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BSI Standards Publication

Characterization of sludges — Sludge management in relation to use or disposal

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National foreword

This Published Document is the UK implementation of CEN/TS 13714:2013. It supersedes PD CEN/TR 13714:2010 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EH/5, Sludge characterization.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Characterization of sludges - Sludge management in relation to use or disposal

Caractérisation des boues - Gestion des boues en vue de leur valorisation ou de leur élimination

Charakterisierung von Schlämmen - Management von Schlamm zur Verwertung oder Beseitigung

This Technical Specification (CEN/TS) was approved by CEN on 27 August 2012 for provisional application.

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Foreword

This document (CEN/TS 13714:2013) has been prepared by Technical Committee CEN/TC 308 “Characterization of sludges”, the secretariat of which is held by AFNOR.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes CEN/TR 13714:2010.

This document gives recommendations for good practice, but existing national regulations remain in force.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

The purpose of this Technical Specification is to outline the management of sludges both upstream and downstream of the treatment process to ensure that it is suitable for the outlets available. Sludge is the inevitable residue of treating raw potable water and municipal and industrial wastewaters. This Technical Specification refers to all types of sludge covered by CEN/TC 308 including sludges from treating industrial wastewater similar to urban wastewater and from water supply treatment work plants. In considering the likely quality of sludges, it should be remembered that municipal wastewater sludges are composed of materials that have already been disposed of and are consequently likely to be more variable than many industrial sludges that arise from sourced materials or water treatment sludges arising from surface water or groundwater.

The quality of the sludge should match the requirements of the outlets whether that be to land, thermal processing or as a last resort landfill. As a general rule a high quality sludge is likely to be acceptable to a large range of outlets giving greater operational flexibility. High quality sludges are likely to be suitable for those outlets associated with maximum sustainability and minimum environmental pollution. The management of sludges will become increasingly more complex as environmental standards become more stringent and if outlets become more constrained by legislation and public attitudes.

Sludge quality is central to the development of good practice for sludge production in relation to its destination (use or disposal). Sludge quality depends on the composition of the upstream materials and the type of treatment including post treatment storage.

Sludge quality can be characterised by its different properties; biological, chemical and physical:

a) biological properties include the microbiological stability of the organic matter in the sludge, odour and hygienic characteristics;

b) chemical properties include:

   1) content of potentially toxic substances (PTSs) which include inorganic (metals, metalloids, and other minerals), and organic pollutants;

   2) concentrations and form (availability) of plant nutrients and the main components of the sludge;

c) physical properties include whether liquid, semi-solid (pasty-like) or solid, and aesthetic factors associated for instance with removal of unsightly debris by effective screening. Calorific value is a quality criterion if the sludge is to be incinerated or used as a fuel. Other physical properties include, thickenability and dewaterability.

The consistency of these different properties is a critical aspect of the sludge quality and of the ability to determine its end destination (use or disposal).

Standard methods should be used where these are available to measure the quality parameters of sludge. There is a continuing need to develop a full set of standardised and harmonised methods which the manager and operator can use to evaluate the quality of sludge for treatment process design and operational purposes.

This Technical Specification considers the management of sludges against the waste hierarchy, the management of sludge quality and an option evaluation process to determine the options available.

