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MANAGEMENT OF HAZARDOUS MATERIALS AT KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS

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Summary

Information is gathered on the quantity and the nature of hazardous chemical waste materials generated by the King Fahd University of Petroleum and Minerals in order to prepare a temporary plan for its disposal. Since the amount of hazardous waste materials generated is small, land disposal is found to be the most economically feasible disposal method until a regional facility becomes available. Guidelines for chemical storage are prepared, stressing the importance of keeping the quantity of chemicals stored to a minimum. A management plan for collection, transportation, and ultimate disposal of hazardous waste materials is outlined. A manual of safe chemical disposal practices in the laboratory is prepared and distributed to concerned departments of the University.

Introduction

In the past, the King Fahd University of Petroleum and Minerals (KFUPM) had an agreement with the Arabian American Oil Company (a local industry which manages its own hazardous waste material disposal), for the disposal of its hazardouds materials. This agreement has expired, and the company is reluctant to renewing. Therefore, the University elected to develop its own interim disposal facility. Consequently, the Research Institute of King Fahd University of Petroleum and Minerals (KFUPM/RI) sponsored a study to prepare an interim plan for the safe storage, handling, collection, and disposal of hazardous waste materials generated by the University, to evaluate alternative disposal methods and select the most economical and feasible one.

Information on the quantity and nature of the hazardous waste materials was gathered by questionnaire. The questionnaire was designed to obtain the name, quality, and quantity of each chemical considered to be a generator of hazardous waste material. Based on the information received, it was concluded that the hazardous waste materials can be broadly classified as bacteriological,

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inorganic (including acids and alkalies), heavy metal, cyanide compounds, and organic solvents which are further classified as highly toxic, slightly toxic but highly volatile, and slightly toxic but highly flammable. The total amounts of liquid and solid hazardous waste materials generated by the University were estimated from information supplied by departments.

A list of the most commonly used hazardous chemicals has been prepared, and the risks associated with them and the precautionary measures to be adopted have been discussed.

An interim plan has been developed for the safe and economic management of hazardous waste materials generated by the University. This plan is based on the chemical properties of the wastes generated. Methods of disposal were evaluated in view of the relatively small quantity generated by the University. Land disposal was found to be the most economically feasible method until a suitable regional disposal facility becomes available in the Kingdom.

A detailed manual describing safe chemical storage and disposal practices in the laboratory has been prepared. This manual outlines general specifications for the storage of chemicals on campus and guidelines for overall laboratory safety. It also describes a new system of laboratory hazard warning signs in English and Arabic that can bring greater uniformity to safety signs throughout the university.

Overview

The University generates several hundreds of gallons of hazardous organic and inorganic wastes every year. Most of the hazardous waste materials are liquid chemicals. The Departments of Chemical Engineering, Petroleum Engineering, Chemistry, and the Research Institute are found to be the main sources of these wastes. Acids, alkalies, and less toxic chemicals are disposed of through the sewer system after neutralization and heavy dilution with water. Wastes for which disposal is difficult and which require specific methods are stored for safe future disposal.

In view of this, the study described was initiated with the following objectives: (1) to prepare a plan for safe storage and handling of the hazardous waste materials; (2) to provide guidelines for the collection and disposal of hazardous waste materials; and (3) evaluate hazardous waste material disposal alternatives and select the most economical and feasible one.

Hazardous materials

The word "hazard" implies a potential for risk or danger, or a condition with the potential to cause accidental injury or damage. In discussing hazards it is important to consider not only their causes but also the conditions under which they may occur. The cause of an accident may remain latent for some time before it happens. Thus, a chemical which possesses a high degree of reactivity is not inevitably dangerous but may become so if a condition of its use is not

compatible with its hazardous properties. The potential hazard of a chemical may arise from its inherent instability or from interaction with other chemicals or materials. Thus a hazardous material may be defined as a material which may cause or contribute to serious illness or death, or that poses a substantial threat to human health and the environment when improperly managed.

