PUBLISHED DOCUMENT

PD CEN/TR 13983:2003

Characterization of sludges — Good practice for sludge utilisation in land reclamation

ICS 13.030.20; 13.080.99

British Standards

National foreword

This Published Document is the official English language version of CEN/TR 13983:2003.

The UK participation in its preparation was entrusted to Technical Committee EH/5, Sludge characterization, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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Cross-references

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Summary of pages

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Amendments issued since publication

Amd. No.	Date	Comments

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 25 July 2003

ISBN 0 580 42324 7

TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

CEN/TR 13983

July 2003

ICS 13.030.20; 13.080.99

English version

Characterization of sludges – Good practice for sludge utilisation in land reclamation

Caractérisation des boues - Bonnes pratiques pour la valorisation des boues pour reconstitution de sol

Charakterisierung von Sclämmen - Gute praxis des Sclammeinsatzes bei der Rekultivierung

This Technical Report was approved by CEN on 22 December 2002. It has been drawn up by the Technical Committee CEN/TC 308.

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Ref. No. CEN/TR 13983:2003 E

Contents

Foreword

This document CEN/TR 13983:2003 has been prepared by Technical Committee CEN/TC 308 "Characterisation of sludges", the secretariat of which is held by AFNOR.

The status of this document as Technical Report has been chosen because the most of its content is not completely in line with the practice and regulation in each member state. This document gives recommendations for a good practice concerning sludges for utilisation in land reclamation.

1 Scope

This Technical Report gives indication on sludge utilisation within reclamation programmes of disturbed land.

This Technical Report is applicable to sludges described in the scope of CEN/TC 308; for example:

¾ storm water handling;

¾ urban wastewater collecting systems;

¾ urban wastewater treatment plants;

¾ treating industrial wastewater similar to urban wastewater (as defined in Directive 91/271/EEC [18]);

¾ water supply treatment plants;

¾ water distribution systems;

¾ sludge derived materials;

¾ but excluding hazardous sludges from industry.

NOTE Because of the wide range of reclamation sites where sludge use as a soil ameliorate or source of plant nutrients is beneficial, and the different potential final uses of these sites, recommendations for application should be considered on a site-by-site basis. It is far beyond the scope of these guidelines to describe all the possible situations and the individual ways in which sludge could be used. The aim is to address, in a general qualitative way, the key issues which will determine in each particular case whether, how much and which type of sludge can be used.

Planning considerations (clause 5) are emphasised due to the fact that a general scheme can be adopted as a common procedure in nearly all situations.

2 References

EN 1085:1997, *Wastewater treatment — Vocabulary.*

EN 12832:1999, *Characterisation of sludges — Utilisation and disposal of sludges — Vocabulary*.

EN 12255-8, *Wastewater treatment plants — Part 8: Sludge treatment and storage.*

ISO 5667-13:1997, *Water quality — Sampling — Part 13: Guidance on sampling of sludges from sewage and water treatment works.*

ISO 10381, *Soil quality — Sampling.*

CR 13097, *Characterisation of sludges — Good practice for utilisation in agriculture.*

CR 13714, *Characterisation of sludges — Sludge management in relation to use or disposal.*

CR 13846, *Recommendations to preserve and extend sludge utilisation and disposal routes.*

3 Terms and definitions

For the purposes of this Technical Report, the terms and definitions given in EN 12832 and EN 1085 and the following terms and definitions apply.

3.1
sludge utilisation
beneficial and harmless use of sludge [based on 3.2 EN 12832:1999]

3.2
land reclamation
improvement or restoration of the natural soil functions of disturbed land e.g. by application of sludge or other humus producing material [3.14 EN 12832:1999]

NOTE According to the ecological aim of the reclamation project, the final intended use can fit into three different approaches:

1) restoration, when the closest reproduction of the previous ecosystem or land use (e.g. agriculture) is intended;

2) rehabilitation, if the aim is just to achieve an ecosystem/land use similar to the original one;

3) new assignment, when there is an attempt to achieve a different use or ecosystem to the one existing before land disturbance.

3.3
disturbed land
land so damaged by human uses or natural causes that has the soil properties and functions drastically impaired

NOTE 1 Examples of disturbed land are given in 4.1.

NOTE 2 Natural soil functions are:

1) a basis for life and habitat for people, animals, plants and soil organisms;

2) part of natural systems, especially by means of its nutrient and water cycles;

3) a medium for decomposition, balance and restoration as a result of its filtering, buffering and substance conversion properties.

4 General considerations

4.1 Properties of disturbed land

Under the general term of "disturbed land" where sludge might be beneficially used, it is possible to find sites of very different origins. Examples of them (in a non-exhaustive list) are the following:

¾ deep mine spoils (particularly colliery spoils);

¾ strip mine spoils/open cast mine sites;

¾ sand and gravel excavation sites;

¾ construction sites and road verges;

¾ highly eroded areas and abandoned agricultural soils;

¾ disturbed urban sites;

¾ abandoned military areas;

¾ finished areas of landfill sites;

¾ former industrial sites;

¾ deposition sites of dredged materials.

Despite the wide range of situations, it is possible to define some common features, namely:

¾ they generally present a harsh environment to establish vegetation without treatment;

¾ topsoil, if present, is usually deficient in nutrients and lacks organic matter;

¾ poor physical properties are usually found.

In addition, disturbed sites can often be harmful to the surrounding environment due to their current status. They can cause problems such as water pollution caused by high erosion rates, presence of toxic levels of trace metals, acid leachate, aesthetic impact and other land degradation problems.

The reclamation of disturbed sites constitutes a need in any soil protection policy, interpreting soil protection in its broader sense to include erosion control, avoidance of toxicity and improvement of soil capacity to support plant growth.

The final goal of a reclamation programme is to re-establish the drastically disturbed soil functions of these sites in such a way that the final intended use is possible (e.g. a self-sustaining and diverse vegetation in landscaping or a productive soil for agricultural use). The rapid establishment of a vegetative layer is essential since soil cover is a key element in initial site stabilisation. In this initial goal, sludge can be considered as a suitable product.

4.2 Value of sludge in land reclamation

The biological, chemical and physical qualities of different sludge types depend on the composition of water from which they are derived and the extent of processing they receive during water and sludge treatment. The relative importance of sludge quality criteria varies according to the utilisation option. In the case of its use as a material which improves the natural soil functions or to create a topsoil substitute mixed with other materials in reclamation of disturbed sites, the value of sludge rests on two main components:

- **organic matter -** Organic matter improves the poor physical conditions of disturbed soil by improving soil structure and structural stability, permeability and water holding capacity. The high organic carbon content also provides an energy source for stimulating functioning microbial communities, modulates the nutrient uptake and acts as a pH buffer;

- **plant nutrients -** Generally, the nutrient content of sludges is mainly in organic forms and are thus released slowly providing a gradual supply of nutrients (e.g. nitrogen and phosphorus in sewage sludge). The organic fertiliser characteristics of sludge are advantageous since a nutrient reserve for long-term plant growth can be applied in one application, but account must be taken of the possible pollution due to nutrient losses.

