3. Notes on the analysis and evaluation of environmental impacts

3.1 Introductory remarks

To gain a full **understanding** of a wastewater disposal project is it vital to determine the **underlying conditions** and **constraints** of the project, against the background of its ecological and economic effects. The project **description** may be based on the following **criteria**:

- previous history of the plan.
- water legislation and standards.
- current wastewater situation (wastewater volume, existing works and their function).
- actual condition of the receiving bodies of water (discharge, quality, self-purification capacity, uses etc.).
- target condition of the receiving bodies of water (management aims: ecological function, uses, expansion requirements etc.; quality targets:

characteristics, limits).
- previously established wastewater objectives e.g. based on existing general sewerage plans or other evidence of demand.
- incorporation into regional, national and countryside planning objectives and also the regional/supraregional disposal system.
- reasons for choice of planned works and its main components (pumping stations, storm basins, storm overflows, wastewater treatment plant(s), sludge polders etc.).
- alternatives (e.g. sewerage processes such as dual/combined system, wastewater pumping, sludge recycling/storage, extension or expansion of existing works) as well as baseline state.

Further components of the **environmental impact assessment** of a wastewater disposal project are descriptions of

- the location-finding process for relevant alternatives, including any necessary socio-economic analyses of sex- and group-specific questions of the population settled in the surrounding area or area covered by the wastewater treatment works in question.
- the location comparison and results.
- the relevant works and their failure risks.

- factors of the project adverse to the environment and those plants or plant components which should eventually form the object of an environmental impact survey.

Major environmental impacts result from the construction and operation of the **sewage treatment plants** referred to below with minimum size/capacity as follows:

- pumping stations, output $Q_p \geq 4\,500\ m^3/2h^{1)}$
- rainwater basins (rainwater retention basins, rainwater overflow basins etc.), dry weather discharge $Q_t \geq 1\,500\ m^3/2h$ in the sewer before the rainwater basin system
- rainwater overflows, dry weather discharge in the sewer before the overflow $Q_t \geq 1\,500\ m^3/2h$
- wastewater treatment plants, which are designed for (see (1)):

$Q_{in} \geq 1\,500\ m^3/2h1)$ (intake) or

$B_{d,x} \geq 3\,000$ kg/d BOD_5 (org. daily load in intake) or

$P_C \geq$ 50 000 PE (connected load in population equivalents with a sewage load per inhabitant of 0.060 kg/d)

The above values should be regarded as **guideline figures**; in addition, the **scope of the assessment** must be decided on a case-to-case basis, depending on the **environmental relevance of the plant components**. This applies particularly, for example, to **rainwater retention basins** which are installed underground and so are "invisible".

Domestic sewage mainly comprises:

- lavatory wastewater
- kitchen wastewater
- wastewater from baths/showers
- cleaning wastewater (from house cleaning).

It therefore has a **varied** structure, but as a rule its **quality is not such** that the existence, operation and safety of the **sewage plants** or the **health of the operating personnel** could be **endangered**. Moreover it lacks properties which could result in adverse changes to the environment, provided the sewage works are designed correctly, the bodies of water managed appropriately and the sewage sludges produced disposed of and recycled properly.

However, here one should note that special **attention** should be paid to the correct operation of "domestic" sewage plants and hence water conservation, if the **volume of wastewater** is subject to large **variations** (sudden loads or temporary and sometimes complete absence of wastewater). This applies particularly to hotels, highway service areas, campsites, convalescent homes and similar installations with individual drainage. Special planning and operating methods are required here to prevent avoidable pollution of bodies of water (33), (34).

The following Sections 3.2 to 3.4 therefore deal only with the analysis and evaluation of the environmental impact of **commercial or industrial** wastewater, primarily as a component of municipal wastewater (indirect discharges) rather than in terms of discharges from commercial and industrial establishments (direct discharges). For **guidance**, refer to the **German regulations**.

3.2 Wastewater collection and removal area

The direct discharge of commercial or industrial wastewater is safe if as a result

a) the health of the staff employed in public sewage works is not adversely affected,

b) the state and operation of public sewage works are not adversely affected,

c) the bodies of water which take the wastewater from the public sewage works cannot be polluted beyond the permitted level or otherwise adversely affected,

d) no lasting odour nuisance occurs at the sewage works and

e) the sludge treatment, sludge recycling and sludge disposal are not seriously hindered.

If **adverse effects** of the type described above are anticipated, then the discharge of the wastewater into a public sewage works should be conditional on **pre-treatment** at the point of production or other suitable measures (see German ATV Arbeitsblatt A 115 (35)).

Safety is generally assured if the **figures** given in Annex I of (35) for the composition and constituents of wastewater are not **exceeded**. Permissible concentrations of substances not listed in Annex I must be decided on a case-to-case basis.

Substances which **block** the sewerage network, form **poisonous, foul-smelling or explosive vapours and gases** or **attack buildings and building materials** to a significant degree must **not be discharged** into a public sewage works.

The German ATV Arbeitsblatt A 115 does not yet contain any **specific regulations for indirect discharge of hazardous materials** within the meaning of 7a WHG (German

Federal Water Act (11)), e.g. of certain chlorinated hydrocarbons such as hexachlorobenzene, pentachlorophenol, trichloroethene etc. Basically, 7a WHG and the relevant follow-up regulations of the Federal States required that the **state-of-the-art** be assessed in order to **determine the permissibility of indirect discharge** of such substances.

In Germany, the wastewater in question must be monitored and analysed in accordance with the relevant DIN standards (DIN 38400 ff.) (36).

3.3 Wastewater treatment area

In the **Federal Republic of Germany,** under 7a WHG (11), **binding emission standards for the discharge of wastewater into surface waters** are given in the appendices to the "Allgemeine Rahmenverwaltungsvorschrift ber Mindestanforderungen an das Einleiten von Abwasser in Gewsser" (General Administrative Framework Regulation on Minimum Requirements for the Discharge of Wastewater into Waters) (12). A summary of the relevant administrative regulations is given in (37).

For **discharges from municipal sewage works**, the standards are defined in appendix 1 of (12). According to this document, the following **limit values** apply for different size classes of sewage works in Germany in accordance with the generally recognised rules of the art:

Table 2 - **Minimum standards for discharges from municipal sewage works**

Size class[1]	BOD_5 (mg/l)	COD (mg/l)	NH_4-N (mg/l)	P_{tot}(mg/l)
1 (≤ 60)	40	150	---	---
2 (≥ 60 ≤ 300)	25	110	---	---
3 (≥ 300 ≤ 1200)	20	90	10	---
4 (≥ 1200 ≤ 6000)	20	90	10	2
5 (≥ 6000)	15	75	10	1

1) Figures in brackets: intake values BOD_5 (raw) [kg/d]

With increasing plant size (connected load), the standards become more stringent as a result of the greater operational reliability of the sewage works.

Here too, the monitoring analysis is based on the relevant assessment procedures according to the German DIN standard 38400 (36). The same applies to analysis of wastewater from commercial and industrial establishments. The method and scope of sampling also very largely depend on the relevant administrative regulations.

If it is apparent in a particular case that despite the application of relevant emission standards, an unacceptable burden may be imposed on the bodies of water (insufficient capacity of the receiving water), it may be necessary to lay down stricter standards for the condition of the wastewater to be discharged, if other measures, such as transfer of part of the volume into another river basin, are not possible. As regards discharge monitoring (analysis), the same regulations are to be applied as already mentioned above.

3.4 Sludge disposal area

The environmental implications of (municipal) sewage sludge are primarily in relation to its disposal in the form of agricultural fertiliser. Important criteria have been defined in Germany under the Klrschlamm-Verordnung (sewage sludge ordinance) (16) which establishes permitted values for the concentrations of selected heavy metals in the soil and in the sewage sludge itself; in addition, restrictions are imposed on the quantities which may be applied. See Table 3 below.

***Table 3* - Permitted concentrations of heavy metals in accordance with the Klrschlamm-Verordnung (sewage sludge ordinance)**

Heavy	Generally	Quantity	Maximum permitted

Heavy metals(HM)	permitted concentrations in sewage sludge	permitted to be applied	heavy metal concentration upon application of sewage sludge	
	mg/kg 1)	t/(ha3a) 1)	g(ha3a)	g/(ha3a)
Cadmium	20	5	100	33.3
Mercury	25	5	125	41.7
Nickel	200	5	1000	333.3
Lead	1200	5	6000	2000
Chromium	1200	5	6000	2000
Copper	1200	5	6000	2000
Zinc	3000	5	15000	5000

1) related to dry sludge residue

At least in temperate zones, if the regulations contained in the sewage sludge ordinance are complied with, no long-term harm will be inflicted on soil, plants, animals or humans through the use of sewage sludge in agriculture; moreover, in particular, the health of people or animals will not be harmed by consumption of foodstuffs or fodder produced on land to which the sludge is applied (15).

When actually constructing a sewerage system, it may be advisable to determine the heavy metal concentrations which a sewer network may discharge to the central sewage works so as to ensure that the permissible heavy metal concentrations of the sewage sludge can be maintained in accordance with the sewage sludge ordinance. Suitable procedures are indicated in publication (38).

For the sewage sludge analysis, reference should again be made to the relevant regulations in accordance with DIN 38400 ff. (36).

4. Interaction with other sectors

Because of their geographical and physical impact, supply and disposal projects must stand in a clear and plausible relationship with other environmental and geographical areas. This is particularly true of wastewater disposal (WWD) projects, bearing in mind the potential danger posed by the domestic, commercial and industrial wastewater to be disposed of.

Areas which may be affected by WWD projects, such that this may lead to conflicts of use and interactive effects include, in particular, the following:

- bodies of water (surface water, groundwater); water resources management, hydraulic engineering
- soil; agriculture and forestry
- air
- water production, water supply
- waste management, waste disposal
- nature conservation, countryside preservation, recreational resources
- urban/community planning, industrial development
- monuments and heritage
- traffic planning (roads, railways, waterways, flight paths)
- existing/future regional planning, land-use and development planning; activity planning
- distance problems in existing and planned residential areas
- availability of land and soil.

If conflicts of use occur, the options must be weighed up. The standard against which these are judged is not the status quo, i.e. the structures and services existing prior to execution of the wastewater disposal project, but rather the development potential of the area in question. The criterion is thus the capacity and not the present performance (39). This approach also stresses the importance of identifying and assessing the soil potential, the biotope potentials and the hydrogeological potentials (in terms of both

quantity and quality). Adjustment, alleviation and compensatory measures may provide crucial help in arriving at the environmentally ideal overall solution.

5. Summary assessment of environmental relevance

To sum up, the following may be said with regard to the environmental relevance of wastewater disposal projects:

The plants of such a project must be planned, built and operated in accordance with the generally accepted rules of the art or wastewater technology and, if hazardous substances are to be eliminated in treating wastewater, in accordance with the state of the art. One must take into account the immission situation (burden), other uses and the hydrological and biological capacity of the receiving body of water.

If the capacity of the receiving body of water in question is not sufficient to absorb the wastewater treated in accordance with the rules of the art, then for the sake of water quality, further requirements must be laid down for the treatment efficiency of the sewage works or the wastewater discharge. A management plan may then be necessary to ensure that the receiving body of water serves the good of the general public, in

harmony with the benefit of individuals, and prevent any avoidable adverse effects (1a WHG (11)).

As a general rule, every area must be appropriately treated before the drinking water can be used; this is especially true when wastewater discharges are situated above the point where water is drawn off.

As a general rule, to relieve pressure on wastewater disposal systems, the volume of wastewater should be minimised, both in the domestic and in the industrial and commercial sectors.

Other non-water related effects of a wastewater disposal project, such as occupation of land, noise and odour emissions, flue gas emissions etc. are normally of lesser importance in assessing the environmental relevance. This is because the plant components are mainly installed underground and because few installations affecting air purity, such as sludge incineration plants, are ever built.

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13. Solid waste disposal

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Contents

1. Scope

1.1 Definitions

Waste is movable objects which the owner wishes to dispose of (subjective definition of waste) or whose controlled disposal is necessary to ensure the well-being of the general public and in particular the protection of the environment (objective definition of waste). Regarding the distinction from hazardous waste, see environmental brief Disposal of

Hazardous Waste. Waste disposal comprises the collection, transport, treatment, storage (intermediate storage), dumping and recycling of waste. The avoidance and minimisation of waste does not form part of waste disposal. They are in fact another part of waste management.

Waste management comprises the sum total of all measures for the avoidance and minimisation as well as the controlled and environmentally acceptable disposal of waste of all types, i.e. domestic waste as well as commercial and industrial waste.

The generally accepted rules of the art include those rules which have been tested in practical applications, whereby the majority of the people working in this specialist field regard the processes, plant, facilities or operating methods as correct (3). The technical nature of the rules may vary according to the requirements in individual countries.

The state of the art is the state of development of advanced processes, plant, facilities or operating methods, guaranteeing the practical suitability of one of such technical measures. To determine the state of the art, an assessment must be made in particular of comparable processes, plant, facilities or operating methods which have been successfully tested during operation. The technical nature of the state of the art may vary according to requirements in individual countries (4).

1.2 Problems

The world-wide industrial development of recent decades with its effects on the manufacture of goods and on the consumption patterns of the population, particularly in areas of high population density, has led to an appreciable increase in the volume of waste. In this respect, targeted and target-group-related waste disposal (WD), involving careful analysis and taking into account not only the local conditions and options but also the environmental aspects of the relevant plant, can bring about the necessary improvements. As a rule, these relate to measures not only in the fields of waste management and waste technology, but also in the fields of law, administration, business management and organisation.

The necessary improvements should also aim to achieve reasonable representation for women, as one of the target groups, in the institutions and bodies responsible for waste disposal. This is the best way to guarantee that their legitimate interest in participating in the development and implementation of administrative, business and environmental monitoring will be served.

1.3 Objectives

The controlled disposal of domestic waste and commercial and industrial waste forms a vital part of the infrastructure of human settlements built on the principles of hygiene. It

is an essential component of waste management, whose function must be to help

- to protect human health,
- to contribute to the quality of life by improving environmental conditions,
- to maintain the ecological equilibrium of the environment, particularly of the soil and groundwater, and - where it has been disturbed - to restore it,
- to ensure safe disposal of the waste produced by the population as well as by commercial and industrial establishments, depending on the quantity and type of the waste and taking into account the need for avoidance and minimisation, ensuring the long-term sustainability of resources which serve the well-being of the general public and the legitimate needs of individuals.

Figures show that in many countries there is a marked imbalance between waste production and controlled waste disposal. This is because in the countries in question a clear priority has been given to the matter of industrial development, without however paying at least equal attention to the necessary development of waste disposal facilities.

Very often this relates to waste arising from imported industrial goods. There are seldom incentives to avoid waste.

1.4 Stages of waste disposal

The area of waste disposal (WD) comprises the following disposal stages:

- **waste collection and transport (separate collection where applicable)**
- **waste treatment**
- **intermediate waste storage**
- **waste dumping (landfill) and**
- **waste recycling.**

The disposal stages or steps apply to both domestic and commercial and industrial waste. It is not always absolutely necessary, or even advisable, to follow all of these stages; rather, combinations of certain of these steps may be technically the best solution.

Waste transport (in collection vehicles) mostly involves the movement of empty, part-full and full vehicles, but also includes processes for emptying vehicles in transfer stations and treatment plants as well as at landfill sites. The object of waste transport (in special vehicles) is to transport waste between transfer stations and the relevant disposal plants. One must always consider whether the distance between the collection area and disposal plant (e.g. landfill site) has become uneconomic and, if so, provide transfer stations. Within this environmental brief, the transfer of waste is also considered as waste transport.

