

Recommendations to preserve and extend sludge utilization and disposal routes

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National foreword

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English version

Recommendations to preserve and extend sludge utilisation and disposal routes

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Foreword

This document has been prepared by CEN /TC 308, "Characterisation of sludge".

This document is currently submitted to CEN/BT for publication as a CEN Report.

This document has been endorsed by EUREAU¹⁾.

1) EUREAU is European Union of National Associations of Water Suppliers and Waste Water Services

Summary

This report has been prepared within the framework of CEN/TC 308 on Characterization of Sludges. The Scope includes sludges from treating municipal, industrial and food processing wastewaters, sludge from treating raw water to make it potable, and other residues having similar potential environmental impacts. The objectives of the report are to analyse the current situation with regard to sludge management in Europe, and to recommend the approaches to preserve and extend sludge use and disposal outlets for the future.

Sludge is the inevitable residue of treating raw potable water and municipal and industrial wastewaters. However, knowledge of the quantities of sludges produced is incomplete. Treatment of these waters is designed to remove unwanted constituents from the water and concentrate them into a small side-stream - "sludge". The sludge may also contain surplus biomass cultured during biological treatment processes. The objective of treatment is to avoid adverse impacts on the environment and human health when the effluent is discharged into the environment or water is supplied for human consumption. The concentration of beneficial constituents and of pollutants in (and health risks associated with) a sludge depends on the initial quality of the wastewater or raw water, and the extent of treatment required to meet quality standards for effluent discharge, and potable water.

Where effluent quality standards are raised, in order to reduce pollutant loads on the environment, the quantity of sludge produced inevitably increases. To be consistent, the use or disposal of the sludge must also be environmentally acceptable, sustainable and cost-effective. Sludge management typically represents about half of the overall costs of wastewater treatment. Its management will become increasingly complex as environmental standards become more stringent, and if outlets for sludge become more constrained by legislation and public attitudes.

EU policy on waste is to discriminate against disposal and promote waste avoidance, minimisation and recycling. Disposal of sludge to sea was legislated to cease by the end of 1998. Disposal of sludges to landfill, which is currently the major outlet for some sludges in Europe, is widely regarded as unsustainable. Sludge production cannot be avoided (although the quantity can be reduced by treatment) in fact demands for higher effluent quality will generally increase the amount of sludge produced. The only remaining options are recycling or destruction by combustion. Recycling options include use on land as an organic fertiliser or soil conditioner for farming, land restoration, etc. Destruction options include combustion with or without energy recovery, gassification, and using the sludge as a process fuel, with the ash being used or landfilled.

It should always be remembered that many sludges and residues contain beneficial constituents and properties that have very positive environmental advantages. For example recycling phosphate and thus reducing the need to extract primary raw material and extending the life of the planet's reserves.

Some countries have applied a greater level of precaution into the regulatory controls for some sludges in an attempt to build stakeholder confidence, and this has made sludge management increasingly difficult and costly. Nevertheless, sludge must go somewhere, and the challenge for sludge managers is to secure cost-effective outlets for sludge that are sustainable and protect the environment and human health, and to encourage political and public acceptance of this. This will require improvements in sludge quality and the methods of disposal and recycling, which may be achieved through improved up-stream control of the quality of wastewater treated, the adoption of advanced sludge treatment processes, and perhaps changing the formulation of products and other measures to reduce diffuse inputs or sources.

The opportunities for improving the quality of water and municipal wastewater entering treatment plants are limited. For potable water, the source and quality of raw water is usually fixed to the surface and groundwater resources available locally. For sewage, industrial effluent controls have dramatically reduced point source pollution over the last 30 years (in those countries with effective legislation) to the extent that sludge quality is now increasingly dictated by diffuse pollution of water entering the sewerage system from domestic premises and road run-off, and these sources are inherently difficult to control. Industrial recession can also have a beneficial effect on sludge quality when polluting factories are forced to close. For industrial wastewater treatment, the quality of sludge has been improved through the adoption of production processes that generate less waste, and further improvements are likely through developments in industrial process technologies and integrated pollution prevention and control measures.

A range of sludge treatment options is available to improve sludge quality and processes have been developed and adopted as necessary, according to local circumstances and legal requirements. These generally focus on reducing the content of water, odour and pathogens in sludge. Technologies are emerging for the removal of contaminants, such as heavy metals, but they are expensive and are therefore not a practicable option at present. In order to secure outlets for sludge in the near future, advanced treatment of sludge may increasingly be required, for instance to have assured pathogen removal, or to produce sludge of high dry solids content to improve the flexibility of use options as a fuel or as a high quality soil additive. These choices will be largely driven by legislation and customer and public pressures, and depend in part on an entrepreneurial management approach. High quality sludge products have a market value, offering the possibility of increased revenues in the future, and this will be an additional incentive to achieve quality assured sludge products, provided that legislation and controls permit such developments.

Currently, only the use of sewage sludge in agriculture is controlled by specific legislation. There are no comparable regulations on the recycling of other sludges, animal manures or organic wastes despite the fact that they are likely to incur the same environmental problems, although they may be subject to more general environmental legislation. Some countries have some integration of environmental standards for sludge and waste use, but none is comprehensive. A uniform and comprehensive approach is urgently needed at the EU level to ensure that all sludges, animal manures and organic wastes are subject to the same consistent control measures. The benefit of this would be that the environmental loads from some major sources of potential environmental contamination would be controlled and accounted for. One very unfortunate consequence of the present inconsistencies is so called sludge tourism (i.e. the transboundary movement of sludges to regions with less stringent environmental controls).

In a similar way a consistent approach to emissions to atmosphere from all combustion processes (power stations, incinerators, brickworks, cement plants, etc.) and of dust is recommended. These processes can have wide-reaching impacts. Globally atmospheric deposition is the dominant of some elements or pollutants.

In addition to global environmental impacts it is important that the loadings on specific sites are considered to ensure the sustainable use of those sites.

The quantity of sewage sludge produced is very small in relation to other residuals that may be used on land and that have similar potential environmental impacts, but it is the only strictly regulated residue throughout Europe, with specific requirements for quality, monitoring, record keeping and reporting. Such controls are entirely consistent with the avoidance of environmental pollution and risk to public health, but it is now inconsistent that other sludges are not similarly controlled. This is particularly true for livestock wastes, which are by far the single largest source of organic waste (more than 60%). Despite particular examples such as the Nitrate Directive, there is no comprehensive EU control strategy for livestock wastes, but it is the cause of significant pollution, and it is time that this inconsistency was corrected.

Europe has been rocked by food scares. Even though there is no evidence of disease transmission when sewage sludge has been used according to current legislation, absence of evidence is not the same as absence of effect, and it is time that process standards for stabilisation and sanitisation for all sludges used on soils where food is grown are more closely defined so as to avoid another food scare. This is partly a matter of science, but public perception is another very real concern in this area. It should be remembered that no link has ever been proved between disease transmission and the proper use of sewage sludge in accordance with current controls. However a particular concern is "new" pathogens that are starting to appear in some countries, some examples are brown rot in potatoes, which was thought to be restricted to warm climates but is now in Northern Europe, *E. coli* O157, which is tolerated by sheep and cattle but highly infective of humans, and *Salmonella typhimurium* DT104, which can display multi-antibiotic resistance. In order to control these "emerging" organisms and the "traditional" ones, consistent rules for the management of all sludges are needed. Appropriate hygiene standards for sludges can be achieved through adopting quality assured processes which can reliably reduce pathogen numbers to the desired low levels. This is now the approach being developed in the US for livestock wastes, and it is an appropriate approach for all wastewater treatment sludges in Europe, including livestock wastes.

Recommendations

The principal recommendation of this report is that, notwithstanding subsidiarity, consistent application of the principles of control are necessary at the European level, to regulate the quality and use of all water cycle sludges (including some other residuals) that have similar potential environmental effects. The development of such measures should consider, and would subsequently support, the following key issues, not in any order of priority :

- give confidence to sludge producers to invest in appropriate technologies to achieve safe, secure and sustainable sludge management ;
- reinforce the precautionary principle in a practical and enabling manner consistent with sustainable development ;
- encourage quality assurance with independent audit and accreditation of sludge use and disposal in order to avoid mistakes and to build confidence in the processes ;
- avoid transboundary problems and market distortions in sludge use and disposal ;
- develop and promote integrated co-treatment of sludges and other organic wastes ;
- promote material cycle integration, with the priority on sludge use on land to conserve organic matter and complete nutrient cycles, combustion as an energy source, or material use such as animal feed, etc. while discriminating against disposal options (material cycle exclusion) ;
- promote acceptance of sludge management and use by all stakeholders ;
- encourage/require improved reporting and publication of data about the use and disposal of sludges to encourage improvement by peer comparison and to promote stakeholder confidence by transparency.

The priority in securing sustainable management of all sludges is establishing consistent standards based on sound scientific principles that protect human, animal and plant health and the environment (including soil and its fauna and flora). This would include formulating appropriate sludge quality standards and an appropriate strategy for maintaining sludge use and disposal during the period whilst they are phased in. Such standards would lead to industry developing the technologies by which these can be achieved reliably and cost-effectively.

