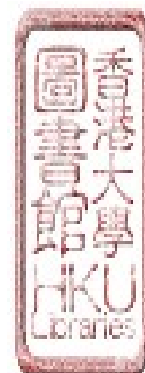
The large offensive plants discussed are abattoirs, sewage treatment plants, screening plants, refuse transfer stations, refuse collection points. The type of odorous materials are hydrogen sulfide, mercaptans, ammonia, urea, hydrocarbons and amines as listed in the table. However, only a careful odour survey combined with dispersion modeling will provide sufficient information to determine the required control strategy since the odour components varies from time to time.



Numerous analysis of odorous gases from a variety of municipal sources have shown the presence of one hundred to two hundred organic molecules. Virtually every family of organic compounds has been found including organic acids, aldehydes, ketones, ethers along with mercaptans, amines and halogenated hydrocarbons.

Control of odour may include oxidation, absorption, adsorption, biological reaction and chemical addition to the sources or process modifications in an effort to prevent anaerobic conditions in the system itself. More commonly, the odour sources should be covered and a ventilation system delivers these off-gases to an odour removal system.

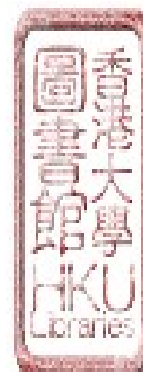
There are numerous odour control systems available, including adsorption, incineration, biofiltrations, and wet scrubbers. Each system has advantages and disadvantages, and only a careful analysis of the problem will help to select an effective odour control equipment.



2.21 Adsorption: Activated Carbon

Activated carbons can be produced from a variety of carbonaceous, raw materials such as wood, coal, peat, nut shells, lignite, bone and petroleum residues. The manufacturing process involves heating slowly in the absence of air to 400-600°C, sometimes with the addition of a dehydrating agent such as zinc chloride or phosphoric acid. Activation is by steam treatment at 750-1000°C, it is a combination of combustion and oxidation resulting in the creation of a fine pore structure and large internal surface area. The non-polar surface of activated carbon making it particularly effective for the adsorption of organic vapours from humid air streams. Some carbons are further treated by impregnation with metals or salts to produce “catalytic” carbons for the adsorption of specific adsorbates. Granular activated carbons typically have surface areas in the range 500-1400 m² g⁻¹ (Dorling, 1978)

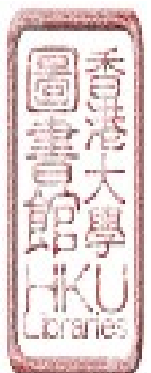
Adsorption is the attraction and accumulation of molecules on the surface of a solid, involves weak forces (physical adsorption) and is usually reversible. Hence, activated carbon is only a storage system for the odorous vapours or gases which it removes, i.e. if regeneration procedures are employed the intensely odorous emission produced must be subjected to thermal or catalytic incineration to destroy the odorous constituents. If the filter are discarded they must be disposed of by dumping or incineration.



The adsorption capacity of activated carbon depends upon:-

- the concentration of adsorption of adsorbate in the space around the adsorbent
- the total surface area of the adsorbent
- the total volume of pores in the adsorbent with diameters small enough to facilitate the condensation of the adsorbed gases
- the temperature
- the presence of other gases which may compete for a place on a adsorbent
- the characteristics of the molecules to be adsorbed, weight, electrical polarity and shape
- the electrical polarity of the adsorbent surface
- the contact time between adsorbate and adsorbent in a dynamic system

The dynamic adsorption can be expressed in graphical terms and a simplified picture of what happens in a static bed of activated carbon is shown in [Fig 3.1](#). For an activated carbon bed of face area $A \text{ cm}^2$ and length $d \text{ cm}$, subjected to air flowrate of $V, \text{ cm}^3 \text{ s}^{-1}$, containing an odorant at a concentration of $C_0, \text{ g cm}^{-3}$, the equilibrium concentration of adsorbate in the vapour phase (XY) progresses through the bed with time. The distance occupied by the wave (XY) is termed the Mass Transfer Zone (MTZ).



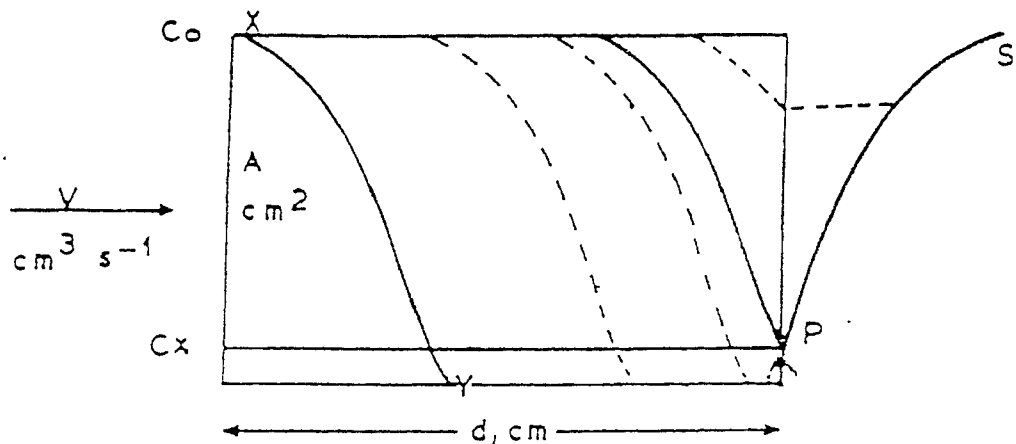
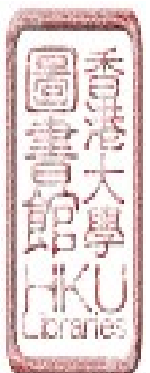


Fig 3.1 Dynamic Adsorption on Activated Carbon

If the maximum tolerable concentration permitted in the treated effluent is C_x , g cm^{-3} (the breakthrough concentration) the point P will eventually be reached when this concentration is attained. The time interval from the start of the operation to this occurrence is termed the Penetration Time, and the amount of odorant adsorbed per unit weight of carbon at this stage is a measure of the Penetration Capacity. In odour control applications these become the most important parameters as they indicate when the carbon requires regeneration or replacement, and when the treated air is likely to cause an odour nuisance.

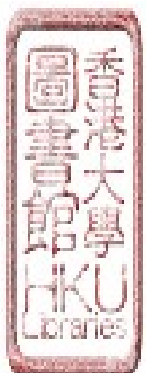
Performance of thin filters at short contact time was done by Dorling. Odour from the animal by-products was examined. The odorous constituents from cooking of animal alcohol, ethanal, hydrogen sulphide, methyl mercaptan and carbonyl sulphide. It was shown that although removal efficiencies was in excess of 90% for



some constituents, the analytical and sensory results concluded that at short time of contact, say 0.5 sec. activated carbon is not efficient for the sustained removal of malodorous organic compounds. Activated carbon with short contact time are not suitable as a primary abatement system for the animal by-products rendering plant.

The efficiency of adsorption of activated carbon filters for the removal of odorant species in air is dependent upon the origin and properties of the carbon, the chemical nature of the odorant and the operating conditions.

The most important operating variable is the contact time which, for any given filter thickness, is inversely proportional to the linear velocity and can be equated to the volume of carbon per unit volume of air to be treated in one second. The value can be adjusted by varying the flowrate or the quantity of carbon. The higher the contact time the better the performance. Practical limitations are the cost and size of the equipment and the increasing air resistance of the filters with increasing thickness. the odour abatement efficiency was never entirely satisfactory for dealing with primary odour emission.

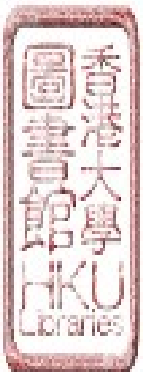


Addition of ozone

The addition of ozone before adsorption can be very beneficial and economic in prolonging the working life of the carbon filter. It is most effective with sulphur-containing compounds at long contact time and high ozone/odorant molecular ratio. Ozone does itself eventually break through the filter and steps should be taken to guard against any toxic effects.

Some Advantages and Disadvantages of Activated Carbon:

ADVANTAGES	DISADVANTAGES
+ High removal efficiency for Low concentration malodour	- Removal efficiency decreases, zero removal after breakthrough point
+ Product recovery possible	- Relatively high operation cost
+ Easy control	- Regeneration problem
+ No chemical disposal problem	- Disposal problem
	- Particulate or humid air will decrease the removal efficiency



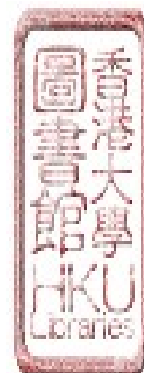
2.22 Absorption: Scrubber

Wet scrubber is a common specified odour control device. There are two approaches to wet scrubbers, one method disperses a small quantity of finely atomized droplets into the gas stream and provides a 15 second to 30 second contact time for exchange of odorous gases to the liquid droplets.

The other method utilizes absorption columns filled with a packing material. The purpose of the packing is to provide a retention time for the liquid, create a large liquid surface area and allow thorough contact between the gas and the liquid. Packing is available in a variety of shapes, sizes and materials.

Packing provides and extends the surface area for the transfer of the gas to the liquid phase. The route for both the gas and liquid increases the retention time between them. Good packing has a large void space, has a large exposed surface area, is lightweight, large exposed surface area. This surface area is required for the transfer of the contaminant from the gas phase into absorbent solution.

Generally, packed absorption columns consist of a vertical cylindrical tower with appropriate supports to hold the packing material, a liquid distributor above the packing to provide even water distribution. Air enters the bottom of the tower and exists at the top after demisting. Water falls counter currently under the influence of

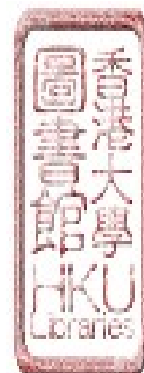


gravity, where the flow is impeded and redistributed as it spreads around, across and through the packing surfaces.

The scrubbing solution falls into a collection tank (sump) where chemical adjustments are made and the solution is re-circulated to the top of the scrubber. The major criteria in the design of the absorption column is selecting the correct chemistry and providing optimum conditions for transfer of the odorous molecules from the air stream to the liquid for removal. The common odorous gases from the waste water such as hydrogen sulfide, mercaptans, amines and many other odours are readily absorbed, and oxidized in a wet scrubber when the re-circulating solution contains the correct chemicals at sufficient a concentration.

Some Advantages and Disadvantages of scrubber:

ADVANTAGES	DISADVANTAGES
+ Constant removal efficiency	- Need to handle chemicals
+ Relatively small space required (compare with biofilter)	- Create waste water disposal problem
+ Able to collect particulate as well (No need of prefilters)	- High operating cost (More mechanical movement parts and chemicals)
+ Fiberglass construction can resist corrosive gas, e.g. H ₂ S	



2.23 Incineration

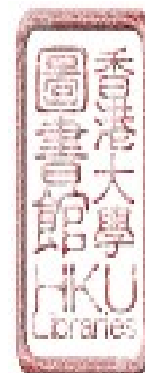
Thermal incineration

Incineration of many gases and vapour can be completely destroyed by rapid oxidation. For example, the incineration of carbonaceous compounds can be destroyed to carbon dioxide, and water vapour. Every hydrocarbon material has a property which we call the auto-ignition temperature. But in practice, a few hundred degree of temperature should be added to it in order to overcome some heat loss

Table 3.2 (Ross, 1975).

Acetone.....	1000	Hydrogen.....	1076
Ammonia	1200	Hydrogen cyanide.....	1000
Benzene	1075	Hydrogen sulfide	500
Butadiene,	840	Kerosene	490
Butyl alcohol	693	Maleic anhydride.....	890
Carbon disulfide	257	Methane	999
Carbon monoxide	1205	Methyl alcohol	578
Chlorobenzene	1245	Dichloromethane	1185
Cresol	1038	Methyl ethyl ketone.....	960
Cyclohexane	514	Mineral spirits.....	475
Dibutyl phthalate	760	Petroleum naphtha	475
Ethyl ether.....	366	Nitrobenzene	924
Methyl ether.....	662	Oleic acid	685
Ethane	950	Phenol	1319
Ethyl acetate	907	Phthalic anhydride	1084
Ethyl alcohol	799	Propane	874
Ethyl benzene	570	Propylene	910
Ethyl chloride.....	965	Styrene	915
Ethylene dichloride	775	Sulfur	450
Ethylene glycol	775	Toluene	1026
Ethylene oxide	804	Turpentine	488
Furfural	739	Vinyl acetate	800
Furfural alcohol	915	Nylene	924
Glycerin	739		

Table 3.2 Autoignition Temperature of Hydrocarbons, °F

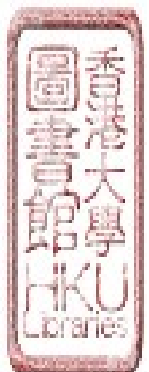


To achieve complete combustion by the thermal destruction of odours, generally, gaseous odour is retained at 1200 to 1500 °F, for 0.3 to 0.5 seconds, and it will be oxidized, providing adequate turbulence and oxygen are present. Some cases, auxiliary supply of oxygen and fuel is required. Therefore additional fuel cost leads to the disadvantage of using incineration for odour control.

There exists advantages by using thermal destruction of odours. It is claimed to be simple, effective, permanent, and will not give rise of secondary effluent problem, a drawback of wet scrubbing but there are disadvantages. Note that incomplete combustion of many odorous materials can produce substances that are even more offensive. Saturated hydrocarbons can burn to aldehydes, alcohols to organic acids, and aromatics to unsaturated compounds which are pungent and irritating. Furthermore, some final combustion products e.g. oxides of sulphur and nitrogen are odorous and will properly require dispersion via a tall chimney. Moreover, another drawback of using incinerator for deodourization is the fuel cost. It is comparatively higher than other methods.

Catalytic Oxidation

A catalyst is a material that causes or accelerates a chemical reaction without itself being permanently affected by the reaction. Common catalyst materials include

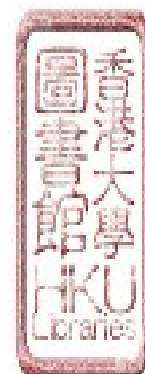


platinum, palladium and vanadium although other materials such as chromium, nickel, manganese and copper are used. Gases before entering the catalyst incinerator should be free of dusts that might cause catalyst loss by abrasion and from other compounds that might impair catalyst activity by coating the catalyst or poisoning it. Catalytic combustion will successfully destroy odours from many processes such as amines, aldehydes. Capital investment will have to be considered carefully as it may be higher than for other comparable processes. Where the catalyst cannot cope with the type of pollution additional treatment is required

Catalytic Materials for the Odours:

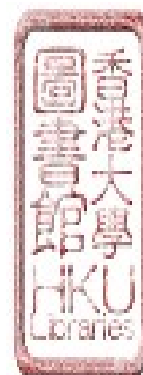
Reactant	Resulting product	Catalyst
Amines	Nitrites	Ag
Aldehydes	Maleic anhydride	V
Mercaptans	Sulphurs	Al ₂ O ₃
		(Activated)

Source (Summer, 1963)



2.24 **Masking**

Odour masking is based on the principle that when two odours are mixed, the stronger one will predominate. Thus, when a sufficient amount of a pleasant odour is mixed with an unpleasant one, the latter will become un-noticeable. However, the solution to an odour problem is complicated because the unpredictable reactions of people to unfamiliar or unusual odours. In controlling odours originating outdoors in such places the odours cannot be contained, the masking compound must vaporize rapidly enough to overcome the unpleasant odour and slowly enough to last for a reasonable length of time. Masking agents are usually organic aromatic compounds, natural or synthetic, such as heliotropin, vanillin, eugenols, benzyl acetate, and phenylethyl alcohol (Cheremisinoff, 1988).



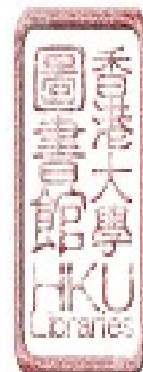
2.25 Ozone

Ozone is a powerful and useful oxidant. It occurs naturally in the upper atmosphere, at heights of 18,300 m to 27,500 m above sea level, in concentrations of 10 to 12 ppm by volume. However, ozone can be formed artificially.

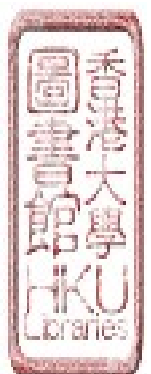
The mechanism of producing ozone is that an oxygen atom O produced by decomposing oxygen molecule O_2 joins together with another oxygen molecule O_2 and become O_3 (ozone) under the energy of certain wavelengths, such as electrical discharging, ultraviolet ray and electrical decomposition of water (Cheremisinoff, 1988), and so on. There are three basic methods of generation ozone:

1. Electrical discharging system
2. Electrical decomposition of water system
3. Plasma resonancing system

Most odours are associated with molecules which have centres of high electron density, such as amines, sulfides, and unsaturated hydrocarbons. Ozone most often reacts chemically, as if it were an electron-deficient molecule. Thus a molecule having a site of excess electrons (i.e., the odours molecule) is attracted to molecule which is deficient in electrons, ozone. The two molecules interact chemically to produce compounds, usually oxides and oxygen, which do not possess any odour.



Cheremisinoff recommended that a time of 3 to 60 seconds must be provided for the ozone, and the exhaust to mix and react. Ideally, ozone is introduced into a plug flow ozone contact chamber having the appropriate contact time. After the oxidation has been completed in the contact chamber, the odourless gas and the reduced ozone, now in the form of oxygen, are exhaust to the atmosphere.

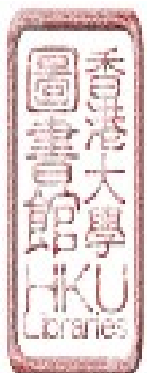


2.26 Biofiltration

Biofilter is a relatively new control equipment used in the treatment of odorous gases contaminated with biologically degradable compounds. In biofiltration, odorous gas is brought in contact with biological active substrate. The odorous compounds from the gas are first adsorbed on the surface of the substrate or adsorbed in the water which is typically present in the substrate. Subsequently, the compounds are biodegraded by a variety of microbiological processes.

The distribution of microbes in the biofilters has been described as being vertically segregated (Neff, 1991). In the lower portions of the biofilter bed, the total microbial population density is the highest. It has been assumed that the microbes at the bottom of the biofilter preferentially metabolize the more readily degradable influent compounds and utilize less of the nutrients in the filter material. Conversely, the less degradable compounds are more readily assimilated in the upper portion of the biofilter.

The typical size of the biofilters are about 100 cm deep and contain packing material. The size of the biofilter was determined by the partition coefficient and the bio-degradation rate (Hodge, 1995). The packing material or carrier substance serve a purpose of providing with the microorganisms with sufficient nutrients. Therefore porous media capable of adsorbing gaseous compounds and supporting biological

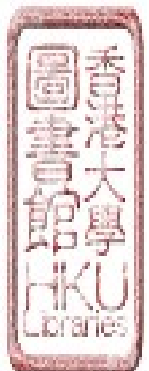


growth substances are used as filter material, such as compost, soil, peat moss granular activated carbon (GAC).

There is insufficient available data on elimination rates of pollutants for various filter media. The removal of odour by biofiltration or the mass transfer rates depends on steps similar to: wet scrubbing (gas/liquid contacting such as absorption) and dry scrubbing (gas/solid contacting such as adsorption). However, the inter-relationship is quite complex and highly specific only limited number of parameter correlation can be found in literature (Allen, 1994). In general, operating conditions such as moisture content, pH, temperature, and nutrient concentrations are the critical factors affecting the process rate but it has not been extensively tested.

A mathematical model was developed that describes basic transport and biological processes for a biofilter (Hodge, 1995). In the modelling, (i) compost, (ii) GAC granular activated carbon, and (iii) a mixture of compost and diatomaceous earth as biofilter packing materials to treat ethanol vapours. While the adsorption capacity of the GAC was substantially reduced by water and microbial growth, it remained highest for the three media. The compost microbial community had a higher degradation rate constant. Carbon provided the best treatment overall.

The biological-treatment processes used in wastewater treatment facilities and contaminated soil treatment plots have proven effective (Hodge, 1995). Most research and development of the technology has occurred in Europe (Allen, 1991 & 1994) & (Leson, 1991). In the US, there was limited application of biofilter (Neff, 1991). The

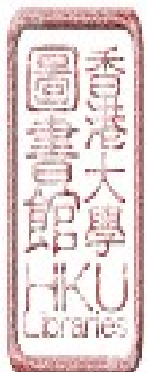


reason was that it was due to the problem of high pressure required for the air distribution in the old system. But after modification of the air distribution design, it will become more popular. Successful applications in Europe include abatement of odours from composting works, wastewater treatment plants, and similar facilities. In the Federal Republic of Germany , about 30 companies and manufacturers are active in the design and construction of biofilters (Koenig, 1990).

Relationship between the particles size of the biofilter and the pressure drop of the filter was examined (Allen, 1994). If the pressure drop increased to 2.5 kPa, the filter bed needs to be repacked or the compost replaced. When water content of the filter was increased, coagulation of small viscous particles was enhanced and the pressure drop increased sharply. However, the rapid built-up in pressure could be suddenly released by channeling, i.e., a breakdown of the overall flow restriction by the formation of a channel of much less resistance caused by a separation of packed materials. It is not desirable because it allows pollutant to exit the system without treatment.

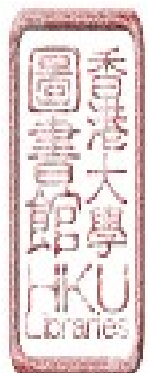
The following lists the operating conditions for the biofilter to treating the H₂S, (Allen, 1994):

1. Temperature: 25 to 50 °C
2. Compost pH: >3.0
3. Compost water content: 50+-15 percent
4. Compost sulfate content: <25 mg-S/g
5. Pollutant retention time: > 15 sec



Recently, biofiltration treatment has expanded to include control of volatile organic compounds (VOCs) and air-toxics emissions from a variety of contaminant sources. Typical control efficiencies for removing VOC (Ray, 1995) ranged from 70 to 86 percent. The control efficiency of ammonia ranged from 78 to 96 percent.

A possible advantage of biofiltration over other air pollution control equipment is in treatment of large volumes of off-gases containing low concentration of easily biodegradable constituents. Current approaches for treating such waste gas streams have disadvantages. Chemical methods such as incineration, chlorination, ozonation, and combustion expensive, requiring elaborate equipment and substantial amounts of addition fuel. Adsorption on activated carbon is also costly, and the saturated carbon may be a hazardous waste, requiring either regeneration or transportation to a hazardous waste landfill. Below lists some advantages and some disadvantages of biofiltration. It is good for the municipal wastewater treatment plant, as the odours usually caused by a mixture of low molecular weight reduced sulfur compounds and various other compounds. The highly odorous reduced sulfur compounds are relatively easily oxidizable into less odorous forms by wet scrubbing. However, wet scrubbing with oxidative reactions is sometimes less effective with other types of odorants (Ostojic, 1989). Therefore activated carbon is sometimes needed to polish the odours remaining after wet scrubbing. Biofiltration was shown to be capable of achieving high odour removal efficiency without a need for several stage of treatment.



