# RISK MANAGEMENT AND POLICY OF B3* WASTES FROM NATURAL GAS INDUSTRY IN INDONESIA

by

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*ABSTRACT*

*The main natural gas industry activities that may produce by-product or wastes are exploration, production, storage, gathering, processing, transmission, distribution or some combination of these. Compressor station, for example, generates various types and quantities of waste, which must be managed responsibly, in a manner that does not threaten human health or the environment.*

*It is helpful to identify types and quantities of waste produced, especially hazardous and toxic material (B3), in order to determine waste disposal options and to prepare management procedures in advance of waste being generated. In other side, regulatory body has provided some regulations regarding hazardous and toxic waste management.*

*Finally, it is important to evaluate the risk of hazardous and toxic wastes in order to provide waste management policy. These topics will be discussed in detail in this paper.*

## I. INTRODUCTION

Waste has become an important global issue since the conference of Rio de Janeiro in June 1992. This issue is likely to give a significant impact either to human health or the environment, if it is wrongly managed. Deciding whether a waste poses problem requires consideration not only of its composition but also of what happens to it. For most waste it is not necessary to know more than what it is in very general terms, but subsequent holders must be provided with a description of the waste that is sufficient to enable them to manage the waste properly.

For the natural gas industry, the main processes may include exploration, production, storage, gathering, processing, transmission, distribution or some combination of these. Such diverse operations represent a large number of potential waste sources. It is helpful to identify these sources and the processes associated with each. This information can be very useful to determine waste disposal options and to prepare management procedures in advance of waste being generated. It can also be used for assessing waste minimization and pollution prevention opportunities.

Waste management program at natural gas industry faces sensitive disposal issues associated with hazardous and non-hazardous wastes. Compressor station, for example, generates various types and quantities of waste, which must be managed responsibly, in a manner that does not threaten human health or the environment.

Therefore, this paper will discuss general waste management practice at natural gas industry, risk assessment of waste disposal options, and an overview of waste management regulation as applied in Indonesia, in the handling of wastes from "cradle to grave".

## II. REGULATORY OVERVIEW

Most waste management activities are driven by regulations. In fact, regulatory compliance is probably the most challenging aspect of an environmental managers position as several regulations effect waste manage-

* *Bahan Berbahaya dan Beracun (Hazardous toxic materials)*

ment at natural gas facilities. Therefore, understanding these regulations is an essential part of disposal process, so it may be useful to briefly review several important statutes.

In Indonesia, waste management regulations are in the form of legislation, government regulation, ministerial decrees, and others (decree of directorate general, ministerial instructions, etc). The following laws and stringent regulations are mandatory and have to be complied with by the gas industries :

- ***Government Regulation (PP) Number 19/1994 and Decrees of The Head of Environmental Impact Management Agency No.: KEP-01,02,03, 04,05/BAPEDAL/09/1995*** are the significant regulations affecting hazardous and toxic waste management. The PP defines hazardous and toxic waste and controls their handling through a cradle to grave management system. Standards are applicable to hazardous and toxic waste's generator, storage and collection, manifests (documentation), treatment and landfill sites, and symbols and labels of hazardous and toxic waste.

  These regulations will give the Environmental Impact Management Agency (BAPEDAL) necessary tools to prevent human health and environmental damage by: (1) establishing standards for hazardous and toxic waste's generators, transporters, treatments, storage and disposal facilities; (2) creating licensing system for hazardous and toxic wastes generators, transporters, treatments, storage and disposal facilities; (3) mandating strict penalties for violations; and (4) promoting waste minimization.
- ***Decree of the Minister of the Environment No.: Kep-42/MENLH/10/1996*** is the regulation, which provides the standard for liquid waste produced from oil, gas and geothermal activities, such as exploration and production, refinery, installation, depot, and terminal.

  The persons who are responsible for the above activities should: (1) manage the quality of liquid waste produced below the standard for liquid waste, (2) monitor daily liquid waste velocity, (3) monitor the quality of liquid waste produced monthly, (4) report monitoring activities to the Governor, the Head of BAPEDAL, and the Minister of Mines and Energy as well as the Director General of Oil and Gas every three months.
- ***Decree of the Minister of the Environment No.: Kep-13/MENLH/3/1995*** is the regulation, which provides the standard for gas emission produced from stationary sources such as gas processing plants, gas compressor stations, etc. This regulation has been complemented by the technical guidance of air pollution prevention stated in the Decree of the Head of BAPEDAL No.: Kep-205/BAPEDAL/07/1996.

