Chapter 5

Treatment and Disposal of Hazardous Waste

5. Treatment and Disposal of Hazardous Waste

5.1 Current Conditions

Hazardous waste management is variable in Romania, management of organic wastes from the oil sector and organic chemicals sector has in the past been fairly good, and in some cases still is. However several in-house facilities for treatment and/or disposal of organic wastes have been allowed to fall into disrepair and have become unusable due to economic difficulties. The situation regarding inorganic wastes is worse, in that a significant proportion of in-house treatment systems have been allowed to fall into disrepair and have become derelict.

In addition enterprises in Romania; are often failing to identify some hazardous wastes (either deliberately, because of unwillingness to pay for proper management or lack of available options for proper management, or unwittingly), secondly, some non-hazardous wastes are being incorrectly categorised as hazardous wastes.

Some hazardous wastes are however being identified and segregated and many of these are being “stored” pending later management. The term “storage” implies a future intention to do something with the material stored, but in Romania the term storage is used interchangeably with the term “disposal”. Most “stores” are in reality waste dumps.

5.2 Issues

Not all hazardous waste generation can be avoided, similarly it is not practicable to reuse, recover, recycle or utilise all unavoidable hazardous wastes. There will always be a need for environmentally sound hazardous waste treatment and disposal.

Wastes, wastewaters, emissions and hazardous wastes are all inter-related. Treatment of hazardous wastes is principally aimed at reducing the hazardous nature of the waste in order to facilitate simpler final disposal. For example, toxic heavy metals may be precipitated as water insoluble hydroxides, the resultant sludge being dewatered and stabilised to give a non-toxic, non-hazardous, solid material for landfill and an effluent for wastewater treatment. Equally, wastewater treatment generally results in a hazardous sludge for treatment and disposal. Figure 5.2.1 is a general schematic illustrating industrial waste management activities and their inter-relationships.

As indicated above, where facilities exist they are often poorly maintained and many have fallen into disuse. It is important to ensure that adequate facilities are developed to manage hazardous wastes currently being generated and likely to be generated in the future. This will require a combination of upgrading existing facilities and development of new facilities. Various national approaches to achieve this objective are discussed in the next section.

Whatever method is used to secure the development of necessary infrastructure, it is important that coherent plans should be produced, and that these are properly integrated with other inter-related plans such as the plans for municipal and solid waste management.

A key issue in Romania is the policy of EU Accession and the current programme of approximation of Romanian legislation. The majority of current hazardous waste management practices and waste management facilities do not comply with current EU standards.

In developing this strategy and plan certain key policies and principles have been considered, these are listed in Table 5.2.1.

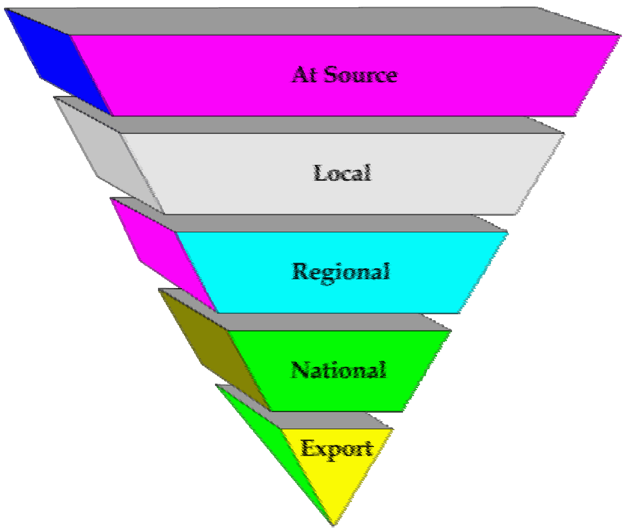
Table 5.2.1 Key Principles and Policies in Romania

EU Accession	Romania is committed to EU Accession.
Waste Management Hierarchy	Hierarchy of waste management options.
Polluter Pays Principle	The principle that the polluter should pay for proper management of wastes generation and cost of any abatement measures.
Proximity Principle	Where practicable, wastes should be managed at or close to the place of waste generation. A hierarchy can be expressed as illustrated in Figure 5.2.1.
Duty of Care	Generator responsible for the proper management of wastes generated.
Precautionary Principle	Avoiding practices which are not known to be environmentally sound.
BATNEEC	Use of "Best Available Technology Not Entailing Excessive Cost."

Source: JICA study team

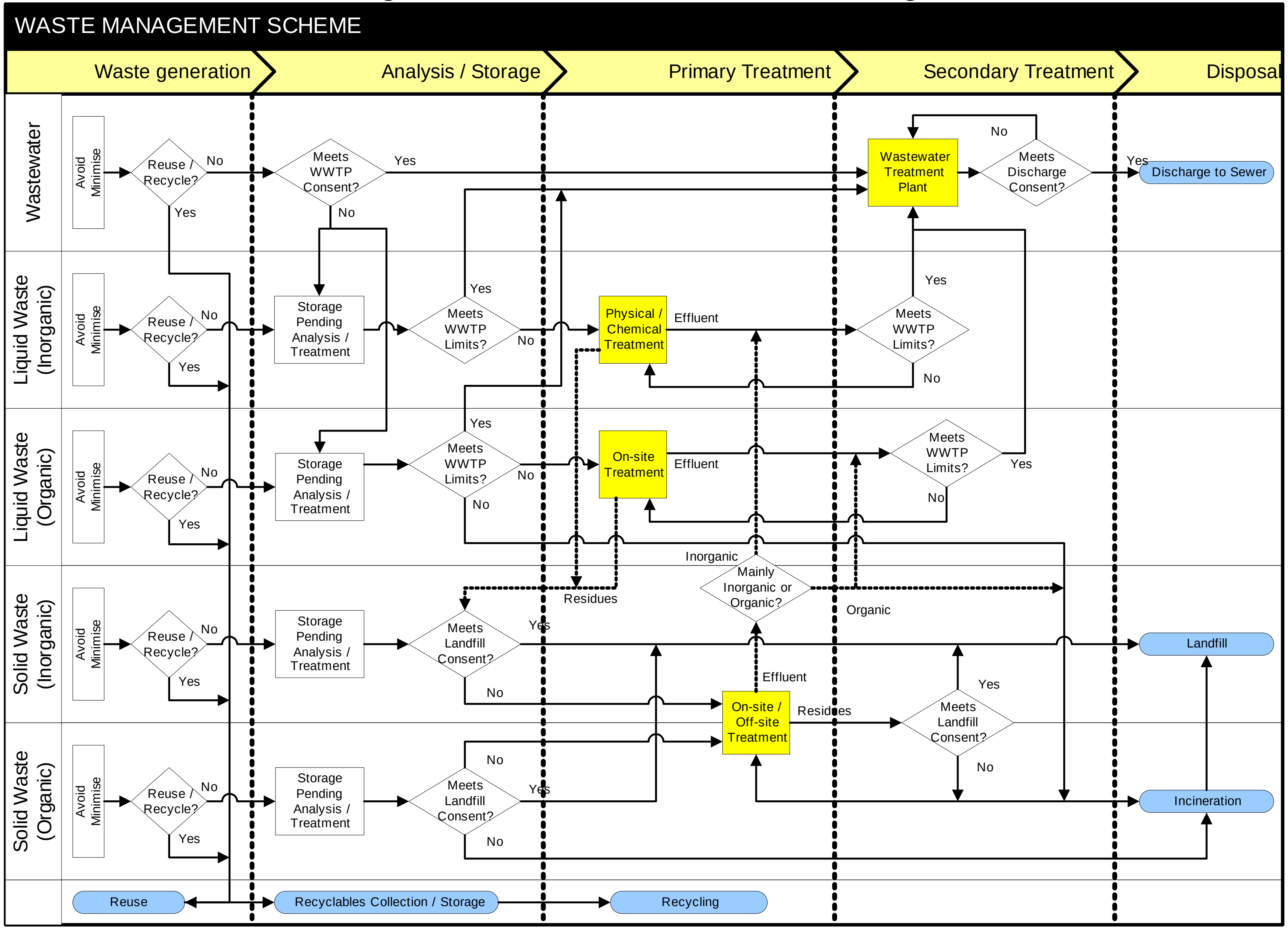
None of the principles can be considered in isolation, for example treatment of all wastes at source is impracticable, and many enterprises do not for example generate sufficient hazardous organic wastes to justify constructing a dedicated incinerator. Similarly there may be insufficient such wastes to justify constructing an incinerator to serve just one city or county. Similarly, the waste management hierarchy generally takes precedence over the proximity hierarchy (e.g. it is better to recycle waste at a national facility than dispose of it locally).

