

# **CHAPTER 6**

## **INDUSTRIAL SOLID WASTE**

### **6.1 INTRODUCTION**

Environmental pollution is the major problem associated with rapid industrialisation, urbanisation and rise in living standards of people. For developing countries, industrialisation was must and still this activity very much demands to build self reliant and in uplifting nation's economy. However, industrialisation on the other hand has also caused serious problems relating to environmental pollution. Therefore, wastes seem to be a by-product of growth. The country like India can ill-afford to lose them as sheer waste. On the other hand, with increasing demand for raw materials for industrial production, the non-renewable resources are dwindling day-by-day. Therefore, efforts are to be made for controlling pollution arising out of the disposal of wastes by conversion of these unwanted wastes into utilisable raw materials for various beneficial uses. The problems relating to disposal of industrial solid waste are associated with lack of infrastructural facilities and negligence of industries to take proper safeguards. The large and medium industries located in identified (conforming) industrial areas still have some arrangements to dispose solid waste. However, the problem persist with small scale industries. In number of cities and towns, small scale industries find it easy to dispose waste here and there and it makes difficult for local bodies to collect such waste though it is not their responsibility. In some cities, industrial, residential and commercial areas are mixed and thus all waste gets intermingled. Therefore, it becomes necessary that the local bodies along with State Pollution Control Board (SPCB) work out requisite strategy for organising proper collection and disposal of industrial solid waste.

Management of Industrial Solid Waste (ISW) is not the responsibility of local bodies. Industries generating solid waste have to manage such waste by themselves and are required to seek authorisations from respective State Pollution Control Boards (SPCBs) under relevant rules. However, through joint efforts of SPCBs, local bodies and the industries, a mechanism could be evolved for better management.

In order to provide guidance to the local authorities some relevant information are provided under this Chapter so that a better understanding and awareness is created.

## 6.2 THE PROBLEMS

Assessment of industrial solid waste management problem greatly varies depending on the nature of the industry, their location and mode of disposal of waste. Further, for arriving at an appropriate solution for better management of industrial solid waste, assessment of nature of waste generated is also essential.

Industries are required to collect and dispose of their waste at **specific disposal sites** and such collection, treatment and disposal is required to be monitored by the concerned State Pollution Control Board (SPCB) or Pollution Control Committee (PCC) in Union Territory. The following problems are generally encountered in cities and towns while dealing with industrial solid waste

- There are no specific disposal sites where industries can dispose their waste;
- Mostly, industries generating solid waste in city and town limits are of small scale nature and even do not seek consents of SPCBs/PCCs ;
- Industries are located in non-conforming areas and as a result they cause water and air pollution problems besides disposing solid waste.
- Industrial estates located in city limits do not have adequate facilities so that industries can organise their collection, treatment and disposal of liquid and solid waste;
- There is no regular interaction between urban local bodies and SPCBs/PCCs to deal such issues relating to treatment and disposal of waste and issuance of licenses in non-conforming areas.

## 6.3 INDUSTRIAL SOLID WASTE

The major generators of industrial solid wastes are the thermal power plants producing coal ash, the integrated Iron and Steel mills producing blast furnace slag and steel melting slag, non-ferrous industries like aluminum, zinc and copper producing red mud and tailings, sugar industries generating press mud, pulp and paper industries producing lime and fertilizer and allied industries producing gypsum.

**Table: 6.1 Source and Quantum of generation of some major industrial waste**

S. No	Name	Quantity (million tonnes per annum)	Source/Origin

1.	Steel and Blast furnace	35.0	Conversion of pig iron to steel and manufacture of Iron
2.	Brine mud	0.02	Caustic soda industry
3.	Copper slag	0.0164	By product from smelting of copper
4.	Fly ash	70.0	Coal based thermal power plants
5.	Kiln dust	1.6	Cement plants
6.	Lime sludge	3.0	Sugar, paper, fertilizer tanneries, soda ash, calcium carbide industries
7.	Mica scraper waste	0.005	Mica mining areas
8.	Phosphogypsum	4.5	Phosphoric acid plant, Ammonium phosphate
9.	Red mud/ Bauxite	3.0	Mining and extraction of alumina from Bauxite
10.	Coal washery dust	3.0	Coal mines
11.	Iron tailing	11.25	Iron Ore
12.	Lime stone wastes	50.0	Lime stone quarry

(Source : National Waste Management Council- Ministry of Environment & Forests-1990/1999 )

## 6.4 DESCRIPTION OF IMPORTANT INDUSTRIAL SOLID WASTE

### 6.4.1 Coal Ash

In general, a 1,000 MW station using coal of 3,500 kilo calories per kg and ash content in the range of 40-50 per cent would need about 500 hectares for disposal of fly ash for about 30 years' operation. It is, therefore, necessary that fly ash should be utilised wherever possible to minimize environmental degradation. The thermal power plant should take into account the capital and operation/maintenance cost of fly ash disposal system as well as the associated environmental protection cost, vis-a-vis dry system of collection and its utilisation by the thermal power plant or other industry, in evaluating the feasibility of such system.

The research and development carried out in India for utilisation of fly ash for making building materials has proved that fly ash can be successfully utilised for production of bricks, cement and other building materials. Indigenous technology for construction of building materials utilising fly ash is available and are being practised in a few industries. However, large scale utilisation is yet to take off. Even if the full potential of fly ash utilisation through manufacture of fly ash bricks

and blocks is explored, the quantity of fly ash produced by the thermal power plants are so huge that major portion of it will still remain unutilised. Hence, there is a need to evolve strategies and plans for safe and environmentally sound method of disposal.

#### **6.4.2 Integrated Iron & Steel Plant Slag**

The Blast Furnace (BF) and Steel Melting Shop (SMS) slags in integrated iron and steel plants are at present dumped in the surrounding areas of the steel plants making hillocks encroaching on the agricultural land. Although, the BF slag has potential for conversion into granulated slag, which is a useful raw material in cement manufacturing, it is yet to be practised in a big way. Even the use of slag as road subgrade or land-filling is also very limited.

#### **6.4.3 Phosphogypsum**

Phosphogypsum is the waste generated from the phosphoric acid, ammonium phosphate and hydrofluoric acid plants. This is very useful as a building material. At present very little attention has been paid to its utilisation in making cement, gypsum board, partition panel, ceiling tiles, artificial marble, fiber boards etc.

#### **6.4.4 Red Mud**

Red mud as solid waste is generated in non-ferrous metal extraction industries like aluminum and copper. The red mud at present is disposed in tailing ponds for settling, which more often than not finds its course into the rivers, especially during monsoon. However, red mud has recently been successfully tried and a plant has been set up in the country for making corrugated sheets. Demand for such sheet should be popularised and encouraged for use. This may replace asbestos which is imported and also banned in developed countries for its hazardous effect. Attempts are also made to manufacture polymer and natural fibres composite panel doors from red mud.

#### **6.4.5 Lime Mud**

Lime sludge, also known as lime mud, is generated in pulp & paper mills which is not recovered for reclamation of calcium oxide for use except in the large mills. The lime mud disposal by dumping into low-lying areas or into water courses directly or as run-off during monsoon is not only creating serious pollution problem but also wasting the valuable non-renewable resources. The reasons for not reclaiming the calcium oxide in the sludge after recalcination is that it contains high

amount of silica. Although a few technologies have been developed to desilicate black liquor before burning, none of the mills in the country are adopting desilication technology.

#### **6.4.6 Waste Sludge and Residues**

Treatment of industrial wastes/effluents results in generation of waste sludge/residues which, if not properly disposed, may cause ground and surface water pollution.

#### **6.4.7 Potential Reuse of Solid Wastes**

Research and Development (R&D) studies conducted by the R&D Institutions like Central Building Research Institute, Roorkee (CBRI) and the National Council for Building Research, Ballabgarh (NCBR) reveal that the aforesaid solid wastes has a very good potential to be utilised in the manufacture of various building materials.