Understanding the regulations is challenging and will likely frustrate environmental managers attempting to select waste disposal methods. The overview presented here is not inclusive of every regulation, which controls waste management at the gas industries. However, sources of information and reference materials are readily available and can be obtained easily. Regulatory knowledge, moreover, is an important part of the waste management decision process and an understanding of regulations is necessary to maintain a good compliance record.

The Agencies which enforce the laws and monitor company compliance, such as BAPEDAL and Directorate General of Oil and Gas, often issue permits. The permit represents a "contract" between the gas industry and issuing agency, which allows the gas industry to lawfully conduct the activities. Permits are usually required before construction or facility modification and containing operating standards to which we must be adhere.

Violation of the permit conditions can result in: (1) shutdown of operations, (2) fines and penalties, (3) criminal charges, (4) poor public image, (5) difficulty in acquiring future permits.

## III. RISK MANAGEMENT OF NATURAL GAS INDUSTRIAL WASTE

### A. *Types of Waste Generated*

As natural gas is produced and processed, by-products and wastes are generated. They include such things waste water from drilling, processing, cooling, and other operations; and waste chemicals, sludges, solvents, lubricants, and trash.

These by-products and wastes are disposed of in air, water, or land. A comprehensive list of waste streams associated with natural gas production, transmission, and storage is presented in Table 1 and Table 2.

As waste streams are produced infrequently and in small quantities, it is more practical to address waste streams which might occur during normal operations. Using this approach the list can be shortened and described in terms of solids, liquids and sludges as presented in Table 3. These three tables can provide valuable information which may be used to establish current and future waste management plans.

**B. *Risk Management of Waste Disposal***

The majority of wastes are disposed of directly to land without chemical treatment or stabilized or solidified, and few per cent being incinerated. The main reason is low cost needed and easier than other methods. However, it can be argued that landfill is not suitable for some hazardous and toxic (B3) wastes such as polychlorinated biphenyls (PCBs) and highly flammable wastes.

Although incineration is not commonly used, it is considered to be extremely effective in destroying toxic organic. Yet incineration will not treat toxic metals which are more efficiently treated by chemical oxidation. The choice of wastes disposal is therefore dependent upon several factors such as cost, waste composition and technology.

**Table 1**
**Typical gas transmission, processing, liquid pipeline and waste streams: liquids**

| Stream Source | Description |
|---|---|
| Air system - Air dryer/receiver | Water condensate |
| Air system - Compressor engines | Used Oil, hydraulic oil, transmission fluid |
| Amine plant | Spent MDEA |
| Amine plant - MDEA vaporizer | Vaporizer blowdown |
| API Separator | Oil and Sludge |
| Boiler | Boiler blowdown |
| Boiler maintenance | Spent caustic |
| Building floor drains | Waste water |
| Carbon filter | Support matrix |
| CCI tailgas | Spent caustic |
| Coalescer - Inlet to treating plant | Produced water |
| Cooling system | Spent glycol - glycol/oil/water mixtures |
| | Off-spec corrosion inhibitor |