Within waste treatment the following processes in particular may be used:

biological processes

a) aerobic processes:

- **in liquid phase (aeration)**
- **in solid phase (composting)**

b) anaerobic processes (fermentation/biogas extraction):

- **single-phase systems (mixing reactor; solid-bed reactor)**
- **two-phase systems (hydrolysis with complete mixing; solid-bed hydrolysis)**

chemical processes: precipitation/flocculation, neutralisation, oxidation, reduction etc.

physical processes: sorting; decanting, dewatering, drying; reverse osmosis, ultrafiltration, emulsion separation etc.

Intermediate waste storage may be important if waste must be temporarily stored in fixed installations, because for economic or process technology reasons it cannot be transported directly for recycling, treatment or landfill.

Waste dumping is a method of controlled final disposal at landfill sites which must be done using state-of-the-art methods (base sealing, treatment of percolation water, landfill gas disposal/utilisation etc.). Waste dumping to some extent represents the final stage of any disposal sequence, regardless of the detailed technical structure of the sequence. The only exception is where waste substances or residues are fully recycled (e.g. agricultural use of sewage sludge, used glass recycling etc.).

Waste recycling includes all processes (methods) for recovering or utilising valuable materials in waste. The principal waste recycling processes are:

- **material recycling (e.g. of used glass, used oil, waste paper, plastics, metals etc.)**
- **liquid phase aeration, composting, biogas extraction (these processes also represent processes of biological waste treatment; see above)**
- **incineration (utilisation of waste heat, incineration residues)**
- **agricultural sewage sludge utilisation.**

The environmental impacts of the above-mentioned types of waste disposal should first be considered in isolation in order to assess their importance. An integrated assessment should then be carried out for the project, also taking into account any significant interactions.

2. Environmental impacts and protective measures

2.1 Introductory notes

In spite of the basically environment-oriented objective of waste disposal, various problem factors may arise which may be impossible or difficult to overcome:

a) technically/economically unavoidable emissions (residual emissions), from the waste disposal installations which have an overall impact on air, soil and water, on people and on ecosystems

b) adverse consequences of unsuitable use of composting and other forms of recycling on the ecological infrastructure of the region in question

c) unforeseen increase in volume of waste from private households

d) unforeseen increase in volume of waste from commercial and industrial establishments

From the start, reasonable allowance should be made for the above-mentioned problem

factors in all project management activities, in order to minimise from the outset any conceivable effects, using suitable measures of an organisational, structural, operational and charge-related nature, and in certain circumstances also with recourse to emergency measures. Considering each relevant sub-sector of waste disposal in turn, the potential typical environmental impacts are as follows (5), (6).

2.2 Typical environmental impacts

2.2.1 Impact of waste collection and waste transport

The collection of domestic waste from individual homes is often not expedient as it is too expensive and the standard of road and housing construction does not permit this. So frequently collection systems with central collection points (interchangeable containers, stationary intermediate storage) must be used. The following must be considered here:

- the consequences of climatically induced, rapid decomposition of waste (insect infestation, odour nuisance, spontaneous ignition, etc.)
- the scattering of waste by animals (dogs, cats, rats).

In the case of large transfer stations, noise and odour nuisance may occur if

- the distance from adjacent buildings is too small or

- soundproofing, aeration, ventilation and deodorisation measures are inadequate or non-existent.

2.2.2 Impact of waste treatment

2.2.2.1 Introductory remarks

The qualitative and quantitative criteria for proper waste treatment are derived primarily from its environmental impact and from emission and immission standards, which in turn are derived from the relevant waste management requirements and from the legislation, regulations etc. in force. In many countries the latter rarely exist or where they do exist are inadequate. Direct application of, say, German, EC or American laws and regulations rarely provides an appropriate solution.

Rather, it is necessary to develop measures suited to the prevailing general constraints and to implement them with the involvement of the population.

2.2.2.2 Biological treatment

a) Composting

The organic components of domestic waste are converted during the composting process

into humus-forming substances. Both the raw and finished compost can be used in agriculture, horticulture and landscaping to improve the soil. If local (digested) sewage sludge is rotted down with it, this improves the fertilising value of the compost.

On the whole the technologically simplest composting processes have proved the best, even if the labour costs are higher. Static rotting processes, particular stack composting, are ideal. The following discussion therefore focuses primarily on this type of process.

Compost has a beneficial and relatively long-lasting effect as a soil improver, but can also have very adverse environmental effects. The compost raw materials, namely domestic waste and possibly sewage sludge, may contain substances which in high concentrations have a harmful effect on soil, plants and hence also, via the food chain, on consumers (animals, people). Heavy metals are a particular hazard. The only research carried out so far into the importance of organic toxic compounds has produced conflicting findings. It is vital to reduce the pollutant content to harmless levels through appropriate selection and pre-sorting of relevant raw materials. See also 3.3 and (7).

The groundwater and surface waters may also be at risk from leaching and percolation of pollutants.

An assessment of the environmental impact of composting plants must start by considering the following problem factors:

- occupation of land (by construction works, machinery, areas for compost stacks and residue landfill etc.)
- noise emissions from the composting works (due to raw material deliveries, removal of compost and residues) and from the residue landfill process
- odour emissions from the composting works (should be minimal with careful operation and favourable general conditions).

b) Fermentation (biogas extraction)

Although composting and biogas extraction are fundamentally different processes, they do not differ substantially in their environmental impact. See also 2.2.2.2 a).

Other forms of energy can be saved by the use of biogas, though the operation of biogas plants carries technical risks (see environmental brief Renewable Sources of Energy).

2.2.2.3 Physical, chemical treatment

Plants for physical and/or chemical treatment may differ very considerably as regards the processes used (see also 1.4). It would therefore be going beyond the scope of this brief to describe in detail these plants' effects on the environment. Depending on the individual case, some or all of the following problem factors may be involved:

- occupation of land (by construction works, machinery, areas for storage of materials/waste materials and for residue landfill sites etc.)
- noise emissions (due to delivery and removal of waste materials, valuable materials and residual materials)
- odour emissions
- pollution of surface waters (after treatment of liquid residues)
- pollution of groundwater (due to leaking and insufficiently drained storage areas for materials/waste materials, etc.)
- air contamination by pollutants (immissions)

2.2.3 Impact of intermediate waste storage

What is said in 2.2.2.3 applies here too, provided the holding time is not too long.

2.2.4 Impact of waste dumping

Waste dumping is the final stage of almost every disposal sequence (see 1.4). However the type and quantity of the waste to be dumped depends on the socio-economic circumstances of the disposal area and on the waste technology structure of the disposal sequence. To a very large extent, this also applies to the field of commercial and industrial waste disposal.

If the landfill is located on a geologically and hydrogeologically suitable site and has an effective base seal and drainage system, as well as proper percolation water and landfill gas disposal and an optimised system for incorporating the waste, one can assume that

- percolation water, gas, odour and noise emissions,
- nuisance from insects, rats and birds and
- dust and paper drift

will be limited to a degree controllable by modern methods.

The scarcely avoidable adverse environmental impacts of a landfill site can be outlined as follows:

- Because of the relatively large area occupied, establishing a landfill site involves considerable interference with nature and the landscape. This can, however, be very largely offset by appropriate recultivation measures.
- In the body of a landfill site for domestic waste, the decomposition processes which take place are largely biological and predominantly anaerobic. However, there is a potential long-term risk for the environment - arising from the waste which cannot be rendered inert - which should not be underestimated. This applies especially to commercial and industrial waste which is not or only poorly degradable (5).

- Recultivated landfill sites can only be used for a few purposes. Generally it is not possible to build on them. Every landfill produces landfill percolation water and landfill gases (including methane), which must be properly treated or disposed of, or utilised in the case of landfill gas. The only problem is that percolation water continues to be produced even when the landfill has ceased to operate, although in diminishing quantities.

Overall it can be said that landfill - in spite of its ecological disadvantages - at present is an indispensable component of a central waste disposal system.

2.2.5 Impact of waste recycling

2.2.5.1 Preliminary remarks

The recovery or utilisation of valuable materials in waste should always take precedence over other forms of disposal. This is true for the following reasons:

a) By extracting and recycling secondary raw materials from waste, raw materials and energy are saved and at the same time pollution of the environment is reduced.

b) By saving raw materials the countries in question can reduce their dependency on imports.

c) Recycling of domestic waste or its conversion into compost, if possible also using population-equivalent quantities of domestic sewage sludge, should lead to a corresponding reduction in the importation or production of mineral fertiliser. Mineral fertiliser is less energy-efficient to produce and less ecologically favourable to use.

d) When using compost made from waste and waste/sewage sludge, one must ensure that concentrations of heavy metals and organic substances which are not readily degradable do not exceed certain figures (cf. 3.3) (7), (8). If only limited chemical analyses are possible, corresponding estimates must be made using plausibility assessments of the origin of the compost raw materials. The same applies to thermal recycling (incineration) of waste and the recycling of the residual materials produced (slag, ash).

2.2.5.2 Impact of material recycling

The separation of valuable materials from domestic waste greatly facilitates its proper disposal. If relevant waste items are already collected at source (i.e. pre-sorted), this can greatly facilitate the collection and transport of the remaining waste, likewise if generally accessible banks are used for the valuable materials, and these materials are taken away in accordance with market-economy principles. On the whole one should note that:

- The landfill sites have to take less waste, and so their operating life is

extended and this then reduces the occupation of new land and soil.

- In the case of refuse incinerators, less ash and slag are produced, as the glass and metal intake is reduced (9). On the other hand, since the waste contains less paper, plastics and textiles, the calorific value of the waste is also reduced. This is however partly compensated for by the simultaneous reduction in the inert content. Moreover, by reducing the plastic content, particularly PVC, the pollutant content of the flue gases is reduced.
- Separation of valuable materials from domestic waste also has certain advantages in the case of composting: the treatment of the compost raw material and of the finished compost is facilitated by the separation of glass, metal and plastic components.
- The separated materials can, depending on their category, be reused in the manufacture of paper, glass, metals, building materials, etc. When undertaking projects of this kind, one should on no account fail to take an overall view, balancing out the possible environmental impacts (see also (10) - (16)).

If raw material recovery from waste is carried out on a commercial scale, thus if for example domestic waste is extensively sorted and treated under the split-bin collection system (dry fraction/wet fraction) with reference to the total dry fraction produced, and then returned to production on the relevant recycling lines, the operation of the relevant plants can have adverse effects on the environment. In this regard, section 2.2.2.3 also

applies here (physical, chemical treatment).

2.2.5.3 Impact of composting

Biological waste treatment processes are normally used for composting. For this reason, see also 2.2.2.2 a) concerning the effects of composting.

2.2.6 Impact of waste incineration

The incineration of domestic waste largely has the following waste management benefits (5), (12):

- substantial reduction in the waste quantities to be dumped:

Volume reduction without slag recycling between 80 and 90 %, with slag recycling as high as 97 %; weight reduction (without slag recycling) is around 60 - 70 %

- production of heat energy and recyclable by-products (slag for road-building). Calorific value of domestic waste is 6,000 to 10,000 KJ/kg (5), (9), (10)
- safe sterilisation and disinfection of waste
- as a result of the small quantities of residues, finding new landfill sites is far easier than in the case of waste-only landfill.

Disadvantages of waste incineration are:

- relatively high investment and operating costs, for flue gas cleaning among other things.
- proper servicing and maintenance require well-trained staff and sufficient operating revenues. If a waste incinerator is not operated correctly, considerable pollution of the environment may occur, in particular through:

flue gas emissions (dioxins)

wastewater (with wet flue gas cleaning and cooling of slag with water)

- there will be unavoidable production (even with correct operation) of:

flue dust from flue gas dedusting

solid residues from flue gas cleaning

dioxins and other environmental toxins.

The above-mentioned residues require disposal in special waste landfill sites or in special areas of domestic waste landfill sites.

In addition one can expect noise emissions from the waste incinerator (due to delivery of waste and the removal of ash/slag and other residual materials), as well as (to a lesser degree) odour emissions.

On the whole, waste incinerators are particularly suitable where waste has to be disposed in densely populated areas which are highly sensitive in terms of groundwater conservation, i.e. where there is a lack of suitable landfill sites, and where waste avoidance is poor.

2.3 Avoidance and safety measures

2.3.1 Waste avoidance

Waste which has not been produced does not need disposal! In other words: the use of appropriate procedures and measures to reduce or avoid the production of waste takes pressure off the capacities of waste disposal systems and thus off the environment.

In the domestic sphere waste can largely only be avoided if the general public adopts a waste-saving attitude (avoidance of superfluous packaging, non-returnable containers, disposable articles etc.) and if industry is motivated to economise on packaging (less packaging material, reusable containers etc.). There are opportunities here for state intervention via prohibitions, taxes etc.

To avoid waste in the commercial and industrial sphere it is always best to avoid or at least reduce the production of commercial and industrial waste (special waste) at source, in particular by adopting new recycling-oriented production processes. Appropriate avoidance strategies are however not always easy to implement, particularly in view of the technical and economic conditions prevailing in factories and the legal and practical difficulties of enforcement.

It is easier to adopt recycling strategies for commercial and industrial waste. First it is necessary to identify relevant establishments with the quantities and types of waste produced (creating a waste register).

There are relatively good opportunities for recycling commercial and industrial waste/residues in many countries, e.g. in the sectors of chemical cleaning and metal surface treatment (electroplating), as the process materials and raw materials are relatively expensive and thus recycling is profitable in these establishments. Information on the general options and processes is given in (17), (18), (19).

2.3.2 Safety measures

2.3.2.1 Introductory notes

In this section, the term "safety measures" is used to denote all those measures which

serve to minimise and compensate for the environmental impact and, where applicable, to make up for disturbances of the natural order, ensuring or safeguarding the environmental effectiveness of waste disposal measures.

Waste disposal plants are to be built and operated with observance of the conditions of use and stipulations laid down by the authorities in accordance with the applicable rules of the art (27). By applying this principle and carefully identifying at an early stage, i.e. during the planning of the waste disposal project, the effects on man and the relevant ecological conditions, e.g. in the area of flora and fauna, as well as the hydrological and geological conditions, and if allowance is made for their conservation in the project, one can expect minimal adverse effect on the natural balance.

Moreover, safe waste disposal demands not only detailed knowledge of the waste constituents but also compliance with stringent requirements in respect of the technologies, installations and building structures to be used (17).

2.3.2.1 Safety measures in waste collection and transport

In the design, construction and operation of plants and facilities for the collection and transport (removal) of waste, in the interests of reducing the environmental impact the objectives should be as follows:

- introduction of a collection system for separate collection of recyclable materials (e.g. split-bin system: wet/dry fraction). Where appropriate in the individual case, banks (for glass, paper etc.) should be provided. If this is not possible due to cost or other constraints, other ways of separating valuable materials should be sought, e.g. in the course of delivery of waste to transfer stations, landfills, etc.; use of scavengers (waste sorters)
- optimisation of collection frequency, to avoid noise and odour emissions etc.
- creation of organisational and physical conditions for reliable disposal and a flexible collection system
- assurance of sanitary conditions to prevent the spread of disease
- creation of facilities for proper collection, removal and disposal of commercial and industrial waste
- in the case of transfer stations:

against noise: enclosure of noise-producing machinery, motors etc.

against odours and other emissions into the air: enclosure of relevant areas, containment and filtration of waste air etc.

where necessary: landscaping to soften the visual impact.

