GUIDELINES FOR THE UTILISATION AND DISPOSAL OF WASTEWATER SLUDGE

Volume 2 of 5

Requirements for the agricultural use of wastewater sludge

water & forestry
Department:
Water Affairs & Forestry
REPUBLIC OF SOUTH AFRICA

TT 262/06

Water Research Commission

GUIDELINE VOLUMES

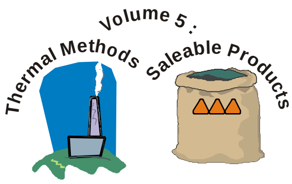
These Guidelines were developed to encourage the beneficial use of wastewater sludges. Rather than trying to develop a single guideline to address all the management options, a separate Guideline Volume deals with each of the management options. This Volume deals with the management, technical and legislative aspects associated with the agricultural application of sludge as well as the sludge characterisation and monitoring requirements for sludge application to agricultural land.

Volume 1: Selection of management options

Volume 2: Requirements for the agricultural use of sludge

Volume 3: Requirements for the on-site and off-site disposal of sludge

Volume 4: Requirements for the beneficial use of sludge



Volume 5: Requirements for thermal sludge management practices and for commercial products containing sludge

THESE VOLUMES ARE AVAILABLE FROM:

Water Research Commission
Private Bag X03
Gezina
0031
Tel: (012) 330 0340
Fax: (012) 331 2565
E-Mail: info@wrc.org.za
Webpage: www.wrc.org.za

The Department of Water Affairs and Forestry
Resource Protection and Waste
Private Bag X 313
Pretoria
0001
Tel: (012) 336 7541
Fax: (012) 323 0321
Webpage: www.dwaf.gov.za

Guidelines for the Utilisation and Disposal of Wastewater Sludge

Volume 2: Requirements for the agricultural use of wastewater sludge

Prepared for the
Water Research Commission
by

HG Snyman and JE Herselman
Golder Associates Africa

WRC Report No. TT 262/06

March 2006

The publication of this report emanates from a project entitled: *Permissible utilisation and disposal of sewage sludge, Edition 2* (WRC Project No. K5/1453)

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ISBN No 1-77005-423-5

ISBN Set No 1-77005-420-0

Printed in the Republic of South Africa

FOREWORD

This Guideline Volume was specifically developed to encourage the responsible use of wastewater sludge in agricultural practices. The agricultural use of sludge is defined as the beneficial use of certain constituents in sludge to benefit either the soil condition and/or enhance crop production in a sustainable manner. The potential benefits of the nutrients (nitrogen, phosphorus and potassium) and the high organic carbon content of sludge have been well demonstrated and have led to the utilisation of sludge for agricultural practices in many countries.

The agricultural use of sludge is seen as an appropriate cost effective management option for South Africa both for the agricultural and wastewater industry. Sludge can also assist in increasing the organic content of soil. Generally, cultivated soils in South Africa are low in organic matter due to its rapid decomposition in our climate. This has contributed to a widespread deterioration of soil physical properties. The improvement of the physical properties of soil (water holding capacity, permeability etc.) as a result of an increase in organic carbon plays an important role in promoting the agricultural application of wastewater sludge in South Africa. Subsistence and small-scale farmers can particularly benefit from the agricultural use of sludge, since the farmer will benefit financially due to savings on commercial inorganic fertilizers.

As with the widespread use of inorganic fertilisers or organically rich products, such as manures, the potential negative effects on environmental resources need to be managed. For this reason, the agricultural application of sludge must be controlled effectively and monitored for the protection of human and animal health, crop quality, protection of water resources and land productivity. This Guideline Volume has been specifically developed to maximise the responsible beneficial use of sludge in agricultural practices.

The aim has been to develop this Volume in such a manner that regulatory authorities, managers, practitioners and operators responsible for sludge management can easily understand and interpret it. At the same time, in the interest of transparency, the scientific basis, assumptions made and the thought processes were also documented in a separate document which is available from the Water Research Commission.

The Sludge Guidelines will remain living publications, and will be reviewed periodically based on comments received on the current requirements and approaches. All users are urged to critically review the Guidelines in terms of its usefulness and appropriateness. It is believed that feedback will ensure continual improvement. Comments should be directed to the Senior Manager: Resource Protection and Waste, Department of Water Affairs and Forestry, Private Bag X313, Pretoria, 0001.

Ms Buyelwa Patience Sonjica (MP)

MINISTER OF WATER AFFAIRS AND FORESTRY

ACKNOWLEDGEMENTS

The guidelines in this Volume emanated from a project funded by the Water Research Commission entitled:

"PERMISSIBLE UTILISATION AND DISPOSAL OF SEWAGE SLUDGE, EDITION 2"

The Reference Group responsible for this project consisted of the following persons:

Mr HM du Plessis	Water Research Commission (Chairman)
Mr G Steenveld	Water Research Commission
Dr DJ Jaganyi	University of Natal
Mr W Johannes	Africon Engineering International
Ms M Hinsch	Department of Water Affairs and Forestry
Mr L Gravelet-Blondin	Department of Water Affairs and Forestry
Mrs L Boyd	Department of Water Affairs and Forestry
Mrs M Ligthelm	Department of Water Affairs and Forestry
Mr AT van Coller	Department of Agriculture
Ms N Deyeva	Department of Agriculture
Mr K Taylor	Department of Agriculture
Mr FB Stevens	Ethekwini (Durban) Water Services
Mr B Pfaff	Ethekwini (Durban) Water Services
Mr KS Fawcett	City of Cape Town
Mr GB Saayman	Tshwane Metro
Mr PN Gaydon	Umgeni Water
Prof GA Ekama	University of Cape Town
Dr AR Pitman	Johannesburg Water
Mr RB Avis	Johannesburg Water

Project team:

Dr HG Snyman	Golder Associates Africa (Project leader)
Dr AM Van Niekerk	Golder Associates Africa
Mrs JE Herselman	Agricultural Research Council – ISCW
Mr CE Steyn	Agricultural Research Council – ISCW
Mr Graeme Kasselman	Department of Water Affairs and Forestry
Mr JW Wilken	ERWAT

The financing of the project by the Water Research Commission and the contribution of the members of the Reference Group are gratefully acknowledged.

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INTRODUCTION

The South African wastewater industry often views wastewater sludge as a waste product that should be managed as such. Due to the cost of the handling and disposal, sludge is increasingly being stored on site and many local authorities and service providers are not able to successfully manage the sludge in an environmentally acceptable manner.

Wastewater sludge has beneficial soil conditioning and fertilising properties. In fact, a wide array of elements contained in sludge are essential for plant growth and the organic content of sludge has led some agronomists to suggest that sludge is a more complete fertiliser than inorganic fertilisers. However, the presence of a wide variety of potentially harmful chemicals in sludge (albeit in trace amounts) with the potential for uptake by plants and animals, together with the potential presence of human pathogens mean that sludge cannot be treated like any other fertilisers.

A fundamental premise of this Volume is that sludge can be beneficially recycled to agricultural land provided that both the processing and application of sludge to land are subject to adequate management and control and provided that the sludge is applied at a rate that does not exceed the nitrogen needs of crops. In other words, rather than viewing sludge as a waste product that should be disposed of (e.g. by way of landfilling) which has its own adverse environmental effects, it is viewed as a valuable resource worth recycling to agriculture.

PURPOSE OF THIS VOLUME

The purpose of this Volume is:

- To encourage the appropriate use of sludge in agricultural practices;
- To give guidance on how to maximise the beneficial properties when applying sludge at agronomic rates;
- To create an understanding of the operational and legal requirements; and,
- To present guidelines for the monitoring of sludge for agricultural use, before application.

Agricultural use include:

- Use of stabilised sludge as a **nutrient source** and/or **soil conditioner** at an application rate designed to supply a crop's nitrogen needs, while at the same time minimising the risk of nutrient leaching. This applies to both commercial as well as to small scale and subsistence farming practices.
- To manage **compost** containing sludge that is not sold or distributed to the general public for use. Compost that is of such a high quality that it can be distributed to the general public is viewed as "a saleable product", the requirements of which are detailed in Volume 5 of the Sludge Guidelines.
- When sludge is used for municipal parks. If these parks are used by the public, additional pathogen management strategies will apply.

WHO SHOULD USE THIS VOLUME?