*Source : Kissane, D. (1996)*

**Table 1 (cont.)**
**Typical gas transmission, processing, liquid pipeline and waste streams: liquids**

| Stream Source | Description |
|---|---|
| CPR system | Spent caustic |
| SCP catalyst | Spent Pd catalyst |
| Dehydration tower scrubber | Produced water |
| Dehydration unit - Glycol reboiler | Regeneration condensate |
| Dehydration unit - Glycol reclaimer | Reclaimer bottoms |
| Dehydration unit - Regenerator | Spent glycol |
| Drips - pipeline | Condensate |
| Fin/fan hydraulic system | Waste oils |
| Gas compressor engines/Compressor | Waste lube oil |
| Gas filter | Molecular sieve |
| Gas measurement | Mercury |
| | Water/hydrocarbons |
| Gas sweetener | Iron mass or sponge |
| H2 offgas system | Spent caustic |
| Helicopter maintenance | Fuel dump |
| Interstage manifold scrubbers | Water |
| Isobutane processing | Activated alumina |
| Laboratory | Lab waste |
| Maintenance - Buildings | Paint [off-spec] oil or water based |
| | Paint solvents |
| Maintenance - Parts cleaning, etc. | Solvents/degreaser |
| | Spent caustic |
| Methanol production | Water/alcohols |
| Methanol recovery unit | Water |
| Pesticide/herbicide/biocide | Water wash |
| Pipeline hydrostatic testing | Water |
| Pipeline maintenance | Pigging wastes |
| Pipeline pigging | Pre-pig fluids,pigging wastes,tank bottoms/pipeline residues |
| Processes and separation vessels | Misc. oil/HC liq./water |
| Resin bed generation | Hydrochloric acid |
| | Sulfuric acid |
| Sanitary system | Sanitary waste |
| Storage tank, condensate | Condensate |
| Sulfinol process | Liquids from gas dewatering |
| Sulfinol process - Demineralizer | Regeneration water |
| Sulfinol process - Reclaimer | Reclaimer sludge |
| Sulfinol process - Surge tank | Tank skimmings |
| Sulfinol reclaimer | Reclaimer fluid |
| Vehicles | Used oil |

*Source : Kissane, D. (1996)*

**Table 2**
**Typical gas transmission, processing, liquid pipeline and waste streams: solid materials**

| Stream Source | Description |
|---|---|
| Water softener | Backwash and regeneration |
| Liquid - Wellhead accumulator tank | Produced waters |
| Air system - Air dryer | Filter vessel desiccant |
| Air system - Filter system | Spent condensate filters |
| Amine plant - MDEA regenerator | MDEA filters |
| Amine plant - MDEA unit | Charcoal filter media |
| Coalester - Inlet to treating plant | Pleated paper filters |
| Cooling system | Off-spec corrosion inhibitor |
| Cryogenic expander cooling system | Filters |
| Dehydration unit - Gas filter | Flash gas filter elements |
| Dehydration unit - Glycol reboiler | Filter elements, Scale/sand from cleaning, Spent charcoal media |
| Drum storage | Empty drums |
| Filter separators | Filter elements |
| Gas compressor engines | Inlet air filters |
| Gas compressor engines/compressors | Used oil filters |
| Gas compressor engines Lube system | Sock filters |
| General trash | Domestic trash/rubbish |
| Maintenance | Tank bottoms |
| Maintenance/Renovation | Waste asbestos/transite, Paint [dried], Scrap metal, Equipment, Waste rags |
| Mercury manometers | Mercury containing manometers |
| Methanol recovery unit | Spent charcoal filter media, Used filters |
| Molecular sieve dehydration | Spent mol sieve |
| Oliflex feed dryer | Spent alumina |
| Painting operation | Painting/sandblasting waste |
| Pipeline maintenance | Pipe scale,HC solids, Pyrophoric iron sulfides |
| Primary reformer | Spend Ni catalyst |
| Secondary reformer | Spent Pt catalyst |
| Stretford plant | Solid sulfur |
| Stretford plant - Filter press | Vanadium/ADA containers, Filter cake/slurry |
| Stretford plant - Oxidizer tanks | |
| Stretford plant Tank/absorber tower | Sludge bottoms<br>Tank bottoms/tower liquids |
| Sulfinol process | Charcoal filter media, Sock filters |
| Synthesis Catalyst | Spent Cu catalyst |
| Synthesis Gas oil filter | Spent activated carbon |
| Vehicles | Oil filters/tires |
| Wastewater treatment | Sludge |
| Water treatment | Ion exchange resins, Soil |

*Source : Kissane, D. [1996]*

**Table 3**
**Typical waste streams**

| Liquid | Solids | Sludges |
|---|---|---|
| Solvents | Filters | Pig sludge |
| Paint Thinners | Absorbents/Rags | Tank Bottom Sludge |
| Wastewater | Blasting Abrasive | Pit Sludge |
| Lube Oil [used] | Soil/Gravel | Oil/Water Separator Sludge |
| Oil/Water Mixtures | Coatings | |
| Brine | Baterries | |
| Condensates | | |
| **Miscellaneous** | **PCB Waste, Asbestos Containing Materials** | |

