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Characterization of sludges — Good practice for sludge utilisation in agriculture

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National foreword

This Published Document is the UK implementation of CEN/TR 13097:2010. It supersedes PD CR 13097:2001 which is withdrawn.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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Characterization of sludges - Good practice for sludge utilisation in agriculture

Caractérisation des boues - Bonne pratique pour la valorisation des boues en agriculture

Charakterisierung von Schlämmen - Leitfaden für die Verfahrensweise bei der Verwendung von Schlämmen in der Landwirtschaft

This Technical Report was approved by CEN on 9 February 2010. It has been drawn up by the Technical Committee CEN/TC 308.

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Foreword

This document (CEN/TR 13097:2010) has been prepared by Technical Committee CEN/TC 308 “Characterisation 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 CR 13097:2001.

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

1 Scope

This Technical Report describes good practice for the use of sludges in agriculture (where national regulations permit). It is applicable to all of the sludges described in the scope of CEN/TC 308 (and any of the forms in which they may be presented - liquid, dewatered, dried, composted, etc.) i.e. 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.

Such sludges may be used on land as a source of plant nutrients, and/or soil improver, and/or alkaline amendment for crop production. Despite differences in the statutory controls between sewage sludge and other sludges, the use of all types of sludge should follow good practice to maximise benefits for the crops or soils, to minimise potential risks of environmental contamination and adverse impacts on plant, animal and human health, and to ensure sustainability, energy efficiency and cost-effectiveness.

Sludge producers should be aware that if a sludge is used as a fertilising or alkaline amendment, national or EU fertiliser or liming regulations may apply.

The document assumes that an evaluation of sludge utilisation has already been made, and a decision was taken that use of sludge within a land spreading policy is the best option.

For evaluation and decisions for use of sludges, other documents have been developed (see CR 13714, CR 13846).

Many countries and/or local administrations have regulations and/or standards and/or codes of practice applicable to the use of some of the types of sludge that are within the scope of this Technical Report, however it cannot, and does not, attempt to summarise or take account of these regulations, etc. because of their very wide range. It is thus essential that this Technical Report is read in the context of the conditions that prevail locally.

NOTE Adoption in France in 2002 of a standard for standardized composts containing substances from wastewater treatment NF U44-095: *Organic soil improvers – Composts containing substances useful for agriculture, stemming from water treatment*.

2 Normative references

The following referenced documents are indispensable for the application of this document. 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 — Utilisation and disposal of sludges — Vocabulary*

CEN/TR 15809, *Characterization of sludges — Hygienic aspects — Treatments*

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3 Terms and definitions

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

3.1
potentially toxic substances (PTS)
substances which, when present in excess and in forms that are available to the subject in question, can be toxic

(CEN/TR 15584)

3.2
BPEO
best practicable environmental option

4 Requirements

4.1 General

The purpose of this Technical Report is to assist sludge utilisation operations to:

a) achieve compliance with 86/278/EEC and other environmental legislation or codes of good practice which are relevant to the type and use of sludge or to the location of operations;

b) gain and maintain the confidence of users, authorities responsible for monitoring regulatory compliance, food purchasing and/or processing companies and third parties which (amongst others) include members of the public (particularly those local to where the sludge is applied);

c) make maximum use of the valuable constituents in the sludge;

d) have a long term sustainable solution with minimum cost and maximum benefit to the environment consistent with the above.

Considerations of treatment, source control of pollutants and preparation of sludges are discussed in CEN/TR 13714, CEN/TR 15473 and CEN/TR 15809.

The widely recognised waste management hierarchy recommends, in general, the utilisation of sludge as preferable to disposal options such as landfill. Where agricultural land is available and conveniently accessible, this is usually the best practicable environmental option.

Sludges usually contain nutrients, organic matter and trace elements, which are beneficial to the growth of crops (including energy crops and grass) and to the fertility, structure and/or texture of soils. They are therefore valued by farmers. Sludges may contain contaminants, and/or pathogens, and may be odorous. Consequently, the whole process (from source control of potential pollutants, through sludge treatment, to sludge application and the way the land is farmed) should be controlled to avoid adverse impacts on the environment, or on plant, animal and human health. Such safe controlled use of sludge on land can be considered a component of sustainable development.

Many European countries have developed guidelines and regulations for the safe use of sewage sludge. These have been placed on a common statutory basis in the European Union through the implementation of the EU Directive 86/278/EEC which requires certain limit values for PTSs in soil and sludge. Other EU legislation encourages the utilisation of suitable industrial sludges on land provided measures are taken to avoid endangering human health or harming the environment (91/156/EEC [3] amending Directive 75/442/EEC on waste). However, unlike the situation for sewage sludge, there is little detailed information available and there is less legislative control for these other sludges. In the past the emphasis has been on preventing chemical pollution, but whilst this is still essential, the modern agenda also includes hygiene

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(CEN/TR 15809), and the need to demonstrate safety through quality assurance and independent validation. European legislation has effectively eliminated many hazardous substances from products and the environment. The REACH programme [4] continues the control on hazardous substances at source.

In order to establish and maintain cost-effective, safe and sustainable operations using sludge in agriculture, certain procedures should be established for effective operational management, to meet legal requirements and to address the concerns of stakeholders.

This document has been constructed in an order that attempts to reflect the logical steps of a successful (which also means sustainable) sludge utilisation operation. It starts with the initial steps in designing an operation, and then considers the quality control, design, etc., before moving on to the day-to-day operations. Although marketing (finding outlets) and support are also continuing activities they are treated in separate sections because they are general and not particular to each individual outlet. Despite this linear structure, continuous improvement is recognised as an important component, which therefore implies the cycle of design, operate, review, refine, operate, review, etc.

4.2 Preliminary procedures

4.2.1 General

This section discusses the more significant procedures and considerations for setting up a new programme to use sludge in agriculture or modifying an existing one. These would include understanding the relevant regulations within which the sludge is used, the quantity of the sludge, the quality of the sludge, whether there are programmes for ensuring sludge quality, and whether there would be demand for the sludge; including whether there are competing materials, e.g. animal manure or compost and biogas residues of other materials.

