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Sludge recovery, recycling, treatment and disposal — Beneficial use of biosolids — Land application

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Contents

Page

Foreword ..... **vi**
Introduction ..... **vii**
1 Scope **1**
2 Normative references **1**
3 Terms and definitions **1**
4 Benefits of biosolids land application **4**
5 Nutrients in biosolids **5**
5.1 General 5
5.2 Nitrogen 5
5.2.1 General 5
5.2.2 Nitrogen content and availability in biosolids 5
5.2.3 Determination of biosolids application rate according to nitrogen content 6
5.3 Phosphorus 6
5.4 Potassium 6
5.5 Calcium 6
5.6 Sulfur 6
6 Nuisance and risks associated with biosolids land application **7**
6.1 General 7
6.2 Odours 7
6.3 Vector attraction 7
6.4 Pathogens 7
6.4.1 General 7
6.4.2 Viruses 8
6.4.3 Bacteria 8
6.4.4 Protozoa 8
6.4.5 Helminths 8
6.5 Trace elements 9
6.6 Organic compounds 9
6.6.1 General 9
6.6.2 Source control of potential contaminants 9
6.7 Environmental considerations 10
6.7.1 General 10
6.7.2 Climate and season 10
6.7.3 Topography 10
6.7.4 Protection of water sources 11
6.7.5 Identification of sensitive uses and associated setbacks 11
6.8 Biosolids treatment 11
6.8.1 General 11
6.8.2 Foreign matter 12
6.8.3 Odour reduction 12
6.8.4 Vector attraction reduction 13
6.8.5 Pathogen reduction 13
6.9 Biosolids quality criteria — Groups of biosolids 15
6.9.1 General 15
6.9.2 Group 1 biosolids 15
6.9.3 Group 2 biosolids 15
6.10 Potential uses 15
6.11 Biosolids and soil monitoring 16
7 Biosolids application programme development and management **16**
7.1 General 16
7.2 Community consultation 16
7.2.1 Involving the community 16

7.2.2 Consultation principles ... 17
7.3 Programme development ... 18
7.3.1 General ... 18
7.3.2 Programme design and decision considerations ... 18
7.4 Programme management ... 19
7.4.1 General ... 19
7.4.2 Programme management considerations ... 19
7.4.3 Biosolids and soil monitoring ... 21
7.4.4 Continuous improvement ... 24
7.4.5 Voluntary agreement and quality assurance ... 24

8 Objectives of agricultural land application ... 26
8.1 General ... 26
8.2 Agronomic considerations ... 26
8.2.1 Nitrogen management — General ... 26
8.2.2 Nitrogen in biosolids ... 26
8.3 Phosphorus management ... 30
8.3.1 General ... 30
8.3.2 Determination of biosolids application rate according to phosphorus content ... 30
8.4 Annual biosolids application rate ... 31

9 Storage, staging, fencing and signage ... 31
9.1 General ... 31
9.2 Signage ... 32

10 Haulage and field deliveries ... 33

11 Application techniques ... 33

12 Specific pathogen mitigation measures for agricultural land application ... 34

13 Record keeping ... 34
13.1 General ... 34
13.2 Spreading records ... 35
13.3 Field inspection ... 35

14 Objectives of land reclamation ... 36
14.1 General ... 36
14.2 Site management ... 37
14.2.1 General ... 37
14.2.2 Soil/substrate properties ... 37
14.3 Environmental considerations ... 38
14.3.1 Climate and season ... 38
14.3.2 Topography ... 38
14.3.3 Protection of water sources ... 39
14.3.4 Identification of sensitive uses and associated buffer zones ... 39
14.4 Operations management ... 39
14.4.1 Site preparation ... 39
14.4.2 Biosolids batch management and transport ... 40
14.4.3 Substrate sampling ... 41
14.4.4 Substrate analysis ... 41
14.5 Biosolids applications equipment and considerations ... 42
14.6 Determination of biosolids application rate ... 43
14.6.1 General ... 43
14.6.2 Biosolids application rates based on agronomic nitrogen application rate ... 43
14.6.3 Biosolids application rates based on maximum nutrient loads ... 43
14.6.4 Biosolids application rates based on target carbon to nitrogen ratio (C:N) ... 43
14.6.5 Biosolids application rates based on target organic matter ... 44
14.6.6 Biosolids application rates based on target pH adjustment ... 44
14.7 Revegetation ... 45
14.8 Environmental post application monitoring ... 45
14.8.1 General ... 45