Figure 5.2.1 – Proximity Hierarchy



Source: David Newby Associates

Figure 5.2.2 Schematic of Industrial Waste Management



Source: David Newby Associates

5.3 Identification and Assessment of Existing Facilities

5.3.1 Interim Storage of Hazardous Waste

Wastes may be stored at the point of generation, pending transfer to longer term storage, landfill or for further management (reuse, recovery, recycling, treatment or disposal). This “interim” storage is often under very poor conditions with very poor containment of wastes.

5.3.2 Waste Treatment and Disposal at Source

In common with many countries with transitional economies, many of Romania’s industries have old, out-dated, inefficient processes and equipment. This is particularly true of waste treatment and disposal systems where these exist.

Many factories have in the past have had physical/chemical treatment systems and incineration systems which, due to economic pressures, have been allowed to fall into disrepair and have become inoperative as a result. Similarly, due to the general decline some factories have opted not to use their existing treatment facilities and also discharge wastes untreated or are stockpiling the wastes. Whilst this is a fairly general problem there are some examples of good practice too.

It is not uncommon for enterprises to compensate for lack of adequate wastewater treatment to rely on massive dilution of hazardous wastes to meet discharge consent concentrations.

Several enterprises have dedicated hazardous waste incinerators; these are listed in Table 5.3.1 these are generally used for management of the respective enterprise’s own wastes although some do accept wastes from third parties.

5.3.3 Waste “Storage”

ICIM have estimated that approximately 500,000 tons of hazardous industrial wastes were accumulated and stored within various companies by the end of 2000. In theory this is temporary storage pending utilisation, recovery, recycling, treatment or final disposal/landfill. However, it is noted that such “temporary” storage clearly lasts more than two years in some cases, essentially changing the local storage area into an unprotected landfill, located on companies’ sites.

The most commonly used storage methods are: bulk storage, storage in metallic containers and storage in basins/settling tanks. Storage conditions are often very poor and containment often poor - some metal containers observed holding wastes have almost completely rusted away.

5.3.4 Waste Collection and Transportation

Waste collection agents appear to be generally private companies and are essentially local enterprises rather than national organisations. Most of the existing collectors in Romania are municipal waste collection and transportation contractors and these largely only collect municipal wastes. Some of these collectors also collect refuse-type wastes from commercial and industrial sources, park wastes and construction and demolition wastes. These contractors claim not to collect any hazardous wastes.

There are waste recycling organisations that collect wastes from generators, some of these collect hazardous wastes, most notably waste oils, car batteries and, to a lesser extent, solvents.

There are a very small number of hazardous waste management contractors in Romania. Those that do exist generally offer waste collection but their transportation capacity is generally small. No dedicated haulage contractors have been identified who collect hazardous wastes.

The remainder of hazardous waste transported is transported by the waste generators themselves. However, more than 80% of hazardous waste is deposited or stored and this generally happens at or close to the place of waste generation requiring minimal transportation.

5.3.5 Waste Treatment and Disposal Off-site

A country in transition like Romania generally does not have many hazardous waste contractors (companies which collect, transport, treat and/or dispose of hazardous wastes), however, there are a small number of hazardous waste management contractors. Note that hazardous waste recycling contractors have been covered separately (see Chapter 3).

There are a large number of waste collectors in Romania but these are only collecting municipal wastes. Some industrial wastes find their way into this collection stream but this is unofficial and claimed to be small volume.

These collection contractors generally do not operate the landfill sites; these are generally developed and operated by municipalities although private sector landfill operations are becoming more common. Industries largely transport their own wastes to municipal landfills or operate their own landfills / dumps – these activities are being covered by the waste generation sources survey activities (see Volume 3 Chapter 1). The situation is further discussed in the following sub-Chapters:

Table 5.3.1 Incinerators on Industrial Enterprises Own Sites in Romania

Organisation	Type of Incinerator	Gas Cleaning System	Wastes Processed	Capacity T/yr (Total)	Capacity (Currently Used)	Operating (Yes/No)	Likely to meet EU Standards (Yes/No)
Arpechim, Pitesti [1]	3 Incinerators for process emissions 1 liquids incinerator		Acrylonotiriles (process emissions) Electroplating wastes!	80 cu.m / hr unknown	Unknown unknown	 Yes	 Unknown
Oltchim, Rm. Valcea	Fixed hearth liquid waste incinerator [2]	Acid gas absorber (for recovery of HCl)		18,000	18,000		Possible
Petrobrazi	3 Fixed hearth liquid incinerators 1 Rotary Kiln			5,000 16,500	?	No [3] No	No No
Petrom, Bucharest	Fixed hearth, dual combustion chamber.	Caustic soda scrubber.	Oil wastes.			No (awaiting authorisation)	No
Uzina Produse Speciale – Fagaras [1]	1 unknown type	unknown	Explosives (own and 3rd party)	unknown	65 tonnes (2001)	Yes	Unknown
S.C. Kober SRL	Unknown type	unknown	Paints/varnishes	unknown	unknown	Yes	Unknown

1 Process third party wastes as well as their own wastes
2 Oltchim want to add solids handling capability.
3 PetroBrazi claim that at least one is operating but this is considered unlikely to be the case.

Source: MoWEP/JICA Study Team

1) Principally Organic Industrial Wastes

Principally organic wastes can be suitable candidates for recovery / recycling, this is discussed in Chapter 3. With respect to the treatment and disposal of these wastes, the preferred technology is thermal treatment (incineration or utilisation in cement kilns).

There are several hazardous waste incinerators currently operating in Romania, some of these are operated as independent entities and some are operated by waste generators for their own wastes but which are potential resources for management of other generators wastes. Most of these organisations operate incinerators and a small number operate physical/chemical treatment processes. The identified incinerators, operated by waste generating companies, were listed in Table 5.3.1, Table 5.3.2 lists incinerators which are operated solely as a commercial service.

In addition two cement manufacturers, Lafarge Romcim and HolCim have rotary cement kilns in which they hope to process hazardous waste as a supplementary fuel. At present, neither of these accept significant volumes of hazardous waste due to certain barriers including lack of willingness to pay.

Sotem Romania SRL is a company formed recently by Civa (USA) and HolCim which has an organic waste blending facility at the HolCim Campulung cement plant (see Figure 5.3.1). Sotem has put considerable efforts into developing the market for cement kiln incineration and has met with limited success. Sotem’s facility at Campulung has the capability of processing a wide variety of organic wastes including liquids, sludges and solids and supplies blended waste as a fuel to the HolCim cement kiln. Figure 5.3.2 shows the blended waste feed system at the cement kiln.

The cement kiln operations do not currently fully meet European standards with respect to level of automation and continuous monitoring but Sotem/HolCim have a programme of improvements underway which will result in a system that will largely comply with EU standards.

Figure 5.3.1 – Sotem Organic Waste Blending Facility

Source: JICA Study Team

Figure 5.3.2 – Blended Waste Feed System at Cement Kiln

Source: JICA Study Team

The two merchant incinerators for hazardous waste shown in Table 5.3.2 currently known to operate in Romania do not meet current EU standards. Both of these are very small scale units and disposal charges are high (largely due to the lack of economies of scale). One or both of these could potentially be upgraded to meet such standards. Because the units are small scale they are likely to serve small local waste generators and are unlikely to be of great strategic significance.

2) Principally Inorganic Wastes

Other than recovery/recycling, the preferred methodology for management of principally inorganic waste is physical/chemical treatment to reduce the level of hazard of the waste followed by ecologically sound landfill.