Information on the principles and environment-friendly methods of waste collection and

transportation in developing countries, and also on waste management in general, is given in (20). See also (5).

2.3.2.2 Safety measures in waste treatment

In terms of conserving resources in developing countries, biological waste treatment systems, namely

- **composting plants**
- **biogas extraction plants**

are particularly relevant (21), (26). In addition, depending on the circumstances, the following should be considered:

- **plants for physical treatment (sorting plants, material recovery plants, sludge dewatering plants etc.) as well as**
- **plants for chemical treatment (fermentation/flocculation and neutralisation plants etc.) (5), (17).**

Safety measures include:

- **those against noise emissions: enclosure of noise-producing equipment,** motors, blowers and other machinery etc.

- those against odours and (other) emissions into the air: enclosure of relevant areas, containment and cleaning or filtration of waste air etc.
- those against harmful pollution of surface waters by relevant process materials, stored materials and residues: building and operation of (wastewater) treatment plants (where necessary), (further) proper disposal of the relevant emissions (e.g. discharge into public sewerage system)
- fencing of open landfill sites
- those against harmful pollution of underground waters: creation of impermeable and properly drained storage areas, work areas etc. and appropriate supervision
- those to soften the visual impact: planting, building of aesthetically appropriate buildings, provision of compensation areas etc.
- specification and monitoring of adherence to regulations for industrial and operational safety of biogas plants.

2.3.2.3 Safety measures in intermediate waste storage

See also 2.3.2.2.

2.3.2.4 Safety measures in waste dumping

In the case of landfill sites, bearing in mind what is said in 2.2.4, in principle the following measures are necessary:

- where no geological barrier is present as a substratum (clay, marl), production of a permanently effective base seal (as a rule a combination seal with a mineral component (clay) and a layer of carefully jointed, high-grade plastic sealing strips) covered by a likewise permanently effective drainage layer
- construction and operation of a plant to treat the landfill percolation water produced
- construction and operation of degassing facilities
- reliable control of incoming waste (entry control)
- application of the prescribed methods for incorporation of waste
- daily covering of the operating areas (for reduction of odour emissions, paper drift, insect infestation; to avoid fire danger and unaesthetic appearance)
- against dust and noise: moistening of landfill surfaces and landfill roads, regular cleaning of the landfill and access roads, construction of tyre cleaning plants, planting of peripheral areas; installation of acoustic barriers, protective planting
- checking of groundwater using observation wells
- stage-by-stage recultivation

- follow-up measures after closure of the landfill site (percolation water treatment, monitoring of observation wells etc.).

It is expressly pointed out that the above-mentioned requirements concerning the planning, construction and operation of landfill sites may vary (i.e. become more or less stringent) depending on the potential risk posed by the waste sent to the landfill site, e.g. in the case of soil landfills, building waste landfills or special waste landfills with particularly hazardous wastes.

2.3.2.5 Safety measures in waste recycling

See also 2.3.2.2.

See (14), (15), (5), (17) for information on appropriate and environment-friendly management of material recycling and waste utilisation.

2.3.2.6 Safety measures in waste incineration

In the case of waste incineration plants, bearing in mind what is said in 2.2.6, the following measures are necessary:

- dedusting of (cooled) waste gases with electrostatic precipitators or fabric

filters, followed by

- removal of anorganic toxic gases (dioxin risk) in a flue gas scrubber, using one of the established sorption processes:

wet sorption process
dry sorption process
half-dry sorption process.

- proper recycling or disposal of the solid residues produced, namely grate slag/ash, filter dusts and the reaction products from waste gas cleaning:

grate slag/ash:

Dumping in landfills, but recycling in road-building and dam construction where possible (particularly if evenly and thoroughly burnt)

filter dust:

In view of the high pollutant concentration, disposal on special waste landfills, compacting where applicable

reaction products of flue gas cleaning:

Depending on the neutralisation products, common salt, Glauber's salt, calcium chloride or gypsum are produced. Dumping on suitable special waste landfills; evaporation, then recycling. Recycling processes are still being developed.

- Proper disposal of liquid residues, which are produced as wastewater:

washing water from flue gas cleaning
cooling and washing water from the wet slag remover
sealing, rinsing and spray water.

The above-mentioned wastewater is highly polluted; it must be cleaned and discharged into the public sewerage system, or evaporated.

Moreover, steps must be taken to prevent noise emissions and, to a lesser degree, odour emissions, also measures to compensate for the land occupied. In addition see also 2.3.2.2 and (5) 7610 ff.

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3. Notes on the analysis and evaluation of environmental impacts

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3.1 Introductory remarks

To gain a full understanding of a waste disposal project, it is vital to determine the underlying conditions and constraints of the project, against the background of its ecological and economic effects. The project description may be based on the following criteria:

- planning history
- waste and water legislation and standards
- existing waste situation (waste production, existing plants and their functions)
- previously established objectives (e.g. from waste disposal plans, district waste management programmes etc.), evidence of demand for the planned plant
- incorporation into regional and national planning objectives and also the regional and supraregional disposal system
- reasons for choice of planned disposal system and its main components (collection containers, vehicle fleet, intermediate storage, recycling processes

and facilities, plants for special waste treatment, plants for waste incineration and dumping etc.)

- alternatives (e.g. incineration/landfill, percolation water treatment suitable for landfill/co-composting in district sewage works; extension or expansion of existing plants and facilities as well as baseline state).

Further components for the evaluation of the environmental impacts of a waste disposal project are descriptions of

- the location-finding process for relevant alternatives, including any necessary socio-economic analyses of sex- and group-specific aspects of the population settled in the surrounding area or area covered by the waste disposal plant in question,
- the location comparison and results,
- relevant plants and their failure risks,
- the polluting factors of the project and
- those plants or plant components which should eventually form the object of an environmental impact study.

Major environmental impacts result from the construction and operation of the (fixed) waste disposal plants referred to below, and in the event of substantial changes to such

plants or their operation:

- **intermediate stores**
- **transfer stations**
- **domestic waste and special waste landfill sites**
- **incinerators**
- **thermal treatment plants, such as pyrolysis plants**
- **physical, chemical and biological treatment plants, in so far as these may have serious adverse environmental impacts.**

The scope of the assessment must depend on the environmental relevance of the plants in question. This applies particularly to intermediate stores without hazardous waste, which may differ considerably in terms of their size and technical facilities.

In addition to the quantity, the origin and condition of the waste are crucial in terms of the disposal sequence and environmental impact. Special attention should therefore be paid to waste analysis. In view of its normally very heterogeneous composition, sampling, sample preparation and sample analysis must be carried out to obtain useful and representative results. In the Federal Republic of Germany, the relevant Regulations of the *LAGA*-state work group on waste ("Lnderarbeitsgemeinschaft Abfall") are of particular importance (31), as are also the inspection procedure set forth in the German

standard DIN 38400 ff. (32) and the designing of analytical procedures according to (33).

3.2 Waste collection and transport

The collection and transport of waste is safe, if as a result

a) the health of the general public and of personnel concerned with the equipment, vehicles and facilities is not put at risk

b) there is no lasting odour nuisance and

c) further or subsequent disposal measures are not seriously hindered.

With regard to possible noise emissions at transfer stations, the limits set forth in (34) apply.

3.3 Waste treatment

Briefly, this concerns (see also 2.3.2.2):

- **composting and biogas extraction plants (biological treatment) and**
- **physical and chemical treatment plants (sorting plants; material recovery**

plants; precipitation/flocculation and neutralisation plants; sludge dewatering plants etc.).

In the assessment one should take into account their contribution to saving fossil fuels, COD/BOD reduction, odour reduction, health effect.

Composting and biogas extraction plants affect the environment through the products created, namely compost or digested sludge used for agricultural purposes, and through waste gases and drainage water (1).

The main rule book used in Germany, which may also serve for guidance in other countries in the matter of compost, is LAGA's *Merkblatt 10* concerning quality criteria and recommendations for use of compost made from refuse and refuse/sewage sludge (7). This specifies permitted concentrations of selected heavy metals in the soil and values to be adhered to when applying compost. This states that:

- Compost should not in principle be applied if soil analyses show that concentrations of the following heavy metals exceed any of the following limits (milligrams per kilogram air-dried soil):

	Soil value (mg/kg)

Cadmium	3
Chromium	100
Copper	100
Lead	100
Mercury	2
Nickel	50
Zinc	300

Compost may be applied in certain cases where the above figures are exceeded if, taking into account the site conditions and use, no adverse effect will be caused to the well-being of the general public. If the soil figures for cadmium and mercury are exceeded no compost should be applied.

- In case of repeated application of composts, the following concentrations (grams per hectare and year on a long-term average) should not be exceeded.

	Concentration (g/haa)
Cadmium	33
Chromium	2 000

Copper	2 000
Lead	2 000
Mercury	42
Nickel	330
Zinc	5 000

In the case of agricultural use of the digested sludge produced in biogas plants, the guidelines of the sewage sludge ordinance *Klrschlamm-Verordnung* (35) are also to be observed. These establish permitted values for concentrations of selected heavy metals in the soil and in the sludge; in addition, restrictions are imposed on the quantities of sludge which may be applied (see Table 1). Furthermore, care must be taken to ensure that the soil values in question are identical to the corresponding soil figures in the case of compost application (see above).

Table 1* - Permissible concentrations of heavy metals in accordance with the sewage sludge ordinance *Klrschlamm-Verordnung

Heavy	Generally permitted	Quantity permitted to	Maximum permitted heavy metal concentration

metals (HM)	concentrations in sewage sludge1)	be applied1)	upon application of sewage sludge	
	mg/kg	t/(ha3a)	g(ha3a)	g/(ha)
Cadmium	20	5	100	33.3
Mercury	25	5	125	41.7
Nickel	200	5	1000	333.3
Lead	1200	5	6000	2000.0
Chromium	1200	5	6000	2000.0
Copper	1200	5	6000	2000.0
Zinc	3000	5	15000	5000.0

1) related to dry sludge residue

At least in temperate zones, if the regulations contained in the sewage sludge ordinance are complied with, no long-term harm will be inflicted on soil, plants, animals and humans through the use of sewage sludge in agriculture; moreover, in particular, the health of people or animals will not be harmed by the consumption of foodstuffs or fodder produced on land to which the sludge is applied (36).

With regard to specific compost tests, reference should be made to the appendices to

(7). In addition, the test procedures mentioned in 3.1 must be observed in so far as applicable.

In the case of biological waste treatment plants, for noise emissions the limits of *TA-Lrm* [Technical Instructions on Noise Abatement (34)] provide evaluation guidelines; for emissions into the air the limits set forth in *TA-Luft* [Technical Instructions on Air Quality Control (37)] are appropriate; for wastewater disposal see in particular the limit values contained in the appendices to the *Allgemeine Rahmen-VwV* [General Administrative Framework Regulation on Minimum Requirements for the Discharge of Wastewater into Waters (39)] issued under 7a *WHG* (German Federal Water Act (38)). The quoted regulations apply similarly to physical and chemical waste treatment plants .

3.4 Intermediate storage

This is likewise subject to the regulations mentioned in 3.1 and 3.3 concerning test procedures and the establishment of limits in relation to potential environmental impacts.

3.5 Waste dumping

To examine and evaluate the environmental impact of a landfill site, it is vital that the delivery of waste be carefully monitored (delivery notes, entry controls). If deficiencies and irregularities occur here, constant incorrect filling of the landfill site will produce

potential hazards quite different from those anticipated in the original planning, i.e. in the original positive-negative brief drawn up for the waste to be sent to the landfill site. This can be remedied by more frequent unannounced sampling - and possible subsequent analysis - of the waste on its way from the producer to the landfill site in order to determine its characteristic features (appearance, consistency, content etc.). Reliable and practical testing and analytical procedures will prove extremely useful in this respect. See also 3.1 and 3.2.

Limits for the permissibility of dumping at special waste landfill sites are established in Germany under TA-Abfall, Teil 1 (Technical Instructions on Waste Management, Part 1(27)).

For noise emissions from landfill sites, the limits set forth in (34) provide guidelines; for landfill percolation water treatment, refer to the limits contained in Appendix 51 to the Allgemeine Rahmen-VwV (39) and for questions relating to landfill gases, see the explanations and requirements of the LAGA document on landfill gas *Informationsschrift "Deponiegas"*(30)).

3.6 Waste recycling

See also 3.3 (Waste Treatment)

3.7 Waste incineration

The main emission to be considered when assessing the environmental impact of a waste incinerator is the flue gas emission. Because of the normally heterogeneous composition of waste (e.g. of domestic waste), the incineration must be carried out with a high level of excess air in order to achieve thorough combustion of the incineration material and of the flue gases. In the case of domestic waste incineration, the excess air coefficient is approximately 2; this produces 5,000 to 6,000 m^3 of crude gas per tonne of incineration material. With the crude gas from domestic waste incineration,

- gaseous pollutants (mainly HCl, HF, SO_2, NO_x, CO and C_xH_y)
- dust pollutants (mainly heavy metals such as Pb, Cd, Hg, Sb, Be, Cr, Ni) and
- organic, mainly gaseous substances (such as PCB, HCB, chlorophenols, but also dioxins and furans)

are emitted. Under TA-Luft (37), the following limits apply to the clean gas:

- dust $\leq$ 30 mg/m^3
- carbon monoxide $\leq$ 0.10 mg/m^3
- organic substances (counted as total C) $\leq$ 20 mg/m^3

- sulphur oxides (counted as SO_2) $\leq$ 0.10 mg/m^3
- halogen compounds

* anorg. chlorine compound (counted as HCl) $\leq$ 50 mg/m^3
* anorg. fluorine compounds (counted as HF) $\leq$ 2 mg/m^3

Further details, particularly regarding sampling and measurements and also the applicable general conditions, can be found in TA-Luft (37). This also provides information on emission propagation.

For noise emissions from incinerators, the limits indicated in (34) may serve as a guideline; in the case of wastewater treatment and disposal, decisions must be made on a case-to-case basis according to the current state of the art (the appendices to the Allgemeine Rahmen-VwV (39) may indirectly serve as a guide). Where the eluate values permit, the slag should be used for building purposes (see (40)).

4. Interaction with other sectors

Because of their geographical and physical impact, supply and disposal projects must stand in a clear and plausible relationship with other environmental and geographical areas. This is particularly true of waste disposal projects (WD projects), bearing in mind the potential danger posed by the domestic, commercial and industrial waste to be disposed of.

Areas which may be affected overall by WD projects, and the related possible conflicts of use and interactive effects include, in particular, the following:

- **soil; agriculture and forestry**
- **water (surface water, groundwater); water resources management, hydraulic engineering,**
- **water production, water supply, wastewater disposal**
- **nature conservation, countryside preservation, recreational resources**
- **urban/community planning, industrial development**
- **monuments and heritage**
- **traffic planning (roads, railways, waterways, flight paths)**
- **existing/future regional planning, land-use and development planning; activity planning**
- **distance problems in existing and planned residential areas**
- **availability of land and soil.**

If conflicts of use occur, the options must be weighed up. The standard against which these are judged is not the status quo, i.e. the structures and services existing prior to execution of the waste disposal project, but rather the development potential of the area in question. The criterion is thus the capacity and not the present performance (41). This approach stresses the importance of identifying and assessing the soil potential, the biotope potentials and the hydrogeological potentials (in terms of both quantity and quality).

Adjustment, alleviation and compensatory measures may provide crucial help in arriving at the environmentally ideal overall solution.