### **6.5 WASTE MANAGEMENT APPROACH**

A two-tier approach should be thought of for waste management, e.g., (a) prevention & (b) control of environmental pollution. Prevention aims at minimisation of industrial wastes at source, while the latter stresses on treatment and disposal of wastes. A schematic diagram of waste management is shown in Fig.6.1.

#### **6.5.1 Prevention- A Waste Minimisation Approach**

Reduction and recycling of wastes are inevitably site/plant specific. Generally, waste minimisation techniques can be grouped into four major categories which are applicable for hazardous as well as non-hazardous wastes. These groups are as follows :

### **Inventory Management and Improved Operations**

- Inventorisation and tracing of all raw materials ;
- Purchasing of fewer toxic and more non-toxic production materials ;
- Implementation of employees' training and management feedback ; and
- Improving material receiving, storage, and handling practices.

### **Modification of Equipment**

- Installation of equipment that produce minimal or no wastes ;
- Modification of equipment to enhance recovery or recycling options;
- Redesigning of equipment or production lines to produce less waste ;
- Improving operating efficiency of equipment ; and
- Maintaining strict preventive maintenance programme.

### **Production Process Changes**

- Substitution of non-hazardous for hazardous raw materials ;
- Segregation of wastes by type for recovery ;
- Elimination of sources of leaks and spills ;
- Separation of hazardous from non-hazardous wastes ;
- Redesigning or reformulation for products to be less hazardous; and
- Optimisation of reactions and raw material use.

### **Recycling and Reuse**

- Installation of closed-loop systems ;
- Recycling off site for use ; and
- Exchange of wastes.

Waste minimisation at source may be achieved within the industry through application of various approaches described above. The systems for waste minimisation, utilisation and recycling are schematically shown in Fig. 6.2.



### **6.5.2 Waste Management at Source**

A specific example worth-mentioning in this context is removal of fly ash through coal beneficiation process at the mine head in view of high ash content. It is evident that the larger the volume of waste and the longer the distance of transportation of raw material (coal), the bigger will be the economic benefit in favour of coal beneficiation instead of carrying the filthy fly ash. However, benefit-cost analyses have to be made before taking appropriate decision.

**6.5.3** It is possible to cut down waste generation at source by simple, inexpensive measures modifying production processes, through changes in raw

materials/product design and by employing recovery/recycling and reuse techniques (Fig.6.3)

**6.5.4** To avoid treatment through utilisation of waste, it is important from the environmental pollution view point as well as for the benefit of entrepreneurs to recycle and reuse the wastes generated by adoption of certain process change or by use of low/no-waste generation technology.

**6.5.5** Waste minimisation can be practised at various places in the industrial processes. Waste minimisation requires careful planning, creative problem evolving, changing in attitude, some times capital investment, and most important a real commitment. More often than not, investment on waste minimisation and recovery pays off tangibly within a short time. Such studies have been conducted and results are provided in Table 6.2.

**TABLE: 6.2 Investment on Waste Minimisation and Recovery**

Industry	Total waste-water flow(Cubic metres per day)	Total cost of plant (Rs. in thousand)	Net annual recovery (Rs. in thousand)	Investment pay back period (yrs)	Remarks
Textile Industry	6,450	4,625	4,375	1.05	Recycle in process house
Alcohol Industry	1,725	2,250	975	2.30	Reuse of energy in process house
Food Processing	1,460	10,500	4,250	2.47	Recycling for irrigation/ process house and reuse of energy
Viscose Rayon	4,500	200	36	5.5	Recovery and reuse of zinc. Foreign exchange saving.
Cement Industry (1200 t.p.d. production capacity)	-	3,44,000	2,24,000	1.50	Recovery & reuse of cement and clinker dust.

( Source : Industrial Waste Management, NWMC, 1990)

**6.5.6** The initial investment for a pollution prevention project may be higher in some cases than the cost of installing conventional pollution control equipment. However, the annual operation and maintenance cost of the removal will almost always make the total cost of treatment higher than the total cost of preventive measures at sources. However, treatment and disposal of residual waste even after taking preventive measures should be given due consideration.

**6.6 AREA OF APPLICATION OF SOME IMPORTANT INDUSTRIAL WASTES**

S.No.	Waste	Areas of Application
1.	Flyash	<ul style="list-style-type: none"> <li>i. Cement</li> <li>ii. Raw material in Ordinary Portland Cement(OPC) manufacture</li> <li>iii. Manufacture of oilwell cement.</li> <li>iv. Making sintered flyash light-weight aggregates.</li> <li>v. Cement/silicate bonded flyash/clay binding bricks and insulating bricks.</li> <li>vi. Cellular concrete bricks and blocks, lime and cement fly ash concrete.</li> <li>vii. Precast flyash concrete building units.</li> <li>viii. Structural fill for roads, construction on sites, Land reclamation etc.</li> <li>ix. As filler in mines, in bituminous concrete</li> <li>x. As plasticiser</li> <li>xi. As water reducer in concrete and sulphate resisting concrete</li> <li>xii. Amendment and stabilisation of soil.</li> </ul>
2.	Blast Furnace Slags	<ul style="list-style-type: none"> <li>i. Manufacture of slag cement, super sulphated cement, metallurgical cement.</li> <li>ii. Non-portland cement</li> <li>ii. Making expansive cement, oilwell, coloured cement and high early-strength cement.</li> <li>iv. In refractory and in ceramic as sital</li> <li>v. As a structural fill ( air-cooled slag)</li> <li>vi. As aggregates in concrete.</li> </ul>

3.	Ferro-alloy and other metallurgical slags.	<ul style="list-style-type: none"> <li>i. As structural fill</li> <li>ii. In making pozzolana metallurgical cement</li> </ul>
4.	By product gypsum	<ul style="list-style-type: none"> <li>i. In making of gypsum plaster, plaster boards and slotted tiles</li> <li>ii. As set controller in the manufacture of portland cement</li> <li>iii. In the manufacture of expensive or non-shrinking cement, super sulphated and anhydrite cement</li> <li>iv. As mineraliser</li> <li>v. Simultaneous manufacture of cement and sulphuric acid</li> </ul>
5.	Lime sludge (phos-phochalk, paper and sugar sludges)	<ul style="list-style-type: none"> <li>i. As a sweetener for lime in cement manufacture</li> <li>ii. Manufacture of lime pozzolana bricks/ binders</li> <li>iii. For recycling in parent industry</li> <li>iv. Manufacture of building lime</li> <li>v. Manufacture of masonry cement</li> </ul>
6.	Chromium sludge	<ul style="list-style-type: none"> <li>i. As a raw material component in cement manufacture</li> <li>ii. Manufacture of coloured cement as a chromium-bearing material</li> </ul>
7.	Red mud	<ul style="list-style-type: none"> <li>i. As a corrective material</li> <li>ii. As a binder</li> <li>iii. Making construction blocks</li> <li>iv. As a cellular concrete additive</li> <li>v. Coloured composition for concrete</li> <li>vi. Making heavy clay products and red mud bricks</li> <li>vii. In the formation of aggregate</li> <li>viii. In making floor and all tiles</li> <li>ix. Red mud polymer door</li> </ul>
8.	Pulp & Paper	<ul style="list-style-type: none"> <li>i. Lignin</li> </ul>

( Source : Industrial Waste Management, NWMC, 1990)

## 6.7 CURRENT PRACTICE OF INDUSTRIAL SOLID WASTE MANAGEMENT

### 6.7.1 Collection and Transport of Wastes

Manual handling of industrial waste is the usual practice in developing countries; there are very few mechanical aids for waste management. Wastes are shovelled by hand into storage containers and loaded manually into lorries. The

people undertaking salvaging do so mainly by hand, picking out useful items, usually not even wearing gloves. Although there may not be a health risk in handling clean waste paper, people handling or salvaging waste without protective clothing are at risk when waste is mixed with chemicals. Apart from the likelihood of cuts caused by broken glass or sharp metals, sorting through waste contaminated with hazardous chemical materials could cause skin burns, excessive lacrimation, or even loss of consciousness; chronic hazards include respiratory problems from dust inhalation, and potential carcinogenicity from toxic chemicals present in discarded containers or surface deposits in other waste. Personnel handling waste from tanneries or hide processors may also be exposed to such diseases as anthrax. Necessary precautions will reduce and minimise hazards associated with manual handling of industrial wastes. Personnel handling hazardous wastes should wear appropriate protective clothing. Mechanical methods for handling waste should be adopted wherever possible, and people should be educated about the dangers of manual handling of hazardous waste.