Waste treatment in Romania is well behind Western practices. Table 5.3.3 derived from the ICIM 2002 Survey (for which the information is provided by the local EPIs) identifies the percentages of hazardous waste managed by different recovery and treatment and disposal methods. Many facilities are extremely basic with no means of mixing contents to ensure adequate treatment, no fixed pipework systems or storage tanks for reagents, no means of taking adequate samples and so on.

Some enterprises have no access to sewer discharge systems and rely on tanker collection of wastewaters for disposal to sewage treatment works.

Table 5.3.2 Merchant Incinerators Currently Existing in Romania

Organisation	Type of Incinerator	Gas Cleaning System	Wastes Processed	Capacity T/yr (Total)	Capacity (Currently Used)	Operating (Yes/No)	Likely to meet EU Standards (Yes/No)
Mondeco, Suceava	Fixed hearth (2 units)	Gravity settling of heavy particulate only	Clinical wastes	40 kg/hr 10 kg/hr	40 kg/hr (2nd unit inoperative)	Yes	No
Pro-Air Clean, Timisoara	Fixed hearth, dual combustion chamber.	Activated carbon, alkali scrubber / filter	Clinical and other hazardous wastes	1,200	1,200 [1]	Yes	Possible

1) In 2001 only operated 39 days but since February 2002 operating full time.

Source: MoWEP/JICA Study Team

Table 5.3.3 Hazardous Waste Treatment Methods in 2002

RECYCLING OPERATIONS for hazardous waste (2002)	Code	%
recovery and regeneration of solvents	R1	0.025
recycling and recovery of organic waste	R2	0.033
recycling and recovery of metallic waste	R3	3.3
recycling and recovery of other inorganic waste	R4	1.149
regeneration of acids and bases	R5	0.463
recycling of materials used for pollutants collection	R6	0.227
recycling of catalysts	R7	0.002
refining of used oils	R8	0.584
use as combustible material or other mean for energy production	R9	0.941
use in agriculture, composting, other biological operations	R10	0.02
other non-mentioned use of waste	R11	0.438
waste exchange between operators	R12	3.113
temporary storage	R13	1.355
non-specified		0.12
TOTAL		**11.77**

DISPOSAL OPERATIONS for hazardous waste (2002)	Code	%
disposal on soil and in subsoil	E1	5.246
waste treatment in contact with soil	E2	0.013
underground injection	E3	0
discharge on surfaces	E4	71.945
disposal on special landfills	E5	3.186
discharge in waters	E6	0.492
discharge in sea	E7	0
biological treatment	E8	0.408
physico-chemical treatment	E9	2.28
incineration on soil	E10	0.003
incineration on sea	E11	0
permanent storage	E12	3.706
mixing	E13	0.004
reconditioning	E14	0.001
temporary storage	E15	0.868
non-specified		0.079
TOTAL		**88.23**

Source: ICIM 2002 Survey

It should be noted that in Romania, the terms ‘storage’, ‘landfill’ and ‘land disposal’ are often used interchangeably, as there has been tendency to label many wastes as materials being stored for future reuse, whether or not this is ever likely to be feasible.

According to data held by ICIM, in 1999 there were 846 industrial waste landfill sites in Romania; ICIM 2002 data indicates there are currently 687 industrial waste landfills. Landfill accounts for >80% of final disposal for industrial waste. It should be noted that in certain landfills for urban waste industrial waste is also disposed; some belonging to the category of hazardous waste, a fact that represents a serious infringement of the norms regarding the management of such waste. Many of the ‘landfills’ for industrial waste deposits are basic with little or no special provisions for containment of waste, leachate control or final cover; also, there are a large number of landfills for mining spoils (203) and settling ponds /

catch pits (189) (Table 5.3.4). Table 5.3.5 shows landfills by EU hazard category.

Table 5.3.4 Industrial Landfills by Categories

	Mining Waste Landfills	Catch pits and ponds	Drying beds	Landfills for slag and ashes	Simple deposits	Underground deposits	Other
Number	203	189	55	77	107	45	11
Occupied surface (ha)	5409	1608	50	3102	129	2	47

Source: ICIM 2002 Survey Data

Table 5.3.5 Landfills by Hazard Categories

	Inert	Non-hazardous	Hazardous	Not Specified
Number	103	351	147	86
Occupied surface (ha)	4500	4428	749	669

Source: ICIM 2002 Survey Data

Only 30% of the landfills for industrial waste have authorisation to operate. The remainder operate without such authorisation. 34% of landfills for industrial waste are located within built-up areas, 60% are outside settlements and 6% are located near waters.

Although the vast majority of industrial waste landfills are unsuitable for hazardous wastes, many probably receive a certain amount of hazardous wastes due to poor segregation of waste at source.

The majority of industrial waste landfills (about 76%) occupy relatively small areas (up to 5 ha). At least 50 industrial waste landfills do not have any investment for environmental protection. Some landfills have one or more special features (eg lining, drainage for leachate, perimeter ditches, monitoring boreholes), but very few have all the necessary features to comply with the conditions for the environmental protection. None meet full EU engineering or operational standards. In addition, fly tipping is common.

According to UNECE Environmental Report For Romania 2001, there are 83 land disposal sites specifically for hazardous wastes, with a total area of about 450 ha, located in 30 counties. 75% of these sites accept more than 10 tons of hazardous waste per day.

Only 10% of the landfills for hazardous waste are authorised by the environmental protection authorities. Most hazardous waste is deposited in landfill sites (60%), or stored (20%) at the industrial facility where the waste was generated, although some larger waste storage areas have been established on the sites of obsolete production plant where the ground was already contaminated.

5.4 Objectives and Targets

The general objectives with respect to the treatment and disposal of hazardous wastes are defined within Romania’s laws specifying that:

- Wastes are managed in such a way as to avoid damage to the environment and human health (do not present risks for the human health, water, air, soil, fauna and vegetation),

- Wastes are managed in such a way as to avoid nuisance (do not produce noise pollution or unpleasant smells and do no affect the landscape and protected areas),
- The Polluter Pays Principle should be adopted.
- Wastes should be avoided and minimised as far as practicable
- Preference should be given to **environmentally sound** recycling and recovery of wastes that cannot be avoided,
- The principle of the producer's responsibility should be adopted,
- The principle of using the best available techniques, not entailing excessive costs (BATNEEC) is specified,
- The proximity principle should be adopted, stating that waste shall be capitalized and disposed of as near as possible to the point of its generation,
- With respect to export, the principles of non-discrimination, consent and agreement for hazardous waste transport only in countries having adequate disposal technologies; must be observed in international commerce with waste.

In addition, in line with Romania's policy of EU Accession, the objectives are to progressively move towards compliance with EU standards in accordance with Romania's program for approximation.

5.5 Strategy

5.5.1 Basic Concept

Current economic industrial and regulatory circumstances in Romania suggest that the strategy should draw strongly upon:

(i) The private entrepreneurial skills and resources that already exist within the local economy, and

(ii) The government's role in ensuring that legislation, regulations and control are available, implemented and enforced within an appropriate timeframe.

(iii) Government encouraging investment in environmental improvements by economic instruments, for example by facilitating access to economical commercial loans. (see discussion in Chapter 7.3)

The initial focus should be upon mobilising these resources to provide low-cost, scaleable facilities using relatively basic technologies to meet the known immediate demand as early as possible at affordable prices. This approach would retain the flexibility to expand existing facilities or to provide additional facilities at a later time when (i) the regulatory and enforcement system has been fully implemented, (ii) when waste generators have a greater awareness of the waste problem and its potential solutions, and (iii) when the magnitude of the waste flows is better known and waste generators come under more systematic regulation.

5.5.2 Waste Generation and Interim Storage

With respect to waste generation and waste segregation the objectives are to move from generally poor avoidance and minimisation of waste to good waste avoidance and minimisation and from poor identification of, and lack of segregation of, hazardous wastes to the situation where they are properly identified, properly segregated and therefore can be managed effectively.