Research plan

Two major methodologies are presently in use for identifying wastes as hazardous: a list approach and a criteria approach. In the list approach, a waste is analyzed for certain prescribed species and, depending on the presence of these species, a judgement on the degree of hazard is made. On the other hand, the criteria approach identifies the properties of wastes that cause hazardous effects to the environment and then recommends methods and procedures to measure these properties.

Both the list approach and the criteria approach are difficult to implement. The testing is complex and still under development. Therefore, no specific

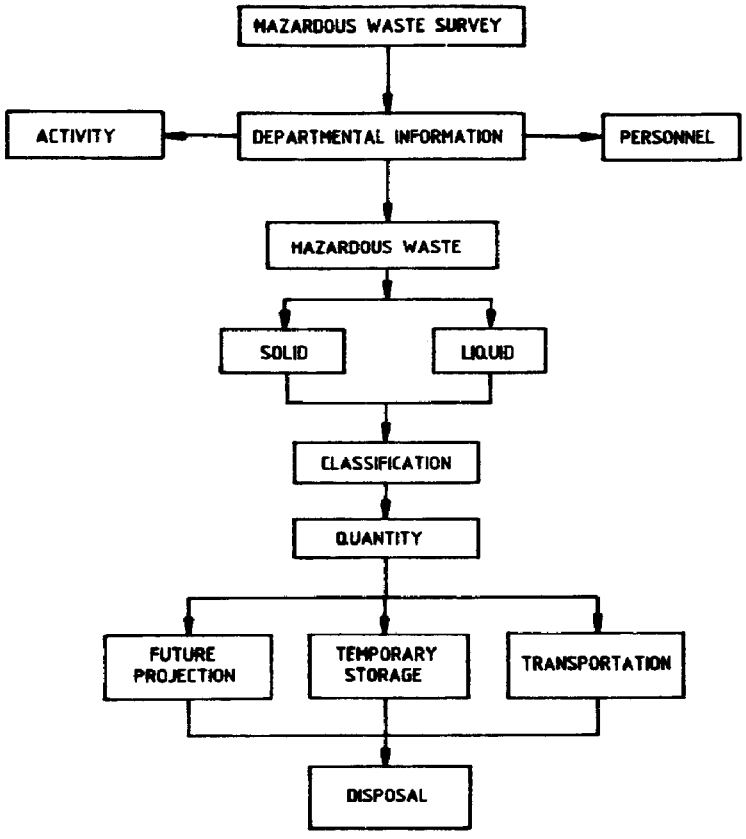

Fig. 1. Flowchart of Questionnaire on Hazardous Waste Survey.

methodology, as such, was feasible for the identification of University hazardous waste materials. However, a questionnaire was prepared to categorize potentially hazardous materials into broad categories to aid in formulating proper handling and management practices. The questionnaire consists of a 10-page booklet. The study was initiated by circulating it to various departments of the University to determine the quantity and quality of hazardous materials. A flow chart describing the questionnaire is provided in Fig. 1.

Present and future waste generation plan

Estimates of current and future University hazardous waste material generation based on information obtained through the questionnaire are shown in Tables 1 and 2. It was found that four departments are currently generating hazardous wastes. Most of the hazardous wastes from these departments are liquid chemical wastes generated by research and teaching laboratories. Other departments are, at present, not contributing any significant amount of hazardous waste materials.

The Departments of Civil Engineering and Mechanical Engineering contribute relatively insignificant volumes of hazardous waste materials. The small

TABLE 1

Stored liquid hazardous waste

Department	Chlorinated solvents (l/y)	Nonchlorinated solvents (l/y)	Inorganic chemicals (l/y)
Chemistry	10	110	15
Chem. Engineering	62	183	37
Pet. Engineering	100	50	–
Res. Institute	17	536	39
Total	189	879	91