Advantages

Disadvantages

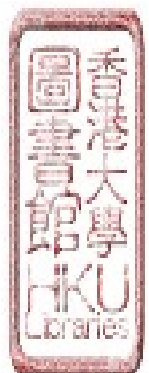
-
- | | |
|--|--|
| <ul style="list-style-type: none">• high odour removal possible
• low capital and operating cost for in-soil biofilters
• low maintenance (primarily for in-soil biofilters)
• versatility in performance (e.g. in comparison with wet scrubbing which offers limited types of reactions) | <ul style="list-style-type: none">• bacteria cultures sensitive to changes in inlet conditions (temperature, composting)
• may require gas conditioning
• space requirements (for in-soil filters)
• potential deterioration of the uniformity of flow distribution |
|--|--|

Advantages and Disadvantages of Biofiltration

Table 3.3

Cost implication of biofilter & compare with other measures

Biofilter technology in general represents the most cost effective means of controlling odours. A comparison of cost data was prepared (Neff, 1991) for several odour control technologies. A comparison basis used air flow rate of 10,000 cfm (cubic feet per minute) with an inlet H₂S concentration of 20 ppm and an outlet concentration of <1ppm. The cost comparison is presented in TABLE 3.4. As seen in



the table, the biofilter is the less expensive system to construct and operate in an annually base.

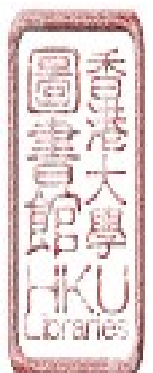
	Deutsckmark per 1000m ³ of air
Incineration	DM 9.1
Chlorine	4.2
Ozone	4.2
Activated Carbon, with generation	1.5
Biofiltration	0.6

Cost of odour removal at a waste water treatment plant in Heidelberg, Germany, by Neff, 1990.

Table 3.4

Tests indicate that the lifetime of the filter media exceeded three months and may well extend to beyond six months.

Research and development work is required to reduce the costs of construction and to find materials to which will not deteriorate quickly. Work is also required to reduce the large surface for the biofilter especially for accommodation in the plants of Hong Kong.

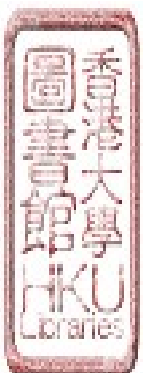


3. Objective & Methodology

This dissertation aims to investigate (i) the nature of odour (ii) the odour problems generated from large offensive smell facilities (iii) the measurement of odour (iv) the deodourization measures (v) the legislation control of the odour nuisance.

The methodology includes the literature search and questionnaire survey. A literature search will give some brief explanation on the deodourization measures and comparison of effectiveness among the odour removal equipment.

Besides, a questionnaire was set and a survey has also been carried out on the study of the odour problem, its measures and regulations adopted by the overseas countries. Information was also gathered from various departments in Hong Kong through questionnaire and interviewing of the relevant persons. Many government departments such as EPD, DSD, USD and RSD have been approached to review the existing problems and measures.



4. A Review of Odour Problems

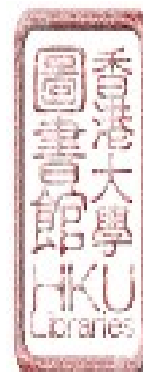
4.1 Odour Problems and its Control in Overseas Countries

One of the objective of this project is to review the development of the deodourization measures and legislation in the overseas countries. This is to compare with the existing one in Hong Kong. The data collection process involved :

- a questionnaire survey on the relevant organisations and authorities of overseas countries;
- a questionnaire survey on the relevant departments in Hong Kong, and interview with the relevant engineers and officers

A questionnaire as shown in Appendix 3 was designed to assist in gathering information on odour control and legislation by overseas countries. The questionnaire has three main themes, first it aimed to identify the odour problem and the seriousness in different facilities. Secondly, it is to find out what kind of measures are being used for odour control. Finally, it is to obtain information on the legislation or code of practice directly related to the control of odour in the facilities.

A total of 59 organisations or authorities in overseas countries were approached. The approached overseas countries include U.S.A, Canada, West Germany, Denmark, Australia, France, Brussel, Singapore, Thailand, Taiwan, etc.



Many of them are government offices, agencies and research centres, (Appendix 9).

Response were received from 16 of them. However, only 9 of them had completed the questionnaire, the list of the responders is shown in Appendix 4 and the completed questionnaires are shown in Appendix 5.

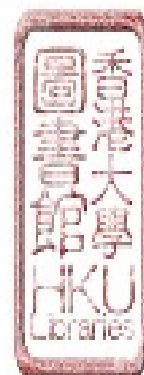
Analysis and summary of the returned questionnaires

The summary of the information provided by these 9 responders was tabulated in Appendix 6. Each responder has adopted various kinds of control measures and there exists legislation/code of practice for the odour control on the offensive smell facilities. They are described as follows:

Responder #1

New York State Department of Environmental Conservation, Division of Water

Information from the New York State Department of Environmental Conservation, Division of Water, was only concerning the sewage treatment plants. They recorded 592 numbers of sewage treatment plants in their state. In which 585 of them were in acceptable odour level. And 7 of them were between moderate and serious odour level. Five plants have adopted the improvement of operation for reducing the odour. Only one plant has equipped with water scrubber to mitigate the problem and the other one has changed it's process to avoid the odour. As seen from these figures, the problem of odour emitting from the sewage treatment plants in this state is not substantial.



As shown in the returned questionnaire that the affected persons were restricted only to the operators and the passers-by, but not the nearby inhabitants. The reasons may be due to the low odour emission or the inhabitant are situated farther away from the plants. The reasons for those plants adopting odour control equipment are: (1) they generated high level of odour, (2) there exists sensitive receivers. As such, the plants with moderate and serious odour problem have adopted some measures such as scrubber and improvement of operation as needed.

No legislation was directly related to the control of the odour level inside or outside the sewage treatment plants, but there is only a general nuisance provisions of local legislation, operation and maintenance conditions of permit to discharge.

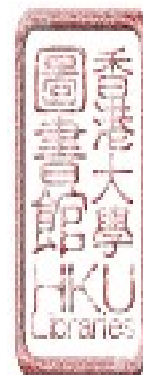
Responder # 2 & 3

New York State Department of Environmental Conservation,

Division of Solid & Hazardous Materials

This division manages the refuse collection stations and the composting plants. They listed out the legislation related to these plants and showed that there are different kinds of control equipment for these processes.

There is legislation directly related to the control of odour level of the refuse transfer plant. As reported by the Division of Hazardous Materials that “New York State’s Environmental Conservation Law states that the Department has the power to

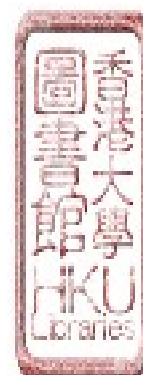


adopt and promulgate, amend and repeal rules and regulations directed at the prevention and reduction of obnoxious odours”. New York State’s Part 360 regulations which govern the operation of transfer stations include a requirement that processing, tipping, sorting, storage and compaction areas must be located within an enclosed building. Furthermore, the regulations state that transfer stations and transfer vehicles must be cleaned to prevent odours. The regulations also state that odours must be effectively controlled so they do not constitute nuisances or hazards to health, safety, or property”.

It is clearly showed that it is a statutory requirement of controlling the odour generated from the refuse transfer station. Of 481 refuse transfer stations, 194 are large ones and there are moderate odour emission from these plants. Hence, mitigation are adopted in the large plants. They employ odour-control utilize perfumed misting agents inside their tipping floor area.

For the composting plants, there is legislation to follow. In the document from, entitled 6NYCRR Part 360, Solid Waste Management Facilities, New York State, there is a requirement of that the facility must be designed and operated to control and odours. (Page 5-3 Section 360-5-3, h).

Subsequent to this regulation, 34 numbers of composting plants which generating moderate odour are equipping with atomizer for spraying into the pile of the compost.

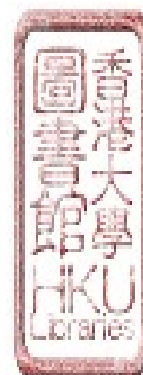


Responder # 4

Florida Department of Environmental Protection

According to the data provided by the Florida Department of Environmental Protection, there are 3475 numbers of sewage treatment plant and 6 numbers of composting plant respectively in Florida. The odour problems affect the operator, the passers-by and the nearby inhabitants. Although, in the questionnaire, they do not indicate which kind of control measures are adopted, it is clear that they should follow stringent rules for new treatment plants and modifications to existing plants. These plants shall be designed and located on the site so as to minimize adverse effects resulting from odours, noise, aerosol drift and lighting. In the rule 62-600 of Florida, they require the plants to avoid causing the above mentioned adverse effect and reasonable assurance may be based on such means as aeration, landscaping, treatment of vented gases, setback distances, chemical additions, prechlorination, ozonation, innovative structure design or other similar techniques and methods. (62-600.400 of Domestic Wastewater Facilities, chapter 62-600, rule of Florida DEP)

Moreover, terms of conditions are imposed in the rule that if the plants no longer function as intended, or no longer safe in terms of public health and safety, or odour adversely affect neighboring developed areas, corrective action shall be taken by them. (62-600.410 of Domestic Wastewater Facilities, chapter 62-600, rule of Florida DEP)



Responder # 5

Perth, Western Australia, Department of Environmental Protection

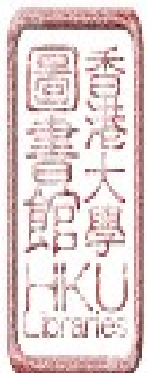
In the response of the Department of Environmental Protection of Perth, Western Australia, there exists no odour problems in the pumping station and the refuse transfer stations. However, the sewage treatment plants and the abattoirs are facing moderate problems of odours. The effective area of odours affecting is about 500 meters to 1000 meters. It is revealed that 10% of the plants have been equipped with control measures. They are scrubber and incinerator/after burner, both in 5%. And there are about 1% of activated carbons.

Code of Practice exists for the abattoirs. However for the other types of plants they are only ensure adequate buffer distances around the plant.

Responder # 6

Texas Natural Resource Conservation

It was seen that there are 2430 sewage treatment plant reported and the odour problem is in moderate but there is serious problem in the composting plant. The method of treating the odour is by the scrubber and various management method such as operation and maintenance, design, and collection system.



It is a need to use odour control equipment if there exist sensitive receptors and also it is a statutory requirement. Similarly, the buffer zone distance is adopted to control the odour emitted from the plant.

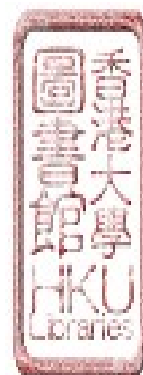
Responder # 7

State of New Jersey, Department of Environmental Protection

The information provided by the State of New Jersey shows that they are facing very serious problem in the sewage treatment plants, and composting plants. Therefore all the composting plants have installed the odour control equipment. But there are only 10% of the sewage treatment plant have installed such equipment.

Other than the commonly used scrubber as the odour control equipment, they also adopted the biofilter and the activated carbon. The percentages of these equipment installed are 60%, 30% and 10% respectively.

Insufficient information was provided on the legislation of the control but it is known that they are required to set the operation limit of the plants in a level of no odours scented beyond the property line.



Responder # 8

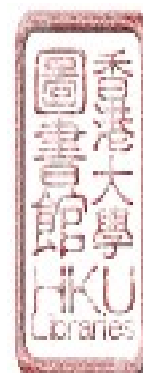
State of Illinois, Environmental Protection Agency

In the State of Illinois, there are about 1400 sewage treatment plant, only 10 of them have moderate odour problem. In which only 4 or 5 sewage treatment plants have odour control equipment. It is in an extremely low proportion. However nearly all of the refuse transfer stations and the composting plants have adopted various kinds of measures, such as the activated carbon, chemicals, and operating control. Setback requirements from receptors are the means to control the odours in a legislative manner.

Responder # 9

Republic of Singapore, Ministry of the Environment

There are altogether 6 numbers of sewage treatment plant and 134 numbers of pumping stations in Singapore. The seriousness of them were classified as moderate. The only one refuse transfer station is in an acceptable level. The affected persons are the passers-by and the nearby inhabitants within the 2.8 ha area coverage. They indicated that all of the sewage treatment plants have only been installed activated carbon as the control equipment for treating the high level of odour emission. And the odour control equipment in all those plants will be upgraded in the future. On the legislation size, 1 km buffer zone imposed around the plants, in which only industrial development are permitted. Plans underway to reduce buffer zone in the long-term.

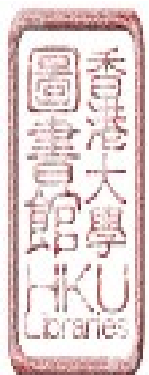


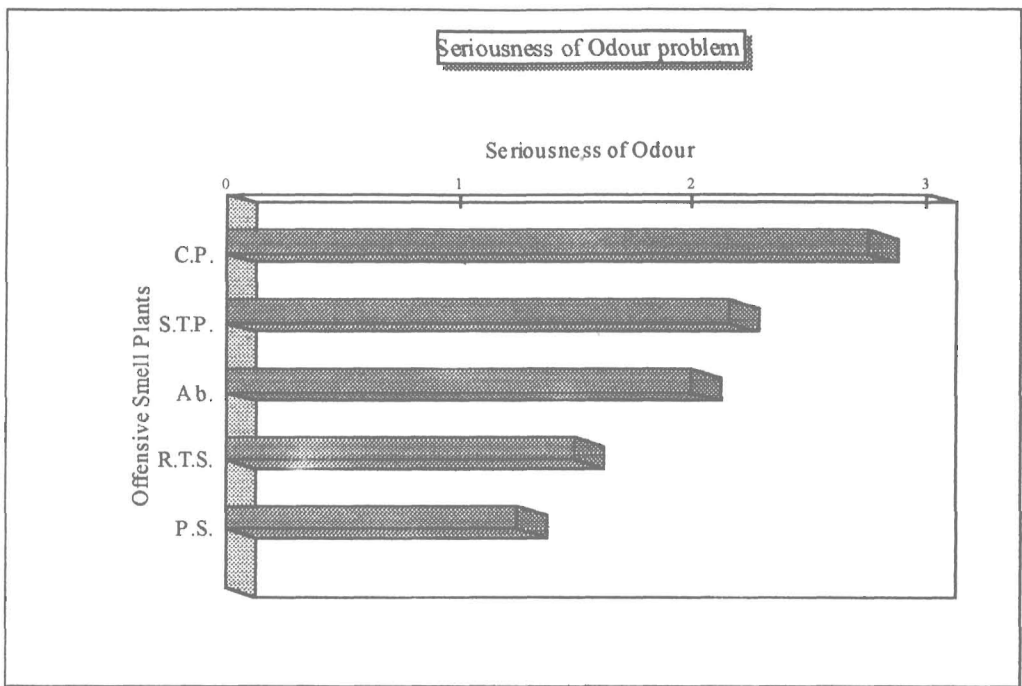
Analysis of the result:

Based on the data provided by the questionnaires from the overseas countries, the seriousness of odour problem generated by the offensive smell plants can be analyzed. As classified in the question 1 of the questionnaire, the seriousness of the malodour can be divided into the following 5 classes for ease of calculation: no odour, acceptable, moderate, serious and very serious, with grades 0 to 4. It was found that the overseas authorities or organisations have a serious problem in the composting plant and moderate to serious problem in the sewage treatment plants and little problem for another plants, (Fig. 4.1.)

It was calculated that there are 44% of the offensive smell plant installed air pollution control equipment for deodourization. Fig 4.2 shows the breakdown of the kinds of control equipment. The most common one are the scrubber and the activated carbon with a small number of biofilters and others.

Regarding to the question 6 & 7, the reasons for installing and not installing odour control system was asked. The summary of the questionnaire survey is shown in Appendix 6. Fig 4.3 and Fig 4.4 are the graphical representation of results of question 6 & 7. The main reasons for them to install such equipment is the existence of sensitive receiver and the odour emission is high, only about 18% is according to the statutory requirement (Fig 4.3). On the contrary, they did not install odour control equipment because odour was in low concentration emission, however the economic factor is increased to 26%. Economic concern plays an important role in considering the odour control equipment Fig 4.4.





	<u>Offensive Smell Plants</u>	<u>Seriousness of Odour</u>
C.P. :	Composting Plant	0 : No Odour
S.T.P. :	Sewage Treatment Plant	1: Acceptable
Ab. :	Abattoir	2 : Moderate
R.T.S. :	Refuser Transfer Station	3 : Serious
P.S. :	Pumping Station	4 : Very Serious

Fig 4.1

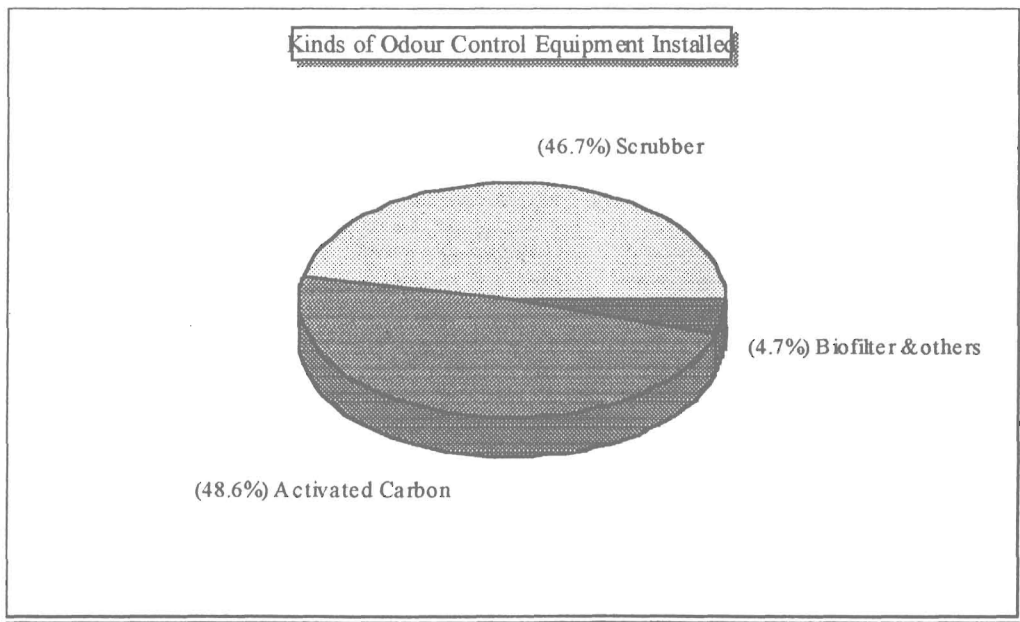
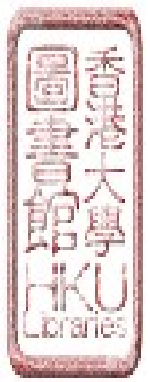


Fig 4.2



Reasons for those plants to install control equipment

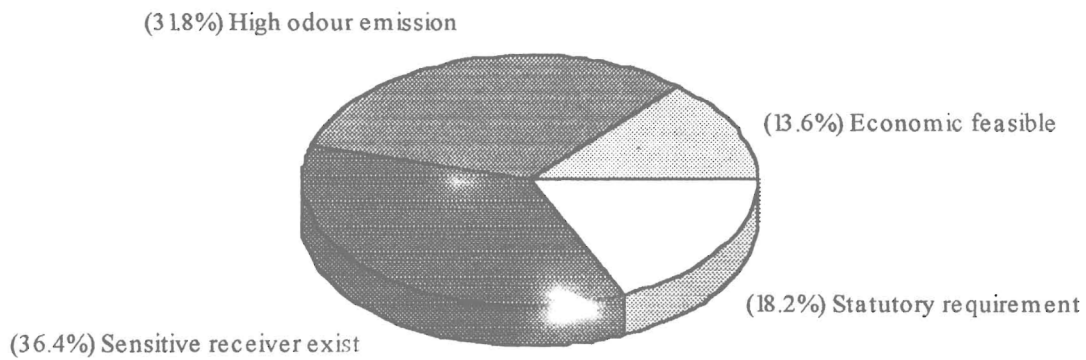


Fig. 4.3

Reasons for those plant without installing control equipment

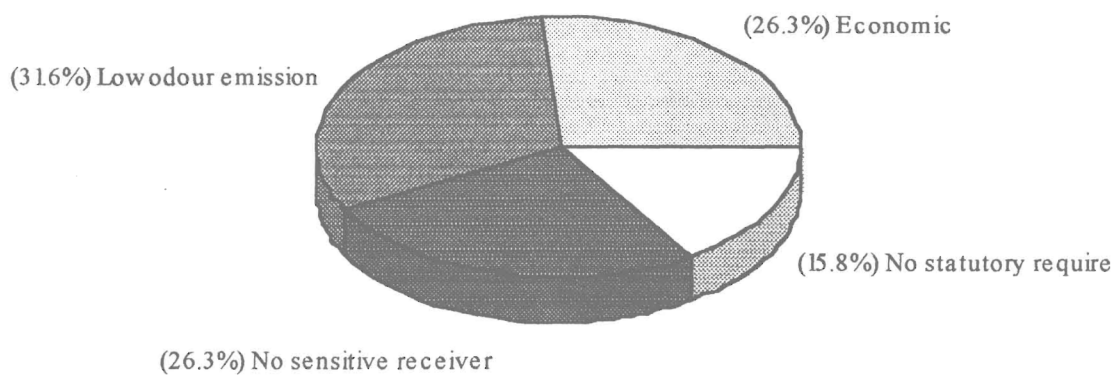
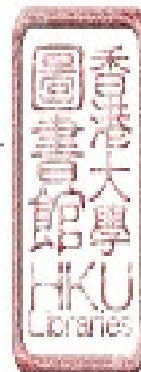


Fig. 4.4



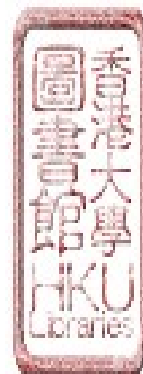
4.2 Odour Problems and their Control in Hong Kong

The offensive smell plants in Hong Kong, including Sewage treatment plant, composting plant, abattoir, refuse collection point and refuse collection station, have also been studied. The details are shown in the Table 4.1. The information on these plants was gathered from:

1. questionnaire to the appropriate departments, see Appendix 7;
2. interview with the officers; and
3. search from EIA reports

The abattoir in the Kennedy Town created environmental problems to the nearby inhabitants. This was due to the close distance between the plants and the inhabitants and the inadequate of deodourization measures. Therefore, in the EIA reports of the abattoir (MacDonald, 1995) & (ECEL, 1995) and the refuse transfer station (HKG EPD 1992, 1993, 1994), it was found that air pollution nuisance should be considered and abated in the newly designed plants.

There is no statutory requirements for the composting plants, sewage treatment plants, and refuse collection points to have any air pollution control measure. For existing plants the authority is acting in a complaint basis. That is, if there is no complaint then there is no air pollution problem. However, for some of the plants such as the composting plant they have installed wet scrubber to treat the



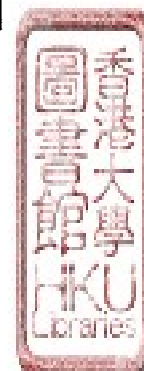
odorous gas from the bio-degradation of the compost. There are also some scrubbers in the refuse collection points as reported by the Urban Services Department and Regional Services Department in their returned questionnaires.