14.8.2 Soil monitoring ... 46
14.8.3 Water monitoring ... 46
14.8.4 Foliage monitoring ... 47
14.9 Quality assurance ... 47
15 Nuisance and risk management for biosolids use for land reclamation ... 47
16 Biosolids treatment ... 47
16.1 Biosolids quality criteria ... 47
16.2 Pathogens ... 48
16.3 Vector attraction ... 48
16.4 Odour ... 48
16.5 Fencing and signage ... 48
16.6 Record keeping ... 48
Annex A (informative) **Soil carbon dynamics ... 49**
Annex B (informative) **Benefits of biosolids land application ... 51**
Annex C (informative) **Average concentrations of organic matter and plant macronutrients in biosolids ... 54**
Annex D (informative) **Comparative pathogen and indicator limits for Group 1 biosolids ... 55**
Annex E (informative) **Source of trace elements in wastewater and biosolids and examples of trace elements standards in biosolids and in soil after biosolids application ... 56**
Annex F (informative) **Standards for maximum concentration of organic compounds in biosolids ... 62**
Annex G (informative) **Organic compounds ... 63**
Annex H (informative) **Setbacks (buffer zones) in different regions ... 64**
Annex I (informative) **Biosolids quality based on treatment method ... 66**
Annex J (informative) **Determination of plant available phosphate ... 67**
Annex K (informative) **Determination of maximum biosolids application rates based on trace elements ... 68**
Annex L (informative) **Examples of source control/pollution prevention tools and regulating industrial discharges ... 73**
Annex M (informative) **Biosolids sampling frequencies ... 74**
Annex N (informative) **Soil and biosolids tests and methodologies ... 75**
Annex O (informative) **Community consultative workshop ... 82**
Annex P (informative) **Benefits and value of biosolids use in rehabilitation ... 84**
Annex Q (informative) **Examples of restricted activities and withholding periods for Group 2 biosolids ... 85**
Annex R (informative) **Revegetation ... 86**
Bibliography ... 87

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 275, *Sludge recovery, recycling, treatment and disposal*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Biosolids are organic–based materials from industrial or municipal sludge and municipal biosolids derived products, in the form of solids, semi–solids, semi–liquids, and liquids which have been treated to meet applicable standards, guidelines or requirements including the reduction of pathogens, vector attraction and contaminant criteria.

The land application of biosolids, which is considered an integrated approach to sustainable management of this resource, can be beneficial in many ways such as:

— increasing soil organic matter;

— increasing biological activity in soil;

— decreasing soil bulk density and improving soil porosity;

— improving water infiltration rate, water holding capacity and erosion prevention;

— improving soil aggregate stability;

— increasing cation exchange capacity, which can result in a lower frequency of fertilizer application;

— increasing soil pH;

— providing additional nutrients to the soil for plant growth;

— recovering phosphorus from the urban and industrial environment;

— providing potential for carbon sequestration in soil; and

— decreasing the use of mineral fertilizers and related greenhouse gas (GHG) emissions related to production and application of mineral fertilizers.

This document does not prioritize, or suggest a hierarchy amongst various beneficial use options, but aims to identify and address the different criteria that could be considered to develop a sustainable and environmentally successful land application programme. These criteria include the nature of the treatment process, the selection of an appropriate application site, the method of application, the rate of application and the establishment of protective barriers or setbacks to environmentally and socially sensitive areas such as surface water and residences.

Control of non–beneficial substances, odour and potential risk to human, animal and environmental health are important parts of any beneficial use strategy. These can be managed by employing tools such as point source control, appropriate treatment methods and land–use restrictions.