5. Summary assessment of environmental relevance

For any waste disposal project, in the interests of minimising the environmental impact, the following basic rules apply (see also (45)):

Waste avoidance, i.e. preventing it being created in the first place, particularly in the field of industrial production, takes precedence over recycling.

Recycling takes precedence over other forms of disposal.

Waste or residues which cannot be recycled are to be disposed of properly, i.e. in line with environmental requirements.

Ecologically and economically favourable solutions can be achieved anywhere by applying these principles, provided they are adapted to the local conditions in a technically appropriate way.

To sum up, the following may be said with regard to the environmental relevance of waste disposal projects:

The plants of such a project must be planned, built and operated in accordance with the generally accepted rules or the state of the art, e.g. in the case of air purification plants (see 5 *BImSchG* - German Federal Immission Control Act (4)) or wastewater treatment plants, for the purpose of eliminating hazardous substances for example (see 7a *WHG* - Federal Water Act - (38)). Special measures are always necessary in the case of waste incinerators and landfill sites, especially where the distance from residential buildings is relatively small or a large area of land is occupied. The main reasons for this in the case of incinerators are the pollution potential of the flue gas emissions and in the case of landfill sites the long-term groundwater pollution potential of the deposited waste.

If not intended for special waste and if there is no possibility of special waste being

introduced, the other installations in waste disposal projects, such as intermediate stores, transfer stations, composting works, physical/chemical treatment plants etc. are rated as comparatively less environmentally polluting, as their effects are usually less long-lasting, less numerous and less far-reaching, especially if particular attention has been paid to noise reduction and odour-abatement at the planning stage.

6. References

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14. Disposal of hazardous waste

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Contents

1. Scope

Special waste management planning and environment-oriented waste disposal are vital requirements in all countries. In developing countries (DCs) the associated functions and problems are intensified because of the general shortage of financial resources, which in most economies are applied where they are most urgently needed, or where policy-makers consider they are most urgently needed. Looking at the problem from a short-term perspective, the environmentally acceptable disposal of hazardous waste is often not considered a priority. This attitude often gives rise to adverse long-term effects on

man and the environment, which at a later point in time require further resources, sometimes more than those initially saved, to put them right.

Effective planning of special waste management is also limited by the lack of suitable technical solutions, either for financial reasons or because of the lack of an administrative system for waste disposal or because of deficiencies in training. The situation is often characterised by administrative and organisational weaknesses, by inadequate control and sanctioning capacities and failures in the implementation of the 'polluter pays' principle as a guideline for environmental policy.

Only if identified waste with a known waste composition is recorded, checked and transported in suitable containers and, after prior examination of the options for reuse, directed to the most suitable type of disposal, can the inevitable hazards and environmental effects of special waste disposal be reduced to a minimum.

The present environmental brief sets out the main effects and possible measures associated with special waste management and disposal. This document is largely based on the study published jointly by the World Bank, WHO and UNEP "The Safe Disposal of Hazardous Wastes - The Special Needs and Problems of Developing Countries, World Bank Technical Paper Number 93, Vol. I, II, III, Washington D.C., 1989".

The disposal of radioactive waste is not dealt with, as this requires very specific

measures.

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2. Environmental impacts and protective measures

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2.1 Definitions according to the Basel Convention

The "Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention)" of 22.3.1989 can be regarded as an important step forwards in the development of an international environmental law. This convention is the result of many years intensive consultation with the participation of over 100 states. It provides a basis for the necessary restraint of the increasingly problematic and to date virtually uncontrolled transboundary movements of hazardous wastes, some of which are declared as economic goods, which are sent to other countries for disposal. It is very helpful for the international harmonisation of the term "hazardous

wastes".

The term "hazardous wastes" is more closely defined in Article 1 (see Annex 1 in conjunction with Annex III). In addition, however, the signatory countries to this convention also have the possibility of closer national definition, by subsuming further types of waste under the term "hazardous wastes" on the basis of national legislation.

Within this Basel Convention, of worldwide importance, Article 2 defines the "environmentally acceptable management of hazardous wastes and other wastes" as "taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes."

For a more detailed specification of the term disposal, the same Article refers to the operations listed in Annex IV to this convention. The above-mentioned Annexes with the types of waste, hazardous characteristics and disposal methods can be found in Annexes 1 - 3 of this document. Annex 4 gives a list of the hazardous materials, as taken from the Annex to the EC Directive on toxic and dangerous waste. This shows the extent to which the Basel Convention is based on this EC Directive.

2.2 Specific problems in developing countries

The situation in developing countries is typically characterised by the following problems in handling and treating or disposing of hazardous waste:

1. The hazardous nature of these substances for man and the environment, as well as the resultant need for action is not recognised, or is insufficiently recognised by the operators of industrial plants (waste generators), political decision-makers and the general public.

2. There is no political or economic-policy framework aimed at avoiding or reducing hazardous waste; at the same time, the legal framework for disposal monitoring, including the administration necessary to implement the standards, is inadequate.

3. A proper disposal facility and a suitable monitoring system for these substances is lacking.

4. Accompanying observations and monitoring of air, soil, water etc. are not carried out or are carried out only in a rudimentary manner.

Certain secondary conditions restrict the scope for action and decision-making. Some of these restrictions which are of particular relevance in developing countries are as follows:

limited financial resources: particularly convertible foreign currencies

shortage of human resources: particularly in the fields of engineering sciences, management and administration

limits to land use: in particular because of the high population concentrations at certain points in urban areas (polarisation)

local environmental conditions: in particular because of the relative shortage of water resources and the fact that in areas of high population density in developing countries the groundwater table is usually close to the surface, so pollution can have devastating consequences for health and the environment.

Environmentally acceptable special waste management must take these factors into account. Some of these side effects may be so serious that in view of the inadequate disposal facilities there is no alternative to waste minimisation.

2.3 Survey of the types of waste found in developing countries

2.3.1 General

As already stated, the quantity, type and composition of special waste primarily depend

on the industrial operations within the geographical area in question. Furthermore, complex imported goods are relevant to the waste situation. The economic and sectorial structure typically found in developing countries is often characterised by a high level of standardised production processes in the secondary (industrial) sector, using processes which as a rule do not correspond to the state of the art in industrialised countries and tend to be much more waste-intensive (though this does not necessarily involve hazardous waste). Moreover the primary sector (agriculture, forestry and mining) plays an important part. Specific types of waste are produced by these sectors, particularly bulk waste with a varying hazard potential. For example, waste heaps, sludge lagoons, and liquid discharges may contain toxic heavy metals (Hg, Cd, As, Pb etc.), radioactive substances and cyanides. This applies particularly to non-ferrous and precious-metal mining.

Problems must always be expected in dealing with the following substances, which, unlike the more general wastes from industrial production, can also result from consumption processes:

oils and oil-containing substances, some containing PCBs (e.g. from vehicle fleets, workshops etc.)

agrochemicals and their residues

hospital waste.

Building materials containing asbestos must also be considered.

2.3.2 Generation points

The most important sector for the generation of special waste is industry (taking into account imported industrial products). The generation points are hence the starting points for the reduction of waste production. They must be considered differently in the enterprises in question depending on the type of waste, hazard sources and possible recycling strategies:

- In point 2 reference has already been made to Annex I of the Basel Convention and the Listing of Waste Types provided therein, which fall under the definition of hazardous waste (cf. Annex 1).
- A further classification scheme for special waste with references to possible areas of occurrence is given in Summary 2 (Annex 6).
- Another waste classification differentiated by sectors for the occurrence of these substances is taken from World Bank Technical Paper 93 and set out in Annex 7.
- Reference should be made at this point to the schedule of special waste types in accordance with TA-Abfall [Technical Instructions on Waste Management]

(or in accordance with the waste definition order AbfBestV) used as the basis in Germany, in which examples of areas of origin are given. TA-Abfall also gives disposal recommendations for the types listed therein and which are given a waste code.

In the past, the following industrial sectors have proved to be particularly large producers of "special" waste:

chemical industry and oil processing
pharmaceutical industry
non-ferrous/ferrous metal industry
vehicle manufacturing/mechanical engineering/surface treatment industry
electrical engineering/precision engineering
printing trades/dyes and pigments production and processing
plastics processing
glass processing
leather manufacture
asbestos processing
mining, metallurgy, smelting

Consumption activities and the services sector generally produce much smaller quantities of waste. Oil-polluted waste often creates specific disposal problems in developing countries. The Table in Annex 8 gives an idea of the types of special waste produced in small establishments and by the use of certain products.

The area of complex imported goods poses a particular problem. Such substances often give rise to serious problems of disposal and handling after they have become waste. This must be taken into account beforehand, i.e. at the time of importation; possible solutions include import bans or obligations to take waste back.

Particular attention must be paid to special hospital waste, already mentioned above. This may give rise to very serious health problems (cf. environmental briefs Analysis, Diagnosis, Testing; Public Facilities).

2.3.3 Identification of waste

In Summary 1 (Annex 5) a simple form of classification and identification of waste materials has already been proposed. Chemical laboratory analyses offer important detailed identification methods, but these can involve a great deal of work and expense, and suitable laboratory installations are not always available. It is more practical to examine the production processes. Because of their standardisation, one generally knows what waste materials and related products are produced by the various production processes. Further investigation can then be carried out, comparing data sheets on the various material properties. Such data sheets are available in a number of countries; in Germany, for example, in the form of continuously updated loose-leaf collections. These describe substances by their chemical properties and appearance, which is a help in identifying substances.

In the USA there is an official register of hazardous materials (Federal Register), which is constantly revised and updated. Other countries also have detailed, statutory regulations and classifications for handling of materials and for reducing the hazardous effects associated with them. Annex B of TA-Abfall already mentioned above gives detailed sampling and analysis procedures for the declaration and identification of hazardous waste, with reference to the relevant German DIN standards.

The basic problem in identifying waste is that substances generally become mixed, so that conclusive identification is not possible on the basis of the material properties alone. Added to this, many substances are difficult to analyse, particularly those which can be toxic in very small quantities (e.g. dioxins, furans).

2.3.4 Ways of allocating hazardous waste to environmentally acceptable disposal methods

Whether such allocation will lead to environmentally acceptable disposal depends

primarily on the type and equipment of these plants (i.e. the state of the art reached). Statutory provisions must ensure that priority is given to recycling waste wherever technically possible (i.e. where a suitable process is available) and economically feasible (i.e. any additional costs are offset by corresponding revenues).

When allocating waste to appropriate disposal routes, the following aspects are important:

consistency,
appearance, colour,
odour,
combustibility under normal conditions,
reactions with water, air and other substances,
reaction products from the anticipated disposal route

In addition, there are many other criteria which should be examined on a case-to-case basis.

Whether waste can be dumped on a landfill site depends mainly on the elution behaviour. Particularly reactive substances may only be incorporated after appropriate pretreatment. In principle, inorganic, solid or compact wastes are suitable for tipping. Annex D of TA-Abfall lists a large number of criteria for overground tipping, which is

the main disposal method in developing countries (cf. Table 1). This comparatively cheap disposal option should always continue to be used when "geological barriers" (impermeable rocks such as clays and marls) of sufficient thickness (several tens of metres) are identified and/or can be reinforced or replaced by technical barriers (artificial membranes).

***Table 1* - Allocation criteria for overground tipping in accordance with German TA-Abfall**

Parameters			**Allocation figure**
Stability			
Side shear strength	≥	25	kN/m
Axial deformation	≤	20	%
Unconfined compression strength (flow value)	≥	10	kN/m
Loss on ignition of dry			wt %

residue of original substance	≤	10	
Extractable lithophilic substances	≤	4	wt %
Eluate criteria	4-13		
pH value	≤	100,000	uS/cm
Conductance	≤	200	mg/1
TOC	≤	100	mg/1
Phenols	≤	1	mg/1
Arsenic	≤	2	mg/1
Lead	≤	0.5	mg/1
Cadmium	≤	0.5	mg/1
Chromium (VI)	≤	10	mg/1

Copper	≤	2	mg/l
Nickel	≤	0.1	mg/l
Mercury	≤	10	mg/l
Zinc	≤	50	mg/l
Fluoride	≤	50	mg/l
Ammonium	≤	1,000	mg/l
Chloride	≤	10,000	mg/l
Cyanides, readily liberated	≤	1	mg/l
Sulphate	≤	5,000	mg/l
Nitrite	≤	30	mg/l
			mg/l

AOX	≤	3	mg/l
Water-soluble component	≤	10	% wt

Chapter 6 (Hazardous Waste Treatment Technologies) and 7 (Technical Requirements for the Safe Disposal of Hazardous Waste) of the joint study by the World Bank, WHO and UNEP "The Safe Disposal of Hazardous Waste, World Bank Technical Paper Number 93" in volumes II and III offer assistance for more detailed examinations.

Special wastes should only be disposed of by incineration where (assuming they have sufficient calorific value for incineration in e.g. rotary kilns as used in the cement industry) they are unsuitable for overground tipping because of their organic pollutant content and where, in addition, this heat treatment guarantees the safe destruction of these troublesome components. Wastes suitable for incineration contain only limited quantities of heavy metals and heteroatoms (fluorine, chlorine).

The different types of chemical/physical and biological special waste treatment serve to reduce the pollutant content and/or quantity of the waste. These are used for wastes with a high pollutant content and where the process enables separation, conversion or immobilisation of the environmentally polluting components.

Wastes are allocated to the most environment-friendly disposal method by means of a suitability test, which is generally carried out on the basis of waste composition analyses. When the waste composition is known, the waste may be allocated on the basis of disposal recommendations.

2.4 Identification of hazards due to incorrect handling of special waste

The study of the dangers of handling hazardous waste materials varies considerably depending on the specific material properties, subdivided into the phases of collection, transport and treatment/disposal. Various types of hazard must be distinguished in terms of their effects on man and the environment.

The anticipated environmental disturbances again largely depend on the material properties (e.g. bio-toxicity, human toxicity, degradability, accumulation properties, mobility). Obviously it will be impossible, within the framework of this study, to define these for the vast number of hazardous waste materials (cf. more detailed study in World Bank Technical Paper Number 93, Chapter 2 Volume I).

For the individual stages of waste disposal, on the other hand, a number of general observations may be made. Complete recovery (collection) of waste materials at the generation point in suitable receptacles is essential for environmentally acceptable disposal of this hazardous waste. The collection receptacles used for this must be

appropriate to the material properties of the substances (e.g. flammable, explosive, corrosive etc.) and take into account other aspects (strength, resistance, density, logistical suitability etc.). In addition, they must be of adequate size to accommodate the regular volume of waste generated.

It should be noted that mistakes which are made at this stage of waste disposal are often unrectifiable later on. Conclusive identification of the waste to ensure appropriate collection is of paramount importance.

The same applies to transport and disposal and to the recycling or treatment of these hazardous materials. Some countries already have regulations containing detailed disposal recommendations for the relevant types of waste, e.g. in Germany, the TA-Abfall. Within the EC, Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances is applicable (subject to the implementation period since the end of 1981). The USA and other countries also have appropriate statutory regulations in this area.

2.5 "Source-Transport-Destination" hazard assessment

In view of the aspects described above a detailed hazard assessment can only be carried out in the light of specific hazard factors. However, a number of general comments can

be made which will serve to illustrate the general principles.

2.5.1 Stages of hazard assessment

A hazard assessment consists of several stages. To start with there is the inventory analysis, whose function is to provide an accurate pollutant inventory listing. This is the total of all substances which may in principle pose a long-term threat to man and the environment. In the case of "special waste disposal" this will clearly depend to a very large extent on the composition of the waste and the method of disposal.