The kinds of air pollution control equipment used in various plants are listed in the Table 4.1. It is revealed that the most common measures are scrubber and activated carbon. Only one biofilter is being used in the sewage screening plant in North Point and also there is a proposal to use the technique of ozonation to abate the odorous gas from the newly constructed abattoir in Sheung Shui.

Plants	Activated Carbon	Scrubber	Biofilter	Ozone	Nil
Abattoir Kennedy Town Sheung Shui (proposal) Others (TW,CSW,CC,YL)*		✓ ✓		✓	✓
Refuse Collection Point (USD) Quantity: (105)	✓ (10)	✓ (61)			✓ (34)
Refuse Collection Point (RSD) Quantity: (2537)	✓ (7)	✓ (2)			✓ (2528)
Refuse Transfer Station Kln Bay Island East Sha Tin	✓ ✓	✓			
Sewage Screening Plant Kwai Chung StoneCutters Island Wanchai West North Point	✓ ✓	✓	✓		
Composting Plant		✓			

*TW: Tsuen Wan, CSW: Cheung Sha Wan, CC: Cheung Chau, YL: Yuen Long

Table 4.1 Hong Kong's Offensive Smell Plants;

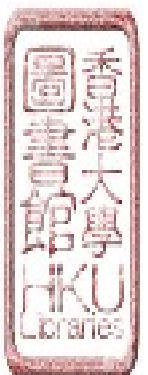


The odour limit for odorous plants

In general, there is no statutory criterion for maximum levels of odours in Hong Kong but the Environmental Protection Department recommend a level of 5 odour units predicted over 5 minutes for assessing impacts at any sensitive receiver. EPD also recommend a maximum level of 2 odour units at the site boundary. This is the common acceptable level in EIA and the criterion set in the Best Practicable Means (BPM) of the Specified Processes. This odour unit is recognised as a means of predicting whether odour nuisance will occur once the proposed use is in operation.

Among the aforesaid offensive smell plants, the abattoir is the only one which is classified as the Specified Process under the provisions of the Air Pollution Control Ordinance. The abattoir, by-products plant of the slaughterhouse, is fall within the category of rendering works and is under licence control and is necessary to incorporate best practicable means to prevent noxious emissions. Notes on the requirements of BPM are provided in Appendix 8.

Licence will only be granted to the specified process if the owner of the premises conducting the works can provide and maintain BPM for the prevention of the air pollution emissions from it and the air pollution emissions from the premises will not cause unacceptable air quality so that the Air Quality Objective can be attained, and the health of the people in the surrounding will not be jeopardized.



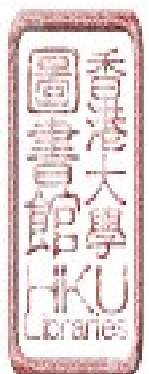
4.2.1 Abattoir

Although in this study the abattoir is the only plant which is classified as specified process, and under the control of EPD, the notes on Best Practicable Means (BPM) can still be adopted as a reference for other offensive smell plants.

In BPM, the design of the chimney is governed by the mathematical or dispersion modelling such that the emission from the exhaust will not cause air pollution. The chimney height, efflux velocity, exit temperature and the mode of discharge are the essence design conditions for the chimney. Secondly, the emission limits of 2 odour units must be complied with. And emission concentrations for air pollutants such as hydrogen sulphide, mercaptans, chlorine and its compounds, ammonia, amines and amides are limited to certain figures. Thirdly it has recommended some kinds of odour control equipment such as scrubber, incinerator, biofilter, or similar suitable control equipment. It has also emphasized on the good handling of raw material, processing and housekeeping to minimize odour emission. Lastly, the monitoring of the control equipment to maintain its efficiency is needed.

4.2.2 Sewage Works

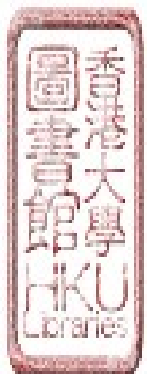
The sewage treatment plants in Wan Chai and North Point had been installed with odour control equipment. Before the retrofit of the odour control equipment, there existed serious odour problem in the vicinity of the plant as they are located



closely to the commercial and residential areas therefore measures should be made. Biofilter was introduced to the sewage treatment plant in North Point and scrubber was used in Wan Chai.

EIA on the study of the sewage screening plants and pumping station have been conducted by Drainage Services Department, 1992. East Kowloon improvements Works of the sewage involved an upgrading of an existing pumping station in Kwun Tong and installation of a new pumping station at Yau Tong. Odour emissions from the pumping stations will consist of a range of different odorous compounds. The sewage to be handled at the two proposed pumping stations will be of domestic and industrial origin due to the nature of the Kwun Tong and Yau Tong surrounding areas and therefore its components are difficult to category in the planning stage.

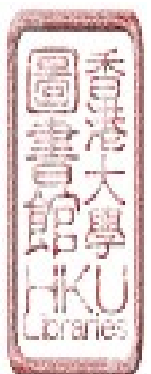
It was shown in the EIA of the plant that odour panel tests were undertaken at the Kwun Tong Screening plant to provide data for the predictions through the use of an atmospheric dispersion model. It is seen that the condition was carried out base on the worse case assumption. In summer time the odours scented near the Yau Tong pumping station is over 25 odour unit and down to 3.4 odour unit by reaching the sensitive receptors. This modelling results indicate that the levels of odour at the boundary of Yau Tong pumping station exceeded an odour level of 2. Two odour units is the normally acceptable threshold therefore odour mitigation measures are required.



Unfortunately, there is no statutory requirement by the government to force the contractor in the proposal stage to install odour abatement equipment in pumping stations or in other sewage works. The only requirements laid down in the contract was that no exceeding 2 OD should be received at the boundary. Therefore the proponent might only need to allocate space at the stations for retrofitting odour treatment works if required later. However, in order to manage the odour problem, the plant should be totally enclosed and the control system should be properly designed for the removal of particular chemicals. The system may include completely capturing devices to direct the odorous emissions to the control system. Moreover, as mentioned before, the odour may consist of various chemical components, it is therefore essential to examine them in the early stage and hence odour control equipment can be chosen in the proposal stage. Without having a thorough assessment on the odour problem in the design stage, the retrospective installation of control systems may arise accommodation problem and other technical problems.

4.2.3 Refuse Transfer Stations

The refuse transfer stations, Kowloon Bay, Island East and Sha Tin, were commissioned between 1990 and 1994 (HKG EPD Environment of Hong Kong 1995). Another five numbers of refuse transfer station are targeted to be

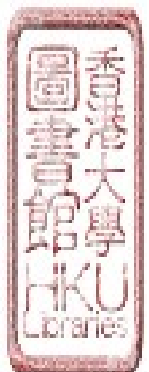


commissioned in 1997 and one will be at 2000. The odour problem of these stations are well be aware and therefore all existing refuse transfer stations had incorporated with odour control equipment such as activated carbons and scrubber.

EIA studies on the new refuse transfer stations have been conducted for stations in North West New Territories and Outlying Islands. They were being undertaken in the year of, 1993 and 1994 respectively, (HKG EPD, 1993 & 1994). These two refuse transfer stations are at the rural areas and there exists a very large buffer zone in between the sources and the nearest sensitive receptors.

As in general practice, the reports first analyzed the nuisance which would be caused in the construction stage of the works, then in the operation stage. There would not be any odour problems in the construction stage. Therefore odour would only be considered in the operating stage. There was no existing data of odour levels for the various sites in the remote islands, But the numerous complaints relating to odour of the existing plants should serve for consideration of the interface between the source and the receptors.

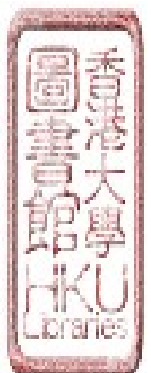
The potential odour emission sources from the refuse transfer stations are the deposition of refuse and refuse liquors in the transfer facility; surfaces contaminated by deposited refuse; waste water collection facilities and refuse collection vehicle and container vehicle.



The study recommended that leachate treatment process at Mui Wo will result in the removal of odours compounds. But at the Discovery Bay, the enclosure of the operation within a building with appropriate air control systems should ensure compliance of 2 odour units at the site boundary. For others outlying island station, the problem would be limited to its minimum as the scale of the refuse transfer station are small.

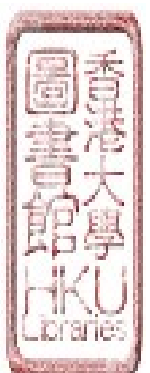
4.2.4 Refuse Collection Point

In the Table 4.1, it shows that there are a large numbers of refuse collection points in Hong Kong managed by the Urban Services Department and Regional Services Department. In order to facilitate the collection processes , the refuse collection points are placed very close to the residential areas, therefore odour problem exists and might get worse in the hot and humid conditions. Therefore a good housekeeping and a proper operation procedures inside the collection point and the proper cleansing of vehicles are essence for air pollution abatement. It was found that scrubbers and activated carbons are the odour control equipment used in the refuse collection points.



4.2.5 Composting Plant

The only composting plant is located in Sha Lan, northern part of Hong Kong. In which scrubber is used as air pollution control equipment. Odours will be generated during the bio-degradation process of the agriculture waste and it is shown that composting plants in overseas countries might have a serious odour problem. However, the composting plant in Hong Kong is situated in a remote rural area, hence there is no sensitive receptors near the boundary of the plant and nuisance will be minimized.



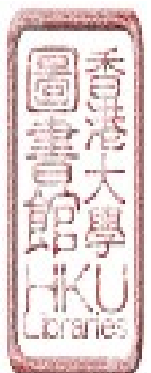
5. Legal Aspects

5.1 The related legislation and regulations in Hong Kong

The related legislation for the control of odour emission is the Air Pollution Control Ordinance. The main purpose of the ordinance is to control the emission of air pollutants into the atmosphere of Hong Kong from stationary sources. The Ordinance applies to all premises in which air pollutants are emitted from any chimney, engine, furnace, oven or industrial plant. In definition, air pollution nuisance means any emission of air pollutant which either alone or in conjunction with any other such emission:-

- a) is prejudicial to health;
- b) is a nuisance to the inhabitants of the neighbourhood

Therefore the plant which generates odour and arising nuisance to the public can be actionable under the Air Pollution Control Ordinance. Sections 9 and 10 of the APCO are provisions for controlling the air pollution nuisance: “When in the opinion the Authority an air pollutant nuisance exists or is imminent, he shall notify the owner of the premises the existence or imminence of such nuisance, requiring him to reduce the emission of the air pollutant from the relevant plant. If such air pollutant nuisance is likely to be prejudicial to health the Authority shall require the owner to eliminate the emission of such pollutant. If the owner of the premises fails to abate an air



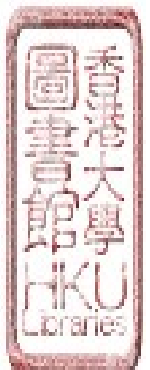
pollutant nuisance in such a manner as is specified in the abatement notification, he is liable on conviction to a fine.” The court, however, will not convict the owner unless the prosecution proves that the air pollutant nuisance mentioned in the notification existed or was imminent at the time the notification was given to the owner.

In determining whether the air pollution nuisance can be established, the authority is based on the criteria in the Technical Memorandum of the Air Pollution control Ordinance.

Criteria in the Technical Memorandum:

1. Objectionable Odour Caused by the Emission
2. The Relative Location of the emission source and the place affected;
3. The Locality of the place affected;
4. The Time, Duration and Frequency of the Emission.

It is noted that there is no quantitative approach to define the level of the objectionable, how far apart is classified as a relatively close distance between the source and the receptor and even there is not a limit on the duration or frequency of the emission.

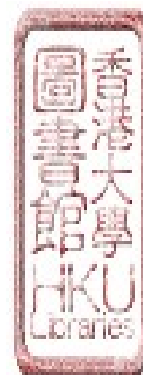


5.2 The qualitative approach policy

The provisions of the Air Pollution Control Ordinance is according to the policy of qualitative approach.

This is a very common approach in overseas countries [31], regulations generally are phrased as no perceivable odour at the boundary or no justifiable complaints. The problem is that regulations do not provide a clearly established criterion to determine if and when nuisance occurs. This lack of definition of terms invites the need to define these terms almost on a case by case basis. Also, it leads the operator of the source difficult to follow, because the criteria may shift as time progresses. In turn, this creates the possibility to use odour annoyance complaints as a means to influence developments, when in reality the complainants may be of a different nature. This is highly unfavourable for industry, as operators have an interest in a reasonably stable and clear framework in which they can fit their operations.

The following table shows the advantages and disadvantages of qualitative approach policy.

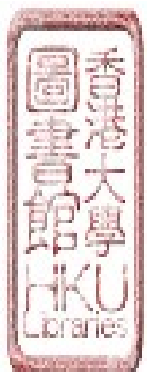


The advantages and disadvantages of qualitative approach policy:

ADVANTAGES	DISADVANTAGES
+ Direct 'Measure' of the undesirable effect: odour annoyance	- Very subjective criterion; nuisance needs case-by-case definition
+ Cheap for the regulator (NO measurements)	- Provides no 'Continuity of Regulation' to either the community or the operator (Industry)
+ No Complaints - No Problem	- Virtually impossible to control
	- Impossible to enforce well
	- Annoyance almost by definition Impossible to measure, due to external factors (press, community activities etc.)

(Harreveld, 1994)

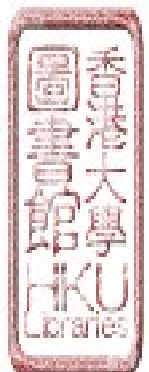
The method of qualitative approach is also adopted in the New Jersey of United States (Leo, 1994). They are using the similar method as in Hong Kong but they have classified the annoyance to the public into 6 scales. The air pollution nuisance is expressed in odour intensity description. This can provide comparative data to the authority to make decision. However the same problem is that the nuisance is assessed by the officer and they might have subjective point of view on different cases.



Odour Intensity Scale

Scale/ Description	Odour Intensity Description
0	Odour not detectable
1 - Very Light	Odour present in the air which activates the sense of smell but the characteristics may not be distinguishable
2 - Light	Odorant present in the air which activates the sense of smell and is distinguishable and definite but not objectionable in short duration (Recognition Threshold)
3 - Moderate	Odorant present in the air which easily activates the sense of smell, is very distinct and clearly distinguishable and may tend to be distinguishable and/or irritating.
4 - Strong	Odorant present in the air which would be objectionable and cause a person to attempt to avoid it completely, could indicate a tendency to possibly produce physiological effects during prolonged exposure.
5 - Very Strong	Odorant present which is so strong it is overpowering and intolerable for any length of time and would tend to easily produce some physiological effects

(Leo, 1994)



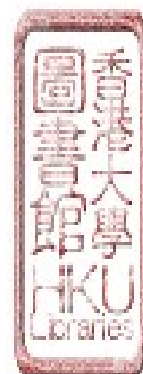
5.3 The quantitative approach policy:

Besides the qualitative approach, the quantitative approach takes quantitative angle, based on emission measurements combined with modelling to determine odour annoyance potential.

In this case the emission from the source is measured, using olfactometry to determine the odour concentration. Then, the frequency of occurrence of concentrations that may cause odour annoyance is calculated for the area around the source, using dispersion modelling. The odour annoyance potential is then determined using empirical 'dose-effect' relations, between exposure and actual occurrence of odour annoyance in similar situations. Air quality guidelines can be set using this approach. These can be specified in terms of emission limits for specific sources.

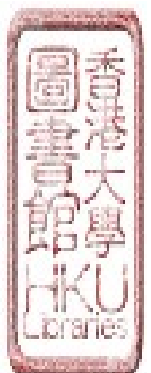
The quantitative approach is adopted in the EIA study in Hong Kong and the requirements of the best practicable means of the specified processes. The acceptable limit for the odour emission at the boundary is 2 odour units or 5 odour units for 5 minutes in an air dispersion modelling basis. This kind of approach can give a clear definition of the requirement for the operators and the authority.

The result of the odour assessment from the qualitatively approach can provide the authorities, the courts, the community, administrators and enforcers a clear basis for assessment of the situation and enforcement of regulatory decisions. In



Netherlands (Harreveld, 1994), this approach has been adopted, and welcomed by the industry to develop a clear basis for licensing to allow them to involve odour management in longer term planning.

This method is not without its problems, however. The dose-effect relationship between the frequency of exposure to certain odour concentrations and annoyance potential is not an easy one, influenced by factors such as the very quality of the odour (the difference between a bread factory and a rendering plant!). This approach depends on the availability of a sufficiently reliable, traceable method for odour concentration measurement (olfactometry). Inter-laboratories in the Netherlands have demonstrated (Harreveld, 1994) that olfactometry can be improved to provide the required reproducibility, also using result obtained by more than one laboratory. The overall error margin (as a ratio between the upper and lower limit of the 95%-confidence interval for two single results, each obtained by a separate laboratory) has been demonstrated to be less than a factor 3 which is acceptable for regulatory use.

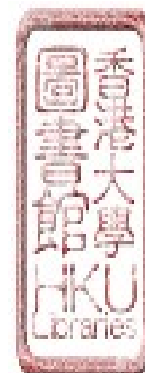


The advantages and disadvantages of quantitative approach policy:

ADVANTAGES	DISADVANTAGES
+ Assessment can be well defined, using tools familiar to air pollution managers	- Modelling provides no direct measure of annoyance; a 'yardstick' compared with empirical annoyance
+ Provides clear evidence to law courts in case of conflict	- The dose-effect relationship between calculated exposure and actual annoyance is still insufficiently documented
+ Allows identification of major sources, and consequently the basis for abatement strategy	- Odour concentration measurement (Olfactometry) must be sufficiently accurate and solidly traceable (QA/QC framework for certification)
+ Clear license conditions possible	
+ Enforcement straightforward and objective	

(Harreveld, 1994)

Odour policy should be a reasonable balance between the interests of communities, wanting clean air, and industry/public works, wanting to know where they stand and what it will cost them. Broadly, two types of odour policy can be distinguished. Firstly the qualitative approach states that annoyance may not be caused, but generally fails to provide a clear way to assess presence or absence of annoyance. The second approach, that takes a quantitative angle, based on emission



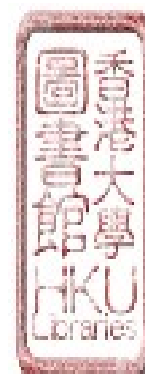
measurements combined with dispersion modelling to determine odour annoyance potential.

5.4 Requirements to implement the quantitative approach policy

Odorous emissions shall be adequately controlled to ensure that the operation of the plant would not cause an odour nuisance or impose unacceptable constraint on land use. To satisfy this requirements, the authority laid down the limitation of 2 odour units for the plants. As described in previous chapter, one odour unit is the concentration of the odorant which just induces an odour sensation among half of the panelist. Two odour units is two fold of this concentration. Hence it is a stringent requirement. Therefore sophisticated odour control is needed to bring the odour to this level.

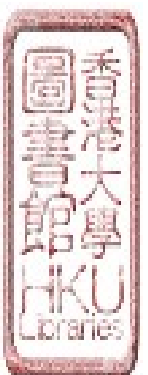
Difficulties may be encountered in the implementation of enforcement by the authority. The odour samples collected at the site boundary may be mixed with the background air pollutants. It cannot actually represent the odour concentration.

How to produce a reproducible, traceable method to determine odour concentration is also important. Analytical methods have so far not been able to reliably predict the response of the nose to the complex mixtures that are involved in



environmental odours. Therefore, olfactometry is still the one and only method to measure odour concentration. However, results of olfactometry in literature have been generally very wide apart. Such differences, are not acceptable when using olfactometry as a basis for regulations.

The aim of it was to first improve the consistency of measurements, that is expressed as the quality parameter repeatability. Then the second aim is to achieve comparable results, for different laboratories.

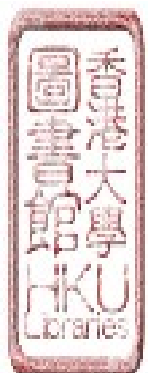


6. Recommendation

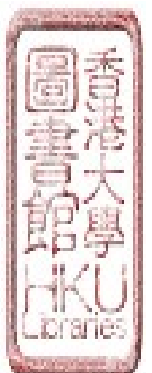
It is noted that there is an increasing use of biofilter in the western countries due to its high efficiency and less operation technique. But the main consideration is the space for accommodation. Hence, it is recommended to look into detail of its application in Hong Kong since the high temperature and humid condition favour its working environment.

By sampling the odorous gas at the boundary, the background air pollution may add to the sample. It is inadequate for the authority to enforce the control of 2 odour units at the boundary. Therefore in order to eliminate the influence of the background air pollution, the sample should not be taken at the site boundary. The odour concentration should be measured at the chimney or emission point of the plant and it can be converted to the value of 2 OU at the boundary by the mathematical modelling. Hence it is more realistic to set an odour emission limit at the chimney or emission point at the plant instead of at the site boundary. And odour sample is taken at those designated positions.

Finally, the qualitative approach to the control of odour nuisance laid down in the provisions of the Air Pollution Control Ordinance should be changed to quantitative one. But the pre-requisition is the sophisticated olfactometer and its reliability. Therefore the quality of the olfactometer should be traceable and be accredited by recognized authority such as Hong Kong Laboratory Accreditation Scheme HOKLAS.



The recommended quantitative approach can only represent an odour unit of the air pollutant. However, it was found that two different natures of air pollutants with the same level of odour unit may not equal in intensity of annoyance. Therefore, even with the adoption of the quantitative approach to the legislation or code of practices, the control authority may still not easy to judge whether the air pollutant is acceptable. There are many kinds of air pollutants and they will cause annoyance in different level. Hence, it is recommended further defining the statutory limits of every kinds of popular air pollutants in terms of odour unit.



7. Conclusions

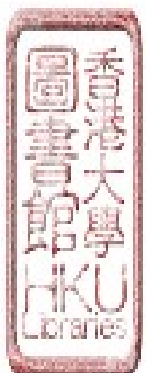
The emission of odours from industrial and waste management sources has become a major problem for industry and water authorities. A decreasing tolerance by the community for nuisance odours has necessitated programs aimed at minimizing odours at the source and reducing emissions using a range of odour control technologies. A first step towards odour reduction is an accurate determination of the problem, and recent developments in dynamic olfactometry have seen this sensory quantification technique take over from chemical analysis methods as the predominant method used.

Odour problems are likely to get worse due to:

- Industry and public utilities being increasingly enveloped by housing
- Increasing public awareness and political choice for clean environment
- More established mechanisms of community action/legal action

Odour control equipment

Odour control techniques consist of oxidation, adsorption and use of bacteria. The usage of activated carbons and scrubbers for deodourization are widely used in overseas countries and in Hong Kong. But the wet scrubber has its advantage of

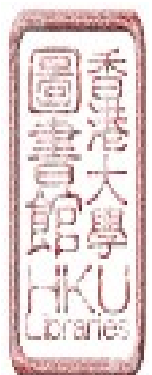


constant removal efficiency and its versatile in handling other particulate. Besides, it was seen that the activated carbon, with its simple principle and easy operation is widely accepted by the community for the odour controls. The activated carbon has a very high odour removal efficiency, but the drawback is that the short breakthrough period increases its operational cost and the removal efficiency will be decreasing once the carbon becomes saturated. On the contrary, biofilter has the advantages of simplest operation procedure and lowest operation cost. Recently, the acceptance of biofilter to be the odour control equipment is increasing.