Volume 2 was developed to ensure the safe use of sludge on agricultural land. Any person who effectively applies the Guidelines will comply with all the environmental and health requirements. This Guideline was developed for:

- **Wastewater treatment plant operators** – to implement acceptable good practice pertaining to the beneficial use of sludge in agriculture.
- **Wastewater treatment service providers** – to implement agricultural use of sludge as a sludge management strategy.
- **Local authorities and town/city councils that own and operate wastewater treatment plants** – to design, operate and maintain a sustainable agricultural sludge application strategy to benefit the community as well as the local authority.
- **Wastewater engineers/scientists** – to develop improved treatment methods and monitoring protocols which will ensure the sustainable agricultural application of sludge.
- **Technical advisors** – to encourage the beneficial use of sludge in agricultural practice, both for sludge producers and users.
- **Legislators** – to assess compliance in cases where the Sludge Guideline Volumes have been referred to in a water use authorisation.
- **Farmers/Users** – to effectively utilise sludge in agricultural practice.
- **Educators** – to build capacity and create awareness.

OVERVIEW OF VOLUME 2: REQUIREMENTS FOR THE AGRICULTURAL USE OF WASTEWATER SLUDGE

Requirements for the agricultural use of sludge

Part 1

Background

Approach

Motivation

Part 2

Legal requirements for the agricultural use of sludge

Part 3

Classification of sludge intended for agricultural use

Assign a - Microbiological class
- Stability class
- Pollutant class

Part 4

Specific restrictions and requirements for the agricultural use of different sludge classes, including crop types and buffer zones

Part 5

General restrictions and requirements for the agricultural use of sludge including sludge storage, application rates and a monitoring programme

PART 1:

BACKGROUND

Volume 2 of the Guidelines was developed with a view of maximising the beneficial sludge properties for use in agricultural practices, while also addressing aspects that could be of concern. This Volume deals specifically with the agricultural use of sludge, including the management, technical and legislative aspects, as well as the sludge characterisation and monitoring requirements. It provides ceiling limits for metals and microbiological constituents in sludge intended for agricultural use, and encourages the implementation of vector attraction reduction options to stabilise the sludge. General and specific restrictions and requirements for the agricultural use of sludge are presented to minimise health risks and to protect the environment.

APPROACH FOLLOWED TO DEVELOP VOLUME 2

The Guidelines for the beneficial use of sludge in agricultural practices is based on the following information:

- Local and international research findings
- International guidelines and legislative trends
- The results of risk assessments
- Practical considerations

The scientific premise for this Volume was based on a risk assessment and risk management process. All the benefits and potential risks associated with the use of sludge in agricultural practices were identified. The process revealed which potential receptors were more sensitive to agricultural use of sludge. For example, the restriction on the sludge application rates to limit nitrate leaching to the aquatic environment, in effect achieves an acceptable risk for the metal leaching. In other words, if the sludge application restrictions were based on the environmental effects of metal mobility, the aquatic environment would have been at risk in terms of nitrate.

The following constituents and properties of sludge received particular attention due to their potential negative effects:

- Nutrients – This volume stipulates that the agronomic rates of nutrient application may not be exceeded to minimise leaching.
- Metals – Acceptable metal limits were developed both for the sludge as well as for the receiving soil and water environment. Even though these metal limits are achievable, they remain conservative and protective of the receiving environment.
- Odours – Odours and vector attraction affect the public negatively, therefore the stability of sludge, the reduction of the odours and vector attraction potential received attention in these Guidelines.
- Pathogens – Internationally acceptable standards were adopted for the sludge intended for distribution to the general public (without restrictions). Locally achievable pathogen standards were set for sludge intended for agricultural use with restrictions, in order to lower the pathogen numbers in the sludge, while still being practically achievable.

The potential negative effects were managed in one of two ways:

- Specifying treatment requirements to remove the risk (such as the destruction of pathogens); or,
- Specifying management requirements to isolate potential receptors from the potential risk (such as implementing crop restrictions for sludge which is not disinfected).

The conceptual thinking, development process and assumptions are presented in a document which is available from the WRC[1].

MOTIVATION FOR THE AGRICULTURAL USE OF SLUDGE

Sludge can be a valuable resource if used as a fertiliser and soil conditioner. The major benefits of sludge application are:

- Supply of major plant nutrients (calcium, magnesium, potassium, phosphorus, nitrogen);
- Supply of some essential micronutrients (zinc, copper, molybdenum and manganese) and;
- Improvement in soil physical properties, *i.e*. better soil structure, increased water retention capacity and improved soil water transmission.

According to the Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (Act 36 of 1947) a fertiliser can only be classified as an organic fertiliser if it contains less than 20% ash and 40% water. Sludge does not comply with these criteria and can therefore not be classified as an organic fertiliser. However, it can still improve the organic status of soils. Table 1 illustrates the typical nutrient content of South African sludge.

TABLE 1: TYPICAL NUTRIENT CONTENT OF DRY SOUTH AFRICAN SLUDGE

Nutrient	Range
Total N	3.2 - 4.5 %
Total P	1.5 - 1.7 %
Total K	0.2 - 0.3 %
Organic content	40 - 70 %

Toxic compounds such as heavy metals and human pathogens could compromise the beneficial use of sludge. Therefore, the benefits of sludge should always be weighed against the restrictions. This Volume was developed to reduce the risk of toxic effects and environmental contamination to an acceptable level.

[1] Snyman, H.G. and Herselman, J.E. 2005. Guidelines for the utilisation and disposal of wastewater sludge: Literature review of South African and international guidelines and legislation and Scientific premise for Volumes 1 and 2. WRC Report 1453/1/05.

PART 2:

LEGAL REQUIREMENTS FOR THE AGRICULTURAL USE OF SLUDGE

The South African environmental legislation is complex and authorisation by more than one Government Department needs to be considered. The Department of Water Affairs and Forestry (DWAF), Department of Environmental Affairs and Tourism (DEAT), Department of Health (DoH) and Department of Agriculture (DoA) have a regulatory role in the agricultural use of sludge. For example, DWAF requires a positive Record of Decision (ROD) for an Environmental Impact Assessment from DEAT, in order to issue a licence. Similarly, the national and provincial Departments of Health and of Agriculture could have requirements that must be taken into consideration.

The Department of Water Affairs and Forestry will, typically, be the lead agent and will consult with the other departments. The different departments have committed to co-operative governance and to improve inter-departmental communication, which should simplify the regulatory process.

The Department of Water Affairs and Forestry has indicated the minimum legal requirements for sludge producers and sludge users as follows:

Legal requirements for sludge producers (individual/entity producing sludge)

- For sludge producers applying dewatered sludge on their own property at agronomic rates for crop production:
  - The producer must comply with the Guidelines (Volume 2).
- For sludge producers supplying dewatered sludge to a user for use at agronomic rates for crop production:
  - The producer must have a legal contract and the user must comply with the Guidelines (Volume 2). The aspects that need to be covered in the contract have been attached Appendix 1.
- For sludge producers applying liquid sludge on their own property at agronomic rates for crop production:
  - The producer must have authorisation for such a water use (General Authorisation or licence).
- For sludge producers supplying liquid sludge to a user for use at agronomic rates for crop production:
  - The producer must have a contract (Appendix 1) with the user. The contract must specify that the user must obtain a water use licence and must adhere to the Guidelines (Volume 2).
  - The producer must have authorisation for such a water use (General Authorisation or licence).

Legal requirements for sludge users (individual/entity using sludge)

- For sludge users applying dewatered sludge at agronomic rates for crop production:
  - The user must have a contract and comply with the Guidelines (Volume 2).
- For sludge users applying liquid sludge at agronomic rates for crop production:
  - The user must apply for an authorisation for a water use (General Authorisation or licence) and comply with the Guidelines (Volume 2).

PART 3:

CLASSIFICATION OF SLUDGE INTENDED FOR AGRICULTURAL USE

All sludge producers currently using or intending to use sludge in agricultural practices must confirm the classification of the sludge, even if a preliminary classification was done as stipulated in Volume 1 of the Guidelines.

CLASSIFICATION SYSTEM

The South African Wastewater Sludge Classification System must be applied to classify the sludge intended for agricultural use:

TABLE 2: CLASSIFICATION SYSTEM FOR SLUDGE

Microbial class	**A**	**B**	**C**
Stability class	**1**	**2**	**3**
Pollution class	**a**	**b**	**c**

The characterisation and classification should be repeated if any major sludge production or processing changes occur that could affect the classification. This could include:

- When major extensions are implemented at the wastewater treatment plant.
- When major operational changes are made at the wastewater treatment plant.
- When the raw influent quality to the wastewater treatment plant changes in such a way that the sludge quality could be affected. In other words, when any major new wastewater contributor starts/ceases to discharge to the plant.