The second stage is the emission analysis, in which an attempt is made to determine the discharge of pollutants actually occurring. This is determined by the mobility of the pollutants.

In a third stage, an exposure analysis is carried out, the function of which is to consider the possible pollutant burden paths for goods and people. Such burden paths may be:

contamination of the groundwater	**drinking water**
pollution of the air	**inhaled air**
discharge of pollutants into the soil	**food chain/groundwater**
uptake of pollutants through dermal resorption	**skin contact**

As a final stage, the actual risk analysis is carried out. This assesses the effect on the environment and human health of the hazards and risks resulting from the different exposures. This is done on the basis of limit values, where available, or in the form of individual assessments. The hazard model also includes further aspects such as the weighting of risks of occurrence and an estimate of possible effects of damage or incidents.

The following discussions should help to recognise or to reduce the hazard factors associated with handling special waste.

2.5.2 Source: Waste generation points

As already mentioned, hazardous waste originates mainly from industrial production or imported goods; hazardous waste can also arise in the areas of agricultural production, mining, conversion of raw materials, consumer goods and capital goods. The following general rules may be applied for handling such materials, so as to minimise the associated hazards:

mixing ban:

recovery and collection of substances in receptacles appropriate to the material properties and ban on mixing different types of special waste,

regular checking of waste composition,
observance of safety regulations during handling and temporary storage of hazardous waste,
preparation of contingency plans for possible incidents,
training to be provided for personnel involved in the handling of the materials.

2.5.3 Transport

The transport of hazardous waste differs very considerably in developing countries from the common practice in industrialised countries. On the one hand one can assume relatively low traffic density - a positive factor in a comparative hazard assessment. However, there may be very high traffic concentrations in some densely populated areas with at the same time a very poorly developed transport infrastructure in terms of traffic routes, with unsuitable modes of transport and often inadequate vehicle safety standards.

Problems therefore exist primarily because of the following factors:

poor traffic routes,
overstretching of existing transport facilities, especially in the vicinity of urban centres,
inadequate vehicle safety,

drivers inadequately trained to handle dangerous materials.

To draw conclusions in order to make a hazard assessment, it is necessary to determine:

1. The goods transported and their properties
2. The mode of transport
   road, railway, inland waterway
3. The probability of accidents/incidents
   and the modes of transport in the disposal area
4. The extent of the damage to man and the environment in case of accident
   e.g. effects of shipwreck compared with road accidents.

The choice of transport mode and the route should be based on such considerations.

If one compares these countries with the practice in many other countries, where substantial resources are devoted to the administration and monitoring of waste transport, one will appreciate the importance attached to this area. Besides national regulations there are also international and supranational provisions in force in the transport sector which must be observed. The United Nations have also prepared regulations on the carriage of hazardous goods, differentiating the hazard classes by hazard characteristics of the goods to be transported (cf. also Annex 3).

2.5.4 Destination: Special waste treatment/disposal plants

The environmental hazards arising from treatment/disposal plants for special wastes depend primarily on the method of waste disposal or treatment and the suitability of the substances for these methods. The principles of location planning are dealt with in a separate environmental brief.

The large number of thermal, chemical/physical or biological treatment processes available mean that specific environmental restrictions have to be imposed. It is therefore important to subject only appropriate and permitted wastes to the relevant processes. Regulations should be drawn up in this regard, or existing ones adapted, to ensure the exclusion of unsuitable substances from certain disposal methods (e.g. Table 1 gives a list of requirements for overground tipping of wastes). Allocating certain wastes to defined disposal methods or, as a first step, excluding such materials from unsuitable disposal procedures can bring about a major improvement in special waste disposal leading to less environmental pollution (see also 2.3).

Chemical/physical and biological methods of special waste treatment represent only a very small part of developing countries' disposal capacity.

Generally speaking, the main disposal methods of landfill and incineration involve various forms of environmental pollution and hazards. A special waste incineration plant

may sometimes produce sporadic emissions, while in the case of landfill sites for special wastes, insufficient knowledge of the long-term behaviour of the structure poses fundamental problems. The medium of water (groundwater and surface water) is particularly at risk from the tipping of waste materials and must be considered carefully. Overground landfill sites often pose serious environmental hazards because of polluted leachate. Here too, it is advisable to assess the specific dangers posed by the individual substances present, therefore a careful analysis must be made to determine which substances must be allocated to which waste treatment or disposal procedures. Specific legislation should be passed in this regard using exclusion criteria or more extensive allocation provisions.

With regard to hazard assessments to determine the potential adverse effects on the local population, it can be said that thermal waste treatment plants are usually located near areas of high population density and therefore pose different hazards (health risks e.g. due to accidents or dioxin emissions from waste incineration and particularly special waste incineration) from landfill sites which, because of land-use priorities, are more remote and very land-intensive. It should also be taken into account that dumping is an unavoidable part of all treatment processes, as substances are always generated which cannot undergo any further treatment and therefore must eventually be dumped.

To minimise the hazards associated with the two main disposal methods, the following

measures must be adopted or allowed for:

Special waste incineration:

Operation/execution of thermal treatment:

Rotary kilns with an incineration temperature of 1000-1200 C are particularly suitable;

Efficient waste gas cleaning / flue gas scrubbing is vital.

Special waste landfill:

Choice of suitable location taking into account geogenic conditions,

Structural measures:

Base sealing (natural/synthetic), capping, control of density, minimisation of leachate, recovery and treatment of leachate, degassing measures.

Landfill operation

Measures to avoid drift and noise emissions, minimisation of leachate, compaction, consolidation, noise protection, separate tipping/incorporation of certain waste

materials, measures to guard the site, incident precautions,

Monitoring after closure of the site:

Inspection shafts above and below the groundwater flow.

2.6 Elements and stages of environmentally acceptable management of hazardous waste

A schedule of waste types must be established indicating precisely defined waste characteristics. Summary 1 in Annex 5 is an excerpt from a simple and practical classification scheme, which already provides a good basis for assessment of substances and appropriate handling of the waste thus classified.

2.6.1 Stages of waste management planning

The subsequent, second stage involves planning of specific handling measures for the further handling (collection-transport-disposal/treatment) of the materials and evaluation of the resultant hazards given the specific local context of these stages

collection/separate collection - with temporary storage where applicable
transport - with loading and unloading where applicable
disposal - according to treatment/disposal method.

The planning result will depend on the specific material properties, which are known in most cases. One must however bear in mind that the waste materials are mixtures, which makes it difficult to evaluate and classify them, and again requires knowledge of the waste composition. Furthermore the local socio-economic and geo-ecological conditions must be taken into account, where these have obvious effects.

Such aspects include - lifestyle and consumption habits,

- **forms of settlement and land-use**
- **economic structure,**
- **population density and distribution,**
- **soil composition,**
- **existence and availability of water resources,**
- **climatic situation, etc.**

These and other factors therefore affect the planning result and the assessment of the resultant hazards. Thus it is imperative that the assessment, leading to an environmentally acceptable disposal practice for hazardous wastes, be carried out taking into account the specific problems arising, using different criteria or a different weighting from those applicable in industrialised countries (ICs)

Furthermore, measures must be distinguished in terms of their efficacy over time and

the period of time for which they are designed. On a short-term horizon, measures are necessary to do away with the most unfavourable methods of handling and disposing of hazardous wastes, while on a long-term horizon acceptable solutions must be found to develop a strategy appropriate to the scant financial and environmental resources available.

The starting point for identifying and controlling hazardous waste is an analysis of possible sources (i.e. waste producers/imports). Hazardous waste results from production processes and is a consequence of the consumption of goods. However, industrial production is a very important factor, so that the compilation (and later updating where necessary) of an inventory of industrial establishments in the planning area will provide valuable pointers to the special waste types anticipated and arising. This process of identifying the existing situation is therefore an important basic step in special waste management. Particularly in developing countries, one must consider complex imported goods, which may produce very troublesome hazardous materials at the end of their life cycle.

Proceeding on this basis, further information must be obtained for efficient waste management planning. The following important process stages should be mentioned:

1. Inventory of the present generation points: type, quantity and composition of

hazardous wastes,

2. Estimate of future development,

3. Consideration of the occurrence of hazardous waste associated with imports,

4. Examination of the potential for safe collection and transport,

5. Inventory of existing and actually planned disposal/treatment plants for special wastes, by type (suitability for certain types of waste) and capacity,

6. Examination of possible alternatives identified in 5,

7. Examination of potential for waste minimisation through avoidance (e.g. use of new, environment-friendly technologies) and opportunities for marketing any recycled products (thermal/material),

8. Allocation of certain waste materials to suitable disposal methods (compilation of an allocation schedule or formulation of exclusions),

9. Preparation of longer-term, regionally coordinated waste management plans.

In addition to or alongside the above, further activities are required:

Legal:

- creation of a legal framework for waste management planning (legal foundation),
- legal establishment of priority of avoiding or recycling waste materials over (environmentally acceptable) disposal,
- prohibition of importation of hazardous waste within the meaning of the Basel Convention,
- verifying the appropriateness of an import ban on imported goods producing hazardous wastes at the end of their life cycle,
- establishment of the need for an environmental acceptability test in the case of important special waste disposal measures,
- legal establishment of defined planning stages in the construction of new plants for the disposal of hazardous waste (establishment of approval procedures),
- development of an administrative apparatus with clearly defined powers and responsibilities for implementing the regulations governing environment-friendly waste management,
- development of an effective system of sanctions

- establishment of rules governing liability for damage to property, ecological damage and human injury as a result of violations of the principles of environmentally acceptable waste management.

Economic:

- development and implementation of a system of economic incentives to avoid and minimise the occurrence of hazardous waste (e.g. by levying charges),
- establishment and implementation of the 'polluter pays' principle as a guideline for waste management,
- creation of local markets for used and residual materials,
- provision of waste banks for certain materials.

Other:

- measures to ensure that people working in this area have the relevant qualifications,
- training for a wider circle of people (e.g. plant operators, drivers, administrative staff),
- establishment of regionally coordinated waste management plans/planning aspects

2.6.2 importance of measures to avoid/minimise waste and promote recycling/reuse.

Stages 1 - 5 are the main steps towards waste management planning; stages 6 and 7 aim for minimisation of waste quantities, which will form the centrepiece of future waste management systems. Preventing hazardous waste from occurring in the first place (e.g. by using safer substitute materials or changing to a different system) is now and will in future be a basic and indispensable part of special waste management, of particular importance in developing countries.

Various measures can be taken to avoid and minimise special waste produced by commercial and industrial establishments:

- **input of low-polluting raw materials (with pretreatment where applicable);**
- **use of production processes generating minimal waste and residues;**
- **minimisation of pollutant burdens in the residual materials produced;**
- **use of closed circuits for recycling of residual materials;**
- **separation of domestic type waste and special types of waste.**

A further important step is the enshrinement in law of an obligation to recycle waste before disposal of hazardous wastes. This should be accompanied by measures to develop local markets for used and residual materials.

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3. Notes on the analysis and evaluation of environmental impacts

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In countries affected by the problems described above, it is vital to be able to identify hazardous wastes at the place of generation and to have knowledge of the associated hazard potential, in order to control these hazards effectively within the framework of waste management planning and to put the planning into practice. Therefore a binding schedule of waste types must be compiled in preparation for the further stages of planning and implementation of waste management measures. Demarcation criteria and definition questions must be formulated for maximum harmonisation with existing international regulations, so as to control transboundary movements of waste materials within the meaning of the Basel Convention (see Section 2. and Annex 1) as far as possible from this side of the border.

4. Interaction with other sectors

On the basis of information concerning the quantity, composition, hazardous nature etc. of the waste types, the actual waste management plan is drawn up with the following objectives:

1. **Regular collection (examining possibilities for separate collection) and removal of materials,**
2. **Safe and controlled transport of materials from the generation point to the treatment or disposal plant,**
3. **Availability of environmentally acceptable treatment/disposal plants appropriate to the material,**
4. **Regulation of administrative powers in the field of licensing and for any necessary monitoring.**

This scheme of objectives therefore embraces a very large number of aims and requirements. The following areas are addressed:

- effects on health,
- effects on the environment (questions of environmental compatibility),
- technical reliability, operational safety,

- political acceptance,
- recovery of (marketable) resources,
- economic efficiency,
- conservation and preservation of raw materials .

5. Summary assessment of environmental relevance

The first step in the environment-friendly planning and disposal of special wastes is to identify the waste materials arising at their generation point and to classify these materials on the basis of a schedule of waste types.

Waste management planning is limited by a number of secondary conditions which restrict the scope for action (listed in 2.2). These factors create conflicts in the disposal of special waste.

The most important requirements for (special) waste disposal, with a view to achieving minimal environmental pollution, can be summed up as follows:

1. Minimisation of waste through the use of production processes and imports which generate as little environmental pollution as possible,

2. Identification of waste at the waste production point,
3. Examination of these waste materials with a view to possible reuse and recycling,
4. Collection systems appropriate to the material properties and, where applicable, temporary storage of the materials recovered,
5. Transport of the waste materials to be disposed of or recycled by specially designed and officially approved vehicles; transportation by qualified and reliable drivers; establishment of the appropriate mode of transport and the precise transport routes,
6. Disposal of waste materials after examining the potential for recycling in suitable plants which have been constructed within a regional waste management scheme and have been tested for environmental acceptability. One should consider here:

- **maintenance of the state of the art for maximum reduction of the environmental pollution (emissions) associated with the plants, expansions of such plants and the resultant atmospheric immissions;**
- **emphasis on reuse and recycling of materials;**
- **heat generation, where the waste materials are suitable for this;**
- **matching of disposal capacities to the types and quantities of special waste generated;**

7. Development of regional markets for recycled products,
8. Planning and implementation of economic measures in the sphere of waste

management,

9. Encouragement to develop and implement plans to deal with commercial and industrial waste,

10. Establishment of authorities for effective planning and monitoring of the necessary measures and their actual implementation,

11. Creation of a legal framework for waste management planning and policy.

In assessing hazards, it is first necessary to trace the hazard sources. As described above, specific hazards occur depending on

- **the waste materials and their properties,**
- **the transport routes and modes of transport chosen against the background of the (traffic) situation within the disposal area,**
- **the disposal plants available and their environmental protection facilities,**
- **the application of regulations under health and safety law.**

Besides these different types of objective hazards, other sources of hazard must be borne in mind when dealing with these materials. That is to say, the factors of

- **human error,**
- **technical faults,**
- **extraneous factors (earthquake, flood etc.)**

must be included in the hazard model (preparation of incident plans with contingency measures, worst-case scenarios etc.).

Since there are so many aspects to take into account, putting all these measures into practice is no easy matter. Compatible strategy elements must be therefore planned and implemented on a long-term horizon. As waste is produced as an end product of economic processes, a waste management policy will in turn have many different effects on these economic processes. This is all the more true of special waste because of its immediate proximity to the production area. Annex 9 summarises the main elements of this environmental field.