However, odour control systems do not give overall success unless the entire facility is properly enclosed and maintained, especially for the densely populated area like Hong Kong. The air pollution control system includes capturing devices to direct the odorous emissions to the control systems. It also includes effective housekeeping and general cleanliness, proper raw material/finished product handling and storage, good spill protection and waste disposal procedures. In addition with the dispersion through the chimney, the odour could be reduced to the acceptable level.

Survey on deodourization

Only 44 % of the large offensive plants in overseas countries have been installed with odour control equipment. The common air pollution control equipment are the activated carbon and wet scrubber. Although there was no quantitative requirements on the odour limit set by the overseas countries, the setback distance



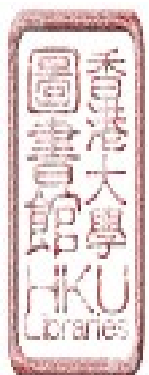
and sufficient buffer zone between the source and the receptors is adopted as one of the requirement.

Similarly, activated carbon and scrubber are the two common odour control equipment used in Hong Kong. However, only one biofilter is adopted in the sewage treatment plant and ozonator is being proposed to be used in the abattoir. Thus more study should be made on using biofiltration or ozone as deodourization in Hong Kong.

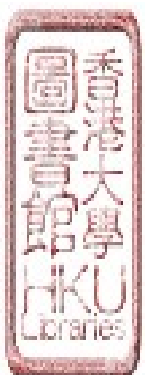
Legal aspect

There is no statutory requirements for the odour control but the general limit for the odour which would be scented at the boundary of the site is not exceeding 2 odour units.

In Hong Kong, the quantitative approach for controlling the air pollution nuisance is only used in the design stage of the large facilities such as the planning of locating a refuse transfer station or the slaughter house. Usually, the Government might lay down limitations on the air pollution impact arising from these plants. Two odour units detected at the boundary of such plants is usually the requirement. The consultants will conduct air sampling and air dispersion modelling to calculate the odour concentration at the boundary and hence based on these assessment they will recommend some kinds of measures to abate the air pollution if necessary.

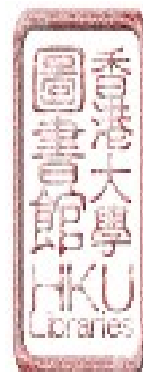


Normally, the application of the qualitative approach is on the complaint case against the objectionable odours. When there is a complaint case on the air pollution odour the officer will carry out an investigation and their assessment is based on their opinion or the criteria set in the technical memorandum, then when the case is warranted or legal action will be carried out. By performing such kind of assessment procedures it may be very easy to make the case under control but it is not an efficiency way. Undoubtedly, the quality of the assessment cannot be traced. And the scale of the annoyance for the officer is not the same if subject to a certain kind of air pollutant. Therefore, it is recommended to set up a quantitative approach to control odour nuisance

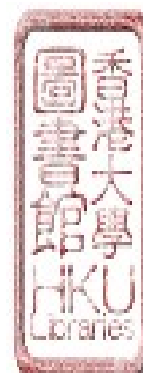


7. Reference

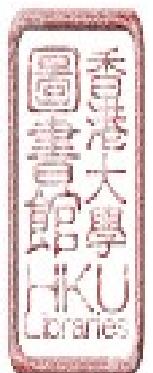
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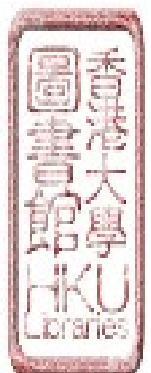
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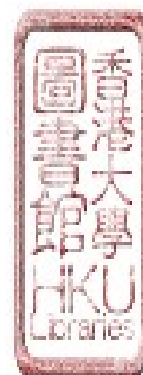
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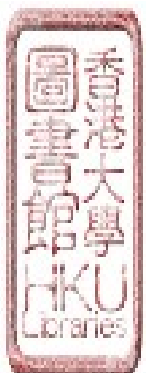
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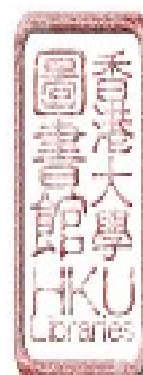
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Appendix 1

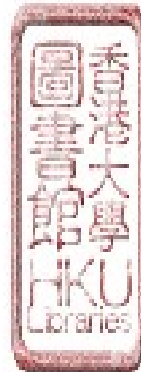


Substance	Recognition Threshold,* ppm by volume	Recognition Description
Acetaldehyde	0.21	Green sweet
Acetic acid	1.0	Sour
Acetic anhydride	0.36	Sour acid
Acetophenone	0.60	Sweet almond
Acetone	100.0	Chemical sweet, pungent
Acrolein	0.21	Burnt sweet, pungent
Acrylonitrile	21.4	Onion-garlic pungency
Allyl amine	28.0	
Allyl chloride	0.47	
Allyl mercaptan		
Amine, dimethyl	0.016	Garlic-onion pungency, green
Amine, monomethyl	0.047	
Amine, trimethyl	0.021	Fishy
Aminonia	0.00021	Fishy, pungent
Aniline	46.8	Fishy, pungent
Benzene	1.0	Pungent
Benzyl chloride	4.68	Pungent
Benzyl sulfide	0.047	Solvent
Bromine	0.0021	Solvent
Butyl cellosolve	0.047	Sulfidy
Butylene oxide	0.48	Bleach, pungent
Butyraldehyde	0.71	Sweet ester
Butyric acid	0.039	Sweet alcohol
Carbon disulfide	0.001	Sweet rancid
Carbon tetrachloride	0.21	Vegetable sulfide
(chlorination of CS ₂)		
Carbon tetrachloride	21.4	Sweet, pungent
(chlorination of C ₁₁ H ₇)		
Carbitol solvent	100.0	
Cellosolve acetate	1.10	Sweet musty
Chloral	0.250	Sweet musty
Chlorine	0.047	Sweet
Cyclohexanone	0.314	Bleach, pungent
Dibutyl sulfide	0.24	Sweet sharp
Diethylamine	0.18	
Diethyl sulfide	0.498	Fishy
Diethyl trisulfide	(0.006)	
Dimethylacetamide	(0.001)	
Dimethylformamide	46.8	Amine, burnt, oily
Dimethyl sulfide	100.0	fishy, pungent
Dimethyl trisulfide	0.001	Vegetable sulfide
1,4 Dioxane	(0.001)	
Diethyl ether	5.7	Sweet alcohol
(perfume grade)	0.1	

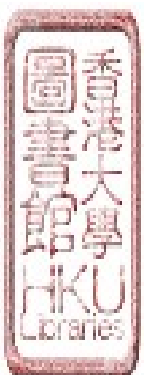
(continued)

Substance	Recognition Threshold,* ppm by volume	Recognition Description
Diphenyl sulfide	0.0047	Burnt rubbery
Ethanol (synthetic)	10.0	Sweet
Ethyl acrylate	0.00047	Hot plastic, earthy
Ethyl mercaptan	0.001 (0.0003)	Ferrous, sulfidy
Ethyl methyl sulfide	(0.014)	
Formaldehyde	1.0	Hay/straw-like, pungent
Hydrochloric acid gas	10.0	Pungent
Hydrogen sulfide (from Na ₂ S)	(0.0005) 0.0047	Eggy sulfide
Hydrogen sulfide gas	0.00047	
Isobutanol	2.05	Sweet musty
Isobutyraldehyde	0.336	Sweet fruity
Methanol	100.0	Sweet
2 Methyl-1-butanol	0.23	Sour sharp
Methyl cellosolve	0.40	Sweet alcohol
Methyl chloride	above 10	
Methylene chloride	214.0	
Methyl ethyl ketone	10.0	Sweet
Methyl isobutyl ketone	0.47	Sweet
Methyl mercaptan	(0.001) 0.0021	Sulfidy, pungent
Methyl methacrylate	0.21	Pungent, sulfidy
Monochlorobenzene	0.21	Chlorinated, moth balls
Morpholine	0.14	fishy
Nitrobenzene	0.0047	Shoe polish, pungent
Paracresol	0.001	Ion-like, pungent
Para-xylene	0.47	Sweet
Purchloroacetylene	4.68	Chlorinated solvent
Phenol	0.047	Medicinal
Phosgene	1.0	Hay-like
Phosphine	0.021	Oniony, mustard
Pyridine	0.021	Burnt, pungent, diamine
Styrene	0.22	
Styrene (inhibited)	0.1	Solventy, rubbery
Styrene (uninhibited)	0.047	Solventy, rubbery, plasticity
Sulfur dichloride	0.001	Sulfidy
Sulfur dioxide	0.47	
Thiophene	(0.001)	
Toluene (from coke)	4.68	floral, pungent, solventy
Toluene (from petroleum)	2.14	Moth balls, rubbery
Toluene dithiocyanate	2.14	Medicated bandage, pungent
Trichloroethylene	21.4	Solventy
Vinyl acetate	0.40	Sour sharp

*Values in parentheses are odor detection threshold values



Appendix 2



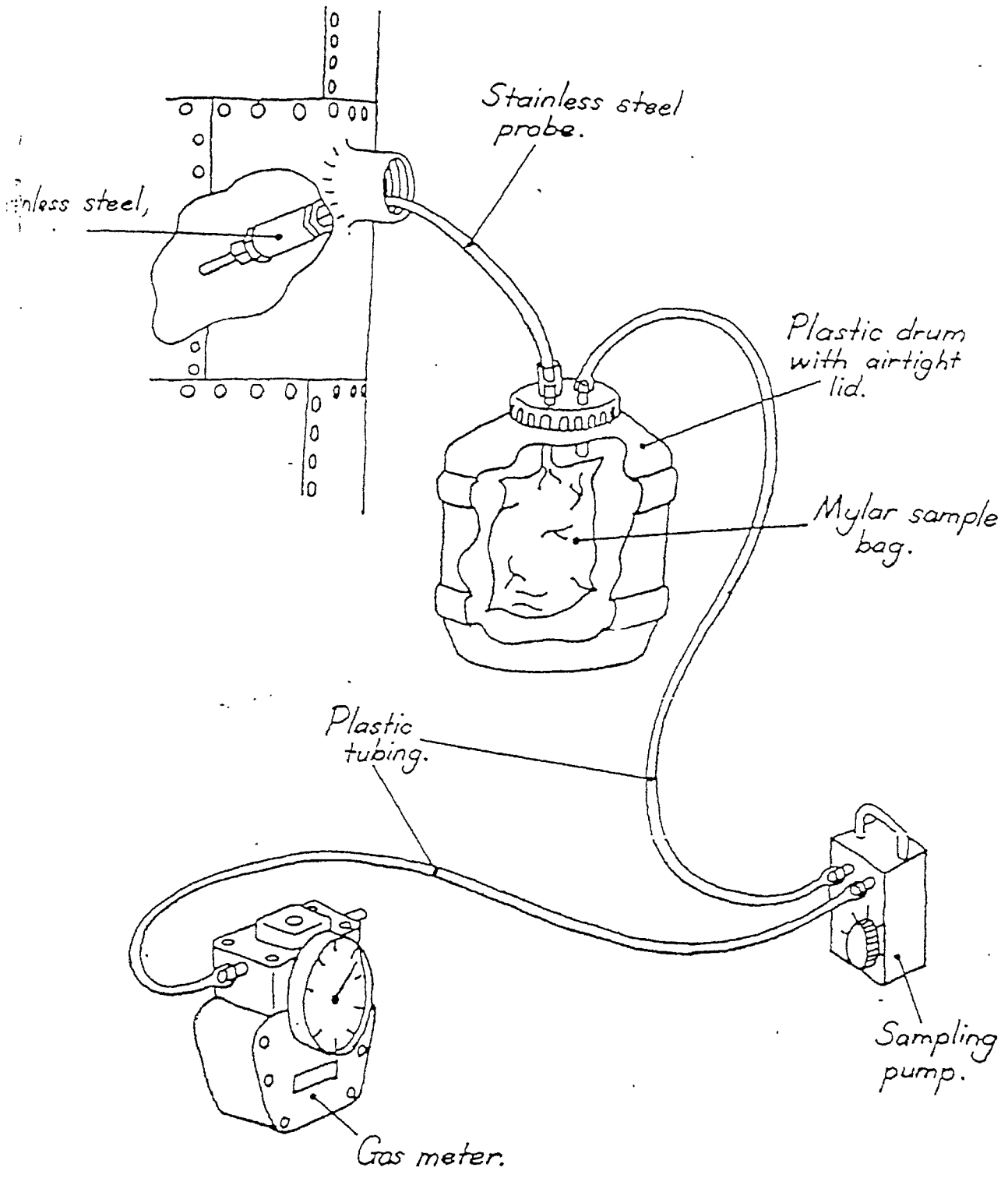
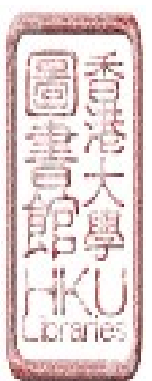


Diagram I - Sampling Apparatus - EPA Odour Testing



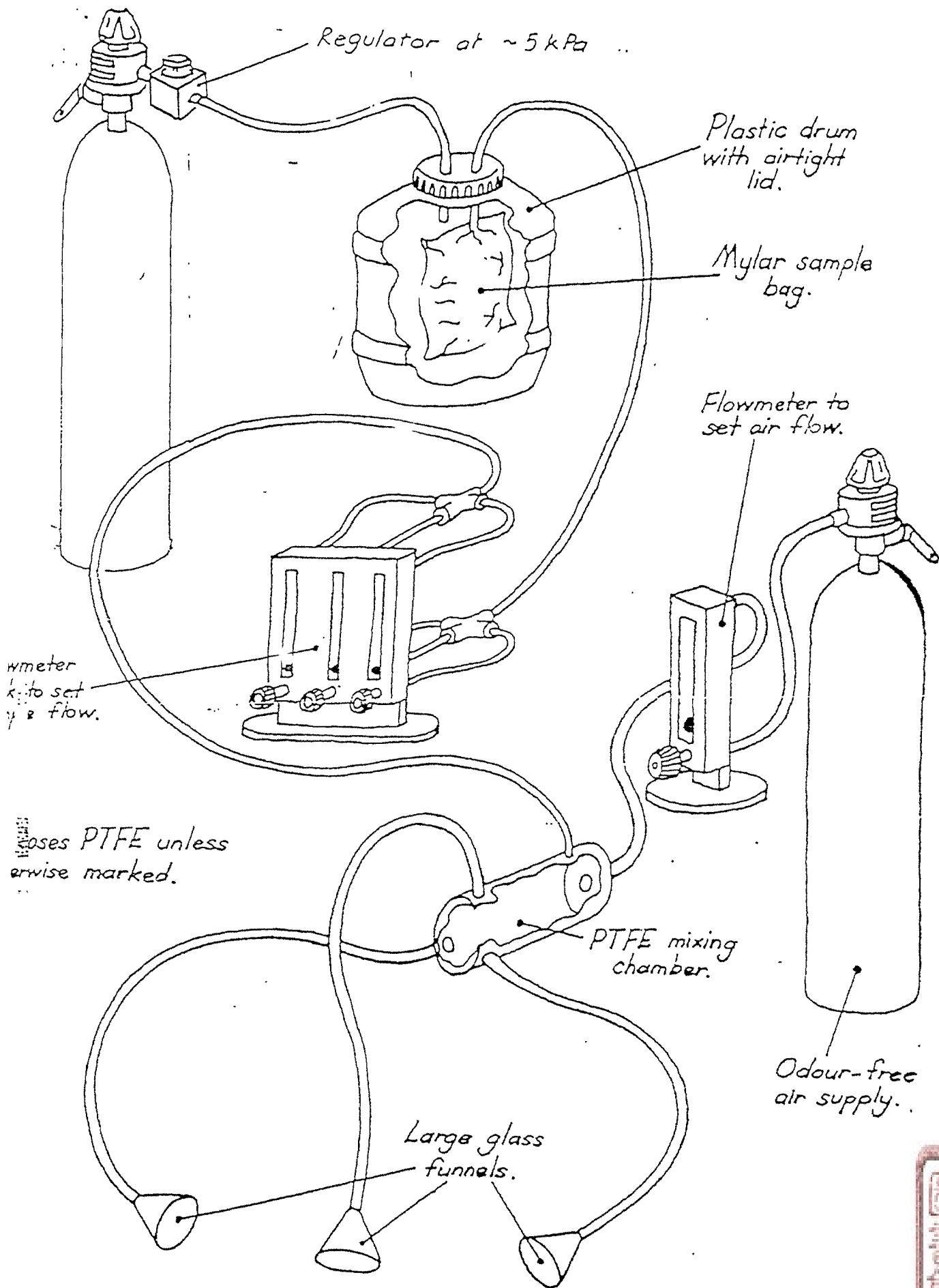
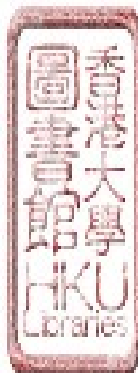


Diagram II - Dilution System - EPA Odour Testing



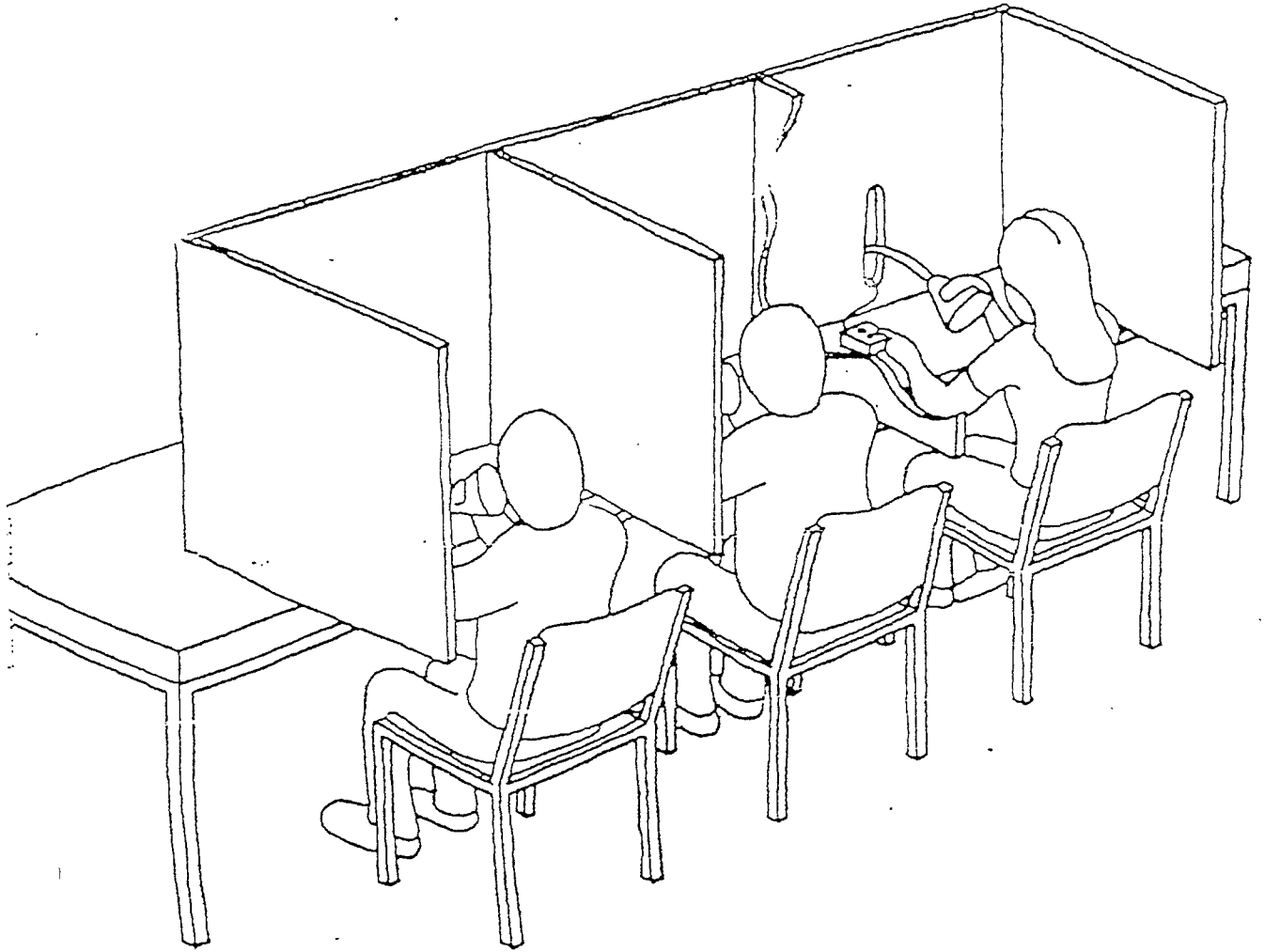
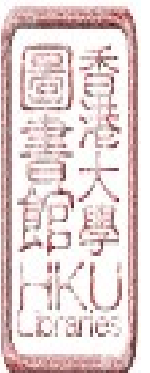


Diagram III - Testing Panel - EPA Odour Testing



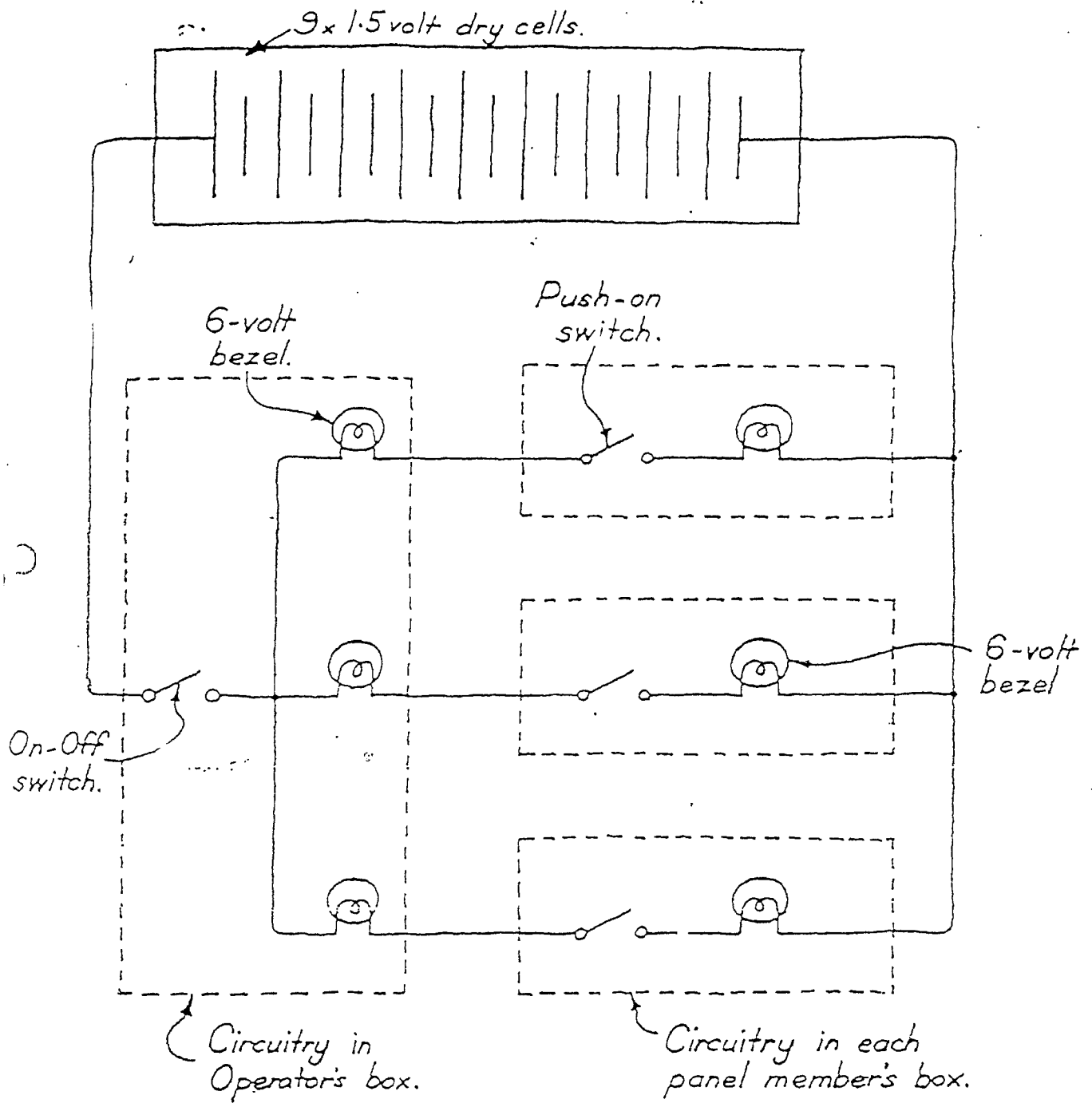
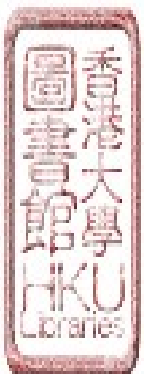
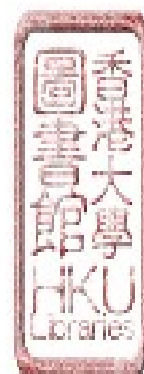


Diagram IV - Indicating System - 4th Odour Testing



Appendix 3



Dear Sir/Madam,

Questionnaire on the Deodourization of
Sewage Treatment Plant, Composting Plant, Abattoirs, Pumping Station,
and Refuse Transfer Station

Being a student of the University of Hong Kong, I am conducting research for the dissertation of Msc. in Environmental Management. The theme of my project is the odour control of the sewage treatment plant, composting plant, abattoirs, pumping station, and refuse transfer station in various countries as well as in Hong Kong. Specifically, it will be very useful for my research in collecting information on:

- the number of the sewage treatment plant in your country
- the seriousness on the odour problem
- the area affected by the plants
- the control equipment
- the control legislation

For the research to be successful, your kind cooperation is important. I would be grateful if you would take a few minutes to complete the questionnaire and return it to me on the following address or by fax.