The sampling procedure (number of samples, sampling frequency and sample location) for the classification of sludge is the same as for the monitoring of the sludge. This is discussed in part 5, Section 6 “Restriction/Requirement: Monitoring Programme”. The laboratory analyses and methods required for sludge classification are detailed in Appendix 2.

Microbiological classification

The results of the microbiological analyses of the sludge samples can be used to determine the Microbiological class (Table 3).

TABLE 3: COMPLIANCE AND CLASSIFICATION CRITERIA: MICROBIOLOGICAL CLASS

Microbiological class	**Unrestricted use quality**		**General use quality**		**Limited use quality**
	A		**B**		**C**
	Target value	Maximum permissible value	Target value	Maximum permissible value	
Faecal coliform (CFU/g_{dry})	< 1 000 (5 log reduction)	10 000 (4 log reduction)	< $1x10^6$ (2 log reduction)	$1x10^7$ (1 log reduction)	> $1x10^7$ (no reduction)
Helminth ova (Viable ova/g_{dry})	< 0.25 (or one ova/4g)	1	< 1	4	> 4
Compliance requirements					
Requirements for classification purposes (Minimum 3 samples)	All the samples submitted for classification purposes must comply with these requirements	Not applicable	Two of the three samples submitted for classification purposes must comply with these requirements	The sample that failed may not exceed the Minimum Permissible Value	Not applicable
Requirements for monitoring purposes	90% compliance	The 10% (maximum) of samples that exceed the Target Value, may not exceed the Maximum Permissible Value	90% compliance	The 10% (maximum) of samples that exceed the Target Value, may not exceed the Maximum Permissible Value	Not applicable

Note: Table 3 requires a 90% compliance for the monitoring programme. Some plants such as those producing < 1 tdry sludge/day are required to collect only three samples once a year. These plants will therefore only be able to prove 90% compliance after a few years. Larger plants will be able to prove compliance on an annual basis.

Note to plants that produce Microbiological class A sludge: The product produced by these facilities **could** be distributed to the public without any restrictions. If this is the case, each batch (or other reasonable sampling interval) leaving the plant must be sampled immediately after the process and the Microbiological class confirmed. Products that do not meet the specification will need to be re-processed.

Stability classification

The Stability class (the potential to generate odours and attract vectors) was specifically introduced in the Sludge Guidelines as this is typically the issues that influence public perception.

The Stability class can be determined analytically and/or by complying with a vector attraction reduction requirement. A sludge producer is required to prove compliance to at least one of the vector attraction reduction options at any stage during operation. The different vector attraction reduction options are listed in Table 4 and described in detail in Appendix 3.

The achievement of a Stability class is especially important during the operational stages of a wastewater treatment plant. It is more important to consistently comply with a vector attraction reduction option, than the actual initial Stability classification.

Confirm the Stability class of the sludge by selecting at least one of the vector attraction reduction options in Table 4. Note that only Stability classes 1 and 2 are suitable for agricultural use of sludge.

TABLE 4: DETERMINING THE STABILITY CLASS

Stability class	1	2	3
	Plan/design to comply with one of the options listed below on a 90 percentile basis.	Plan/design to comply with one of the options listed below on a 75 percentile basis.	No stabilisation or vector attraction reduction options required.
Vector attraction reduction options (Applicable to Stability class 1 and 2 only)			
Option 1	Reduce the mass of volatile solids by a minimum of 38 percent		
Option 2	Demonstrate vector attraction reduction with additional anaerobic digestion in a bench-scale unit		
Option 3	Demonstrate vector attraction reduction with additional aerobic digestion in a bench-scale unit		
Option 4	Meet a specific oxygen uptake rate for aerobically treated sludge		
Option 5	Use aerobic processes at a temperature greater than 40°C (average temperature 45°C) for 14 days or longer (eg during sludge composting)		
Option 6	Add alkaline material to raise the pH under specific conditions		
Option 7	Reduce moisture content of sludge that do not contain unstabilised solids (from treatment processes other than primary treatment) to at least 75 percent solids		
Option 8	Reduce moisture content of sludge with unstabilised solids to at least 90 percent solids		
Option 9	Inject sludge beneath the soil surface within a specified time, depending on the level of pathogen treatment		
Option 10	Incorporate sludge applied to or placed on the surface of the land within specified time periods after application to or placement on the surface of the land		

Pollutant classification

The results of the sludge analyses can be employed to determine the Pollutant class (Table 5).

TABLE 5: DETERMINING THE POLLUTANT CLASS

***Aqua regia* extractable metals (mg/kg)**	**Pollutant class**		
	a	**b**	**c**
Arsenic (As)	<40	40 - 75	>75
Cadmium (Cd)	<40	40 - 85	>85
Chromium (Cr)	<1 200	1 200 - 3 000	>3 000
Copper (Cu)	<1 500	1 500 - 4 300	>4 300
Lead (Pb)	<300	300 - 840	>840
Mercury (Hg)	<15	15 - 55	>55
Nickel (Ni)	<420	420	>420
Zinc (Zn)	<2 800	2 800 - 7 500	>7 500
Note : A 90% compliance is required to comply with the requirements of a pollutant class. The compliance will therefore only be evident once 10 sample results are available.			

Note: Table 5 requires the analyses of eight (8) potentially toxic metals and elements. These were specifically chosen as they are typically the elements that might be of concern. However, the sludge produced at a specific wastewater treatment plant could be compromised by other elements due to unique circumstances. A full elemental analysis including a number of other trace metals and elements is required for the preliminary classification as detailed in Volume 1. The results of those analyses need to be consulted to determine if any other element is of concern. In cases where additional element(s) were identified, these also need to be included in the analyses for classification and monitoring purposes.

PART 4:

SPECIFIC RESTRICTIONS AND REQUIREMENTS FOR AGRICULTURAL USE OF WASTEWATER SLUDGE

Table 6 gives an overview of which sludge classes may be used for agricultural applications.

It is important to note that all classes that permit agricultural use of sludge are equally protective of the environment and human health. However, the restrictions and management requirements become more onerous with deteriorating sludge quality. For example, due to the presence of pathogens in Microbiological class C, this class may not be distributed to the public for general use and the sludge producer and/or user must have strict access control when this class of sludge is applied in order to adequately protect the public.

TABLE 6: PERMISSIBLE UTILISATION OF SLUDGE IN AGRICULTURAL APPLICATIONS BASED ON THE SOUTH AFRICAN SLUDGE CLASSIFICATION SYSTEM

South African Sludge Classification		Is agricultural use an option?	Any additional restrictions and requirements?	Notes
Microbiological class	A	Yes (i)	No	Could potentially be used as a saleable product.
	B	Qualified yes (ii)	Yes	General restrictions / requirements apply.
	C	Maybe (iii)	Yes	Only permissible if Stability class 1 or 2 is achieved. (General restrictions / requirements apply).
Stability class	1	Yes (i)	No	Could potentially be used as a saleable product.
	2	Qualified yes (ii)	Yes	Additional management actions required to encourage compliance with class 1.
	3	No (v)	Not applicable	Stability class 3 may not be used in agricultural practices.
Pollutant class	a	Yes (i)	No	Could potentially be used as a saleable product.
	b	Qualified yes (ii)	Yes	If the soil analysis is favourable.
	c	No (v)	Not applicable	Pollutant class c may not be used in agricultural practices.

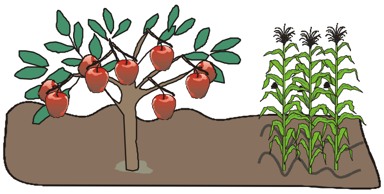
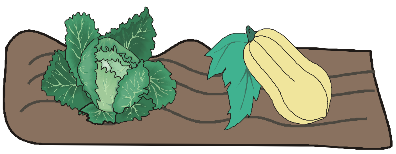
Note: Sludge that complies with all the requirements of class A1a may be sold or alienated to the public for unrestricted use.

USE RESTRICTIONS BASED ON THE MICROBIOLOGICAL CLASS

Crop restrictions

Table 7 list examples of crops harvested from below the soil surface, directly above the soil surface and those that bear edible parts above the soil surface. The specific restrictions pertaining to the crop types listed in Table 7 are detailed in the sections that follow.

