HAZARDOUS WASTE MANAGEMENT

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Summary

The management of hazardous wastes has become a specialized discipline because of the complex nature of the problem and the solutions available to us. The mismanagement examples of hazardous wastes causing disastrous human and environmental consequences are numerous, including the Love Canal, Sydney Tar ponds, and Times Beach incidents. Therefore, the current emphasis is on "cradle to grave" waste management. The management process begins with an understanding of the definition and classification of the different wastes, and their harmful effects on human health, and ends with the application of risk management to control human health and environmental impacts of hazardous waste.

Hazardous waste and contaminated sites are defined and the concepts of risk and risk assessment are introduced. Pollution prevention and pollution control methods are introduced as risk management options. Some details of the procedures of environmental audits and life cycle analysis are provided. Concerns and techniques of storage, transportation and treatment of hazardous wastes are discussed, together with broad categories of treatment approaches. Safe disposal and deep injection methods are presented as alternative pollution control methods.

It is encouraging to note that several countries including the United States and Canada have taken steps in the right direction to manage hazardous waste. These initiatives include not only the cleaning up of contaminated sites but also the control and reduction of hazardous waste generation. Worldwide initiatives are expected to continue and grow as we progress in the new millennium.

1. Introduction

With the rapid pace of urbanization and industrialization, waste generation activities resulting from the provision of goods and services have increased at an alarming rate throughout the world. The modern standards of living require the usage of products made and refined from various natural resources. Almost all the manufacturing processes generate solid, liquid and/or gaseous emissions as by-products. Some of these emissions are potentially harmful to human health and environment, and thus warrant special techniques of management. Hazardous waste management, therefore, deals with minimizing harmful effects on humans and environment by applying special techniques of handling, storage, transportation, treatment and disposal of hazardous emissions. Current practice also calls for pollution prevention, a term used to describe source reduction and recycling activities contributing to a reduction in the volume of waste generated at the source.

Contaminated sites are the result of poor management of hazardous waste in the past. Therefore, effective hazardous waste management should minimize short-term risks immediately after generation of the waste and the long-term risks associated with potentially contaminated sites. Consequently, the process of hazardous waste management starts with problem definition or identification and characterization of waste, application of pollution prevention activities to minimize waste needing handling, storage, transportation and pollution control involving appropriate treatment and safe ultimate disposal to minimize the potential for creation of contaminated sites.

The motivation to manage hazardous wastes to minimize human health and environmental risks came from a public awareness that grew over many historical incidents of uncontrolled disposal of hazardous waste. Some of the most publicized landmark incidents are worth recounting as reminders.

1.1. Love Canal, United States

The Love Canal incident in the United States is a classic example of contamination of a site with hazardous waste over a period of time. As part of a hydroelectric and industrial project, a businessman named W.T. Love originally excavated the Love Canal in Niagara Falls, New York. However, the project was terminated prior to completion. The Hooker Chemicals and Plastic Company subsequently used the blocked-off canal as a chemical disposal site from 1942 to 1953. An estimated twenty thousand tonnes of chemical waste, much of it containing dioxin and other highly toxic compounds, was dumped there.

In 1953, Hooker Chemical and Plastic Company sold the site to the local Board of Education for one dollar, with the condition that the company would be cleared of any liability for the site. An elementary school was built on the site, and the remaining land was sold to developers for housing developments. With time, Love Canal's water, soil and air were contaminated with hazardous chemicals. The hazardous contents within the canal started migrating into the surrounding soil and water environment. Even though the contents of the canal were highly toxic, it took a while before health problems were noticed and residents complained.

The site eventually became the first U.S. federal environmental disaster area. The level of on-site contamination was found to be 250 to 5000 times the level deemed safe for human exposure. In 1978, two hundred and forty families were evacuated from the area. Subsequently, over five hundred homes near the site were also evacuated. There were abnormally high rates of miscarriages, birth defects and cancer among the former residents.

In 1990, after over a decade of studies, remediation and relocation costing over 275 million dollars, some of the area was reopened to new occupancy. The now deemed habitable part of Love Canal was renamed Black Creek Village.

1.2. The Sydney Tar Ponds, Canada

The Sydney Tar Ponds have been called "Canada's Love Canal". For over 80 years, the property has been home to the Sydney Steel Corporation (SYSCO), a steel mill that is still in operation. The spot where the coke ovens stood is estimated to be polluted to a depth of 24 meters with immeasurable quantities of carcinogens and heavy metals. The nearby estuary of Muggah Creek is estimated to contain 770,000 tonnes of toxic sludge.