### **6.7.2 Storage & Transportation**

The storage of industrial solid waste is often one of the most neglected areas of operation of a firm. Very little attention is paid to proper storage and heaps of mixed waste piled against a wall or on open ground are a common sight in many factories. Concrete bays or disused drums are also often used for storage. Whereas the sludges originating from holding tanks or interceptors do not present storage problems as no separate sludge storage is required, because the sludge is retained in the tank until sufficient quantities are collected.

Waste is rarely covered, protected from vermin or pretreated in any manner. There are no restrictions on access and employees are often encouraged to sort out through such wastes and take away any useful material or articles they find. Waste is regarded as an unwanted product by firms and very often no senior person is assigned for its control.

Transportation of industrial waste in metropolitan areas of developing countries is generally not by purpose-built vehicles such as skip-carrying lorries, but by open trucks. The wastes are not covered during transportation. It is typical for a firm not to have any standing arrangements with one contractor, but to allow collection by whoever is the contractor quoting lowest rates. It is rare for special arrangements to be made for hazardous wastes; they are usually collected together with the other wastes. Contractors who carry hazardous waste do not need to be licensed, and consequently, there is little control over either the types of firms engaged in carrying hazardous waste or the vehicles used. Drivers are not given a list

of precautions to be taken; there is no manifest or labeling system of wastes during transport. Fly-tipping is often prevalent and wastes are often taken to disposal sites inappropriate for the type of waste concerned.

### **6.7.3 Disposal of Industrial Solid Waste**

Industrial waste, whilst presenting the same disposal problems as domestic waste, also contains hazardous waste, thereby exacerbating the difficulties of disposal. Fortunately, the types of industrial wastes generated in a municipal area of a developing country are such that there are not usually large quantities of particularly hazardous wastes for disposal. In the past there has been little control over the disposal of industrial wastes; indeed, it has only been during the last decade that even developed countries have brought in legislation to curb the uncontrolled and environmentally unacceptable practices that were widespread. Without such legislation disposal is almost always by uncontrolled landfill at sites which often pose a threat of water pollution due to leachates.

## **6.8 HEALTH CONSEQUENCES OF POOR INDUSTRIAL WASTE DISPOSAL**

The solid waste generated from industrial sources contains a large number of chemicals, some of which are toxic. The waste is considered toxic, if the concentration of the ingredients exceeds a specified value. Although the levels of some ingredients may occasionally exceed the permissible level, the waste as such is considered to be toxic only if the average value of ingredients exceeds the toxicity level. Various criteria and tests have been devised by different agencies to determine the toxicity of a given substance. It is necessary to know the properties of the waste so as to assess whether its uncontrolled release to the environment would lead to toxic effects on humans or other living organism in ecosystem. This evaluation is carried out using criteria such as toxicity, phytotoxicity, genetic activity and bio-concentration. The potential toxic effects also depend on quantity of the toxic constituents. Substances are classified as hazardous or otherwise depending on the dose, exposure, and duration of exposure. For a chemical to affect human health it must come in contact with or enter the human body. There are several ways in which this can happen.

**Skin contact** :Chemicals that cause dermatitis usually do so through direct contact with skin. Some chemicals like corrosive acids can damage the skin by a single contact while others, like organic solvent, may cause damage by repeated exposure.

**Inhalation :** Inhalation is the most common source of workplace exposure to chemicals and the most difficult to control. Air pollutants can directly damage respiratory tract or gets absorbed through lung and cause system/systemic effects. An adult male will breathe about 10 cubic meters of air during a normal working day.

**Ingestion :** Ground water and sub soil water contamination from leachates from refuse dumps and poorly managed landfill sites can result in ingestion of toxic chemicals by population groups who live far away from the factory sites and decades after the garbage has been dumped.

There are very few studies conducted in India on specific health problems resulting from accidental exposure to toxic industrial solid waste. There had been reports that sacks, cardboard cartons and paper envelopes contaminated with chemicals packed in them were burnt and the irritating fumes from these caused respiratory problems. There had also been reports of skin or respiratory irritation following exposure to corrosives chemicals. There has been no efforts to systematically investigate and obtain reliable epidemiological data on health consequences of exposure to hazardous industrial wastes in different States.

Wastes from slaughter house is potentially infectious. All precautions to ensure that potential pathogens to not gain a foot hold in the workers in the slaughter house and in the general population, have to be taken during collection, storage and disposal of the slaughter house waste.

Wastes from non hazardous industries can at times produce health problems, not only among the workers and handlers of waste, but also among general population. One example of this category is the cotton dust. Cotton waste are generally non hazardous; however they may, in susceptible individuals provoke respiratory allergic reactions; allergy may be due to inhalation of dust containing cotton wastes or fungus or other contaminants in the waste dust.

## **6.9 COLLECTION, STORAGE TREATMENT & DISPOSAL OF WASTES**

### **6.9.1 Waste Segregation**

Many wastes are mixtures of hazardous and non-hazardous wastes. Much of their contents may even be water. By segregating key toxic constituents, isolating liquid fraction, keeping hazardous streams away from non-hazardous wastes, generator can save substantial amounts of money on disposal or find new opportunities for recycling and reuse of wastes. The Ministry of Environment,

Government of India, had identified toxicity of different chemicals, through the 'Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989' in exercise of power conferred by Section 6, 8 and 25 of Environment Protection (E.P). Act, 1986, and had notified mandatory requirements for its management. In India quantum of generation of wastes (solid/liquid and hazardous/non-hazardous) for different industry has not been detailed, which is necessary for wastes exchange system or for adopting treatment/ disposal alternatives for different wastes segregated.

### **6.9.2 Collection, Storage and Transport**

The unsatisfactory state of storage of hazardous wastes can be remedied to a large degree by such low-cost measures as restricting access, fencing off the storage area to minimise any wind-blown nuisance, providing separate covered storage for putrifiable of hazardous wastes, and ensuring regular and frequent collection.

There are certain measures a municipal authority can take to control the transportation of industrial wastes, even if it does not want to become actually involved itself. For instance, contractors should be licensed after ensuring that they are technically competent and environmentally aware and should be allowed to handle industrial wastes. Labeling and coding of hazardous waste load can be made mandatory so that in the event of an accident, the emergency services know how to handle a spillage. Municipal authorities can be given the responsibility to monitor the contractors to minimise cases of fly-tipping and ensure that industrial wastes are disposed at the appropriate sites. If a municipal authority can also collect industrial waste; industries must pay the charge which will be based on the quantity and nature of the waste. This might minimise the quantity of waste produced by industry and at the same time the programme will become financially viable and self sustaining. The principle 'the polluter pays' should be adhered to in all such cases.

### **6.9.3 Combined Treatment Facilities**

Small-scale industries, which contribute about more than half of the total production, also generate huge quantity of wastes. The small-scale industries are not in a position to treat their solid wastes or liquid effluent because of space, technical know-how and financial constraints. It is, therefore, deemed that in a cluster of small-scale industries the different wastes are characterized, identified, quantified and stored for treatment through a combination of recycling, recovery and reuse of resources such as, raw material, bio-gas, steam and manure, besides providing an efficient service facility, to make the system less expensive. The combined effluent treatment plants (CETP) are to be operated by the local bodies, where the cost of construction, operation and maintenance need to be shared by individual industries

depending upon the quality and quantity of wastes generated. However, such common treatment facility may require pre-treatment at individual industry to the extent specified by the State Pollution Control Board. With regard to availability of wastes along with their identification, quantum of waste generated should also be ascertained so that technology development/adoption can be considered on economic grounds for a small-scale or organised sector of industry. If economics justify movement of wastes over longer distances for a centralised plant, specific subsidies for storage, collection and transportation could be considered. The flow chart for waste collection centre is shown in Fig.6.4.