4.2.2 National regulations

In the case of sewage sludge, national regulations set quality standards for the receiving soil and may set standards for the sludge. The specific values and combinations of control mechanisms vary between countries, and a combination of sludge, waste management, water and general agricultural and environmental regulations may apply. Few countries have comprehensive regulations to control all sludges that may have similar environmental impacts. Those using sludges should make themselves aware of the regulations that apply in the areas where they are working. CEN/TC 308 has compared and discussed different sludge treatment operating parameters in CR 13846.

4.2.3 Voluntary agreements

In some countries, some sludge producers have gone beyond national regulations by voluntarily entering agreements with interested parties (such as food retailers and processors, farmers and landowners). These agreements have addressed the question of perception and increased the acceptance of using sludge in agriculture. Any applications of sludge should be consistent with these agreements.

4.2.4 Quality assurance

It is recommended that there should be a quality assurance system for the whole process from source control of potential pollutants, through sludge treatment and spreading, and finally to how the land is farmed. To prove transparency and ensure the confidence of stakeholders, it is desirable that this is validated by an independent audit.

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The principal criteria should include:

a) sludge quality, particularly:

- control of potential pollutants from point sources;
- sampling and analysis strategy to monitor sludge quality (PTSs, pathogens and its fermentability (i.e. potential to produce bad odours);
- treatment of sludge.

b) soil quality, particularly:

- a soil sampling strategy to monitor soil quality for the concentrations of specified PTSs, often in relation to certain soil conditions, such as pH, soil type and content of organic matter and/or cation exchange capacity, in order that limit values are not exceeded.

c) sludge application rate, particularly:

- average quantity of PTSs that can be applied to the land and over what period, usually in terms of kg PTS/ha·y (or multiple of years), or mg PTS/kg nutrients;
- amount of sludge dry solids that can be applied per year or multiple of years;
- quantity of nutrients which can be applied in accordance with the content of soil and the need of crops grown;
- timing of and method of applying the sludge and after-use of the land and crops; these are generally designed to protect animals and food consumers from pathogen transfer, and/or conserve plant nutrients, and/or reduce the risk of run-off.

It is a general legal requirement for sewage sludge that appropriate records are maintained which in addition to the above criteria, should include information on sources and quantities applied and the location of the receiving land. However most countries do not yet require the same rigour for other sludges, even though they may have environmental effects similar to sewage sludge.

4.2.5 Strategic evaluation

In order to launch a sludge utilisation programme, a strategic exercise should be undertaken in order to evaluate its probable viability and sustainability within the area of land that is being considered for sludge recycling. This is particularly important where there has been no previous experience of using sludge, or when introducing a new sludge product.

A two phased approach should be adopted:

a) firstly, a comprehensive evaluation of the whole sludge strategy should be undertaken, employing BPEO methodologies. This would test the security, practicability environmental sustainability and economic viability of a proposed operation in an objective manner. Such evaluations would cover a wide range of factors that would probably include many of the following, which is neither exclusive nor in an order of priority:

- area of land that might be available;
- possibilities for temporary storage, if necessary;
- farming practices and other relevant land use information;
- use of alkaline amendment and fertilisers;

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- what other "competitor" materials are available and their quality and quantity;
- national and local legislation and controls that would affect the operation of the proposed sludge use programme;
- reaction of farmers' organisations, the food industry and other stakeholders;
- management and organisation of the sludge production plant;
- sensitive zones (surface and ground water protection, housing, etc.);
- soil (type, quality, trafficability, nutrient status and pollutant content);
- sludge type, sludge quality, sludge quantity;
- climate, e.g. is there a rainy season when trafficability is low or a long frozen period when sludge application can be prohibited;
- topography, roads, bridges, etc. to evaluate access;
- consultation with a wide range of organisations to check the environmental and practical sustainability of the proposed sludge use programme;
- type of sludge that might be produced (e.g. liquid, dewatered, dried, composted, digested, limed, etc.) by varying the production or treatment process, that is the most appropriate for a sustainable sludge use programme, bearing in mind the whole life cost of the alternatives;
- size, structure and location of storage facilities;
- some countries may require public consultation on the intention to start a sludge utilisation programme that involves advertising the intention and consulting with municipal administrations.

b) secondly, as an extension to a BPEO study, or as a separate exercise where sludge use programmes have been initiated or are ongoing, it is crucial to understand the potential customer base, its business needs, and how the proposed sludge use programme can satisfy these needs. This should be done using the whole marketing mix to test whether there is actually a market for the sludge.

4.2.6 Sludge quality

The preliminary stage should develop a methodology for controlling, monitoring, improving and maintaining sludge quality. The quality of sludge is crucial for its safe, beneficial and sustainable use, and for its suitability to be brought to the market". This invariably requires a rigorous source-control programme. A range of chemical, physical and microbiological quality criteria is important for compliance with legislation, for providing agronomic value, and for it to be aesthetically acceptable.

In the case of sewage sludge it is important to ascertain at the preliminary stage whether there is enabling legislation and an effective system for controlling discharges from factories to the sewerage system or whether such control at source can be implemented. A wide range of contaminants can be found in some sewage sludges due to discharges from industries, dwellings and surface drainage into sewers. Soil with an active microflora is capable of breaking down many organic compounds found in sludges. Experience has shown that, when sewage sludge has been used in compliance with the current controls over loading rate and use established in 86/278/EEC, no detrimental impact has been detected. For other sludges comparable systems should be designed to prevent excessive contamination from entering the sludges. Animal manures, food processing and abattoir sludges, and industrial residuals (e.g. paper, etc.) can contain significant concentrations of PTSs (and/or pathogens). The use of these materials on land should be taken into consideration when sewage sludge is applied in order to avoid over-application of PTSs and nutrients. It is important to recognise that agricultural land receives inputs of potentially harmful compounds from other sources, such as atmospheric deposition, traffic emissions, inorganic fertilisers and crop protection chemicals.