*Source : Kissane, D. (1996)*

## 1. Risk Assessment of B3 Waste Contamination

Risk assessment is a well-developed technique in many fields, whereas its application to environmental topics has so far been rather limited. The main stages in assessing the environmental contamination are as follows:

- Hazard Identification; as this stage requires knowledge of the source of contamination and the chemicals, the ease of assessment can be greatly affected by the number of chemicals potentially involved and by how well understood they are.
- Exposure Assessment; the assessment of how much of a given substance comes into contact with human population or other receptors.
- Dose-response Assessment; this stage depends on toxicology and ideally epidemology. The Environmental Agency has laid down guidelines to improve the accuracy of the dose-response assessment of chemicals.
- Risk Characterization; this stage summates all the information to produce meaningful statements of risk.

However, the risks from environmental contamination are difficult to assess as the scope of such contamination in terms of target and effect tends to be very wide, the knowledge of ecological effects and environmental pathways is limited, chronic low-level doses tend to be involved which presents problem for detection and dose-response assessment. The basic sequence to estimate the risks arising in any discharge is illustrated in Figure 1.

For each particular type of emission, the risk to a population can be assessed only after an examination of pathways has given some figures for the number of people who might be affected and the dose of toxic materials they may have received. The procedure is illustrated in Figure 2, while an idealized pattern of research leading to dose-risk relationship is given in Figure 3.

## 2. The Disposal of B3 Waste to Land

Generally, there are two types of landfill, dilute and disperse sites, and containment sites. The trend in most developed countries has been toward containment site as it is engineered in order to isolate their contents from the environment. Containment site is effective for radioactive materials or other toxic substances that lose their toxicity with time.

The common problems, which are resulted in the disposal of B3 wastes to land, are surface and groundwater pollution by leachate, accumulation and disposal of