CETPs are being successfully operated in Gujarat and Andhra Pradesh and such facilities should be promoted in other States. A typical wastewater segregation and treatment system in an industrial estate is depicted in Fig. 6.5

Small scale industries having waste characteristics similar to those of near by large industry having waste treatment facilities can take help in treating their wastes on payment basis.

#### **6.9.4 Disposal Methods**

Depending upon the characteristics of the wastes, different types of disposal methods can be used for hazardous and non-hazardous industrial wastes. The most predominant and widely practised methods for wastes disposal are : (a) Landfill, (b) Incineration and (c) Composting.

For thousands of years, man has disposed the waste products in a variety of ways, the disposal method might reflect convenience, expedience, expense, or best available technology. There were no major ecological or health hazards associated with these practices until the last century. Explosive increase in the amount of



chemical waste produced and the indiscriminate dumping of hazardous industrial waste in the last few decades has created health and ecological crisis in many areas of the world. In many instances, leachate from the wastes dumped by one generation haunts the later generation in the form of ground water and subsoil water contamination. The recent discovery of volatile organic chemicals from landfills and industrial disposal ponds is disturbing because many of these chemicals are known or suspected carcinogens and are not removed easily by natural geochemical processes. The risk of the contamination of groundwater supplies due to leachates from landfills depends on several factors; toxicity and volume of the contaminant generated at each site, the nature of the geologic medium underlying the site, and the hydrologic conditions dominant in the area.

In the past, the least expensive and most widely used waste management option for both municipal and industrial waste has been the sanitary landfill, where wastes are compacted and covered with earth. In any geographic area other than arid

zones, the fill is subjected to percolating rainwater or snowmelt which eventually flows out from the bottom of the landfill site and moves into the local groundwater system. Leachate is a liquid that is formed as infiltrating water migrates through the waste material extracting water-soluble compounds and particulate matter. The mass of leachate is directly related to precipitation, assuming the waste lies above the water table. Much of the annual precipitation, including snowmelt is removed by surface run off and evaporation; it is only the remainder that is available to form leachate. Since the landfill covers to a large extent and controls leachate generation, it is exceedingly important that the cover be properly designed, maintained and monitored in order to minimise leachate production. Fortunately, many substances are removed from the leachate as it filters through the unsaturated zones, but leachate may pollute groundwater and even streams.

These leachates, can contain large amount of inorganic and organic contaminants. At some sites, the leachate is collected and treated. But even in the best engineered sites, some leachate escapes into the groundwater system because no permanent engineering solution has been found to isolate the leachate completely from the groundwater.

It is now recognised that the interaction between leachate and soil are actually very complex and depend both on the nature of soil and on the leachate. When leachate percolates through solid wastes that are undergoing decomposition, both biological materials and chemical constituents are picked up. Recent research in the United Kingdom (U.K) has, however, shown that chemical and biological phenomena in landfill such as microbiological process; neutralisation; precipitation and complexion; oxidation and reduction; volatilisation; adsorption reduce the quantity and quality of polluting leachate from landfill site and achieve some degree of on-site treatment or immobilisation. In spite of all these, the leachate often pose severe disposal problem at a landfill site. Two of the most economic but efficacious purification methods are spraying over grassland or percolation through an aerobic bed of sand or gravel.

In general, it has been found that the quantity of leachate is a direct function of the amount of external water entering the landfill. In fact, if a landfill is constructed properly, the production of measurable quantities of leachate can be eliminated. When sewage sludge is to be added to the solid wastes to increase the amount of methane produced, leachate control facilities must be provided. In some cases leachate treatment facilities may also be required.

The pollution of static water ditches, rivers or the sea can occur when a sanitary landfill adjoins a body of water. The normal source of the leachate causing this pollution is rain falling on the surface of the fill, percolating through it, and

passing over an impermeable base to water at a lower level. The quantity of leachate can be substantially increased when upland water drains across the site of the landfill, but the worst case is when a stream crosses the site. The solutions to these problems lie in appropriate site engineering such as :

- (i) diversion or culverting of all water courses which flow across the site,
- (ii) diversion of upland water by means of drainage ditches along appropriate contours,
- (iii) containment of leachate arising from precipitation by the construction of an impermeable barrier where necessary, such as a clay embankment adjoining a river,
- (iv) grading the final level of the site so that part of precipitation is drained across surface, thereby reducing percolation below the level needed to produce a leachate.

Works of this nature will obviously add to the cost of a sanitary landfill project. However, when capital expenditure is spread over the life of the project, the cost/ton of waste disposed might be less than for any alternative method of disposal. Furthermore, some of these forms of expenditure, such as culverts or river walls, represent capital assets of continuing value when the reclaimed land is handed over for its final use, perhaps for agriculture or recreation.

Incineration of hazardous industrial waste has been advocated in developed countries. Guidelines for safe incineration of hazardous chemical waste have been drawn up by United States Environmental Protection Agency. Incineration of hazardous waste is a process requiring sophisticated expensive incinerators and a high degree of technological expertise for satisfactory operation. The capital cost of incinerator is high, especially if it is intended for hazardous wastes and gas scrubbing equipment is required. Some wastes such as oils and organic solvents can be readily treated by incineration. If financial constraints come in the way of purchasing sophisticated incinerators then the utilisation of open pit incinerator under careful technical supervision can be considered as an option.

#### **6.9.4.1      *Landfill***

The owner or operator of a facility must follow the design and operating criteria stipulated by the regulatory agencies. However, depending upon the characteristics of the waste, the landfill system with leachate collection system has to be designed with necessary facility for ground water quality monitoring.

The common centralised facility of the operating agency is likely to consist of land-fill type of disposal and hence, it will be worthwhile to know certain definitions to begin with.

(i) **Definitions:**

- **Disposal** is the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water, so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.
- **Land disposal** is defined to include, but not limited to, any placement of hazardous waste in a landfill, surface impoundment, waste-pile, injection well, land treatment facility, salt dome formation, or underground mine or cave. It can also consider placement of hazardous wastes in concrete vaults or bunkers intended for disposal purposes as methods of waste management subject to certain restrictions. However, it does not include and permit open burning on land and detonation.
- **Landfill** means a disposal facility or a part of a facility where hazardous waste is placed in or on land and is not a land treatment facility, a surface impoundment or an injection well. Landfill cell means a discrete volume of a hazardous waste landfill that uses a liner to provide isolation of wastes from adjacent cells or wastes. Examples of landfill cells are trenches and pits.
- **Land treatment facility** means a facility or part of a facility at which hazardous waste is applied onto or incorporated into the soil surface, such facilities are disposal facilities if the waste will remain after closure.
- **Surface impoundment** means a facility or part of a facility that is a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials), that is designed to hold an accumulation of liquid wastes or wastes containing free liquids, and that is not an injection well. Examples of surface impoundments are holding, storage, setting and aeration pits, ponds and lagoons

(ii) **Why landfills?**

While new methods of hazardous waste disposal are being developed, it appears that landfills will, at least for the time being, continue to be the most

favoured technique. In many countries, land is a readily available commodity and often areas of non-productive or derelict land may be made available for waste disposal. In many instances, land can be utilized in the near vicinity or on the premises of industrial companies, thereby reducing transportation costs. The potential also exists to reclaim certain areas for recreational purposes.

Landfilling is still the major disposal method in many countries. Yet in many instances landfilling sites are not properly chosen in terms of geophysical soil properties, hydrogeology, topography and climate. On a proposed site there is a need to carefully consider the potential for ground or surface water contamination from pollution by leachate migration or surface run-off from the site. Nonetheless, even when a site appears to have the right geophysical properties, its selection and use are not an absolute guarantee that contamination of groundwater can be avoided. Hence, continuous surveillance of the site and its surroundings must be maintained to check that the disposal of hazardous wastes can continue without posing a threat to the environment and to the general public. To reduce this threat landfill sites have been lined, for example with plastic materials, in order to prevent leaching into groundwater supplies.