TABLE 7: EXAMPLES OF CROPS IMPACTED BY SLUDGE APPLICATION

Harvested / edible parts that :		
Usually do not touch the soil/sludge mixture	**Usually touch the soil/sludge mixture**	**Are within soil/sludge mixture**
		
Fruit growing on trees such as peaches, apples, oranges, grapefruit, grapes, bananas, pineapples, avocados. Grains such as corn, wheat, oats, barley, cotton, soy beans.	Fruit and vegetables such as melons, strawberries, eggplant, squash, tomatoes, cucumbers, celery, cabbage, lettuce, spinach.	Fruit and vegetables such as potatoes, sweet potatoes, peanuts, onions, leeks, radishes, turnips, beets.

Microbiological class A: Restrictions for Agricultural Use

No restrictions and requirements apply.

Microbiological class B: Restrictions for Agricultural Use

Operators are encouraged to achieve a Microbiological class A classification to reach a “no restriction” status in terms of the Microbiological class.

The following crops may not be cultivated on soils amended with Microbiological class B sludge:

- Vegetables consumed raw.

Management practices and site restrictions:

- Crops with edible parts that do not touch the soil/sludge mixture, shall not be harvested until 30 days after the last sludge application.
- Crops with harvested parts that touch the soil/sludge mixture and are directly above the soil surface shall not be harvested until 14 months after the last sludge application.
- Crops with harvested parts below the soil surface where:

- Sludge remains on the surface for 4 months or longer before incorporation into the soil shall not be harvested until 20 months after the last sludge application.
- Sludge remains on the surface for less than 4 months before incorporation into the soil, shall not be harvested until 38 months after the last sludge application.

- Animals shall not be allowed to graze on land until 30 days after the last sludge application.
- Access to land with low public exposure (private farmland) is restricted for 30 days after the last sludge application.

Microbiological class C: Restrictions for Agricultural Use

Only suitable for agricultural use if Stability class 1 or 2 is achieved.

The following crops may not be cultivated on soils amended with Microbiological class C sludge:

- Vegetables consumed raw
- Vegetables that touch or are below the soil/sludge mixture (see Table 7)
- Vegetables with harvested parts below the soil surface (see Table 7)

Management practices and site restrictions:

- Crops whose edible parts do not touch the soil/sludge mixture, shall not be harvested until 90 days after the last sludge application.
- Animals shall not be grazed on land until 90 days after the last sludge application.
- Access to land with low public exposure (private farmland) is restricted for 90 days after the last sludge application.

USE RESTRICTIONS BASED ON THE STABILITY CLASS

Stability class 1

No restrictions apply

Stability class 2

Depending on the reliability of the vector attraction reduction measures implemented, additional management systems may be required. Odours and vector attraction are potentially the most important aspect that influences public perception of sludge application to agricultural land. It is more important to consistently comply with a vector attraction reduction option, than the actual initial Stability class classification.

Stability class 3

Not suitable for agricultural use. At least one vector attraction reduction option should be implemented, before any application to land can be considered.

USE RESTRICTIONS BASED ON THE POLLUTANT CLASS

Figure 1 details the route to follow to establish a pollutant class as well as the restrictions that apply to Pollutant class b.

Pollutant class a

No restrictions apply (Figure 1).

Pollutant class b

Sludge that does not comply with Pollutant class a, can also be used in agricultural applications. However, additional analyses will be required to assess whether the receiving soil can accommodate the pollutant load. Figure 1 details the steps to follow to determine if the soil can receive Pollutant class b sludge.

Start by determining the total metal content of the soil using the *aqua regia* extraction method (Volume 1, Appendix 2). Compare the results with the values in Table 8. If the total metal content of the soil is below the Total Investigation Level (TIL; Table 8), sludge of a Pollutant class b can be applied and the situation re-assessed after five (5) years. The 5-year monitoring intervals are required to ensure that the total soil metal content remains below the Total Investigation Level.

If the total metal content of the soil is found to be higher than the Total Maximum Threshold (TMT; Table 8), sludge application is not permissible for this soil. The risk to the environment is unacceptable when the total metal content of the soil exceeds TMT.

TABLE 8: METAL LIMITS FOR SLUDGE AMENDED SOILS (mg/kg)

Metal Elements	Total investigative level (TIL) (aqua regia)	Total maximum threshold (TMT) (aqua regia)	Maximum available threshold (MAT) (NH_4NO_3)
Arsenic (As)	2	2	0.014
Cadmium (Cd)	2	3	0.1
Chromium (Cr)	80	350	0.1
Copper (Cu)	100	120	1.2
Lead (Pb)	56	100	3.5
Mercury (Hg)	0.5	1	0.007
Nickel (Ni)	50	150	1.2
Zinc (Zn)	185	200	5.0

If the total metal content of the soil is found to be between the TIL and the TMT (Table 8) the mobility of the metals concentration in the soil needs to be assessed. The available metal content of the soil is determined using the NH_4NO_3 extraction method (Appendix 2). If the available metal content of the soil exceeds the Maximum Available Threshold (MAT, Table 8) level, Pollutant class b sludge may not be applied on this soil. If the available metal content of the soil is lower than the Maximum Available Threshold (MAT; Table 8), sludge of a Pollutant class b can be applied and the situation re-assessed after two (2) years. After two years, the total and available metal content of the soil must be determined. If either of these results exceed the TMT or MAT, the sludge application should be terminated.

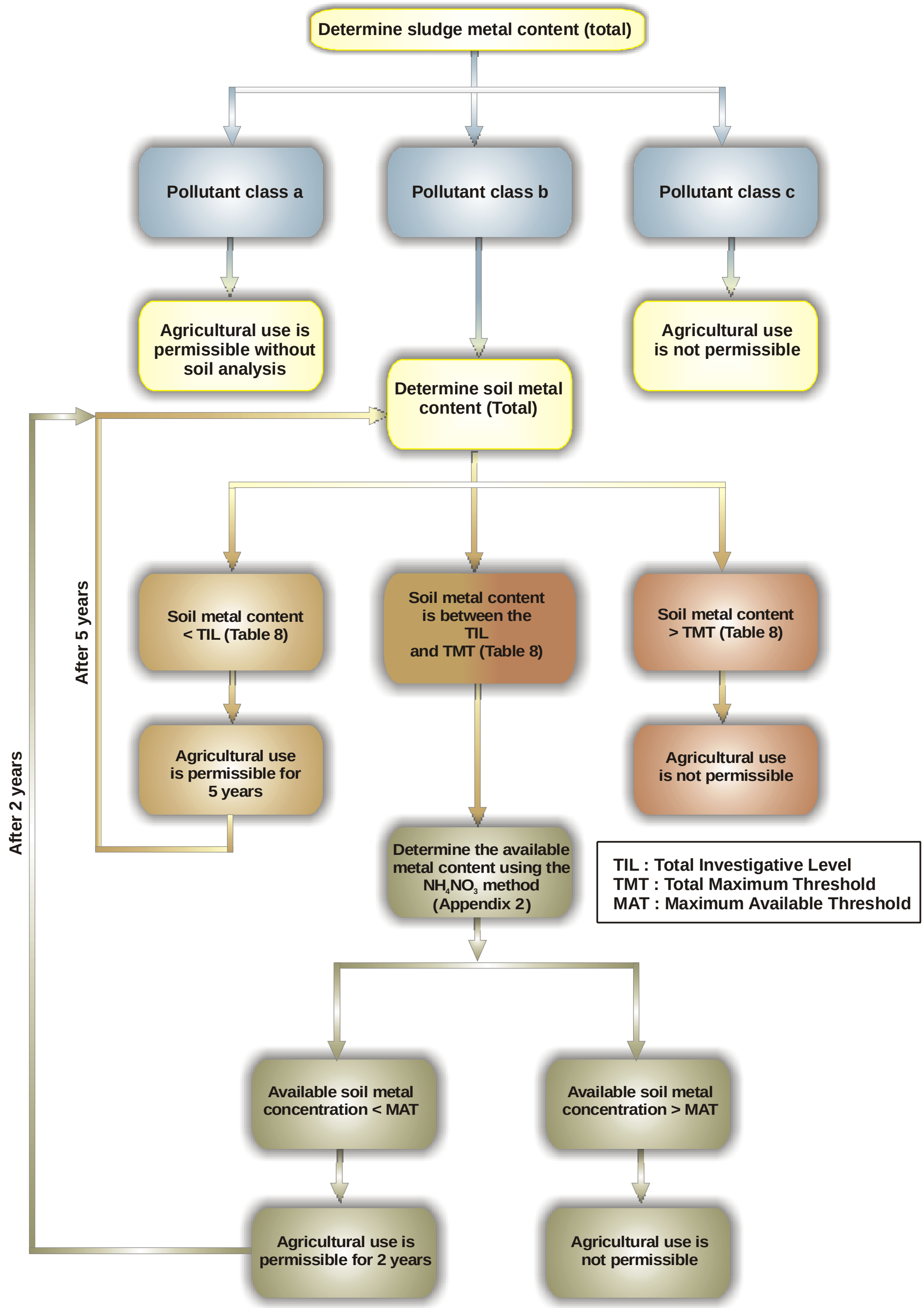


Figure 1: Schematic presentation of Pollutant class classification and restrictions applicable to agricultural use

Pollutant class c

Sludge of Pollutant class c may not be used in agricultural practice (Figure 1). The sludge metal content is too high. Source control should be implemented to improve the Pollutant class classification.