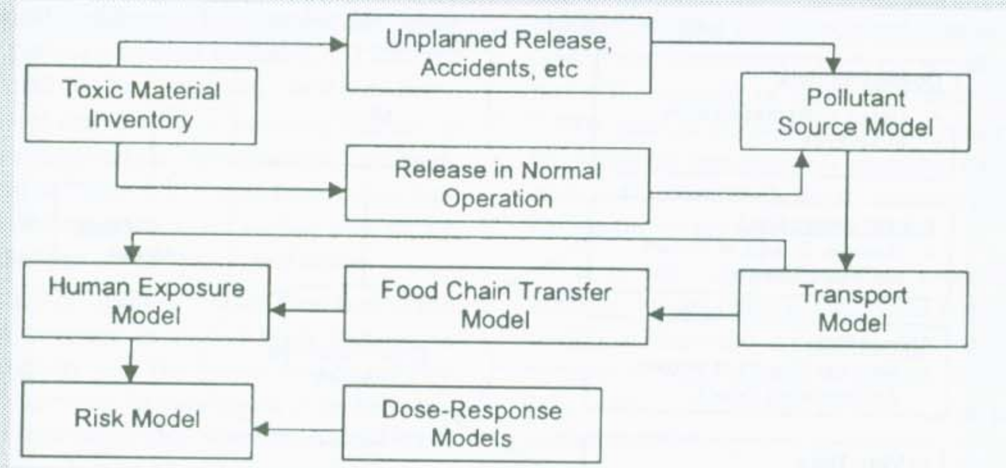



**Figure 1**
**Overview of models in risk assessment**

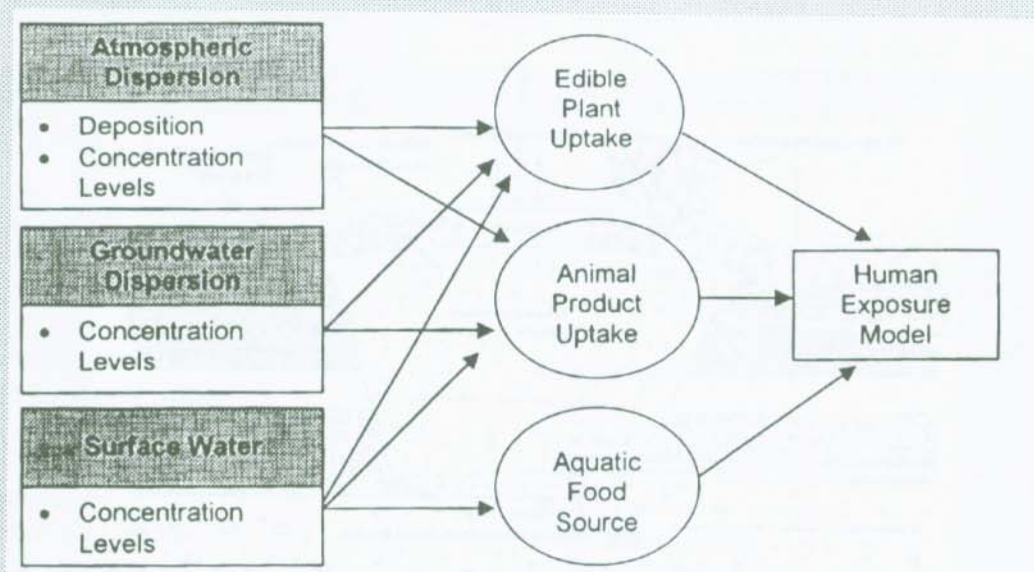
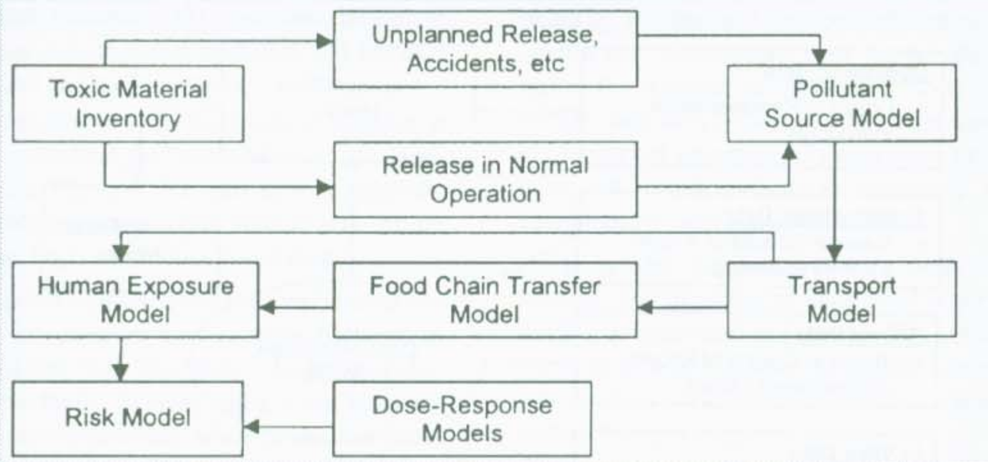



**Figure 2**
**Role of food chain transfer models in the risk assessment framework**

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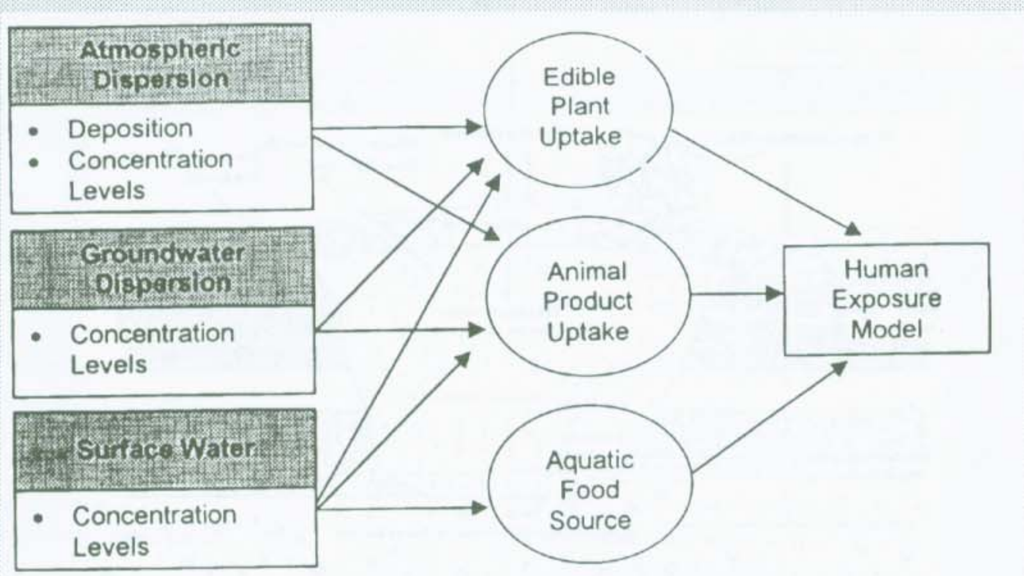