There has been a huge amount of scientific research into the effects of sludges, especially sewage sludge. Development of an integrated approach should be based on risk assessment. Quality standards should be set according to the precautionary principle, to ensure environmental protection and sustainable development. The exercise should also be conducted in the context of expansion of the EU and the situation of the new members. There should be a commitment to the necessary research and operational surveillance to establish the rigorous scientific basis for standards and technologies that are appropriate for securing sludge use for the long term future. A new regulatory regime should be designed to encourage and enable beneficial use of sludges in line with the EU waste strategy, to ensure the integration of sludge within material cycles, and should discriminate against disposal. This should be backed by quality assurance with independent audit to avoid mistakes and validate compliance. Independent accreditation is also desirable to give confidence to the processes.

1 Introduction

Increased material flows in the environment are a natural consequence of development, however, for sustainable growth the flows particularly of wastes have to be managed in order to conserve resources and protect the environment.

The promotion of sustainable growth respecting the environment is one of the primary objectives of the Treaty on European Union. Article 130 r (1) of the Treaty lays down that action by the Community relating to the environment shall be based on :

- the precautionary principle ;
- the principles of preventive action ;
- rectification of environment damage at source ;
- the polluter should pay.

The principles of preventative action require that the European Community must first address itself to waste avoidance and minimisation before considering waste recovery, recycling and how waste should ultimately be disposed of if none of the previous options are feasible. The basic principle of action must be to support and ameliorate the valuable components in wastes and reduce the presence of harmful substances.

CEN/TC 308 "Characterization of Sludges" considers that water cycle sludges are part of the material flows. These sludges include :

- 1) Wastewater sludge/sewage sludge of household and municipal origin ;
- 2) Industrial organic wastewater sludge from :
 - potato processing ;
 - slaughterhouses ;
 - sugar beet processing ;
 - animal food production ;
 - dairy farming ;
 - livestock farming ;
 - fish processing and canning ;
 - tanneries ;
 - pulp and paper industries ;
 - olive oil production ;
 - pharmaceutical production ;
 - fruit and vegetable processing and canning ;
 - soft drinks production breweries ;
 - vinification ;
 - alcohol and alcoholic liquors production ;

- gelatine and glue production ;
- malt factories ;
- margarine and fat production ;
- starch production ;
- biological production of drugs ;
- other ;

- 3) Water works sludges ;
- 4) Sludges from the sewerage network ;
- 5) Cesspool and septic tank sludges (night soil).

The implementation of the Urban Waste Water Treatment Directive (91/271/EEC) will dramatically increase the amount and quality of municipal and industrial wastewater treatment throughout the European Union. Inevitably, the production of sludge will increase and this will require appropriate treatment and disposal. However, this is occurring over a period when there is a number of important changes to European and national waste management policies that will impact all of current sludge use and disposal options. The challenge of the next 10-20 years is to identify the sustainable balance between sludge production, recycling and disposal, and the protection of human and environmental health in an affordable, sustainable and acceptable manner.

Identifying secure and cost-effective disposal and use outlets for sludges (and wastes in general) in the European Union, which are also publicly and politically acceptable, has become an increasingly difficult and complex issue. Some outlets will be prohibited (such as sea disposal from the end of 1998) and all other outlets are facing increasing restrictions (agriculture, landfill and incineration), yet the amount of sludge produced in the EU is increasing rapidly, by at least 50% by 2005. Public expectations of environmental protection are high and the principle of recycling is widely acknowledged as sensible, yet the use of sludge, particularly sewage sludge, barely achieves public acceptability.

Council Directive 75/442 EEC on waste, as amended by Council Directive 91/156/EEC, sets out the following objectives for waste management to be adopted by Member states :

- increased prevention and reduction of waste through the development of clean technologies as well as of products that can be used or recycled ;
- recycling and recovery of waste as secondary raw material ;
- use of waste as a source of energy ;
- recovery and disposal of waste without endangering human health or the environment.

Where the production of waste cannot be avoided, the second priority of EC Directive 75/442 EEC is the use of waste as secondary raw material or for energy production. The use of "sludges for utilisation" constitutes an instrument of importance to both waste management and national economies. The measures taken to this end intend that :

- amounts of waste are reduced, thus reducing the reliance on landfill disposal ;
- primary raw materials and energy are conserved and, hence, the pressures on the environment and the landscape are eased.

The general waste management policy of the EC is summarised by the hierarchy which gives priority to waste avoidance and minimisation, recycling and recovery of materials and energy, and considers landfill disposal as the least favoured option. The basis of a Community strategy for sludge could be the positive adoption, through policy and action, of the principles of this hierarchy, since this is conceived to be the basis of sustainable development. Since sludge production cannot be avoided if effluent and water quality standards are to be met, then minimising the quantity of sludge for recycling is the highest feasible objective within this hierarchy.

Usefulness is an essential principle of Directive 75/442/EEC, and both harmlessness and usefulness are prerequisites for the use of wastes.

In different European countries, there are various initiatives to maximise the use of sludges but there are no uniform guidelines or measures. TC 308 was founded due to the lack of, and differences in, technical guidelines on the investigation and evaluation of waste for recycling. Working Group 3 of TC 308 was established to establish uniform principles for the future utilisation of sludges and specifically to undertake the following :

- identify appropriate contacts within each country covered by CEN ;
- develop a questionnaire to derive information on type, quality and outlets of sludges ;
- identify current and prospective sustainable methods of reducing, handling, utilisation and disposal of sludges ;
- produce a report to CEN on recommendations to preserve and extend sludge utilisation and improve other disposal routes.

This report addresses the last and considers issues of sludge quality criteria, classification for disposal/utilisation options, quality assurance, comparison with other wastes and the development of a European strategy on sludge. More detailed recommendations are provided by specific codes of practice developed by Working Group 2 (listed in Annex A).

TC 308 defines sludge qualities and the factors which control them. The TC does not set out limit values when defining qualities, although the principles may be established by which appropriate standards may be set. There is scope to extend the range of standard methods available for measuring sludge quality. Sludge quality criteria can be used to classify sludge as to its suitability for particular use or disposal option and this has been undertaken by allocating priorities to particular properties according to outlet. Assignment of numerical standards must be done locally, but within the EU framework, because of the complex social, political, geographical, climatic and scientific factors which determine where they are set.

It is imperative that the suitability of all types of sludge for use and disposal, and their associated potential environmental impacts, are evaluated according to uniform criteria. Impacts in this context do not necessarily imply readily quantifiable "damage", they also refer to increases in the background concentrations of contaminants throughout the environment, which may lead to an overall degradation of the environmental quality, possible unforeseen and long-term impacts, and positive environmentally enhancing aspects. Hence the need for a precautionary approach to setting standards to protect air, water and soil to ensure sustainable development.

Providing residue/waste producers and recyclers, and the competent authorities with relevant and uniform guidelines will help ensure that pollutants are not purposefully, or as a side effect of use, channelled into the ecosystem by way of dilution or non-specific binding. A uniform framework would also ensure that the most appropriate sludge management option can be selected for local conditions that not only provides consistent environmental protection but also avoids unnecessarily stringent restrictions that could prejudice sludge recycling and force sludge to be disposed of in a less sustainable manner.

Thus the priority must be to :

- improve the sustainability of existing outlets ;
- ensure optimum sludge utilisation in the future ;
- find new useful outlets.

2 Principles of use and Disposal

2.1 Options for sludge use and disposal

The Waste Framework Directive (91/156/EEC amending 75/442/EEC on waste) requires Member States to take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without using processes that could harm the environment, and in particular :

- without risk to water, air, soil and plants and animals ;
- without causing a nuisance through noise or odours ;
- without adversely affecting the countryside or places of special interest.

Member States shall also take the necessary measures to prohibit the abandonment, dumping or uncontrolled disposal of waste. The Directive incorporates the polluter pays principle and introduces the concept of the waste management hierarchy, which places the priority on waste avoidance, minimisation and recycling and discriminates against disposal. In decreasing order of preference, the hierarchy is :

- avoidance ;
- minimisation ;
- re-use - recycling, energy recovery ;
- landfill.

This general strategy addresses waste management in the context of sustainable development, the principle of which is to replace technologies which are polluting and based on non-renewable resources, by ones which do not consume finite resources and are based on avoiding, minimising and reusing wastes. The aim is to achieve development that is in ecological balance, avoids pollution and preserves biological diversity.

Waste use and recovery incorporates materials recycling, beneficial use on land, and recovery of energy. No one single type of use should automatically be preferred to any other as this will depend on the best practicable environmental option for a particular waste stream in a particular locality.

Priority is given to the use of wastes over other disposal routes, if :

- it is technically feasible ;
- it is environmentally acceptable ;
- it is secure ;
- the cost is acceptable ;
- there are economic advantages from the use or sale of sludge, such as from energy production, sludge-based products, etc.

A range of outlets has been developed for the management of sludges, which includes various recycling and disposal options, and the relative importance of these varies between countries according to local operational and economic circumstances, and national policy and legislation on waste management and environmental protection.