Typical municipal sewage sludge nutrient contents are given in annex A.

The application of sewage sludge, or other sludges having similar properties, can "kick start" soil processes, stabilise soil structure and provide the reserves of plant nutrients that are necessary for successful land reclamation. Other kinds of sludges may not be able to achieve this effect without supplementing with plant nutrients but can be valuable because of other properties, for example, their pH adjustment capabilities (e.g. lime sludges from drinking waterworks) or their role as soil texture modifiers (e.g. adding silt to excessively drained coarse textured soils).

Although sludge can be used at different stages (during site working and in site aftercare), sludge use in land reclamation usually implies a single two step operation: application of a suitable amount of sludge and revegetation of the treated area.

Despite the recognised beneficial role that sludge can play in reclamation projects, when it is properly managed, and the numerous successful experiences reported in bibliography [3], [4], some potential environmental effects should be taken into account when using sludge. Such effects, if appropriate measures are adopted, are usually negligible when compared to those present on site prior to reclamation. The use of sludge in land reclamation programmes can constitute in certain situations the best option from the environmental and economic point of view.

The beneficial use of sludges is a balance of benefit against risk. Therefore, the general principle that should prevail is that the sludge utilisation in land reclamation should be compatible with any future land use. Consequently a conservative approach in the application rates and sludge quality requirements should be adopted. Land reclamation should be considered just like another outlet in sludge land application programmes and all the environmental and public health issues, particularly those regarding soil and water protection, should be observed. Disturbed sites for reclamation result from many former uses and may be restored for various future uses; which will require appropriate standards to be adopted.

The aim of this guideline is to maximise benefits from recycling the valuable resources present in sludge or sludge derived products, whilst reducing the potential for adverse environmental effects.

4.3 Legislation framework

There is a general lack of specific regulations in relation to the use of sludge in land reclamation at the European and National levels.

However, different regulations can contain provisions applicable to certain aspects of sludge use for reclamation purposes which should be consulted to achieve compliance. These regulations vary between countries but they are usually within the legislation framework defined by:

¾ waste legislation;

¾ fertiliser legislation;

¾ environmental protection legislation;

¾ water legislation;

¾ soil protection legislation;

¾ mining legislation.

According to the criteria stated in these regulations, sludge use can be restricted in specific areas (e.g. because of current metal concentrations in soil, nature reserves or nitrate vulnerable zones). It should be noted that, under this framework, the legal status of different sites (e.g. areas under mining or military law) can influence the planning and implementation of reclamation measures. Notification and/or approval of application programmes, record keeping and submission of reports to pertinent authorities can be legal requirements for sludge use in land reclamation.

The priority of recycling over other disposal routes in the waste management hierarchy and the duty to reclaim particular sites after exploitation, are also stated as general criteria.

The requirements of EU Directive 86/278/EEC [16] on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture" and the national regulations related to sludge application for agricultural purposes do not apply systematically to the use of sewage sludge nor to other sludges in the scope of this guide in land reclamation. Nevertheless, sometimes the provisions of these regulations are adopted or taken as "reference values", especially if the final intended use of the disturbed site is agriculture. In such cases, the specified criteria for sludge and soil quality and maximum application rates can have to be observed. However, the revision of EU Directive 86/278/EEC is likely to include reclamation activities.

Despite the lack of legislation, there are relevant codes of practice and technical requirements at national or regional level (for example, see [1], [2], [10]).

4.4 General strategic evaluation

An evaluation of the different options for sludge final disposal or utilisation should be done as part of the general strategic planning of sludge management (see CR 13714) and in this comprehensive exercise, land application of sludge can be the preferred option. It is recommended that a quality control system for the whole procedure of evaluation is developed, according to authorities requirements.

Where land application is identified as an option, then it is necessary to assess if land reclamation can constitute a feasible and sustainable outlet. The first step is to identify potential reclamation areas, which usually involves different scenarios (see 4.1), by consulting local administrations, mining authorities and by means of land use maps and field surveys.

In this preliminary feasibility assessment a land suitability map should be drawn up. It is useful to evaluate the amount of land requiring reclamation within economic transport distance of sludge production site and the opportunity of co-ordinating future projects.

Since the use of sludge on a reclamation site is usually a one-off opportunity, a planned sequence of reclamation projects should be managed to ensure the future continuity of the outlet. This strategy can be carried out with consecutive projects at different disturbed sites or with a progressive reclamation project at a single site of sufficient size. Projects are often discrete and will not have the potential for repeat orders. The possibility of small but continuous reclamation schemes for municipalities (roadside verges, urban dereliction...) should be considered.

A sludge management programme based entirely in the use of sludge for land reclamation is uncommon. This outlet usually constitutes a minor but valuable adjunct to agriculture and other options, and is useful for diversifying the recycling opportunities and making sludge management operations more flexible with regard to market changes. However, in certain situations, it can become the main outlet if local characteristics are suitable and a feasible, well designed programme is implemented (e.g. mining areas, small localities surrounded by high eroded areas or without agricultural activity).

Finally, in view of the future restrictions on conventional sludge outlets, land reclamation can be expected to play an increasing role within the recycling options.

4.5 Presentation to potential users

Product presentation to potential users is one of the first actions to be carried out. The main objective of marketing activity is to ensure that sludge use in disturbed land reclamation is perceived as a legitimate beneficial opportunity. It should be taken into account in the marketing strategy that users are likely to be public administrations, mining companies and landscaping or reclamation companies instead of individual owners. This fact implies generally a small user base but with high potential. Therefore it is possible to have regular users and long term arrangements/commercial relationships in which the quality of service is crucial. Success of each and every reclamation job is important to ensure a continuity of reclamation opportunities.

Some recommended tasks are:

a) a specific marketing support for the reclamation use of sludge. It could include special promotional brochures, field trials, workshops, results of previous experiences, .etc. The creation of products specially prepared for its use in disturbed sites should be evaluated;

b) technical and scientific advice to support a site-specific planning and operational procedures. This technical support should include agronomic, regulatory and operational aspects and guidance on good practices to be adopted over the whole process;

c) voluntary agreements between users and sludge producers on the maintenance and/or improvement of sludge quality are desirable to increase the acceptance and to enhance the sustainability of this recycling option (operational best practices to increase the reliability of sludge quality are given in CR 13714);

d) certificates from a third party can also be beneficial for the market.