**Figure 2**
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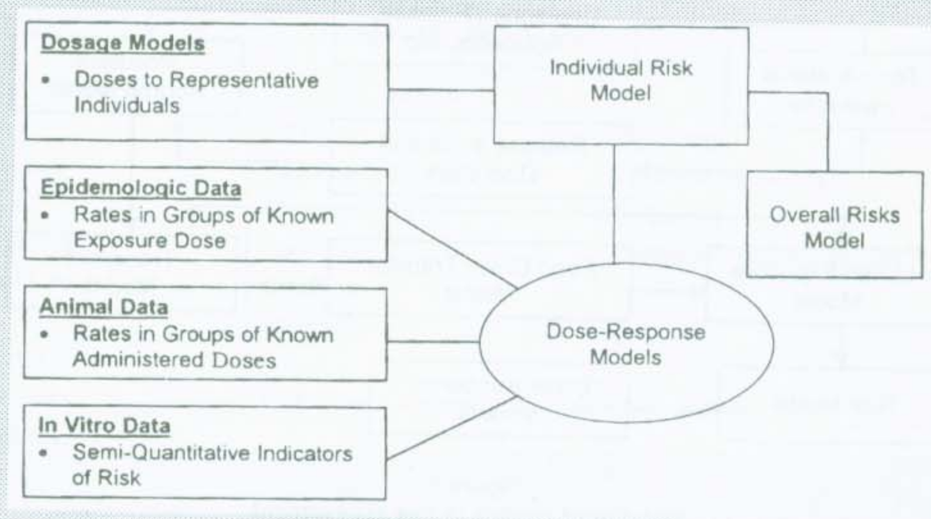


**Figure 3**
**Data required to establish a risk-dose relation**

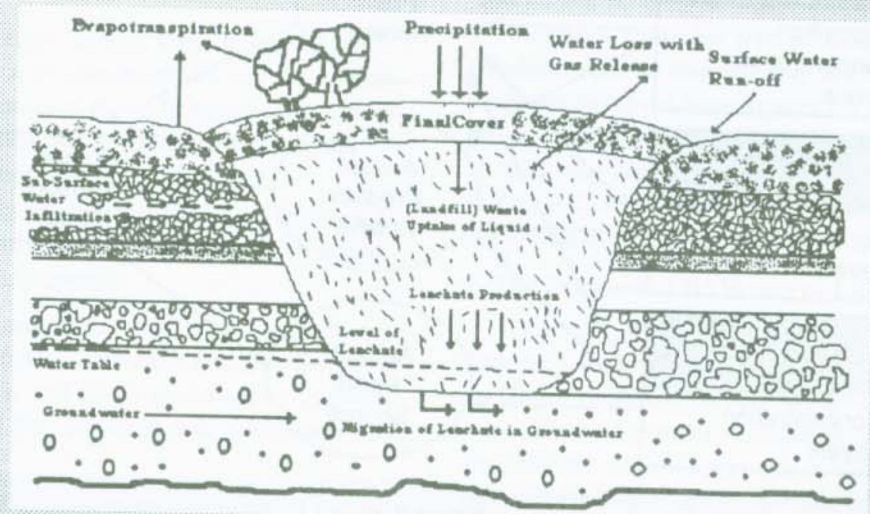


**Figure 4**
**Landfill water balance**

landfill gas. Accordingly, there are six alternative treatments for leachate: (1) disposal to sewage works, (2) aerobic biological treatment, (3) anaerobic biological treatment, (4) physical-chemical treatment, (5) leachate circulation, (6) soil and land treatment.

It is suggested that in order to minimize leachate, it is important to understand the "water balance" of a landfill, as illustrated in Figure 4. The main factors contributing to this balance are water input, surface area, nature of wastes, site geology, and surface liquid storage.

Mellanby (1992) suggested that the ideal landfill site is a large hole, covering an area of many hectares, in level ground in a clay soil. The thicker the layer of clay below the site, the better. In some cases, it has been impossible to find convenient sites, whereas artificial liners made from bitumen, butyl rubber or various plastics may be used.