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Annexes

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Annex 1 - Categories of wastes to be controlled under the basel convention

Waste streams

Y 1 Clinical wastes, from medical care in hospitals, medical centres and clinics

Y 2 Wastes from the production and preparation of pharmaceutical products

Y 3 Waste medicines, drugs and wastes from pharmaceutical products

Y 4 Wastes from the production, formulation and use of biocides and phyto-pharmaceuticals

Y 5 Waste from the manufacture, formulation and use of wood preserving chemicals

Y 6 Wastes from the production, formulation and use of organic solvents

Y 7 Wastes from heat treatment and tempering operations containing cyanides

Y 8 Waste mineral oil, unfit for its originally intended use

Y 9 Hydrocarbon/water mixtures, emulsions

Y 10 Waste substances and articles containing polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)

Y 11 Waste tarry residues arising from refining, distillation and pyrolytic processes

Y 12 Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers and varnish

Y 13 Wastes from the production, formulation and use of resins, latex, plastics, glues/adhesives

Y 14 Waste chemical substances arising from research and development or teaching activities and which are not identified and/or are new and whose effects on man and/or the environment are not known

Y 15 Wastes of an explosive nature not subject to other legislation

Y 16 Wastes from the production, formulation and use of photographic chemicals

Y 17 Wastes resulting from surface treatment and finishing of metals and plastics

Y 18 Residues arising from industrial waste disposal operations

Waste having as constituents

Y 19 Metal carbonyls

Y 20 Beryllium, beryllium compounds

Y 21 Hexavalent chromium compounds

Y 22 Copper compounds

Y 23 Zinc compounds

Y 24 Arsenic, arsenic compounds

Y 25 Selenium, selenium compounds

Y 26 Cadmium, cadmium compounds

Y 27 Antimony, antimony compounds

Y 28 Tellurium, tellurium compounds

Y 29 Mercury, mercury compounds

Y 30 Thallium, thallium compounds

Y 31 Lead, lead compounds

Y 32 Inorganic fluorine compounds excluding calcium fluoride

Y 33 Inorganic cyanides

Y 34 Acid solutions or acids in solid form

Y 35 Basic solutions or bases in solid form

Y 36 Asbestos (dust and fibres)

Y 37 Organic phosphorus compounds
Y 38 Organic cyanides
Y 39 Phenols: phenol compounds including chlorophenols
Y 40 Ethers
Y 41 Halogenated organic solvents
Y 42 Organic solvents excluding halogenated solvents
Y 43 All substances, polluted with polychlorinated dibenzo-furans
Y 44 All substances, polluted with polychlorinated dibenzo-p-dioxins
Y 45 Organohalogen compounds other than those substances referred to in this Annex.

Annex 2 - List of hazardous characteristics in accordance with the basel convention

Hazardous characteristics United Nations class	Code number	Characteristics
1	H1	Explosive substances or waste An explosive substance or waste is a solid or liquid substance or waste (or a mixture of substances or wastes) which is in itself capable by chemical reaction of

		producing gas at such a temperature, pressure or speed as to cause damage to the surroundings.
3	H3	Flammable liquids Flammable liquids are liquids or mixtures of liquids containing solids in solution or suspension (for example paints, lacquers, varnishes, etc., but not including substances or wastes otherwise classified on account of their hazardous characteristics) which give off a flammable vapour at a temperature of not more than 60.5C, closed-cup test, or not more than 65.6C, open-cup test.
4.1	H4.1	Flammable solids Solids, or waste solids, other than those classed as explosives, which under conditions encountered in transport are readily combustible, or may cause or contribute to fire through friction.

4.2	H4.2	Substances or wastes liable to spontaneous combustion Substances or wastes which are liable to spontaneous heating under normal conditions encountered in transport, or to heating up on contact with air, and being then liable to catch fire.
4.3	H4.3	Substances or wastes which, in contact with water, emit flammable gases Substances or wastes which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities
5.1	H5.1	Oxidising substances or wastes which, while in themselves not necessarily combustible, may, generally by yielding oxygen cause, or contribute to, the combustion of other materials.

5.2	H5.2	Organic peroxides Organic substances or wastes which contain the bivalent O-O structure and are thermally unstable substances which may undergo exothermic self-accelerating decomposition.
6.1	H6.1	Poisonous substances (with acute action) Substances or wastes liable either to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact.
6.2	H6.2	Infectious substances Substances or wastes containing viable micro-organisms or their toxins, which are known or suspected to cause disease in animals or humans.
8.	H8	Corrosives Substances or wastes which, by chemical action, will cause severe damage when in contact with living tissue, or, in case of leakage, will materially damage, or even

		destroy, other goods or the means of transport; they may also cause other hazards.
9.	H10	Liberation of toxic gases in contact with air or water Substances or wastes which, by interaction with air and water, are liable to give off toxic gases in dangerous quantities.
9.	H11	Toxic substances (with delayed or chronic action) Substances or wastes which, if they are inhaled or ingested or if they penetrate the skin, may involve delayed or chronic effects, including carcinogenicity.
9.	H12	Ecotoxic substances Substances or wastes which if released present or may present immediate or delayed adverse impacts to the environment by means of

		bioaccumulation and/or toxic effects upon biotic systems.
9.	H13	Substances, capable, by any means, after disposal, of yielding another material, e.g. leachate, which possesses any of the characteristics listed above.

Annex 3 - Disposal operations under the basel convention

A Operations which do not lead to the possibility of resource recovery, recycling, reclamation, direct re-use or alternative uses

D1 Deposit into or onto land, (i.e. landfill etc.)
D2 Land treatment (e.g. biodegradation of liquid or sludgy discards in soils etc.)
D3 Deep injection (e.g. injection of pumpable discards into wells, salt domes or naturally occurring repositories etc.)
D4 Surface impoundment (e.g. placement of liquid or sludge discards into pits, ponds, lagoons etc.)
D5 Specially engineered landfills (e.g. placement into lined, discrete cells, which are capped and isolated from one other and the environment etc.)

D6 Release into a water body except seas/oceans

D7 Release into seas/oceans including sea-bed insertion

D8 Biological treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations in Section A

D9 Physico-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations described in Section A (e.g. evaporation, drying, calcination, neutralisation, precipitation etc.)

D10 Incineration on land

D11 Incineration at sea

D12 Permanent storage (e.g. emplacement of containers in a mine etc.)

D13 Blending or mixing prior to submission to any of the operations in Section A

D14 Repackaging prior to submission to any of the operations in Section A

D15 Storage pending any of the operations in Section A (temporary storage).

B. Operations which may lead to resource recovery, recycling, reclamation, direct re-use or alternative uses

R1 Use as a fuel (other than in direct incineration) or other means to generate energy

R2 Solvent reclamation/regeneration

R3 Recycling/reclamation of organic substances which are not used as solvents

R4 Recycling/reclamation of metals and metal compounds
R5 Recycling reclamation of inorganic materials
R6 Regeneration of acids or bases
R7 Recovery of components used for pollution abatement
R8 Recovery of components from catalysts
R9 Used oil re-refining or other reuses of previously used oil
R10 Land treatment resulting in benefit to agriculture or ecological improvement
R11 Use of residual materials obtained from any of the operations numbered R1-R10
R12 Exchange of wastes for submission to any of the operations numbered in R1-R11
R13 Accumulation of materials intended for any operation described in Section B.

Annex 4 - List of toxic or dangerous substances and materials

According to the Annex to the EC Directive on toxic and dangerous waste of 20 March 1978 (78/319/EEC - O.J. L 84 of 31 March 1978, p. 43)

1 Arsenic; arsenic compounds
2 Mercury, mercury compounds
3 Cadmium; cadmium compounds

4 Thallium; thallium compounds
5 Beryllium; beryllium compounds
6 Chrome 6 compounds
7 Lead; lead compounds
8 Antimony; antimony compounds
9 Phenols; phenol compounds
10 Cyanides, organic and inorganic
11 Isocyanates
12 Organic-halogen compounds, excluding inert polymeric materials and other substances referred to in this list or covered by other Directives concerning the disposal of toxic or dangerous waste
13 Chlorinated solvents
14 Organic solvents
15 Biocides and phyto-pharmaceutical substances
16 Tarry materials from refining and tar residues from distilling
17 Pharmaceutical compounds
18 Peroxides, chlorates, perchlorates and azides
19 Ethers
20 Chemical laboratory materials, not identifiable and/or new, whose effects on the environment are not known
21 Asbestos (dust and fibres)

22 Selenium; selenium compounds
23 Tellurium; tellurium compounds
24 Aromatic polycyclic compounds (with carcinogenic effects)
25 Metal carbonyls
26 Soluble copper compounds
27 Acids and/or basic substances used in the surface treatment of metals.

Annex 5 - Summary 1

Simple and practical scheme for the identification and classification of special wastes (e.g. Naples 1983) (excerpt)

(1)	**Consistency**		
	- solid	- liquid	- sludgy
(2)	**Appearance/size of components**		
	Powder	Emulsion	wet
	small particles	oily	dry

	medium particles	water-based	non-aqueous
	large particles	other base	not known
	not known	not known	
(3)	**Main components/origin**		
	organic (of chemical or petrochemical origin)		
	organic (of biological origin)		
	metallic		
	inorganic and organic		
	inorganic		
	not known		
(4)	**Occurrence of**		
	heavy metals		
	phenols and derivatives		
	cyanides and isocyanides		
	halogenated organic		

	substances		
	organic solvents (non halogenated)		
	biocides, pharmaceuticals		
	tar residues		
	asbestos		
	oxidising organic materials		
	none of those mentioned		
	not known		
(5)	**pH value of waste material**		
	acid		
	basic		
	neutral		
	not known		
(6)	**Combustibility**		
	readily ignitable		
	ignitable		

	flammable combustible		
etc.			

***Source*: World Bank Technical Paper 93, Vol. I, p. 154 f.**

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Annex 6 - Summary 2 (A-O)

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Checklist for special wastes

Type of works	Special wastes liable to occur (and other information)

A	
Absorption of oils (in case of incident)	Sawdust, inorganic solvents and chips soaked in oil
Absorption of oils (in case of incidents)	Sawdust, anorganic solvents and oil-soaked chips
Absorption of other liquids and sludges (in case of incident)	Sawdust, inorganic solvents and chips otherwise polluted, all possible solvents, acids and alkalis; inquire about substances
Absorption of solvents	Sawdust, inorganic absorbents and chips, solvent-soaked, HCs, CHCs, other organic solvents
Absorption of solvents (in case of incident)	Sawdust, inorganic solvents and chips soaked in solvent, hydrocarbons, chlorinated hydrocarbons, other organic solvents
Accumulator battery manufacture	Lead-containing dust, sulphuric acid

Acid sludge splitting plants	Acid sludge preparation residues
Air and gas cleaning, filtration processes	Paper filters, asbestos filters, a very large number of hazardous materials possible
Air and gas compressors	Compressor condensates, used oils
Aluminium production	Bauxite residues, alkaline sludges (containing iron (III)), fluoric salts
B	
Barrel and tank cleaning	Sludge from tank cleaning and barrel washing
Blast furnaces	Slags with all heavy metals possible, sulphur compounds
Blasting plants	Heavy metals (arsenic, lead, mercury)
Bleaching works, textile industry, cellulose production	Hypochlorite spent lye
Building and plant demolition	Materials containing asbestos
Building and plant demolition, oil	Rubble, chemically polluted with

and chemical incidents	solvents, oil, PCBs, asbestos
Buildings and wood preservation	All paints, dispersants, solvents (e.g. chlorinated hydrocarbons, methanol, formalin, impregnating materials)
C	
Cables and batteries production, lead production, lead foundries, lead processing, printing works, electrical engineering	Lead-containing dust
Capacitors	PCBs
Cellulose production	Sulphite spent lye, wastewater/sludges containing cellulose
Cellulose production, textile industry, bleaching works	Hypochlorite spent lye
Ceramic products and glass manufacture, textile industry, hardening shops	Barium salts, lead salts

Ceramic products and glass manufacture, textile industry, chemical industry, hardening shops	Barium salts
Ceramic products manufacture	Barium salts, lead salts, oxides
Ceramic products manufacture, manufacture and processing of glass, glazing preparation	Glass and ceramic waste with product-specific admixtures
Ceramic products manufacture, glass, glazing preparation	Glass and ceramic waste with production-specific admixtures
Ceramics industry, chemical industry, metallurgy	Silicic acid and quartz waste with production-specific admixtures
Chemical cleaning, redistillation	Distillation residues, salt-and solvent-free; distillation residues, containing solvent (halogen-free), distillation residues, containing salt
Chemical industry	
Air and gas cleaning, filtration processes	Paper filters, otherwise unpolluted, a very large number of hazardous materials possible

	(process-dependent)
Building and plant demolition	Rubble, chemically polluted with solvents, etc.
Ceramics industry, metallurgy	Silicic acid and quartz waste with production-specific admixtures (e.g. lead salts)
Chemical cleaning, redistillation	Perchloroethane, tetrachloromethane, distillation residues, salt- and solvent-free, distillation residues containing solvents (halogen-free), distillation residues, containing salts
Chlorine production	Barium sulphate sludge, containing mercury
Cleaning and degreasing of metal surfaces, manufacture of paints, varnishes and similar products, textile industry, plastics processing	Nitrodilution, chlorinated hydrocarbons, other solvents

Commerce	Fine chemicals of all types
Crop treatment products	Copper chloride
Electroplating works, zinc coating shops, printing works	Zinc hydroxide, hydrochloric acid
Leather production	Alkali and alkaline earth sulphides, chromates
Manufacture, distribution and application of crop treatment products and pesticides	Old stocks of such products
Manufacture of ceramic products, manufacture and processing of glass, glazing preparation, electrical engineering, manufacture of fluorescent tubes, lamps, television tubes	Glass and ceramic waste with production-specific admixtures
Manufacture of ceramic products and glass, textile industry, hardening shops	Barium salts
Manufacture of detergent raw materials	Arsenic trisulphide, phosphorus salts

Manufacture of detergents, cleaning and scouring materials	Manufacturing residues from detergent manufacture, liquid surfactants, solid surfactants
Manufacture of nonferrous metals	Salts of heavy metals, some water-soluble
Manufacture of paints, varnishes and similar products	Aromatic amines, glycol ethers, nitrodilutions, cresols, butanol, ethanol, other solvents, colouring pigments (some containing heavy metals)
Manufacture of pharmaceutical products, textile industry, manufacture of paints, varnishes and similar products	Ethanol, butanol, organic active ingredients
Manufacture of viscose and dyes, gas cleaning	Residues with elementary sulphur
Metal production	Metallic salts and oxides of all types in various mixtures, some water-soluble, nearly always acid-soluble.