- Flat A, 39/F., Hoi Fung Mansion,
Riviera Gardens, Tsuen Wan,
Hong Kong

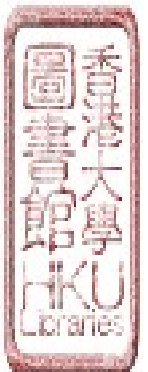
- Fax No: (852) 2402 8275

If you have any questions about the questionnaire please do not hesitate to contact me.

I appreciate your time and cooperation for participating in this research.

Yours faithfully,

KWAN Yiu-keung



Questionnaire on the Deodourization of Sewage Treatment Plant, Composting Plant, Abattoirs, Pumping Station, and Refuse Transfer Station

To: KWAN Yiu-keung, John
Fax No.: (852) 2402 8275

From:
Organisation/Department:
Address:
Fax No:

1. Please indicate the number of plants under different categories, and the seriousness of the odour problem generated by these plants:

Sewage Treatment Plant, number:	_____	, seriousness :	_____
Composting Plant, number:	_____	, seriousness :	_____
Abattoirs, number:	_____	, seriousness :	_____
Pumping Station, number:	_____	, seriousness :	_____
Refuse Transfer Station, number:	_____	, seriousness :	_____

(Please classify it into: very serious, serious, moderate, acceptable or nil)

2. What kind of people would be affected by the odour?

- operators
- passers-by
- nearby inhabitants
- others, please specify: _____

3. How large in average is the area (inside and outside of the plant) that would be affected by the odour?

Approx. Area: _____

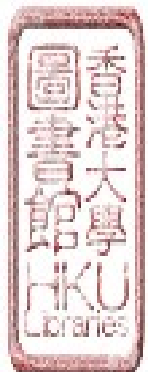
4. What percentage of the plant has been installed with odour control equipment?

Percentage: _____

5. What kind of odour control equipment was equipped in the concerned plants?
(You can tick more than one)

- scrubber, in what number: _____ (%)
- activated carbon, in what number: _____ (%)
- other pls specify _____, in what number: _____ (%)
- _____ , in what number: _____ (%)
- _____ , in what number: _____ (%)

Total 100%



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: _____

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: _____

8. How many existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

Number: _____ (or in _____ %)

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

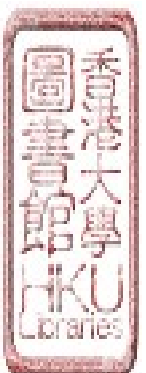
Number: _____ (or in _____ %)

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

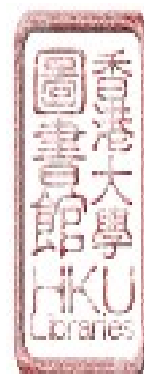
yes, please give details: _____

no,
if no, is there any other
related code of practice
or general guidelines: _____

11. Any additional information: _____



Appendix 4



List of Responders:

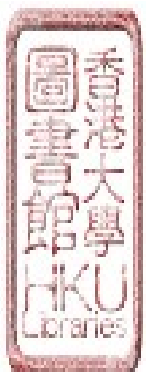
1. New York State, Department of Environmental Conservation, Division of Water
2. New York State, Department of Environmental Conservation, Division of Solid & Hazardous Materials (Refuse Transfer Stations)
3. New York State, Department of Environmental Conservation, Division of Solid & Hazardous Materials (Composting Plants)
4. Florida Department of Environmental Protection
5. Perth, Western Australia, Department of Environmental Protection
6. Texas Natural Resource Conservation
7. State of New Jersey, Department of Environmental Protection
8. Illinois Environmental Protection Agency
9. Republic of Singapore, Ministry of the Environment

(The above organisations have returned the completed questionnaires)

10. State of Washington, Department of Ecology
11. Swedish Environmental Protection Agency
12. Der Rat von Sachverständigen für Umweltfragen
13. Republik Österreich Bundesministerium für Umwelt
14. Israel Export Institute, Environmental Tech Centre
15. Austrian Ministry for Agriculture & Forestry
16. Umwelt Bundes, Federal Environmental Agency



Appendix 5



New York State Department of Envir
Division of Solid & Hazardous Materials
50 Wolf Road, Albany, New York 12233-72
518-457-6934 FAX 518-457-0629



Michael D. Zagata
Commissioner

NOV 17 1995

Mr. John KWAN Yiu-keung
Flat A, 39/F., Hoi Fung Mansion
Riviera Gardens, Tsuen Wan
HONG KONG

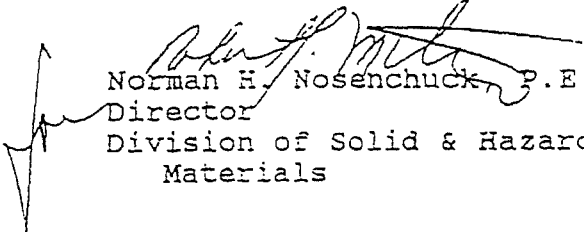
Dear Mr. KWAN Yiu-keung:

This is in response to your recent questionnaire regarding the deodourization of sewage treatment plants, composting plants, and refuse transfer stations.

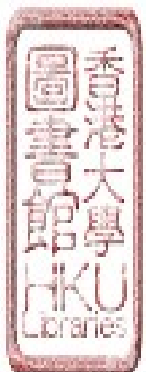
The following information represents facilities located in New York State. In addition, I am forwarding you a January 1994 document entitled, Municipal Sewage Sludge Management Practices in New York State, produced by the New York State Department of Environmental Conservation; and information on composting facilities located in New York State by Region. New York State consists of nine Regional Offices as shown on the enclosed map.

Should you have any questions regarding the completed questionnaires or the reports, please contact Mr. Robert Mitrey, Assistant Director, at (518) 457-3691.

Sincerely,


Norman H. Nosenchuck, P.E.
Director
Division of Solid & Hazardous
Materials

Enclosures



Questionnaire on the Deodourization of
Sewage Treatment Plant, Composting Plant, Abattoirs, Pumping Station,
and Refuse Transfer Station

To: KWAN Yiu-keung, John
Fax No.: (852) 2402 8275

From: New York State Department of Environmental Conservation
Organisation/Department: Division of Water
Address: 50 Wolf Road, Albany, New York 12233
Fax No: (518) 485-7786

1. Please indicate the number of plants under different categories, and the seriousness of the odour problem generated by these plants:

	2 - serious
	5 - moderate
Sewage Treatment Plant, number: <u>592</u> , seriousness :	<u>585</u> - acceptable to nil
Composting Plant, number: _____, seriousness :	_____
Abattoirs, number: _____, seriousness :	_____
Pumping Station, number: _____, seriousness :	_____
Refuse Transfer Station, number: _____, seriousness :	_____

(Please classify it into: very serious, serious, moderate, acceptable or nil)

2. What kind of people would be affected by the odour?

- operators
- passers-by
- nearby inhabitants
- others, please specify: _____

3. How large in average is the area (inside and outside of the plant) that would be affected by the odour?

Varies
Approx. Area: _____

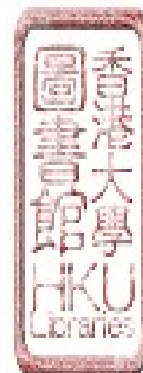
4. What percentage of the plant has been installed with odour control equipment?

Percentage: _____

5. What kind of odour control equipment was equipped in the concerned plants?
(You can tick more than one)

<input checked="" type="checkbox"/> scrubber,	in what number: <u>2</u> (<u> </u> %)
<input type="checkbox"/> activated carbon,	in what number: _____ (<u> </u> %)
<input checked="" type="checkbox"/> other pls specify _____	in what number: _____ (<u> </u> %)
improved operation	in what number: <u>5</u> (<u> </u> %)
process change	in what number: <u> </u> (<u> </u> %)
Total 100%	

1/2



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: _____.

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: _____.

8. How many existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

Number: 0 (or in _____ %)

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

Number: 0 (or in _____ %)

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

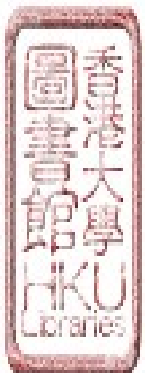
yes, please give details: _____

no,
if no, is there any other
related code of practice
or general guidelines: General nuisance provisions of local legislation
operation and maintenance conditions of permit
to discharge.

11. Any additional information: _____

End

2/2



Questionnaire on the Deodourization of
Sewage Treatment Plant, Composting Plant, Abattoirs, Pumping Station,
and Refuse Transfer Station

To: KWAN Yiu-keung, John
Fax No.: (852) 2402 8275

From: New York State Department of Environmental Conservation
Organisation/Department: Division of Solid & Hazardous Materials
Address: 50 Wolf Road, Albany, New York 12233
Fax No: (518) 485-7733

1. Please indicate the number of plants under different categories, and the seriousness of the odour problem generated by these plants:

Sewage Treatment Plant, number:	_____	seriousness :	_____
Composting Plant, number:	_____	seriousness :	_____
Abattoirs, number:	_____	seriousness :	_____
Pumping Station, number:	_____	seriousness :	_____
Refuse Transfer Station, number:	<u>481*</u>	seriousness :	<u>moderate at large tra</u>
	<u>see note</u>		<u>sta</u>

(Please classify it into: very serious, serious, moderate, acceptable or nil)

2. What kind of people would be affected by the odour?

- operators
- passers-by
- nearby inhabitants
- others, please specify: _____

3. How large in average is the area (inside and outside of the plant) that would be affected by the odour?

Not known. Odor problems typically are a problem for _____ persons at the facility or those who are immediately adjacent to the facility.

4. What percentage of the plant has been installed with odour control equipment?

Percentage: Approximately 40-50% of the large transfer stations in New York State.

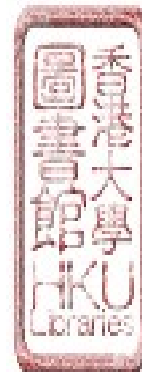
5. What kind of odour control equipment was equipped in the concerned plants?
(You can tick more than one)

- | | | | | | |
|---|-----------------------|-----------------------|-------|-------|----|
| <input type="checkbox"/> scrubber, | in what number: _____ | (| _____ | %) | |
| <input type="checkbox"/> activated carbon, | in what number: _____ | (| _____ | %) | |
| <input checked="" type="checkbox"/> other pls specify _____ | in what number: _____ | (| _____ | %) | |
| | _____ | in what number: _____ | (| _____ | %) |
| | _____ | in what number: _____ | (| _____ | %) |
| | | Total | 100% | | |

The large transfer stations which are odor-control utilized perfumed misting

*NOTE: Of these 481 facilities, 194 are large refuse transfer stations accepting more than 50,000 cubic yards or 12,500 tons annually. The remaining are small transfer stations which accept less than 50,000 cubic yards annually. Odors are not generally a problem at the small transfer stations.

agents inside the tipping floor are



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: _____

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: _____

8. How many existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

Number: Unknown (or in _____ %)

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

Number: Unknown (or in _____ %)

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

- yes, please give details: New York State's Environmental Conservation Law states that the Department has the power to adopt and promulgate, amend and repeal rules and regulations directed at the prevention and reduction of obnoxious odors (see attached page). New York State's Part 360 regulations which govern the operation of transfer stations include a requirement that processing, tipping, sorting, storage and compaction areas must be located within an enclosed building. Furthermore, the regulations state that transfer stations and transfer vehicles must be cleaned to prevent odors. The regulations also state that odors must be effectively controlled they do not constitute nuisances or hazards to health, safety, or property.
- no, if no, is there any other related code of practice or general guidelines: _____

11. Any additional information: _____

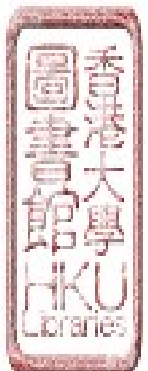
Additional information:

End

2/2

The Part 360 regulations state that all putrescible solid waste must be removed from the transfer station whenever transfer containers are full, or within 7 days of receipt, whichever comes first. This aids in preventing very serious odor problems.

Attachment



§ 27-0701

ENVIRONMENTAL CONSERVATION

lished by the Public Health Council and enforced by local public health agencies, have been ineffective because of the diffusion of responsibility and a lack of uniformity in enforcement policies.

"In recognition of the need for and the cost of providing improved solid waste management facilities, the people of the state approved the environmental quality bond act of nineteen hundred seventy-

two [L.1972, c. 658] which will assist local governments in financing improved facilities.

"It is the purpose of this act [L.1973, c. 399] to assure that solid waste management is conducted in a safe, sanitary, efficient, economic and environmentally sound manner throughout the state by providing a unified regulatory framework therefor."

Cross References

Definitions—

- Inactive hazardous waste disposal sites, see section 27-1301.
- Industrial hazardous waste management, see section 27-0901.
- Industrial siting hazardous waste facilities, see section 27-1101.
- Litter and solid waste control, see section 27-1003.
- Solid waste management and resource recovery facilities, see section 27-0701.
- State aid for implementation of resource recovery and other improved solid waste management systems, see section 27-0501.
- Waste transporter permits, see section 27-0303.

New York Codes, Rules and Regulations

Additional definitions, see 6 NYCRR 360.1.

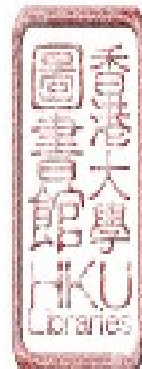
Library References

- Health and Environment 25.5(5).
- C.J.S. Health and Environment §§ 91 et seq., 106 et seq., 131.

§ 27-0703. Powers of the department

The department shall have the power to:

1. Adopt and promulgate, amend and repeal rules and regulations governing the operation of solid waste management facilities. Such rules and regulations shall be directed at the prevention or reduction of (a) water pollution, (b) air pollution, (c) noise pollution, (d) obnoxious odors, (e) unsightly conditions caused by uncontrolled release of litter, (f) infestation of flies and vermin, and other conditions inimical to the public health, safety and welfare. In promulgating such rules and regulations, the department shall give due regard to the economic and technological feasibility of compliance therewith. Any rule or regulation promulgated pursuant hereto may differ in its terms and provisions as between particular types of solid waste management facilities and as between particular areas of the state.
2. Provide technical assistance to municipalities and other persons engaged in solid waste management and provide training for proper operation of solid waste management facilities.



Questionnaire on the Deodourization of
Sewage Treatment Plant, Composting Plant, Abattoirs, Pumping Station,
and Refuse Transfer Station

To: KWAN Yiu-keung, John
Fax No.: (852) 2402 8275

From: New York State Department of Environmental Conservation
Organisation/Department: Division of Solid & Hazardous Materials
Address: 50 Wolf Road, Albany, New York 12233
Fax No: (519) 485-7733

1. Please indicate the number of plants under different categories, and the seriousness of the odour problem generated by these plants:

Sewage Treatment Plant, number: _____, seriousness : _____
Composting Plant, number: 34*, seriousness : moderate to problem
Abattoirs, number: _____, seriousness : _____
Pumping Station, number: _____, seriousness : _____
Refuse Transfer Station, number: _____, seriousness : _____

(Please classify it into: very serious, serious, moderate, acceptable or nil)

*See attached list of facilities.

2. What kind of people would be affected by the odour?

- operators
- passers-by
- nearby inhabitants
- others, please specify: _____.

3. How large in average is the area (inside and outside of the plant) that would be affected by the odour?

Varies
Approx. Area: _____

4. What percentage of the plant has been installed with odour control equipment?

Percentage: _____

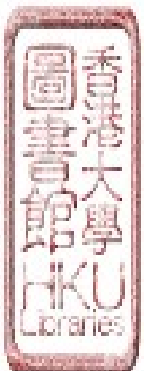
5. What kind of odour control equipment was equipped in the concerned plants?

(You can tick more than one)

- scrubber, in what number: _____ (%)
- activated carbon, in what number: _____ (%)
- other pls specify _____, in what number: _____ (%)
- _____ in what number: _____ (%)
- _____ in what number: _____ (%)

Total 100%

Atomizer - spray
into pile.



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: _____

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: _____

8. How many existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

Number: Unknown (or in _____ %)

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

Number: Unknown (or in _____ %)

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

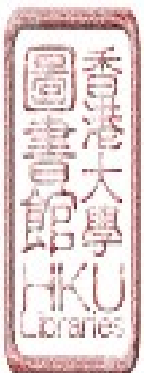
yes, please give details: See page 5-3 /Section 360-5-3 (h) / of the New York State document entitled 6NYCRR Part 36 Solid Waste Management Facilities

no,
if no, is there any other related code of practice or general guidelines: _____

11. Any additional information: _____

End

2/2



Questionnaire on the Deodourization of
Sewage Treatment Plant, Composting Plant, Abattoirs, Pumping Station,
and Refuse Transfer Station

To: KWAN Yiu-keung, John
Fax No.: (852) 2402 8275

From: Richard Addison
Organisation/Department: Florida Department of Environmental Protection
Address: 2600 Blair Stone Road Tallahassee FL 32399-2400
Fax No: 904-921-6385

1. Please indicate the number of plants under different categories, and the seriousness of the odour problem generated by these plant:

State of Florida, USA

Sewage Treatment Plant,	number: <u>3459</u> ,	seriousness: <u>Varies by plant</u>
Composting Plant,	number: <u>6</u> ,	seriousness: <u>Varies by plant</u>
Abattoirs,	number: <u>unknown</u> ,	seriousness: <u>unknown</u>
Pumping Station,	number: <u>unknown</u> ,	seriousness: <u>Varies by pumping station</u>
Refuse Transfer Station,	number: <u>unknown</u> ,	seriousness: <u>unknown</u>

(Please classify it into: very serious, serious, moderate, acceptable or nil)

2. What kind of people would be affected by the odour?

- operators
- passers-by
- nearby inhabitants
- others, please specify: _____

3. How large in average is the area (inside and outside of the plant) that would be affected by the odour?

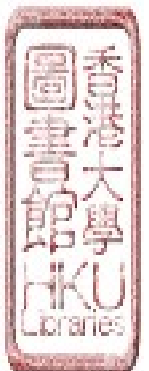
Approx. Area: Varies by plant

4. What percentage of the plant has been installed with odour control equipment?

Percentage: Unknown, we do not track this.

5. What kind of odour control equipment was equipped in the concerned plants?
(You can tick more than one) Unknown, we do not track this.

- | | |
|---|----------------------------------|
| <input type="checkbox"/> scrubber, | in what number: _____ (_____ %) |
| <input type="checkbox"/> activated carbon, | in what number: _____ (_____ %) |
| <input type="checkbox"/> other pls specify _____, | in what number: _____ (_____ %) |
| _____ | in what number: _____ (_____ %) |
| _____ | in what number: _____ (_____ %) |
| Total 100% | |



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: _____.

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: _____.

