

ENVIRONMENTALLY SOUND MANAGEMENT OF HAZARDOUS WASTES

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Summary

Generation of hazardous wastes has been an integral part of many of the activities of modern civilization, but the problems associated with their safe disposal, captured the world's attention only in the late 1970s after the environmental disasters that occurred in the Love Canal area of Niagara Falls, New York and at other places.

As the improper disposal of hazardous wastes has led to the contamination of soil, groundwater and surface water in many parts of the world, a sound hazardous waste management system is required to be developed which must include issues beyond safe storage and disposal practices. Environmentally sound management of hazardous wastes requires a holistic and comprehensive approach on all alternatives available to institute a cradle – to – grave management system. It should consider not only the characteristics, volume and location of the wastes, but also how and why wastes are being produced and what effective steps can be taken to reduce substantially the quantity and toxicity of wastes ultimately to be disposed of. *The best approach to manage hazardous wastes in Environmentally Sound way is to avoid its generation at source to the maximum extent possible.*

The objectives of an integrated and effective waste management program thus include minimisation of the quantity, toxicity and containment of waste in a given space and time period. For cost-effective waste management system, it is important to minimise the generation of waste right at the source. This can be fulfilled by a commitment towards a waste hierarchy concept. In the hierarchy of waste management, the prime attention should be given to Waste Avoidance, Waste Minimisation and Waste Reuse/Recycle in an Environmentally Sound Waste Management Approach. Therefore, special emphasis must be placed on the application of clean technologies that produce no or little waste.

Traditional methods for managing industrial waste are being phased out or are undergoing significant up-gradation/modification in response to the more stringent regulations & market forces. Industrial firms also have to work hard to minimize their waste and reduce potential future liabilities due to environmental and public health concerns related to hazardous waste management practices. The adoption of above waste management hierarchy also involves handling, storage & transportation of hazardous wastes.

In order to manage such wastes in an environmentally sound manner, *the hazardous wastes once generated have to be managed scientifically and systematically, right from their source of generation to ultimate disposal in order to prevent environmental contamination.* Considering the importance of the above issues and implications thereof a systematic approach has been developed and presented in this article towards managing hazardous wastes scientifically and in an environmentally sound manner.

1. Introduction

Rapid industrialisation has improved quality of life by providing chemical products, which have improved health and life expectancy, increased agriculture production, enhanced economic opportunities and improved the facilities for luxury and comfort. However, it is also true that chemical residues, which are generated unavoidably during the production of these chemicals, have also posed unprecedented risks to human health and environment.

The quantity and diversity of wastes generated, as a consequence of industrial development, has become a major cause of concern in developing countries. Some of these wastes may be toxic and hazardous depending upon their nature and characteristics. Several countries have already made great efforts to develop effective technologies and administrative framework for effective hazardous waste management. While substantial progress has been made, hazardous waste management is still in developing stage in third world countries.

Today, it has become clear that the health of the public and the surrounding environment is put at risk as a result of past practices of uncontrolled waste dumping. Some of these wastes have been proven to be extremely toxic and hazardous; the uncontrolled dumping of such wastes has brought about the death of live stocks and an increasing number of incidents have caused health hazard to human beings in many countries. A potentially more serious risk to human health is due to contamination of surface and ground water. In view of the growing impacts of such wastes on natural resources, the community world over has addressed this issue at the international level.

Once the environmental resources whether land or water gets contaminated with toxic and hazardous components of waste, it is almost impossible to clean up these resources economically. It is essential for both the regulatory authorities as well as industries to manage hazardous wastes under strict control. One of the instruments used for controlling hazardous wastes, is introduction & enforcement of appropriate legislation. To support and enforce the legislative system, appropriate administrative and organisational structure needs to be established. In order to ensure safe and scientific disposal of hazardous and toxic wastes specialised and engineered facilities are needed. Furthermore, constant monitoring is required to ascertain that disposal has been effective and there is no more threat to human health and environment.

2. Hazardous Waste - Definition

The waste is something, which the owner no longer wants at a given place and time and which has no current or perceived market value. Till date there is no uniform internationally accepted definition of hazardous waste as it has been defined differently in different countries. In general, hazardous waste is the waste, which has certain physical, chemical, or biological characteristics, which require special handling and disposal procedures to avoid risk to health and the environment. In attempting to define hazardous waste, the following questions must be answered. It is –

- i) hazardous to what? : receptor

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|------|-----------------|-------------------------|---|------------------------------------|
| ii) | hazardous for | <u>what reasons?</u> | : | <i>characteristics</i> |
| iii) | hazardous to | <u>what degree?</u> | : | <i>concentration/exposure time</i> |
| iv) | hazardous at | <u>what time?</u> | : | <i>present/ future</i> |
| v) | hazardous under | <u>what conditions?</u> | : | <i>quantity, forms etc.</i> |

