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TECHNICAL MANAGEMENT OF HAZARDOUS WASTE FOR GREEN BIODIVERSITY

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Abstract

Hazardous waste management converts the waste material into less harmful or make environment sound in chemicals by biological, physical, and thermal processes, followed by the disposal or dispersal of the solid, liquid or gaseous products or residues under managed conditions.

Because of the widely differing physical and chemical characteristics of hazardous wastes, treatment technologies have to be carefully matched to each waste type, taking into consideration the nature of the wastes, the degree of hazard reduction required, as well as economic and other factors.

Advances in biological processes have resulted in systems that permit faster degradation rates and treatment of higher levels of contamination by raising treatment temperature and improving oxygen transfer rates. Novel physicochemical processes have been developed that use combinations of chemicals, often aided by the passage of an electrical current, to oxidize as well as to recover constituents in the waste from aqueous solutions.

New thermal processes have utilized technologies such as plasma arc combustion and gasification to improve destruction efficiencies and produce an inert, vitrified ash product. Continuing innovation is seen as the key to providing more cost effective and environmentally acceptable solutions to both long-standing and, as yet, unresolved problems with hazardous waste.

The purpose of this paper is to describe the variety of technical options for hazardous waste management. The technical detail is limited to that needed for examining policy options and regulatory needs. Still, there are many technologies, and their potential roles in hazardous waste management are diverse. Thus, there are many technical aspects related to policy and regulation issues.

Keywords: *Hazardous, Contamination, physicochemical, Oxidation, Innovation*

Hazardous Waste Management Practices:

Waste may be grouped into three major categories, depending on its production:

1. from the primary sector of production (mining, forestry, agriculture, animal breeding, fishery)
2. from the production and transformation industry (foods, equipment, products of all types)
3. from the consumption sector (households, enterprises, transportation, trade, construction, services, etc.).

Waste can be also classified by legislative decree:

- Municipal waste and mixed waste from enterprises which may be aggregated as municipal waste, since both consist of the same categories of waste and are of small size (vegetables, paper, metals, glass, plastics and so on), although in differing proportions.
- Bulky urban waste (furniture, equipment, vehicles, construction and demolition waste other than inert material)
- Waste subject to special legislation (e.g., hazardous, infectious, radioactive).

Management of Municipal and Ordinary Hazardous Waste:

Collected by trucks, these wastes can be transported (directly or by road-to-road, road-to-rail or road-to-waterway transfer stations and long-distance transportation means) to a landfill, or to a treatment plant for material recovery (mechanical sorting, composting, biomethanization), or for energy recovery (grid or kiln incinerator, pyrolysis).

Treatment plants produce proportionally small quantities of residues which may be more hazardous for the environment than the original waste. For example, incinerators produce fly ashes with very high heavy metal and complex chemical content. These residues are often classified by legislation as hazardous waste and require appropriate management. Treatment plants differ from landfills because they are “open systems” with inputs and outputs, whereas landfills are essentially “sinks” (if one neglects the small quantity of leach ate which deserves further treatment and the production of biogas, which may be an exploited source of energy on very large landfills).

Industrial and Domestic Equipments:

The present trend, which also has commercial contributions, is for the producers of the waste sectors (e.g., cars, computers, machines) to be responsible for the recycling. Residues are then either hazardous waste or are similar to ordinary waste from enterprises.

Construction and Demolition Waste:

The increasing prices of landfills are an incentive for a better sorting of such waste. Separation of the hazardous and burnable waste from the large quantity of inert materials allows the latter to be disposed of at a far lower rate than mixed waste.

Chemical Waste:

Chemically hazardous waste must be treated through neutralisation, mineralisation, insolubilisation or be made inert before it can be deposited in special landfills. Infectious waste is best burnt in incinerators. Radioactive waste is subject to very strict legislation.

Solid Waste Management and Recycling:

Recovery of hazardous materials from process effluent followed by recycling provides an excellent method of reducing the volume of hazardous waste. These are not new industrial practices. Recovery and recycling often are used together, but technically the terms are different. Recovery involves the separation of a substance from a mixture. Recycling is the use of such a material recovered from a process effluent. Several components may be recovered from a process effluent and can be recycled or discarded. For example, a waste composed of several organic materials might be processed by solvent distillation to recover halogenated organic solvents for recycling; the discarded residue of mixed organics might be burned for process heat.