8. How many existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

Number: _____ (or in _____ %) *UNKNOWN, we do not track this*

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

Number: _____ (or in _____ %) *UNKNOWN, we do not track this*

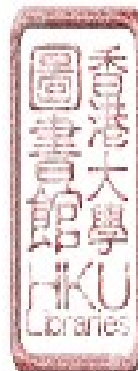
10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

yes, please give details: *Rule is attached. See pages 22-23 and 27-28.*

no,

if no, is there any other
related code of practice
or general guidelines:

11. Any additional information: *EPA Design Manual "Odor and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants" is attached for your use.*



REMARKS: Notes These figures are an estimate for Western Australia as accurate information is not available

Questionnaire on the Deodourization of Sewage Treatment Plant

at

If not claimed within 7 days, please return to:
Westralia Square, 141 St George's Terrace, Perth, Western Australia
GPO Box S1400, Perth, Western Australia 6001

To: KWAN Yiu-keung, John
Fax No.: (852) 2402 8275

Department of Environmental Protection

From: NGSL DRAINAGE

Organisation/Department: DEPARTMENT OF ENVIRONMENTAL PROTECTION
Address: PO BOX 73030, EAST ST GEORGE'S TERRACE, PERTH WA 6832
Fax No: (619) 222 0455

1. Please indicate the number of plants under different categories, and the seriousness of the odour problem generated by these plants:

Sewage Treatment Plant,	number: <u>200</u> ,	seriousness: <u>MODERATE</u>
Composting Plant,	number: <u>NIL</u> ,	seriousness: <u>N/A</u>
Abattoirs,	number: <u>100</u> ,	seriousness: <u>MODERATE</u>
Pumping Station,	number: <u>1000</u> ,	seriousness: <u>NIL</u>
Refuse Transfer Station,	number: <u>5</u> ,	seriousness: <u>NIL</u>

(Please classify it into: very serious, serious, moderate, acceptable or nil)

2. What kind of people would be affected by the odour?

- operators
- passers-by
- nearby inhabitants
- others, please specify: _____

3. How large in average is the area (inside and outside of the plant) that would be affected by the odour?

Approx. Area: 500 m - 1000 m

4. What percentage of the plant has been installed with odour control equipment?

Percentage: 0%

5. What kind of odour control equipment was equipped in the concerned plants?

(You can tick more than one)

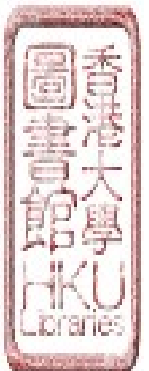
- scrubber, in what number: _____ (5 %)
- activated carbon, in what number: _____ (1 %)
- other pls specify: _____, in what number: _____ (5 %)
- _____ in what number: _____ (_____ %)
- _____ in what number: _____ (_____ %)

INCINERATOR / AIR POLLUTANT CONTROL

TO DESTROY ODOR

Total 100%

In most cases odour control is achieved by ensuring adequate buffer distances around the plant.



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: _____.

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: _____.

8. How many existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

Number: NIL (or in _____ %)

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

Number: NIL (or in _____ %)

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

yes, please give details: _____

no.

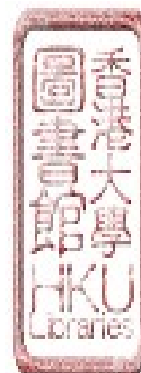
if no, is there any other related code of practice or general guidelines:

CODES OF PRACTICE EXIST FOR FACTORIES

11. Any additional information: VEGETARIAN ENVIRONMENTAL PROTECTION AUTHORITY HAS MORE COMPREHENSIVE INFORMATION.

End

2/2



Questionnaire on the Deodourization of
Sewage Treatment Plant, Composting Plant, Abattoirs, Pumping Station,
and Refuse Transfer Station

To: KWAN Yiu-keung, John
Fax No.: (852) 2402 8275

TEXAS NATURAL RESOURCE
CONSERVATION COMMISSION
P.O. Box 13087
Austin, Texas 78711-3087

From: Municipal Permits
Organisation/Department: Texas Natural Resource Conservation
Address: P.O. Box 13087
Fax No: 512 239-4430

1. Please indicate the number of plants under different categories, and the seriousness of the odour problem generated by these plants:

Sewage Treatment Plant, number: 2430, seriousness: ~~moderate~~ moderate
Composting Plant, number: 90, seriousness: ~~serious~~ serious
Abattoirs, number: _____, seriousness: _____
Pumping Station, number: 2 x 10⁴, seriousness: ~~acceptable~~ acceptable
Refuse Transfer Station, number: 10,170, seriousness: ~~acceptable~~ acceptable

(Please classify it into: very serious, serious, moderate, acceptable or nil)

2. What kind of people would be affected by the odour?

- operators
- passers-by
- nearby inhabitants
- others, please specify: _____

3. How large in average is the area (inside and outside of the plant) that would be affected by the odour?

Approx. Area: 500 Ft

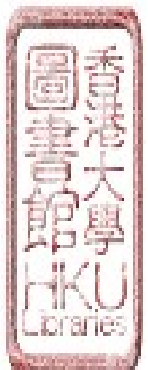
4. What percentage of the plant has been installed with odour control equipment?

Percentage: 10%

5. What kind of odour control equipment was equipped in the concerned plants?

(You can tick more than one)

<input checked="" type="checkbox"/> scrubber,	in what number:	<u>9</u>	(_____	(_____	%)
activated carbon,	in what number:	_____	(_____	(_____	%)
<input checked="" type="checkbox"/> other pls specify <u>ORM</u>	in what number:	<u>20</u>	(_____	(_____	%)
<u>Design</u>	in what number:	<u>10</u>	(_____	(_____	%)
<u>collection system</u>	in what number:	<u>10</u>	(_____	(_____	%)
						Total 100%	



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: _____

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: _____

8. How many existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

Number: 212 (or in _____ %)

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

Number: 53 (or in _____ %)

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

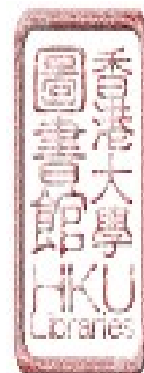
yes, please give details: Buffer Zone Distance

no,
if no, is there any other
related code of practice
or general guidelines: _____

11. Any additional information: _____

End

2/2



5.2.6 Siphons

Siphons, also called inverted siphons or depressed sewers, are used to convey wastewater under streams or highways, conduits or other obstructions to the normal sewer grade line, and to regain as much elevation as possible after passing the obstruction. Siphons are normally limited to pipe sizes greater than 20-cm (8-in) diameter. Sewage in siphons is under pressure, since the conduits are below the hydraulic grade line. Because the siphon remains full even during periods of no flow, it is a potential site of significant sulfide generation and odor release.

Methods of controlling sulfide generation that would be applicable to siphons were discussed in Chapter 3. These techniques include improving the oxygen balance by air or oxygen injection, or by addition of chemicals to oxidize or precipitate the sulfide or prevent its formation.

Siphon design must consider the potential for odor release. Positive pressure develops in the atmosphere upstream of the siphon due to the downstream movement of air induced by the wastewater flow. Air thus tends to exhaust from the manhole at the siphon inlet and may escape in large amounts from small openings, such as pick holes in manhole covers. At less than maximum flow, wastewater dropping into the inlet may cause turbulence and odor release.

One technique that has been successfully used to minimize odor release at siphons is the use of air jumpers. These are pipes that take the air off the top of the inlet structure and convey it to the end of the siphon. In most cases, air jumpers run parallel to the siphon, although the pipe can be suspended above the hydraulic grade line. Provisions should be made to drain the air jumper to periodically remove accumulated condensate. Usually, the diameter of the air jumper pipe is approximately one-half that of the siphon (5). Solids deposition is another potential problem and siphons should normally be designed for velocities of 0.9 m/s (3.0 ft/s) to prevent solids deposition and subsequent odor generation. In some cases, multiple siphon lines are installed to ensure adequate velocities during the early design lifetime of the system. In these instances, the unused sewer line may be used as the air jumper line during the early design period when flow is small and sulfide generation may be a problem.

5.3 Ventilation of Sewers

5.3.1 Objectives of Ventilation

Ventilation of sewers is often undertaken for a variety of reasons. For the most part, only the control of odors is practically achievable with ventilation. Some of the reasons ventilation has been attempted are discussed here.

5.3.1.1 Increasing the Oxygen Content of the Sewer Atmosphere

The oxygen content of the sewer atmosphere does not change significantly as a result of the septicity of the wastewater. In partially filled sewers, rise and fall of the liquid level results in displacement and replacement of air, and there is normally a downstream flow of air due to a drag effect between the air-sewage interface. Oxygen concentrations in such sewers are rarely less than 90 percent of normal. If oxygen concentrations are above 90 percent of normal, ventilation is unlikely to make a significant difference in the oxygen balance of the stream.

5.3.1.2 Reducing the Atmospheric H₂S Concentrations

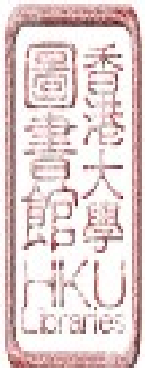
Although it would seem feasible to ventilate sewers to reduce the atmospheric sulfide concentrations and thus control corrosion, this approach has little practical value. In order to have measureable results, complete replacement of the sewer atmosphere with fresh air would be required at frequent intervals. Even if this approach were economical, there would be the problem of disposal of large volumes of malodorous air.

5.3.1.3 Drying the Walls of Sewers and Other Structures

The oxidation of hydrogen sulfide gas to sulfuric acid does not occur if the surface is dry, since moisture must be present for bacterial oxidation of H₂S. Ventilation has been used with the objective of drying sewer walls. Thistlethwayte estimated that when the relative humidity of the sewer atmosphere exceeds 80 to 85 percent, sufficient moisture will be present on the walls to support bacterial activity (5). Thistlethwayte also proposes a design procedure for ventilation of sewers to control humidity, but indicates that in most cases this approach is not practicable. This is due to the rapid increase in relative humidity of ventilation air with flow along the sewer, the large number of ventilation stations required, and the significant increase in operation and maintenance costs. Pomeroy also indicates that this approach is impractical for year-round protection for even typical sewer distances between manholes (1).

5.3.1.4 Preventing Lethal Atmospheres

Portable fans or blowers are often used to ventilate manholes before workers enter. This is acceptable practice for localized conditions, provided other normal safety procedures are followed. However, it is questionable as to whether this practice would provide a safe environment between manholes. It is not feasible to ventilate large sections of a sewer system sufficiently to assure a safe environment for sewer workers.



5.3.1.5 Preventing Explosive Atmospheres

Explosions in sewers generally result from the presence of large amounts of volatile hydrocarbons or from leaking natural gas mains. Only under very unusual conditions do explosions result from accumulation of sewer gases. Because of the unpredictable causes of explosions and the conditions under which they occur, it is unlikely that ventilation could assure protection from explosions in a wastewater collection system.

5.3.1.6 Controlling Odor Emissions

Sewer ventilation can withdraw malodorous air at one point in order to prevent odor emissions at other locations. Normally, contaminated air must undergo treatment by one or more of the techniques discussed in Chapter 4. Ventilation is often practiced at wastewater treatment plants, where air is withdrawn at the downstream terminus of the sewer (plant headworks) and either treated separately or piped to existing biological stabilization processes for removal of odors. Although most other possible objectives have not been achieved by practical levels of ventilation alone, control of odor emissions can be effectively served by continuous ventilation.

5.3.2 Methods of Ventilation

Ventilation of a sewer can occur through both natural and mechanical means. Virtually all sewers incorporate some method of natural ventilation. Mechanical ventilation, on the other hand, is normally employed only in response to complaints of odor emissions from a portion of the collection system following the original design. The two methods are discussed below.

5.3.2.1 Natural Ventilation

Collection systems in the United States do not normally incorporate special vents or hardware to assist in natural sewer ventilation. Rather, manholes and building vents are generally considered adequate to keep sewers sufficiently ventilated (6).

Natural ventilation occurs from the following forces (5)(8).

1. Change in barometric pressure along the sewer
2. Wind velocities past vents
3. Frictional drag of wastewater on sewer air
4. Rise and fall of the wastewater level in the sewer
5. Relative density differences of sewer air and outside air

The degree of natural ventilation which occurs in a sewer is difficult to predict, since fluctuations in the above variables may change both the direction of movement and velocity of the air contained in the sewer.

Whereas no special provisions are normally made to enhance natural ventilation of sewers in the United

States, special ventilation systems are routinely incorporated into sewer designs in the United Kingdom and Australia (5). The reason for this is that collection systems designed in the United Kingdom and Australia have typically incorporated "boundary traps" or "running traps" at building sewers or house laterals, which effectively prevent the transfer of air between the sewer and building vents. Since the building vent is no longer a source of ventilation air, induct and educt stacks are placed at various locations in the collection system to allow air movement into and out of the sewer. Research on natural sewer ventilation systems is discussed in References 7 and 8, and detailed design procedures for such ventilation systems are presented in Reference 4.

5.3.2.2 Mechanical Ventilation

Mechanical ventilation may be employed where a constant velocity and direction of air flow is desired. This may be necessary where odor emissions from sewers must be controlled, as in residential neighborhoods, or where hydraulic conditions that occur in siphons or surcharged sewers result in stagnant air pockets with reduced oxygen contents. Mechanical ventilation may also be employed at headworks of wastewater treatment plants in order to convey malodorous sewer gases to odor control systems.

Figure 5-9 shows two examples of the use of mechanical ventilation for odor control in Austin, Texas (10). At Williamson Creek, odors escaping from septic wastewater entering the wet well necessitated sealing of the wet well and upstream manhole to allow withdrawal of air from 5,980 m (19,600 ft) of 106-cm (42-in) diameter concrete outfall line. A 7.1- m^3/min (250-scfm) blower was used to remove odorous gases from the sewer and discharge them to an aerated stabilization pond. This approach was successful in controlling odors from the system.

A similar approach was used for the Walnut Creek system. This was a total gravity system which included a siphon for conveying wastewater under Walnut Creek. Two 14.2- m^3/min (500-scfm) blowers were used to remove odorous gases from 3,200 m (10,500 ft) of concrete sewer at a sealed manhole upstream of the siphon. The blower discharged the gases through air lift pumps in the aeration basin of the treatment plant to achieve better mixing of the tank contents and absorption and oxidation of the odorous components of the gas in the aerated liquid.

Ventilation of pumping stations is part of normal design procedures for these structures. A minimum of 12 air changes per hour is recommended for continuously ventilated wet wells and 30 air change per hour for intermittently ventilated wet wells. A minimum of 6 air changes per hour is recommended for continuously ventilated dry wells and 30 air

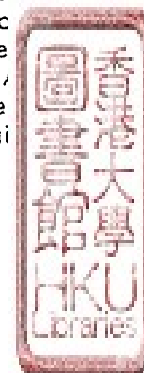
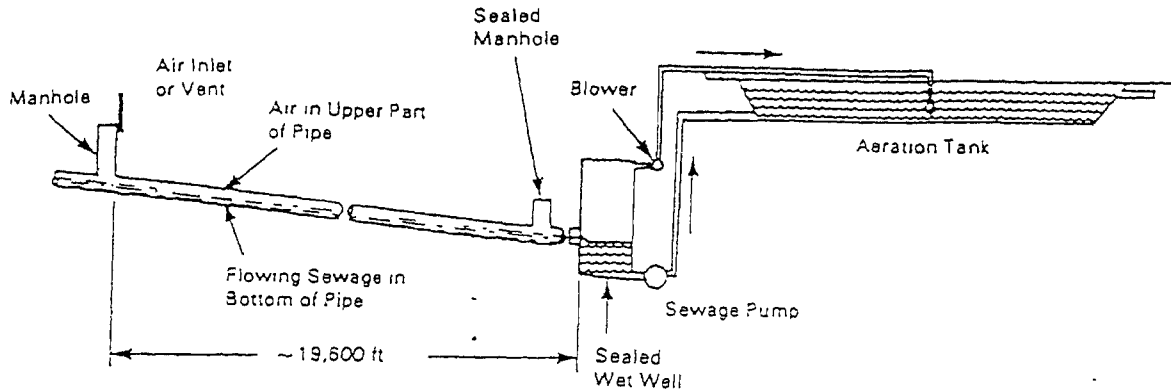
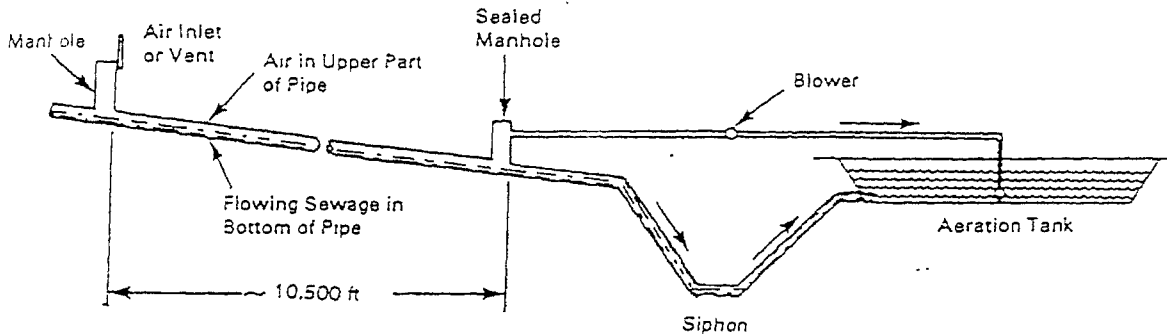


Figure 5-9. Forced draft ventilation for odor control, Austin, TX (9).



a) Ventilation System at Williamson Creek, TX



b) Ventilation System at Walnut Creek, TX

changes per hour for intermittently ventilated dry wells and other below grade structures (11).

5.4 Selection of Materials

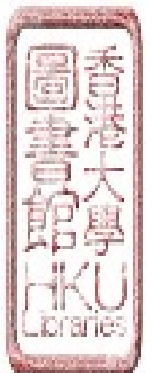
Materials selection is a critical aspect in design of wastewater collection systems in which sulfide generation is likely to pose problems. The additional expense of using materials with greater degree of corrosion resistance may be justified by the cost savings for replacement or rehabilitation of deteriorated structures at some later date. The following discussion describes the various materials used in collection systems, with particular emphasis on the corrosion-resistant properties of each material.

5.4.1 Pipe Materials

If sulfide is expected to be present in sufficient quantities to cause corrosion, consideration must be

given to the use of pipe materials with higher degrees of corrosion resistance. Design considerations in selecting such materials are (1):

1. Availability of the materials in the pipe sizes required
2. Minimum and maximum levels of sulfide expected in the wastewater
3. Factors other than acid resistance of the pipe (abrasion resistance, stress-corrosion resistance, load-bearing strength, and other durability considerations)
4. Hydraulic characteristics of the materials under conditions of actual use
5. Other advantages or disadvantages of the material (ease of installation, resistance to infiltration, flexibility, etc.)
6. Expected future service requirements
7. Relative costs vs. expected service lifetimes of various kinds of pipe



Questionnaire on the Deodourization of
Sewage Treatment Plant, Composting Plant, Abattoirs, Pumping Station,
and Refuse Transfer Station

To: KWAN Yiu-keung, John
Fax No.: (852) 2402 8275

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF ENVIRONMENTAL QUALITY
CN 027
TRENTON, NEW JERSEY 08625-0027

From: MAX FRIEDMAN

Organisation/Department: NJ DEPARTMENT OF ENVIRONMENTAL PROTECTION
Address: 401 EAST STATE STREET, TRENTON, NJ 08625
Fax No:

1. Please indicate the number of plants under different categories, and the seriousness of the odour problem generated by these plants:

Sewage Treatment Plant, number: 50, seriousness: Very Serious
Composting Plant, number: 5, seriousness: Very Serious
Abattoirs, number: _____, seriousness: _____
Pumping Station, number: 100, seriousness: Moderate
Refuse Transfer Station, number: 40, seriousness: Serious

(Please classify it into: very serious, serious, moderate, acceptable or nil)

2. What kind of people would be affected by the odour?

- operators
- passers-by
- nearby inhabitants
- others, please specify: _____

3. How large in average is the area (inside and outside of the plant) that would be affected by the odour?

Approx. Area: DEPENDS ON SIZE OF SITE

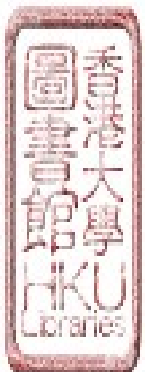
4. What percentage of the plant has been installed with odour control equipment?

Percentage: _____
Sewage Treatment 100%
Compost Plant 100%
Pump Station 25%
Transfer Station 100%

5. What kind of odour control equipment was equipped in the concerned plants?

(You can tick more than one)

- scrubber, in what number: _____ (60%)
 - activated carbon, in what number: _____ (10%)
 - other pls specify Biofilters, in what number: _____ (30%)
 - _____ in what number: _____ (%)
 - _____ in what number: _____ (%)
- Total 100%



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: _____

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: _____

8. How many existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

Number: _____ (or in 10 %)

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

Number: _____ (or in 100 %)

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

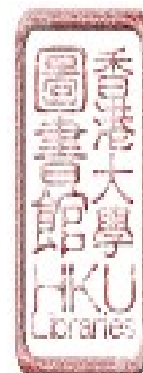
yes, please give details: NJAC 7:27-5
NO ODORS BEYOND THE
PROPERTY LINE

no,
if no, is there any other
related code of practice
or general guidelines: _____

11. Any additional information: _____

End

- 2/2





State of Illinois
ENVIRONMENTAL PROTECTION AGENCY

Mary A. Gade, Director
217/782-3397

2200 Churchill Road, Springfield, IL 62794-9276

November 30, 1995

John Yiu-keung Kwan
Flat A, 39/F, Hai Fung Mansion
Riviera Gardens, Tsuen Wan
Hong Kong

Dear Mr. Kwan:

Your recent questionnaire on odor problems at sewage treatment plants, compost sites, waste transfer sites and other environmental areas is enclosed. Our staff completed the questions for only those areas over which we have jurisdiction. We do not keep records on sewage pumping stations because of the number of them in Illinois.

All of the data provided is for the State of Illinois only. We hope this provides meaningful input into your research. If you need clarification contact Tom McSwiggin of our staff.

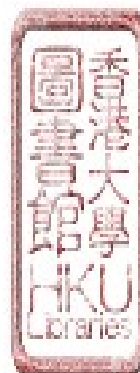
Sincerely,

A handwritten signature in cursive script that reads "Mary A. Gade".

Mary A. Gade
Director

MAG:TGM:med

Enclosure



Questionnaire on the Deodourization of
Sewage Treatment Plant, Composting Plant, Abattoirs, Pumping Station,
and Refuse Transfer Station

To: KWAN Yiu-keung, John
Fax No. (852) 2402 8275

From: Thomas G. McSwiggin, Manager, Permit Section, DWPC
Organisation/Department: Illinois Environmental Protection Agency
Address: 2200 Churchill Road, Springfield, IL 62794-9276
Fax No. 217/782-9891

1. Please indicate the number of plants under different categories, and the seriousness of the odour problem generated by these plants:

Sewage Treatment Plant,	number: <u>Approx 1400</u> ,	seriousness: <u>10 plants</u> - moderate odour
*Composting Plant,	number: <u>80</u> ,	seriousness: <u>4</u>
Abattoirs,	number: _____,	seriousness: _____
Pumping Station,	number: <u>Unknown</u> ,	seriousness: <u>Unknown</u>
Refuse Transfer Station,	number: <u>50</u> ,	seriousness: <u>1</u>
*Landscape waste & refuse		

(Please classify it into: very serious, serious, moderate, acceptable or nil)

2. What kind of people would be affected by the odour?

- operators
- passers-by
- nearby inhabitants
- others, please specify: _____.

3. How large in average is the area (inside and outside of the plant) that would be affected by the odour?

Approx. Area: 1 Sq. Mile

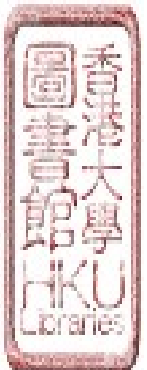
4. What percentage of ~~the~~ plant has been installed with odour control equipment?