Neutralisation, flue gas desulphurisation	Gypsum sludges with production-specific admixtures
Petrochemicals	Hydrocarbons, tars, distillation residues, metallic soaps, chain and cyclic hydrocarbons
Photographic chemical works	Other concentrates, some containing heavy metals
Plant construction, mineral oil processing	Contact compounds
Plastics processing	Manufacturing residues from plastics manufacture and processing, plastic sludges, containing solvents (halogen-free), aliphatic amines, plasticizers, additives
Transformers	Transformer oils, thermal oils, possibly with traces of PCBs
Chemical industry, metallurgy and other sectors, industrial wastewater treatment	Other sludges from precipitation and solution processes with product-specific admixtures, salts containing cyanide

Chemical industry, manufacture of crop treatment products and pesticides	Old stocks of crop treatment products and pesticides
Chemical industry, trading	Fine chemicals of all types
Cleaning and degreasing of metal surfaces, manufacture of paints, varnishes and similar products, textile industry, plastics processing	Nitrodilutions, petroleum, solvents, chlorinated hydrocarbons, other solvents
Cleaning and scouring products, detergents manufacture	Manufacturing residues from detergent manufacture, liquid surfactants, solid surfactants
Cleaning and scouring products, detergents manufacture	Manufacturing residues from detergent manufacture, liquid surfactants, solid surfactants
Coking works, gas works,	Anthracene residues, naphthalene-containing residues, residues containing phenol, sludge from coking works and gas works wet dust scrubbers, distillation

petrochemicals	residues from tar oil production, phenol water, other sludges from coking works and gas works, polycyclic aromatic hydrocarbons
Conductor plates manufacture	Copper chloride, iron chloride, solutions/sludges
Coolant manufacture and use	Coolants, ammonia, CFCs
Crop treatment products and pesticides manufacture, trading and application	Old stocks of crop treatment products and pesticides
Crop treatment products and pesticides manufacture, trading and application	Old stocks of crop treatment products and pesticides
D	
Decanting plants, emulsion separation plants	Sludge from oil separation plants
Detergent raw materials manufacture, chemical industry	Arsenic trisulphide
Detergents manufacture, cleaning and scouring products, chemical	Manufacturing residues from detergent production, liquid

industry	surfactants, solid surfactants
Dry flue gas cleaning	Mineral residues from waste gas cleaning, cyclical organic compounds
Dyes and viscose manufacture, gas cleaning	Residues with elementary sulphur
E	
Electrical engineering, lead production, foundries, printing works, manufacture of batteries and cables, lead processing	Dust containing lead
Electrical engineering	Copper chloride
Electrical engineering and electroplating works and electroplating divisions of works	Electroplating slduge containing chrome (III), electroplating sludge containing copper, zinc, nickel, cobalt and noble metals
Electroplating works, zinc coating shops, printing works, manufacture of printing blocks	Zinc hydroxide
Electroplating works, zinc coating	

shops, printing works, manufacture of printing blocks	Zinc hydroxide
Electroplating works and electroplating divisions of works	Electroplating sludge containing cyanide, chrome (III), copper, zinc, nickel, cobalt or noble metals, other heavy metals such as lead, arsenic, tin
Emulsion separation plants, decanting plants	Sludge from oil separation plants
Etching works, printing works	Copper chloride solution
F	
Filling stations, vehicle workshops	Used oil, hydrocarbons, organic compounds
Filling stations, motor vehicle workshops	Used oil (containing PCBs?), hydrocarbons, solvents of all types
Film development and copying	Bleaching baths, containing silver
Filtration processes, air and gas cleaning	Paper filters, asbestos filters, a very large number of possible hazardous materials, process-

	dependent
Flue gas desulphurisation, chemical industry, neutralisation	Gypsum sludges with production-specific admixtures
Foundries	Organic adhesives possible (containing formaldehyde, phenol and cyanate), pyrolysis products
G	
Gas and air cleaning, filtration processes	Paper filters, asbestos filters, a very large number of hazardous materials possible, process-dependent
Gas and air compressors	Compressor condensates
Gas and air compressors	Compressor condensates
Gas cleaning, manufacture of viscose and dyes, chemical industry	Residues with elementary sulphur
	Anthracene residues, residues containing naphthalene, residues containing phenol , sludge from coking plants and gas works wet

Gas works, petrochemicals, coking plants	dust scrubbers, distillation residues from tar oil products, phenol water, other sludges from coking works and gas works, organic sulphur compounds, anthracene, toluol, xylol, phenol, phenandrene, cyanide
Gasworks, petrochemicals, coking plants	Anthracene residues, residues containing naphthalene, residues containing phenol, sludge from coking plants and gas works wet dust scrubbers, distillation residues from tar oil products, phenol water, other sludges from coking works and gas works, organic sulphur compounds, anthracene, toluol, xylol, phenol, phenandrene, cyanide
Glass, metal processing	Grinding sludge containing oil
Glass, metal processing	Grinding sludges containing oil
Glass and ceramic products	Barium salts, lead salts, lead

manufacture	oxides
Glass processing, manufacture of ceramic products, glazing preparation, electrical engineering, manufacture of fluorescent tubes, lamps, television tubes	Glass and ceramic waste with product-specific admixtures
H	
Hardening shop steel treatment	Hardening shop sludge, containing nitrate, containing nitrite; hardening oils, sludges containing ammonia, sludges containing cyanide, barium carbonate sludge
Hardening shops	Thermal oils, usually free of polychlorinated biphenyls and polychlorinated terphenyls
Horticultural establishments, market gardens	Old stocks of crop treatment products and pesticides
Hospitals	Infectious waste, medicines of all types, mercury, cleaning products,

	infective matter
Hospitals, laboratories	Chromic-sulphuric acid, other corrosive or oxidising substances, other chemicals
Hot-dip galvanizing, zinc production	Dust containing zinc
I	
Industrial wastewater treatment from the chemical industry, metallurgy and other sectors	Other sludges from precipitation and solution processes with production-specific admixtures, salts containing cyanide, mercury salts
Institutions, works laboratories, schools	Laboratory chemical residues, biological waste
Iron, steel and malleable iron casting and steel production	Blast furnace dusts, tempering compounds, charging masses, blast furnace sludge; strippings from converters (basic slag), containing heavy metals

Iron and steel production, iron, steel and malleable-iron casting	Blast furnace gas dusts, blast furnace gas sludge, demolition of converters (Thomas steel)
Iron and steel production, iron, steel and malleable-iron casting	Blast furnace dusts, tempering compounds, organic adhesive compounds (phenol, formaldehyde isocyanates)
L	
Laboratories, institutions, schools	Laboratory chemical residues of all types
Laboratories	Corrosive, toxic substances and compounds of all types
Lead foundries, printing works	Lead dross
Lead production, foundries, printing works, electrical engineering, manufacture of batteries and cables, lead processing, electrolysis	Lead-containing dust, lead ash, lead sludge
Leather production, chemical industry	Alkali and alkaline earth sulphides

Light metals production	Slags from smelting electrolysis
M	
Machinery and vehicle construction, electroplating works and electroplating divisions of works	Electroplating sludge containing chrome (III), zinc, nickel, cobalt, noble metals
Magnesium production, foundries, refineries, processing	Dust containing magnesium
Manufacture of clocks, electroplating works and electroplating divisions of works (such as e.g. machine and vehicle construction, electrical engineering, precision engineering and optics, manufacture of iron, sheet and metal goods	Electroplating sludge containing Chrome (III), copper, zinc, nickel, cobalt, noble metals
Manufacture of paints, varnishes and similar materials	Nitrodilution, propanol, cresols, glycol ethers, ethanol, butanol, all other solvents, colouring pigments (some heavy metal oxides)

Manufacture of tools	Erosion sludge (petroleum and graphite)
Metal and glass working	Grinding sludges, containing oil
Metal cutting, surface treatment	Drilling, cutting and grinding oils, cooling lubricants, amines, nitrite salts
Metal cutting, surface treatment	Drilling, cutting and grinding oils; nitrites, amines (nitrous amines possible?), cooling lubricants
Metal processing, refrigeration engineering	Coolant solutions, CFCs, ammonia, solvents of all types, cooling lubricants
Metal surface treatment	Honing sludge, lapping sludge, honing oils
Metal surfaces cleaning and degreasing	Petroleum, hydrocarbons, chlorinated hydrocarbons
Metal surfaces cleaning and degreasing, manufacture of paint, varnishes and similar products,	Nitrodilutions, cold cleaners, chlorinated hydrocarbons,

textile industry, plastics processing	hydrocarbons, other solvents
Metal working, general	Heavy metals, volatile CHCs, cooling lubricants
Metallurgy, ceramics industry, chemical industry	Silicic acid, and quartz waste with production-specific admixtures
Metallurgy and other sectors, industrial wastewater treatment	Other sludges from precipitation and solution processes with production-specific admixtures, salts containing cyanide
Mineral oil processing, plant construction	Contact compounds
Mineral oil processing and storage, filling stations	Volatile chlorinated hydrocarbons, hydrocarbons, petrols, benzene, diesel oil, aromatic hydrocarbons (benzol, toluol)
Mineral oil refinement	Waste acid, containing mineral oil
Mining	Hydraulic oils (some containing PCBs), used oils, lubricants, polycyclic aromatic hydrocarbons

	(benzol and naphthalene derivatives)
Motor vehicles, scrap trade	Battery acids, used oil, hydrocarbons
N	
Neutralisation, flue gas desulphurisation, chemical industry	Gypsum sludges with production-specific admixtures
NF metal production, NF metal foundries	Slags from NF metal melts, filter dusts, containing heavy metals
NF metal production, foundries, refineries, processing	Dusts in salt or oxide form containing metal, compositions and hazards possible
NF metal production, NF metal foundries	Slags from NF metal smelting (all metal compounds possible), filter dusts, containing heavy metals; residues of adhesives (formaldehyde, isocyanate etc.)
NF metal production, foundries,	Dusts and salts containing metal of all compositions and hazards are

refineries, processing	possible; filters and filter residues containing metal dust
NF metals production	Heavy metal sulphides, vanadium salts, chromium salts, lead sulphates
O	
Oil accidents	Used oil binders, PCBs (?), asbestos (?)
Oil and chemical incidents, building and plant demolition	Rubble, chemically polluted with solvents, oil, PCBs (?), asbestos (?)
Optical industry, electroplating works and electroplating divisions of works	Electroplating sludge containing chrome (III), copper, zinc, nickel, cobalt, noble metals

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Annex 6 - Summary 2 (P-Z)

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P	
Paint shops, painting works, trading	Old lacquers, old paints, solvents of all types
Paint shops	Paint shop waste, paints, lacquers, all solvents
Painting works, painting shops, trading	Old lacquers, old paints
Painting works, textile industry, carpet manufacture	Latex sludges, latex emulsions
Petrochemicals	Paraffin oil sludge
Petrochemicals	Coking works
	Distillation residues from tar oil production; phenol water; anthracene residues, residues

Petrochemicals, coking works, gas works	containing naphthalene, residues containing phenol, paraffin oil sludge; metallic soaps; other sludges from petrochemicals
Pharmaceutical products manufacture, processing of animal organs	Protein waste; infection hazard (?)
Phosphating, heat treatment and tempering operations	Phosphating sludge
Photographic chemical works, photographic laboratories, radiography laboratories, printing works, manufacture of printing blocks	Fixing baths, containing silver
Photographic chemical works, photographic laboratories, radiography laboratories, printing works, manufacture of printing blocks	Fixing baths, containing silver, other concentrates

Pickling plants	Chromic-sulphuric acid or other corrosive or oxidising acids, chlorinated hydrocarbons, heavy metals
Plant and building demolition	Materials containing asbestos may occur
Plant and building demolition after oil and chemical incidents	Rubble, chemically polluted with oil, PCBs possible, asbestos
Plastics processing, manufacture of paints, varnishes and similar products	Resin residues, not hardened
Plastics processing, chemical industry	Plasticizers, halogen-free
Plastics processing, cleaning and degreasing of metal surfaces, manufacture of paints, varnishes and similar products, textile industry, chemical industry	Nitrodilutions, CHCs
Plastics processing, manufacture	

of paints, varnishes and similar products, chemical industry	Cresols
Plastics processing	Aliphatic amines, manufacturing residues from plastics manufacturing and processing, plastics sludges, containing solvents, residues of resin oil, CFCs
Plastics processing, manufacture of paints, varnishes and similar products	Resin residues
Precision engineering and electroplating works and electroplating divisions of works	Electroplating sludge containing chrome (III), electroplating sludge containing copper, zinc, nickel, cobalt and noble metals
Printing block production, printing works, zinc coating shops	Zinc sludge
Printing block production, photographic chemical works,	

photographic laboratories, radiography laboratories, printing works	Fixing baths, containing silver
Printing block production, electroplating works, zinc coating shops, printing works, chemical industry	Zinc hydroxide
Printing ink manufacture	Printing ink residues
Printing works, lead foundries	Lead dross, dust containing lead, printing ink residues
Printing works, zinc coating shops, manufacture of printing blocks	Zinc sludge
Printing works, electroplating works, zinc coating shops, manufacture of printing blocks, chemical industry	Zinc hydroxide
Printing works, etching works	Copper chloride solution
Processing of animal organs, manufacture of pharmaceutical	Protein waste

products	
R	
Radiographic laboratories, photographic chemical works, photographic laboratories	Fixing baths, containing silver
Railways	Battery acids, hydrocarbons, used oils, insecticides/pesticides
Refrigeration engineering, metalworking	Coolant solutions, ammonia, CFCs
S	
Schools, institutions, works laboratories	Laboratory chemical residues of all types
Scrap trade, motor vehicles	Battery acids, used oil, hydrocarbons
Slags from blast furnace process and refuse incineration plants	Heavy metals
Starters of fluorescent tubes	PCBs (if made before 1984)
	Transformer oils, thermal oils, some free from polychlorinated

Substations, transformers	biphenyls (PCBs) possible; hydrocarbons, chlorobenzols
Surface finishing, phosphating	Phosphating sludge
Surface finishing of metals	Ammonium bifluoride
Surface treatment, metal cutting	Drilling, cutting and grinding oils
Surface treatment and finishing	Rinsing and washing water, sludges containing metallic salts, cyanide, ammonium bifluoride, phosphate
T	
Tank and barrel cleaning	Sludge from tank cleaning and barrel washing; hydrocarbons
Tank farms	Polluted heating oils, polluted fuels
Tanneries	Tannery liquor, chromates, alkali and alkaline earth sulphates
Television tube manufacture, lamps, fluorescent lamps	Glass and ceramic waste with production-specific admixtures

Textile industry, texturing	Acid oil waste
Textile industry, cellulose production, bleaching works	Hypochlorite spent lye
Textile industry, carpet manufacture, painting works	Latex sludges, latex emulsions
Textile industry, manufacture of paints, varnishes and similar products	Propanol
Textile industry, manufacture and degreasing of metal surfaces, manufacture of paints, varnishes and similar products, plastics processing	Nitrodilutions, ethanol, butanol
Tool manufacture	Glue and adhesive waste, putty and stopping waste
Trading of paint products	Old lacquers, old paints
Transformers, substations	Transformer oils, thermal oils, free of polychlorinated

	biphenyls (PCBs) possible, hydrocarbons, chlorobenzols
V	
Vehicle workshops, filling stations	Used oil, hydrocarbons, lead-organic compound, alcohol
Viscose and dyes manufacture, gas cleaning, chemical industry	Residues with elementary sulphur, copper salts
W	
Waste treatment plants	Hydrocarbons, chlorinated hydrocarbons, used oil
Wood preservation and buildings	All paints, dispersants, solvents
Z	
Zinc coating shops, printing works, manufacture of printing blocks	Zinc sludge
Zinc coating shops, printing works, electroplating works, manufacture of printing blocks,	Zinc hydroxide sludges

chemical industry	
Zinc production, foundry, hot-dip galvanizing, zinc processing	Dust containing zinc

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Annex 7 - A proposed waste classification scheme

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Waste types/Industry groups

		A	B	C	D	E	F	G	H	J	K	L
I	Anorganic waste											
	Acids and alkalis	x		x	x		x	x	x	x		
	Wastes containing cyanide				x							
	Sludges and				x	x	x	x	x			

	solutions											
	containing heavy metals											
	Wastes containing asbestos					x	x					
	Solid residues (n.f.s.)				x							
II	Wastes containing oil								x			
III	Organic waste											
	Halogenated solvents						x	x	x			x
	Non-halogenated solvent residue	x					x	x	x	x		
	Wastes containing PCBs						x	x				
	Paint and resin wastes						x	x	x	x		
	Biocides	x				x	x	x	x	x		

	Other organic chemical			x	x		x					
	residues (n.f.s.)											
IV	Putrefactive organic waste	x					x		x			
V	Wastes with high volume generation and low pollutant potential		x	x			x					
VI	Mixed wastes											
	Infectious wastes	x									x	
	Laboratory wastes						x				x	
	Explosive wastes						x	x				x

n.f.s not further specified

Key, industry/waste groups

A Agriculture, forestry and food industry

B Mining and raw materials production

C Energy sector

D Metal production and processing

E Manufacture of non-metallic raw materials and industrial products

F Chemical and related industries

G Metal processing, motor vehicle production

H Textiles, clothing industry, wood working

J Paper manufacture, printing industry

K Health sector

L Services sector

A Agriculture, forestry and food industry

Agriculture, forestry, fishery sector;
Food sector: animal and plant products;
Drinks industry;
Animal feeds manufacture.