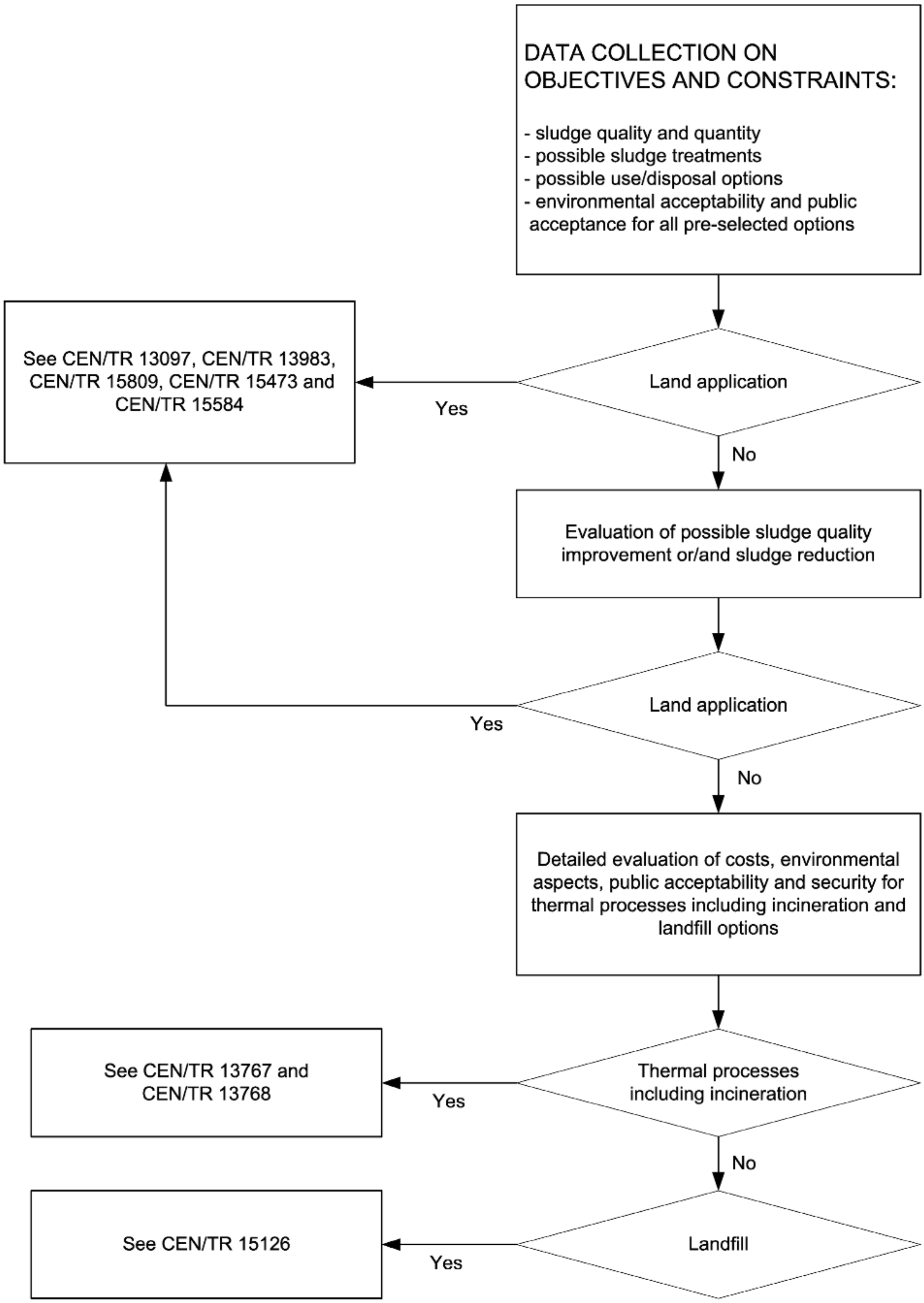

Figure 1 — A basic scheme for deciding on sewage sludge use/disposal options and the relevant CEN/TC 308 guidance documents

1 Scope

This Technical Specification gives guidance for dealing with the production and control of sludge in relation to inputs and treatment and gives a strategic evaluation of recovery, recycling and disposal options for sludge according to its properties and the availability of outlets.

This Technical Specification is applicable for sludges from:

- storm water handling;
- night soil;
- urban wastewater collecting systems;
- urban wastewater treatment plants;
- treating industrial wastewater similar to urban wastewater (as defined in Directive 91/271/EC [1]);
- water supply treatment plants;

but excluding hazardous sludges from industry.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1085:2007, *Wastewater treatment — Vocabulary*

EN 12832:1999, *Characterization of sludges — Utilization and disposal of sludges — Vocabulary*

3 Terms and definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1085:2007 and EN 12832:1999 and the following apply.

3.1.1
industrial wastewater
trade wastewater
trade effluent
wastewater discharge resulting from any industrial or commercial activity

3.1.2
urban wastewater
municipal wastewater
wastewater from municipal areas consisting predominantly of domestic wastewater and which may additionally contain surface water, infiltration water, trade or industrial wastewater

3.2 Abbreviated terms

The following abbreviated terms, necessary for the understanding of this specification, apply:

- BOD: Biochemical Oxygen Demand

— BPEO: Best Practicable Environmental Option

— COD: Chemical Oxygen Demand

— EQO/EQS: Environmental Quality Objectives/Environmental Quality Standards

— PTS: Potentially Toxic Substance

4 Waste hierarchy

4.1 General

In order that the management of waste be conducted in an increasingly sustainable manner, the EU encourages a waste hierarchy as a framework by which Member States should develop their strategy for waste management (EU Directive 75/442/EEC (see [2]) as amended by 91/156/EEC (see [3])).

Figure 2 — The waste hierarchy — Including sludges

This hierarchy encourages:

a) firstly, the prevention or reduction of waste production and its harmfulness, in particular by:

   1) development and implementation of clean technologies more sparing in their use of natural resources;

   2) technical development and marketing of products designed so as to make no contribution or to make the smallest possible contribution, by the nature of their manufacture, use or final disposal, to increasing the amount or harmfulness of waste and pollution hazards;

   3) development of appropriate techniques for the final disposal of dangerous substances contained in waste destined for recovery;

b) secondly, the best possible use of waste:

   1) recovery of waste by means of recycling, re-use or reclamation or any other process with a view to extracting secondary raw materials;

   2) or the use of waste as a source of energy.

The hierarchy places disposal as the last management choice.

Four of the stages within the hierarchy can be applied to sludges, namely reduction, recycling, recovery and disposal. Obviously, the latter is the least desirable and efforts should be made to minimise the proportion of sludge which is disposed of, by the adoption of clean technologies, recycling and recovery strategies.

The waste hierarchy can be applied equally to activities upstream of the sludge production process and to the processes employed within the treatment process. These are discussed separately below. In considering what management options should be selected, all stages in the sequence of sludge production and its ultimate fate should be scrutinised.

4.2 Context

The overall objective of a sludge management strategy should be to find outlets for the sludge which are safe, environmentally acceptable (carbon foot print), secure and economic. The availability of outlets (see Clause 8) determines how sludge should be treated.

In order to do this, it is important to address quality (Clause 5) and management processes (Clause 6) and operational practices (Clause 7).

5 Management of sludge quality - Upstream processes

5.1 General

The significant difference between municipal sludges and industrial sludges and to a certain extent water treatment sludges is the degree and complexity of control over the inputs.