**(iii) Design:**

While preparing the lay-out of a land-fill site, it may be seen that it comprises at least the following units, viz.

- I. Vehicle weigh bridge
- II. Vehicle and instrument work-shop
- III. Laboratory for sample analysis
- IV. Operational area
- V. Operational building with amenities
- VI. Control systems
- VII. Illumination, roads, fencing, trenches etc.

The principle objective of a hazardous waste landfill is to isolate the waste materials within a confined area and prevent uncontrolled leakage of liquid contaminants. Design of the facility, therefore, requires provisions for an impermeable liner, a leachate collection and treatment system, and a suitable cover that is resistant to erosion and rainwater infiltration.

In certain situations, hazardous wastes may be disposed of in landfills under semi-controlled conditions. Co-disposal of hazardous wastes with domestic refuse, demolition waste, fly ash, municipal waste and inert industrial wastes in unlined landfills has, for example, been widely practised in the U.K. for many years. Co-disposal is advantageous from the point of view of enhanced neutralisation, detoxification and stabilisation of the waste pile. Where suitable soils exist, attenuation of waste leachate from waste piles is restricted to a relatively small area, thus reducing the potential for ground water contamination.

The Ministry of Environment & Forests (MoEF) guideline of 1991 has suggested a double liner system with synthetic or clay liner for landfill (two designs ) as shown in Fig. 6.6

## CASE STUDIES

- (i) In a German experience, a company found the following arrangement satisfactory. The controlled dumps run by the company have a multiple seal to protect the groundwater. The bottom layer of this seal consists of in-situ or specially deposited and compacted clay forming a 50 cm-thick impermeable layer. To compensate for unevenness in the clay layer, a 10 cm sand layer is spread on top and lined, in turn, with 3 mm-thick, elastic polyethylene sheet, forming a second water-tight layer. This is covered by 30 cm of gravel which takes up the leachate from rainwater or from moist sewage sludge in the dump and channels it to the wastewater treatment plant through a system of drainage pipes. On top of this gravel layer is a 70 cm covering of soil and slag. On this layer the waste itself is deposited. During the period of use, i.e. while waste is still being deposited, the dumps look like enormous troughs. On completion of the controlled dump- when it has reached its projected size- the hill is sealed with an impermeable covering. By planting vegetation and by other measures the hill becomes integrated into the surrounding landscape. The groundwater in the vicinity of all the controlled dumps is required to be carefully monitored. The dumps are surrounded by observation wells. The water from these wells is regularly analysed.
- (ii) Another secure landfill site in Bavaria (Germany) has following features.  
Clay pad construction

- depth of pads : 60 cm
- permeability : 10 cm/sec
- Depth of sidewalls : 60 cm
- Final cover : 0.75 metres

Water-soluble solid wastes containing heavy metals are deposited in drums and covered with concrete to reduce the contamination in the leachate. In addition to daily cover, a plastic membrane is intermittently placed over completed lifts to reduce infiltration. A hand operated vibrator is also utilised to compact daily cover in an effort to reduce the volume of leachate generated.

Leachate is collected by a series of under-drains, located in the clay pad. Leachate is then channeled to a plastic lined ( 3 mm) retention pond from where it is trucked.

The United States Environmental Protection Agency has published regulations. These regulations, implemented primarily in the interests of protecting groundwater resources and the longer-term security of facilities, requires that all new landfills be constructed with a leachate collection system and a liner that is capable of preventing migration of leachate throughout the operational life of the facility. Preference is given to synthetic liners. Unless facilities are constructed with a double liner system with a leak detection system between the liners and a leachate collection system at the base of the landfill (figure 6.7), groundwater has to be monitored both upstream and downstream of the site. At closure, the construction of an impermeable cap is required and maintenance of the facility must be continued throughout the period specified in the permit, which in most cases will be about thirty years.

The operating agency in Indian context, shall take cognizance of all the above experiences and derive a good formula for themselves. Such reasoned communication be submitted to the SPCBs while obtaining an Authorisation. In case any new developments come up, the operating agency should keep an eye on it and adopt the same.

**(ii) Construction:**

The landfill should be as secure as possible, because hazardous waste howsoever treated, lies there as a tickling time-bomb. New construction materials are getting developed everyday. These improved techniques be followed. Before going in for construction, the operating agency should first do a complete geological survey of the property to look for fissures, determine the depth of bed rock, check the percolation rate, and other pertinent factors. Any landfill construction be at least 3 m above groundwater or as may be directed and above the 100 year floodplain. All this compiled data along with proper drawings should be submitted to SPCBs and got approved. They may have any new suggestion. If a 3 m of packing clay is to be put at bottom, it should be placed in 20 layers of 60 mm each by using such clay which has grains long and flat, and layers are continuously compacted to form a very tight, impermeable barrier. This should be checked on Proctor's scale. On the clay blanket, is spread a polyethylene high density sheet welded to each other and weld tested thrice. Once the synthetic liner has been installed, another 300 mm clay is sprayed and compressed on the same. This layer protects the liner and works as third barrier too. On top, there is kept a layer of crushed stone to aid leachate collection and this is a place to house the leachate collection pipe system, described in others experiences.

The operating agency is better advised to report to SPCB if there is any change made in their facility after obtaining authorisation, even minor such as replacement of liner or change in crop pattern.

The operating agency, should not make an oversimplification that landfill is a panacea and any hazardous waste can be dumped into it. A treatment in most cases is necessary and landfill at best can serve as a mode of disposal thereafter, like Poly Chlorinated Biphenyles (PCBs), Halogenated Organic Compounds (HOC), other wastes, and free liquids (unless they are first solidified).

**(iii) Closure & Post Closure:**

The operating agency has a limited land area, on which he is doing his activities of hazardous waste treatment and disposal. This limited area will eventually get filled and then he will have to close the present establishment carefully and go somewhere else. The closure is a period after which wastes are no longer accepted and during which the owner or operator completes all treatment, storage or disposal operations. Partial closure is also possible. The purpose of the closure standards is to ensure that all hazardous wastes management facilities are closed in a manner that to the extent necessary (i) protect human health and the environment; and (ii) controls, minimises or eliminates post-closure escape of hazardous waste, hazardous constituents, leachate or contaminated rain run-off or waste decomposition to the water, air or soil. If the site is housefull, then it is called as closure, but if due to mismanaged leachates and groundwaters pollution, activity is forced to be stopped, then it is not closure it is abandoning the site.

The operating agency while developing its first application for Authorisation has to plan as to in what time period, the accommodation provided by him will be put. Depending on what type of waste he is transporting in, he will have to imagine a closure plan. It should contain

- (1) A description how each of his unit in the facility will be closed.
- (2) A description of how final closure of the entire facility will be conducted.
- (3) An estimate of the maximum inventory of hazardous wastes on site at any time during the active life of facility
- (4) A description of the steps needed to remove or decontaminate all hazardous waste residue
- (5) A sampling and analysis plan to know as to how much decontamination will be necessary
- (6) A time-table of commencement of closure prospects and completion.

The operating agency should prepare a closure plan on paper at least 6 months in advance so that opinion of the SPCB can be obtained. It is better to complete the

closure as per plan speedily, but not hastily. A period of 3 months to 6 months from the SPCB approval should prove adequate.

There can be two options for closure. In one, the residues, spent liners etc. are removed and shifted from the place and in another, the residues are left in place and operating agency taking its post-closure precautions. The post closure care is to:

- (1) Eliminate all free liquids by either removing the liquid wastes/residues from landfill/impoundment or by solidifying them
- (2) Stabilise the remaining waste and waste residues to a bearing capacity sufficient to support a final cover.
- (3) Install a final cover that provides long- term minimisation of infiltration into the closed unit
- (4) In course of time, the material inside a landfill is likely to face settling or subsidence in a small way. The cover be such that all such subsidence of support, it should not get cracked, but its integrity be maintained.
- (5) Provide drainage diversions to prevent any run-on
- (6) To grow an appropriate vegetation on the top of the cover.