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In regard to the microbiological qualities, it is not practicable to undertake frequent monitoring for specific pathogenic organisms because levels present can be extremely low and difficult to detect. As has been adopted for drinking water microbiology, some monitoring of suitable indicator organisms such as *E. coli* may be a preferable way of verifying that the overall processes of treatment and use meets specified hygienic requirements (see also CEN/TR 15809). Information about principles to be followed in different sludge treatment processes to reach specified hygienic requirements is given in CEN/TR 15809.

Some waterworks sludges may be beneficially applied to land to use their contents of organic matter and/or alkaline amendment, or even to modify soil texture. However there are some waterworks sludges that have negligible soil enhancement value. Waterworks sludges generally have a low content of N, P or K. These sludges result from the treatment of surface or ground waters. Their contents of PTSs and other contaminants are generally low. They are useful when soil improvement by the addition of organic matter or textural modification (e.g. adding silt to excessively drained coarse textured soils) or soil pH adjustment (by liming) are required but major plant nutrients are not needed.

4.2.7 Sludge type

Dewatering, drying, lime treatment, nutrient addition, composting and other processes may be beneficial to improve the properties of the sludge for its use in agriculture. Physically the material should be capable of easy storage and application. It should be treated to minimise the possibility of odour emission so that the public (particularly those local to where the sludge is applied) and the farmers' requirements are addressed. Sustainability may be enhanced by use of the appropriate treatment and application techniques.

4.2.8 Design of the sludge utilisation programme

Before commencing a sludge utilisation programme, the overall design, infrastructure, procedures and resourcing should be considered. Many of the components are discussed later in this document. They include the capacity, design and siting of storage facilities, with their relevant equipment (stirring, access, recovery, etc.), vehicles and their servicing, spreading equipment, labour, computer hardware and software. Locally prevailing regulations shall be complied with.

4.3 Quality control (including environmental and agronomic data)

4.3.1 Process control

Rigorous control at certain critical control points in the production and recycling process, backed up by the verification of independent audit contributes to ensuring the safety of sludge recycling and the confidence of important stakeholders. The critical control points and their critical values need to be identified and evaluated for each particular sludge processing and recycling example.

4.3.2 Sludge sampling and analysis

Sludges and sludge products should be sampled and analysed in order to:

— provide reliable information to customers;

— satisfy regulatory requirements;

— confirm that process controls are effective.

The frequency of sludge sampling and analysis should be appropriate to the size of the production plant and any anticipated fluctuation in quality. Plants producing large quantities of sludge, and plants where there is a variety of inputs and where varying quality is expected should be sampled more frequently. In general, sludge should be analysed at least every six months, based on composite samples derived from representative sub-samples.

The method of sampling sludge should be evaluated carefully to ensure that the samples are representative of the quality of the sludge that is actually applied to land. This is particularly important for accurately measuring dry solids content, and the sludge should be well mixed prior to sampling.

The quality of certain industrial residuals for land spreading may vary substantially from batch to batch which should be taken into account in the sampling regime in order to ensure that representative samples are obtained.

The parameters that should be measured routinely in sewage sludge for compliance with regulations and to provide agronomic advice are:

— dry matter;

— loss on ignition (which is used as an approximation of organic matter);

— pH;

— total nitrogen;

— total phosphorus;

— zinc;

— copper;

— nickel;

— cadmium;

— lead;

— mercury;

— chromium.

Some countries may require additional determinants to be analysed. In some circumstances, or for some sludges, analysis to comply with national or EU fertiliser or liming regulations may be required in some countries. It may be desirable to monitor the concentrations of other constituents, where these are known to occur in significant concentrations or would be useful in evaluating agronomic quality. Some examples of these additional parameters are:

— ammoniacal nitrogen;

— available phosphorus;

— potassium;

— magnesium;

— calcium;

— sulphur;

— sodium;

— manganese;

— molybdenum;

— boron;

— selenium;

— arsenic;

— fluoride;

— cobalt;

— neutralising value;

— persistent organic pollutants.

Other sludges should at least be analysed for nutrients and organic matter to determine their agricultural benefit. Whilst the risks have been well characterised for sewage sludges, some other sludges may be less well understood, and the process by which they are produced and the possible contaminants etc. that can be in the sludge should be assessed to decide on the need for monitoring other parameters.

Standard methods of sampling and analysis should be followed where they are available. A permanent record of the information should be maintained, and copies should be provided to the recipients of the sludge.

4.3.3 Maintenance of sludge quality

Litter in sludge that is spread on the land should be avoided by effective screening during the treatment process.

Operational parameters (e.g. digester temperature) should be measured and recorded to ensure that appropriate quality and also traceability is maintained. Aspects of sludge treatment to ensure that hygiene is dealt with are in 4.4.2.

Personnel involved with sludge utilisation programmes should liaise with the sludge producer (and, in the case of sewage sludge, those involved in industrial effluent control) regarding the maintenance and/or improvement of sludge quality for:

— sludge stability and odour;

— consistency of analyses with respect to constituents of agronomic benefit;

— content of PTSs.

4.3.4 Soil sampling and analysis

Many countries require that soils are sampled prior to sewage sludge being applied for the first time to establish baseline concentrations of PTS's (some require that nutrients are also measured), and then at specified frequencies to monitor soil concentrations following repeated applications of sludge. Others have decided from their soil mapping and inventory that this is unnecessary (at least in certain areas) because the concentrations in soil are already known to be very low, and/or the PTSs applied do not exceed an amount similar to that in manure.

When sludge is applied to land repeatedly over many years, PTSs can accumulate in the soil, and if this were permitted to continue unchecked, concentrations could possibly be reached that could cause adverse effects to soils, plants, animals or humans eating food produced on sludge treated soils. In the case of sewage sludge, regulatory limit values have been set for some PTSs (heavy metals) in Directive 86/278/EEC and they shall be complied with and confirmed by soil sampling and analysis.