This should be achieved by a mixture of encouragement and awareness raising backed up by improved compliance-orientated regulation and control. Appropriate guidance notes and standards need to be developed, promulgated and enterprises encouraged/made to comply (see discussion in Chapter 8).

A tool for promoting the proper identification of hazardous wastes at source should be an improved hazardous waste reporting system backed up by relevant regulations and an improved waste management information system (WMIS).

With respect to interim storage of wastes, hazardous wastes need to be stored under improved conditions; again the mechanism for securing improvements has to be the development and promulgation of appropriate standards, followed by the effective application and enforcement of those standards.

With regard to the latter, there is overlap with the issue of control of hazardous substances and their storage and handling. It makes most sense to integrate the control of hazardous waste interim storage with the control of storage of hazardous substances.

STRATEGY

Implementation of awareness raising programmes.

Promotion of waste avoidance and minimisation projects via incentives.

Introduction of regulatory provisions to promote avoidance and minimisation (e.g. statutory targets).

Identification of existing practices at enterprises and development of compliance programmes for securing necessary improvements.

Remediation of inadequate facilities for intermediate storage and waste management at source.

Closure of inadequate facilities which are not suitable for upgrading linked to promotion of the use of environmentally acceptable third party solutions.

STRATEGY

Development of EU compatible standards for storage, treatment and disposal of hazardous wastes.

Progressive implementation and enforcement of those standards.

Identification of external factors resulting in poor hazardous waste management and development of improved integrated approach.

Development and implementation of an improved data collection system linked to development of a national Waste Management Information System (WMIS).

Promotion of the development of Romanian capacity for undertaking avoidance and minimisation projects.

Promotion of industry uptake of avoidance and minimisation projects by awareness raising.

5.5.3 Waste Treatment and Disposal

The sound treatment and disposal of industrial waste and industrial hazardous waste is an essential element of an effective overall waste management system. In general terms, treatment at source is most appropriate for low-capital cost treatment processes or for generators of very large volumes of waste whilst centralised facilities are most appropriate for management of wastes requiring larger capital investments and wastes generated by smaller enterprises.

It is generally accepted that centralised, strategic, facilities for environmentally sound management of hazardous wastes are a necessary element of the overall hazardous waste management system. The availability of suitable facilities is a critical element in that the legislation cannot be complied with unless the facilities exist.

Physical/chemical treatment processes are generally low capital cost and indeed many enterprises have physical/chemical treatment systems but often these are old, low-technology processes and many have been allowed to fall into disrepair to the point at which they are unusable.

Thermal treatment processes are high capital cost processes and generally most viable provided as centralised/regionalised resources. However, because Romania has many large chemical, petroleum and petrochemical industries there are a significant number of incinerators within existing industries.

There are two very small commercially operated incinerators (ProAirClean and Mondeco) and two enterprises take wastes from third parties to burn alongside their own wastes generated (Arpechim and Uzina Produse Speciale – Fagaras). The small sizes of the ProAirClean and Mondeco incinerators are such that they are unlikely to be of strategic importance. The other two incinerators may have some spare capacity but again are unlikely to have great strategic importance.

Once again, many of these are low-technology devices and some have been poorly maintained resulting in some being unusable.

In addition, Romania has an established cement industry with several rotary cement kilns suitable for modification for utilisation of hazardous wastes. Two of the cement companies want to provide a service for the management of such wastes.

Refineries generating large volumes of organic wastes need to treat and or dispose of these wastes and have a need for access to incineration plant. They could be potential investors in incineration, indeed some refineries have developed incinerators but several have been allowed to fall into disrepair and are unusable. Refurbishment / replacement could be extremely expensive, and whilst refurbished / new incinerators on refineries could process third party wastes, cement kiln incineration is likely to be more cost effective.

The situation then in Romania is slightly unusual in that facilities for the proper management of inorganic wastes are more lacking than facilities for proper thermal treatment. The strategy needs to take this into account.

1) Options for the Management of Predominantly Inorganic Wastes

The options for improving the management of the principally inorganic wastes are:

Requiring enterprises with existing treatment facilities to properly maintain these facilities and use them,

- Requiring enterprises without the necessary facilities to develop them and use them,
- Requiring enterprises to use commercial facilities where they exist,
- Promoting and securing the development of regional facilities for treatment and disposal,
- Requiring enterprises to properly store wastes pending the development of commercial facilities and to send the wastes to these facilities once developed,
- Penalising enterprises failing to manage their wastes properly.

Whilst existing treatment technologies in industries may be low-technology, many could be restored / upgraded and made to run in an environmentally sound manner. Indeed the low level of automation can be an advantage in terms of dealing with lower level throughputs. Many existing installations, however, may need complete replacement.

The "compliance program" type mechanism could be implemented with existing enterprises to require the restoration or redevelopment of necessary on-site treatment capacity.

There is a certainly a viable role to be played by waste management companies in offering physical/chemical waste treatment services. It should be noted that these may become less economically viable in the medium to long term as some companies realise that they can treat more cost-effectively at source. The higher the transportation costs the more cost effective treatment at source becomes. In view of this, relatively small scale, regional, facilities for physical/chemical treatment make the most sense.

Industrial waste landfill will always be a requirement, no matter how much effort is put into 3Rs there will always be hazardous waste requiring treatment and disposal. There will be two kinds of need for landfill; the first is the need for mono-disposal landfills for the large volume generation of non-useful wastes by industrial enterprises. The second type is multi-waste industrial waste landfill for the smaller generators of waste requiring landfill.

The EU Landfill Directive requires landfills to be categorised as either:

(1) Inert Waste Landfills (Landfills accepting inert wastes, e.g. most Construction and Demolition Wastes)

(2) Non-hazardous Waste Landfills (Landfills accepting non-hazardous wastes)

(3) Hazardous Waste Landfills (Landfills accepting hazardous wastes).

Hazardous wastes should where practicable be treated to reduce the hazard of the waste prior to disposal (requirement of Waste Management Hierarchy and of Article 6a of Landfill Directive). It is practicable to treat most hazardous wastes to render them non-hazardous for final disposal therefore most hazardous wastes requiring landfill capacity will actually be suitable for non-hazardous waste landfill. There will be some hazardous wastes requiring final disposal which are hazardous but which meet the criteria specified in the Landfill Directive and these will require hazardous waste landfill capacity.

Thermal treatment facilities (except cement kilns) and physical/chemical treatment facilities generate residues requiring landfill. Incinerators generate bottom ash and fly ash for disposal. Some of these may be regarded as hazardous wastes:

19 01 05* - filter cake from gas treatment

19 01 07* - solid wastes from gas treatment

19 01 10* - spent activated carbon from flue-gas treatment

19 01 11* - bottom ash and slag containing dangerous substances

19 01 13* - fly ash containing dangerous substances

19 01 15* - boiler dust containing dangerous substances

No such problem exists with cement kilns as all of the ash is incorporated into the cement clinker.

Similarly, physical/chemical treatment facilities result in treatment products which require further processing / disposal. Effluents are generated which require appropriate wastewater treatment prior to discharge, and solid residues (principally insoluble metal oxides and hydroxides) which require disposal. These residues may be considered hazardous wastes themselves according to the European Waste Catalogue and the new Integrated Waste List, including:

19 02 04* - premixed wastes composed of at least one hazardous waste

19 02 05* - sludges from physico/chemical treatment containing dangerous substances

19 02 11* - other wastes containing dangerous substances

19 03 04* - wastes marked as hazardous, partly stabilised

19 03 06* -wastes marked as hazardous, solidified

In view of this, physical/chemical treatment plants need access to appropriate landfill capacity. If the solid residues are to be disposed of to landfill without further treatment then they would need to go to a landfill designated as a "hazardous waste landfill".

Given the relatively low standard of current landfills and limited in-country experience in relation to sound hazardous waste management practices, and the lack of any hazardous waste landfills at present, it is logical to include stabilisation of solid residues prior to landfill. Following stabilisation, the wastes would, in accordance with the Landfill Directive, be acceptable for disposal at either a hazardous waste landfill or a non-hazardous waste landfill and generally classified according to the European Waste Catalogue and the new Integrated Waste List as:

19 03 05 - stabilised wastes other than those mentioned in 19 03 04

Industrial waste landfills are beginning to appear in Romania but there is a need for accelerated development of these.