Industrial sludges usually arise from the processing of sourced materials and control over their content and consequently the quality of sludge can often be made by analysis of the materials and in many cases by the imposition of quality standards on them. This may not always be possible for instance in the amount of bacteriocides and fungicides in paper waste collected for recycling which could vary from batch to batch. River waters can carry a range of pollutants which could enter the sludge and operators should be aware of the potential pollutants that could enter the river upstream.

5.2 Municipal wastewater sludges

For municipal wastewater sludges strict limits should be imposed on industrial and commercial discharges to the sewer so that the sludge produced from wastewater is ‘clean’ or as free as possible of contaminants of industrial origin.

Industrial point sources of contaminants discharging to the sewer should be identified and restricted or stopped. Key factors are careful discharge consent settings (see below) monitoring and inspection backed by enforcement. Quality assurance in support of the consent requires adequate sampling to check compliance. The extent of sampling of effluent from industrial premises should be decided on a risk assessment basis taking account for instance of size of operation and quantity of chemicals in use.

The "polluter pays" principle should be used to oblige industries failing to produce acceptable effluents to investigate and implement remedial measures. This may entail a change in the production process or the installation on the industrial premises of effluent treatment plant. Often the cost of this is offset by reduced payments for effluent discharge and the recovery and reuse of valuable chemicals that would otherwise have been discharged to the sewer. Experience has shown that by progressively identifying and controlling point source discharges, the quality of sludge can be substantially improved by reducing its content of PTS.

Emergency planning should make provisions to deal with accidental discharges of large amounts of polluting chemicals to the sewer so that contamination of sludge is minimised, and the biological treatment processes of wastewater and sludge are protected.

Conventional wastewater treatments remove most of the organic polluting load of the wastewater; this is measured in terms of BOD or COD. These processes also transfer much of the non-treatable polluting load, consisting of non-degradable or persistent residues, out of the wastewater and into the sludge. This is advantageous for the production of clean effluent but if the wastewater contains significant levels of contaminants of industrial origin then these contaminants are likely to be found in the sludge at levels, which affect its environmental suitability for use and disposal outlets. Some of the PTS contained in an untreated wastewater is found in the sludge after treatment. The percentage of the wastewater load of PTS transferred into sludge depends on many parameters, such as the wastewater and sludge treatment process, pH, solids content, and PTS content.

5.3 Setting limits for discharges from industrial and commercial premises to municipal sewers

The use of public wastewater systems is regulated by the operators according to the relevant legislation in place in all the EU Member States and through by-laws, public law agreement or private law operating conditions.

The EU legislation covering the control of potentially toxic substances in discharges to the aquatic environment is Directive 2006/11/EC [4] and Directive 2000/60/EC [5] known as the Water Framework Directive (WFD). These directives should therefore be the springboard for controlling the discharge of toxic and harmful materials from industry and commercial activities. There should be an effective control of the discharge from the wastewater treatment process and the quality of the sludge emanating from it.

Directive 2006/11/EC [4] introduces two lists of 132 dangerous substances to limit discharges from industrial and commercial premises:

— List 1 Substances (e.g. mercury, cadmium, organophosphorus compounds and organochlorine compounds) should be removed as completely as possible from all industrial wastewater discharges using the best available technology (BAT). Whenever possible, List 1 substances should be replaced by more benign and less toxic alternatives.

— List 2 Substances (e.g. copper, chromium, zinc, and nickel) should be reduced in discharges by the application of the "Best Available Technology Not Entailing Excessive Cost" with respect to the level of environmental risks. A cost/benefit analysis is therefore an essential element in deciding the appropriate level of treatment.

Annex 10 of Directive 2000/60/EC [5] sets out a list of 33 priority substances or group of substances selected amongst those which present a significant risk to or via the aquatic environment. For those pollutants, specific control measures are required that aim for the progressive reduction and for 11 priority hazardous substances the cessation or phasing-out of discharges, emissions and losses.

Directive 2008/105/EC [6] amending the Water Framework Directive 2000/60/EC (WFD) establishes environmental quality standards for priority substances and other substances from Directive 2006/11/EC [4]. Reduction of the pollution by these substances shall be assessed through inventories of their discharges, emissions and losses. This text also proposes a list of 13 substances for their identification as priority or hazardous priority substances. Directive 2006/11/EC [4] is repealed by the WFD as from the end of 2013.

Requirements for these dangerous substances are the subject of varying national regulations. In all cases, dangerous substances should be reduced at source as far as possible by suitable pre-treatment of the industrial waste stream prior to discharge to sewer.

Improvements in environmental protection as regards both sludge recycling or disposal, and discharges from treatment plants to the watercourse, require the periodic review of industrial and commercial discharge permit conditions.

5.4 Other factors

5.4.1 General

Factors additional to sludge quality have to be considered in setting limits for chemicals in industrial discharges to the sewer. These are given below.

5.4.2 Protection of biological municipal wastewater treatment processes

Biological processes depending on the action of bacteria and other micro-organisms include biofilm processes and activated sludge. The chosen threshold values for individual contaminants from industrial and commercial discharges should be protective enough to avoid damage to the biota with the consequent failure of the biological wastewater processes.

5.4.3 Protection of biological sludge treatment processes

This normally applies to anaerobic digestion but also to sludge treated by aerobic processes such as composting. Heavy metals and organic contaminants such as pentachlorophenol have been found to inhibit anaerobic digestion of sludge.