5 Preliminary procedures

5.1 Basis of assessment

The site and sludge specific evaluations for a particular land reclamation situation are key factors in providing all the information required in the following analysis, and as a basis for discussing the necessary operations.

5.1.1 Sludge assessment

Two kinds of assessment in relation to the sludge should be carried out:

a) Sludge availability

- ¾ location of sludge production sites;
- ¾ types of sludge or sludge derived products available;
- ¾ quantity of sludge produced;

- ¾ means of storage.

b) Sludge quality

Sludge characterisation is essential to evaluate the suitability of sludge for its use on specific sites, to determine the appropriate application rates and also to satisfy the requirements of any regulations. Information about origin and treatment procedures are crucial to understanding the sludge quality.

The sludge which is under investigation for its potential use in a land reclamation scheme should be appropriately sampled and analysed. Sludge sampling, treatment of samples and analysis should be performed in accordance to the published standard methods.

Selected sampling methods should ensure in any case the representativity of samples (see ISO 5667-13 for additional information about sludge sampling methods).

Parameters routinely monitored in sludges depend on the origin and type of sludge; they can include:

¾ dry residue and loss on ignition content;

¾ pH;

¾ electrical conductivity;

¾ organic matter content;

¾ total, nitrate and ammoniac nitrogen. It should be desirable to evaluate the mineralisation factor for organic N in the sludge for assessing the available N content. This can be performed by incubation procedures or other studies with the soil from the site to be reclaimed;

¾ total and available phosphorous;

¾ potassium;

¾ content of screenings. In order to avoid aesthetic problems of debris on soil under reclamation sludge should be effectively screened;

¾ trace elements (Cd, Ni, Cu, Zn, Pb, Cr, Hg);

¾ liming value;

¾ pathogens;

¾ any other element or compound required by any regulation.

To achieve better characterisation, the determination of additional agronomic parameters (secondary nutrients) is useful. A risk assessment should be made to decide the need for other parameters (e.g. organic contaminants, Ag, As, Br, Se, Mn, B, Mo, Pt...).

5.1.2 Site assessment

An adequate site assessment will provide information for the analysis process and the development of the application programme in aspects related to environmental issues, site preparation needs, potential end uses, sludge requirements and other technical considerations.

Three kinds of site assessment should be carried out:

a) Land use before reclamation works

¾ causes of soil disturbance/degradation (e.g. coal strip mining, dumping, erosion...);

¾ type and quantity of materials involved during site exploitation (inert materials, potential toxic elements...);

- previous attempts of reclamation, if any;
- residual hazards from former use;
- any other useful information available (e.g. detailed maps, environmental data...).

b) Current land status

- topographic characteristics and accessibility on cartographic and field survey data base (slopes, distances to roads...);
- climatic characteristics. Risk of drought and provision for irrigation;
- hydrogeologic characteristics and site status regarding surface and groundwater protection. At mining reclamation sites, sampling and analysis of ground water is desirable in order to assess its quality, the potential future use and flow patterns;
- site drainage pattern;
- urbanisation. Proximity to local residents will indicate the level of sludge treatment necessary to reduce odour emissions and/or the precautionary measures to be adopted for reducing health-sanitary risks. Site status regarding urban planning rules;
- characteristics of the biological environment (existing vegetation, evaluation of wildlife and livestock in the surrounding area...). Site status regarding the protection of the sensitive and notable ecological features;
- evaluation of the current environmental impact of the site due to the present status (landscape impact, soil losses by erosion, leaching of potential toxic elements...);
- soil sampling and analysis.

An assessment of the soil quality is essential to evaluate sludge application rates and to identify problems that could endanger the final proposed use. Regulations can also require soil analysis prior to reclamation. Soil sampling, treatment of samples and analysis should be performed in accordance with suitable standard methods (see ISO 10381 for guidance about soil sampling). Care should be taken to ensure that the samples are representative, since in disturbed sites the soil physical and chemical characteristics can vary greatly in short distances (availability of several soils for the relevant use).

The following parameters should be determined:

- total and available nutrients (N, P, K);
- organic matter;
- pH;
- Cation Exchange Capacity / Exchange frequency;
- electrical conductivity;
- carbonate content;
- structure, texture. An excess of coarse materials can make reclamation difficult, and the amount of fine material fraction < 2 mm will determine properties such as water holding capacity, nutrient retention capacity, etc.;
- soil physical conditions (e.g. structure, porosity, density);
- trace elements (Cd, Ni, Cu, Zn, Pb, Cr, Hg);
- any other element or compound required by any regulation (e.g. organic contaminants).

The need to analyse other parameters will depend on local conditions, history of the site or if their presence is suspected. Depending on the intended use of the restored site; it may be relevant to determine the physical characteristics of the sub-soils.

c) Future intended land use

From a practical point of view, there is a wide range of potential end uses to which disturbed land can be put as a result of a suitable reclamation process.

Before starting the treatment of any disturbed site, its potential use in the future should be clearly defined. This final use depends, among other factors, on ecological considerations, current site status, the appraisal of local needs and present or projected land use plans at regional or local levels. The following general use categories can be distinguished:

¾ agriculture;

¾ forestry;

¾ non exploited natural environment and leisure activities areas: shrub beds, woody areas, extensive landscaping meadows, golf courses, recreational amenity use etc...;

¾ other end uses as residential or industrial uses.

In nearly all of them a careful selection of plant species (see 5.2.1) should be done. Species choice and management practice of the developing vegetation will determine the level of fertility required in each particular case (nutrient demand, pH, physical condition of the soil...).

For further discussion about alternative endpoints, see [6].

5.2 Analysis and diagnosis

From the analysis of the results of these assessments (5.1), the following can be established:

¾ the site map suitability in relation to the possible utilisation of available sludge or sludge derived products and preparative operations necessary for minimising any incompatibilities and/or unfavourable characteristics for revegetation;

¾ the additional requirement and complementary treatment required for sludges, the application rates and the application method;

¾ site maps.

There are four main topics that should be considered in this feasibility analysis: agronomic, environmental, technical and economic. In each of them the national or European regulations applicable should be taken into consideration.

5.2.1 Agronomic analysis

Agronomic analysis focuses on the factors on which the establishment of soil fertility depends. Fertility, in its widest sense, could be defined as the soil's capacity to support plant growth under specific climatic conditions, and comprises physical, chemical and biological soil properties.