Application of this document presupposes awareness of applicable legal requirements.

Sludge recovery, recycling, treatment and disposal — Beneficial use of biosolids — Land application

1 Scope

This document provides guidance on the conditions of beneficial use of biosolids produced from industrial and municipal sludge and municipal biosolids derived products (e.g. composts, growing media) in the production of food and feed crops, energy crops, forestry crops and for the remediation of disturbed sites.

This document applies to biosolids for land application and includes biosolids from wastewater treatment (municipal, industrial and private onsite systems).

This document does not apply to hazardous sludge that originates from wastewater which, due to its nature, physical, chemical or infectious properties, is potentially hazardous to human health and/or the environment during use, handling, storage or transportation and which requires special disposal techniques to eliminate or reduce the hazard.

This document includes:

— general guidelines for the land application of biosolids and biosolids derived products;

— specific guidelines for the land application of biosolids and biosolids derived products for food and feed crop production and for non–food and non–feed crop production (e.g. horticulture, fibre for bio–mass, silviculture, etc.); and

— specific guidelines for the land application of biosolids and biosolids derived products for other beneficial uses (e.g. land reclamation or rehabilitation).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
alkaline stabilized biosolids
biosolids or non–toxic sludge which has undergone alkaline treatment to meet specific requirements for reduction of pathogens and vector attraction

3.2
alkaline treatment
process where biosolids or non–toxic sludge is mixed with alkaline additives to enhance wastewater solids stabilization by increasing the pH of the biosolids up to 12 or higher for a minimum amount of time

3.3
batch
definite quantity of material manufactured or produced under conditions which are presumed to be uniform

3.4
biocenosis
community of biologically integrated and interdependent plants and animals

3.5
biosolids
organic–based materials from industrial or municipal wastewater sludge and their derived products, in the form of solids, semi–solids, semi–liquids (pasty), and liquids which have been treated to meet specific standards, guidelines or requirements including the reduction of pathogens, vector attraction and contaminant criteria

3.6
cation exchange capacity
measure of the soil's ability to hold positively charged ions (cations)

3.7
compost
organic soil improver obtained by decomposition of a mixture consisting principally of various plant residues, occasionally with organic materials of animal origin, and having a limited mineral content

[SOURCE: ISO 8157:2015, 2.2.8.6]

3.8
composting
natural aerobic biological process, carried out under controlled conditions, which converts organic material into a stable humus–like product

Note 1 to entry: During the composting process, various microorganisms, including bacteria and fungi, break down organic material into simpler substances.

3.9
contaminant
biological, chemical, physical, or radiological substance released to the environment from anthropogenic sources which, in sufficient concentration, can adversely affect living organisms through air, water, soil, and/or food

3.10
dewatered biosolids
biosolids that have undergone a reduction of the water content to produce paste-like biosolids or solid biosolids by the use of one or several technologies, usually by natural or mechanical means

Note 1 to entry: These treatments lead to the production of biosolids whose mechanical characteristics allow a storage in heap on a minimum height of 1 m. As an indication, the dryness obtained is generally within a range between 15 % and 40 % (wet mass).

3.11
foreign matter
material of anthropogenic origin as opposed to natural objects such as sand, stones and wood fibres

EXAMPLE Plastics, glass, metal, small/large or sharp debris.

3.12
industrial sludge
mixture of water and solids separated from various types of industrial wastewater (e.g. food processing plants) as a result of natural or artificial processes and meet specific standards, guidelines or requirements including the reduction of pathogens, vector attraction and contaminant criteria

3.13
mineralization
final stage of the biodegradation of organic matter or organic substances into carbon dioxide, water and the hydrides, oxides and other mineral salts

[SOURCE: ISO 11074:2015, 3.3.19]

3.14
mesophilic anaerobic digestion
biological conversion of organic matter to biogas and residual solids at temperatures between 20 °C and about 40 °C, typically 37 °C with a mean residence time of 15 to 30 days

3.15
micronutrient
element, such as boron, manganese, iron, zinc, copper, molybdenum, cobalt, and/or chlorine, which are essential, in relatively small quantities, for plant growth

[SOURCE: ISO 8157:2015, 2.1.3.3, modified — Note 1 to entry has been deleted.]