It is not easy to designate threshold values for individual contaminants above which biological wastewater or sludge treatment processes may fail because this depends also on the composition of the wastewater, operating conditions and whether the plant is acclimatised to the contaminant. It is now the case that in order to meet sludge quality requirements for use or disposal, concentrations of PTS in wastewater shall be restricted to levels below those which would be expected to adversely affect biological wastewater, sludge treatment processes or subsequent use of the liquid.

5.4.4 Protection of environmental quality in the receiving watercourse

The maximum permissible concentrations of substances discharged to the wastewater given by the national regulations have to be related to the standards set for the final discharge effluent from the wastewater treatment works including storm water overflows from the sewerage system, and those for the receiving watercourse.

5.4.5 Protection of sewer fabric

This is usually controlled by limits for the acidity, alkalinity and temperature of discharges and their content of sulphate and sulphide.

5.4.6 Protection of sewer maintenance workers

Personnel should observe the normal rules of hygiene and it is necessary that chemicals which could generate toxic fumes in the sewer are strictly controlled.

5.5 Minimising contamination including diffuse sources in municipal wastewater

There are sources of contamination of municipal wastewater and sludge other than industrial and commercial discharges to the sewer. These are inputs among others from domestic sources and from runoff from roads, etc. and they are diffuse and less readily controlled than point source inputs.

A programme of public education to minimise discharge of unsuitable substances and materials into domestic wastewater can be advantageous.

The public should be advised of those substances, which are not permitted for discharge down drains or the lavatory and be given instructions as to how they can be safely disposed of. Such substances include waste oil, solvents, paint residues, medicines and pesticides.

The public should be encouraged not to put non-degradable litter items down the lavatory; some countries have instigated campaigns therefore (e.g. ‘bag it and bin it’ campaign in the UK). The message should be that collective individual action can make a major impact on the environmental problems.

Organic contaminants in sludge include detergent-derived compounds and other compounds that are widely used by industry or in the home. It is important to test chemicals before they are put into products for widespread domestic and other use to ensure that they do not cause a hazard to the environment or man with respect to sludge use or disposal and to receiving waters. Whether this is done or not is usually beyond the control of those responsible for sludge quality and safe disposal. There should be more accountability of the manufacturers of these compounds to ensure treatability. This would be in accordance with the "polluter pays" principle. To some extent this problem is addressed by Directives 67/548/EEC [7] and 82/242/EEC [8] and 82/243/EEC [9].

6 Sludge management

6.1 Measures upstream of water and wastewater treatment facilities

6.1.1 Source prevention

Prevention at source of contaminants and quantity of discharges to sewer is a preferable policy when new industrial or commercial premises are being connected to the sewer or when processes are being redesigned.

6.1.2 Source reduction

Reduction of sludge by reducing the input to treatment processes is the most difficult of the hierarchy levels to achieve. This often requires industry and commercial activities to pre-treat their effluents often producing their own sludge but reducing the amount and/or pollutants at the municipal wastewater treatment works. A large proportion of the sludge from municipal wastewaters is derived from domestic wastewater and this is difficult to control although a public relations programme to indicate to the public what should not be put down the sewer is advisable.

Sludge quantities from industry and water treatment are related to the rate of production and demand. Potable water sludge can be reduced by ensuring that water is not taken from rivers when they are carrying large loads of silt.

6.2 Measures at sites of sludge production and processing

6.2.1 Water and Wastewater treatment processes

When selecting water and wastewater treatment processes, consideration should be given to the quantity and type of sludge that is produced and its characteristics relative to the proposed ultimate use or disposal of the sludge.

Proper operating procedures can help to keep sludge production at a low level (e.g. operation at high sludge residence time in biological processes, optimisation of chemical dosages).

Volumes of industrial sludges have been reduced by reducing inputs into the process. In the Tannery industry, average chemical consumption has been reduced from 400 kg/t hide to 250 kg and lime input from 5 % to 2 % to 3 % of hide weight.

Water treatment sludges can be reduced by choosing the optimum flocculant, pH, energy input and retention time in the mixing and flocculation steps. Where iron and manganese are to be removed, the amount of sludge produced may be minimised by consideration of the oxidant used. There is also an opportunity to reduce the amount of dry solids in sludges (Tons of Dry Solids, tDS), if chemical softening is employed by using caustic soda instead of calcium hydroxide though in this last case there are other drawbacks related to the drinking water quality and to the dewatering of sludge.

6.2.2 Sludge treatment

6.2.2.1 General

All recommendations have to be adapted to the local context and constraints associated to the outlets.

Appropriate treatment practice should be used to control the pathogen risks. More information on hygienic aspects is given in CEN/TR 15809 [10].

6.2.2.2 Water content reduction

The reduction in the volume of water present in a sludge by thickening, dewatering and drying is the primary route by which sludge quantity may be reduced following treatment.

All sludge concentration processes in water and wastewater treatment generate a liquor requiring treatment by a separate process or with wastewater sludge by recirculation through the wastewater treatment works.

There is a limit to the amount of water that can be removed from sludge by mechanical means, and most dewatered sludges (for instance by belt press, filter press, centrifuge, etc., see prCEN/TR 16456 on sludge dewatering [11]) have a dry solids content in the range 15 % to 40 %.

Thermal drying of sludge (see CEN/TR 15473 [12]) reduces the volume of sludge by evaporating water that cannot be removed mechanically to as high as 95 % dry solids. However, considerable energy is used to dry sludge to this degree and local circumstances dictate whether any environmental benefit is gained from thermal drying over the transport of large volumes of wet sludge for recycling or disposal purposes. It is essential for such factors to be appraised in the strategic evaluation of options (Clause 8).