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The method of soil sampling should comply with that described by ISO/TC 190 on Soil Quality.

Parameters which require monitoring to comply with 86/278/EEC are:

— pH;

— zinc;

— copper;

— nickel;

— cadmium;

— lead;

— mercury;

— chromium.

Individual countries, regions or areas may require additional parameters.

It may be advisable occasionally to monitor other PTSs, such as molybdenum, arsenic, selenium and fluoride, particularly in areas that may have naturally high background soil concentrations and where the land is used for grazing or forage production.

Soil analyses ensure compliance with statutory limit concentrations, but because each application of sludge can add only very small quantities of PTSs, monitoring over an extended period is advisable and is addressed by states' regulations. Frequent sampling may be advisable depending on the concentrations of PTSs in the sludge and how close soil concentrations are to their respective limit values, or how close they are predicted to be based on the cumulative loading to date. Some countries, regions or areas may specify a frequency for soil sampling.

Soil analyses should be compared with the theoretical calculation of soil concentrations, based on sludge quality and rate of sludge application. This information should be used (from time to time) to readjust the model of how many applications of sludge the land can be permitted to receive before it approaches the limit value of the most limiting PTE. It may also be used to allow calculations of steady state levels of PTSs to avoid further accumulation in the long run.

4.4 Assuring hygiene when sludges are used in agriculture

4.4.1 General

Hygienic aspects of sludge treatment are covered in detail by CEN/TR 15809.

When sludges are used in agriculture for their beneficial constituents and effects, consideration should also be given to the overall hygiene of the process. As has been stated before, Europe has a model for protecting hygiene in its regulations for the use of sewage sludge in agriculture. This established a dual barrier approach. One barrier is provided by sludge treatment and another by specifying intervals between sludge application and crop harvest or grazing or by prohibition of certain crops. Incorporating sludge into soil can also provide a barrier.

The health of people involved in treating and using sludge should be protected by educating them in the need for relevant hygiene precautions including personal protective equipment (overalls, boots, gloves, etc.).

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4.4.2 Hygiene control by application and relating sludge type to land use

Application techniques and timing of application are both barriers to the possible transfer of pathogens. Incorporating sludge into soil may provide a barrier. Directive 86/278/EEC stipulates that grass or forage crops should not be harvested or grazed until at least 3 weeks after land has been treated with sewage sludge. It also states that fruit and vegetable crops that are normally in direct contact with the soil and normally eaten raw should not be harvested for at least 10 months following treatment of the soil with sewage sludge. These are minimum standards for members of the EU. Countries have set their own protocols for relating types of sewage sludge to the ways that land may be safely farmed appropriate to their local climatic and farming conditions which states some national regulations exemplary. It is usual to combine timing or prohibition of application and quality control of the sludge with special land use practices. To protect people, animals and plants from disease transmission, control measures have to be operated correctly. There have been no proven cases of disease transmission as long as these control measures have been operated correctly. For example, the newsletter from the French Institute of Sanitary Survey (IVS) have not reported sanitary risk associated with spreading of sludges in agriculture in many years.

It is also very important that the information about the incidence of sludges spreading on farming, harvest intervals, etc. are effectively communicated to the farmers whose land has been treated.

As CEN members may have set more stringent or more detailed standards for sewage sludge, it is strongly recommended that where relevant these protocols are adopted for all sludges.

4.5 Operation

4.5.1 General

This section discusses the day-to-day operation of a sludge utilisation programme. It is useful to develop a "beneficial use culture" amongst everybody involved with sludge utilisation as opposed to a "disposal culture". Adopting a beneficial use culture means that people think about sludge as a material to be used (not disposed) which in turn militates for environmental protection and against pollution.

4.5.2 Communication strategy and public relations

4.5.2.1 General

Communication is an important part of any successful sludge utilisation operation so that customers can make best use of the beneficial constituents and avoid any adverse effects and to satisfy the requirements for information by other people. This communication strategy is partly day-to-day and partly a more strategic activity (see also 4.6).

4.5.2.2 Communication with farmer-customers

Farmers who are well informed about the benefits of sludge and receive the quality of service promised, are more likely to be regular customers. Establishing "repeat business" should be a priority for operational security and cost-effective operation. The provision of sound and objective agronomic advice should be an integral part of efficient sludge use programmes and ensuring customers' satisfaction. To achieve this, marketing and quality control staff involved in customer contact should be well trained in agronomy and/or specialist schemes where they are available.

Before spreading, and within the framework of a forecast programme, local regulations may require the sending of documentation to customers informing them on the agronomic quality of the sludge to be applied, as well as the quantities to be made available for their application.

After the sludge has been applied, local regulations may require that information is sent to customers about the sludge with which they have been supplied. The directive (86/278/EEC) requires sewage sludge producers to regularly provide users with all the information referred to in Annex II A of this directive (i.e. the sludge analysis).

4.5.2.3 Consultation with others

In some countries and locations, prior to the application of sludge to an area of land, consultation with various organisations responsible for the environment, waste management, infrastructure, etc., and other interest groups may be necessary or desirable. The necessity depends on the locality and is intended to ensure compliance with any restrictions placed on the land, or transport routes to the land, and that there are no conflicts with local inhabitants. Where it is found to be desirable, consultation should be part of routine operations as and when needed.

The types of responsible organisations to be consulted depends on national and local conditions, and legislation, and therefore varies between countries and possibly even between local areas or regions. The following are examples of possible constituents of a consultation programme (written in no order of priority):

— groundwater and surface water are protected. The consultation should establish whether the proposed land for sludge application lies within an exclusion zone or sensitive area, that would prevent or restrict either the quantity or timing of sludge use;

— agricultural organisations, farmers' unions, etc.;

— sites of special scientific or environmental interest are protected. This could prevent or restrict sludge applications;

— appropriate routes for sludge transport are selected, avoiding weight restricted bridges;

— built-up areas, narrow roads, etc., as necessary. Sludge transfer points are selected to avoid obstructing the highway or creating a hazard;

— proposed method of delivery, storage and application of sludge does not conflict with local waste management and environmental health plans and policies;

— there are no conflicts with neighbouring sludge recycling programmes;

— local authorities are kept informed of sludge spreading operations.