Recovery and recycling operations can be divided into three categories:

1. If several products are produced at one plant by various processes, materials from the effluents of one process may become raw materials for another through in-plant recycling. In-plant recycling is performed by the waste (or potential waste) generator, and is defined as recovery and recycling of raw materials, process streams, or by-products for the purpose of prevention or elimination of hazardous waste. An example is the recovery of relatively dilute sulphuric acid, which is then used to neutralize an alkaline waste, In-plant recycling offers several benefits to the manufacturer, including savings in raw materials, energy requirements, and disposal or treatment costs.
2. Commercial (offsite) recovery can be used for those wastes combined from several processes or produced in relatively small quantities by several manufacturers. Commercial recovery means that an agent other than the generator of the waste is handling collection and recovery. These recovery systems may be owned and operated by, or simply serve, several waste generators, thereby offering an advantage of economy of scale. In most cases commercial recovery systems are owned and operated by independent companies, and are particularly important for hazardous waste generators.

Commercially Applied Hazardous Waste Recovery Technologies

Generic Waste	Typical source of Effluent	Recovery Technologies
Solids in aqueous suspension	Salt/soda ash liming operations	Filtration
Heavy metals	Metal hydroxides from metal-plating waste; Electrolysis sludge from steel-pickling operations	Electrolysis
Organic liquids	Petrochemicals/mixed alcohol	Distillation
Inorganic aqueous solution	Concentration of inorganic salts/acids	Evaporation
Separate phase solids, grease/oil	Tannery waste/petroleum waste	Sedimentation/skimming
Chrome salt solutions	Chromium-plating solutions/tanning solutions	Reduction
Metals; phosphate sulphates	Steel-pickling operations	Precipitation

SOURCE*: Ice of Technology Assessment*

In commercial recovery, responsibility for the waste and compliance with regulations and manifest systems remain that of the generator until recovery and recycling is completed. Material exchanges (often referred to as "waste" exchanges) are a means to allow raw materials users to identify waste generators producing a material that could be used. Waste exchanges are listing mechanisms only and do not include collection, handling, or processing, Although benefits occur by elimination of disposal and treatment costs for a waste as well as receipt of cash value for a waste, responsibility for meeting purchaser specifications remains with the generator, Standard technologies developed that can be adapted for recovery of raw materials or by-products may be grouped in three general categories. Physical separation includes gravity settling, filtration, flotation, flocculation, and centrifugation. These operations take advantage of differences in particle size and density; Component separation technologies distinguish constituents by differences in electrical charge, boiling point, or miscibility. Examples include ion exchange, reverse osmosis, electrolysis, adsorption, evaporation, distillation, and solvent extraction. Chemical transformation requires chemical reactions to remove specific chemical constituents. Examples include precipitation, electro dialysis, and oxidation-reduction reactions. A typical recovery and recycling system usually uses several technologies in series. Therefore, what may appear as a complex process actually is a combination of simple operations. For example, recycling steel-pickling liquors may involve precipitation, gravity settling, and flotation. Precipitation transforms a component of high volubility to an insoluble substance that is more easily separated by gravity settling, a coarse separation technique, and flotation, a finishing separation method, Integration of process equipment can introduce some complexity, The auxiliary handling equipment (e.g., piping, pumps, controls, and monitoring devices that are required to provide continuous treatment from one phase to another) can be extensive. Recovery and recycling technologies applied to waste vary in their stages of development. Physical separation techniques are the most commonly used and least expensive. The separation efficiency of these techniques is not as high as more complex systems, and therefore the type of waste to which it is applied is limited. Complex component separations (e.g., reverse osmosis) are being investigated for application to hazardous waste. These generally are expensive operations and have not been implemented commercially for hazardous waste reduction. Chemical transformation methods are also expensive. Precipitation and thermal oxidation, however, appear to have current commercial application in hazardous waste management.

Solid wastes are traditionally described as residual products, which represent a cost when one has to resort to disposal.

Management of hazardous solid waste encompasses a complex set of potential impacts on human health and safety, and the environment. The impacts, although the type of hazards may be similar, should be distinguished for three distinct types of operation:

- handling and storage at the waste producer
- collection and transportation
- sorting, processing and disposal.

One should bear in mind that health and safety hazards will arise where the waste is produced in the first place i.e. in the factory or with the consumer. Hence, waste storage at the waste generator - and especially when waste is separated at source - may cause harmful impact on the nearby surroundings. This research paper will focus on a framework for understanding solid hazardous waste management practices and situating the occupational health and safety risks associated with the waste collection, transportation, processing and disposal industries.

Principles of Hazardous Waste Management:

Hazardous waste management involves a complex and wide range of occupational health and safety relations. Hazardous waste management represents a “reverse” production process; the “product” is removal of surplus materials. The original aim was simply to collect the materials, reuse the valuable part of the materials and dispose of what remained at the nearest sites not used for agriculture purposes, buildings and so on. This is still the case in many countries.

Sources of waste can be described by different functions in a modern society (Table-1).