PART 5:

GENERAL RESTRICTIONS AND REQUIREMENTS FOR AGRICULTURAL USE OF WASTEWATER SLUDGE

Irrespective of the classification, some general restrictions apply for the agricultural use of sludge.

RESTRICTION / REQUIREMENT 1: SLUDGE STORAGE BEFORE AGRICULTURAL USE

It is recognised that not all sludge produced can be utilised immediately after production and processing. Treated sludge destined for agricultural application must be stored in a properly designed facility that minimises the impact on the environment. The sludge should be applied as soon as possible or, alternatively, adequate precautions must be taken not to generate odours or attract vectors.

RESTRICTION / REQUIREMENT 2: SLUDGE APPLICATION RATES

Sludge should be applied at rates that do not exceed the plant nutrient requirements (agronomic rates). In addition, an application rate of **10 tons dry mass per hectare per year** may not be exceeded.

Note: There may be cases where the maximum rate of 10 tons per hectare per year may not be sufficient for a specific crop's requirements. For these cases, a motivation can be submitted to the Department of Water Affairs and Forestry for consideration. Remember that the Pollutant class restrictions (metal limits) may need to be adapted when the sludge is applied at rates higher than 10 tons per hectare per year.

The nutrient content of the sludge must be confirmed before each major planting season by determining the nitrogen, phosphorus and potassium concentration on at least four composite samples.

Table 9 illustrate the typical sludge nutrient load based on the data presented in Table 1. Note that the nutrients are not immediately available, but are released slowly over time. For example, only 30 to 50% of the nitrogen becomes available during the first year after application.

At a sludge application rate of 10 tons dry mass per hectare per year, approximately 320 kg of N is added per hectare per year, of which 96 to 160 kg N/ha becomes available in the first year.

TABLE 9: TYPICAL NUTRIENT LOADS AT DIFFERENT APPLICATION RATES

Application rate	N application	P application	K application
ton/ha/year	kg N/ha/year	kg P/ha/year	kg K/ha/year
1	32 - 45	15 - 17	2 - 3
2	64 - 90	30 - 34	4 - 6
3	96 - 135	45 - 51	6 - 9
4	128 - 180	60 - 68	8 - 12
5	160 - 225	75 - 85	10 - 15
6	192 - 270	90 - 102	12 - 18
7	224 - 315	105 - 119	14 - 21
8	256 - 360	120 - 136	16 - 24
9	288 - 405	135 - 153	18 - 27
10	320 - 450	150 - 170	20 - 30
Note : Typically 30 - 50% of the N will become available in the first year.			

RESTRICTION/REQUIREMENT 3: PREVENTION OF SOIL EROSION

Topography (slope) and agricultural land preparation influence the amount of soil erosion and potential surface run-off of applied sludge. The application method of sludge should not contribute to soil erosion.

RESTRICTION/REQUIREMENT 4: BUFFER ZONES FOR GROUNDWATER AND/OR SURFACE WATER

To protect groundwater and surface water from pollution, the following buffer zones are recommended between the area of application and the water receptor:

- Depth to aquifer - >5m
- Distance from surface water/borehole - >200m

Note: The buffer zone may be relaxed on condition that proof is provided that the groundwater and surface water is adequately protected.

RESTRICTION/REQUIREMENT 5: DISTANCE FROM URBAN AREAS AND INFORMAL SETTLEMENTS

To protect the community from possible vectors and odours, sludge should not be applied to land within 500 m from dwellings.

Note: The restriction can be relaxed on condition that adequate vector attraction reduction and odour control is implemented.

RESTRICTION / REQUIREMENT 6: MONITORING PROGRAMME

The sludge quality and where applicable soil quality needs to be monitored and records kept.

Sludge monitoring programme

Table 10 provides guidance in this regard.

TABLE 10: SLUDGE SAMPLING AND ANALYSES FOR MONITORING

What should be monitored ?	Microbiological quality Physical characteristics Chemical characteristics		
How often should samples be taken ?	**Amount of sludge produced ($t_{dry\ weight}$)**		**Monitoring frequency**
	Daily average	**Yearly average**	
	<1	<365	Once per year
	1 - 5	365 - 1 825	4 times per year
	5 - 45	1 825 - 16 500	6 times per year
	>45	>16 500	Monthly
Type of samples	Grab samples to constitute a representative composite		
How many samples ?	At least 3 composite samples for each sludge stream		
When to sample ?	Before use or disposal		
Where to collect samples ?	Anaerobically digested	Collect from sampling valves on the discharge side of sludge pumps	
	Aerobically digested	Collect from sampling valves on discharge side of pumps	
	Thickened	Collect from valves on the discharge side of pumps	
	Heat treated	Collect from valves on the discharge side of pumps after decanting	
	Dewatered, dried, composted	Collect from collection conveyors or bulk containers	
	Dewatered by belt filter press, centrifuge	Collect from discharge chute	
	Dewatered in drying beds	Divide bed into quarters, sample from each quarter and combine samples	
	Compost piles	Collect from product	
Sample sizes	At least 500g dry mass		
Analytical methods	See Volume 1 - Appendix 2 and Volume 2 - Appendix 2		

Soil monitoring programme

A soil monitoring programme is recommended for the agricultural use of sludge. Monitoring should be done to:

- Determine nutrient requirements. Collect soil samples from all agricultural fields and analyse to determine the nutrient requirement for the particular crop to be cultivated (Table 11). This will ensure that the sludge application rate does not exceed agronomic rates. (Refer to fertiliser suppliers for sampling method and size).

- Determine whether the soil can continue receiving **Pollutant class b** sludge in cases where the:

  - Total metal content does not exceed the Total Investigative Level (TIL).

  - Total metal content (any metal) exceeds the Total Investigative Level (TIL), but is lower than the Total Maximum Threshold (TMT) in which case the available metal content (NH_4NO_3) should also be determined and the results compared with the Maximum Available Threshold (MAT).

TABLE 11: SOIL SAMPLING AND MONITORING

	Which soils to monitor	What to monitor	Frequency
What should be monitored and how often ?	All agricultural fields receiving sludge	Soil nutrient content (N, P, K)	Before each planting season
	Total metal content < TIL	Total metals	Once every 5 years
	TMT>Total metal content >TIL and Available metal content<MAT	Total and available metals	Once every 2 years
Type of samples	Composite samples of total area where sludge is applied.		
How many samples ?	Collect numerous samples, mix well and submit at least one composite sample for each field.		
When to sample ?	After planting season, before next sludge application.		
Sample sizes	1kg dry mass.		
Analytical methods	Volume 1 - Appendix 2 and Volume 2 - Appendix 2.		

RESTRICTION/REQUIREMENT 7: RECORD KEEPING

Once the applicable permits and licences have been granted sludge disposal and utilisation essentially become self-regulatory. This implies that certain records must be kept by the sludge producer and sludge user.

Table 12 summarises the general record keeping requirements for the producer (irrespective of the class of sludge produced). It is the responsibility of the producer to get data from the user as per their contract (see Appendix 1).