3.16
municipal biosolids
biosolids produced from municipal sludge which has been treated to meet jurisdictional standards, guidelines or requirements including the reduction of pathogens and vector attraction

3.17
municipal sludge
mixture of water and non–stabilized solids separated from various types of municipal wastewater as a result of natural or artificial processes

3.18
organic matter
matter consisting of plant and/or animal organic materials, and the conversion products of those materials

[SOURCE: ISO 11074:2015, 2.1.8]

3.19
organic compound
any of a large class of chemical compounds in which one or more atoms of carbon are covalently linked to atoms of other elements, most commonly hydrogen, oxygen or nitrogen

3.20
plant nutrient
chemical element, which is essential for plant growth

[SOURCE: ISO 8157:2015, 2.1.2]

3.21
sample
part of a defined bulk product taken for the purpose of characterization

[SOURCE: ISO 14488:2007, 3.8]

3.22
setback
buffer
determined distance, sometimes based on risk assessment, that provides protection to environmentally sensitive features such as humans and water

3.23
sludge
mixture of water and solids originating from various types of wastewater during natural and artificial treatment

3.24
sodium adsorption ratio
measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste

3.25
soil quality
all current positive or negative properties with regard to soil utilization and soil functions

[SOURCE: ISO 11074:2015, 2.1.15]

3.26
stakeholder
person or organization that can affect, be affected by or perceive themselves to be affected by a decision or activity

[SOURCE: ISO 28007-1:2015, 3.6, modified — Note 1 to entry has been deleted.]

3.27
thermophilic anaerobic digestion
biological conversion of organic matter to biogas and residual solids, that takes place between 49 °C and 57 °C

3.28
total organic carbon
TOC
amount of carbon found in an organic compound

3.29
trace element
element present in very low concentrations

3.30
vector
living organism capable of transmitting a pathogen from one organism to another either mechanically (by simply transporting the pathogen) or biologically by playing a specific role in the life cycle of the pathogen

[SOURCE: EPA/625/R–92/013 Revised July 2003: Control of Pathogens and Vector Attraction in Sewage Sludge]

3.31
vector attraction reduction
treatment processes that stabilize and reduce the odours and other aspects of biosolids that attract flies, rodents and other potential vectors

4 Benefits of biosolids land application

The land application of biosolids can be beneficial in many ways including:

— adding organic matter to the soil which can have a positive impact on soil biological activity, soil porosity, soil bulk density, soil water infiltration rate, aggregate stability and cation exchange capacity;

— increased soil organic matter can also reduce soil erosion;

— potential to increase carbon sequestration in the soil while reducing chemical fertilizer input and greenhouse gas emissions from their production (see Annex A); and

— responsible utilization of essential macro and micro nutrients that could otherwise be wasted.

Alkaline stabilized biosolids, in the context of the many positive soil effects, can also be an economical and effective soil amendment to increase the pH of acidic soils.

The use of biosolids should go through a global assessment taking into account the various factors, in order to ensure the positive effect on crops and soils.

See Annex B for further information regarding benefits of biosolids.

5 Nutrients in biosolids

5.1 General

Biosolids contain organic matter and plant nutrients. See Annex C for average concentrations of organic matter and plant macronutrients in biosolids.

5.2 Nitrogen

5.2.1 General

Growing plants require a continuous source of nitrogen (N), which is an essential component of proteins that build cell material and plant tissue. It is also necessary for other plant functions.

Nitrogen applied to soils in mineral fertilizers, biosolids or other organic amendments is subjected to biochemical and physical processes which form the nitrogen cycle. Inorganic forms of nitrogen are the available forms to plants. All forms of nitrogen can be present in the soil at any point of time, mainly because nitrogen readily shifts from one form to another.