4.5.3 Operational planning

A method of planning the work is necessary to ensure that there is a balance between the rate of sludge production and the demand created amongst customers. There should also be a balance between the spreading resource, the time available for spreading, the quantity to be spread, and the storage facilities.

4.5.4 Storage

Storage of either liquid or dewatered sludges is required as a part of the sludge management process. Storage is a strategic necessity because the availability of agricultural land for sludge use is not continuous due to legislated restrictions of spreading periods, local cropping practices, adverse weather, etc. Where storage forms part of the treatment process, adequate assurance (supported by monitoring) should be put in place to ensure the required level of treatment is achieved. The individual countries, regions or localities may have different regulations on storage.

Liquid sludge is generally stored in tanks or lagoons at the production plant, or may be stored in on-farm lagoons, or at some other site. Stirring or some other form of homogenisation of sludges may be required. Permission to construct a lagoon may be required from local regulatory authorities, and this generally requires an impermeable liner to prevent escape of sludge liquors into the soil. Lagoons should be securely fenced and should meet standards for health and safety. Liquid sludge can be temporarily stored in mobile transfer tanks, to facilitate the transfer of sludge from road transport to field application equipment (and should not be considered as storage). This generally does not require any specific permission for use as a storage container. A device to warn against or prevent over-filling is desirable.

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Dewatered sludge may be stored on treatment plants on prepared hard-standings and is also commonly stored on farmland (on a short-term basis) prior to application.

When choosing/evaluating a site for storage of sludge, consideration should be given to the risk of possible leaching to groundwaters and run-off to surface waters. Consideration should also be given to the existence of field drains, slopes that might result in the stockpile slumping (down slope) or being flooded (if it is in a valley bottom) and other safety considerations. The possibility of odours should be taken into account and storage sites should be chosen with regard to the level of stabilisation of the sludge.

The nutrient content of a sludge (especially nitrogen) and the availability of nutrients, can change during storage and it may be necessary to evaluate this in the interests of giving good agronomic advice.

4.5.5 Delivery

Adequate supervisory methods should be put in place to ensure transport is undertaken responsibly.

Liquid sludges should be transported in enclosed tankers, usually fitted with an integral pump, or vacuum/pressure system for efficient filling and discharge. Vehicles should be well designed and maintained to avoid spillages of sludge on the roads and escape of odours.

Dewatered sludges are transported in lorries or skips, these should be fitted with covers, particularly if the sludge is odorous or semi-fluid, and to prevent spillage.

All vehicles should be kept clean and well presented to avoid adverse public reaction, etc. The chosen route and time should be those most likely to limit inconvenience to the population and damage to the road system. After delivering sludge to a farm, any mud or sludge should be cleaned off the vehicle to avoid contaminating the road.

4.5.6 Application techniques

There are several techniques for applying sludge to land, and there are many manufacturers supplying a wide range of equipment specifications. Liquid sludge can be applied to the surface of the land by tanker or irrigation equipment, or may be applied sub-surface by injection. Dewatered sludges are applied by manure spreaders. Dried sludges may be spread using bulk fertiliser, lime or manure type spreaders depending on the quantity, target application rate and flowability of the dried sludge. Application equipment can be specialised self-propelled units, conventional tractor-drawn tankers or manure spreaders, or liquid sludge may be supplied by flexible pipe to an applicator or injector mounted directly to a tractor (umbilical system) or to a retracting reel irrigator when it is authorized.

Surface application of sludge is generally less expensive and technically less demanding than injection, however spreading sludge on the surface may give rise to complaints, particularly if there is offensive odour. There are several technical solutions for reducing odours to an acceptable level during application, the more important ones are:

— cultivating the land as soon as practicable after application. If odorous sludge is left on the surface, particularly during hot weather, a smell and/or fly nuisance may be created that may last for several days, and the operator could risk prosecution;

— avoiding surface application of sludges with a high odour risk close to housing (or other sensitive areas);

— using sub-surface injection for liquid raw sludge and near to dwellings, etc.;

— not using high trajectory sprayers. These could cause aerosols or mists that could drift for several kilometres. Low trajectory splash-plate, boom spreaders and trailing hose applicators give rise to less odour during the spreading operation.

For liquid sludges, subsurface injection into soil has a number of potential operational and agronomic advantages over surface application of sludge, but the extra draught required can result in more wheel slip in

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wet conditions, disruption to plant roots can cause die-back in dry conditions, and in stony ground rocks can be brought to the surface. Apart from avoiding odour, loss of ammonia to the atmosphere is reduced, which increases the fertiliser value of the sludge, and farmers may also appreciate the soil loosening effect of injection. Any pathogens in the sludge are buried by injection so hygiene is improved. If the application technique, and subsequent cropping/grazing restrictions, forms part of the control process to avoid transmission of target organisms, there should be adequate checks of compliance.