If environmental water quality is to be protected, it is impossible to avoid producing sludge. If tighter effluent quality standards are applied, sludge production will be increased. It is difficult to minimise sludge production without additional sludge treatment to reduce the bulk (e.g. by dewatering, drying, etc.) and solids content (e.g. by incineration, gassification, wet air oxidation, thermal hydrolysis followed by digestion, etc.) of sludge.

Use is the preferred option for wastes, provided that this is compatible with protection of the environment and human health. Landfill disposal is the option of last resort and discriminatory measures are being introduced in many countries to ensure that this principle is followed.

Thus, in broad terms, there are only two possible outlets for sludge (see Figure 1) :

- 1) reintegration into material cycles ;
 - direct utilisation (agriculture, land reclamation, etc.) ;
 - indirect - modified utilisation ;
 - composting - soil improvers, fertiliser, etc. ;
 - thermal treatment or processing - energy recovery (e.g. fuel production by pyrolysis, incineration, co-combustion as a fuel in power plants and industrial processes such as brick and cement production) and mineral recovery (e.g. vitrified products) ;
- 2) removal from material cycles ;
 - direct landfill (mono or mixed) ;
 - indirect - modified after thermal processing (disposal of ash, vitrified material).

To select the most appropriate outlet for sludge depends on detailed assessment of sludge quality and the local opportunities for sludge use or disposal. The key sludge quality criteria are :

- chemical ;
- biological ;
- physical ;
- vector attraction (odour, aesthetic consideration, etc.).

The presence of contaminants and/or pathogens in sludges is unavoidable due to the nature of wastewater and potable water production and treatment, since the objective of wastewater treatment is to remove potentially environmentally harmful components into a small amount of sludge so that the larger portion of water can be returned safely to the environment or used for human consumption. This is also the reason why sludges have beneficial uses in agriculture and energy recovery due to the presence of nutrients and organic matter, the latter containing significant calorific value which is released by combustion.

Mitigation measures are adopted which are effective in reducing the significance of undesirable components in sludge, as well as the imposition of specific controls on sludge quality and its use on land (e.g. Directive 86/278/EEC) to avoid uncontrolled and excessive accumulation of contaminants in the soil which may prejudice soil fertility in the long-term.

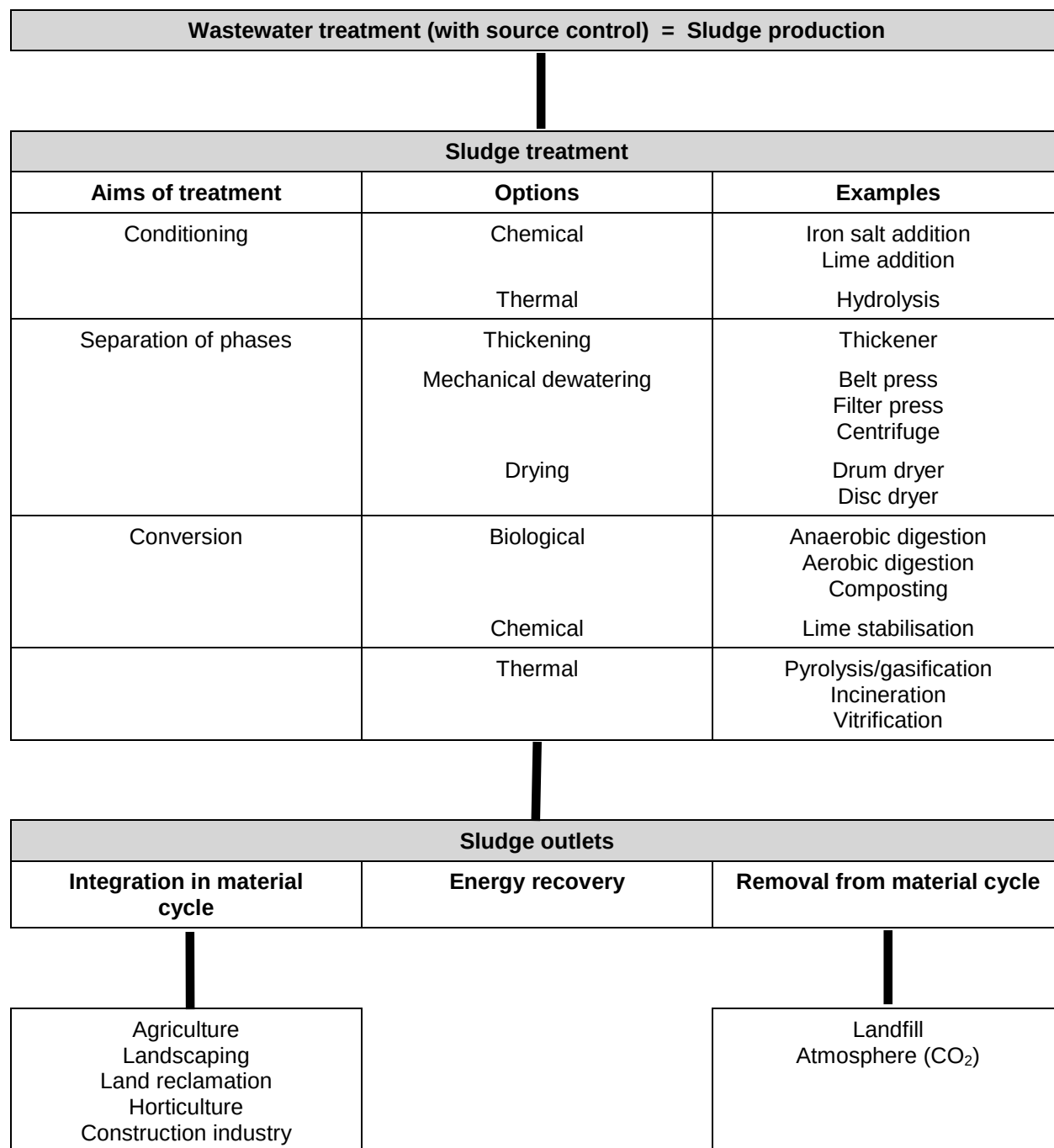


Figure 1 — Examples of options for sludge treatment and disposal

The prevention of the contamination of sewage sludge by controlling the quality of industrial effluent discharge to sewer is well recognised as an essential measure in maintaining good sludge quality (see CEN/TC 308 WG2 Code 2). The principle of up-stream control to avoid contaminating wastewater before treatment and sludge production should be applied to all industries and sludge producers since it encourages wider beneficial use of sludge. Point source pollution control is well understood and widely adopted in the context of sewage, but it is low level contamination possibly from diffuse sources that is difficult to avoid. An approach here is material substitution in products that may contribute to diffuse pollution, for (instance zinc in shampoo). Such sources are of increasing significance to sludge quality, particularly as environmental quality standards for sludge continue to be tightened. This requires further study to understand the type and significance of diffuse sources, and how these may be controlled.

The presence of pathogens in sludges, particularly sewage sludge, depends on the source of wastewater. Infection of man, animals and crops can be avoided by sludge treatment and control of the use of sludge and receiving land. However, the hygienic quality of sludge continues to be a focus of concern, particularly for the large quantities of sludge produced.

and in order to maintain the security of agricultural use, this may require increasing reliance on thermal and chemical treatment processes to achieve higher acceptable sludge quality standards.

2.2 Principles of option selection and control

The principles of precaution and of proportionality are at the centre of European environmental policy. The establishment of environmental quality objectives and standards within this context is essential to protect the environment and human health for sustained development, particularly where sludge is to be integrated into the material cycle.

For the use and disposal of sludge, this requires knowledge of the constituents of sludge, including their potential hazard to all compartments of the environment, the concentrations at which harm may occur, and what constitute safe levels, in the short and long-term. The precautionary approach is applied where knowledge of effects is uncertain, and even where the effects are well characterised, to select how close or how far maximum acceptable values should be set in relation to levels which may cause unacceptable effects. The latter may be set according to lowest or no observable effect level by toxicology.

Where knowledge is uncertain (for instance where a new contaminant is encountered or sludge is to be used in a novel way), risk analysis is used for defining hazard levels and identifying appropriate safety levels. The level of precaution is subsequently set according to the level of safety required, which in part is dependent upon local or national conditions and political and economic considerations. This helps explain the disparities in sludge quality standards for agricultural use in different countries derived from a common scientific basis, for instance between the United States and Europe (described in Annex D)

When sludge is used on agricultural land, the primary objective is to exploit the beneficial properties of the sludge whilst at the same time protecting the soil, consumers of agricultural products and the environment at large. The precautionary principle reflects continuing and sustainable agriculture and implies that the spreading of sludges can under no circumstances lead to an irreversible or unacceptable pollution of soil, even if it is slow and diffuse.

Where the level of safety required is in excess of what can be achieved (i.e. where a contaminant exists at excessive concentrations and may give rise to unacceptable impacts), then alternative approaches are necessary, either to reduce the concentration at source or to find an acceptable alternative means of disposal.