6.2.2.3 Biological treatment

Anaerobic digestion typically achieves a 40 % to 50 % volatile matter reduction and aerobic stabilisation achieves a volatile matter reduction of 30 % to 40 %. These processes partly reduce the pathogen content of the sludge (if present) and importantly its odour potential. Centralised digestion units can be considered for receiving various industrial wastes, for instance olive oil, tomato and wine wastes in the Mediterranean regions. Centralisation for municipal wastewater sludges is a common feature with sludges brought in for treatment from a number of different catchments and this should always be considered where a regional strategy is being examined.

Composting is an aerobic controlled process (biological oxidation of organic matters with heat generation) to produce a stable and disinfected product of value as soil amendment. A composting process can be characterised by the maximum temperature and duration. The composting of most sludges can be optimised by the addition of bulking agent such as straw, wood chips, bark or garden and park wastes. The Carbon to Nitrogen ration (C/N) has to be around 25:1 and the air pore volume around 35 % for optimal composting. Selection of the bulking agent should avoid any negative impact in the quality of the composted product due to the presence of any contaminants in the bulking agent. Sludge criteria which should be considered for the composting process include sludge fermentability, sludge type and treatment prior to composting, and sludge rheology. Factors which should be considered in the design of a composting plant are listed in EN 12255-8 [13].

6.2.2.4 Thermal treatment

Incineration (see CEN/TR 13767 [14]) is a reduction of the organics in the sludge by combustion at high temperature. It produces an ash (about 20 % to 50 % of sludge dry weight) which has to be disposed of unless a use can be found for it. Vitrification is a technique for reducing the volume of incinerator ash to make an environmentally inert material. Landfill disposal can be avoided since it is possible to use this technique to make environmentally inert construction materials. The temperature required for vitrification is much higher than for incineration and consequently has a high energy cost.

A positive aspect is the opportunity for some energy recovery through waste-to-energy facilities and these should preferentially be employed over incineration with no energy recovery. With the improvement in sludge dewatering and incineration techniques, modern fluidised bed incinerators are autothermic in operation, only requiring support fuel at start-up, and when coupled with gas cleaning systems, have very low emissions to the atmosphere. Co-incineration (see CEN/TR 13768 [15]) with other organic wastes, such as municipal solid waste, may also be an option under some circumstances.

Wet oxidation is a reduction of the organics in the sludge by thermal degradation, hydrolysis and oxidation of sludge organic matter in aqueous phase in a single-stage reaction at high temperature and pressure. The technique does not require the complex gas cleaning equipment which is needed in many combustion processes. During the process, some of the organic matter is made soluble and it produces ashes and high COD and BOD liquors that are to be treated.

6.3 Solutions for recycling recovery and disposal

6.3.1 General

There are opportunities for recovery of the resource value of sludges at the site of sludge production (e.g. biogas) or downstream of the site of sludge production (e.g. nutrient content of the sludge).

Sludges can be used in liquid, dewatered, dried or incinerated form. The level of processing employed should be the optimum necessary to ensure the quality of the sludge for the selected end use.

All these activities should be conducted according to the relevant legislation in place in the relevant Member States, and other CEN guidance documents.

6.3.2 Application to land (see CEN/TR 13097 [16] and CEN/TR 13983 [17])

The most common method of sludge recycling is application to land. For this application, the levels of PTS have to be verified against national requirements. There is an existing legal framework for the utilisation of sludges in agriculture in the European Union [18].

Recycling to land involves the processing of waste materials to produce a usable, secondary raw material. Sludge may be recycled in a range of ways which vary in the degree of processing and energy required. The potential to cause an odour nuisance shall be assessed for any sludge being applied to land.

Sludge may be beneficially used to supply plant nutrients and add organic matter and/or lime to soil in agriculture, land reclamation, forestry operations, landscaping, amenity horticulture and horticulture. Apart from municipal sludge, many industrial sludges are applied to land including those from paper recycling, brewing and fruit and vegetable processing. Some waterworks sludges can be beneficially applied to land to utilise their organic matter and/or lime content such as in the improvement of acid mine spoils. However they generally have a low N,P,K content and some have negligible soil enhancement value. Waterworks sludges can be used in topsoil manufacture in some circumstances.

Detailed information on quality should ensure that each type and source of sludge is used appropriately according to its quality. Maximum benefit and maximum fertiliser replacement value will be achieved if the nutrient values and release characteristics are matched to the crop needs including the timing of applications. For example, the nitrogen release characteristics of a digested liquid municipal sludge differ from those of a digested dewatered cake, and the manner of their use should reflect this to minimise the risk of nitrate leaching losses. Digested liquids should not be used in the autumn as available nitrogen will leach and not be taken up by crops.

There are several sludge processing techniques that involve the addition of materials in order to produce a more stable, easily handled material for land application. One such technique is lime addition for stabilisation, disinfection, dewatering and storage purposes.

6.3.3 Other uses

Municipal wastewater sludge incinerator ash and some waterworks sludges where they contain iron, manganese and aluminium can be used in the production of construction materials, such as fibre board, bricks, ceramic lightweight blocks, paving blocks, etc. Water works sludges with high calcium carbonate content can be used in the filling material industry and in the paper industry for surface processing. Paper waste sludge can be used for the production of ethanol and lactic acid. Such processes are high cost but may be the Best Practicable Environmental Option (BPEO) in some circumstances.