Table-1 Sources of waste

Activity	Waste description
Industry	Product residues, Default products
Wholesale	Default products
Retail	Transport packaging, Default products, Organics (from food processing), Food waste
Consumer	Transport packaging, Retail packaging (paper, glass, metal, plastics, etc.) Kitchen waste (organics) Hazardous waste (chemicals, oil), Bulky waste (used furniture) etc., Garden waste
Construction and demolition	Concrete, bricks, iron, soil, etc.
Infrastructure activities	Park waste, Street cleaning waste, Clinkers, ashes and flue gas from energy production, Sewage sludge, Hospital waste
Waste processing	Rejects from sorting facilities Clinkers, ashes and flue gas cleaning products from incineration

Each type of hazardous waste is characterized by its origin or what type of product it was before it became waste. Hence, basically its health and safety hazards should be laid down upon the restriction of handling the product by the waste producer. In any case, storage of the waste may create new and stronger elements of hazards (chemical and/or biological activity in the storage period).

Hazardous solid waste management can be distinguished by the following stages:

- separation at source into specific waste fraction depending on material characteristics
- temporary storage at the waste producer in bins, sacks, containers or in bulk
- collection and transportation by vehicle:
  - manual, horse team, motorized and so on
  - open platform, closed truck body, compacting unit and so on
- transfer station: compaction and reloading to larger transport units
- recycling and/or waste processing facilities
- waste processing
- manual or mechanical sorting out into different material fractions for recycling
- processing of pre-sorted waste fractions to secondary raw materials

- processing for new (raw) materials
- incineration for volume reduction and/or energy recovery
- anaerobic digestion of organics for production of soil conditioner, fertilizer and energy (biogas)
- composting of organics for production of soil conditioner and fertilizer

Hazardous waste disposal:

Landfill, which should be designed and located to prevent migration of polluted water (landfill leach ate), especially into drinking water resources (groundwater resources, wells and rivers). Recycling of waste can take place at any stage of the waste system, and at each stage of the waste system, special occupational health and safety hazards may arise.

In low-income societies and non-industrial countries, recycling of solid hazardous waste is a basic income for the waste collectors. Typically, no questions are put on the health and safety hazards in these areas. In the intensely industrialized countries, there is a clear trend for putting increased focus on recycling of the huge amounts of waste produced. Important reasons go beyond the direct market value of the waste, and include the lack of proper disposal facilities and the growing public awareness of the imbalance between consumption and protection of the natural environment. Thus, waste collection and scavenging have been renamed recycling to upgrade the activity in the mind of the public, resulting in a steeply growing awareness of the working conditions in the waste business.

Today, the occupational health and safety authorities in the industrialized countries are focusing on working conditions which, a few years ago, passed off unnoticed with unspoken acceptance, such as:

- improper heavy lifting and excessive amount of materials handled per working day
- inappropriate exposure to dust of unknown composition
- unnoticed impact by micro-organisms (bacteria, fungi) and endotoxins
- unnoticed exposure to toxic chemicals.

Techniques of Source Separation:

Source separation will, by today's technology, result in fractions of waste which are "designed" for processing. The goal of the source sorting system should be to avoid a mixing or pollution of the different waste fractions, which could be an obstacle to easy recycling.

The collection of source-sorted waste fractions will often result in more distinct occupational health and safety hazards than does collection in bulk. This is due to concentration of specific waste fractions- for instance, toxic substances. Sorting out of easily degradable organics may result in producing high levels of exposure to hazardous fungi, bacteria, end toxins and so on, when the materials are handled or reloaded.

Techniques of Central Sorting:

Central sorting may be done by mechanical or manual methods. It is the general opinion that mechanical sorting without prior source separation by today's known technology should be used only for production of refuse derived fuel (RDF). Prerequisites for acceptable working conditions are total casing of the mechanical equipment and use of personal "space suits" when service and maintenance have to be carried out. Mechanical central sorting with prior source separation has, with today's technology, not been successful due to difficulties in reaching proper sorting efficiency. When the characteristics of the sorted out waste fractions become more clearly defined, and when these characteristics become valid on a national or international basis, then it can be expected that new proper and efficient techniques will be developed. The success of these new techniques will be closely linked to prudent consideration to obtaining acceptable working conditions.

Manual central sorting should imply prior source separation to avoid occupational health and safety hazards (dust, bacteria, toxic substances and so on). The manual sorting should be limited to only a limited number of waste fraction "qualities" to avoid foreseeable sorting mistakes at the source, and to facilitate easy control facilities at the plant's reception area. As the waste fractions become more clearly defined, it will be possible to develop more and more devices for automatic sorting procedures to minimize direct human exposure to noxious substances.

Hazardous-waste treatment:

Most treatment of hazardous (or toxic) waste now takes place in purpose-built facilities by hazardous-waste workers. From an environmental point of view, the test of effectiveness of a hazardous-waste facility is that it produces no outputs which are not inert or virtually inert, such as silica, insoluble inorganic compounds, insoluble and non-corrosive slags, gaseous nitrogen or carbon dioxide - though carbon dioxide is a "greenhouse gas" which causes climate change and is, thus, a further environmental detriment.