TABLE 2

Future hazardous waste generation

Department	Liquid (l/y)	Solid (kg/y)
Chemistry	400	50
Chemical Engineering	288	–
Petroleum Engineering	200	–
Research Institute	540	5
Total	1428	55

amount of liquid inorganic chemical wastes generated by the above departments, consist mainly of acids and bases, and are normally, after neutralization, disposed of through the sewer system followed by heavy dilution with water. In this way the disposal does neither affect the sewer system nor the biological treatment process of waste water. The Departments of Chemistry, Chemical Engineering, Petroleum Engineering, and the Research Institute were found to be the largest generators of hazardous waste materials.
These four sources generate significant amounts of a variety of waste materials which cannot be disposed of by drain. It is evaluated that the total quantities of liquid and solid hazardous waste materials generated annually by the University are 1159 l and 480 kg, respectively. It is estimated that future solid and liquid hazardous waste material generation will be approximately 55 kg/y and 1428 l/y, respectively.

Storage and transportation of hazardous chemicals

Guidelines for chemical storage were prepared. A 5-year shelf life is recommended by manufacturing chemists for most chemicals. Some chemicals, because of their deterioration to unstable forms, should have a shelf life of only 1 year or of only 6 months from the date of opening. Emphasis was given to the storage of minimum quantities of chemicals and to employment of a controlled, rotational stock system. It was suggested that chemical purchases be limited to quantities that can reasonably be expected to be used within 6 months to 1 year. Some of the more hazardous chemicals such as perchloric or picric acids, liquid paraffins, olefins, organic peroxides, or any of the ethers, should be purchased in 3-month quantities or less because of their unstable natures. A *first-in, first-out* system of chemical stockkeeping storage time limits, and central storehouse were recommended. This system could provide most common laboratory chemicals on short notice and eliminate the need for purchasing large quantities of chemicals by individuals.

Minimization of hazardous waste production is a major consideration for laboratories. Often material substitution can be practiced so that highly toxic wastes are not produced. A list of the hazardous chemicals most commonly used in labortories has been prepared, providing information on properties such as health hazard, flammability, reactivity, and recommended precautions.

Caution must be exercised to ensure that incompatible chemicals are not mixed together. A list of incompatible chemicals has been prepared for ready reference. Specifications for containers in which to store and dispose of different types of chemical wastes were provided and recommendation made to eliminate the potential for leakage or potential deterioration of packaging.

It was proposed that a storage facility with adequate ventilation and exhaust be provided at a campus location for temporary storage and identification of University chemical wastes.

Recommendations were made on methods of transporting hazardous waste

materials for ultimate disposal, proper labeling, types of vehicles, and the responsibilities of the transporter.

Hazardous waste material disposal

The KFUPM Plan provides a system to manage the small amount of hazardous waste materials generated by the University based on their chemical properties. These properties can be classified as inorganic, including acids; alkalies; heavy metal and cyanide compounds and organic solvents. Organic solvents can be further classified as follows:

1. Highly toxic
2. Slightly toxic but highly volatile
3. Slightly toxic but highly flammable

In order to ensure safe and economical disposal, specific disposal methods are recommended for the different types of waste materials. For those departments which generate very little amount of inorganic liquid chemical wastes, it was recommended that diluted acids and alkalies can be disposed of into the sewers. Heavy metal and cyanide compound wastes can be treated using a chemical fixation process. The stable, solid polymer formed using this technique can be safely disposed of at a landfill site. The recovery of organic solvents, especially halogenated solvents, by distillation in the laboratory is highly recommended. To further minimize the volume of waste for final disposal, the following steps are recommended:

1. Volatile materials of low toxicity and flammability at the landfill site.
2. Burn flammable, nontoxic organic solvents at the landfill site*.

Finally, highly toxic organic solvents will be disposed of the landfill site using the surface land disposal methodology.

Proposed hazardous waste landfill site†

Recommendations included isolation of the site from residential or commercial activities. There should be no evidence that shallow groundwater underlies the site. The geological structure should be capable of preventing the movement of leachate to groundwater strata. The site should be accessible from an existing highway. A fixed fence with lockable gate must surround the site. The trench method of disposal is recommended. For this operation, the two rectangular trenches, 16 m×4 m each, should be constructed. The soil

*The authors have reluctantly recommended the burning of flammabale-nontoxic organic solvents since the proposed site will be at an isolated place and the plan is of a stop-gap nature. It is also felt that the amount of the flammable-nontoxic solvents will be too small to have any significant environmental impact.