Percentage: Only 4 or 5 Sewage Plants have odor control equipment
See below for compost and refuse transfer site

5. What kind of odour control equipment was equipped in the concerned plants?

(You can tick more than one)

<input type="checkbox"/> scrubber,	in what number: _____ (_____ %)
<input checked="" type="checkbox"/> activated carbon,	in what number: <u>10</u> (<u>8</u> %)
<input checked="" type="checkbox"/> other pls specify <u>Chemicals</u> ,	in what number: <u>20</u> (<u>15</u> %)
<u>operating control</u> ,	in what number: <u>100</u> (<u>77</u> %)
_____,	in what number: _____ (_____ %)
Total 100%	



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: _____

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: _____

8. How many existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour-control equipment?

Number: 0 (or in %)

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

Number: ? (or in %)

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

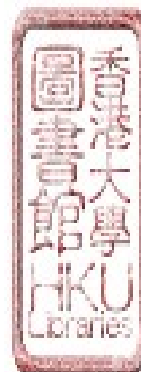
yes, please give details: Setback requirements from receptors

no,
if no, is there any other
related code of practice
or general guidelines: _____

11. Any additional information: This questionnaire covers both sewage treatment and solid wastes, which have different problems

End

2/2





SEW/32.7

11 Dec 95

Mr Kwan Yiu-Keung
Flat A, 39/F, Hoi Fung Mansion
Rivera Gardens, Tsuen Wan
Hong Kong

Dear Sir

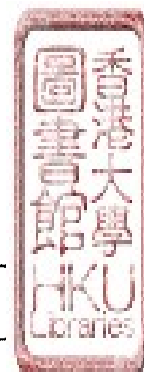
QUESTIONNAIRE ON DEODOURISATION

I refer to your letter on the above subject.

2. We are pleased to return the questionnaire on our Sewage Treatment Works and Pumping Station and Refuse Transfer Station.
3. We hope the information given are sufficient for your research. Should you need further information, please free feel to write to us.

Yours faithfully

LOO HAK JAN
for HEAD
SEWERAGE DEPARTMENT



Questionnaire on the Deodourization of
Sewage Treatment Plant, Composting Plant, Abattoirs, Pumping Station,
and Refuse Transfer Station

To: KWAN Yiu-keung, John
Fax No.: (852) 2402 8275

From:
Organisation/Department:
Address:
Fax No:

1. Please indicate the number of plants under different categories, and the seriousness of the odour problem generated by these plants:

Sewage Treatment Plant,	number: <u>6</u> ,	seriousness: <u>Moderate</u>
Composting Plant,	number: <u>-</u> ,	seriousness: <u>--</u>
Abattoirs,	number: <u>-</u> ,	seriousness: <u>-</u>
Pumping Station,	number: <u>134</u> ,	seriousness: <u>Moderate</u>
Refuse Transfer Station,	number: <u>1</u> ,	seriousness: <u>Acceptable</u>

(Please classify it into: very serious, serious, moderate, acceptable or nil)

2. What kind of people would be affected by the odour?

- operators
- passers-by
- nearby inhabitants
- others, please specify: _____

3. How large in average is the area (inside and outside of the plant) that would be affected by the odour?

Approx. Area: 2.8ha

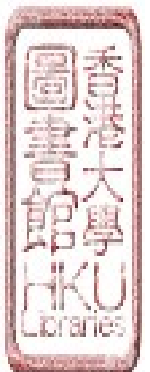
4. What percentage of the plant has been installed with odour control equipment?

Percentage: can't put a % value. Ans: Concentrated sources of odour

5. What kind of odour control equipment was equipped in the concerned plants?

(You can tick more than one)

- | | |
|---|-------------------------------|
| <input type="checkbox"/> scrubber, | in what number: _____ (%) |
| <input checked="" type="checkbox"/> activated carbon, | in what number: _____ (100 %) |
| <input type="checkbox"/> other pls specify _____, | in what number: _____ (%) |
| _____, | in what number: _____ (%) |
| _____, | in what number: _____ (%) |
| Total 100% | |



6 The reasons for those plants without equipping odour control equipment are
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify _____

7 The reasons for those plants equipping with odour control equipment are
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify _____

8 How many existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

Number 6 (or in 100 %)

9 How many new plants are planned to lower their odour emissions by incorporating the odour control equipment? No new plants being planned yet

Number NA (or in _____ %)

10 Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

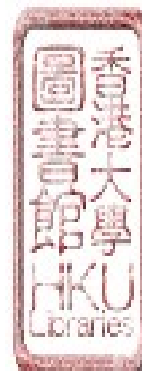
yes, please give details: 1 km buffer zone imposed around the plants, in which only industrial developments are permitted. Plans underway to reduce buffer zone in the long-term

no,
if no, is there any other related code of practice or general guidelines _____

11 Any additional information _____

End

2/2





STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

P.O. Box 47600 • Olympia, Washington 98504-7600
(360) 407-6000 • TDD Only (Hearing Impaired) (360) 407-6006

October 30, 1995

Mr. KWAN Yiu-keung
Flat A, 39/F., Hoi Fung Mansion
Riviera Gardens, Tsuen Wan
Hong Kong

Dear Mr. KWAN Yiu-keung:

This letter is in response to your request for information on odor problems and controls from various facilities in the state of Washington.

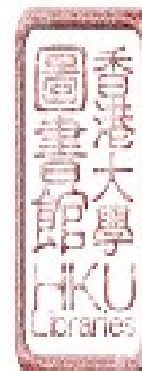
As a matter of priority and due to resource limitations, the Department of Ecology does not keep a data base on the odor problems and the regulatory actions taken to control them. The state of Washington has water and air quality standards which require that aesthetic values shall not be impaired by the presence of materials or their effects which offend the senses of sight, smell, touch, or taste. These standards apply to the municipal or industrial facilities.

Generally, design of such facilities incorporates provisions that will eliminate or reduce odors, or they are located in areas that present little or no odor problems. Where odors are detected from a sewerage system, they are usually reported to the local public utility department or, in the case of an industrial operation, to the facility manager. Usually, the utility department or the facility manager will act to eliminate the source and there is no need for a regulatory action against the party responsible. However, for a persistent odorous source, removal of which requires major planning and investment, a regulatory order may be issued to ensure that the public entity or the facility manager responsible will eliminate the source in a timely manner.

Recently, in response to relatively new air pollution control requirements, a few large wastewater treatment facilities, which are primarily located in densely populated areas, are taking steps to control the emission of Volatile Organic Compounds (VOCs). Although these requirements primarily target VOCs, steps taken to control their emission (e.g., collecting and treating the air from some unit processes) will also reduce the release of odorous compounds from these facilities.

Sincerely,

Foroozan Labib, PhD, P.E.
Water Quality Program



Swedish Environmental
Protection Agency
Infrastructure Department
Water Management Section
Ms Kajsa Sundberg, M Sc
Tel + 46 - 8 698 12 16
Fax + 46 - 8 698 14 33
e-mail kas@environ.se

Aberoppa vid korrespondens

Datum
1996-01-10

SNV:s diarienummer
622-7003-95 Sv

KWAN Yiu-keung
Flat A,39/F..Hoi Fung Mansion
Riviera Gardens, Tsuen Wan
Hong kong

Dear Sir/Madame,

As response to your letter sent to the Ministry of Environment we can send you the following information.

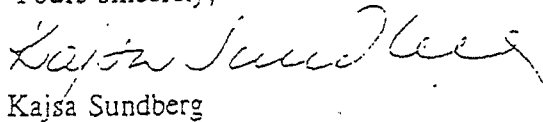
In Sweden we have about 8 900 000 inhabitants and just over 1 000 waste water treatment plants constructed to treat sewage water from more than 200 persons.

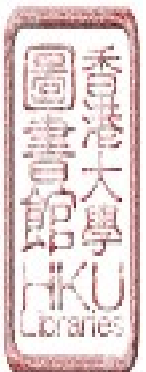
It does exist problems with odour in the surroundings of waste water treatment plants, but it is not very common. When there are problems, the problems are solved according to the swedish legislation, the Environment Protection Act. That means that the owner of the plant, which normally is the municipal, installs for instance a biological filter or a scrubber, to reduce or eliminate the odour in the surroundings of the plant.

We have found that the use of activated carbon to reduce odour from waste water treatment plants is not very effective.

The control of odour from waste water treatment plants is performed according to the Environment Protection Act and the Health Protection Act.

Yours sincerely,


Kajsa Sundberg



Der Rat von Sachverständigen für Umweltfragen

Der Rat von Sachverständigen für Umweltfragen - 65180 Wiesbaden

Ms./Mr. KWAN Yiu-keung
Flat A, 39/F., Hoi Fung Mansion
Riviera Gardens, Tsuen Wan,
Hong Kong

Geschäftsstelle
Postfach
65180 Wiesbaden

Telefon-Durchwahl (0611) 754 210 - 12
Telefax (0611) 731269

30. Oktober 1995
NA

Your request for information dated 17.10.1995

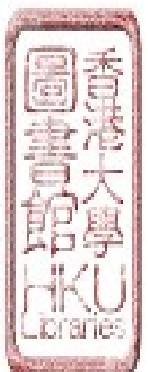
Dear Ms./Mr. KWAN Yiu-keung,

unfortunately the Council of Environmental Advisors has no information about the topic you are working on. Therefore we sent your request to the Federal Environmental Protection Agency (Umweltbundesamt) from where you will probably get some information.

Yours sincerely



i.A. Nicola Albus





REPUBLIK ÖSTERREICH
Bundesministerium für Umwelt

SEKTION III

Zl. 43 3803/14-III/7/95

To
Mr. KWAN Yiu-keung
Flat A, 39/F., Hoi Fung Mansion
Riviera Gardens, Tsuen Wan,
Hong Kong

A-1010 Wien, Stubenbastei 5

Telefon: (0222) 515 22-0

Durchwahl: 3422

Telefax Nr. (Sektion III):

(0222) 515 22/ 7502

DVR: 0441473

Sachbearbeiter: Glantschnig

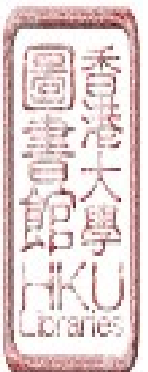
Wien, am 28. November 1995

Dear Mr. Kwan Yiu-keung!

Referring to your letter, concerning waste water treatment in Austria, we can tell you, that the ministry of environment is not competent. The competent ministry in this case is the ministry of agriculture and forestry. We transmitted your letter to the competent ministry.

The adress of this ministry is:
Ministry of agriculture and forestry
Stubenring 12
1010 Vienna
Austria

With best regards
on behalf of the federal minister
MR Dipl.-Ing. Doleisch



ISRAEL EXPORT INSTITUTE

29 Hamered St., Tel Aviv 68125. Tel: 972-3-5142830. Fax: 972-3-5142902



מכון היצוא הישראלי

רח' המוד 29, תל אביב 68125 טל: 03-5142830, פקס: 03-5142902

14/11/95
115150.17

4E(UE)7

Mr KWAN Yiu-keung
fax # 00-852-24028270
HONG KONG

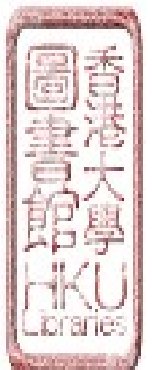
RE: YOUR LETTER + QUESTIONNAIRE REG DEODOURIZATION

Unfortunately, this information is not available in mi Institute.

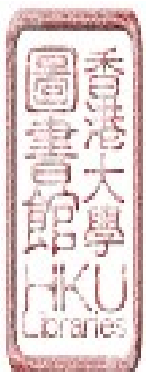
I sent your questionnaire to the ministry of the Environment, endorsed to
Dr. Michael Graver
Director of the Air Quality Dpt
POB 34033 - JERUSALEM 95464 - ISRAEL

Best regards,

Itzhak Rozen
Environmental Tech Center

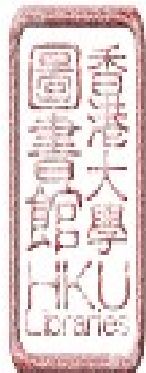


Appendix 6



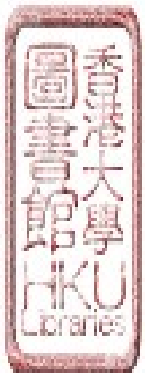
Summary of the questionnaire survey from overseas countries on the deodorization:

Question	Responders								
	1	2	3	4	5	6	7	8	9
1a) Quantity of plants : - Sewage Treatment Plant, - Composing Plant, - Abattoirs, - Pumping Station, - Refuse Transfer Station,	592 - - - -	- - - - 481	- 34 - - -	3475 6 - - -	200 - 100 1000 5	2430 90 2000 10170	50 5 - 100 40	1400 80 - - 50	6 - - 134 1
1b) The seriousness of the odour problem : (serious; moderate, acceptable) - Sewage Treatment Plant, - Composing Plant, - Abattoirs, - Pumping Station, - Refuse Transfer Station,	accept - - - -	- - - - moderate	- moderate - - -	- - - - -	moderate - moderate nil nil	moderate serious - accept accept	very serious very serious - moderate serious	moderate moderate - - moderate	moderate - - moderate accept
2. What kind of people affected by the odour? - operators - passers-by - nearby inhabitants - others	x x - -	x x x -	x x x -	x x x -	x x x -	- - x -	x x x -	x x x -	- x x -
3. How large in average is the area affected by the odour?	Varied	-	Varied	-	500- 1000 m	500 ft	-	1 sq mile	2.8 ha
4. What % of the plant is installed with odour control equipment?	-	40-50%	-	-	10%	10%	60%	-	-

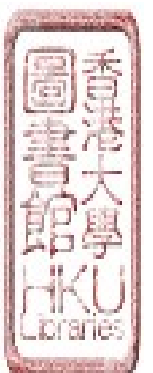


Question	Responders								
	1	2	3	4	5	6	7	8	9
5. Kinds of odour control equipment equipped - scrubber - activated carbon - others:	1 0 operation process	0 0 perfumed mist	0 0 Atomizer	- - -	5% 1% incinerator	9 - O&M design system	60% 10% biofilter. 30%	- - -	- - 100%
6. Reasons for those plants without equipment - economic - low odour emission - no sensitive receiver - no statutory requirement	x - - x	- x - -	x - - -	x x x x	x x x x	- - x -	- x x -	x x x -	- x - -
7. Reasons for those plants with equipment: - economic feasible - high odour emission - sensitive receiver exist - statutory requirement	- x x -	- x x x	- x x x	x x x x	x x x -	- - x x	- x x -	x - x -	- x - -
8. How many existing plants are planned to lower their odour emissions by incorporating/upgrading the odour control equipment? % of low many new plants are planned to lower their odour emissions by incorporating the odour control equipment?	- -	- -	- -	- -	- -	212 53	100% 100%	- -	6 0
10. Are there any legislation/code of practice directly related to the control of odour level inside/outside the concerned plants?	local legislation	part 360 regulation (*)	part 360 regulation (*)	rule 62-600 (*)	cop for abattoir	buffer zone	NJAC 7.27-5	setback	1 km buffer zone

(*) : Legislation or code of practice was provided by the responder



Appendix 7



Questionnaire on the Deodourization of
Refuse Collection Point & Abattoir

MELOE-111
To: KWAN Yiu-keung.
Fax No.: 2402-8275

From: Mr. CHAN Chi-kuen
Organisation/Department: Urban Services Department
Address: 45/F, Queensway Government Offices Building, Queensway, H.K.
Fax No: 25301368 Tel: 28675290

(The information given below applies to urban area only)

1. How many Refuse Collection Point & Abattoir are there in Hong Kong:

Refuse Collection Point, quantity: 105
Abattoir, quantity: 2

2. Will there be any odour problem in such plants?

Refuse Collection Point	Abattoir
<input checked="" type="checkbox"/> yes	<input checked="" type="checkbox"/> yes (only the By-products Plant (BPP) ; Kennedy Town Abattoir (KTA))
<input type="checkbox"/> no	<input type="checkbox"/> no

3. If no, Why? The reason is:

no odour emission at all
 large buffer distance between the receptor
 ventilate the odour to high position for dispersion
 it was totally enclosed

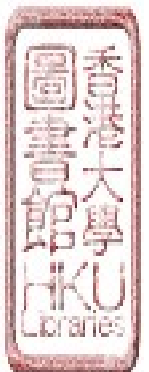
4. If there is odour problem in these plants, have there any odour control equipment in these plants?

Refuse Collection Point	Abattoir
<input checked="" type="checkbox"/> yes	<input checked="" type="checkbox"/> yes
<input type="checkbox"/> no	<input type="checkbox"/> no

5. What kind of odour control method is used in the RCP? And please indicate the total quantity used in RCP & Abattoir of Hong Kong. (You can tick more than one)

Type:	Quantity:
<input checked="" type="checkbox"/> scrubber,	R.C.P. <u>10</u> Abattoir <u>1 (KTA BPP)</u>
<input checked="" type="checkbox"/> activated carbon	R.C.P. <u>51</u> Abattoir <u>1 (KTA BPP)</u>
<input type="checkbox"/> biofilter	R.C.P. _____ Abattoir _____
<input type="checkbox"/> electrostatic precipitator	R.C.P. _____ Abattoir _____
<input type="checkbox"/> incineration	R.C.P. _____ Abattoir _____
<input type="checkbox"/> totally enclosed	R.C.P. _____ Abattoir _____
<input checked="" type="checkbox"/> vent to high position	R.C.P. <u>51</u> Abattoir <u>1 (KTA BPP)</u>

page 1/2



- large buffer distance R.C.P. _____ Abattoir _____
- other, pls specify _____, in what quantity: _____
 _____, in what quantity: _____

6. The reasons for those plants without equipping odour control equipment are:
 (You can tick more than one)

	R.C.P.	Abattoir
economic	_____	_____
low odour emission	<u>X</u>	<u>X</u> (Cheung Sha Wan Abattoir)
no sensitive receiver	_____	_____
no statutory requirement	_____	_____
others, please specify:	_____	_____

7. The reasons for those plants equipping with odour control equipment are:
 (You can tick more than one)

	R.C.P.	Abattoir
economic feasible	_____	_____
high odour emission	<u>X</u>	<u>X</u>
sensitive receiver exist	<u>X</u>	_____
statutory requirement	_____	_____
others, please specify:	_____	_____

8. How many numbers of the existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

R.C.P.	Abattoir
Quantity: <u>51</u>	Quantity: <u>1</u> (KTA BPP)

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

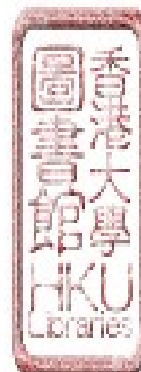
R.C.P.	Abattoir
Quantity: <u>12</u>	Quantity: <u>nil</u>

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

yes, please give details: _____

no,
 if no, is there any other related code of practice
 or general guidelines: no

11. Any additional information: nil



Questionnaire on the Deodorization of
Refuse Collection Point & Abattoir

To: KWAN Yiu-keung
Fax No.: 2402 8275

From: Mr. SOI Tse-wan
Organisation/Department: Regional Services Department
Address: 15/F, Regional Council Building, 1-5 Fan Tau Street, Sha Tin, N.T.
Fax No: 2402 8275 Tel: 2601 8022

1. How many Refuse Collection Point & Abattoir are there in Hong Kong:

in Regional Council areas

Refuse Collection Point/quantity: 2537, (including 64 nos. village-type refuse collection point (RCP), 270 nos. fibreglass RCP and 1566 nos. bin sit
Abattoir, quantity: _____

2. Will there be any odour problem in such plants?

Please consult the Urban Services Department in respect of RCPs in Urban Council areas.

Refuse Collection Point		Abattoir
<input type="checkbox"/> yes	<input checked="" type="checkbox"/> some yes,	<input type="checkbox"/> yes
<input type="checkbox"/> no	<input type="checkbox"/> some no.	<input type="checkbox"/> no

3. If no, Why? The reason is:

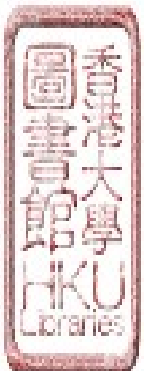
no odour emission at all
 large buffer distance between the receptor
 ventilate the odour to high position for dispersion
 it was totally enclosed

4. If there is odour problem in these plants, have there any odour control equipment in these plants?

Refuse Collection Point	Abattoir
<input checked="" type="checkbox"/> yes	<input type="checkbox"/> yes
<input type="checkbox"/> no	<input type="checkbox"/> no

5. What kind of odour control method is used in the RCP? And please indicate the total quantity used in RCP & Abattoir of Hong Kong. (You can tick more than one)

<u>Type:</u>	<u>Quantity:</u>	
<input checked="" type="checkbox"/> scrubber,	R.C.P. <u>2</u>	Abattoir _____
<input checked="" type="checkbox"/> activated carbon	R.C.P. <u>7</u>	Abattoir _____
<input type="checkbox"/> biofilter	R.C.P. _____	Abattoir _____
<input type="checkbox"/> electrostatic precipitator	R.C.P. _____	Abattoir _____
<input type="checkbox"/> incineration	R.C.P. _____	Abattoir _____
<input checked="" type="checkbox"/> totally enclosed	R.C.P. <u>55</u>	Abattoir _____
<input type="checkbox"/> vent to high position	R.C.P. _____	Abattoir _____



- large buffer distance R.C.P. 2477 Abattoir _____
 other, pls specify _____, in what quantity: _____
 _____, in what quantity: _____

6. The reasons for those plants without equipping odour control equipment are:
 (You can tick more than one)

	R.C.P.	Abattoir
economic	<u>/</u>	_____
low odour emission	<u>/</u>	_____
no sensitive receiver	<u>/</u>	_____
no statutory requirement	<u>/</u>	_____
others, please specify:	_____	_____

7. The reasons for those plants equipping with odour control equipment are:
 (You can tick more than one)

	R.C.P.	Abattoir
economic feasible	_____	_____
high odour emission	<u>/</u>	_____
sensitive receiver exist	<u>/</u>	_____
statutory requirement	_____	_____
other, please specify:	_____	_____

8. How many numbers of the existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

R.C.P. Quantity: 5 Abattoir Quantity: _____

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

R.C.P. Quantity: *10 Abattoir Quantity: _____
 * Preliminary planning, subject to revision.

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

- yes, please give details: _____

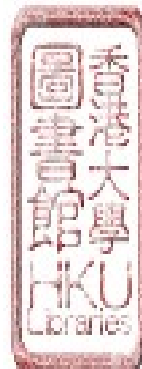
 no,
 if no, is there any other related code of practice
 or general guidelines: _____

Please consult the Environmental Protection Department on this subject.

11. Any additional information: As requested, a copy of operation & maintenance manual for the water sprayer installed in our Yi Chun Street ROP, Tai Wai is enclosed.