Table 5.5.1 shows the indicative total quantities of inorganic hazardous wastes generated by Region. If Ilfov and Municipiul Bucharest are combined the generation is relatively uniform across Romania, ranging from 10,000 tons per annum (tpa) in the South West Region to 21,000 tpa in the Central Region.

Table 5.5.1 Principally Inorganic Wastes by Region

Region	Quantity of Waste
North East	11,299
South East	8,822
South	11,371
South West	6,305
West	7,943

Region	Quantity of Waste
North West	10,796
Centre	13,521
Bucharesti	975
Municipality of Bucharest	8878
TOTAL	79,911

Source: JICA Study Team Survey

It is recommended that the Strategy for improving the management of Inorganic Wastes comprise the following elements:

- The identification and prevention of improper practices (Regulation and Control activity, see Chapter 8, particularly the massive dilution of wastes to meet wastewater discharge concentrations.
- The reinstatement / refurbishment of on-site treatment facilities for inorganic wastes.
- Promotion of the development of small scale flexible regional facilities for inorganic waste treatment and/or disposal (Hazardous Waste Treatment and Disposal Facilities – HWTDFs).

The aim would not initially be to develop HWTDFs in every region, rather to develop three or four initially as pilot facilities. Iridex Group is keen to develop a facility in the Bucharest region this should be encouraged along with the development of a facility in the central region and perhaps facilities in the North-West and North-East.

These facilities should comprise basic physical/chemical treatment processes (oxidation-reduction, neutralisation-precipitation, dewatering, stabilisation, wastewater treatment and residues landfill). To facilitate the latter these facilities should be located on or close to a landfill.

2) Options for the Management of Predominantly Organic Wastes

Figures 5.5.1 to 5.5.3 show the distribution of generation of principally organic wastes by County and by Region.

As already indicated, there are currently several incinerators in industrial enterprises, two small commercial incinerators and there are operators of rotary cement kilns who are keen to offer waste management services. So, an intrinsic lack of facilities is not a major issue. The locations of the major cement kilns are overlaid on Figures 5.5.1 and 5.5.3.

However, it is fair to say that many of the existing incinerators are unlikely to meet EU standards for emissions and operational monitoring and control. Options for improving the management of principally organic wastes then include;

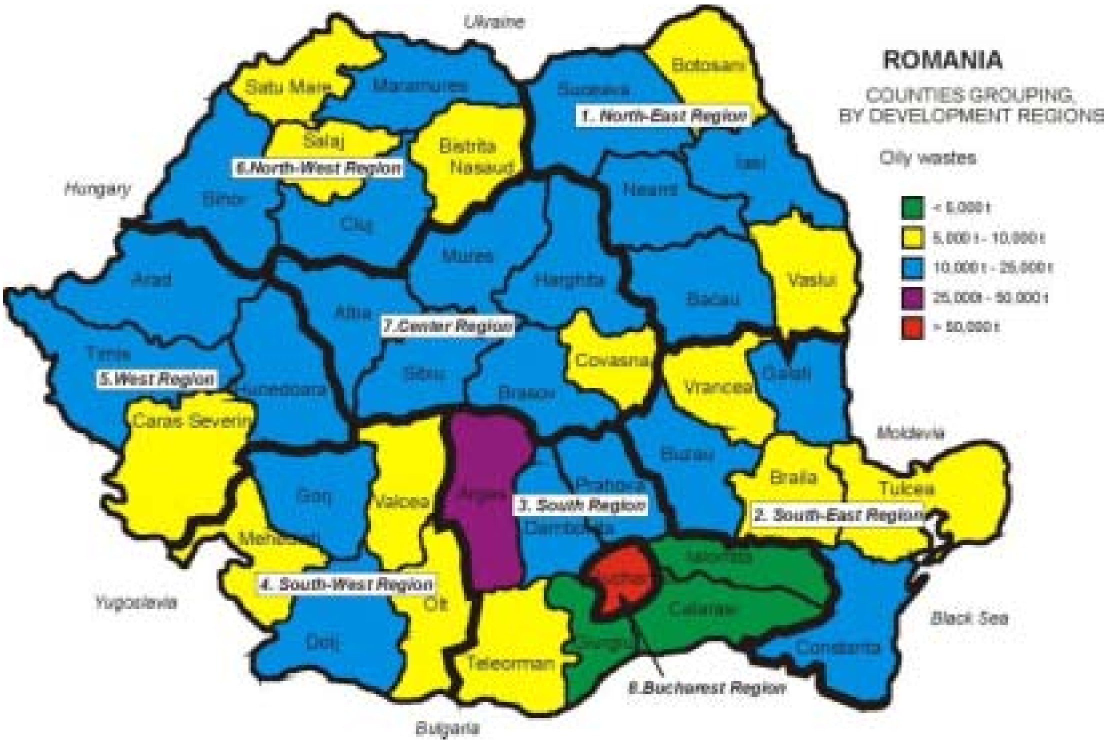
- Requiring enterprises with existing treatment facilities to properly maintain these facilities and use them

- Requiring enterprises to plan for the upgrading of existing facilities to ensure that they will meet EU standards (currently being transposed into Romanian standards), or plan for their replacement as necessary to meet proposed Romanian standards
- Maximise the use of existing commercial facilities (which also need to be upgraded as an when necessary to comply with the Romanian standards under development)
- Remove the barriers to the use of cement kilns, these are mainly associated with willingness to pay
- Plan for the development of strategic centralised/regionalised facilities

Our short term / medium term recommendation is not to focus on the development of additional thermal treatment systems for industrial waste but to maximise the further development and appropriate use of existing thermal treatment resources (existing incinerators and cement kilns).

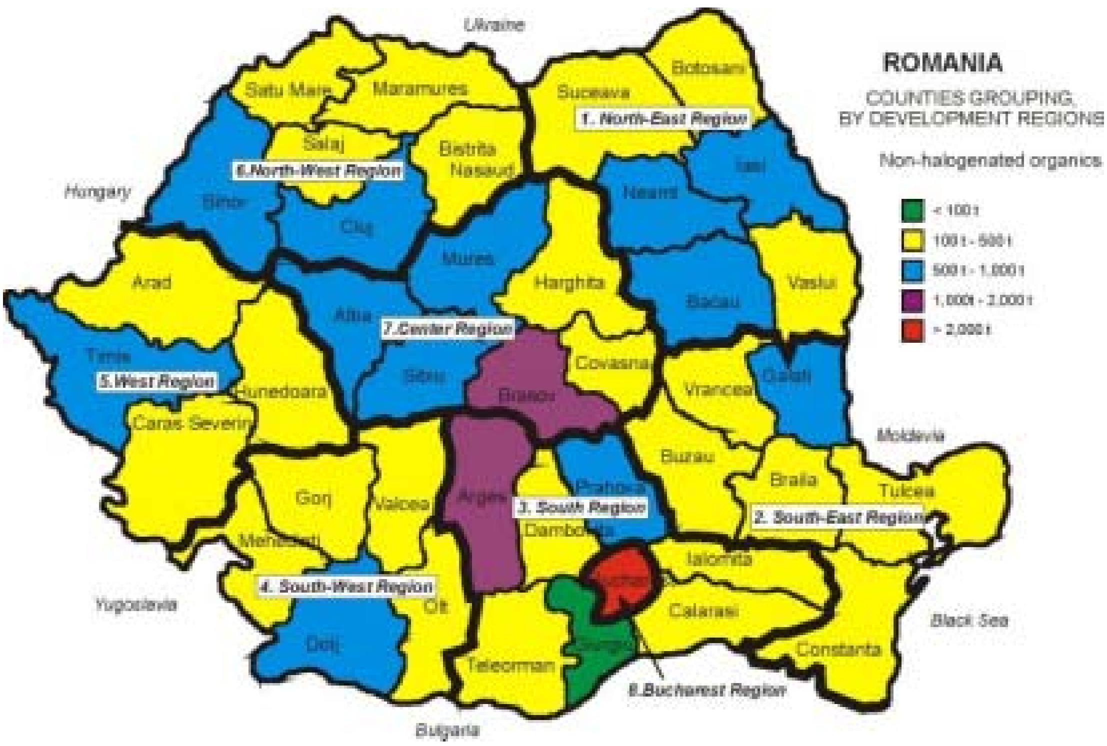
Currently generators are reluctant to pay even 12 – 15 $ per ton for cement kiln disposal, this impacts upon the viability of this option and this issue needs to be addressed by effective enforcement, this in turn will stimulate the investment by cement companies and their willingness to upgrade operations to full EU standards.