Use of the Best Available Technology (BAT), (also Best Available Technique) may be regarded as an application of the precautionary principle. The principle of BAT states that environmental disturbances are to be prevented wherever technology allows. As it has been formulated in various international conventions and in the draft directive of the European Community on Integrated Pollution Prevention and Control (IPPC), it includes not only the choice of production technology but also the design, maintenance and operation, as well as the eventual dismantling/destruction of the facilities being assessed. The application of the principle in different countries depends on the formulation of the national legislation, including which criteria are to be taken into consideration concomitantly with the best available technology. Normally, there is some kind of financial consideration - the technology must not be unreasonably expensive. The technology must be developed or proven at a scale which allows its implementation in the relevant industrial context. The USEPA uses what it refers to as MACTs (Maximum Achievable Control Technology) for toxic substances, meaning the technology in use at the best ten per cent of the facilities in question.

The principle of BAT may be used to prevent emissions of pollutants even when knowledge of their environmental impact is uncertain. However, application of BAT is no guarantee for acceptable environmental quality. Alternatively, BAT may necessitate unnecessarily extensive measures. Less expensive solutions may be found if there are effect-related targets, for example stating that certain target values for air or water quality are to be met. However, there is an objection to strategies based on the implementation of measures in order to achieve certain environmental quality targets: they allow pollution up to a certain level with no consequences. The demand for BAT may serve as a means of maintaining low levels of pollution in areas that are relatively unpolluted today. For this and other reasons, most countries now combine effect-related and technology-related requirements.

In recent years the principle of the Best Environmental Practice (BEP) has been established. BEP is a broader concept than BAT, and involves the best combination of measures to restrict environmental disturbances for all kinds of sources. It comprises a number of means beyond the implementation of technological measures, such as information to the general public and consumers, economic instruments, and the establishment of systems for recovery or recycling.

The selection sludge use or disposal option(s) for an existing or planned wastewater treatment plant should not be separated from sludge treatment, but should be considered holistically. Ideally the selection of the optimum outlet for the sludge should dictate the choice of sludge treatment, so that the Best Practicable Environmental Option (BPEO) is identified, taking into consideration:

- environmental impacts ;
- practicability ;
- operational security ;
- economics.

This requires a balanced approach where economic considerations should not be the overriding factor. However, historical investments often require that there is a compromise, at least in the short term, but the objective should be to apply the appropriate level of sludge processing, which in the future may increasingly require advanced treatment methods, to secure the most acceptable, safe, affordable and secure method of use or disposal. This should be achievable through comprehensive strategic evaluation of sludge management operations and the uniform compliance within the requirements or the precautionary principle, IPPC and BAT.

Methodologies for assisting in identification of sludge management strategies to meet these requirements are described in Annex F2 and F3.

3 Legislation and environmental quality standards

3.1 European legislation

Environmental legislation in Europe is complex as national legislation is overlain by international agreements and European Council legislation.

There is a number of international agreements (such as the Paris, Helsinki, Basel, North Sea Conventions) and strategic action plans for the Black Sea, Danube and Mediterranean Sea, etc.) whose primary objectives are to address and reduce transboundary pollution, particularly of rivers, lakes and seas which cross or are bounded by several countries. The key issues are nutrient emissions which cause eutrophication and the disposal of wastes. Under the North Sea Convention, it was agreed to cease the disposal of sludge at sea (which was subsequently enforced through EC Directive 91/271/EEC). A major consideration of all of these agreements is the contribution of polluting nutrients from agriculture and wastewater.

The European Commission has established a legal framework for a wide range of environmental issues which have to adopted by Member States through national legislation. The most relevant to sludge management are :

- waste Framework Directive (91/156/EEC amending 75/442/EEC on waste) established the waste management hierarchy ;
- the “Sludge Use in Agriculture” Directive (86/278/EEC) set sludge and soil quality standards and monitoring requirements when sludge is spread on agricultural land. This Directive, (in conjunction with the Standardised Reporting Directive 91/692/EEC) requires (Article 17) :
 - “Five years after notification of this Directive, and every four years thereafter, Member States shall prepare a consolidated report on the use of sludge in agriculture setting out the quantities used, the criteria followed and any difficulties encountered; they shall forward this report to the Commission, which shall publish the information contained therein. In the light of that report, the commission shall if necessary submit appropriate proposal for increased protection of the soil and the environment” ;
 - as noted elsewhere few members have complied fully with Article 17. The Commission will propose revision of this Directive in 1999 which may reduce the existing sludge and soil limits for potentially toxic elements (PTEs) and extend its provisions to pathogens and organic contaminants; however the majority of members have still not satisfied the reporting requirements of 86/278/EEC ;

- urban Waste Water Treatment Directive (91/271/EEC) set minimum sewage treatment standards to be achieved in stages by end of 2005, and prohibits sea disposal of sludge by end of 1998. This Directive also requires Member States to submit reports every two years on its sludge disposal activities ;
- nitrates Directive (91/676/EEC) required Member States to define Nitrate Vulnerable Zones (NVZs) where water quality has or will exceed the EC drinking water standard of $50 \text{ mg NO}_3 \text{ l}^{-1}$, and to impose maximum annual limits on the addition of nitrogen in fertiliser and organic wastes. Some Member States have designated their whole countries as NVZs ;
- european Waste Catalogue (developed as a requirement of 75/442/EEC) and the Hazardous Waste Directive (91/689/EEC) lists sources and types of wastes and properties which may render them hazardous ;
- ecolabel for Soil Improvers (94/923/EEC) set standards for composted wastes in order to achieve an Ecolabel. The latest revision to this Ecolabel arbitrarily excludes sewage sludge irrespective of quality or performance. The EC intends to publish a draft Directive on compost in 1999 ;
- landfill Directive which will make the disposal of sludge to landfill more difficult ;
- directives and proposals on the incineration of hazardous and non-hazardous wastes ;
- various legislation has improved sludge quality by limiting pollution at source (e.g. Directive 76/464/EEC).

3.2 International, European and national standardisation

Many existing standards produced by ISO and CEN committees have relevance for the use or disposal of water cycle sludges. All of these international standards committees are supported by national standards organisations which contribute to their review and implementation.

The ISO and CEN committees which are working on topics of relevance to sludge management are lists in Annex B.

4 Sludge production, quality and disposal in europe

4.1 Sludge production

Table 1 shows the estimated quantities of various municipal, agricultural and industrial sludges produced in the European Union (Davis and Dalimier 1994). These estimates cover only the EU12 Member States and include organic wastes other than sludge, such as livestock manures (which are already recycled to agriculture) and municipal solid wastes (MSW) (of which the composted organic fraction is increasingly available for use).

Table 1 — Estimated quantities of municipal, agricultural and industrial wastes produced within the European Community (EU12) ($^000tDS\ y^{-1}$) (Davis and Dalimier 1994)²⁾

Waste source	Approximate quantities	Use/disposal options
Sewage sludge	6,500	Agriculture, landfill, incineration.
Livestock manure	154,000	Agriculture, compost.
Vegetable/fruit		
Solid residues	?	Animal feed, agriculture landfill.
WWTP sludge	2,000	Agriculture, landfill.
Sugar		
Pulp	?	Animal feed, agriculture.
Lime sludge	?	Agriculture, landfill.
WWTP sludge	6,000	Agriculture, landfill.
Meat		
Blood	?	Agriculture, rendering.
Offal	?	Rendering, landfill, incineration.
WWTP sludge	450	Agriculture, landfill.
Dairy		
Milk/whey	?	Animal feed, agriculture.
WWTP sludge	220	Agriculture, landfill.
Beverage		
Solid residues	?	Animal feed, agriculture, landfill.
WWTP sludge	320	Agriculture, landfill.
Paper		
Pulp	?	Agriculture, landfill.
De-inking	?	Landfill.
WWTP sludge	1,850	Agriculture, landfill.
Textiles	680	Landfill, agriculture.
Leather	40	Landfill, agriculture.
Drinking water	500	Landfill, land.
Chemical industry	?	
e.g. Pharmaceuticals, dyes, Chloroalkali, petroleum, metal finishing		Landfill - often hazardous waste landfills. Some agricultural use.
Domestic Waste		
Whole MSW	65,000	Landfill, incineration.
(biowaste is approx. 33% of total)	?	Composting, recycling, landfill, incineration.
Source separation		

2) WWTP = waste water treatment plant

The estimated relative quantities of the main sludge types produced in Europe are illustrated in Figure 2. The figures for the food and industrial sludges are very approximate as these are based on theoretical calculations since no quantitative data are available. There will also be large regional variations; for instance paper sludge will predominate in Scandinavia, and livestock wastes in the Benelux countries. Clearly there are commercial sensitivities in relation to industrial waste production, but a mechanism by which reliable quantitative (and qualitative) data can be collected throughout the EU is urgently required. From such information, the true resource value as a whole can be assessed, as well as the potential environmental loads. This should lead to a more focused regime that ensures maximum beneficial use commensurate with environmental protection.