TABLE 12: RECORD KEEPING REQUIREMENTS FOR THE SLUDGE PRODUCER

Nr	Description of records to be kept
	Sludge records
1	Mass, solids content and volume of each sludge stream produced and a supporting wastewater treatment plant mass balance
2	Detailed description of sludge management process
3	Classification of each sludge stream that leaves the plant
4	Results supporting initial classification in terms of the : ○ Microbiological class ○ Stability class ○ Pollutant class
5	The original or certified copy of the contract between the sludge producer and user (if applicable)
6	A copy of applicable permits and licences
7	Monitoring data pertaining to the : ○ Microbiological class ○ Stability class ○ Pollutant class
8	Operational problem register: It is recognised that no plant runs smoothly 100% of the time. Document any operational problems that could affect the sludge management by detailing: ○ The nature of the problem ○ Duration of the problem ○ What was done with off-spec sludge ○ How the problem was rectified
9	Complaints register: (This includes complaints by the user as well as the public or other I&AP) which includes the: ○ Date, time of complaint ○ Nature of the complaint ○ A description of steps taken to address the complaint
	Soil records
10	Monitoring data pertaining to the: ○ Nutrient status of the soil ○ Metal content of the soil (total and/or NH_4NO_3 extractable)

CONCLUSION

Volume 2 of the Sludge Guidelines informs the reader regarding the classification of sludge for agricultural use and the legal requirements for sludge producers and agricultural users relating its use. The specific restrictions pertaining to the different sludge classes and the general restrictions/requirements for the agricultural use of sludge are also detailed.

Sludge and soil monitoring programmes are introduced to collect data on the variability in sludge composition over time and to ensure that the maximum permissible concentrations for the application of sludge to agricultural land are not exceeded.

It is recognised that new information is constantly being generated. For example the management of pathogens and the associated restrictions are still debated both nationally and internationally. Guidelines pertaining to the management of pathogens have therefore been developed using available information. It is therefore recommended that the Guidelines be revised every 5 to 10 years. This will allow the South African wastewater industry sufficient time to implement these Guidelines and highlight shortcomings, constraints and operational difficulties. Furthermore, by implementing the monitoring requirements stipulated in these Guidelines, case specific data will be generated that will enrich our local knowledge base.

APPENDIX 1: ESSENTIAL CONDITIONS TO BE INCLUDED IN A CONTRACTUAL AGREEMENT BETWEEN A SLUDGE PRODUCER AND SLUDGE USER

Producer

1. Name and address
2. Classification of sludge
3. Quality:

   Hygienic - stability and micro-organisms

   Moisture content

   Nitrogen, phosphate and potassium content

   Maximum metal and inorganic content
4. Limiting metal and maximum application rate in dry t/ha/year
5. Recommended maximum application rate in t/ha/yr in terms of nitrogen demand of crop
6. Notification of local authorities involved

User

1. Name and address
2. Name of transporter of sludge
3. Name of farm or site where sludge will be stored and used
4. Size of sludge application area
5. Crops to be fertilised or alternative use
6. Previous sludge application – annual rate and frequency
7. Metal and inorganic content of soil. Soil to be analysed before commencing sludge application and monitored as described in this document
8. Details of sludge processing, addition of other materials or chemical and quality of final product, if produced for selling

Agreement

1. Sludge to be used in terms of Guideline Volume 2
2. Inspection of user's activities by any appropriate local authority
3. Breach of contract – termination of sludge supply and punitive measures

APPENDIX 2: PARAMETERS AND ANALYTICAL METHODS REQUIRED FOR THE CLASSIFICATION AND MONITORING OF SLUDGE AND SOIL

TABLE A1: ANALYSES REQUIRED FOR CLASSIFICATION OF SLUDGE FOR AGRICULTURAL USE

Characteristic	Parameter	Guidance on methodology and/or recommended extraction method
Physical characteristics	pH	Direct measurement pH on saturated paste or solution
	Total solids (TS)	Standard method 2540B[1]
	Volatile suspended solids (VSS)	Standard method 2540E[2]
	Volatile Fatty Acids (VFA)	Adapted from Standard methods. The full method is detailed in Volume 1, Appendix 2.
Nutrients	Total Kjeldahl Nitrogen (TKN)	The suggested method description has been attached in Volume 1, Appendix 2.
	Total Phosphorus (TP)	The suggested method description has been attached in Volume 1, Appendix 2.
	Potassium (K)	The suggested method description has been attached in Volume 1, Appendix 2.
Metals and micro-elements	Arsenic Cadmium Chromium Copper Lead Mercury Nickel Zinc (Any other metal or element identified during the comprehensive characterisation detailed in Volume 1)	Extraction of trace elements soluble in *aqua regia* solution. International Standard ISO 11466 Method Reference number: ISO11466:1995 (E) Note: A semi-quantitative ICP scan would give concentrations for all mentioned metals. Remind the laboratory to manage the interferences on the ICP appropriately, especially for compounds such as Arsenic.
Microbiological quality	Faecal coliforms	Appropriate sample preparation based on moisture content and expected coliform count followed by incubation with selective growth media. Note: Determine moisture content on a sub-sample
	Total viable Helminth ova	Filtration/flotation and also determine viability (Volume 1, Appendix 2). Note: Determine moisture content on a sub-sample

[1,2] Standard Methods for the Examination of Water and Wastewater, 20th edition (1998) or latest, by Leonore S. Clesceri, Arnold E. Greenbert and R. Rhodes Trussell.

TABLE A2: SLUDGE ANALYSES REQUIRED FOR MONITORING PURPOSES

Characteristic		Parameter	Guidance on methodology and/or recommended extraction method
Physical characteristics		pH	Direct measurement pH on saturated paste or solution
		Total solids (TS)	Standard method 2540B[1]
		Volatile suspended solids (VSS)	Standard method 2540E[2]
		Volatile Fatty Acids (VFA)	Adapted from Standard methods. The full method is detailed in Volume 1, Appendix 2.
Chemical characteristics	Nutrients	Total Kjeldahl Nitrogen (TKN)	The suggested method description has been attached in Volume 1, Appendix 2.
		Total Phosphorus (TP)	The suggested method description has been attached in Volume 1, Appendix 2.
		Potassium (K)	The suggested method description has been attached in Volume 1, Appendix 2.
	Metals and micro-elements	Arsenic Cadmium Chromium Copper Lead Mercury Nickel Zinc (Any other metal or element identified during the comprehensive characterisation detailed in Volume 1)	Extraction of trace elements soluble in *aqua regia* solution. International Standard ISO 11466 Method Reference number: ISO11466:1995 (E) Note: A semi-quantitative ICP scan would give concentrations for all mentioned metals. Remind the laboratory to manage the interferences on the ICP appropriately.
Microbiological quality		Faecal coliforms	Appropriate sample preparation based on moisture content and expected coliform count followed by incubation with selective growth media. Note: Determine moisture content on a sub-sample
		Total viable Helminth ova	Filtration/flotation and also determine viability (Volume 1, Appendix 2). Note: Determine moisture content on a sub-sample

[1,2] Standard Methods for the Examination of Water and Wastewater, 20th edition (1998) or latest, by Leonore S. Clesceri, Arnold E. Greenbert and R. Rhodes Trussell.

TABLE A3: SOIL ANALYSES REQUIRED FOR MONITORING PURPOSES

Characteristic	Parameter	Guidance on methodology and/or recommended extraction method
Nutrients	Total Kjeldahl Nitrogen (TKN)	The suggested method description has been attached in Volume 1, Appendix 2.
	Total Phosphorus (TP)	The suggested method description has been attached in Volume 1, Appendix 2.
	Potassium (K)	The suggested method description has been attached in Volume 1, Appendix 2.
Metals to assess compliance in terms of the TIL and TMT	Arsenic Cadmium Chromium Copper Lead Mercury Nickel Zinc (Any other metal or element identified during the comprehensive characterisation detailed in Volume 1)	Extraction of trace elements soluble in *aqua regia* solution. International Standard ISO 11466 Method Reference number: ISO11466:1995 (E) Note: A semi-quantitative ICP scan would give concentrations for all mentioned metals. Remind the laboratory to manage the interferences on the ICP appropriately.
Metals to assess compliance n terms of the MAT	Arsenic Cadmium Chromium Copper Lead Mercury Nickel Zinc (Any other metal or element identified during the comprehensive characterisation detailed in Volume 1)	Extraction of trace elements soluble in Ammonium Nitrate solution. The suggested method description has been attached in Volume 2, Appendix 2 (the following page).

Method for the determination of NH_4NO_3 extractable (available) metal content of soil samples

Place 20 g air dry soil in a shaking bottle (100-150 ml), add exactly 50 ml ammonium nitrate solution (1 mol/l) and shake for 2 hours at 20 rpm at room temperature. Then allow the solid particles to settle for 15 min. Decant the supernatant solution and filter (0,45 µm). Dispose the first 5 ml of the filtrate. Collect the remaining solution in a 50 ml bottle for analysis.