The hazardous wastes cause harm either through contact/ inhalation or direct/indirect ingestion. The indiscriminate disposal of these substances contaminates natural resources like soil, groundwater, surface water and ambient air. The impacts of the indiscriminate waste disposal have manifested in many forms like fatal accidents, increased mortality rate and irreparable damage valuable natural resources. In defining hazardous waste, the concern is essential with waste that presents either:

- *Short Term Acute Hazard*, such as acute toxicity by ingestion, inhalation, or skin absorption, the risk of fire or explosion;
- *Long Term Environmental Hazard*, include chronic toxicity upon repeated exposure, carcinogenic, resistance to detoxification processes such as biodegradation, the potential to pollute underground and/ or surface waters.

In order to classify a waste as toxic/hazardous, the waste is usually subjected to evaluation based on its attributes such as nature, composition and inherent characteristics. It is appropriate to make a distinction between toxicity and hazardous characteristics of wastes. “*Toxicity*” refers to the capacity of a waste to cause internal damage to living systems whereas “*Hazard*” refers to the capacity of a waste to cause external injury to living systems and damages to property or environment. The degree of risk from a waste is, therefore, dependent on the toxicity characteristics and the nature of hazard involved. The characteristics like chronic toxicity and synergistic and/or antagonistic effects of waste make the issue of defining waste as intricate. In general, the definition of hazardous waste is centered around the “effects” of a particular waste on man or other forms of life, material and environment. It is evident that toxic constituents are primarily responsible for adverse effects. Broadly, two systems are followed for classification of hazardous wastes.

- (a) Exclusive List System
- (b) Inclusive List System

(a) Exclusive List System

According to this system, only groups of non-hazardous wastes have been listed (by experience and perhaps by intuition) and those wastes, which do not fall in this category, have been designated as hazardous. This system was followed earlier by a few developed countries.

(b) Inclusive List System

In the inclusive list system, the list includes only hazardous chemicals and wastes. Belgium, Denmark, France, Federal Republic of Germany, The Netherlands, India, Sweden, United Kingdom, and United State of America follow this system today. In this approach, solid wastes are considered hazardous through three different methods of

listing as given below:

- 1) **“general listing approach”**, based on assumption of hazard or non-hazard without test
- 2) **“listing approach”**, prior listing as hazardous wastes based on profile of the potential health effects
- 3) **“listing by characteristics”**, identification of characteristics by testing and declaration of hazard.

Since, there is no universally accepted definition of hazardous wastes, some of the definitions adopted by various countries or international organizations are given below.

“Wastes other than radioactive wastes which, by reason of their chemical reactivity or toxic, explosive, corrosive or other characteristics causing danger or likely to cause danger to health or the environment, whether along or coming into contact with other wastes, are legally defined hazardous in the State in which they are generated or in which they are disposed or through which they are transported.” **(UNEP)**

“A solid waste or a combination of solid wastes which because of its quantity, concentration or physical, chemical or infectious characteristics may (1) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible or incapacitating reversible illness or (2) pose a substantial present or potential hazard to human health or the environment when improperly, treated, stored, transported, or disposed of or otherwise managed”. **(USEPA)**

“Hazardous wastes are wastes which by reason of its nature, condition or quantity constitutes a particular danger to health or to the quality of air or water or which is particularly exposable or inflammable or which contains or may produce pathogens of transmissible disease”. **(Federal Republic of Germany)**

“Hazardous wastes are the waste which has physical, chemical or biological characteristics which require special handling and disposal procedure to avoid risks to health and/or other adverse environmental effects”. **(IRPTC-7-Section, UNEP)**

The definition of hazardous waste as given by “US-EPA” has been accepted by most of the developed as well as developing countries. Thus, from the above definitions it can be concluded that hazardous waste is any residue that may cause harm to human health and/or environment, when handled, stored, transported, treated and disposed *improperly*. Such wastes have to be managed in environmentally sound manner in order to protect the health & the environment. The various characteristics of hazardous waste as identified by US-EPA, Basal Convention and The European Commission are given at Annex 1.

Annex- 1

CHARACTERISTICS OF HAZARDOUS WASTE

As per Environmental Protection Agency of the United States (US-EPA) the

characteristics of hazardous waste are defined as:

Ignitability: Wastes that pose a fire hazard during routine management. Fires not only present immediate dangers of heat and smoke but also can spread harmful particles over wide areas.

Corrosivity: Wastes requiring special containers or segregation from other wastes because of their ability to dissolve toxic contaminants.