From these estimates, there is in excess of 170 million tonnes of sludge produced annually in Europe (EU12), including livestock wastes, but excluding MSW and other solid organic wastes streams from industry. With an estimated 154 million tonnes per year, livestock wastes contribute by far the largest proportion (about 90%) of the wastes in Europe and yet have the least environmental control over its quality and use on land. Eutrophication from excessive application of organic manure is well known, but questions are now being raised about hygienic aspects, especially because of the “emerging” human pathogens. In contrast, sewage sludge contributes less than 4% of the total and its quality, use and monitoring requirements are prescribed in detail.

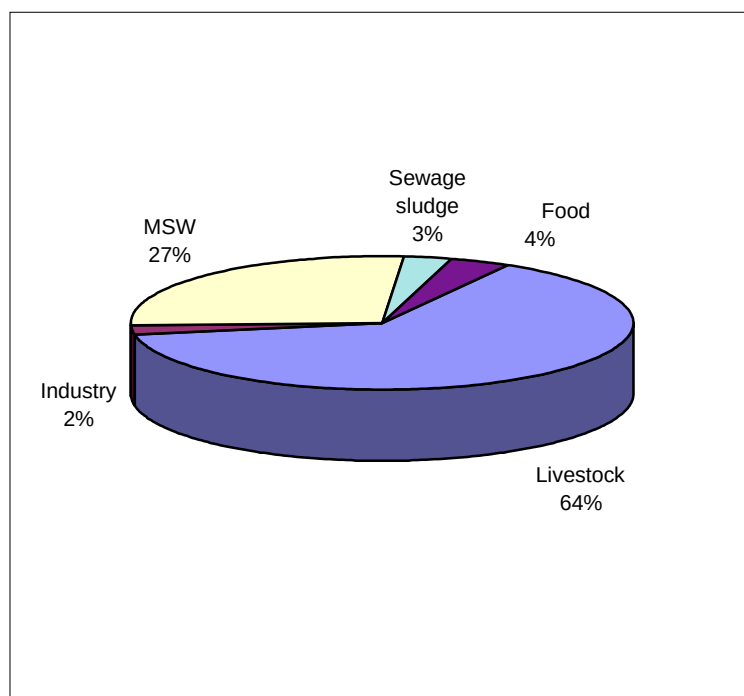


Figure 2 — Estimated relative quantities of principle types of sludges and organic wastes (DS basis)

4.2 Sludge quality

Sludge quality is based on its biological, chemical and physical properties with the emphasis altering according to the outlet of the sludge. Sludge quality depends on the composition of the wastewater from which it is derived and the extent of processing it receives during treatment. Biological properties include the microbiological stability of the organic matter in the sludge, odour and hygienic aspects. Chemical properties include content of potentially toxic elements (PTEs - mostly heavy metals) and organic contaminants, and includes their concentrations and forms which affects their availability to different environmental pathways (e.g. crop uptake, groundwater, etc.). Physical properties include whether solid, plastic or liquid (extent of thickening and dewatering and drying) and aesthetic factors associated for instance with removal of unsightly debris by effective screening. Calorific value will be a quality criterion if the sludge is to be gassified or burnt. The biological and physical qualities of sludge can be altered substantially by treatment processes; such treatment is usually necessary to meet the requirements for use and disposal. Sludges can exhibit wide differences in their physical, chemical and biological characteristics and there can also be seasonal variations in the sludge characteristics. Characterisation of sludge quality criteria is necessary for the design and operation of sludge treatment processes and for assessment and control of environmental impact of the sludge on disposal.

Maximum limit concentrations for six PTEs in sewage sludge and the receiving soil were set by Directive 86/278/EEC, which has required all Member States to introduce these measures into national legislation. The Directive permits countries to introduce lower limit values as local circumstances dictate, and most have done so, and some countries have included additional parameters. As a result the range of national limit values are very wide and often substantially below the maximum limits permitted by the Directive (see Annex C). Significantly lower limit values are now attainable in Europe due to the large reductions in PTE concentrations in sewage sludge achieved over the last 20 years through improvements in industrial processes and the control of industrial discharges to sewer.

Significantly, these limit values only apply to the use of sewage sludge in agriculture, and only a few countries have so far introduced measures to monitor and limit PTE additions to land by other sludges and organic wastes. This is important since sewage sludge contributes only a small proportion of total PTE burden on the environment (Hall and Dalimier 1994) and significant amounts are applied in total to land by other means, particularly livestock manures, atmospheric deposition and fertilisers. This is illustrated by estimates for England and Wales in Table 2.

Table 2 — PTE additions to agricultural holdings in England and Wales (t y^{-1}) (Carrington *et al* 1998)

Source	Zn	Cu	Ni	Pb	Cd	Cr	As	Hg
Sewage sludge	388	237	29	113	2.1	94	1.8	1.5
Atmospheric deposition^a	2543	647	104	485	20.8	104	33.5	23.1
Fertilisers inc. trace elements	246	96 ^b	24	11	11.9	115	9.0	0.1
Lime	44	10	20	8	1.2	24	0	0
Agrochemicals	26	8	0	0	0	0	0	0
Industrial by-products and wastes	210	154	1	<1	<1	210	<1	<0.1
Animal manures^c	1992	710	56	52	4.1	39	16.2	0.2
Total	5449	1862	234	669	40.2	586	60.5	25.0

^a Deposition on 1.156 million ha. All agricultural land including rough grazings and commons

^b Includes 58 t Cu as trace element fertiliser applications

^c Gross additions including metals recycling in farm system

Directive 86/278/EEC (Article 17) and the Standardised Reporting Directive 91/692/EEC require Member States to submit consolidated reports on sewage sludge use in agriculture - the last national reports were in 1998. The previous report had been far from satisfactory with only Flanders, Germany, Spain and UK making comprehensive reports according to the requirements of 86/278/EEC. Directive 91/271/EEC also requires Member States to report on all sludge disposal activities. Consequently, sludge treatment, quality, use and disposal should be reasonably well characterised when all members comply fully with the reporting requirements. The most recent comprehensive report on this for the EU(12) relied on data for 1992 or earlier (Hall and Dalimier 1994). The situation in the countries seeking to join the EU is even more unknown.

Detailed information on sewage sludge quality is only provided on sludge used in agriculture, and since the Directive sets maximum limit concentrations for agricultural use, these data may well under-estimate the full range of sludge qualities since the more contaminated sludges have to be disposed by other means. However, detailed quality information on all sewage sludges is increasingly available in many, but not all, EU countries. An example is given for the UK in Table 3.

Table 3 — Sludge quality in the UK according to different outlets (median and weighted average concentrations : dry solid and nutrients as %; PTEs as mg kg⁻¹DS, 1996/97 data) (FWR, 1999)

Parameter	Agriculture		Dedicated site	Incineration	Sea disposal	Landfill	Land reclamation	Forestry	Compost	On-site storage
	Median	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
DS %	-	15	6	47	3	22	57	28	32	14
N %	3.53	4.34	5.58	-	4.27	4.27	1.87	2.75	3.47	3.40
P %	1.90	2.24	2.72	-	2.32	1.72	1.91	1.69	0.57	-
Zn	559	792	938	643	993	1242	749	-	423	653
Cu	373	568	472	537	472	457	443	625	277	394
Ni	20	57	68	74	47	98	96	84	-	36
Cd	1.6	3.3	6.5	4.0	3.0	4.2	-	6.9	2.0	2.9
Pb	99	221	361	301	436	244	269	550	173	193
Hg	1.5	2.4	2.6	0.6	1.8	2.4	2.5	3.3	1.0	2.1
Cr	24	157	226	153	245	625	237	158	107	814
Mo	4.7	7.6	9.3	42.3	10.3	12.2	5.9	8.7	4.9	10.3
Se	1.6	2.0	1.7	2.5	1.4	2.2	1.7	1.1	1.5	1.2
As	2.5	5.7	6.4	16.8	6.8	9.7	8.5	8.4	2.1	6.7
F	157	221	295	506	263	339	167	377	144	225

Member States collect the information for the EC reports by periodically carrying out national surveys of sludge management activities, but there is a potential lack of comparability of data between Member States. For instance, mean values of PTEs and nutrients are normally presented (which may or may not be weighted according to sludge production) and this approach is inadequate in describing the significance of these components in sludge. The Commission recently commissioned a study on the problem of comparability (Jacobsen *et al.* 1997), and one of the recommendations was that data should be presented as median values (percentile distributions would be better), which are far more informative on sludge quality than the arithmetic mean.

An example of this is given in Table 3 where median and mean data on the quality of sludge used in agriculture in the UK are compared. The arithmetic mean values are consistently higher than the medians, indicating that the data are not normally distributed, i.e. a few high values skew the data, whereas the majority of sludges have relatively low concentrations. This means that environmental loads of contaminants are likely to be over-estimated where mean values are used.

With the exception of sewage sludge, there are no systematic and comprehensive data available on the quality of other sludges in Europe, although some countries do collate data on certain types of recycled wastes. Where limited data exist on such sludges being used in agriculture, these show that most food and industrial sludges tend to have significant nutrient concentrations but relatively low concentrations of PTEs (Table 4).