Minimum concentrations which have to be quantified accurately with the Ammonium Nitrate extraction method (DIN 19730) for good results in the field of soil protection

Element		1 mol/l Ammonium Nitrate solution	Ammonium Nitrate extractable in the air dry soil
		(µg/l)	(µg/kg)
Ag	Silver	< 0,4	< 1
As	Arsenic	10	25
Be	Beryllium	1	2,5
Bi	Bismuth	< 0,4	< 1
Cd	Cadmium	2	5
Co	Cobalt	20	50
Cr	Chromium	4	10
Cu	Copper	100	250
Hg	Mercury	< 0,4	< 1
Mn	Manganese	2000	5000
Mo	Molybdenum	10	25
Ni	Nickel	100	250
Pb	Lead	< 8	< 20
Sb	Antimony	10	25
Tl	Thallium	4	10
U	Uranium	1	2,5
V	Vanadium	10	25
Zn	Zinc	100	250

Reference: DIN [Deutsches Institut für Normung Hrsg.] 19730 (1997-06): Extraction of trace elements in soils using ammonium nitrate solution — Beuth Verlag, E DIN 19730: Berlin.

APPENDIX 3: VECTOR ATTRACTION REDUCTION OPTIONS

The following options are available to reduce the vector attraction potential. These options have been adopted from the US EPA Part 503 Rule.

Option 1: Reduction in Volatile Solids Content

Vector attraction is reduced if the fraction of volatile solids in the primary sludge is reduced by at least 38 percent during the treatment of the sludge. This percentage is the amount of volatile solids reduction that is attained by anaerobic or aerobic digestion plus any additional volatile solids reduction that occurs before the sludge leaves the treatment works, such as through processing in drying beds or lagoons, or by composting.

Digestion process efficiency can be measured by the reduction in the volatile solids content of the feed sludge to the digester and the sludge withdrawn from the digester. Anaerobic digestion of primary sludge generally results in a reduction of between 40 and 60% of the volatile solids.

O'Shaunessy's formula can be used to calculate the volatile solids (VS) reduction in a digester:

VS reduction (%) = $\{(V_i – V_o)/ V_i – (V_i \times V_o)\}\times100$

Where V_i = volatile fraction in feed sludge

V_o = volatile fraction in digested sludge

Example of calculation of VS reduction

Assume volatile solids in feed sludge	=	84%		
Therefore volatile fraction of feed sludge	=	0.84	=	V_i
Assume volatile solids of digested sludge	=	68%		
Therefore volatile fraction of digested sludge	=	0.68	=	V_o

VS reduction (%) = $\{(0.84 – 0.68) / 0.84 – (0.84 \times 0.68)\} \times 100$

= 59%

Option 2: Additional Digestion of Anaerobically Digested Sludge

Frequently, primary sludge is recycled to generate fatty acids or the sludge is recycled through the biological wastewater treatment section of a treatment works or has resided for long periods of time in the wastewater collection system. During this time, the sludge undergoes substantial biological degradation. If the sludge is subsequently treated by anaerobic digestion for a period of time, it adequately reduces vector attraction. Because the sludge will have entered the digester already partially stabilized, the volatile solids reduction after treatment is frequently less than 38 percent.

Under these circumstances, the 38 percent reduction required by Option 1 may not be achievable. Option 2 allows the operator to demonstrate vector attraction reduction by testing a portion of the previously digested sludge in a **bench-scale unit** in the laboratory. Vector attraction reduction is demonstrated if, after anaerobic digestion of the sludge for an additional 40 days at a temperature between 30º and 37ºC, the volatile solids in the sludge are reduced by less than 17 percent from the beginning to the end of the bench test.

Option 3: Additional Digestion of Aerobically Digested Sludge

This option is appropriate for aerobically digested sludge that cannot meet the 38 percent volatile solids reduction required by Option 1. This includes activated sludge from extended aeration plants, where the minimum residence time of sludge leaving the wastewater treatment processes section generally exceeds 20 days. In these cases, the sludge will already have been substantially degraded biologically prior to aerobic digestion.

Under this option, aerobically digested sludge with 2 percent or less solids is considered to have achieved vector attraction reduction, if in the laboratory after 30 days of aerobic digestion in a batch test at 20ºC, volatile solids are reduced by less than 15 percent. This test is only applicable to liquid aerobically digested sludge.

Option 4: Specific Oxygen Uptake Rate (SOUR) for Aerobically Digested Sludge

Frequently, aerobically digested sludge is circulated through the aerobic biological wastewater treatment process for as long as 30 days. In these cases, the sludge entering the aerobic digester is already partially digested, which makes it difficult to demonstrate the 38 percent reduction required by Option 1.

The specific oxygen uptake rate (SOUR) is the mass of oxygen consumed per unit time per unit mass of total solids (dry-weight basis) in the sludge. Reduction in vector attraction can be demonstrated if the SOUR of the sludge that is used or disposed, determined at 20ºC, is equal to or less than 2 milligrams of oxygen per hour per gram of total sludge (dry-weight basis). This test is based on the fact that if the sludge consumes very little oxygen, its value as a food source for micro organisms is very low and therefore micro-organisms are unlikely to be attracted to it. Other temperatures can be used for this test, provided the results are corrected to a 20 ºC basis. This test is only applicable to liquid aerobic sludge withdrawn from an aerobic treatment process.

Option 5: Aerobic Processes at Greater than 40 ºC

This option applies primarily to composted sludge that also contains partially decomposed organic bulking agents. The sludge must be aerobically treated for 14 days or longer, during which time the temperature must always be over 40ºC and the average temperature must be higher than 45ºC.

This option can be applied to other aerobic processes, such as aerobic digestion, but Options 3 and 4 are likely to be easier to meet than the other aerobic processes.

Option 6: Addition of Alkaline Material

Sludge is considered to be adequately reduced in vector attraction if sufficient alkaline material is added to achieve the following:

- Raise the pH to at least 12, measured at 25 ºC, and without the addition of more alkaline material, maintain a pH of 12 for at least 2 hours.
- Maintain a pH of at least 11,5 without addition of more alkaline material for an additional 22 hours.

The conditions required under this option are designed to ensure that the sludge can be stored for at least several days at the treatment works, transported, and then used or disposed without the pH falling to the point where putrefaction occurs and vectors are attracted.

Option 7: Moisture Reduction of Sludge Containing no Un-stabilised Solids

Under this option, vector attraction is considered to be reduced if the sludge does not contain unstabilised solids generated during primary treatment and if the solids content of the sludge is at least 75 percent before the sludge is mixed with other materials. Thus, the reduction must be achieved by removing water, not by adding inert materials.

It is important that the sludge does not contain un-stabilised solids because the partially degraded food scraps likely to be present in such sludge would attract birds, some mammals, and possibly insects, even if the solids content of the sludge exceeds 75 percent. In other words, simply dewatering primary sludge to a 75% solid is not adequate to comply with this option. Activated sludge, humus sludge and anaerobically digested sludge can, however be dewatered to 75 % solids and comply with option 7.

Option 8: Moisture Reduction of Sludge Containing Unstabilised Solids

The ability of any sludge to attract vectors is considered to be adequately reduced if the solids content of the sludge is increased to 90 percent or greater, regardless of whether this contains primary sludge or raw unstabilised sludge. The solids increase should be achieved by removal of water and not by dilution with inert solids. Drying to this extent severely limits biological activity and strips off or decomposes the volatile compounds that attract vectors.

The way dried sludge is handled, including storage before use or disposal, can again create the opportunity for vector attraction. If dried sludge is exposed to high humidity, the outer surface of the sludge will increase in moisture content and possibly attract vectors. This should be properly guarded against.

Option 9: Sludge Injection

Vector attraction reduction can be demonstrated by injecting the sludge below the ground surface. Under this option, no significant amount of sludge can be present on the land surface within 1 hour of injection, and if the sludge is Microbiological Class A or B, it must be injected within 8 hours after discharge from the pathogen-reducing process.

The reason for this special consideration for Microbiological class A and B sludge (assuming vector attraction has not been reduced by some other means) is that pathogens could regrow and Microbiological class A and B sludge has no site restrictions to provide crop, animal grazing of access protection.

Note: Microbiological class A and B can be applied to soil much later than 8 hours after discharge from the pathogen-reducing process if another vector attraction reduction option such as dewatering and/or drying is applied. The time periods referred to in Option 9 are intended for liquid sludge application of Microbiological classes A and B.