6.3.4 Energy recovery

Useful energy can be recovered from:

a) Methane from anaerobic digestion of sludge.

Gas from anaerobic digestion of municipal sludge contains about 2/3 CH_4 by volume, 1/3 CO_2 by volume and small amounts of N_2, H_2, H_2S, water vapour and other gases. Total gas production can fluctuate over a wide range, depending on the volatile solids content of the sludge feed and the biological activity of the digester. Typical values vary from 0,75 m^3/kg to 1,12 m^3/kg of volatile solids destroyed. Because digester gas is typically about 65 % methane, the calorific value of digester gas is about 22 400 kJ/m^3 (by comparison, methane has a low calorific value of approximately 37 300) kJ/m^3). Combined heat and power plants make efficient use of methane for digester heating, air compression, and electrical power for use on the treatment plant or for export. Digester gas can be burned directly to provide heat for sludge drying or it can also be upgraded to vehicle fuel. As digester gas contains hydrogen sulphide, particulates, and water vapour, the gas has to be cleaned in dry or wet scrubbers before it is used in internal combustion engines.

Anaerobic digestion is increasingly being used for industrial sludges including those from food and beverage production, meat, dairy and wool processing with the biogas being used to offset energy requirements and reduce the carbon footprint of the process.

b) Combustion techniques applied to dried and dewatered sludges.

The calorific value of sludges depends on the concentration of water and organic material content.

1) Dedicated or co-incineration with other wastes (see CEN/TR 13767 [14] and CEN/TR 13768 [15]).

Energy may be recovered as heat to be used for space heating or raising steam for power generation. For municipal wastewater sludge, the calorific value of the dry matter of untreated primary sludge is the highest.

2) Co-combustion with other fuels in power stations.

3) Use in an industrial process, such as cement and asphalt production. Conventional fuel can be supplemented by substituting sludge to fuel.

4) Other high temperature treatment options exist such as gasification with or without wastes to produce fuels.

For the uses mentioned in the first and second bullet points, the level of sludge addition depends on the particular application, the quality of the gas being produced during incineration, and the specific atmospheric emission standards to be achieved.

In all cases, the energy balance (including energy for removing water, etc.) and carbon footprint of the processes shall be calculated to verify the environmental benefit of the project.

6.3.5 Component recovery

Recovery processes for sludge components have only been applied experimentally because, until now, they are not commercially viable. However rises in the costs of basic commodities such as phosphate may change the economics and hence the interest. Recently there has been further interest in the extraction of oils from municipal sludge.

6.4 Disposal

Waste disposal to landfill is the least desirable management option and should be avoided where environmental benefit can be derived by an alternative outlet. In some countries, sludges with a content of organic matter above certain levels are forbidden to be disposed of in landfills.

Landfill can be cheaper than other options, but costs are increasing through the introduction of environmental taxes. A carbon limit value for wastes disposed of to landfill is likely to be introduced (already in place in some countries) and this encourages reuse options or incineration prior to landfill disposal of ash.

The main parameters to be considered for sludge landfilling are:

— sludge rheology (important for the transport and incorporation to the other wastes);

— odours;

— dry matter content (important for the water balance of the landfill).

7 Operational good practices

7.1 General

The adoption of operational good practices increases the reliability of sludge quality by minimising the influence of chance on operational activities. Consistency of sludge quality, both chemical and physical, increases the number of endpoint choices open to sludge managers and enables them to improve the quality of products offered to users of sludge materials. This in turn increases the confidence with which sludge can be used in areas such as agriculture, land restoration and forestry.

Operational best practices should be applied at all stages within the sequence of sludge production and management both upstream and indeed downstream of the production site and at the site of production.

7.2 Upstream of the sludge production site

7.2.1 General

Efforts should be made to ensure that upstream activities are operating optimally to minimise potential negative impacts on the sludge production site.

Keeping a regular check on the conditions of connections used by all dischargers where a separate collection system is being operated ensures an effective sludge management.

7.2.2 Communication process between all participants upstream of the sludge production

The quality of sludges is affected by any material or process used upstream or in the treatment plant. It may be necessary to determine not to accept a material if to do so would negatively impact the options within the waste hierarchy, which may be applied to a sludge.

Good communication should be established in all industrial, drinking water and municipal wastewater plants with the providers of materials, which will become a constituent of the sludge.

This should include notification of a system failure or quality failure which could impact on sludge quality to be made within a set period to the receiving treatment works in order that emergency procedures to protect sludge quality and treatment process integrity, can be invoked.

Good communication with industrial users of a municipal sewerage system should be maintained to create a climate of mutual trust. This can be reinforced by placing the condition of notifying a system failure on the acceptance of an industrial wastewater.

The nomination of contact persons and definition of agreed notification procedures facilitates effective communication for this purpose.

7.2.3 Sewerage system structure improvement and maintenance

Upstream infrastructure integrity influences the quality of the delivered wastewater and hence, of the treatment sludge. In particular, malfunctions that reduce the speed of delivery of wastewater should be avoided through the development and operation of an effective maintenance plan for all structures and equipment in the collection system.

7.3 At the sludge production site

7.3.1 General

To the extent to which it is possible, the procedures employed at a treatment works should aim to produce a sludge of as high quality as possible, thereby maximising its recycling potential. This should include processes to reduce odour production particularly where the sludge is to be used in agriculture. Production of a high quality consistent material increases end-user confidence and reduces the risk of misuse through ignorance of the characteristics of sludge. Hence, the treatment system and the final product quality should be closely monitored and controlled using a set protocol. In many instances this will be with a QA system but particularly where there are hygienic considerations for the quality of the end product a Hazard Analysis and Critical Control Point HACCP system should be applied. This is described in detail in CEN/TR 15809 [10].