Nevertheless, there is potentially a need for development of strategic thermal treatment facilities specifically for health-care wastes (in view of the decision to close hospital `incinerators' in 2004). There are other project activities looking at this issue and it is logical to allow those project activities to proceed to their logical conclusion and recommend a health-care waste management strategy.



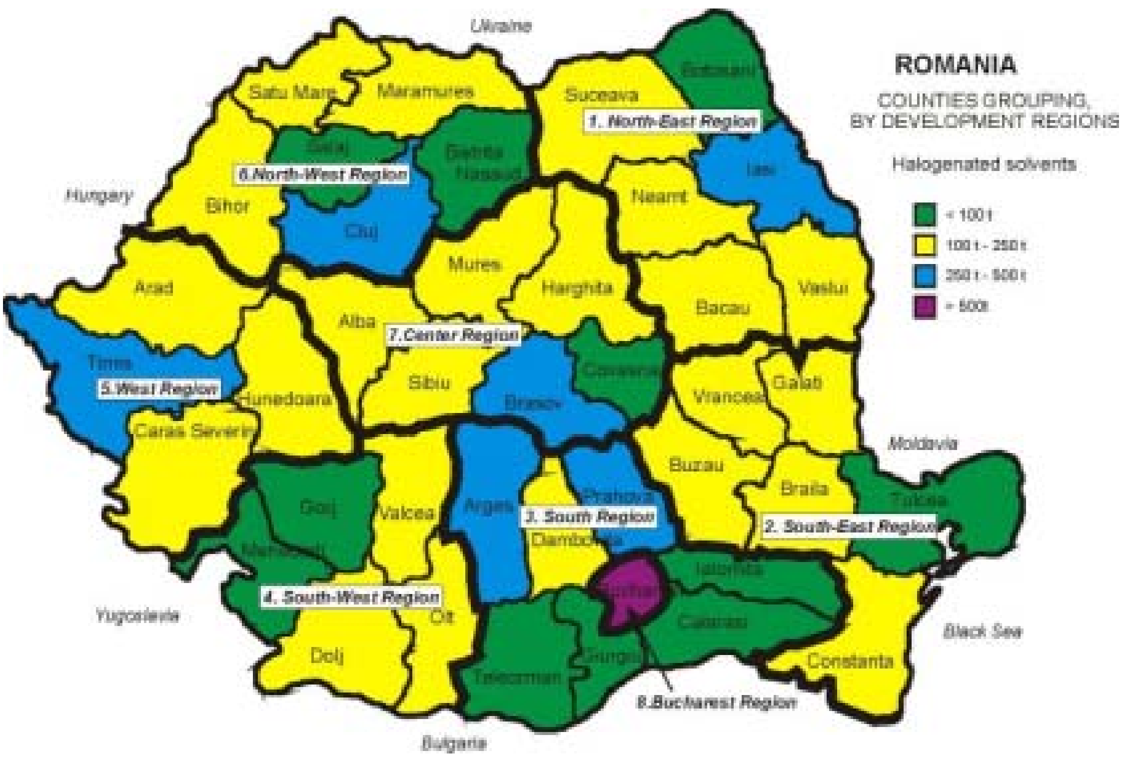
Source: JICA Study Team (waste survey data)

Figure 5.5.1 – Oily Waste Generation



Source: JICA Study Team (waste survey data)

Figure 5.5.2 – Non-Halogenated Waste Generation



Source: JICA Study Team (waste survey data)

Figure 5.5.3 – Halogenated Waste Generation

3) Options for the Management of Particularly Difficult Organic Wastes

There are some organic hazardous wastes which are particularly difficult to manage. These include:

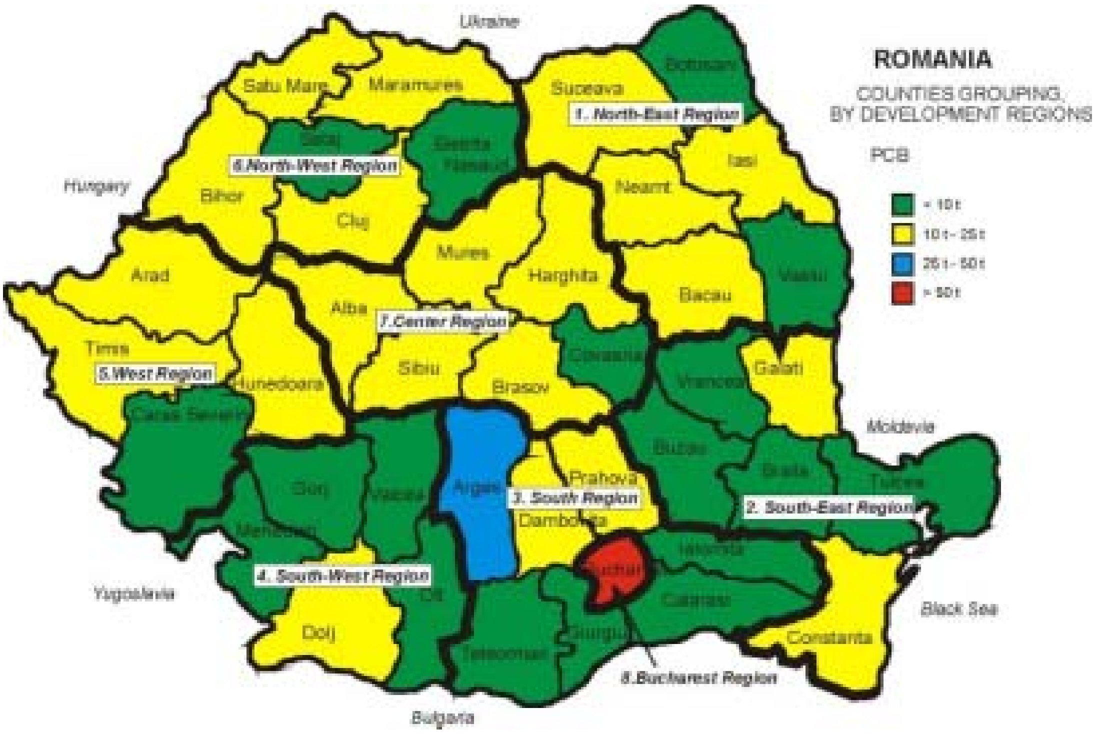
- PCBs
- HCH
- Organic pesticides
- Persistent halogenated solvents

The options for the environmentally sound management of these wastes include:

- Treatment in specially equipped cement kilns
- Treatment in dedicated hazardous waste incinerators
- Physical/chemical treatment processes (e.g. dehydrochlorination of PCBs)
- Export for environmentally sound management in a country with the necessary facilities

PCB wastes by County and Region are shown in Figure 5.5.4. Currently, no facilities exist in Romania to take these wastes which are particularly difficult to handle and treat. The existing Sotem facility could handle small quantities but it is current HolCim policy not to accept PCB wastes (organic wastes containing > 50 ppm PCBs).

A suitably equipped cement kiln could handle these wastes if blended with other organic wastes to ensure that the halogen content is within acceptable limits (and PCB content remains below 50ppm). Such blending processes are a normal pre-processing activity for all incinerators and cement kilns and should not be considered as contravening rules of not blending wastes with the objective of reducing hazard. Solid pesticide wastes could also be processed in a cement kiln, for example by equipping the kiln with a pneumatic canon to propel fibreboard kegs of solid pesticides into the hot zone of the kiln.