B Mining and raw materials production

Mining and production of non-metal raw materials;
Mining and production of metallic raw materials.

C Energy

Coal production and recycling;
Oil and gas industry, including oil and petrol production and other refinery products;
Power generation;
Drinking water production;
Energy distribution.

D Metal production and processing

Ferrous metals;

Non-ferrous metals;
Foundries.

E Manufacture of non-metallic raw materials and industrial products

Minerals, ceramics and glass;
Salt refining;
Products containing asbestos;
Abrasives.

F Chemical and related industries

Petrochemicals;
Production of primary chemicals and chemical starting materials;
Production of paints, lacquers, colourings and adhesives;
Manufacture of photographic products;
Perfume industry and manufacture of soaps and detergents;
Manufacture of consumer goods from rubber and plastic;
Manufacture of explosives and blasting powder;
Manufacture of biocides.

G Metal processing, motor vehicle manufacture

Mechanical engineering;
Manufacture of data processing equipment, computer industry;
Electrical engineering;
Automobile industry;
Manufacture of other transport equipment;
Plant construction, process engineering;
Other metal-processing industrial sectors (n.f.s.),

H Textiles, leather and clothing industry, wood working

Textiles, clothing and shoe industry;
Fur and leather industry;
Building timber, structural timber and furniture industry;
Other non-metal processing industries (n.f.s.)

J Paper manufacture, printing industry, publishing

Paper and board manufacture;
Printing industry, publishing, reproduction.

K Medical sector and health sector/veterinary services

Health; hospitals, doctors' surgeries and laboratories;
Veterinary services.

L Other services

Laundries, chemical and dry cleaning; dryers;
Cosmetics institutions;
Other services sectors (n.f.s.).

Source World Bank Technical Paper 93, Vol. I, p. 14f and 20f.

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Annex 7a - Waste types according to the specimen classification scheme

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Batstone, R., Smith, J.E., Wilson, D. (ed.):

The Safe Disposal of Hazardous Wastes, The Special Needs and Problems of Developing Countries, Vol. I, II, III; World Bank Technical Paper Number 93. A joint study sponsored by the World Bank, the World Health Organization (WHO), and the United Nations Environmental Programme (UNEP), Washington D.C., 1989.

I INORGANIC WASTE

ACIDS AND ALKALIS

Waste streams	Industry/process	Industry groups
Acids		
Sulphuric acid Pickles containing iron Acid solvents Nitric acid Chromic acid Stainless steel cleaning products Acid sludge Reagents	Electroplating Steel pickling Metal finishing Organic synthesis Electrolytic oxidation Metal surface treatment Coking Pesticide manufacture	D D D F D D C F
Alkalis		

Alkaline detergents Corrosive liquids containing ammoniaPickling baths Wastes containing ammonia Pickling sludges Pickling Sludges containing ammonia	Metal degreasing Electrical engineering Metal finishing Copying shops, chemical synthesis Oil, re-refining Oil, refining Coking/gas works	D G D F/L F C C
Wastes containing cyanide		
Untreated rinsing water Electroplating process solvents Heat treatment waste Concentrates and semi-concentrates	Electroplating Steel production Hydrometallurgy Chemical synthesis Spraying(pest control)	D D D D F L
Heavy metal sludges and solutions containing heavy metals		
Lead sludges Wastewater treatment sludge from mercury cell process, brine cleaning,	Chlorine production Chrome dyes	F F

mercury cell process Wastewater treatment sludges Surface treatment Cleaning sludges Acid plant Process sludges from electrolysis - cadmium residues - lye residues - lead sludges - other sludges Briny sludges from acid plants Wastewater treatment/sewage sludges Pickling Zinc and other heavy metal sludges Filter dusts Pickles and sludges	Wood storage (1) Lead smelting process (2) Lead smelting process (3) Zinc production Battery production Tin plate mill Electroplating works Copper production (2) Copper production Textile industry Steel production Steel finishing	H D D D G D D D D H D D
Untreated wastewater and wastewater treatment sludges Mixed metal sludges	Explosives manufacture Manufacture of paints, varnishes and similar products Photographic process	F F F

Waste sludges Reagents Asbestos dust Pipe cleaning and insulation materials Compounds containing asbestos	Electrical industry Preparation and process technology for asbestos Power station, industrial manufacture, gas works, ports, hospitals and schools Chlorine production	F G E F
Solid residues (n.f.s.)		
Filter dusts Dusts and sludges Waste sands Filter dusts Draught furnace slag Old catalysts Solid residues Wastes containing carbon	Steel production Ferromanganese furnace Silicon manganese electric furnace Ferrochromium electric furnace Iron and steel smelting Iron and steel smelting Lead smelting process (3) Copper smelting process (3) Chemical synthesis Rubber production Manufacture sulphuric acid, chemical synthesis	D D D D D D D D F F F

Scrap batteries Iron oxides	Different sources Gas cleaning/coking	Various C

Notes:

(1) When using chromated copper arsenates
(2) Primary mat.
(3) Secondary mat.

n.f.s. not further specified

II WASTE CONTAINING OIL

Waste streams	Industry/process	Industry groups
Used oils Contaminated benzine oils Compressor condensates Grit chamber residues	Car workshops, filling stations, textiles Oil tanks and containers Compressors Manufacture of decomposition materials,	G/L H Various Various E

	Chemical synthesis	F
	Grit chamber, vessels	Various
Sludges containing oil, containing cyanide	Surface treatment of metals	G
Sludges containing oil	Oil production/cleaning	F
	Mining	C
	Petroleum refining	C
Sludges containing oil	Coking plant and gas works	C
Pickling sludges	Re-refining of oils	F
Drilling and cutting oils	Metal processing	G
Used fruit oil	Manufacture of fruit oils	A

III ORGANIC WASTE

ORGANIC CHEMICAL RESIDUES (N.F.S.)

Waste streams	Industry/process	Industry groups
	Propylene oxide/propylene glycol	F F

Halogenated substances[1)]	Ether and aldehyde Isocyanate Alkalised bromide Dye intermediates and dyes Pharmaceuticals and fine chemicals Plastic and rubber Diazo process intermediate products Epoxide and phenol resin Product research Chlorocarbon	F F F F F F F F F

***Source*: Her Majesty's Stationery Office. 1979. Halogenated Organic Wastes, Waste Management Paper No. 15, Annex 2, London. - adapted-.**

1) no precise substance description has been given because of the large number of substances.

n.f.s. not further specified

III ORGANIC WASTE ORGANIC CHEMICAL RESIDUES (N.F.S.)

Waste streams	Industry/process	Industry groups
Non-halogenated substances1)	Oil refining Petroleum refining Organic substances from chemicals production Chemicals production Dyes and intermediate products (manufacture) Production of raw chemicals Petrochemicals (manufacturer) Pharmaceuticals (manufacture) Fine chemicals (manufacture) Chemical fibres manufacture	C C F F F F F F F F D

	Lubricants, additives (manufacture)	F
	Aluminium smelting process	F
	Plastic fabrication	C
	Plastic (manufacture)	C
	Town/gas works	F
	Phenol production	F
	Toluol diisocyanate (production)	

***Source*: Her Majesty's Stationery Office. 1977. Tarry and Distillation Wastes and Other Chemical-Based Residues, Waste Management Paper No. 13, Annex 3. London. - adapted -.**

1) no precise substance description has been given because of the large number of substances.

n.f.s. not further specified.

III ORGANIC WASTE ORGANIC CHEMICAL RESIDUES (N.F.S.)[1)]

Waste streams	Industry/process	Industry groups
	 Dry cleaning Textiles and leather Metal cleaning Colour staining Industrial and domestic cleaning Chemical synthesis Bonding agents (manufacture) Automobiles (manufacture) Cleaning products and polishes Mechanical engineering Raw materials industry (essential oils, etc.) flavourings, essences, perfume, cosmetics and health care products (manufacture)	L H G L L F F G F G F

	Maintenance and repair of vehicles, including road, railway and air traffic Leather industry Wood industry, preservatives Photographic industry Printing industry Shipyards and shipbuilding Wheel (manufacture)	G H H J J G

Source: Adapted from Department of the Environment. 1977. Waste Management Paper No. 14, Annex 1. London: Her Majesty's Stationery Office.

1) no precise substance description has been given because of the large number of substances.

n.f.s. not further specified.

POLYCHLORINATED BIPHENYL WASTE

Waste streams	Industry/process	Industry

Waste streams	Industry/process	groups
Solid and liquid waste Dielectric liquid and solid waste Dielectric liquid and solid waste Hydraulic fluids Heat transmission fluids Plastic residues	Manufacture of PCBs Transformer residues Condenser residues Mining equipment, aircraftchemical industry Chemical process technology Production process of plastics manufacture	F G G G F F F

III ORGANIC WASTE

BIOCIDE WASTE			
Chemical classes	**Waste types**	**Industry/process**	**Industry groups**
Insecticides	Bottom residues	Biocide manufacture	F

Organo-phosphorus	Filter media	Biocide formulators	F
Compound	Separation products	Packaging industry	F
Organo-chlorine	Packaging	Importers	F
Compound	Clothing	Wholesalers	F
Carbamate	Treatment domestic wastewater sludges	Distributors/Retail trade	F
Herbicides			
Phenols			
Phenoxy acid	Incident drainage		
Substituted urea	Cleaning		
Triazines			
Benzoic acid			
Dinitroanilines	Empty containers	Use in agriculture	A
Anilides	Unused products	Domestic use (animal care)	A
Other	Accidents	Use in horticulture	A

Fungicides		Industrial uses	
		Wood preservation	H
Dithiocarbamates		Dyes industry	F
Phtalimides		Paper industry	I
		Textile industry	H
		Electrical cables	G
		Tobacco	A
		Adhesives	F
		Building industry	E
		Use in the public sector	L
		Uses in the home and garden sphere	L

BIOCIDE WASTE

Waste streams	Industry/Process	Industry groups
Varnishing residues	Varnishing works	G/H
Old varnishes	Painting/varnishing shops (trade)	G/H
Old paints	Painting/varnishing works	G/H
Varnishing sludges		
Paint residues	Manufacture of paints	F
Printing ink residues	Manufacture of printing inks	F
	Printing works	J
Resin residues	Plastics production	F
	Manufacture of paints	F
	Manufacture of synthetic resins	F
Resin oil residues		F
	Manufacture of resin	H

Paint residues	Manufacture of paint	F

(1) Normally the waste contains a mixture of aliphatic solvents, resins and sometimes also heavy metals

IV PUTREFACTIVE ORGANIC WASTE

Decomposed vegetable oils	Production of edible oil	A
	Production of edible fat	A
Special oil residues	Production of pharmaceuticals	F
	Production of health care articles	F
Animal waste; including blood, faeces and intestines	Abattoir	A
	Meat production	A
	Fish farming	A
Poultry waste	Poultry farming	A
Fish waste	Fish farming	A

Animal corpses/skeletons	Stock farming	A
	Pharmaceuticals industry	F
Skin, glues	Tannery and fleece industry	H
Meat residues		
Tannery sludges		
Sludges and animal remains	Intestine contents	A
Cooking remains, kitchen waste	Processing of animal products	A

V Mass waste with relatively low hazard potential

Waste streams	**Industry/process**	**Industry**
Drilling sludges	Petroleum/gas production	C
Fly ash	Power station cleaning	C
Materials from mining	Mineral production	B
Contaminated soil	Various	Various

Flue gas desulphurisation residues	Power station cleaning	C
Phosphorus gypsum sludges	Fertiliser production	F
Titanium dioxide sludges	Dye production	F

VI Special wastes

Waste streams	**Industry/process**	**Industry groups**
INFECTIOUS WASTE		
Special types of waste	Stock farming	A
	Resulting from veterinary quarantine	K
Pathogenic waste with communicable germs	Health institutions	K
Animal and human tissue	Microbiology laboratories	K
	Hospitals	K

	Biotechnology industry	K
	Microbiology industry	K
Garments	Hospitals	K
	Institutions	K
Disposable materials(hospital waste)		
LABORATORY WASTE		
Waste pharmaceuticals	Pharmacists	L
Laboratory chemical	Manufacture of drugs/fine chemicals	F
residues	Research institutions	Various
	Chemistry laboratories	Various
EXPLOSIVE WASTE		
Armaments waste	Armaments	F/G
TNT, azide	Explosives manufacture	F
Nitrate of organic chemical waste	Chemical synthesis	F

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Annex 8 - Table: Classification of substances presenting problems for particular sectors

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Product group[1)]																		
Sector	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1. Locksmiths				X	X		X	X	X	X	X	X						X
2. Blacksmiths				X	X		X		X	X	X	X						
3. Vehicle mechanics		X		X	X	X	X	X[2)]	X	X	X	X						X
4. Filling stations		X			X		X	X[2)]	X	X	X	X	X					X
5. Coach builders				X	X	X		X[2)]	X	X	X	X						X
6. Small				X	X		X		X					X				

electroplating works																		
7. Painters/lacquerers				X	X	X	X	X				X						X
8. Joiners				X	X	X	X		X	X	X	X	X					X
9. Shoemakers				X	X	X		X										X
10. Glaziers				X	X	X	X	X		X								X
11. Bookbinders/printers				X	X	X	X	X	X	X		X	X					X
12. Building cleaners				X	X		X	X		X		X						X
13. Dyers/chemical cleaners								X					X	X				X
14. Horticultural establishments			X							X	X							X
15. Hairdressers	X												X					X
16. Hotels/inns					X			X										X
17. Photographers		X				X	X						X					
18. Artists/graphic artists				X3)	X	X	X		X	X			X					

19. Gold- & silversmiths				X	X	X	X			X			X					X
20. Dental laboratories				X	X	X	X						X					X
21. Dental practices	X				X	X	X			X			X	X	X	X	X	X
22. Medical specialist practices	X				X					X			X		X	X	X	X
23. Laboratory technicians					X		X		X				X					
24. School/college laboratories					X		X						X					
25. Pharmacists	X				X		X		X				X	X				X
26. Druggists	X							X										

1) Product definition;

2) Including car care products;

3) Including printing and painting inks

1. Drugs and pharmaceuticals
2. Batteries
3. Pesticides
4. Paints, lacquers
5. Solvents
6. Adhesives, glues
7. Acids, pickles
8. Cleaning, care products
9. Oil and oil emulsions
10. Other materials and supplies
11. Used oil/other oil emulsions
12. Oil-soaked cleaning cloths
13. Solid chemical residues
14. Infectious cloths
15. Liquid chemicals
16. Empty disposable syringes
17. Liquid infusions
18. Other product-specific quantities of waste

Source: **Hessisches Ministerium fr Umwelt und Reaktorsicherheit (ed.): Hessische Abfallwirtschaftskonzeption, Anwenderhandbuch, Wiesbaden 1988, - adapted -.**

Generation point of hazardous wastes

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