Reactivity: Wastes that tend to react spontaneously, to react vigorously with air or water, to be unstable to shock or heat, to generate gases or to explode.

Toxicity: Wastes that, when improperly managed, may release toxicants in sufficient quantities to pose a substantial hazard to human health or the environment.

Furthermore, The European Commission has described the following characteristics of hazardous wastes in 1988:

Explosive: substances and preparations, which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene

Oxidizing: substances and preparations, which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances;

Highly Flammable:

- Liquid substances and preparations having a flash point below 21° C (including extremely flammable liquids), or
- Substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or
- Solid substances and preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition, or
- Gaseous substances and preparations which are flammable in air at normal pressure, or
- Substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities;

Flammable: Liquid substances and preparations having a flash point equal to or greater than 21° C and less than or equal to 55° C;

Irritant: non-corrosive substances and preparations, which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation;

Harmful: substances and preparation which, if they are inhaled or ingested or if they penetrate the skin, may involve limited health risks;

- Toxic:** substances and preparations (including very toxic substances and preparations) which, if they are inhaled or ingested or if they penetrate the skin, may involve serious, acute or chronic health risks and even death.
- Carcinogenic:** substances or preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence;
- Corrosive:** substances and preparations, which may destroy living tissue on contact;
- Infectious:** substances containing viable micro organisms or their toxins which are known or reliably believed to cause disease in man or other living organisms;
- Teratogenic:** substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce non-hereditary congenital malformations or increase their incidence;
- Mutagenic:** substances or preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence;
- Ecotoxic:** substances or preparations, which present or may present immediate or delayed risks for one or more sectors of environment.

3. Identification, Classification and Characterization of Hazardous Waste

Based on different criteria used in various countries the following approach can be adopted for identifying and classifying hazardous wastes. Any waste has the potential to be hazardous by virtue of the following:

- a) the substances present in it;
- b) the concentration or chemical reactivity of such substance;
- c) the physical form in which the substances are present;
- d) the quantity and rate of generation of potentially hazardous materials in the environment in which they are placed;

Hazardous waste may be categorized in various ways, and such categorization can aid management control. For example, hazardous waste may be categorized with respect to:

- 1) suitability for various treatment processes;
- 2) suitability for various disposal methods;
- 3) compatibility with other types of waste;
- 4) potential acute hazards such as flammability, corrosiveness or toxicity; and
- 5) physical form, such as solid, liquid or sludge.

The short term acute and long-term environmentally hazardous properties of wastes are functions of the chemical species present. In some cases wastes may have well defined hazardous characteristics and are unequivocally hazardous, however, majority of wastes are likely to be complex mixtures that render them complex chemical characteristics. In such cases the prominent hazard characteristic has to be identified.

The following three approaches are being used in order to classify hazardous wastes:

- 1) **Source of Generation** approach
- 2) **Toxic Component Present** approach
- 3) **Criteria** approach wherein the following characteristics of hazardous waste are defined:
 - Corrosivity,
 - Reactivity,
 - Ignitability,
 - Toxicity (Extraction Procedure)

Different countries have adopted different approaches or combination thereof for identification and classification of their hazardous wastes.

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Bibliography

Booklet on "The Basel Convention: A Global Solution for Controlling Hazardous Wastes", United Nations, New York and Geneva, 1997. (This booklet deals with Basel Convention).

Draft Report on "Sectoral Environmental Assessment" prepared by Environmental Management Center, Mumbai for Ministry of Environment & Forests, Government of India, under support from The World Bank under India - Hazardous Waste Management Project, 1997 (This is a comprehensive policy document on Hazardous Waste Management in India).

Hazardous Waste Management - Selected Papers from an International Workshop convened by UNIDO in Vienna, 1987 Edited by Sonia P. Maltezou, Asit K. Biswas & Hans Sutter, UNIDO, 1989. Published on behalf of UNIDO and IACT by Tycooly, London and New York. (This book provides technical, methodological and managerial issues related to the disposal of hazardous wastes).

Hazardous Waste Management (2nd Edition) by Charles A. Wentz, International Edition of McGraw-Hill, Inc., 1995. (This book deals with technical issues related to the disposal of hazardous wastes).

Management of Hazardous Waste, Edited by Michael J. Suess from WHO Regional Office for Europe & Jan W. Huisman from UNEP, Geneva, WHO Regional Publications, European Series No. 14, 1983. (It presents Policy Guidelines and Code of Practice on Hazardous Waste Management).

Paper on "The Basel Convention and The Import of Hazardous Wastes to India," by Shalini Bhutani, Published by Centre for Environmental Law, World Wide Fund for Nature - India, 1996, New Delhi. (This paper presents the salient features of Basel Convention).