The soil trafficability (type and condition) at the time of application should be evaluated carefully in relation to the method of application and the weight of the spreading equipment. Operating with heavy equipment on wet soils, particularly clay soils, should be avoided if this would cause unacceptable soil damage that could potentially reduce crop yields. There are various options for avoiding unacceptable soil damage:

— stopping the application of sludge if soil conditions are unsuitable for the equipment being used (e.g. if the soil is too hard or too wet);

— reducing tyre pressures because there is a direct relationship between tyre pressure and soil compaction. A compressor could be fitted to the tractor to allow regular and easy adjustment of tyre pressure so as to maximise traction with minimum compaction, and to re-inflate tyres for road travel;

— fitting wide tyres and wheels with a large radius extends the range of soil conditions over which sludge application is acceptable;

— using lightweight application equipment, such as retracting reel irrigator or umbilical spreaders or injectors reduces soil loadings during application;

— using retracting reel irrigator or umbilical systems also avoids the frequent filling that tankers require and the additional soil damage that ensues at the most trafficked areas, especially at the sludge transfer point;

— appropriate training and supervision of field staff to recognise the soil conditions under which land spreading is acceptable and when it should not take place;

— planning the sludge spreading programme in relation to the sensitivity of soils in the operational area. Treatment of the lighter, sandy soils can be restricted because of water protection considerations but when they can be used, they are more suitable for injection in dry weather because the soil is less prone to heaving or cracking which can damage grass growth. Sandy and stony soils are also more trafficable in wet periods as they tend to drain more readily and can often be accessed during the winter when the heavier soils cannot be used, however water protection, particularly nitrate leaching, should not be neglected.

The application of sludge should be carried out accurately to ensure that the target application rate is achieved uniformly over the entire treated area. Equipment is commercially available to measure, control and record the quantity of sludge (liquid or dry) applied, and by linking this to forward speed and spread width application rates can be accurately controlled, and recorded, the latter is becoming increasingly important as the demands of “traceability” for agricultural produce increase. Attention should be paid to the amount of over-lap required between each application. This avoids local over-application that can cause ponding and run-off as well as uneven crop growth.

The layout of the way sludge is applied to fields in relation to topography and obstacles should also be carefully planned to avoid frequent changes of gear or engine speed, since this affects directly the application rate. Computerised control equipment is now available that controls sludge delivery rate in proportion to vehicle speed. The risk of polluting surface waters should be minimised by leaving an untreated margin adjacent to ditches, streams, rivers, lakes etc. of at least 10 m, especially on sloping ground; some countries have written this into legislation or codes of practice.

Application techniques shall comply with national and local regulations.

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4.5.7 Nutrient management, application rate and times

The objective of applying sludges to land is to utilise their nutrient content and/or soil conditioning properties, and/or liming value.

When sludge is treated with lime, the purpose is to stabilize and to make it hygienic by increasing pH and temperature. Such limed sludge is well adapted to acidic soils.

The amounts of plant nutrients and their availabilities to crops depend on the type of sludge and its origin and consistency, and the extent of treatment it has received. These need to be evaluated and integrated into crop management planning.

Some countries restrict the time of year when sludges can be applied with the intention of conserving plant nutrients. These restrictions may apply nationally or vary from one area to another. Spreading of liquid sludge on frozen or waterlogged soil may also be prohibited (or warned against) to reduce the risk of run-off. The restrictions may be different for different sorts of sludge and for landform (slope etc.) and condition, and proximity to water, etc.

The general principle guiding the rate of application of sludge to land should be to balance the nutrient demand of the following crop and/or the need for soil improver and/or soil pH adjustment (as appropriate) with the risk of leaching and run-off of nutrients. However, this is not straightforward and requires judgements, since the analysis of total nutrient content of sludge is not necessarily a reliable indicator of the amount of plant available nutrient and the period of its availability.

Sewage sludges generally contain significant amounts of N and P but little K. Waterworks sludges generally contain low concentrations of nutrients but may contain organic matter and/or alkaline amendment. Some industrial sludges rich in carbon (such as paper sludges) can cause temporary immobilisation of nitrogen in the soil, which later may be mineralised and become available.

The nitrogen content of sludges (and its availability) should to be taken into account for the calculation of the nitrogen dose applied to soils for plant nutrition, fertilisation plans.

NOTE Plants mainly take up nitrogen as nitrate or more rarely ammonium. In aerobic soils organic, ureic and ammonium nitrogen are converted by soil bacteria to nitrate according to the amount of elapsed 'thermal time". The base temperature at which conversion ceases is 0 °C. A fraction of nitrate, ammonia, urea and possibly organic nitrogen is quickly released; another release occurs in the medium-term and yet another in the very long-term. Some of the ammoniacal nitrogen in surface applied sludge can be lost by volatilisation. When N-rich sludges are applied in autumn to warm soils and crops are not going to be sown until spring, there is agronomic benefit in sowing a "green manure" crop such as mustard to take up any nitrogen that has been converted to nitrate and prevent it being lost by leaching. The green manure crop is then ploughed when the land is prepared for the spring crop and the nitrogen it contains is mineralised and becomes available to that spring crop.

A consequence of most intensive farming systems is that in autumn there are some surplus nitrate in soil that is at risk of leaching to surface or ground waters. Situations that can give rise to a large surplus should be avoided. Many countries set maximum nitrogen application rates from fertiliser and organic manure sources, which can be further restricted in quantity and season of application in areas prone to high concentrations of nitrate in water. Under the EU Directive 91/676/EEC [5], Member States should limit nitrogen applications in designated Nitrate Vulnerable Zones. These zones are the areas of land that determine the quality of surface or ground waters used for water extraction which exceed, or are likely to exceed 50 mg NO_3/l. The application rates should be limited depending on the sensitivity of the area and to comply with local legislation or good practice.

Phosphorus is held strongly in soil and does not leach readily, unlike nitrate-nitrogen. The principal environmental risk from soil enrichments with sludge P arises if there is soil erosion. However, the constraints stipulated and applied with respect to land suitability for sludge during the preliminary planning stage (4.2.4) should avoid vulnerable soils. Sludge stabilises the soil surface, once dried, and improves aggregate stability when incorporated, thereby potentially reducing soil erosion losses by surface run-off. Several countries impose restrictions on the amount of phosphorus that may be used on farmland.

Sludge can provide a wide range of secondary nutrients and trace elements, for instance magnesium, calcium, manganese, sulphur, iron, zinc, copper, selenium, boron, etc.

Farmers should be advised of the content and likely availability of nutrients so that they can achieve tangible savings in fertiliser costs and ensure compliance with legislation. This increases the security of the overall programme.