This kind of analysis identifies the agronomic suitability of land and sludges in conjunction with other agronomic aspects, such as the climatic water balance of the area and the choice of the most suitable species for site revegetation.

By evaluating the limiting factors of fertility, the analysis will define the appropriate technical operations and correction measures required in site preparation.

A major point of concern for successful reclamation is often the content of organic matter in the final topsoil. Another concern is the supply and reserves of plant nutrients. Fortunately, adding organic matter to address the first concern normally satisfies the latter. Due to the fact that, usually, in land reclamation projects, sludge is applied in a single and large application, nutrient supply should satisfy the need for a quantity of nitrogen sufficient for the re-establishment of the vegetation over a short-term period and also the need to establish a sufficiently large nitrogen reserve in the soil so that long-term nutrient cycling in the soil occurs. Environmental considerations related to nutrient supply are discussed in 5.2.2.

One of the main results of this first approach is the identification of appropriate sludge application rates (tons dry solids per hectare) adequate from the agronomic point of view. Different methods for the determination of sludge application rates in disturbed soils have been proposed [7], [2]. In some of these methods, a minimum rate of about 50 t organic matter DS/ha has been proposed as pragmatic rule for successful land reclamation, other methods result in lower application rates (an example is given in Annex B). They take into consideration the following factors:

a) Agronomic soil characteristics

- ¾ agronomic value (biological and chemical) of disturbed soil, considering the available nutrient contents of soil;
- ¾ identification of agronomic deficiencies and the properties of the soil regarding nutrient transport;
- ¾ phytotoxicity risks caused by the substrate (metals, salinity, pH);
- ¾ influence of structural stability and physical properties in the treated soil.

b) Agronomic sludge characteristics

- ¾ agronomic value of sludge to ameliorate soil conditions;
- ¾ nutrient content and its availability in the sludge, especially nitrogen. Mineralisation rates of organic nitrogen should be known to evaluate the available nitrogen for vegetation;
- ¾ sludge characteristics related to seed germination and plant growth (soil incorporation requirement, phytotoxicity risks, seed germination and bioassays test results);
- ¾ influence of the method of application and soil conditions on nutrient availability (e.g. ammonia volatilisation).

c) Characteristics of the projected vegetation

Depending on the intended use of the area and in order to assess nutrient and other fertility requirements (e.g. pH or physical conditions), the study of species, native or introduced, which are going to be used to perform the site revegetation is essential.

Species selection is a main point of concern for success or failure in land reclamation schemes. Although the endpoint of reclamation is usually the establishment of a self-sustaining ecosystem through the long-term improvement of soil functions, the initial aim is to establish a vegetation cover as quickly as possible.

There are references to many seed mixtures that have been successfully employed at reclamation sites [3], [7] but as emphasised in the introduction, the needs of each site should be assessed individually. Relevant authorities should be consulted throughout this study in relation to suitable species and seeding/planting techniques.

Some general criteria to be considered are:

- ¾ high germination and initial growth rate to rapidly provide a protective cover, principally to control soil erosion and run-off. Grass germinates quickly and consumes significative quantities of N, avoiding losses by leaching or run-off. Mixtures of perennial grass and legume species (N fixer) are often employed in the revegetation of disturbed sites;
- ¾ species selection is an important issue: whether to promote indigenous flora (more or less spontaneous) or promotion of site revegetation with exogenous flora.

¾ rooting capacity and longevity. Woody species (trees and shrubs)are useful in providing a diverse, stable and balanced ecosystem. Shrubs can be especially suitable in Mediterranean areas. It is important to anticipate and control the competition of herbaceous vegetation due to the rapid growth in response to sludge when woody species are intended to be introduced (tree seedlings versus tree seeds, timing of plantation...);

¾ tolerance to site characteristics and compatibility with all the other species used;

¾ cost factors and availability. Potential economical benefits from the introduced species should be considered.

In addition to species seeded, volunteer native vegetation is greatly stimulated by the application of sludge. Weed competition can be a significant maintenance factor on some sites.

5.2.2 Environmental analysis

The aim of this analysis is to determine the sensitivity of the site. Pollution avoidance is a foundation on which the beneficial use of sludges should be built. Situations demand their own individual strategies. For some sites the risk of pollution is minimal, for others it is a major consideration that needs a carefully designed pollution prevention scheme.

Environmental effects to be evaluated when reclaiming a particular site are:

¾ water protection;

¾ soil protection;

¾ hygienic aspects;

¾ nuisance.

Some main features are briefly described below.

5.2.2.1 Water protection

Avoiding water pollution is one of the most important aspects in land reclamation schemes. Due to sludge nutrient and organic matter content, special care should be taken in its use in order to avoid or minimise surface or groundwater contamination (particularly in the case of an excessive supply of available nitrogen, soluble trace elements and organic compounds). The key factors to ensure that sludge application does not lead to significant water pollution are:

a) **Site location:** Sludge use can be prohibited or restricted when the site is located near drinking water catchment areas, in nitrate vulnerable zones according to Nitrate Directive 91/676/EEC [19] or any other types of sensitive areas. The risks of groundwater pollution are higher on sites where the groundwater level might be very near to the surface, e.g. when dealing with sand and gravel excavation sites

b) **Topography:** It is important to evaluate the surface capacity to retain the sludge on steep sites (> 15 %) and the need for specifically designed vehicles for sludge application. The opportunity during site operations to correct slopes or to implement a system of diversion ditches to protect surface water should be also considered. Sequential maturing and/or use of suitable fixative products (mulching) should be required to prevent sludge run-off on steep areas, but rapid establishment of vegetation will also reduce run-off risks;

Buffer strips along streams and watercourses in which sludge is not to be applied should be established. Buffer width will be determined by run-off risk, but would normally be at least 10 m.

c) **Soil physical properties:** soil structure and texture determine physical properties such as infiltration and water retention capacity, and have a direct influence in the potential risks of run-off and leaching. In some cases, particle size distribution or clay fraction are taken as a basis for sludge admissible load calculations [5]. They are also used to establish minimal values under which sludge application is not recommended (e.g. a minimum of 5 % clay [2] or a minimum fraction of 20 % for particle size < 2 mm [5]);

d) **Sludge type and rate of application:** Nutrient content and availability depend on the sludge type used. A sludge application that exceeds the agronomic needs for each specific situation (immediate and long-term demands) can result in water pollution due to nutrient losses by leaching or run-off. Therefore, an adequate nutrient supply should be identified in order to calculate the agronomic rate. As a general consideration, application rates should agree with agronomic criteria if no other restrictions arise. However there are some cases in which an application rate exceeding the agronomic dose is justifiable, e.g. abandoned acid mine spoils in which water quality is already very poor. In such sites the long-term benefits of the establishment of a stable plant cover can compensate the potential effects of excessive leached nitrogen produced by some types of sludges;

Selection of suitable equipment for the application technique chosen is also an important factor to avoid water pollution.