Residents around the plant lived under a constant rain of orange ore dust from the plant's smokestacks. The company became publicly owned in 1967 but few of the funds that government provided into SYSCO went toward safety improvements or environmental protection. In 1981, the government committed $96 million to a modernization plan that earmarked $14 million for pollution control in the blast furnaces and rolling mills. The installation of new electric arc furnaces would have had a much greater effect, but the coke ovens were not mandated to close until 1998. In the 1980s, Sydney residents began to discover the extent to which the steel mill pollution not only blackened their laundry but also their air, water and soil. The extent of the contamination was staggering. Preliminary studies performed in 1984 suggested the tar ponds contained the equivalent of 594,000 tonnes of dry weight toxic waste, with between 2.0 and 4.0 million kilograms of PAHs (Polycyclic Aromatic Hydrocarbons).

A steady migration of chemical sludge from Muggah Creek into Sydney harbor and the open sea had long been noted. In 1980, the Canadian Department of Fisheries & Oceans published a study which revealed that lobsters in the area carried PAHs (some of which are carcinogens), polychlorinated bi-phenyls (PCBs), mercury, cadmium and lead at levels 26 times higher than those of lobsters caught in the dirty waters of Boston Harbor.

Federal regulations specify that PCBs above 50 ppm require special handling and destruction at temperatures of at least 1,200 degrees Celsius. The tar ponds were estimated to contain PCB concentrations of 633 ppm. With only 6,000 of the 770,000 tonnes successfully burned, the province decided to have an alternative plan. A scheme to encapsulate the waste was authorized in 1995.

There is still debate over the exact amount of pollutants that exist in the area. According to some estimates, the reported amounts of the potentially toxic materials account for only a fraction of the actual amount. Based on increased coke production between 1972 and 1975 and other factors, the amount of toxic waste may actually exceed 11 million tonnes if all toxic materials onsite such as tar, benzene and related compounds, particulate, contaminated soil and slag, contaminated ground, surface water and toxic vegetation are added together.

1.2.1. Stakeholder Involvement

As a result of the increased stakeholder interest at local, provincial and national levels, a multi-stakeholder Joint Action Group (JAG) was formed to conduct broad-based public consultations and devise an effective remediation plan for this site. JAG negotiated a Memorandum of Understanding among the various parties signed on September 19, 1999. Governments at various levels announced $62 million in JAG funding over three fiscal years ending March 31, 2002. This included support for the JAG Secretariat, study and assessment projects, and Phase I remediation projects. The JAG process may become a precedent-setting example of multi-stakeholder co-operation for problem solving in North America.

1.3. Times Beach, United States

Times Beach, United States, is another classic example of hazardous waste pollution and mismanagement over a period of time. The dioxin at Times Beach was a by-product emitted from a chemical plant in Verona, Missouri. In the early seventies, the dioxin at the plant was mixed with used oil by a waste oil recycler to spray onto the roads to keep the dust levels low. Thousands of gallons of this oil were sprayed, potentially causing animals in the area to die and the children to become sick. By 1981, it is reported that seventy-five horses, several dogs, cats, chickens, rodents and birds had perished. Government scientists were recommending people leave the area. The town was officially closed in April 1985.

Children born during the time of the contamination were born with immune cell alterations. Numerous other illnesses, including cancer, were traced to the dioxin. The clean up work cost over two hundred million dollars. The area is now the Route 66 State Park.

1.4. Collective Lessons Learned

The examples highlighted above and the many more similar cases in North America and elsewhere have contributed a vast pool of practical and scientific knowledge about the short-term and long-term effects of hazardous waste on human health and environment. Scientists have realized the need to develop clear cause and effect relationships between chemical agents and human disease. The role of production, storage, transport, disposal and transformation of chemical compounds in the manifestation of human health and environmental effects has become a major topic for scientific research.

Without scientific data to absolve chemical agents, the response of the international community was to implement stringent regulations to control hazardous wastes. Pollution prevention was touted as the solution to all ills associated with hazardous waste. Considering the monumental costs associated with rectifying past mistakes or mismanagement, pollution prevention at a reasonable cost seems to make perfect sense.