By extending the reporting requirements imposed on sewage sludge to other sludges and organic wastes generally, this would provide a quantitative basis upon which informed judgements can be made about the significance of the potential benefits from, and the environmental loads of, all types of sludges (and organic wastes) recycled and disposed.

Livestock manure and MSW are produced in significantly larger quantities than all of the other sludges (as indicated by Figure 2), and both these types of wastes contain significant amounts of organic matter, nutrients, contaminants and pathogens. Consequently, the potential environmental loadings from these wastes is much greater than those from sludges, and it is logical that livestock manure, MSW and sludges should all be subject to the same management and control regime. In a small minority of countries this desirable situation is approached, but the principle should be applied throughout Europe to ensure a consistent approach to beneficial use and disposal and uniform compliance with environmental and health standards.

The lack of a common pan-European approach to the control of all wastes makes the collation of reliable data on waste production, quality, disposal and environmental loads difficult. Since sewage sludge is the most controlled of all sludges and organic wastes, the reporting procedures required under Directives 86/278/EEC, 91/692/EEC and 91/271/EEC could be used as a model for the development of an integrated control mechanism for all wastes recycled to agriculture.

In the absence of sufficient comparable quantitative data, the qualities of different types of food and industrial sludge are described qualitatively in Table 5 (Davis and Dalimier 1994). The ranges in quality indicated are wide due to the large variations that occur in the sources of wastewater and the production and treatment processes involved.

Table 4 — Best available data¹ on chemical quality of a range of food and industrial sludges applied to agricultural land in the UK (mean concentrations, DS and nutrients as %; PTEs as mg kg⁻¹DS)

Parameter	Water treatment	Food and drink				Abattoirs			Industry				
		Gen. food & drink	Dairy	Brewing	Soft drinks	Blood	Stomach	Wash-water	Paper	Textile	Biological treatment	Tannery	Pharmaceutical
DS	20.8	8.2	5.3	9.2	4.9	11.0	8.6	7.8	21.4	6.4	8.4	6.1	9.0
pH	5.4	5.8	5.6	5.8	4.7	6.6	6.3	6.1	6.9	6.9	6.5	6.7	-
N	2.3	3.5	2.1	3.9	1.3	13.4	8.2	3.2	0.9	7.3	2.6	-	4.6
NH ₄ N	0.01	0.5	0.3	0.2	0.2	1.7	0.3	0.6	0.02	5.3	0.4	0.2	1.5
P ₂ O ₅	1.5	1.2	0.9	1.7	0.8	1.3	1.5	1.3	0.4	1.2	2.2	-	0.7
K ₂ O	0.9	1.1	0.5	0.6	0.4	1.0	0.6	0.4	0.2	0.3	0.4	-	0.3
Mg	0.6	0.1	0.05	0.2	0.1	0.03	0.03	0.04	0.1	0.7	0.2	0.0	0.1
Cu	13.3	3.8	2.4	3.1	1.1	3.2	2.4	2.1	32.8	27.5	15.9	<1.0	3.5
Zn	29.3	1.4	1.7	9.9	3.0	12.8	9.0	18.4	29.4	17.2	33.0	-	6.3
Ni	6.1	0.9	0.3	2.4	0.17	0.4	0.8	<1.0	1.3	0.8	1.8	<1.0	0.5
Cd	0.2	0.1	<0.25	0.03	<1.0	<0.25	<0.25	<0.25	0.02	<0.25	<0.25	<0.25	<0.25
Pb	17.4	0.7	5.8	1.3	<1.0	0.3	0.4	<1.0	1.7	2.5	3.5	<1.0	<1.0
Cr	9.9	1.4	0.4	3.2	<1.0	0.3	0.2	1.1	2.4	10.7	5.6	-	<1.0
Hg	0.03	0.06	<0.0106	<0.02	<0.01	<0.01	0.03	<0.01	<0.01	0.08	0.07	<0.01	<0.01
n	8	365	54	80	11	84	6	14	25	3	126	3	24

NOTE 1 Data derived from best available operational information but data sets are small (n= 3 to 365).

Table 5 — Estimated qualities of municipal, agricultural and industrial wastes produced within the European Community (EU12)

Waste source	Dry solids	Nutrients	Contaminants		Pathogens ^a	Acceptability ^b
			Inorganic	Organic		
Sewage sludge	-/+	+	o/+	-/+	-/+	-/+
Livestock manure	-/+	+	-/o	-/o	-/+	-/+
Vegetable/fruit						
Solid residues	o	o	-	-	-	-/+
WWTP sludge	-/o	o	-	-	-	-/+
Sugar						
Pulp	+	o	-	-	-	+
Lime sludge	o/+	o	-	-	-	o/+
WWTP sludge	-/o	o	-	-	-	-/+
Meat						
Blood	-	+	-	-	+	-/o
Offal	o	+	-	-	+	-
WWTP sludge	-/o	o/+	-	-	-/+	-/o
Dairy						
Milk/whey	-	o	-	-	-	-/o
WWTP sludge	-/o	o	-	-	-	-/o
Beverage						
Solid residues	o/+	o/+	-	-	-	o/+
WWTP sludge	-/o	o	-/o	-	-	-/+
Paper						
Pulp	+	-	-	-	-	+
De-inking	-/o	-/o	-/o	-/o	-	-/o
WWTP sludge	-/o	o	-	-	-	-/+
Textiles	-/+	o	-/+	-/+	-	-/+
Leather	-/+	o/+	o/+	o/+	-/+	-/o
Drinking water	-/+	-	-	-	-/o	-/o
Chemical industry	-/+	-	-/+	-/+	-/+	-/o
Domestic Waste						
Whole MSW	+	-/o	o/+	o/+	o/+	o
Source separated	o	o	-/o	-/o	o/+	o/+

^a Occurrence of pathogens depends on type of wastewater and extent of sludge treatment. Sludges derived from processing crops may contain plant pathogens.

^b Odour, aesthetics, etc.

NOTE - = low ; o = medium; + = high ; WWTP = wastewater treatment plant.

4.3 Sludge use and disposal

Table 1 shows the principal outlets for the different types of sludges and organic wastes, but for most of these there is a lack of information on the quantities being used or disposed. Most countries have mechanisms by which the use of sludges in agriculture is authorised, but relatively few countries compile this information at the national level, and no information is available at the EU level.

The exception to this will be sewage sludge when all members comply fully with the reporting requirements of Directives 86/278/EEC and 91/271/EEC on sludge use and disposal activities. However there has been information from European sludge surveys that have been carried out periodically (e.g. Newman et al. 1989 referring to 1984; Hall and Dalimier 1994 referring to 1992). In the latter survey, estimates of future sludge production and disposal were made, based on national programmes for implementing Directive 91/271/EEC. This is summarised in Table 6. There is no comparable information for other sludges from industries which will be impacted by the Urban Waste Water Directive.

Table 6 indicates that sewage sludge production will increase by 64% by the end of 2005, compared with production in 1992, assuming all Member States are able to complete the implementation of the Directive by this time. Dramatic changes were also forecast in sludge disposal practices. The most dramatic change is likely to occur in the quantity of sludge disposed of to landfill and to sea, which is forecast to reduce by 50% compared to 1992. This is as a result of the ending of sea disposal by the end of 1998 and the increased pressure on the disposal of organic wastes to landfill through various national measures. The amount of sludge incinerated with energy recovery will increase substantially by more than 5 fold, and would account for 38% of sludge disposal by 2005. Recycling, predominantly to agriculture would increase by 83% and would account for about 45% of future sludge production. The trends are very positive in that, overall, 83% of sludge is likely to be used beneficially by 2005, compared with only 50% in 1992, suggesting that the principles of the waste management hierarchy are being implemented.

However, there is concern that neither agricultural use nor incineration may enjoy high public acceptance and the concern now is to ensure the future security of these outlets, and avoid regressing to less sustainable disposal options.

Table 6 — Past and future quantities of sewage sludge used and disposed of in the European Union (EU12)
- 10^3tDS y^{-1} (%) (Hall and Dalimier 1994)

Outlet	1984		1992		2000		2005	
Recycling	2057	(37)	2504	(39)	3617	(40)	4576	(45)
Incineration	518	(9)	715	(11)	2088	(24)	3872	(38)
Disposal	2988	(54)	3257	(50)	3200	(36)	1615	(17)
Total	5563	(100)	6476	(100)	8906	(100)	10063	(100)

NOTE Estimate made in 1994.

5 Assessment of sludge management options

5.1 Sludge quality requirements

The relative importance of sludge quality criteria varies according to the use and disposal option for the sludge. Their relative importance according to outlet is given qualitatively in Table 7. Criteria associated with the production and recycling outlets are focused on the acceptability of the sludge to the user together with environmental protection. For incineration and to some extent landfill, the criteria include quality factors that will influence satisfactory running of the process.