Special precautions should be taken in surface spreading of liquid sludges, in particular practices like sequential applications of sludge with quantities which will not cause runoff. Liquid sludge is often used just in aftercare operations in which a vegetation (usually grass) has already been established.

There can be national restrictions on spreading of different sludge types. Sometimes, a rate limiting parameter (e.g. maximum. kg N/ha/year) is imposed.

e) **Timing:** Sludge should not be applied when the soil is saturated, snow covered, frozen or during periods of heavy rainfall, since these conditions will increase the risk of run-off. In some circumstances and depending on application technique for liquid sludges, strong wind can produce an uneven sludge distribution, run-off or spray drift. There can be national restrictions on spreading seasons;

Sludge application schedules should be in line with revegetation operations (seeding or planting techniques).

f) **Water management:** in some cases, it can be possible to treat the water by recirculation or through a wetland.

5.2.2.2 Soil protection

The sludge and soil assessment previously done and the regulatory framework allow an estimate of whether and how much of the available sludge can be used, having regard to trace elements. Utilisation of sludges can be restricted by national soil pollution prevention regulations in addition to those regarding quality and use of sludges.

The need for a soil pH adjustment to reduce trace metal solubility, and therefore their availability, should be also considered. In such cases, operations for pH adjustment (e.g. lime requirements) should be included within the site preparation procedures of the application programme.

Regulations (specific or adapted from other sludge uses in land application such as agriculture) can provide a basis for calculating the maximum rate based on metal loading.

For certain sites (e.g. acidic mine spoils) the convenience of adding important amounts of bulk organic matter to control acid regression can justify exceptionally sludge application rates higher than the calculated nutrient or metal maximum loads.

5.2.2.3 Hygienic aspects

Sludge can contain pathogens (e.g. salmonella or helminth ova) that could represent a potential sanitary risk for human beings or animals. According to sludge characteristics and site considerations (proximity to settlements, public access, presence of livestock or wildlife), an appropriate hygiene control should be set up. This assessment should determine the level of sludge treatment to reduce pathogen contents of sludges before their use (hygiene control by treatment) and/or the precautionary measures to be adopted during and after application (hygiene control by precautionary measures), such as:

¾ health precautions during application [8], including personal protective equipment;

¾ public information notices and restriction periods of public access;

¾ incorporation of the sludge into soil.

These treatments and precautionary measures act as barriers against potential infection risks (see CR 13097) for further information about hygienic aspects on sludges recycling.

There can be national regulations concerning hygienic aspects when sludges are applied to land.

5.2.2.4 Nuisance

If the site to be reclaimed is close to urban settlements or even within a urban/semi-urban zone, it is important to take into account potential nuisance that reclamation operations can cause, particularly those regarding potential odour production. Sludge should be properly treated to reduce odour emissions. Aspects such as the type of sludge (digested, undigested, dusty products...), application systems (potential aerosol or dust generation, incorporation...), sludge transport and storage and weather conditions should be evaluated carefully. Moreover, informing the population potentially affected is essential (see 5.4.2).

If the site is located far away from urban settlements, impacts on native flora and wildlife of the surrounding area should be assessed. These potential adverse effects can occur both during reclamation works and as consequence of the final intended use of the site. Attention should be paid to regulations with regard to prohibition of using sludge in areas of special environmental interest (conservation value areas).

Sludge treatment should include a screening process fine enough to remove litter/plastic material in order to avoid visual aesthetic problems.

All vehicles involved in sludge transport should be designed to avoid spillages and should be washed after loading and unloading (with collection/control of the washes) to prevent tracking of sludge or mud on roads. Watertight trucks are essential even in the case of dewatered sludge. Where there are risk of dust production, spillage or odour, lorries should be covered with a tight-fitting material. A transport schedule and preferred route should be determined taking into account of rush hours and possible disturbance of residents.

A period of restricted public access should be established to cover the spreading operation and post application establishment. Fencing might be an option to restrict public access.

5.2.3 Technical analysis

The aim of this analysis is to identify the technical requirements needed to ensure the feasibility of the programme. Technical aspects should include:

- proximity to sludge production site;
- sludge storage requirements;
- accessibility and transport routes;
- possibilities of mechanisation. Need of specially designed machinery/vehicles for transport, application, incorporation or revegetation;
- operations of site preparation;
- protection measures (fences, information boards...);
- further exploitation techniques.

5.2.4 Economic analysis

Simultaneously to the other analysis, an estimation of capital and operational costs of the whole reclamation process is necessary. The feasibility analysis from the economic point of view should evaluate costs derived from sludge products, fuel, power, management administration, equipment, laboratory and technical services, vegetative species, maintenance operations...etc.

In a more comprehensive analysis the benefits that the reclamation project implies should be considered. These benefits can be derived from the final use of the site (crop production, timber...) or in less tangible terms of soil conservation (environmental improvement, amenity use, landscape impact..). These benefits should be compared to the environmental costs due to the current status of the site.

Cost of reclamation programmes can be high due to the utilisation of expensive machinery, earth movement and transport distances. The opportunity to co-ordinate reclamation projects on several sites located in the same area or a sequential reclamation of different zones of a site with sufficient size, can improve efficiency and reduce costs.

5.3 Application plan

If the result of the analysis is favourable for the use of the available sludge or sludge derived products in the reclamation project, an application plan can be developed.

All the operations to be carried out should be specified thoroughly in this programme. The programme also has to include the necessary resources to achieve the reclamation and final use objectives proposed. The information obtained as a basis of assessment (see 5.1) and the conclusions derived from the analysis (see 5.2) should be included in the application programme. The structure of the application plan should follow a logical sequence, including the following:

¾ general description of the project (site sensitivity and characteristics, reclamation operations and final intended use; distribution of responsibilities);

¾ designation of affected area (zone maps with regard to application rates, buffer strips in which sludge application must be avoided, access...);

¾ sludge characteristics and amount of sludge required. Supply, transport and storage planning. Timing of delivery. Other resources needed;

¾ management plan of the site preparation operations, sludge application and revegetation (co-ordination of operations, timing, application rates, human and technical requirements, species selected...);

¾ monitoring programme for the soil, sludge and vegetation quality before and after reclamation. Aftercare management plan;

¾ economic analysis (distribution of costs, contractors, timescale, opportunities for grants, sources of funds...);

¾ results of trials (if they have been done) and other specific research.