The common problems, which are resulted in the B3 waste disposal to land, are surface and groundwater pollution by leachate and the accumulation and disposal of landfill gas. Accordingly, there are six alternative treatments for leachate in accordance with Parfitt, *et al.* (1993), such as: (1) disposal to sewage works, (2) aerobic biological treatment, (3) anaerobic biological treatment, (4) physical-chemical treatment, (5) leachate circulation, (6) soil and land treatment.

It is also suggested that in order to minimize leachate, it is important to understand water balance of a landfill, as illustrated in Figure 4. The main factors contributing to water balance of landfill site are water inputs, surface area, nature of wastes, site geology, and surface liquid storage.

The ideal landfill site is a large hole, covering an area of many hectares, in level ground in a clay soil. The

**Table 4**
**Potential mechanism affecting release of B3 wastes**

| Period | Mechanism |
|---|---|
| Operational Phase | Draining system obstruction |
| | Improper waste emplacement |
| | Top cover failure |
| | Flooding |
| | Groundwater |
| | Gas Generation |
| | Waste and soil compaction |
| | Fires |
| Post-closure | All of the above excluding fires |
| Restricted used period | Erosion |
| | Weathering |
| | Intrusion by plant roots and animals |
| Post-closure | All of the above and including |
| Unrestricted used period | Construction activities |
| | Groundwater exploitation |
| | Habitation of the site |
| | Salvage and re-use of disposal materials |

**Table 5**
**Incineration information required for risk assessment**

| |
|---|
| **Normal Operation** |
| • Escapes of volatile material from stores, etc. |
| • Fugitive emissions from material handling |
| • Monitoring of site for contamination |
| • Check for completeness of combustion |
| • State of gas filtering equipment, if any |
| • Discharge of liquid effluent |
| • Monitoring of stack emission and surroundings |
| • Disposal of ash and of old plant |
| **Abnormal Events** |
| • Accidents during transport and delivery of toxic |
| • Fires on the site, especially in stores |
| • Mishandling of wastes, e.g. leakage of liquids |
| • Poor combustion conditions, incomplete combustion |
| • Poor operation of plant |

thicker the layer of clay below the site the better. In some cases, it has been impossible to find convenient sites, whereas artificial liners made from bitumen, butyl rubber or various plastics may have been used. These can only be filled with disposable materials, which do not emit soluble substances for long periods.

The potential pathways for migration of landfill disposal are particularly complex. Therefore, the application of risk analysis methods depends upon knowledge of the inventory of toxic materials in a site and the variation of this quantity with time. The main mechanism that may affect the release of B3 waste from disposal site is illustrated in Table 3.

### 3. B3 Waste Incineration

The problems of landfilling B3 wastes can be reduced by chemical destruction techniques. The most widely used chemical destruction method is incineration, which can be regarded as clean, final solution to the management of combustible wastes on various convictions: (1) Certain toxic or harmful contaminants can be converted into harmless compounds by oxidation in the incineration process; (2) Incineration of B3 wastes is an excellent method of volume reduction; (3) In any selection of a technology for waste treatment, organic wastes with sufficient calorific value may preferably be disposed of by incineration with heat recovery to utilize the heat content of the wastes.

However, it should be considered the side effects of the incineration process, such as: (1) emission from incineration, which have to be controlled to eliminate particulate, noxious gases and other hazardous components, (2) effluent from flue gas purification, which may arise for disposal, and (3) by-product that may be generated.

In order to assess the risks of the incineration for B3 wastes, several models have been developed. However, a complete system study of the risks of the incinerator plant should include an estimation of the risks arising from normal operation and appraisal of the frequency and consequences of abnormal events, including mal-operation and accidents. The topics that have to be addressed in the case of incinerators are set out in Table 4.

## IV. WASTE MANAGEMENT POLICY ON B3 WASTES

B3 waste management means the organized and systematic channeling of wastes through pathways to assure their appropriate disposal with acceptable public health and environmental safeguards. In accordance with PP. No. 19/1994 regarding Hazardous and Toxic Waste Management, this includes the storage, collecting, transporting, processing of B3 waste, and the disposal of the products of such processing.