7.3.2 General guidelines for operations

a) Process equipment should be operated within its design specifications; for instance, sludge thickening equipment should not be used for storage;

b) process equipment operating conditions should be closely monitored to ensure consistency of sludge and water products; for instance, a gravity-flow sludge thickener requires careful control of allowable loads (according to the type of sludge and the required sludge concentration) and maximum retention times (according to the type of sludge and in particular its fermenting capacity);

c) treatment systems should be controlled to deliver a specific quality of sludge for particular end uses;

d) all equipment should be maintained according to manufacturers instructions;

e) emergency procedures should be defined and documented and all staff should be familiar with their implementation in order to minimise the impact of any on-site or off-site accidents, on sludge quality. Emergency procedures should include those deriving from equipment specifications under conditions different from design specifications (for example, mass flow rates higher or lower than expected).

7.3.3 Storage

Where storage is needed for logistical reasons, action should be taken to minimise a decline in sludge quality during the storage period. In the majority of land reclamation projects, a large quantity of sludge is used in a short period of time. A typical operation consists of one single application that often lasts only a few days. This fact implies that 'on site' storage facilities are often required. When the sludge supplier is a small wastewater treatment works, the storage period required can be considerable.

Depending on the sludge type, it is necessary to choose the safest practicable method of storage (covered stockpiles, tanks etc). Public health protection and safety requirements shall be taken into account when choosing a storage site including the potential to cause odour nuisance.

Where storage is part of the treatment process, adequate assurance (supported by monitoring) should be in place to ensure the required level of treatment is achieved.

Procedures should be in place whereby conditioning activities are introduced when a sludge has been on-site over a predetermined period of time. In the case of a liquid sludge, tanks should be stirred or homogenised in some form. The rewetting of thermally dried sludges shall be avoided during storage.

Storage facilities should be equipped with loading-unloading devices depending on the sludge's physical state or/and consistency. Unloading and storage areas should be clearly indicated and delineated, with buffer zones to control run-off and diversion of surface water.

Where sludge is to be used for soil improvement, parameters likely to vary during storage should be closely checked before land application. The land application plan should be based on the expected sludge composition after storage (see CEN/TR 13097 [16]).

7.3.4 Site access

Site access should be appropriate to the type, size and frequency of transport units employed to move sludge.

8 Strategic evaluation of options and links with the other good practice documents

8.1 General

The overall objective of a sludge management strategy should be to find outlets for the sludge which are safe, environmentally acceptable, secure and economic.

8.2 Sludge quantity assessment

Most developed countries rely on centralised treatment of wastewater collected from the catchments in a sewerage system to deliver it to the treatment works, which is the site of sludge production. There is probably not immediate scope to minimise sludge production from domestic sources.

At the wastewater treatment works there is the opportunity to minimise the bulk of sludge which can be done progressively by thickening, dewatering, biological stabilisation processes (e.g. digestion, composting), thermal drying and incineration. Thickening is likely to be economical even for small treatment works using local agriculture as the outlet for the sludge.

For the other minimisation processes, there is an economy of scale which can be exploited by having a central sludge treatment centre at one works and transporting sludge to it from surrounding satellite works for treatment.

Planning and operating the sludge management strategy on a regional basis, for several or many wastewater works and a substantial tonnage of sludge, rather than on a local basis can be an advantage.

8.3 Sludge quality

Contaminant inputs to the sewer can and should be minimised as described in Clause 5 above.

Sludge quality is quantified by standards to achieve legislative compliance. Standards should have a sound scientific basis to ensure environmental protection, be readily measurable preferably by standard methods of analysis, and be economically and technically achievable. Focal points for quality assurance in sludge management are:

- industrial effluent control;
- proven treatment processes (especially to produce stabilised and disinfected sludge);
- monitoring protocols;
- standard methods of testing and analysis;
- management systems e.g. Hazard Analysis Critical Control Point (HACCP);
- communications;
- training;
- data handling and reporting.

The relative importance of sludge quality criteria varies according to the use or disposal option for the sludge.

Quality criteria associated with the product and recycling outlets need to be focused on the acceptability of the sludge to the user and concerned populations together with environmental protection. Sludge quality should be managed to satisfy the requirements of the outlet to be used. The higher the sludge quality, the easier it is to dispose of the sludge because more options are available. Producing a high quality or clean sludge may ensure that all outlets are available.

8.4 Developing a strategy for sludge use/disposal

The options for treatment and use or disposal are complex even for a single sludge treatment works and more so if, as is often the case, a treatment and disposal strategy is required for a number of works on a regional basis. One reason for adopting a regional approach is to include the option of central treatment of sludge at one works where expensive plant, such as incineration or drying, can be considered.

A basic scheme for deciding on sludge use/disposal options is shown in Figure 1, which determines outlets for sludge according to sludge quality and makes full use of the CEN/TC 308 guidance documents in the decision process. This approach clearly demonstrates that sludge recycling options require high quality sludge and if this can be achieved, then more outlets are open to the sludge producer.

The availability of outlets determines how sludge should be treated. In large cities, incineration with energy recovery may be more suitable if land application sites are a long distance away entailing a high carbon footprint for transport.