Source: JICA Study Team(waste survey data)

Figure 5.5.4 – PCB Wastes

Barriers to the management of such wastes in cement kilns include:

- The reluctance of kiln operators to accept the more hazardous wastes
- Potential extreme public reaction
- Reasonableness of regulators

The development of a suitable dedicated hazardous waste incinerator, capable of processing these wastes would be an extremely expensive option (capital cost between 20m and 50m US$). Potentially a viable alternative, particularly for wastes which will not be generated in the future is export for destruction in dedicated hazardous waste incineration facilities.

4) Promoting the Development of Regional Treatment and Disposal Facilities

As indicated, de-facto regional facilities for thermal treatment of wastes are appearing (e.g. Sotem/HolCim in Campalung). The cement companies are keen to provide a Romania-wide service and are prepared to invest. The EU Handbook on the Implementation of the EC Environmental Legislation recommends that `in view of the high costs for most hazardous waste facilities, Candidate Countries should consider least cost options such as cement kilns'.

However, regional facilities for physical/chemical treatment of hazardous wastes have not appeared. Most countries have found it necessary to have a combination of end-of-pipe hazardous waste management systems in larger enterprises and centralised or regionalised facilities provided as a commercial service.

It is generally accepted that the management of industrial waste and hazardous industrial waste should be the responsibility of industry and that the polluter pays principle should be adopted. Romania is in line with this approach. Nevertheless, it has been the experience of most countries which have developed an effective hazardous waste management system that public-sector involvement is necessary to stimulate the development of the system (see discussions in Volume 2 Annex 2).

A more pro-active approach is therefore necessary to secure their development. This approach should focus on:

- The identification of priority regions where facility development should be targeted,
- The identification of potential developers,
- Encouraging those potential developers by raising market awareness and economic incentives,

STRATEGY

Implementation of awareness raising programmes.

Preventing use of waste management practices which are not environmentally sound.

Promoting the use of environmentally sound third party waste management options where treatment and/or disposal at source is impracticable.

Uniform application of appropriate, load based rather than concentration based, standards for discharge of wastewaters and for emissions must be established, applied and enforced.

Identification of instances of waste “storage” which are actually “final disposal” and regulate them as such, ensuring application of relevant standards, and determine which is “interim storage” and regulate that as such.

STRATEGY

Application of more effective regulation and control, focussing on a compliance orientated approach.

Application of deterrent sanctions in cases of non-compliance.

Finalisation of Romanian standards for incineration of wastes. Progressive implementation and enforcement of those standards.

Development of guidelines and standards for cement kiln incineration including specifications for waste derived fuels.

Identification of thermal treatment facilities which require upgrading to meet Romanian standards under development.

Development of compliance programmes for upgrading those facilities and enforcing the implementation of those compliance programmes.

Phased closure of thermal treatment facilities which are not capable of being upgraded to Romanian standards currently under development linked to the phased development of environmentally acceptable third party solutions.

Work with the cement companies to promote the incineration of a wider range of wastes in the cement kilns (pesticides for example) building on experience of other countries.

Prevention of inappropriate waste management practices which reduce market demand (e.g. illegitimate trading and use of waste oils). As facilities already exist (cement kilns / blending facility) this should be a short term priority.

Identification of potential developers of regional physical/chemical treatment facilities.

Encourage those potential developers to develop small-scale regional facilities, raising market awareness.

STRATEGY

Stimulate the development of regional facilities by facilitating land allocation and by provision of economic incentives.

Identification of external factors resulting in poor hazardous waste management and development of improved integrated approach.

Export, for environmentally sound waste management, of the small quantities of hazardous organic wastes which are unsuitable for cement kiln incineration (e.g. PCBs).

5.6 Management Methods for Common Hazardous Wastes

5.6.1 Overview

This section outlines the common waste management methods for common waste types. The methodologies are described in section 5.6.2 to 5.6.10 and applicability indicated in Figure.

5.6.2 Oxidation / Reduction

Oxidation / reduction processes are chemical processes which involve changing the oxidation state of some of the waste constituents. The two processes always occur together, for something to be oxidised, something else MUST be reduced. The purpose of the process is to reduce the toxicity of the waste or to convert it to a chemical form more suitable for subsequent processing.

The most common applications are the oxidation of Cyanides and the reduction of hexavalent Chromium. Cyanides are oxidised to Cyanates and/or CO_2 and NH_3 generally using Sodium or Calcium Hypochlorite or Chlorine gas (the latter less common due to higher risk associated with reagent storage). Hexavalent chromium is generally reduced (to trivalent chromium using sodium sulphite, bisulphite or metabisulphite reagent. At centralised merchant waste treatment facilities, wastes with reducing properties (e.g. ferrous solutions) may be used as reducing agents. The objective of converting hexavalent chromium to trivalent chromium is to facilitate precipitation as chromium hydroxide (hexavalent chromium does not form insoluble hydroxide).

The product of the oxidation / reduction process is a solution for further processing (neutralisation/precipitation).

5.6.3 Neutralisation / Precipitation

Neutralisation is the adjustment of the pH of a liquid waste or sludge waste. Wastes that have too low a pH value (acidic) or wastes with too high a pH value (alkaline) will be harmful to the environment. In addition, neutralisation removes most toxic metals from solution by precipitating them as hydroxides / oxides. Typically, sodium hydroxide or calcium hydroxide (lime) are used for neutralisation / precipitation.

Sometimes it is necessary to precipitate metals as sulphides (metal sulphides typically being far less soluble than hydroxides).

The product of neutralisation / precipitation is a sludge, often with high salt content, generally further processed by dewatering, and sometimes by stabilisation, before landfill.

5.6.4 Dewatering

Inorganic sludges (principally metal oxides / hydroxides are often dewatered prior to disposal. The dewatering process may include settling (clarification) and/or filtration. Filtration technologies include multi-plate filter presses (most flexible / reliable) and vacuum belt filters.

The products of dewatering are filtrate / effluent for wastewater treatment and thickened sludge / filtercake for final disposal (with or without stabilisation). Unstabilised filter cake will generally still be regarded as a hazardous waste.

5.6.5 Stabilisation / Solidification

The terms "Stabilisation” and “Solidification" are often used as generic terms covering a wide range of physical / chemical processes, including:

- “Stabilisation” - mixing of the waste with additives which form inorganic "polymer" which prevents leaching of toxic constituents. Processes usually based around the addition of one or more of the following materials - cement, lime, fly ash, sodium silicate, perhaps with other minor additives.
- “Solidification” - similar process to stabilisation with the exception that the mixture is initially wetter and formulated so as to set into a monolithic solid mass.
- “Encapsulation” - here, the objective is to physically encapsulate (rather than chemically bond) waste within a solid material.
- “Vitrification” - as its name suggests, this entails fusing the waste, generally with silica materials to form an inert glass-like substance.

The most common process is the first (stabilisation) and is widely used to process metal hydroxide / oxide / sulphide sludges and filtercakes (e.g. galvanic sludges) to give a waste which is regarded as non-hazardous for simple final disposal.

5.6.6 Shredding / Maceration

Shredding is a mechanical process used to break apart monolithic solids or articles prior to further processing or to reduce the particle size of solids in sludges. The process is used for both dry wastes and for sludges. Typical uses would be to process a waste prior to physical / chemical treatment facilitating better treatment by increasing surface area for reaction, or to enable improved combustion.

Maceration is also a mechanical process and reduces the particle size of solids in a sludge. The process is often utilised to enable a heavy sludge to be pumped more easily, for example to prepare organic sludges for incineration, either via direct feed to a kiln or prior to blending.

5.6.7 Blending

Wastes of similar character and composition, requiring the same treatment and disposal operations may be mixed or blended prior to treatment. For example, prior to Incineration, the majority of wastes are pre-processed and blended.

The objective behind the blending operation is to generate a waste with optimum specification for processing, in this case incineration. This is both from the point of view of effective treatment and also from the viewpoint of cost-effective processing.