Application rate should depend on:

— national and local regulations;

— quality of the soil and its yield potential;

— intended cropping and target yield, and hence the fertiliser requirement;

— analysis of the sludge and the availability of any nutrients.

Application time should depend on:

— national and local regulations;

— crop calendar (e.g. harvesting time and sowing time);

— cultural practices (e.g. ploughing);

— weather opportunities and soil trafficability.

4.5.8 Data recording

The following should be recorded:

— locations where sludge has been spread;

— quantity of sludge spread at each location;

— application dates;

— analysis of the sludge applied.

(For additional advice on data recording see 4.7.3).

4.5.9 Additional guidance to customers

In addition to the references already made to the composition of the sludge with which their land has been treated, farmers should be advised about appropriate hygiene precautions for their grazing animals and for themselves and their employees depending on the hygienic status of the sludge (these should include injections against diseases such as tetanus, which is good practice in any farming situation).

4.6 Promotion of agricultural use

4.6.1 General

Finding a market for sludge and sludge derived products from amongst a pool of potential users has fundamental similarities to any other sales and distribution activity. Because of this similarity, this section is appropriate irrespective of the commercial relationship that exists between the supplier of the sludge and the "customers" who receive it.

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4.6.2 Market development

The preliminary planning stage (4.2.5) should reveal whether there is sufficient potential demand for sludge in an operational area targeted for a sludge use programme. This exercise should provide information on the predominant types of farming and other potential sludge use outlets, and should be used in developing and promoting the markets for sludge.

It is very useful to liaise with farmers' organisations and with agronomists and agricultural extension workers. Frequently they can have anxieties about the use of sludge based either on historic cases of bad or unwise sludge spreading, or on myths and misinformation. These anxieties can be allayed by informed discussion.

Even in areas with established sludge use programmes, promotional activities should be maintained to sustain and increase the existing customer base, and improve public awareness and acceptability of sludge recycling.

Larger operations generally use a computer database to hold all the factors that influence sludge use, such as soil types, crops, climate and topography, from which land areas can be classified according to their ability to accept sludge (easy, difficult, and never). Land suitability maps should be created to include these areas and these should be over-laid by sensitive zones to protect water supplies, buffer zones along water course, and built-up areas. Geographic information systems can be used to improve the ease of managing the data, with easy updating, and improved presentation of the data. The maps resolve target areas that can be developed for sludge use programmes.

A marketing strategy should be developed, to include focused and general marketing activities. Staff should be appointed to conduct the marketing activities, particularly the focused approach, which should target individual farmers and other potential sludge users. This should assess their individual needs, and if they accept sludge, the marketing staff should also co-ordinate soil sampling and analysis, sludge delivery and application, provide all the necessary technical advice on the use of sludge, including agronomy and the regulatory aspects, and provide quality control over the process.

Sludge marketing and quality control staff should be trained to have an awareness of the facets of agronomy relevant to the sludge use programme.

More general marketing activities should include the production of promotional articles and literature, open days, public meetings and other public relations exercises, etc., to generally increase public awareness and acceptance of sludge reuse.

4.6.3 Agronomic support

As has been discussed in 4.5.2, it is important that customers are aware of the agronomic benefits of the sludge with which they are being supplied. In order to give this advice it can be necessary or useful to establish field trials and pot trials to quantity the benefits. These field trials can also provide a useful demonstration facility of the benefits of sludge and the absence of adverse effects.

4.6.4 Marketing and selling procedures

Establishing a market for sludge is considered in 4.6.2. Having established a sludge use programme, marketing activities should be continuous to maintain and broaden the customer base, and to keep customers and the public (particularly those local to where the sludge is applied) informed.

Operational staff already involved with farmer contact should be responsible for ongoing marketing and ensuring customer satisfaction, and should be considered as the key link in successful sludge use programmes.

Other activities worthy of consideration are:

— a demonstration programme, involving farm visits, field trials and open days;

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— publication of newsletters and other promotional and advisory literature for farmers and for the general public;

— website with agronomic details and contact information.

4.7 Support procedures

4.7.1 Quality assurance

The purpose of a comprehensive quality assurance programme is to ensure that all of the operational strategies and systems are applied, legislation is complied with and CAP (common agricultural policy) cross-compliance is achieved, pollution is prevented, customers are satisfied, and overall, that the sludge use programme is sustainable in the long term.

A quality assurance plan may be prepared for each quality-critical step. These should include:

— clear aims and objectives for the plan;

— planned activities;

— defined inputs (e.g. sludge quantity and quality, documentation, etc.);

— defined outputs (e.g. customers' requirements);

— unambiguous responsibilities;

— defined working practices;

— performance indicators including customer opinion surveys;

— record keeping and monitoring;

— training;

— auditing procedures, possibly by an independent accredited authority;

— programme reviews (to account for deficiencies found in monitoring and audits).

The quality assurance plan should be a cohesive document, formally codified into a quality management system. European Standards include examples of quality system standards and there are equivalent international standards. Whether the quality assurance system is accredited or not, it should be transparent and provide efficient control of sludge use programmes, reassurance to regulators and support to customers.

EXAMPLE Examples of certified sludge spreading quality assurance systems: French certified composted sludge spreading quality assurance system, Qualicert, since 2001 (http://www.syprea.org); UK sludge spreading quality assurance system “Safe Sludge Matrix” (www.adas.co.uk).

4.7.2 Continuous improvement

Continuous improvement is an outcome of quality management and the cycle of design, operate, review, refine, operate, review etc. as already referred to in 4.1.

4.7.3 Data and record keeping

Data generation and its recording should be an integral step in the quality assurance programme. With the level of technology currently available, it is possible to create comprehensive databases that can simultaneously integrate several important functions that need to be monitored. These include operational

efficiency, operating costs, compliance with legislation, information on and for customers, and short and long term strategic planning.