For a regional strategy in particular, it may be desirable that there is more than one outlet for the sludge since this provides additional security to the operation. Sludge treatment processing may be selected to achieve this end. Thus, for instance, thermal drying produces a material potentially suitable for all the land spreading options, landfill, incineration or use as fuel and which can be stored if necessary.

Usually, the strategy seeks to find the best environmental option for the sludge, which is compatible with acceptable cost. The strategic management methodology which meets these objectives is BPEO. Table A.1 sets out an example of the stages in the development of a sludge BPEO. It has been successfully applied to the sludge problems of major cities and municipalities in a number of countries. It provides a thorough and flexible approach, which can be applied to any strategic sludge management problem: single site sludge producer, multiple site, waterworks sludge, wastewater sludge, industrial sludge or a combination of sludges and/or wastes.

The scheme assesses the current and future situation for sludge production and quality on a local or regional basis, sets out the options for sludge management and prioritises them on the basis of cost, environmental and public acceptability, and security. Models are available to assist in this process, which is to provide objective information on which to base a strategy for sludge management into the future.

In the context of the Table B.1, the terms ‘feasibility’ and ‘availability’ take account of:

- environmental acceptability in its widest sense, e.g. carbon footprint, surface and groundwater abstractions and quality, geology, centres of population, air movement and quality, transport infrastructure, etc.;
- public acceptance;
- cost;
- security;
- capacity and proximity to the site of production.

Annex A
(informative)

Best Practicable Environmental Option for sludges use or disposal

Table A.1 — Example of the stages in the development of a sludge BPEO

STEP	COMMENT
1. Objective and constraints	Identify what is to be achieved by the study and the constraints. This should include definition of the study area and any constraints associated for instance with costs or prohibition of outlets or treatment processes.
2. Collect treatment and use/disposal options	This should be the information collection stage bringing together all relevant data in the study area about current and future sludge production, treatment and quality, the availability of outlets and details of constraints.
3. General listing of treatment and use/disposal options	This lists the sludge management options for works in the study area on a broad screening basis.
4. Screen treatment and use/disposal options	This step should ‘coarse screen’, on the basis of cost, environmental and public acceptability and security, the list of options generated in Step 3. The aim should be to identify those options which are suitable for full evaluation.
5. Evaluate treatment and use/disposal options	This should be a detailed evaluation of cost, environmental and public acceptability and security. It should plan from the current situation into the future using an economic model to follow ‘net present value’ taking account of operating costs and capital investment needed. Options must be evaluated in relation to compliance with regulations. Wide consultation should be used to seek public acceptability to schemes.
6. Identify preferred option	This stage should select the BPEO on the basis of the detailed evaluation in Step 5.
7. Review the preferred option	This step should, if necessary, review any remaining uncertainties about the BPEO to ensure its feasibility.
8. Presentation of evaluation	A succinct report should be prepared on the data collection methods, generation of options and evaluation procedures. This should be used in all consultations.
9. Implement and monitor the sludge management plan	This final step should implement the BPEO and monitor environmental impact and financial performance as it develops.

Annex B
(informative)

Environmental checklist

Document number (if available): CEN/TS 13714	Title of standard: Sludge Management in Relation to Use or Disposal	TC/SC/WG number: CEN/TC 308WG 2
Work item number (if available): 00308107	Version of the environmental checklist:	Date of last modification of the environmental checklist:

9 Environmental Issue	10 Stages of the life cycle										11 All stages
	Acquisition		Production		Use			End-of-Life			
	Raw materials and energy	Pre-manu-factured materials & components	Production	Packaging	Use	Maintenance and repair	Use of additional products	Reuse/ Material and Energy Recovery	Incineration without energy recovery	Final disposal	Transportation
Inputs											
Materials	x		x								
Water	x		x								
Energy	x		x								
Land	x		x								
Outputs											
Emissions to air	x		x					x	x		
Discharges to water											
Discharges to soil										x	x
Waste								x	x	x	x
Noise, vibration, radiation, heat	x		x					x	x		
Other relevant aspects											
Risk to the environment from accidents or unintended use	x		x							x	x
Customer information										x	

Comments: Although the guide is about management, WG 2 has taken the view that the management decisions themselves will contain environmental issues. Relating to the Guide: Acquisition corresponds to Clause 5, Production to 6.2, and End of life to 6.3. ‘Use’ was not considered to be appropriate for sludge. Ash from thermal processes is included in ‘discharge to soil’ or ‘waste.

NOTE 1 The stage of packaging refers to the primary packaging of the manufactured product. Secondary or tertiary packaging for transportation, occurring at some or all stages of the life cycle, is included in the stage of transportation.

NOTE 2 Transportation can be dealt with as being a part of all stages (see checklist) or as separate sub-stage. To accommodate specific issues relating to product transportation and packaging, new columns can be included and/or comments can be added.

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[15] CEN/TR 13768, *Characterisation of sludges — Good practice for combined incineration of sludges and household wastes*

[16] CEN/TR 13097, *Characterization of sludges — Good practice for sludge utilisation in agriculture*

[17] CEN/TR 13983, *Characterization of sludges — Good practice for sludge utilisation in land reclamation*

[18] 86/278/EEC, Council Directive 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture

[19] CEN/TR 15584, *Characterisation of sludges — Guide to risk assessment especially in relation to use and disposal of sludges*

[20] CEN/TR 15126, *Characterization of sludges — Good practice for landfilling of sludges and sludge treatment residues*

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