5.2.2 Nitrogen content and availability in biosolids

Nitrogen content and availability in biosolids can vary greatly depending on the source of the wastewater and the treatment process. Biosolids produced from some industrial sludges can have a high content of nitrogen while it is the opposite for others such as paper mill biosolids. Forms of nitrogen that can be present in biosolids include organic nitrogen (i.e. nitrogen bound in organic molecules such as proteins), nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_3) and ammonium (NH_4^+).

As plants can only assimilate mineral nitrogen, a primary factor in determining the nutrient value of biosolids should be the mineralization rate of its organic nitrogen. The nitrogen mineralization rate is dependant in part on the sludge treatment process. Other factors that can influence the availability of the nitrogen are intrinsic to the land application sites such as:

— temperature (air and soil);

— moisture;

— soil porosity;

— pH and texture;

— microbial activity; and

— method of application to the land.

Two main mechanisms for nitrogen loss should also be considered:

— volatilisation of the ammonia; and

— nitrate leaching.

5.2.3 Determination of biosolids application rate according to nitrogen content

The rate for biosolids application should be determined to provide the amount of nitrogen needed by the crop vegetation, or in reclamation scenarios, by the biosolids application management plan, to attain a desired result. For information regarding application rates for reclamation projects see 14.6. Whatever the project target is, special care should be applied to minimize or manage the amount of nitrogen that could be leached below the root zone of the crop, or through the soil to the ground water. Specifics related to nitrogen management on agricultural and non–agricultural lands are further explored in 8.2.2 and 14.6.2.

Biosolids application rates should be adjusted to avoid excess trace elements or phosphorus loading. In such case, if insufficient nitrogen is applied in the biosolids, inorganic fertilizer nitrogen can be applied. The addition of biosolids in a fertility plan adds multiple beneficial aspects.

5.3 Phosphorus

Phosphorus (P) is a macronutrient that is present in many organic materials including biosolids, and is important for healthy plant development. Specifically, phosphorus is needed for plant growth, rigidity of cell walls, and for the development of the root system. Phosphorus is of particular value as it is a limited natural resource.

Phosphorus is present in biosolids in organic and inorganic (phosphate) forms. Organic phosphorus undergoes mineralization through a (bio)degradation process in the soil before plant assimilation. Inorganic phosphorus is often predominant in biosolids[6].

The solubility and availability of phosphorus in biosolids is also dependant on soil pH. Plant available phosphorus is the phosphorus that is in the soil solution or is weakly adsorbed by soil particles and organic matter. Biological wastewater treatment does not change the availability of phosphorus. Nitrogen and phosphorus are found in similar concentrations in biosolids but often crop requirements are significantly lower for phosphorus. Subsequently application rates are based on the most restrictive element: nitrogen or phosphorus.

5.4 Potassium

Potassium (K) is soluble in wastewater and remains in the liquid stream. Therefore, potassium is not typically found in biosolids in high concentrations and the ratios K:N or K:P are much lower than with livestock manures, thus additional potassium can be required through the addition of inorganic fertilizers for soil health and plant growth.

5.5 Calcium

Most biosolids contain concentrations of calcium, approximately 2,1 % – 3,92 % (wet mass), similar to the content in animal manures. When lime is added to biosolids during an alkaline stabilization process, (e.g. 30 % lime addition by dry mass to the biosolids) the calcium content is increased. Applying biosolids at agronomic rates can supply a sufficient amount of calcium to correct deficiencies or the application of alkaline stabilized biosolids may be used to increase the soil pH where necessary or maintain the soil pH within a range that is optimum for plant growth.

5.6 Sulfur

Most biosolids contain sulfur, approximately 0,01 % to 2,42 % of SO_3 (wet mass) which promotes plant growth, development and seed formation. In biosolids, sulfur exists in available and slow–release forms resulting from the oxidation of sulphides and decomposition of organic matter respectively. When biosolids are applied at agronomic rates the sulfur demand of the crops can also be met.