Record keeping to comply with legislation should be regarded as a very high priority, and should be transparent and unambiguous recorded data should be kept for at least ten years. The legal criteria that should be recorded can vary between countries, under 86/278/EEC the following are required for sewage sludge and this is a good starting point for all sludges:

— quality;

— type and treatment;

— location of the receiving land;

— soil sampling and analysis;

— quantity and date of application;

— additions of contaminants and nutrients to the soil.

Additional information could be recorded, either separately but preferably in an integrated database. Examples of such additional information are:

— types of crops grown;

— consultation with other organisations, regarding sensitive zones, application restrictions, etc.;

— operational control, including site scheduling and co-ordination of soil sampling and analysis, vehicle routing and scheduling, farm and field data (access, etc.), customer requirements, etc.;

— “non-complying product reports” to record events that were not in compliance with the quality system and the corrective actions that were taken;

— marketing and customer satisfaction;

— strategic planning, seasonal and long term;

— exceptional weather events.

The regulatory authorities may require an annual report of sludge utilisation activities.

Annex A
(informative)

Guides of good practice for use and disposal of sludges

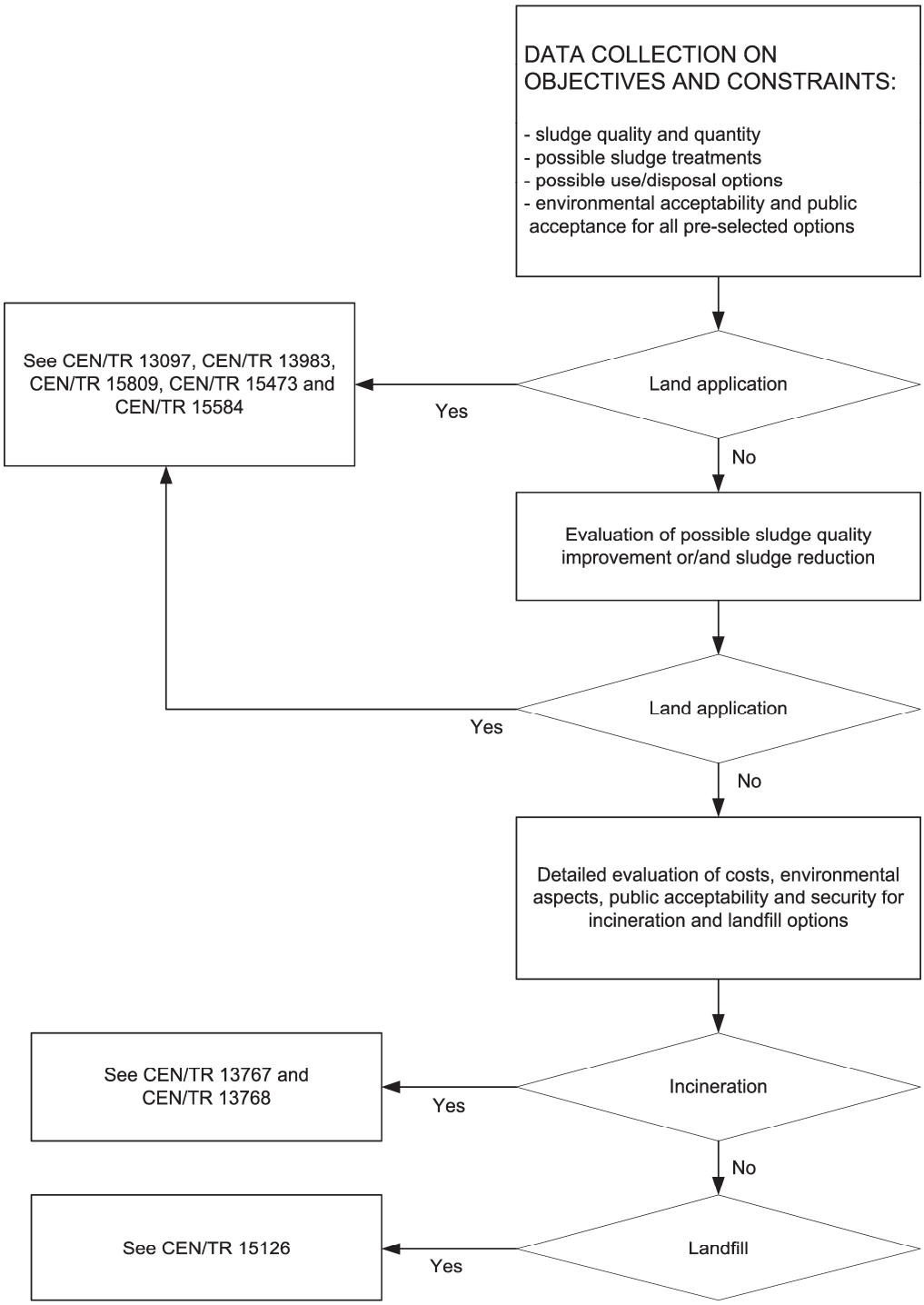

Figure A.1 — A basic scheme for deciding on sewage sludge use/disposal options and the relevant CEN/TC 308 guidance documents

Bibliography

[1] Directive 91/271/EC, Council directive concerning urban wastewater treatment

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

[3] Directive 91/156/EEC, Council directive amending Directive 75/442/EEC on waste

[4] REACH Directive

[5] Directive 91/676/EEC, Council directive concerning the protection of waters against pollution caused by nitrates from agricultural sources

[6] CEN/TR 13714, *Characterisation of sludges — Sludge management in relation to use or disposal*

[7] CR 13846, *Recommendations to preserve and extend sludge utilization and disposal routes*

[8] CEN/TR 15473, *Characterization of sludges — Good practice for sludges drying*

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

[10] EN ISO 5667-13, *Water quality — Sampling — Part 13: Guidance on sampling of sludges from sewage and water treatment works (ISO 5667-13:1997)*

[11] ISO 15161, *Guidelines on the application of ISO 9001:2000 for the food and drink industry*

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