Proceedings of Multi Country Workshop on "Green Productivity & Hazardous Waste Management", 25 - 28, September 2001, New Delhi, India. Organized by Asian Productivity Organization, Tokyo, Japan and National Productivity Council, New Delhi, India. (This highlights the application of Green Productivity in Hazardous Waste Management).

Proposed Guide for Industrial Waste Management for Public Comment. EPA530-R-99-001, U.S.

Environmental Protection Agency, Office of Solid Waste and Emergency Response, 401 M Street, SW, Washington, DC 20460, 1999. (This guide identifies the components of a sound waste management system and why each is important).

The paper on "India and the Transboundary Movements of Hazardous Wastes - The Law and Practice", by Shikhar Ranjan, Doctoral Candidate, International Legal Studies Division, School of International Studies, Jawaharlal Nehru University, New Delhi, India. (This paper describes the problem of transboundary movement of hazardous wastes to India).

World Bank Technical Paper no. 93 on "Safe Disposal of Hazardous Wastes", The Special Needs and Problems of Developing Countries, Volume I, II & III, Edited by Roger Batstone, James E. Smith, Jr., and David Wilson. The World Bank, Washington, D.C, 1989. (This publication provides the framework for evaluating options such as waste minimisation, recycling and waste reduction. The full array of treatment and disposal option is presented along with pros and cons of each).

Biographical Sketches

Dr. A.K. Saxena has a Doctorate in Zoology (University of Rajasthan) and a Post Graduate Diploma in "Water Analysis & Quality" from Loughborough University of Technology, U.K. and advanced training on "Hazardous Waste Management (HWM) at Germany.

Dr. Saxena has a rich and extensive experience of research, project management, consultancy and training. As Director (Environment) in National Productivity Council, he is responsible for planning, managing and monitoring of activities of the Environment Division of NPC; over-all coordination of Indo German project on Industrial Pollution Control.

Before joining NPC, Dr. Saxena has worked as Scientist in Council of Scientific & Industrial Research (CSIR). His job responsibilities in CSIR included coordination between government and industries for the transfer of pollution control technologies and providing advisory services to the industry in the field of pollution control.

He has eighteen years of consultancy cum training experience in the field of Hazardous Waste Management, Waste Minimisation and Green Productivity. Some of his noteworthy assignments in Project Planning & Management are – Planning and Management of Indo German Technical Cooperation Project on Industrial Pollution Control and World Bank assisted Ministry of Environment and Forests (Govt. of India) projects on pollution prevention and control. He was the project leader of some significant projects which include Demonstration of Green Productivity in Dyes & Dye Intermediates, Tannery and Edible Oil in India sponsored by the Asian Productivity Organisation; Waste Minimisation Survey in India as APO's expert; UNIDO's National expert to prepare case studies on Environment Management System in SMEs. He has been engaged as Green Productivity expert by the Asian Productivity Organisation, Tokyo to provide training in various South East Asian countries.

Dr. Saxena is member of various committees constituted by the Ministry of Environment & Forests, Government of India. Hon'ble Supreme Court and State Governments on environment related policy matters. He has to his credit a number of papers published in national & international journals.

Mr. Yogesh Gupta has completed the undergraduate degree (B.Tech.) in Civil Engineering from KNIT, Sultanpur (U.P.) in 1989 and Masters Degree (M.E.) in Environmental Engg. from Punjab University, Chandigarh (1991). Subsequently, he has undergone for 2 - year comprehensive P.G. Course in Industrial Pollution Prevention & Control (IPPC) at Dr. Ambedkar Institute of Productivity, National Productivity Council, Chennai (1994) and obtain Gold Medal. From Oct.94, he is working with National Productivity Council, New Delhi where presently he is Deputy Director in Environment Division.

Mr. Gupta has undergone training at Germany in the field of "Development & Management of Secured Landfill Facility for Hazardous Waste" and at Philadelphia, USA for Municipal & Hazardous Waste Management & Engineering.

In NPC, Mr. Gupta is presently looking after Solid Waste Management including industrial hazardous wastes, bio-medical & municipal solid wastes. As a Dy. Director, he is responsible for planning and execution of consultancy assignment in waste management. He has extensively worked for carrying out environmental impact assessment for identification of waste disposal and management sites, designing of

secured landfill facilities, inventerisation and characterisation of hazardous & bio medical wastes. As a team leader, he has executed the several assignment for Development & Implementation of hazardous waste management system for large industrial houses to track the wastes from the source of generation to final disposal.

Mr. Gupta is also a member of committee for designing course curriculum for M.Sc. in Hazardous Waste Management by Indira Gandhi National Open University (IGNOU), New Delhi. Several papers written by him have been published/presented in National & International Workshops/seminars & journals.