Table 7 — Relative importance of sludge quality criteria for use and disposal

Criteria	Product ^a (not managed by sludge producer)	Recycling (managed by sludge producer)	Landfill	Incineration
Physical				
Dry solids	++	++	++	++
Organic matter	+	+	+++ ^b	++
Mechanical stability	+++	+	++	+
Litter	++	++	o	o
Calorific value	o	o	o ^b	++
Biological				
Odour	++	++ or +	+	+
Stability	+++	++ or +	+ ^b	o
Pathogens	++	++ or +	o	o
Chemical				
Nutrients	++	+++	o	o
Metals	++	++	+	+ ^c
Organics	++	++	+ ^d	o

a This category means that sludge that has been treated (most often composted) and considered as a product, and no longer a waste. This procedure is not allowed in certain countries. National regulations should be followed in the absence of EC regulations.

b There may be a limit on the content of degradable organic matter.

c Particular attention should be given to: volatile metals, such as Hg, Pb and Zn, for their tendency to be present in emissions; Cr due to potential conversion to soluble form (Cr6+); and Cu for its catalysing effect in the formation of dioxins and furans when chlorine is present.

d Review locally on a risk assessment basis.

Priorities for environmental quality criteria :

+++	very important for this use/disposal
++	important for this use/disposal
+	less important for this use/disposal
o	not important for this use/disposal

Table 7 shows that quality requirements for sludge are highest for sludge products, followed by the recycling options with landfill and incineration being less sensitive. It is emphasised that sludge quality must be managed to satisfy the disposal route available, not the reverse if practicable, and the higher the sludge quality the easier it will be to dispose of the sludge because more options will be available. There is therefore a strong incentive to produce a high quality sludge. Sludge quality is quantified by standards that should have a sound scientific basis to ensure environmental protection, be readily measurable preferably by routine methods of analysis and be economically and technically achievable. Quality criteria for the four principal disposal options are discussed in more detail below.

As regards standards, Directive 86/278/EEC deals specifically with the use of sewage sludge in agriculture; there are no other European regulations addressing other sludges and organic wastes in such a specific manner. There is a strong case for providing a single regulatory framework for all sludges covering all treatment and disposal options. The reason for this is to ensure that the management of use and disposal takes into account potential impact on all environmental compartments and finds the best overall environmental solution for sludge disposal in the region in question. Excessively restrictive standards in one particular sector, such as agricultural land or landfill, can preclude sludge use or disposal in that sector, in which case the sludge will have to be disposed of by some other means. As options are lost, the tendency will be to drive sludge disposal by default to expensive minimisation processes with negligible or negative environmental benefit and uncertain sustainability. It is important that restrictive standards can be justified on a scientific basis and that their consequences for sludge disposal have been considered from the perspective of impact on the remaining outlets.

By the same token, sludge producers must make every effort to ensure that their products are as "clean" and as free from contaminants as possible. This can be achieved by strict controls on industrial discharges to the sewer, clean industrial technologies, material substitution in products to reduce diffuse sources of pollutants, suitable treatment of wastewater and sludge, and public education to minimise undesirable inputs from domestic sources such as litter and other nonbiodegradable materials. A case study that demonstrates the benefits of source control is presented in Annex I.

The quality criteria for specific sludges and outlets should be defined as a means of focusing on wastewater quality to reduce contaminants and identifying appropriate sludge treatment methods to achieve the quality objectives. For the quality critical outlets, such as sludge products and use on land, this is likely to increasingly require advance treatment technologies to provide products of suitable physical and microbiological quality. This will probably necessitate developing a similar approach to that adopted by the USEPA for high quality Class A sludges, which can be used relatively freely because of the efficacy of the treatment processes specified for reducing pathogen content, and Class B sludges that are much more restricted in their use opportunities (see Annex D).

Confidence and a positive attitude by stakeholders to the use and disposal of sludges and related environmental issues is very desirable. The alternative may be an increasingly restrictive regime for sludge use, under which only very low levels of contaminants are permissible, hygienic quality has to be assured by high temperature processes, and application rates are restricted to less than the agronomic optimum. Such high quality standards are technically achievable, but the cost that may cause sludge to be disposed of by other means, which have less obvious environmental impacts and may be less sustainable. Some of the factors that could boost stakeholder acceptance are transparency, direct discussion with, and involvement of, stakeholders, quality assurance, independent accreditation and open support by regulators.

Figure 3 illustrates how the waste management hierarchy can be incorporated into strategic management decisions, with reference to the CEN/TC 308 WG2 documents.

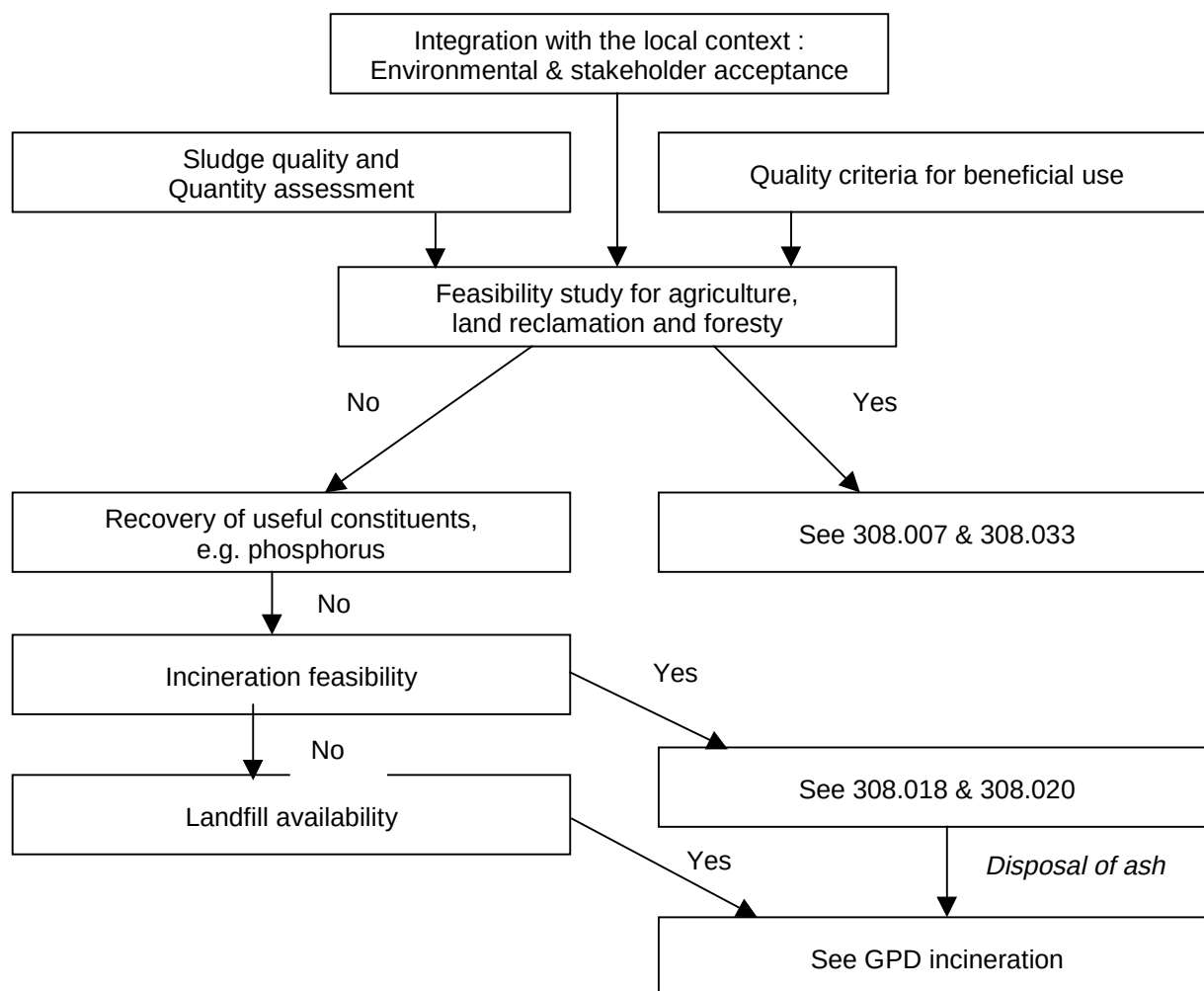


Figure 3 — Basic scheme for deciding on sludge use and disposal options and the relevant CEN/TC 308 WG2 good practice documents (Annex A)

5.2 Technical means of achieving sludge quality objectives

The assessment of technical options for achieving sludge quality objectives in relation to sludge use and disposal should be made with due regard for :

- BAT (Best Available Techniques) - to prevent or minimise pollution to the environment as a whole by direct and indirect releases, having regard for the BPEO (Best Practicable Environmental Option). This would include source control (point and diffuse) of pollutants, supported by enabling legislation ;
- Waste management hierarchy - to prioritise prevention, minimisation, recovery and use, and consider disposal as the last option ;
- BPEO - to evaluate the practicality, environmental impact, security and cost, to ensure that the selected option is the best for the environment as a whole, is sustainable, and does not incur excessive cost.