Injection of sludge beneath the soil places a barrier of earth between the sludge and vectors. The soil removes water from the sludge, which reduces the mobility and odour of the sludge. Odour is usually present at the site during the injection process, but quickly dissipates once injection is complete.

Option 10: Incorporation of Sludge into the Soil

Under this option, sludge must be incorporated into the soil within 6 hours of application to or placement on the land. Incorporation is accomplished by ploughing or by some other means of mixing the sludge into the soil. If the sludge is Microbiological class A or B with respect to pathogens, the time between processing and application or placement must not exceed 8 hours – the same as for injection under Option 9. See the note under Option 9.

Note: Practical restrictions, such as the ability of the plough to function immediately after application, could cause delays in the incorporation of the sludge within the 6 hours. This could cause the development of odours and increase risk of vector attraction. In these cases the sludge producer needs to monitor the development of odours and manage the situation diligently.

DEFINITIONS AND DESCRIPTION OF KEY TERMS

Agricultural land:	Land on which a food crop, a feed crop, or a fibre crop is grown. This includes grazing land and forestry.
Agronomic rate:	The sludge application rate (dry-weight basis) designed (i) to provide the amount of nitrogen needed by the food crop, feed crop, fibre crop, cover crop, or vegetation grown on the land and (ii) to minimise the amount of nitrogen in the sewage sludge that passes below the root zone of the crop or vegetation grown on the land to the groundwater.
Agricultural use:	The use of sludge to produce agricultural products. It excludes the use of sludge for aquaculture and as an animal feed.
Annual pollutant loading rate:	The maximum amount of a pollutant that can be applied to an area of land during a 365-day period.
Assimilative capacity:	This represents the ability of the receiving environment to accept a substance without risk.
Available metal content (Soil):	Specific to Volume 2. Metal fraction extracted with ammonium nitrate in soil samples.
Beneficial uses:	Use of sludge with a defined benefit, such as a soil amendment.
Bioavailability:	Availability of a substance for uptake by a biological system.
Biosolids:	Stabilised Sludge. Organic solids derived from biological wastewater treatment processes that are in a state that they can be managed to sustainably utilise the nutrient, soil conditioning, energy, or other value.
Co-disposal (liquid with dry waste):	The mixing of high moisture content or liquid waste with dry waste. This affects the water balance and is an acceptable practice on a site equipped with leachate management measures.
Co-disposal (dewatered sludge with dry waste):	The mixing of dewatered sludge with dry waste in a general landfill site or hazardous landfill site without affecting the water balance of the site.
Composting:	The biological decomposition of the organic constituents of sludge and other organic products under controlled conditions.
Contaminate:	The addition of foreign matter to a natural system. This does not necessarily result in pollution, unless the attenuation capacity of the natural system is exceeded.
Controlled access:	Where public or livestock access to sludge application areas is restricted or controlled, such as via fences or signage, for a period of time stipulated by this guideline.
Cumulative pollutant loading rate:	The maximum amount of a pollutant that can be applied to a unit area of land.
Dedicated land disposal	Sites that receive repeated applications of sludge for the sole purpose of final disposal.

Dewatering: Dewatering processes reduce the water content of sludge to minimise the volumes for transport and improve handling characteristics. Typically, dewatered sludge can be handled as a solid rather than as liquid matter.

Disinfection: A process that destroys, inactivates or reduces pathogenic microorganisms.

Domestic sewage: Waste and wastewater from humans or household operations that is discharged to, or otherwise enters a treatment works.

Drying: A process to reduce the water content further than a dewatering process. The solids content after a drying process is typically > 75%.

Dry-weight (DW) basis: The method of measuring weight where, prior to being weighed, the material is dried at 105°C until reaching a constant mass (i.e., essentially 100 % solids content).

Faecal coliform: *Faecal coliforms* are the most commonly used bacterial indicator of faecal pollution. *Faecal coliforms* are bacteria that inhabit the digestive system of all warm-blooded animals, including humans.

Helminth ova: The eggs of parasitic intestinal worms.

Incineration: Incineration is both a form of treatment and a form of disposal. It is simply the controlled combustion of waste materials to a non-combustible residue or ash and exhaust gases, such as carbon dioxide and water.

Land application: The spraying or spreading of wastewater sludge onto the land surface; the injection of wastewater sludge below the land surface; or the incorporation of wastewater sludge into the soil so that the wastewater sludge can either condition the soil or fertilise crops or vegetation grown in the soil.

Land disposal: Application of sludge where beneficial use is not an objective. Disposal will normally result in application rates that exceed agronomic nutrient requirements or cause significant contaminant accumulation in the soil.

Landfill: To dispose of waste on land, whether by use of waste to fill in excavation or by creation of a landform above grade, where the term “fill” is used in the engineering sense.

Maximum available threshold (MAT): The maximum available (NH_4NO_3 extractable) metal concentration allowed for soils receiving sludge.

Monthly average: The arithmetic mean of all measurements taken during a given month.

Most probable number (MPN): A unit that expresses the amount of bacteria per gram of total dry solids in wastewater sludge.

Pathogenic organisms: Disease-causing organisms. This includes, but is not limited to, certain bacteria, protozoa, viruses, and viable helminth ova.

pH: The logarithm of the reciprocal of the hydrogen ion concentration. The pH measures acidity/alkalinity and ranges from 0 to 14. A pH of 7 indicates the material is neutral. Moving a pH of 7 to 0, the pH indicates progressively more acid conditions. Moving from a pH of 7 to 14, the pH indicates progressively more alkaline conditions.

Receptor: Sensitive component of the ecosystem that reacts to or is influenced by environmental stressors.

Recycle: The use, re-use, or reclamation of a material so that it re-enters the industrial process rather than becoming a waste.

Residue: A substance that is left over after a waste has been treated or destroyed.

Restricted agricultural use: Use of sludge in agriculture is permitted but restrictions apply (crop restrictions, access restrictions etc).

Sludge-amended soil: Soil to which sludge has been added.

Sludge: Solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works. Wastewater sludge includes, but is not limited to, domestic septage; scum or solids removed in primary, secondary, or advanced wastewater treatment processes; and material derived from wastewater sludge in a wastewater sludge incinerator. It does not include the grit and screenings generated during preliminary treatment of domestic wastewater in a treatment works.

Soil organisms: A broad range of organisms, including microorganisms and various invertebrates living in or on the soil.

Specific oxygen uptake rate (SOUR): The mass of oxygen consumed per unit time per unit mass of total solids (dry-weight basis).

Stabilisation: The processing of sludge to reduce volatile organic matter, vector attraction, and the potential for putrefaction and offensive odours.

Stabilised sludge: Organic solids derived from biological wastewater treatment processes that are in a state that they can be managed to utilise the nutrient, soil conditioning, energy, or other value.

Sterilise: Make free from microorganisms.

Supplier: A person or organisation that produces and supplies sludge for use. This includes a water business producing and treating sludge and processors involved in further treatment.

Sustainable use: The use of nutrients in sludge at or below the agronomic loading rate and/or use of the soil conditioning properties of sludge. Sustainable use involves protection of human health, the environment and soil functionality.

Total investigative level (TIL): The total metal concentration in soils where further investigation is necessary before sludge application can commence.

Total maximum threshold (TMT): The maximum total metal concentration allowed in soils receiving sludge.

Total metal content: Metal fraction extracted using an *aqua regia* solution (HCL/HNO_3 solution).

Toxic: Poisonous.

Unrestricted agricultural use: Sludge is of such good quality that it can be used in agricultural practices without any restrictions.

VAR: Vector Attraction Reduction.

Vector attraction: The characteristic of wastewater sludge that attracts rodents, flies, mosquitoes, or other organisms capable of transporting infectious agents.

Vectors: Any living organisms that are capable of transmitting pathogens from one organism to another, either: (i) mechanically by transporting the pathogen or (ii) biologically by playing a role in the lifecycle of the pathogen. Vectors include flies, mosquitoes or other insects, birds, rats and other vermin.

Waste: An undesirable or superfluous by-product, emission, or residue of any process or activity, which has been discarded, accumulated or stored for the purpose of discarding or processing. It may be gaseous, liquid or solid or any combination thereof and may originate from a residential, commercial or industrial area.

Wastewater Sludge: The material recovered from predominantly domestic wastewater treatment plants. (Also see Sludge)

Wastewater Treatment Plant (WWTP): Any device or system used to treat (including recycling and reclamation) either domestic wastewater or a combination of domestic wastewater and industrial waste of a liquid nature.

Wet weight: Weight measured of material that has not been dried (see Dry-weight basis).