The operating agency should submit a certificate of completion of closure and post-closure to the State Boards.

The operating agency must remember that money is required not only for establishing or for running a facility, but the closure too costs money. Therefore, provision of funds should be made during the process or insurance may be purchased during operating life, that assures funds for closure and post closure care.

#### **6.9.4.2      *Incineration***

Depending upon the categories of waste and its potential hazards, following incineration methods are adopted :

- i. Destruction of hazardous waste by thermal process using incinerator or any other method; and
- ii. Burning of hazardous waste in boiler or in industrial furnace in order to destroy them and/or for any recycling purpose and/or energy source.

The first category of incinerator requires special attention. In India there are very few incinerators installed on a large scale. It is important to have a central

incinerator facility in the remote areas of different regions for incinerating hazardous wastes which may be operated by a corporate body. However, before taking a step in burning hazardous wastes through incinerator it is essential to stipulate standards to be achieved after incinerating such material. The hazardous wastes in the region to be treated can be centrally collected and transported to the facilities. In this process of central facility of treatment, the polluter has to pay for treatment facility depending on the quantity and quality of wastes generated.

In the second category of incineration, there are a number of cement industries and thermal power plants where the wastes can be burnt after considering the nature and quantity of wastes. However, in this case it is to be seen that the gaseous emission through stack does not affect the ambient air quality adversely.

The operating agency will find that the incineration is a costly alternative, but sometimes it is the only alternative. It reduces the volume of waste requiring the landfill capacity, is suitable for most clinical, commercial and house-hold wastes, is the only suitable disposal option for certain waste (practical or legal point of view ) and can recover heat system.

Incinerator means any enclosed device using controlled flame combustion. In designing an incinerator the operating agency should take into consideration the thermal feed rate, waste feed rate, organic chlorine feed rate (where relevant), minimum combustion gas temperature, minimum combustion gas residence time, primary and secondary combustion units, removal of Hydrochloric acid (HCl), Suspended Particulate Matter (SPM) and other air pollutants, minimum oxygen concentration in secondary chamber, controlling fugitive emissions (by keeping combustion zone totally sealed or by maintaining the combustion zone pressure negative), stack height, eventuality of alternative fuel, eventuality of change in waste containing Principal Organic Hazardous Constituent (POHC). The operating agency should convey these criteria to the SPCBs for any comments and if there is any change subsequently in the gadget or geometry, the same too must be informed or authorisation got so amended. This will enable them to take a new trial burn if necessary.

Incineration is not an open burning. Open burning means the combustion of any material without the following characteristics :

- (1) Control of combustion air to maintain adequate temperature for efficient combustion
- (2) Containment of the combustion reaction in an enclosed device to provide sufficient residence time and mixing for complete combustion

- (3) Control of emission of the gaseous combustion products as per regulations.

Open burning on land is not a method for disposal as it does not have a status of either incinerator or landfill. The operating agency should assure the SPCBs that they will undertake only controlled method and it is open for their inspection any time of combustion, emissions, attendant units (like pumps valves, conveyors ) or housekeeping.

In general, industrial incinerators comprise a storage pit, fuel tanks, a furnace (generally of a rotary kiln type), a heat recovery boiler, off gas purification [possibly a scrubbing water treatment unit, and even Electro Static Precipitator (ESP) in good installations], an induced draft (ID) fan, a reheating unit (if necessary) and a stack (incidentally, even co-generation is possible).

In a reported experience of Bayer, AG, Germany, the plant temperature in rotary kiln is maintained at 1000-1200<sup>0</sup>C, with oxygen concentration kept at 11% by volume, and detention of 4 seconds. The detention is 18 seconds in after burner chamber. In the waste heat recovery boiler, the temperature comes down to 320-350<sup>0</sup>C, the HCl, SO<sub>2</sub> is washed down. PCBs are found destroyed. The flow-sheet is shown in figure 6.9 which may encourage the OA to put up an incineration train on such sound footing.

If the operating agency desires to get rid of organics like halogenated solvents, petroleum refinery waste, vinyl chloride monomer, plastics, pesticides, off-spec pharmaceuticals etc. with a chemical destruction efficiency of 99.99%, then incineration will be his only choice, regardless as to whether he feeds as gas, liquid, semi-solid, or solids.

Operating agency has to put only selected crew to run this unit as the precautions are necessary at every place right from unloading the incoming tankers (preferably with nitrogen blanket), segregated storing as per high or low British Thermal Unit (BTU) value. Some, if arriving in a mixed form, has to be sent to a specific gravity based separators through vibratory screen, as also a separate storage for high or low pH wastes. This helps in blending, because the success of operating agency's incinerator cannot be ensured, if the feed is non-uniform in quality and quantity. In this system, organics are destroyed and the inorganics are converted. The clays, dissolved salts or silica are released within the incinerator flue gas and the same ash is required to be trapped and then disposed of in the landfill. The volume reduction be estimated and recorded. The operating agency should also record the temperatures at various points (actual against designed) such as say (1) initial temperature in the primary chamber 1400<sup>0</sup> C, (2) after injecting

aqueous waste as 800<sup>0</sup> C, (3) after passing through scrubber/ spray dryer, (4) after fabric filter 200<sup>0</sup> C in the stack. In the stack, the emission monitoring be done for levels of oxygen, unburnt hydrocarbons, sulfur dioxide and opacity (- a measure of particulate matters going up the stack) and record the same, in computer. The residence time in seconds also be recorded.

The operating agency should keep a safety and security in its plant to boast that nothing moves in the premises without permission, even the rain water (which is collected as run-on, analysed, pH adjusted or settled and then pumped run to allow it out).

#### **6.9.4.3      *Manifest System***

In the management of solid and liquid industrial wastes it is very important to incorporate a manifest system by which the chain responsibility of generator, carrier and receiver is to be realised. This system will help the regulatory agency as nodal agency, where finally the copy of the manifest will be sent, to know whether the actual wastes generated are transported to the facilities where it is to be disposed off. In this process of waste management, all the three, viz. pollution generator, carrier and receiver, will have to take authorisation from the nodal agency. It is felt that in India also for the management of industrial wastes, whether they are hazardous and non-hazardous, a manifest system has to be framed to identify what category of waste has to be transported for disposal and treatment. The schematic sketch of such a system is shown in Fig.6.8.

#### **6.9.4.4      *Post Treatment***

The post treatment precautions to be undertaken by the operating agency depend much on what treatment he has offered to the subjected hazardous waste. The treatment given to the waste shall be complete and not half-way.

If physico-chemical-biological treatment is successfully given, the outgoing post-treatment streams will be three fold. The oil may be sold or sent for incineration, the sludge after dewatering be sent to secure landfill and the water after analysis may join a stream on permission from the SPCB or may be used on adjoining land by irrigation. Operating agency to maintain a full record.

If the treatment-disposal is a secured landfill, if post-treatment leachate appear, the same be collected and recycled into the operating agency's facility for re-treatment. One will find that leachate exhibits very high polluting and hazardous characteristics.

If incineration or thermal treatment is adopted, the captured post-treatment ash be sent for burial and scrubber water be sent back into the facility for treatment. Operating agency at every step should maintain a computerised record.

If recovery is a treatment method, it converts a hazardous waste into a non-hazardous non-waste. This post-treatment, is acceptable to the customers and can be so sold. It may be a hazardous chemical, but no more a hazardous waste.

#### **6.9.4.5      *Back-transport***

There can be only three types of back-transport. Number one, where there is a manifest discrepancy, number two where the waste sent by generator to operating agency facility is not as per contract and number three, when a renovated material after recovery returns back to a customer. The former two be avoided, while the third one is a welcome step.