5.4 Public announcement

At every phase of the preliminary procedures, a suitable public consultation system should be established. This has two objectives:

5.4.1 Consultation and approval by the pertinent authorities

The application plan should be presented to relevant authorities, depending on regulations that apply in each particular case, for notification and, if necessary, approval. These institutions can include local or regional authorities, environmental agencies and mining authorities.

5.4.2 Consultation and liaison with local communities

Public acceptance is a crucial part in developing any strategy for sludge use/disposal. Public participation in the basic scheme for deciding on current and future sludge outlets should be considered from the beginning (see CR 13714), since this constitutes a key factor for the integration of the adopted scheme in the local or regional context.

Moreover, in land reclamation projects, a specific two-way communication system with local communities potentially affected, end users and other groups concerned should be established in order to obtain the desirable public involvement in the evaluation and decision making process.

The information provided should have regard for:

¾ introduction to the application programme;

¾ local concerns about the use and characteristics of sludges;

¾ possible annoyance during project execution (traffic, noise..) and measures adopted. In order to avoid possible nuisance from the transport operations, specific routes should be agreed and designated. In addition, the appropriate type of vehicle should be chosen to suit the site;

¾ potential benefits of the final restored site;

¾ demonstration trials and results of other experiences to explain the benefits of using sludge in land reclamation;

¾ contact during and after the operations to which any suggestion/complaint should be addressed and through which the public can be informed about the status of the project.

The aim is to reach a general agreement in the final application programme.

The process developed to obtain a feasible application programme, with the agreement of all parties involved in the reclamation scheme, is summarised in Figure 1.

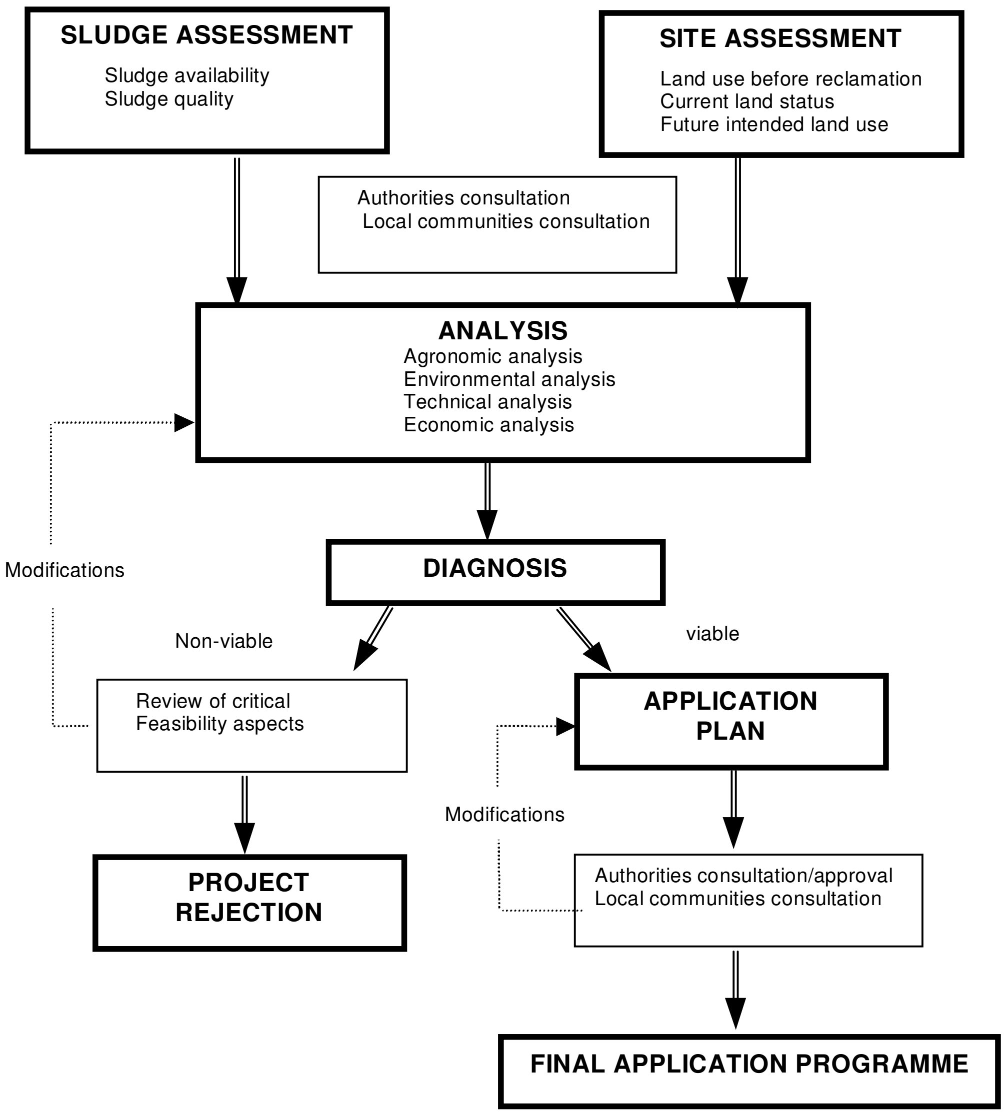

Figure 1 — Preliminary procedures

6 Operational procedures

One of the main risks to the long term viability of land reclamation as a route for sludges arises from inappropriate reclamation activities, for example damaging the structure of soils by working them when they are too wet. A frequent mistake has been in the preparation of land-forms and drainage schemes. Sometimes preliminary site surveys have been inadequate. If the ultimate result falls below expectations in a project where sludges have been used, the sludges may be blamed, irrespective of whether they were part of the cause. See [15] for guidance on site preparation, soil stockpiling, soil handling, etc.

6.1 Site preparation

Generally it is necessary to carry out site preparation prior to sludge application. These operations usually involve considerable earth movement and the use of heavy equipment and so can have a significative impact on programme costs. Site treatment can include the following:

¾ treatment with lime to raise pH soil value;

¾ scarification/ripping to remove compaction;

¾ removal of debris from prior activities in the site (mining, construction...);

¾ grading operations for levelling (landscaping integration requirements, run-off control, reduction of steep slopes...);

¾ operations to improve structure;

¾ erosion and surface run-off control devices or diversions to protect surface water;

¾ conditioning of road access and unloading /storage areas;

¾ drainage.

6.2 Sludge transport and storage

Some precautions have to be taken with sludge transport to avoid unnecessary public nuisance (see 5.2.2.4).