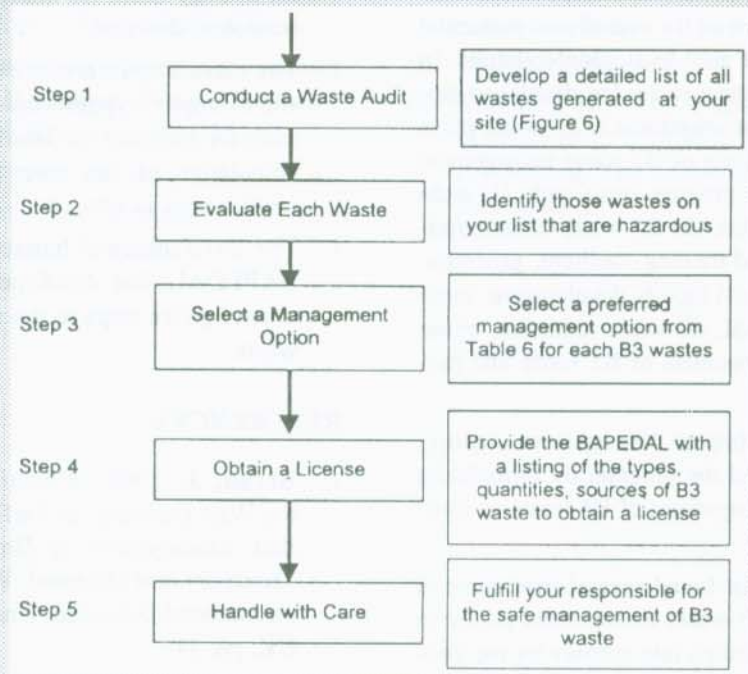


**Figure 5**
**Five steps to the safe management of B3 waste**

**Table 6**
**B3 waste management option**

| Waste Type | Management Options |
|---|---|
| Acids | Neutralization |
| Alkalis | Neutralization |
| Heavy metal solutions | • Precipitation<br>• Flocculation<br>• Sedimentation |
| Cyanides | Alkaline chlorination |
| Inorganic residues | • Stabilization<br>• Landfilling |
| Solvents | • Recovery using distillation<br>• Incineration in a cement kiln or B3 waste incinerator |
| Oils | • Re-refining using distillation and hydrotreating<br>• Incineration in a cement kiln or B3 waste incinerator |
| Organic residues | • Stabilization and landfilling<br>• Incineration in a cement kiln or B3 waste incinerator |

The management of B3 waste has developed increasingly to a central issue in the overall environmental policy in most developed and developing countries. In Indonesia where the industrial sector has developed rapidly during ten years, the management of B3 waste plays an important role in the form of B3 waste management program since 1989. This program deals with: (1) technical drafting of regulations, (2) B3 waste category/priority list, (3) guideline and training: facilities, generator, waste oil, and industries, (4) facility development: treatment, storage, and disposal, (5) waste reduction, reuse, and recycle, (6) the management of B3 waste and project.

The Environmental Impact Management Agency, BAPEDAL, has developed the program by formulating five steps to the safe management of B3 waste as illustrated in Figure 5.

However, there will be found several constraints in the implementation of B3 waste management policy in Indonesia that should be taken into account by the government such as the use of polluting technology, low infrastructure, weak law enforcement, low awareness among the community, waste processing unit considered as non-productive investment, lack of expertise in the process of B3 waste.

## V. CONCLUSION

Based on the above discussion, the following main points can be concluded:

1. Natural gas industry may produce by-products and wastes such as exhaust gas, vent gas, and leaking vapors or gas; waste water from drilling, processing, cooling, and other operations; and waste chemicals, sludges, solvents, lubricants, and trash.
2. Some of them may be categorised as B3 (hazardous and toxic) wastes that should be handled with care in accordance with B3 wastes management regulation that applied in Indonesia. The decision to dispose of B3 wastes is determined by some factors, such as costs, waste composition and technology used. As mentioned, it is basically an economic decision.
3. The current approach to evaluate risk at B3 waste site is largely hypothetical. The application of risk analysis methods to landfill sites depends upon knowledge of the inventory of hazardous and toxic wastes in site.
4. The Environmental Impact Management Agency, BAPEDAL, has developed the program by formulating five steps to the safe management of B3 waste.

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