It will be a good practice if the operating agency keeps a discipline of collecting the waste by himself from the generators' premises. Operating agency can get an opportunity of supervising the waste before loading or even adjusting the form of waste. This will avoid any eventuality of returning. The returning not only involves engaging the transport tankers for one trip during which three normal trips would have been performed, it also means increase of risk. It is, however, also true that operating agency should not accept such material which he cannot handle such as say PCBs, coming suddenly to him unawares. If the return becomes necessary due to discrepancy in the manifest then the operating agency has a room to use his discretion. If the discrepancy is marginal and the material can be accepted by writing a note, he may preferably do so rather than relaying the hazardous waste back all along.

If the operating agency has an acceptable recovered material and a demand for the same, he should make its analysis on Gas Chromatograph (GC) and send the examination report to prospective customer by fax and on his acceptance message the goods be sent. This transport should be done in clean tankers. Dirty tankers should not be pressed for this service, as else unacceptable contamination may take place. The outgoing recovered waste is no more a hazardous waste and hence, manifest system will not be needed. However, it still is a hazardous chemical and whatever obligations under Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 are placed on transport, will have to be studied and followed by the operating agency.

### 6.9.5 Monitoring

Monitoring and laboratory examination is important in many fields, but more so in the field of hazardous waste management. In monitoring we collect a sample and from its analysis we infer about the universe (i.e. full batch). Monitoring will tell the operating agency about the dividing line between hazardous and non-hazardous waste, about the treatability of the hazardous waste, about incompatibility of different wastes, about the performance efficiency of hazardous waste treatment and disposal facility, about the impact, about the quality of the recovered material, and about the post-closure effects if any. Monitoring gives a final signal if something is going wrong in the facility of operating agency, giving an opportunity of rectification. Monitoring becomes handy in investigation of complaints and during the time of any accidental leakages or spills. The operating agency, therefore, should have an excellent set up of materials and methods.

Monitoring should commence one year before the facility is brought in existence by the operating agency, should continue while the facility is in use, to know the migration kinetics and contemporary concentrations, to take a decision as to whether it is a time to abandon a particular site, and till five year after it is abandoned to see that the “ghost” does not reappear as mere ‘cradle to grave’ is not sufficient precaution, it should be “cradle to grave to ghost”.

In consultation with the SPCBs, the operating agency will have to draw samples of air, water groundwater, leachate waters, soils, ash, solid wastes and aesthetics. The periodicity and station selection be done carefully and the following locations might prove appropriate:-

- (a) Air: upwind, downwind, three stations at 120m around the facility, distance depending on stack height and location of any particular sensitive feature. This is for ambient. Samples be selected in stack, vents and ducts.
- (b) Surface waters : upstream and downstream in the stream adjoining local nullah, upstream in the rivulet, on both the banks, upper stream and benthal deposits, and add as per sanitary survey.
- (c) Groundwater : From wells specially dug one upgradient and at least three on down gradient, and deep enough.
- (d) Soil : Surrounding soil at ground level be sampled in a circular grid.
- (e) Vegetative cover : Whether mal-effect is occurred and if yes, in what direction.

- (f) Biological indicator : by planting sensitive plants in all directions and at different distances and to note periodically as to what is the health status of each plant, providing the operating agency with information as to what further precautions are required to be taken. Figure 6.9 below conceptually shows the operating agency that if the incinerator is at centre and specially selected species of plants/bushes are planted in eight directions at suitable distances, the health effects are as shown by vertical bars when quantified. This is a botanist's job, which can be hired by operating agency.

Among all the above, ground water monitoring is a more serious and complicated matter of which the operating agency has very little experience. The groundwater monitoring is of great significance to such operating agency, who are engaged in land treatment, land application, sanitary landfills, secured landfills, surface impoundment or composting. This monitoring is more significant when the groundwater is popularly used either for agricultural or personal purposes. However, it may be of low or no significance if it is found that the operating agency facility is an engineered structure, does not receive or contain free liquids, is designed and operate to exclude liquid, rains, other run-on or run-off, has both inner and outer layers of containment enclosing the waste, and has an eye on leak detection, i.e. there is no potential for migration of liquid from regulated units to the uppermost aquifer (during the facilities active life and to some extent thereafter). This monitoring is also not significant, if there is no groundwater. This is the first stage of self-examination that the operating agency should keep his findings recorded, supported by expert documents that he should gather by contacting universities.

There are three types of groundwater monitoring, depending on its purpose, viz. (i) detection monitoring, (ii) assessment monitoring and (iii) compliance

monitoring. This is shown in a logic chart. The detection monitoring is to determine whether land disposal facility has leaked hazardous waste or constituents into an underlying aquifer in quantities sufficient to cause a significant change in groundwater quality. This can be found out within the first year itself. But if it is detected within say three months, one should not wait for one year, but should immediately begin the assessment monitoring. In detection monitoring, only a few indicator parameters may be analysed to establish, if migration is occurring. The indicator parameters used may include specific conductance, total organic carbon, total organic halogen or any specific waste constituents which the operating agency receives.

Assessment monitoring is a more aggressive programme, if a significant change is discovered in groundwater quality during the detection monitoring. In the place of non-specific, generally, specific chemicals are estimated and vertical-horizontal concentration profiles are attempted. Rate and extent of contaminant migration is studied. This study will lead to design corrective steps to be taken by operating agency.

The success of corrective steps so designed and implemented should be reflected in compliance monitoring. The goal of the compliance monitoring programme is to ensure that leakage of hazardous constituents into the groundwater does not exceed acceptable limits.

The operating agency will know from his experience that these hazardous constituents will be no different than the list of hazardous chemicals given in the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 in its Schedule I, Part II as amended in 1999. The State Boards may not normally announce these limits in the Authorisation. However, if assessment monitoring finds the presence of hazardous chemicals, corresponding standards will be prescribed so that the groundwater remains usable. The corrective action programme by operating agency should include, to remove or treat the constituents specified within an agreed time-frame. The corrective action programme does not terminate, till correction is seen in the groundwater quality.

The operating agency will keep in mind that the groundwater monitoring does not mean a generalised blanket analysis. Specific parameters are required to be selected as a three tier system, viz.(i) indicator parameters, (ii) groundwater quality and (iii) drinking water quality. These can be :

- (i) Indicator parameters : to know the pollutant grossly; they are pH, colour, specific conductance, Total Organic Carbon (TOC) and Total Organic Halogen.

- (ii) Groundwater quality parameters : to know its suitability for other (non-drinking) purposes like agriculture; they are chloride, iron, manganese, phenols, sodium, sulfates etc.

- (iii) Drinking water suitability parameters for its obvious purpose as a source; they are Arsenic, Barium, Cadmium, Chromium, Fluoride (temperature dependent), Lead, Mercury, Nitrate, Selenium, Silver, Endrin, Lindane, Methodoxy chlor, Toxaphene, Radio-activity and Coliform bacteria.

For a groundwater quality understanding, there should be sampling points (well) on hydraulically upgradient and a minimum of three on the downgradient, for a small facility of operating agency. However, the number required may increase depending on the complexity of facilities, of geography and of geology. The monitoring well must give a true picture of the groundwater and nothing else. The monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole. The casing must be screened or perforated and, if necessary, packed with sand or gravel to enable sample collections at depths where appropriate aquifer flow zones exist. The annular space (the space between the bore hole and the well casing) above the selected sampling depth must be sealed with a suitable material, such as bentonite slurry or grout.

The operating agency shall keep a frequency of sampling as once in three months normally, unless the circumstances compel to do it more often to develop confidence. They should continue even after abandoning the site for a fixed period. All this should be done by the operating agency in constant consultation with the SPCBs. A sequence is suggested by a logic chart (figure 6.10).

It may not be out of place to mention that 175 wells are reportedly monitored monthly by a U.S.A. operating agency, CECOS (M/S.Chemical and Environmental Conservation Systems Inc.) for their secure chemical landfilling at Niagara Falls site, spending a quarter million dollars a year (1986) to check and ensure that groundwater does not become contaminated.