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 water treatment works, the storage period required can be considerable.

The minimum requirements of storage zones are:

¾ unloading and storage areas should be clearly indicated and delineated, with buffer zones to control run-off and diversion of surface water;

¾ depending on sludge type it would be necessary to choose the safest practicable method of storage (covered stockpiles, tanks...);

¾ attention should be drawn to public health protection and safety requirements.

NOTE Nutrient content and availability may change during storage and previous agronomic rates should be revised.

See prEN 12255-8 for further guidance about sludge storage.

6.3 Sludge application

The application methods of sludge for land reclamation are similar to those used for agricultural purposes. The specific site conditions can require specific equipment (e.g. adaptation to steep slopes).

The type of sludge to be applied, particular site characteristics and the kind of application chosen (surface or injection) will determine the selection of the equipment and application technique. Whatever the final method, there are some general considerations that should be carefully evaluated:

¾ timing of application. This depends mainly on soil conditions, weather conditions and growing season (see 5.2.2.1);

¾ safety precautions during application. The risk of infection during application can be minimised by protective clothing and other health protection practices. Aerosol or dust production should be avoided. Soil stability should be assessed before the beginning of operations. Applying sludge in a single pass will avoid problems of wheel slip and stability that can occur if the vehicles have to track over previously applied sludge. Special safety measures should be taken when working on steep slopes;

¾ equipment used for sludge application should be designed in such a way that they provide an even sludge distribution at the selected rate;

¾ adoption of measures to minimise soil damage by compaction. For example, using large diameter wheels, low tyre pressures or light equipment.

Some considerations about liquid and cake sludge application, taking into account common characteristics of disturbed sites, are outlined below.

6.3.1 Application of liquid sludge

Liquid sludge application systems include surface and subsurface application. Surface application involves the spreading of liquid sludge by tanker or irrigation equipment (high trajectory spreaders/hydroseeder guns for steep slopes, reels or specifically designed vehicles). Subsurface application involves the injection of the sludge by special injection equipment attached to tank trucks, tractor/tanker combinations or by umbilical systems, where the sludge is supplied continuously through a flexible hose from road tankers to the injector vehicle.

For surface applications, the incorporation of sludge into the soil is recommended to avoid potential odour or health risks, ammonia volatilisation and surface run-off.

The use of liquid sludges in land reclamation should be carried out with extreme care due to the higher water content which pose pollution risks due to the distorted physical properties of disturbed soils causing run-off. Liquid sludges are sometimes employed as part of aftercare programmes (see 7.2) when a vegetative cover has already been established. Application of liquid sludge to bare soils should generally be avoided, particularly when soil structure is weak.

6.3.2 Application of dewatered sludge and solid materials derived from sludge

The application of dewatered sludge to disturbed land can be carried out by means of spreading equipment (similar to those used for fertilisers or animal manure) or forming stockpiles first in several points and spreading and levelling afterwards by a bulldozer or equipment which limit compaction. The last method is also used if the sludge is going to be mixed with top soil or other soil forming material before application.

Surface spreading of dewatered sludge is often followed by incorporation into the soil by disc or plough. Incorporation reduces nitrogen losses by volatilisation, potential odour problems and minimises the risks of water pollution by surface run-off. Incorporation also reduces the exposure of pathogens for animals and humans.

In some cases dewatered sludge can be applied to subsoil prior to ripping and before laying the top soil.

Thermally dried sludge and other sludge derived products can be spread by conventional fertiliser spreaders. Avoidance of dust should be considered.

An alternative method can be the manufacture of substitute topsoils, either on or off-site, incorporating sewage sludge and other sludges and subsequent placement on the reclamation site.

6.4 Revegetation

Once the selection of the species has been made, appropriate planting/seeding techniques could be employed to achieve effective revegetation. Such operations should consider aspects like:

¾ timing of seeding (sometimes, a suitable "rest period" after sludge application is observed), possibilities of sequential operations (e.g. 1st seeding and 2nd planting);

¾ seed system and seeding rates. In case of herbaceous species, the use of broadcast seeding is common and hydroseeders can be used where terrain prevent conventional seeding. Hydro seeding is especially suitable in steep and/or inaccessible areas. Manual or mechanical planting is recommended with woody species. Seeding rates are usually higher than for normal agriculture;

¾ adoption of measures to enhance germination and establishment of vegetation. For example, additive, fixative products (organic or inorganic material applied to the soil to protect the seed) that also reduce erosion and avoid extreme soil temperatures.

7 Monitoring

7.1 Quality processes

Quality assurance is a voluntary support procedure that should be applied to all stages of land reclamation schemes, from the preliminary planning steps to the record keeping. This includes sampling and analysis of sludge and soil before and after application, actions to guarantee that operations are carried out according to the approved plan, legislation requirements and responsibilities for each operation.

The application programme once approved (see 5.3) should be incorporated into a quality management plan. Such a plan should include all steps in the reclamation process.

7.2 Management programme of the restored site

The monitoring and aftercare of the restored site is essential due to the fragility in the first developing stages of the system that is intended to be established. There are two main objectives in a post-application management programme:

¾ appraisal of the system development in the disturbed site (i.e. vegetation quality and growth responses, soil development...) and, if necessary, adopt the appropriate measures for its improvement. Typical actions for this purpose are, for example, field inspections, biomes estimations, fertiliser application, weed control to prevent desirable species from being swamped, replacement of dead plants and new plantations;

¾ verification that the reclamation process does not cause adverse environmental effects (see also 5.2.2) and, if necessary, adopting appropriate measures to reduce such effects. Typical actions for this purpose are, for example, water analysis, management of erosion control and soil analysis for potential toxic elements and nutrient content.

In short, the aftercare programme usually includes field inspections, soil and water monitoring, maintenance operations and general management practices of natural systems. In particular cases, special requirements can be necessary. For example, the analysis of certain trace elements may be required if the vegetation is used for animal consumption, and sludge monitoring if used as fertiliser in site aftercare.

7.3 Data recording and follow up

It is essential to maintain a suitable system of record keeping for any land reclamation project in progress. The responsibility for record keeping can be on the sludge producer or the sludge user depending on national regulations. These regulations can also require the submission of reports periodically to the relevant authorities. Therefore, record keeping can constitute a statutory requirement besides its other practical functions. These functions should include the provision of transparent information to the public, source of useful data for the development of future projects and part of the quality assurance management.

Record keeping may include the following:

¾ sludge quality and origin (sampling and analytical data);

¾ soil quality (sampling and analytical data);

¾ location and size of treated areas;

¾ quantity and dates of application;

¾ species seeded/planted;

¾ operational plan and details related;

¾ identification of the contributors and their respective roles.