†*Editor's note*: The procedures for landfill disposal of chemicals and landfill design are specific for the paper and may not be appropriate for other countries. Indeed, in the United States RCRA would not allow certain aspects of disposal described in this paper.

removed from the excavation of the trench can be stockpiled on the site and later used as a cover material.

The primary objective of transportation should be to assure that hazardous waste materials are properly handled to prevent harm to health and environment. Therefore, detailed specifications for the transport vehicle were outlined. Proper labeling is important because it indicates the danger while handling, transporting, loading and unloading materials. Therefore, all containers must be affixed with a label stating the properties of the waste materials, such as explosive, oxidizer or organic peroxide, irritant, corrosive, spontaneously combustible, dangerous when wet, infectious waste, and radioactive. Care must be taken to ensure that hazardous waste materials are transported to the appropriate waste receptor. Extra emphasis was put to the protection and safety of personnel and recommendations were also made for safety clothing, gloves, boots, and masks.

Liquid waste will be unloaded at the top of the slope of the trench. Volatile materials will be allowed to evaporate inside the trench and the balance of the waste will be absorbed by the soil. The waste will be covered by a layer of 30 cm soil. Finally, the area will be covered by soil compacted to at least 0.6 m in depth.

Leachate from a a sanitary landfill is a potential contaminant. Therefore, an impermeable layer on the base of the trench is recommended. In order to minimize the leachate volume, another layer of the membrane is recommended for capping the trench. To stop erosion and sand deposition as a result of strong prevailing winds, a polymer-based material can be used as a sand stabilizing agent.

Manual of Safe Chemical Disposal Practices in the Laboratory

A handbook entitled "Manual of Safe Chemical Disposal Practices in the Laboratory" has been prepared to inform students, researchers, technicians, and instructors about the many hazards encountered in a laboratory setting. This manual outlines general specifications for the storage of chemicals on campus; provides guidelines for overall laboratory safety, including proper use and storage of compressed gas cylinders, and chemical and radioactive waste collection. Furthermore it contains procedures for handling chemical spills in the laboratory; effective use of fumehoods; and emergency fire protection procedures. It also offers general preventive measures, chemical safety precautions, safe handling techniques for laboratory glassware, and describes hazards that can be caused by electricity, static electricity, and ultraviolet light.

Lists of imcompatible chemicals and hazardous chemicals are included. In the latter the properties and dangers of these chemicals are briefly described.

The manual also describes a new system of laboratory hazard warning signs in English and Arabic that can bring greater uniformity to safety signs throughout the university.

Conclusions

Based on the information gathered by the questionnaire, KFUPM hazardous waste materials can further be classified as flammable, explosive, oxidizing, corrosive, highly reactive, heavy metal, radioactive, and carcinogenic. This classification is very important for the purpose of transportation. Plans for their storage and transportation have been outlined.

Various methods for the disposal of hazardous wastes and their feasibilities were evaluated. It was concluded that in view of the small quantity of wastes and interim nature of the plan, landfilling would be the most feasible and economic method of disposal.

Because the quantity of inorganic chemical wastes is very small, after neutralization, the practice of disposing of acids and alkalies into the sewer system after heavy dilution with water should be continued. Small amounts of such diluted chemical wastes have a negligible effect on the environment and the wastewater treatment system.

Every effort should be made to minimize the generation of hazardous waste materials. Toxic chemical wastes should be disposed of by chemical fixation followed by landfilling. Chemical purchases should be limited to quantities that can reasonably be expected to be used within six months or a year. A first-in first-out system of chemical stock keeping, using shelf lives should be employed.

According to the properties of chemical waste materials, specifications for disposal containers have been recommended. It has also been proposed that a space with adequate ventilation and exhaust be provided on the campus for temporary storage and identification of chemical wastes from the laboratories.

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