A further test is that the facility be energy efficient - that is, energy is not wasted - and as energy non-intensive as possible (i.e., the ratio of energy use to the volume of waste treated be as low as possible). A general rule of thumb (it is fortunately not a universal law) is that the more effective the pollution (or waste) abatement strategy, the more energy is consumed, which by sustainable development criteria is another detriment.

Even when the workers are properly protected, it is easy to see the drawbacks of hazardous-waste treatment as a mode of addressing pollution. Pollution prevention methods can be applied to the operation of the treatment process but they cannot be applied to the principal “input” - the waste to be treated. Hazardous-waste treatment facilities will usually require at least as much energy to treat the waste as was expended in its creation, and there will always be further waste as an output, however inert or non-toxic.

Spills and leaks

The same considerations will apply to chemical spills and leaks as to the clean-up of contaminated sites, with the further hazards caused by the urgency of the clean-up. Workers cleaning up spills and leaks are almost always emergency workers. Depending on the scale and the nature of the pollutant, leaks and spills can become major industrial accidents.

Assessment of Hazardous Waste:

Some pollution prevention schemes work without any hazard evaluation - that is, without criteria to decide whether a plant or facility is more or less environmentally benign as a result of pollution prevention measures. Such schemes may rely on a list of chemicals which are objects of concern or which define the scope of the pollution prevention programme. But the list does not grade chemicals as to their relative hazardousness, nor is there a guarantee that a chemical substitute not on the list is, in fact, less hazardous than a listed chemical. Common sense, not scientific analysis, tells us how to go about implementing a pollution prevention programme.

Other schemes rest on criteria for assessing hazardousness, that is, on hazard assessment systems. They work, essentially, by laying down a number of environmental parameters, such as persistence and bioaccumulation in the environment, and a number of human health parameters which serve as measures of toxicity - for example, acute toxicity, carcinogenicity, mutagenicity, reproductive toxicity and so on.

There is then a weighted scoring system and a decision procedure for scoring those parameters on which there is inadequate information on the chemicals to be scored. Relevant chemicals are then scored and ranked, then (often) assembled in groups in descending order of hazardousness.

Though such schemes are sometimes devised with a specific purpose in mind - for example, for assessing priorities for control measures or for elimination (banning) - their essential use is as an abstract scheme which can be used for a large variety of environmental protection measures, including pollution prevention. For instance, the top group of scored chemicals could be the prime candidates for a mandatory pollution prevention programme, or they could be candidates for phasing-out or substitution. In other words, such schemes do not tell us how much we should reduce environmental health hazards; they tell us only that any measures we take should be informed by the hazard assessment scheme.

For instance, if we have to make decisions about substituting a less hazardous chemical for a more dangerous one, we can use the scheme to tell us whether, prima facie, the substitution decision is a good one: we run both chemicals through the scheme to determine whether there is a wide or merely a narrow gap between them regarding their hazardousness.

There are two sorts of considerations which rarely fall within the scope of hazard assessment schemes. The first is exposure data, or the potential for human exposure to the chemical. The latter is difficult to calculate, and, arguably, it distorts the "intrinsic hazard" of the chemicals concerned. For instance, a chemical could be accorded an artificially low priority on the grounds that its exposure potential is low; though it may, in fact, be highly toxic and relatively easy to deal with.

The second sort of consideration is the socioeconomic impact of eliminating or reducing the use of the chemical concerned. While we can start to make substitution decisions on the basis of the hazard analysis, we would have to make a further and distinct socioeconomic analysis and consider, for example, the social utility of the product associated with the chemical use (which may, e.g., be a useful drug), and we would also have to consider the impact on workers and their communities. The reason for keeping such analysis separate is that it is impossible to score the results of a socioeconomic analysis in the same way that the intrinsic hazards of chemicals are scored. There are two entirely distinct sets of values with different rationales.

However, hazard assessment schemes are crucial in assessing the success of pollution prevention programmes. (They are also relatively new, both in their impact and their utility.) For instance, it is possible to apply them without reference to risk assessments, risk analysis and (with reservations) without reference to cost-benefit analysis. An earlier approach to pollution was to first do a risk assessment and only then decide what sort of action, and how much, was necessary to reduce the risk to an "acceptable" level. The results were rarely dramatic. Hazard assessment, on the other hand, can be utilized very quickly and in such a way that it does not delay or compromise the effectiveness of a pollution prevention programme. Pollution prevention is, above all, a pragmatic programme capable of constantly and speedily addressing pollution issues as they arise and before they arise. It is arguable that traditional control measures have reached their limit and only the implementation of comprehensive pollution prevention programmes will be capable of addressing the next phase of environmental protection in a practical and effective way.

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