Because of the mistakes made in the past, the current approach to hazardous waste management follows the “cradle to grave” concept of comprehensive waste management. Implementation of this concept requires the early identification of hazardous wastes, and actions contributing to formation of such wastes, as well as a step-by-step approach to minimize risks associated with the production, handling, and eventual disposal of such wastes.

2. Hazardous Waste and Contaminated Sites

2.1. Definition and Classification of Hazardous Waste

As a first step, a classification system is necessary to identify waste types capable of causing human health and environmental impacts. Unfortunately, a universal classification system, acceptable to all countries, is currently not available. Nevertheless, there is general agreement on a definition of hazardous waste based on some specific properties of waste. Hazardous wastes are classified based on the following functional properties:

- *Ignitability*

- *Corrosivity*
- *Reactivity*
- *Toxicity*

In addition to identifying wastes based on these properties, specific waste types that are included on hazardous waste lists of local regulatory bodies will be automatically classified as hazardous. In some cases, exceptions to the classification are also listed. With standard tests established by regulatory bodies such as the Environmental Protection Agency (EPA) in the United States, the defining parameters can be described as follows:

- *Ignitability* is the property that could cause a fire during routine management. Examples of ignitable wastes include waste oils and used solvents.
- *Corrosivity*, as indicated by highly acidic and alkaline materials, is a basic property of a hazardous waste because such corrosive materials can react dangerously with other wastes or cause toxic contaminants to migrate from certain wastes. An example of a corrosive waste includes used pickle liquor from steel manufacturing.
- *Reactivity* of unstable wastes can pose an explosive problem at any stage of the waste management cycle. Examples of reactive wastes include water from TNT operations and used cyanide solvents.
- *Toxicity* of wastes that are likely to leach hazardous concentrations of particular toxic constituents into ground water aquifers is an important property for classification. In simulated leaching actions that occur in landfills, if the concentration of the toxic constituent exceeds a regulatory limit, the waste is termed hazardous. Furthermore, any waste exceeding regulatory acute toxicity limits (in terms of LC_{50} or LD_{50} values) is classified as a hazardous waste. Examples include wastes containing high levels of volatile organic compounds (e.g. benzene) and heavy metals such as lead, cadmium and mercury.

A regulatory classification system using the above criteria has a number of limitations. Relative differences in hazards among wastes are not examined by such a system. According to this system, once a waste is classified as hazardous, then it would be accorded the same regulatory coverage regardless of the degree of hazard.

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Web sites

Environmental Protection Agency (EPA) provides comprehensive data and updates on Brownfields in the United States. Interested parties can subscribe for those updates and related information by e-mail to Listserven@unixmail.rtpnc.epa.gov

Toxic Substances Control Act covers government regulations in several areas from storage tanks to drinking water. In the United States, most regulations come under the EPA. They can be accessed through www.rmlibrary.com

http://www.epa.gov/iris/index.html

http://www.epa.gov/

http://www.ec.gc.ca/envhome.html

http://www.ec.gc.ca/envhome.html

http://www.cec.org/home/index.cfm?varlan=english

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Biographical Sketches

Dr.J. Patrick Hettiaratchi, is currently an Associate Professor and Coordinator of the Engineering for the Environment graduate program at the University of Calgary. He holds a bachelors degree in Civil Engineering and Masters and Doctoral degrees in environmental engineering. He has practiced environmental engineering for the past 20 years as a waste management consultant, a research engineer and as an academic. Currently he teaches graduate and undergraduate courses in solid and hazardous waste management and management of contaminated sites. His current research includes landfill technology development to reduce air pollution impacts, methanotrophic biofiltration to control methane emissions from oil and gas operations, slurry and solid phase remediation of flare pit wastes, regional air pollution monitoring and modeling, and contaminated site risk assessment. He has published extensively in international journals and conferences in these topic areas.

M. Gamini Dissanayake obtained his Masters and Doctoral degrees in Environmental Engineering from the Asian Institute of Technology, Bangkok in 1977 and 1981 respectively. Since then he has worked for a number of institutions and universities including United Nations Environment Program (UNEP), University of Calgary, University of Paraiba, Brazil and United States Agency for International Development (USAID). His research interests include solid and hazardous waste management, and wastewater treatment and management. Currently he is attached to a private sector environmental management company in Calgary, Canada.

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