5.6.8 Incineration

Incineration is the most common thermal treatment process used for hazardous wastes. It is an Oxidation process. Technologies range from very basic to highly complex.

For effective incineration, there are five main requirements:

- Proper preparation of the waste prior to incineration.
- The 3 "Ts" common to thermal treatment processes ("Time" - minimum of two seconds at required temperature, required "Temperature" –minimum of $850^{o}C$ or $1100^{o}C$ for wastes with more than 1% of halogen content and "Turbulence" (mixing).
- Presence of sufficient oxygen for complete oxidation of wastes.

In addition to the five basic requirements, the preparation of waste prior to incineration is crucially important. Preprocessing may include:

- Sorting: Wastes received are sorted into different types, for example:
  - Halogenated / non-halogenated,
  - High / medium / low calorific value,
  - High / low solids content
- Shredding: Solid wastes may be shredded prior to incineration
- Maceration: Semi-solid (sludge) wastes with large particle sizes may be macerated prior to incineration
- Blending: This involves mixing the sorted wastes together to form a blend of wastes to a particular specification for feeding through the different incinerator feed systems.

The most common incineration technologies are rotary kiln, static hearth kiln and liquid injection kiln. These are “primary” combustion chambers and incinerators often have secondary combustion chambers to ensure complete combustion of product gases and fly ash.

The products of combustion are bottom ash, fly ash and gaseous emissions (principally CO2 and H2O but also trace organic compounds and often acidic gases such as HCl, SOx and NOx) Incinerators are generally equipped with sophisticated gas cleaning systems which neutralise acid gases formed during combustion, remove particulate from the gas stream and, in some cases, absorb trace organic compounds. The two most common technologies for gas cleaning are spray dry adsorption / baghouse filter and alkaline wet scrubbing. Electrostatic precipitators (wet or dry) have also been used alone or in combination with one of the other technologies.

Bottom ash is generally non-hazardous and is landfilled, fly ash and solid residues from gas cleaning are generally treated as hazardous wastes and are often stabilised before final disposal to landfill.

5.6.9 Cement Kiln Incineration

Cement kilns have many features in common with dedicated hazardous waste incinerators, specifically:

- They use rotary kiln technology,
- They operate at very high temperatures (far higher in fact than dedicated hazardous waste incinerators),
- They have long residence times for solids and gas (again longer than dedicated incinerators),
- They have the capability of removing acid gases generated during combustion due to strongly alkaline environment in the kiln,
- The kilns design promotes mixing (turbulence) due to rotation and due to counter current flow of combustion gases.

In addition, cement kilns have the advantage that any combustion ash produced is incorporated into the cement clinker.

For these reasons, cement kilns are potentially valuable resources for the management of organic hazardous wastes and are widely utilised and capable of meeting the most stringent standards.

Although cement kilns are highly flexible they cannot generally handle wastes with halogen contents as high as can be handled in dedicated incinerators.

5.6.10 Landfill

Landfill is used as a disposal method for hazardous waste. Landfills receiving hazardous wastes must be designated as “hazardous waste” landfills. Typically such landfills are used for the disposal of large volumes of low hazard wastes, e.g. mining wastes, disposal of asbestos wastes and for disposal of residues from physical / chemical treatment and wastewater treatment.

It is an EU requirement that liquid wastes are not landfilled and that any hazardous wastes should be treated prior to landfill as far as practicable to reduce the hazardous nature of the waste. This in effect dictates stabilisation of physical / chemical treatment residues and incineration residues prior to landfilling.

5.6.11 Cost of Hazardous Waste Management

The cost of hazardous waste management varies widely depending on the specific type of waste and whether it is in bulk or packaged. Waste management contractors often do not have any fixed pricing structure but charge the prices that they believe the market will bear. The prices have been rather static in recent years. The following table shows ranges of prices in European countries and Malaysia based on a number of reviews undertaken between 1991 and 1999.

Unit: US dollar

Country	***PCT***	***Incineration***	***Solidification and landfill***	***Landfill***
Denmark	168-290	250 - 1200	-	150 - 145
Finland	440	555	-	-
France	50 - 900	215 - 900	-	25 - 60
Germany	50 - 500	200 - 2200	640	40 - 240
Italy	150 - 2000	-	-	40 - 170
Netherlands	300 - 700	100 - 1300	-	-
Spain	40 - 400	-	-	30
Sweden	330	600	-	-
UK	40 - 600	150 - 2000	-	30 - 200
Malaysia	440 - 1150	190 - 1090	230 - 250	135 - 150

Source: ERM various waste disposal charges reviews, 1991 – 1999
Malaysia data is for 2000

Figure 5.6.1 Treatment Methods for Common Waste Types

		Metal Recovery	Oxidation	Reduction	Acid Cracking	Hydrolysis	Neutralisation (Ph ↑)	Neutralisation (Ph ↓)	Precipitation	Filtration	Separation	Stabilisation	Vitrification	Shredding / Maceration	Blending as Fuel	Cement Kiln Incineration	Cement Kiln Utilisation	Incineration	Landfill	Utilisation / recovery
(1)	**Elemental metals**																			
	Metals (Non - ferrous)	✓																	✓	
	Metals (Ferrous)	✓																	✓	
	Alkali Metals	✓				✓		►✓										✓		
	Miscellaneous metals	✓																	✓	
(2)	**Principally Inorganic Wastes**																			
	Oxidising Agents			✓			►✓	►✓												✓
	Cyanide Bearing Wastes	✓	✓					►✓												
	Acids	✓					✓													
	Alkalis							✓												✓
	Neutral wastes						✓ /	✓											✓(1)	
	Aqueous organic wastes		✓				✓ /	✓			✓				►✓	►✓		►✓		
	Asbestos, inorganic catalysts												✓						✓	
	Slags and Mineral Wastes											✓					✓		►✓	✓
	Metal oxide / hydroxide sludge								▼✓			►✓							✓(1)	
	Incinerator bottom ash											✓(2)							✓	
	Incinerator fly ash											✓							✓(1)	
(3)	**Wastes containing principally organic constituents**																			
	Oils / oil emulsions				✓						✓				►✓	►✓		►✓		✓
	Oily sludges										✓			►✓	►✓	►✓		►✓		✓

Figure 5.6.1 Treatment Methods for Common Waste Types (continued)

	Metal Recovery	Oxidation	Reduction	Acid Cracking	Hydrolysis	Neutralisation (Ph ↑)	Neutralisation (Ph ↓)	Precipitation	Filtration	Separation	Stabilisation	Vitrification	Shredding / Maceration	Blending as Fuel	Cement Kiln Incineration	Cement Kiln Utilisation	Incineration	Landfill	Utilisation / recovery
(3) Wastes containing principally organic constituents																			
Halogenated Solvents														✓	✓		✓		✓
Non-halogenated solvents														✓	✓		✓		✓
Tar / bitumen wastes							✓			✓			✓	✓	✓		✓		✓
Resins / glues													✓	✓	✓		✓	✓	
Pharmaceutical wastes, organic pesticides		✓											✓	✓	✓		✓	✓	
PCB / PCT / PCDD / PCD F bearing wastes													✓				✓		
Organic Wastes NOS										✓			✓	✓	✓		✓		
(4) Wastes which may contain organic or inorganic constituents																			
Polymeric wastes													✓		✓		✓	✓	
Wastes of plant / animal origin													✓		✓		✓	✓	
Packaged chemical reagents	Managed according to constituents / contaminants																		
(5) "Special" Wastes																			
Explosive wastes																	✓		
Infectious Wastes													✓				✓	✓	
Radioactive Wastes	Managed according to constituents / contaminants																		
Nonidentified Wastes	Managed according to constituents / contaminants																		

(1) Landfill of treated residues only - not landfill of untreated wastes
(2) Bottom ash generally does not need stabilisation
(3) An orange tick means that these treatment processes may sometimes be use for some types of these wastes.

Source: David Newby Associates

References:

David Newby Associates

Environmental Resources Management, "*waste disposal charges reviews*", 1991-2000

ICIM 2002 Survey Data

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MoWEP / JICA study team

UK Environment Agency