Annex A

Typical municipal sewage sludge nutrient contents

Source: [17]

	Liquid sludge total	Dewatered sludge (Belt filter press, centrifuges)	Dewatered sludge (chamber filter press lime-iron conditioning)[a)]
Dried solid content %	4,0 (1,6 to 16,0)	24,0 (12 to 36)	42,0 (28 to 71)
Loss on ignition % of dm	39,5 (2,5 to 82,0)	42,0 (9,0 to 75,0)	28,2 (18,0 to 56,0)
Nitrogen total % of dm	2,6 (0,4 to 12,3)	2,8 (1,1 to 5,0)	1,4 (1,0 to 1,8)
N inorg. (Amm.) % of dm	1,0 (0,8 to 4,0)	1,1 (0,7 to 1,4)	0,05 (0,01 to 0,2)
Phosphorus P % of dm	2,0 (0,4 to 5,4)	1,9 (0,5 to 5,5)	1,8 (0,6 to 5,2)
Calcium Ca % of dm	8,0 (0,5 to 40,0)	7,5 (1,5 to 16,8)	22,5 (8,5 to 65,0)
Potassium K % of dm	0,2 (0,02 to 1,4)	0,2 (0,1 to 1,2)	0,2 (0,1 to 1,0)
Magnesium Mg % of dm	0,5 (0,01 to 2,7)	0,6 (0,1 to 2,5)	0,7 (0,1 to 3,5)
Sodium Na % of dm	0,5 (0,04 to 1,2)	0,4 (0,1 to 0,8)	no detail
a) The conditioning on chamber filter presses will partly be switch over from lime-iron to polymer. In this case the values of belt filter or centrifuges are to use.			

Nutrient contents in sludge depend on nutrient removal processes during wastewater treatment.

Nutrient availabilities (% of total in the first year) can be quite different for different sludges, soils and climates, especially in the case of disturbed sites under reclamation. It is strongly recommended that availabilities are assessed on a site- and sludge - specific basis.

Annex B

Example of calculation of sludge application rates (single application) based on maximum nutrient loads

Different methods for the determination of sludge application rates in disturbed soils have been proposed (see 5.2.1). Some of them are based on organic matter, other on maximum nutrient loads.

The maximum sludge application rate (tons dry matter/per hectare) for a specific case is calculated as follows:

¾ nutrient sludge contents are determined by specific analysis;

¾ taking into account sludge nutrient contents and maximum nutrient loads from the table behind that applies in this specific case, sludge application rates for each nutrient are calculated.

NOTE Available N = $N_{mineral}$ ($N\text{-}NH_4$ + $N\text{-}NO_3$) + 20 % $N_{organic}$.

¾ the lowest rate (limiting nutrient) is the resulting maximum sludge application rate in tons dry matter/per hectare.

Projected land use	**Nitrogen** Maximum load of available N (kg N/ha)	**Phosphorus** Maximum load of P (kg P/ha)	**Potassium** Maximum load of K (kg K/ha)
Agriculture	120 to 220 [a)]	130 to 260 [b)]	425 to 850 [b)]
Forestry	30 to 70 [a)]	45 to 90 [b)]	165 to 330 [b)]
Non exploited natural environment	50 to 200 [c)]	20 to 260 [d)]	85 to 850 [d)]

Maximum nutrient loads are based on soil type, water balance and plant uptake and have been proposed for Germany.

a) Depending on hydrogeological site characteristics (three categories).

b) Depending on soil characteristics (five categories with regard to fertilising recommendations).

c) Depending on site characteristics and fertiliser demand of projected vegetation (four land use categories).

d) Depending on soil characteristics and fertiliser demand of projected vegetation (four land use categories).

Adapted from reference [9].

Bibliography

[1] Manual of Good Practice for the use of Sewage Sludge in Land Reclamation, (Draft), Water Research Centre, Medmenham (1996).

[2] Abfallverwertung auf devastietren Flächen (Requirements for the use of biological compost and sewage sludge in recultivation of long term devastated areas in the new Federal Laender), LABO/LAGA-AG, Berlín (1995).

[3] SOPPER,W., Municipal Sludge use in Land Reclamation, Lewis Publishers, (1993).

[4] WOLSTENHOLME R. and HALL J. E., The use of Sewage Sludge in Land Reclamation - A Summary of Experiences from Published Sources, Water Research Center, Medmenham (1996).

[5] Manual de restauració d'activitats extractives amb fangs de depuradora (A Manual for the use of Sewage Sludge in the Reclamation of Extractive Activities Sites) Junta de Sanejament,Generalitat de Catalunya, Barcelona (1996).

[6] BRADSHAW, A. Alternative Endpoints for Reclamation. In: Rehabilitating Damaged Ecosystems. Cairns, J. Ed. Lewis Publishers. Florida (1995).

[7] Land Application of Sewage Sludge and Domestic Septage - Process Design Manual, US Environmental Protection Agency, Ohio (1995).

[8] A Manual of Good Practice for the Use of Sewage Sludge in Forestry, The Forestry Authority, Surrey (UK) (1992).

[9] DELSCHEN,T.; KÖNIG,W.; LEUCHS, W.; BANNICK, C.Limitation of Nutrient Inputs when using Biological Waste in Landscaping anf for Recultivation Measures. Entsorga (1996).

[10] Utilisation des déchets organiques en végétalisation – Guide de bonnes pratiques (Utilization of organic wastes in revegetation – Code of Good Practice). Ademe/Cemagref, Ademe editions N° 3357 112 Pages – France (1999).

[11] Décret 97-1133 du 8 décembre 1997 relatif à l´épandage des boues issues du traitement des eaux usées(Decree from the 8th December 1997 regarding the manuring of sludge stemmed from waste water treatment). France.

[12] Étude de référence - Utilisation des boues d´épuration pour l´engazonnement des talus routiers (Wastewater sludge utilisation for the vegetalisation of the road embankment). Reference study. Ademe. France (1995).

[13] Utilisation des boues pour plantation routière (Sludge utilization for road planting). Regional Laboratory from the West of Paris. France (1980).

[14] DINGER, F. Végétalisation des espaces dégradés en altitude (Vegetalisation of damaged areas in altitude). Cemagref. (1998).

[15] BS 3882:1994, Specification for Topsoil.

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

[17] ATV-Handbuch "Klärschlamm", 4. Aufl. 1996; Verlag Ernst & Sohn, Berlin; ISBN 3-433-00909-0

[18] Directive 91/271/EEC, concerning urban waste treatment.

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

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