The management of sludges should always positively discriminate for use options (i.e. integration in material cycles), which may include :

- landspreading of organic fertiliser - traditional, likely to be the largest, single outlet for non-hazardous sludges ;
- products - value-enhanced materials, perhaps bagged for the domestic market, but quality control, pricing and public perception are critical ;
- resource recovery - such as in building materials, for animal feed, retrieval of valuable components (heavy metals, grease, etc.) are potential use options, but are not widely used internationally due to processing costs and commodity prices ;
- energy recovery - the options are incineration with heat and power recovery (sludge only incineration or co-incineration with municipal solid waste), gassification, or co-combustion in power stations and in industrial processes, such as cement and asphalt production. This will become an increasingly important option in the waste management hierarchy, provided there is energy recovery. However, incineration of sludge still leaves a residue (30% of sludge dry solids may remain as ash), the disposal of which can be costly. In industrial co-combustion, the sludge ash usually becomes a component of the product.

The need for disposal facilities should not be ignored since it is difficult to envisage when disposal without recovery (i.e. removal from material cycles) can be avoided completely for all types of sludge. However, it is widely accepted that the landfill disposal of organic wastes is not a sustainable option. Various measures (policy, taxation, legislation) will ensure that landfill disposal can rarely, if ever, be the BPEO for non-hazardous sludges.

Use of sludges is the generally preferred option, but for any particular instance it should be considered within the overall local context; if it represents the BPEO for a particular waste type, once all of the environmental and economic costs and benefits of the different options have been taken into account. Landspreading can represent an economical and environmentally safe means to recover value from a wide range of wastes. However, the pre-treatment and landspreading of sludges of any origin needs to be carried out in all cases without :

- risk to water, air, soil, plants and animals ;
- causing nuisance through noise and odour ;
- adversely affecting the countryside or places of special interest.

In order to secure a sustainable long-term future for landspreading of sludges, waste producers need to demonstrate commitment to the quality of products and the recycling operations.

Organic-rich sludges, such as sewage sludge, should be subjected to treatment by the producer to achieve one or more of the following objectives :

- avoid or reduce potential environmental and health impacts ;
- improve the consistency of product quality ;
- reduce the volume of sludge requiring transport and disposal or recovery ;
- improve the agronomic value ;
- improve 'marketability' through better handling, odour and visual aesthetics, and enhanced public perception of the wastes ;
- improve the energy value.

The most common treatment processes include :

- fine screening to remove litter ;
- anaerobic and aerobic digestion (reduces volatile solids, odour and pathogens),

- dewatering (volume reduction, improved stackability) ;
- composting (product quality enhancement, co-treatment possibilities) ;
- chemical treatment (e.g. lime - sanitisation and product quality enhancement) ;
- thermal treatment, for :
 - increasing biodegradability before biological stabilisation ;
 - pathogen reduction, preferably before stabilisation ;
 - drying to reduce water content for product quality enhancement and reduced transport costs ;
 - combustion/gassification, to destroy organic matter, for bulk disposal and recovery of energy.

Figure 4 illustrates some of the process options available for treating sludge in relation to the sludge use and disposal options. See also the work of CEN/TC 165 "Wastewater engineering" EN 12255-8:1998 "Wastewater treatment plants - Part 8: Sludge treatment and storage".

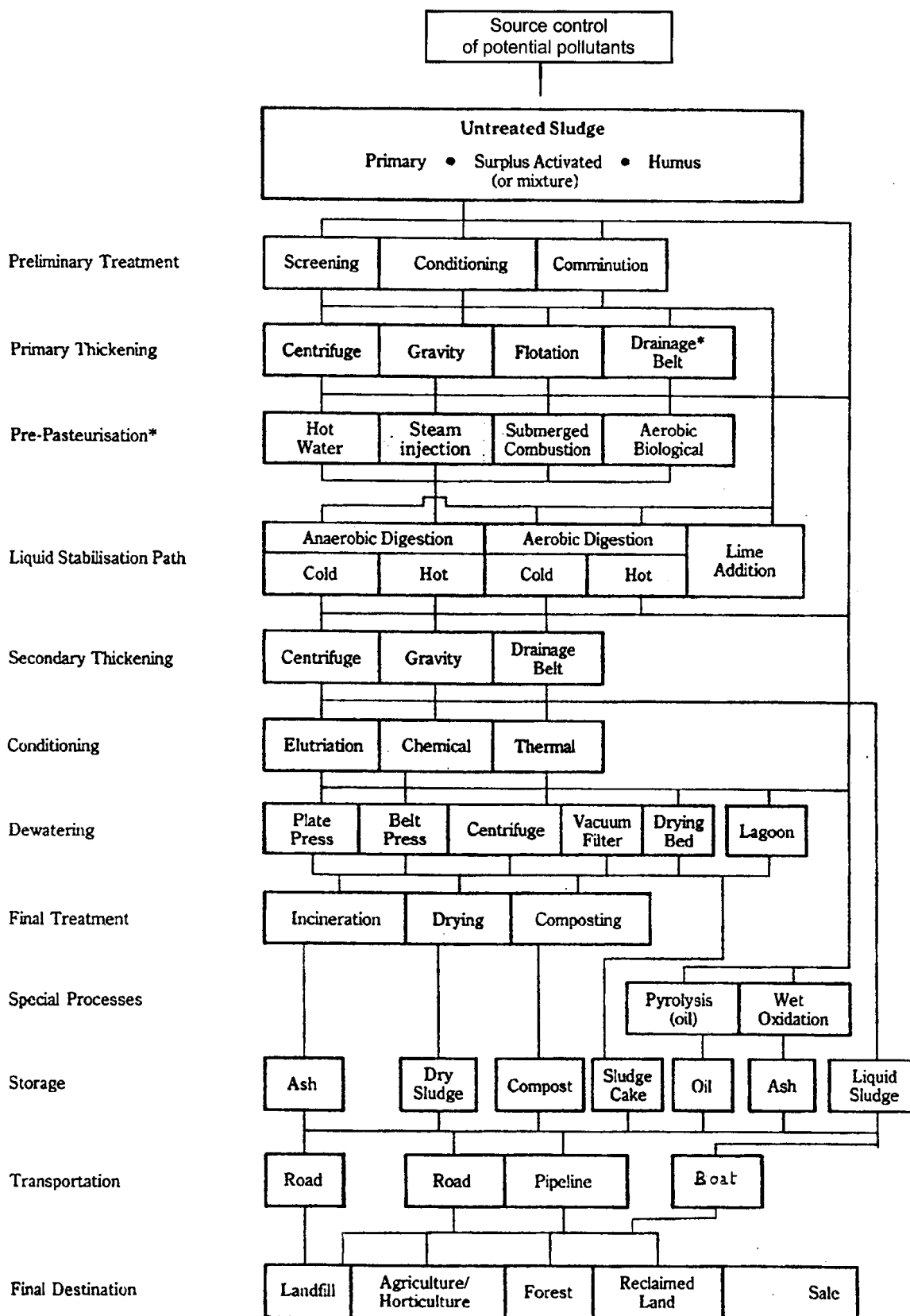


Figure 4 — Technical means of achieving sludge quality objectives in relation to sludge use and disposal

The suitability of these methods is dependent on the chemical, physical and microbiological nature of the sludge, the potential impacts on the potential outlets, and the economics of processing and disposal, including transport. All methods of processing incur additional costs but they can :

- reduce overall costs by minimising the quantity of sludges requiring transport ;
- access lower cost disposal options by improving ;
- make the product attractive to the user, both aesthetically and agronomically ;
- secure long-term access to the landspreading outlet and other recovery options.

Integrated waste management and treatment centres

The concept of completely integrated centralised organic waste treatment centres has been around for some years. A few examples have been constructed in Europe, but it is doubtful that these have been economically viable without state support. In the future, this option may become more attractive and likely to be undertaken by specialised waste management companies. Under certain circumstances, there are benefits from centralised treatment of wastes, where :

- sludges from the same type of industry within a region may be treated at a single treatment centre (this is a common method of operating for sewage treatment works and there are many examples for animal slurry in Europe) ;
- sludges from different industries arising in a locality can be treated in admixture ;
- sludges can be treated in combination with other non-hazardous solid wastes, to produce a single product for use, such as by composting.

The potential benefits of this type of approach are :

- improved treatability ;
- improved economies of scale ;
- avoiding the problems of treating and disposing of difficult or bulky individual non-hazardous sludges or solid wastes ;
- improved product quality, uniformity and marketability.

However, the viability of integrated treatment depends on :

- transport economics - the relative locations of the waste arisings, treatment centres and product outlets ;
- availability of suitable treatment facilities - these may require licensing, planning permission, financing and construction (high cost), and raises issues of ownership, responsibility and liability ;
- suitable outlets for the product - there must be a demand for the product within economic transport distance ;
- product quality - to meet quality standards and public expectations, particularly if revenue is to be raised from the sale of the product.

The treatment processes most suited to integrated treatment and product “manufacture” are :

- anaerobic digestion - of a mixture of different sludges can give enhanced methane production and a product with improved NPK balance. The product can be dewatered (or even thermally dried using biogas) to produce a high quality organic fertiliser ;