End

2/2



Questionnaire on the Deodourization of
Refuse Collection Point & Abattoir

To: KWAN Yiu-keung
Fax No.: 2402 8275

From: *C. S. Kwan, CH1 (M1)*
 Organisation/Department: *Regional Services Department*
 Address: *15/F Regional Council Bldg, 1 Pan Tze-st, Shek Tin*
 Fax No: *2602 0297* Tel: *2601 8726*

1. How many Refuse Collection Point & Abattoir are there in Hong Kong:

Refuse Collection Point, quantity: _____
 Abattoir, quantity: 5 (*3 in R.C. area, 2 in U.C. area*)

2. Will there be any odour problem in such plants?

Refuse Collection Point	Abattoir
<input type="checkbox"/> yes	<input type="checkbox"/> yes
<input type="checkbox"/> no	<input checked="" type="checkbox"/> no

3. If no, Why? The reason is:

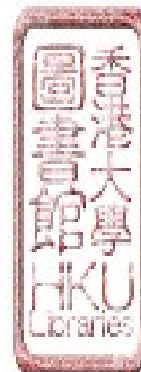
- no odour emission at all
- large buffer distance between the receptor
- ventilate the odour to high position for dispersion
- it was totally enclosed

4. If there is odour problem in these plants, have there any odour control equipment in these plants?

Refuse Collection Point	Abattoir
<input type="checkbox"/> yes	<input type="checkbox"/> yes
<input type="checkbox"/> no	<input checked="" type="checkbox"/> no

5. What kind of odour control method is used in the RCP? And please indicate the total quantity used in RCP & Abattoir of Hong Kong. (You can tick more than one)

<u>Type:</u>	<u>Quantity:</u>
<input type="checkbox"/> scrubber,	R.C.P. _____ Abattoir _____
<input type="checkbox"/> activated carbon	R.C.P. _____ Abattoir _____
<input type="checkbox"/> biofilter	R.C.P. _____ Abattoir _____
<input type="checkbox"/> electrostatic precipitator	R.C.P. _____ Abattoir _____
<input type="checkbox"/> incineration	R.C.P. _____ Abattoir _____
<input type="checkbox"/> totally enclosed	R.C.P. _____ Abattoir _____
<input type="checkbox"/> vent to high position	R.C.P. _____ Abattoir _____



large buffer distance R.C.P. _____ Abattoir _____
 other, pls specify _____, in what quantity: _____
 _____, in what quantity: _____

6 The reasons for those plants without equipping odour control equipment are
 (You can tick more than one)

	R.C.P.	Abattoir
economic	_____	✓
low odour emission	_____	✓
no sensitive receiver	_____	✓
no statutory requirement	_____	✓
others, please specify:	_____	_____

7. The reasons for those plants equipping with odour control equipment are:
 (You can tick more than one)

	R.C.P.	Abattoir
economic feasible	_____	_____
high odour emission	_____	_____
sensitive receiver exist	_____	_____
statutory requirement	_____	_____
others, please specify:	_____	_____

8. How many numbers of the existing plants (with or without control measures) are
 planned to lower their odour emissions by incorporating/upgrading the odour control
 equipment?

R.C.P. _____ Abattoir _____
 Quantity: _____ Quantity: 0

9. How many new plants are planned to lower their odour emissions by incorporating
 the odour control equipment?

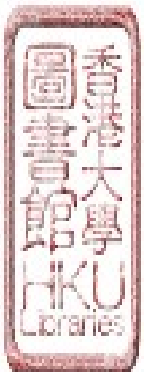
R.C.P. _____ Abattoir _____
 Quantity: _____ Quantity: 1

10. Are there any legislation directly related to the control of odour level
 inside/outside the concerned plants?

yes, please give details: _____

no,
 if no, is there any other related code of practice
 or general guidelines: _____

11. Any additional information: Good house design, well ventilated
naturally, and regularly flush down is the only
environmentally friendly measures to reduce odour. End 2/2



Questionnaire on the Deodorization of
Sewage Treatment Plant

To: KWAN Yiu-keung
Fax No: 2402 8275

From: CS Tse, for Chief Engineer/Sewage Treatment, DSD
Organisation/Department: Drainage Services Dept
Address: 43/F, Gloucester Rd, Manchu, HK
Fax No: 2627 8619 Tel: 2594 7143

29.2.96

1. How many Sewage Treatment Plant are there in Hong Kong

Sewage Treatment Plant, quantity: over 160 of various types

2. Will there be any odour problem in such plant?

yes (some)
 no

3. If no, Why? The reason is:

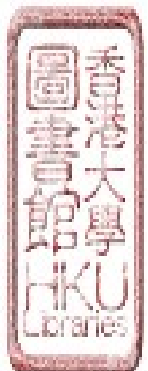
- no odour emission at all
 large buffer distance between the receptor
 ventilate the odour to high position for dispersion
 it was totally enclosed

4. If there is odour problem in these plants, have there any odour control equipment in these plants?

yes
 no

5. What kind of odour control method is used in the STP? And please indicate the total quantity used in STP of Hong Kong. (You can tick more than one)

- | | |
|--|--------------------------------|
| <input checked="" type="checkbox"/> scrubber | in what quantity: <u>1</u> |
| <input checked="" type="checkbox"/> activated carbon | in what quantity: <u>a few</u> |
| <input checked="" type="checkbox"/> biofilter | in what quantity: <u>1</u> |
| <input type="checkbox"/> electrostatic precipitator | in what quantity: _____ |
| <input type="checkbox"/> incineration | in what quantity: _____ |
| <input type="checkbox"/> totally enclosed | in what quantity: _____ |
| <input type="checkbox"/> vent to high position | in what quantity: _____ |
| <input type="checkbox"/> large buffer distance | in what quantity: _____ |
| <input type="checkbox"/> other, pls specify _____, | in what quantity: _____ |
| _____ | in what quantity: _____ |
| _____ | in what quantity: _____ |



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: not provided in the original design

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: For some new plants, the equipment is provided under contract. For some existing plants, the equip. is provided

8. How many numbers of the existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment? reduce the level.

Quantity: _____ (or in _____ %)

As far as we understand there is no plan from the project office to provide the equip. However, the issue is closely monitored by

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

Quantity: _____ (or in _____ %)

this is hard to tell because some plants are being built by other body such as TD, P&S etc. and we do not know whether it

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

would be provided - odour control equ

yes, please give details: _____

no, *Seems there is none, but should check w/ EPD and other authorities.*
if no, is there any other related code of practice or general guidelines: _____

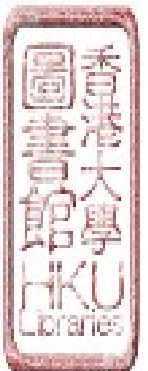
11. Any additional information: _____

Mrs. Kwan:

End

2/2

Please call me at 2944 7143 should you require further information concerning your research subject.



Questionnaire on the Deodourization of
Water Treatment Plant

To: KWAN Yiu-keung

Fax No.: 2402 8275

From: *Chief Chemist*

Organisation/Department: *Water Supplies Dept.*

Address: *48/F Immigration Tower, Wanchai.*

Fax No: *2424 0578* Tel: *2429 4443*

1. How many Water Treatment Plant are there in Hong Kong.

Water Treatment Plant, quantity: 18

2. Will there be any odour problem in such plant?

yes
 no

3. If no, Why? The reason is:

- no odour emission at all
- large buffer distance between the receptor
- ventilate the odour to high position for dispersion
- it was totally enclosed

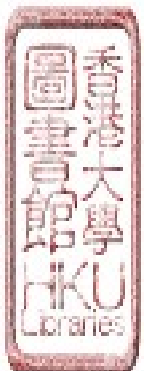
4. If there is odour problem in these plants, have there any odour control equipment in these plants?

yes *see 3*
 no

5. What kind of odour control method is used in the WTP? And please indicate the total quantity used in WTP of Hong Kong. (You can tick more than one)

- scrubber in what quantity: _____
- activated carbon in what quantity: _____
- biofilter in what quantity: _____
- electrostatic precipitator in what quantity: _____
- incineration in what quantity: _____
- totally enclosed in what quantity: _____
- vent to high position in what quantity: _____
- large buffer distance in what quantity: _____
- other, pls specify _____ in what quantity: _____
- _____ in what quantity: _____
- _____ in what quantity: _____

see 3



6. The reasons for those plants without equipping odour control equipment are:
(You can tick more than one)

- economic
- low odour emission
- no sensitive receiver
- no statutory requirement
- others, please specify: _____

see 3

7. The reasons for those plants equipping with odour control equipment are:
(You can tick more than one)

- economic feasible
- high odour emission
- sensitive receiver exist
- statutory requirement
- others, please specify: _____

see 3

8. How many numbers of the existing plants (with or without control measures) are planned to lower their odour emissions by incorporating/upgrading the odour control equipment?

Quantity: _____ (or in _____ %)

see 3

9. How many new plants are planned to lower their odour emissions by incorporating the odour control equipment?

Quantity: _____ (or in _____ %)

see 3

10. Are there any legislation directly related to the control of odour level inside/outside the concerned plants?

yes, please give details: _____

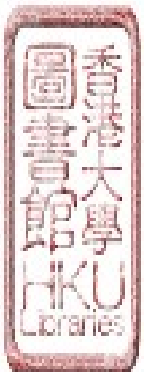
no,
if no, is there any other related code of practice or general guidelines: _____

see 3

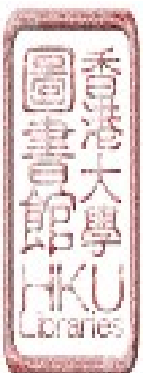
11. Any additional information: _____

End

2/2



Appendix 8



NOTES ON BEST PRACTICABLE MEANS REQUIREMENTS
FOR RENDERING WORKS (BY-PRODUCT PLANT AT SLAUGHTER-HOUSE)

1. INTRODUCTION

1.1 These notes list the minimum requirements for meeting the best practicable means for Rendering Works as a by-product rendering plant at slaughter-house, in which:-

- (i) the processing capacity exceeds 250 kg per hour (expressed as the raw materials); and
- (ii) rendering or reduction or drying through application of heat, or curing by smoking, of animal matter (including flesh, blood, bone, horn, hoof, skin, offal, feather etc.) is carried out.

The slaughter-house mentioned above refers to the place where animals but excluding fish are butchered for food.

1.2 These notes do not cover other processes which are also defined as Rendering Works under the Air Pollution Control Ordinance.

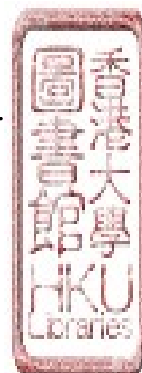
1.3 It should be noted that in granting a licence under the Ordinance, the Authority, i.e. the Director of Environmental Protection, will also consider all other relevant aspects and may impose more stringent and/or additional control requirements by taking into account individual process characteristics, local topography and air quality and any other factors.

2. DESIGN OF CHIMNEY

2.1 Chimneys include structures and openings of any kind, including vents and process exhausts, from or through which air pollutants (including odorous gases), generated from combustion, cooking, drying and/or other processes of the plant, may be emitted.

2.2 The design of chimneys is to be determined by mathematical or physical dispersion modelling techniques acceptable to the Authority. The aims are to ensure :-

- (a) the relevant Air Quality Objective (AQO) will not be threatened;
- (b) the emission of non-AQO pollutants, in particular, heavy metals and carcinogenic organic compounds, will not cause any adverse effect to human health or environment; and
- (c) no undue constraint will be incurred to the existing and future development or land use.



2.3 In any case, the design of chimneys shall at least satisfy the following conditions :-

(a) Chimney height

For combustion process, the final chimney height should be agreed with the Authority but as a general guideline, the chimney height, in a flat terrain situation, should as far as practicable be at least Building Height + 1.5 x Building Width or Building Height, whichever is the lesser. Suitable adjustment should be made to take into account local meteorological data, local topography and background air pollutant concentrations. In any case, the minimum chimney height shall be at least 8 metres above ground level or 3 metres above the roof top of the building to which it is attached, whichever is the greater.

For non-combustion process, the same guideline should be observed as far as practicable and in any case, the chimney height shall be at least 3 metres above the roof top of the building to which it is attached.

(b) Efflux Velocity

The efflux velocity of the chimneys shall not be less than 15 m/s at full load condition.

(c) Exit Temperature

For combustion process, the exit temperature of flue gas from the chimneys shall not be less than the acid dew point.

(d) Mode of Discharge

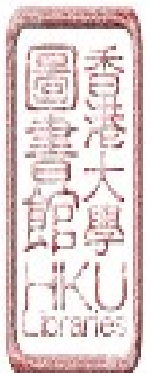
Releases to air from chimneys shall be directed vertically upwards and not restricted or deflected by the use of, for example, plates, caps or cowls.

Where practicable, hot emissions should take place from the minimum number of chimneys and multiplicity of discharge point should be avoided, in order to obtain maximum thermal buoyancy.

Chimney for release of hot emissions should, wherever possible, be insulated. The insulation materials shall be free of asbestos.

3. EMISSION LIMITS

3.1 All emissions to air, other than steam or water vapour, shall be colourless and free from persistent mist, fume and droplets.



3.2 Odorous emissions shall be adequately controlled to ensure that the operation of the by-product plant would not cause an odour nuisance or impose unacceptable constraint on land use. To satisfy the above requirements, all odorous emissions have to meet appropriate emission limits (in terms of odour units) to be approved by the Authority.

(Note : An odour unit is the measuring unit of odour level and analogous to pollutant concentration. In this context, the odour level is defined as the ratio of the volume which the sample would occupy when diluted with air to the odour threshold, to the volume of the sample. In other words, one odour unit is the concentration of the odorant which just induces an odour sensation.

An odour nuisance exists if sampling result established by an odour panel indicates that the ambient odour level at the affected areas exceeds 2 odour units.)

3.3 Emissions from combustion process shall be less than Ringelmann Shade 1. or described in British Standard BS 2742: 1967. #

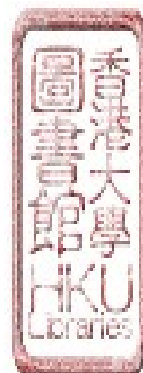
3.4 In addition to the above requirements, the emission limits stipulated below shall be applicable to all emissions during normal operations including load change. The introduction of dilution air to achieve the emission limits is not permitted.

(All figures are expressed as at 0°C temperature, 101.325 kilopascals pressure conditions without correction for water vapour content)

<u>Air Pollutants</u>	<u>Concentrations</u>
Particulates (including emissions from materials and products handling operations)	50 mg/m ³
Total of Hydrogen sulphide, sulphides and mercaptans (expressed as hydrogen sulphide)	8 mg/m ³
Chlorine and its compounds (expressed as hydrogen chloride)	80 mg/m ³
Ammonia	40 mg/m ³
Amines and amides (expressed as ammonia)	4 mg/m ³

4. ODOROUS EMISSION CONTROL

4.1 All possible odorous sources shall be fully identified and investigated. Adequate control measures shall be implemented to

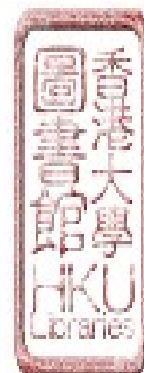


ensure that the operation of the by-product plant would not cause an odour nuisance or impose unacceptable constraint on land use.

- 4.2 For buildings ^{with} in which there are possible odorous sources, they should be designed to prevent the uncontrolled escape of odorous air from the building. Double doors forming an air lock should be used where appropriate. The odorous air shall be effectively collected and vented to a suitable odour control equipment.
- 4.3 The plant surfaces, floor, yards and equipment liable to come into contact with the raw materials, semi-processed or processed materials shall be of impervious construction, capable of being readily cleansed and shall be kept clean.
- 4.4 A good house keeping shall be maintained. Suitable methods shall be provided for the effective cleaning of any area of spillage and for the effective cleaning of the plant. Spillages shall be cleaned up as soon as possible.
- 4.5 Without prejudice to the above general requirements, the following control measures shall be implemented:-

(a) Materials Handling

- (i) Raw materials should be transported from the point of production to the processing plant as quickly as practicable. The design and use of vehicles or containers shall be such as to minimize the emission of any offensive odour or spillage of any liquid or solid matter.
- (ii) Empty vehicles and containers shall be kept clean.
- (iii) Raw materials shall be processed not later than 24 hours. Having regard to the age and type of raw materials involved, refrigeration for the storage and transport of materials may be required if necessary.
- (iv) Raw materials shall be kept dry and cool, out of direct sunlight and in a fully enclosed container or buildings.
- (v) All vehicles, containers, trailers and equipment used for the collection, transfer and handling of raw materials and waste shall be readily cleanable, impervious and kept clean.
- (vi) Raw materials shall be received, transferred, stored or processed inside enclosed areas with double doors which form an air lock through which vehicles enter. Doors shall be kept closed other than for the movement of materials.



- (vii) High air extraction rates in the raw material reception area shall be maintained to vent the odorous air to a suitable odour control equipment.
- (viii) Within the raw material handling and processing areas, adequate negative pressure shall be maintained to prevent the escape of odours. Tanks or receptacles for holding liquid wastes or usable putrescible products shall either be in an area under adequate negative pressure or sealed and vented. All such extraction shall be ducted to a suitable odour control equipment.

(b) Processing Area

- (i) Areas where any processing of animal matters (including flesh, blood, bone, horn, hoof, skin, offal, feather etc.) is carried out shall be totally enclosed. The ventilation of the areas shall be vented to a suitable odour control equipment. These areas shall be fully weatherproof. Doors shall be close-fitting and shall be kept closed when practicable, other than for the movement of materials.
- (ii) The conveying system for the materials being processed and/or products being produced shall be leak-proof and spill-proof.

(c) Processing equipment

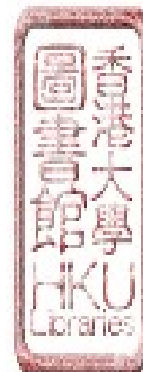
- (i) For batch processes, cookers shall be charged under a sufficiently reduced pressure to prevent the escape of odorous air, or the charging area shall be hooded and the extracted air vented to a suitable odour control equipment.
- (ii) The odorous emissions generated from the process shall be vented to a suitable odour control equipment. Sources of odorous emissions which must be considered include cookers, press, driers, centrifuges, tanks, pans, drainers, materials transfer points, leaking ducts and glands.

(d) Meal Processing

- (i) All grinding and sieving plant shall be constructed and linked in a manner which avoids spillage.

(e) Tallow Processing and storage

- (i) All tanks for tallow processing and/or storing shall be lidded, sealed or vented to a suitable odour control equipment to prevent odour emissions. Catchment provisions shall be provided to contain spillage if any.



- (iii) Bulk tallow storage tanks shall be fitted with a high-level alarm or volume indicator to warn of and thereby prevent overfilling.

(f) Odour Control Equipment

- (i) The efficiency of odour control equipment shall be at least able to satisfy the requirement as stipulated in section 4.1 of these notes.
- (ii) Where emissions of differing odour intensity are produced within the process, the odour streams should be kept separate and treated by an appropriate odour control equipment wherever practicable.
- (iii) As a general guideline, high intensity odours should be treated by multi pass or other chemical scrubbers and those containing certain incombustible gases should be treated by incineration. Lesser intensity odours may be treated by chemical scrubbers, biological filters or similar suitable control equipment.
- (iv) Odour-masking agents and counteractants shall not be used as a means of odour control.
- (v) In the event of odour control equipment breakdown the system shall allow diversion of odour streams to other suitable control equipment or cause interruption of the process.

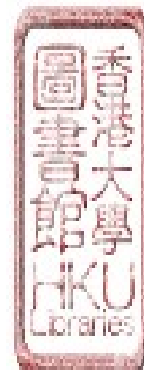
(g) Odorous Emission from Liquid Effluent

- (i) Liquid effluent which is produced by the process including odour control equipment shall be properly handled and treated so as to prevent the emission of offensive odours from the effluent.
- (ii) Where condenser is used for the purpose of minimising odours, it must ensure that the type of condensers be used or proposed is acceptable both in relation to the quantity and quality of liquid discharges.

5. CONTROL OF OTHER FUGITIVE EMISSIONS

5.1 The control of the fugitive emissions of air pollutants other than odour shall be agreed with the Authority. As a general guideline loading, unloading, handling and storage of fuel, raw materials, products, wastes or by-products should be carried out in a manner acceptable to the Authority so as to prevent the release of:-

- (a) visible dust emissions; and/or
- (b) emissions of organic vapours; and/or
- (c) other noxious or offensive emissions.



5.2 In particular, the storage, transportation and handling of dusty materials such as blood powder and ground meal shall be carried out methods which do not give rise to visible dust emissions.

6. MATERIAL/FUEL RESTRICTION

6.1 Gaseous fuel is the recommended fuel to be used but the Authority will also accept the use of liquid fuel with the following specifications :-

Sulphur content: Not greater than 0.5% (by weight)

Viscosity: Not greater than 6 centistokes
(at 40°C)

7. MONITORING REQUIREMENTS

7.1 Parameters and sampling frequency will be determined by the Authority. In general, visual and olfactory assessments of emissions shall be made frequently and at least once a day.

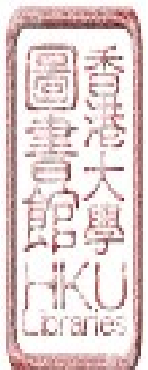
8. COMMISSIONING

8.1 Commissioning trials (to be witnessed by the Authority whenever appropriate) shall be conducted to demonstrate performance capability of the air pollution control measures and a report of commissioning trial shall be submitted to the Authority within 1 month after completion of the trial.

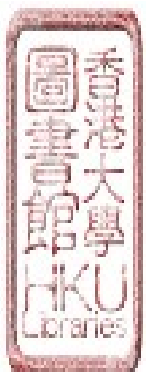
9. OPERATION and MAINTENANCE

9.1 Requirements include not only the provision of the appliances, but proper operation and maintenance of equipment, its supervision when use and the training and supervision of properly qualified staff. Specific operation and maintenance requirements may be specified for individual equipment.

9.2 Malfunctioning and breakdown of the process or air pollution control equipment which would cause exceedance of the emission limits or breaches of other air pollution control requirements shall be reported to the Authority within 3 working days.



Appendix 9



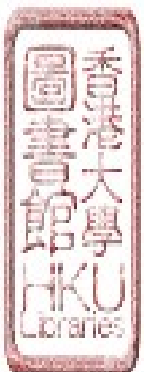
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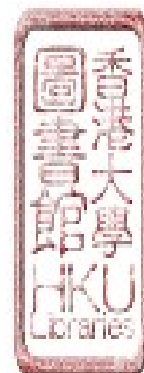
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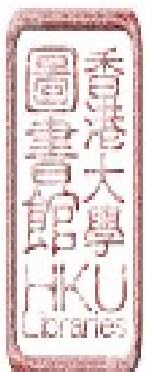


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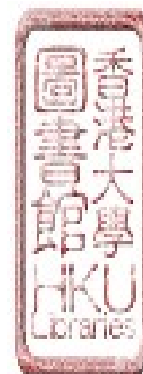
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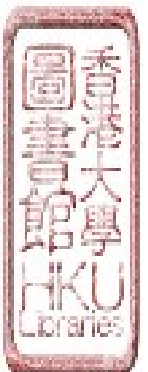
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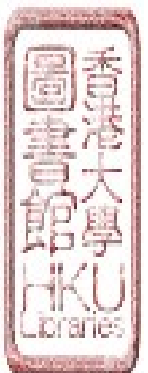
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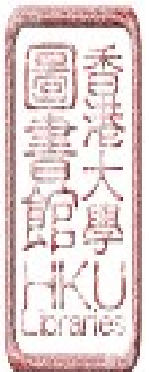
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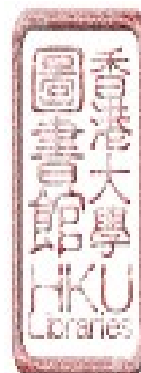
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