### **6.9.6 Record Keeping**

The operating agency should remember that no job is complete unless paper work is complete. The record keeping and reporting is especially important when dealing with hazardous waste. The operating agency should maintain the minimum record as is required by the hazardous waste rules, but should additionally keep other records like health statistics, insurance, cost analysis and whatever may be required by other departments. The statutory authorities sometimes demand only an annual figure. However, to arrive at, the operating agency has to have a daily record. The minimum requirement can be summarised as follows :

**TABLE 6.3 Requirement of information by operating agency**

For Form No.	Preparatory figures
1.	Hazardous waste generation <ul style="list-style-type: none"> <li>- category number</li> <li>- category</li> <li>- origin of manufacturing activity</li> </ul>
3.	Description of hazardous waste <ul style="list-style-type: none"> <li>- physical form</li> <li>- chemical form</li> <li>- quantity (volume and weight)</li> </ul> Description of <ul style="list-style-type: none"> <li>- daily method of storage of hazardous waste</li> <li>- daily method of treatment of hazardous waste</li> </ul> Details of transportation <ul style="list-style-type: none"> <li>- name and address of consignee of package</li> <li>- mode of packing</li> <li>- mode of transportation</li> <li>- date of transportation</li> <li>- quantity transported</li> </ul> Details of disposal of hazardous waste (datewise) <ul style="list-style-type: none"> <li>- date of disposal</li> <li>- Concentration of hazardous material in the final Waste form</li> <li>- Site of disposal ( identify the location on the Relevant layout drawing for reference)</li> <li>- method of disposal</li> <li>- name of persons involved in the disposal</li> </ul> Data on environmental surveillance <ul style="list-style-type: none"> <li>- Date of measurement</li> <li>- Groundwater (sampling location, depth of Sampling, results )</li> <li>- Soil (sampling location, depth of sampling, Results)</li> <li>- Air (sampling location, data )</li> <li>- Any other (keep record)</li> </ul>
4.	Details of waste disposal operations                     Description of hazardous waste <ul style="list-style-type: none"> <li>- Physical form and contents</li> <li>- Chemical form</li> <li>- Total volume of hazardous waste disposed</li> <li>- No. of packages</li> </ul> Mode of transportation to the site of disposal

	Site of disposal (attach sketch showing the location of disposal) Brief description of method of disposal Date of disposal Remark (like discrepancy in manifest etc.) Details of environmental surveillance <ul style="list-style-type: none"> <li>- Date of measurement</li> <li>- Groundwater (sampling location, depth of Sampling, results)</li> <li>- Soil (sampling location, depth of sampling, Results )</li> <li>- Air (sampling location, data )</li> <li>- Any other (keep record)</li> </ul>
5.	Accident Reporting <ul style="list-style-type: none"> <li>- Date and time of the accident</li> <li>- Sequence of events leading to accident</li> <li>- Name of hazardous waste involved in the Accident</li> <li>- Chemical data sheet assessing effect of accident on health and environment</li> <li>- Emergency measures taken</li> <li>- Steps to prevent recurrence of such wastes</li> </ul>
7.	Description of imported hazardous waste <ul style="list-style-type: none"> <li>- Physical form</li> <li>- Chemical form</li> <li>- Total volume &amp; weight (kg)</li> </ul> Description of storage, treatment and disposal of hazardous waste <ul style="list-style-type: none"> <li>- Date</li> <li>- Method of storage</li> <li>- Method of treatment &amp; reuse( give details)</li> </ul>

The operating agency should also maintain a record about the inspection visits of the SPCB officials and other inspectors, if any and the instructions given by them on the spot. This should be followed by the compliance letter of the instructions in a reasonable time and acknowledgement obtained. The operating agency shall maintain his own record of treatability studies and characterisation of raw or recovered wastes with various parameters. Record of training too be maintained.

The operating agency should keep it in mind that if he takes care of record daily, the record will take his care in case of an emergency.

## **6.10 LEGISLATION FOR MANAGEMENT OF HAZARDOUS WASTE AND CATEGORISATION OF HAZARDOUS WASTE**

In exercise of the powers conferred under the Environment (Protection) Act, 1986 (29 of 1986), the Central Government has made the Hazardous Waste (Management & Handling) Rules, 1989 and published in the official Gazette No.S.O.594(E), dated 28.7.1989. These Rules define the Hazardous Wastes and provide specific schedule in which wastes are listed for application of the rule. The rules have been further amended in 1999 called Hazardous Waste (Management and Handling) Rules, January 6, 2000. The occupier generating hazardous waste has obligation to take all practical steps to ensure that such wastes are properly handled and disposed off without any adverse effect, which may result from such wastes. The occupier shall also be responsible for proper collection, transportation, treatment, storage and disposal of these wastes, either by himself or through the operator of a facility. The occupier shall submit application to the SPCB for grant of authorisation for handling of hazardous wastes. The SPCB shall not issue an authorisation unless it is satisfied that the operator of a facility or an occupier, as the case may be, possesses appropriate facilities, technical capabilities and equipment to handle hazardous wastes safely.

The State Govt./U.T. Administration, or a person authorised by it, is required to undertake a continuing programme to identify the sites and compile and publish periodically an inventory of disposal sites within the State/UT for the disposal of hazardous wastes. An environmental impact study shall be undertaken before final identification of a site as waste disposal site. Import of hazardous waste from any country to India shall not be permitted for dumping and disposal of such wastes. However, import of such wastes may be allowed for processing or re-use as raw-material, after examining each case on merit by the SPCB or by an officer authorised in this behalf.

The Hazardous Wastes (Management & Handling) Rules apply to the categories of Hazardous Wastes as specified in the Schedule-I to the Rules amended on January 6, 2000 as given at Annexure 6.1

## **6.11 HANDLING OF HAZARDOUS CHEMICALS**

It has been observed that there is always potential risk due to handling and transportation of toxic/ hazardous chemicals and particularly in residential areas. Storage of such chemicals in residential and commercial areas should be closely monitored.

The MoEF have notified the Manufacturer, Storage and Import of Hazardous Chemical Rules, 1989 (as amended on January 20, 2000) and according to these rules, activities relating to handling and transportation of hazardous chemicals

should be regulated. However, this subject is not under the purview of local bodies but, they can provide assistance to the concerned agencies whenever needed.

## **6.12 INDUSTRIAL LOCATION**

There are certain types of industries though they are small sized/tiny but, cause considerable pollution when they are located in residential areas. Such industries quite often do not seek 'Consents' from SPCBs and even not 'licensed' by the local authorities. Therefore, SPCBs and Municipal authorities should review and interact with each other to ensure that industries do not come up in non-conforming areas. From solid waste generation point of view, small industries dispose variety of solid waste like, packaging materials, oil sludges, scraps, paints, metallic/non-metallic containers, metallic sludges, etc. Based on pollution potential, category of industries which may be examined and restricted for their siting in residential areas may be referred in the Annexure 6.2.

Municipal authorities while providing services in residential and commercial areas when find that there are industries which discharge solid waste, should bring out information to the knowledge of SPCBs so that necessary actions are taken. In commercial areas, service units like flour mills, automobile service stations should be properly served notices by the concerned administration to the effect that such units should dispose their solid waste as per norms laid by Pollution Control Boards/ municipal authorities.

## **6.13 MANAGEMENT OF INDUSTRIAL SOLID WASTES-CO-ORDINATION (SPCBs & LOCAL BODIES)**

Urban local bodies are constantly in the field and they are well aware of the local situation. They also know sources of waste generation and areas under their control. In order to organise proper collection, transportation and disposal of industrial solid waste, there is need to set up co-ordination between SPCBs, local bodies and industrial departments. Following guidelines are suggested to follow :

- i) Urban local bodies should identify the areas from where industrial solid waste is generated.
- ii) Inventorisation of industries could be attempted through SPCBs or industries department for characterisation of wastes.
- iii) SPCBs may take necessary actions for issuance of consents/Authorisations to the industries under relevant Acts and Rules.
- iv) Urban local bodies may undertake collection, transportation and disposal of solid waste on cost recovery basis as per existing rules and may identify

suitable sites for final treatment and disposal of industrial solid waste as per existing rules and regulations.