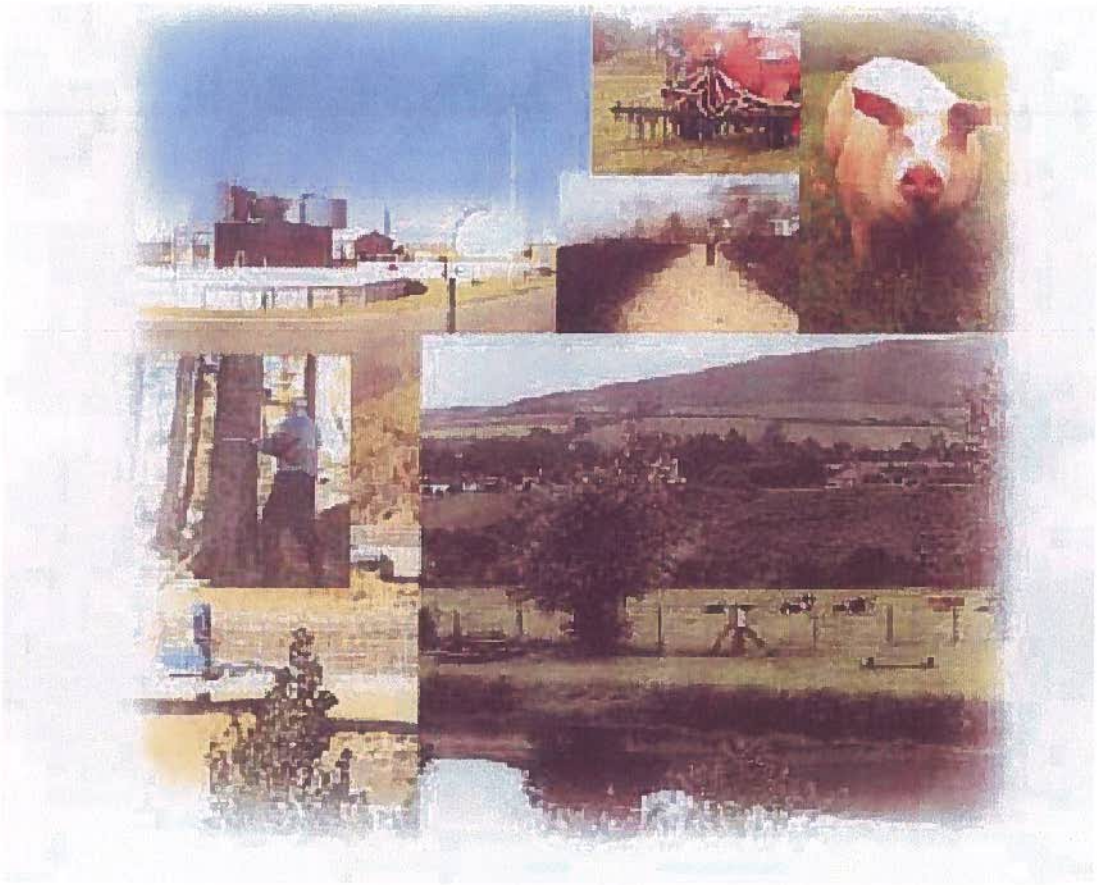
AN ROINN COMHSHAOIL AGUS RIALTAIS ÁITIÚIL
DEPARTMENT OF THE ENVIRONMENT AND LOCAL GOVERNMENT

CODES OF GOOD PRACTICE

FOR THE USE OF BIOSOLIDS IN AGRICULTURE

Guidelines for Local Authorities and Wastewater Treatment Plant Operatives



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CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCE

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APPENDICES

part one

What you should know about the Code and the use of Biosolids in agriculture

What is Biosolids?

Biosolids is the organic by-product of urban wastewater treatment which, by being treated to an approved standard, can be used beneficially as a fertiliser/soil conditioner in agriculture.

Purpose of the Code

The objective of this Code of Good Practice for the Use of Biosolids in Agriculture is to set guidelines for the treatment and use of wastewater sludge. Reuse of wastewater sludge in agriculture is regarded as the most sustainable method of sludge management. The Code of Good Practice has been designed using the best scientific data available to ensure that the use of Biosolids in agriculture will:

- be compatible with good agricultural practice
- not pose a risk to human, animal or plant health
- maintain the integrity of the soil ecosystem
- avoid water pollution
- avoid air pollution
- minimise public inconvenience.

Background to preparation of the Code

Council Directive 91/271/EEC concerning urban wastewater treatment requires treatment of wastewater discharging from all major population centres by 31 December 2005 and places a ban on disposal of sludge to sea by 31 December, 1998. Because of this, the volume of sludge arising from wastewater treatment in Ireland is set to grow substantially. The Directive further encourages use of wastewater sludge wherever appropriate.

The recommendations in this Code of Good Practice are designed to reflect the requirements of relevant legislation at both European and Irish levels; a list of this legislation is provided in Appendix 2.

This Code of Good Practice will complement the *Code of Good Agricultural Practice to Protect Waters from Pollution by Nitrates*, published in July 1996 by the Department of Environment and the Department of Agriculture, Food and Forestry.

What is in the Code?

This Code advises and provides recommendations for Biosolids producers in relation to:

- treatment of Biosolids to achieve pasteurisation
- evaluating spreadlands for the use of Biosolids
- transportation and spreading of Biosolids
- nutrient management planning
- quality control
- liaising with the customer

Where does the Code apply?

The Code of Good Practice applies in all parts of the country and is intended to permit the safe and beneficial use of Biosolids in agriculture nationally.

Status of the Code

This is a mandatory Code, produced in response to Directive 86/278/EEC on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture. Its intention is to promote sustainable agricultural use of the organic matter and nutrients contained in Biosolids. It is designed specifically for the Biosolids producer and should provide an easy guide to the obligations of Biosolids producer under Irish and European legislation.

Why should Biosolids be used in agriculture?

The chain of nutrient recycling is integral to all natural processes. That chain begins in the soil, when plants take up nutrients and transform them into tissue. Plant tissue is consumed by humans, either directly in the form of fruits, vegetables and cereals, or indirectly in the form of dairy and meat products. Not all the nutrient value contained in food is used by humans. The unused portion of nutrients enters the wastewater stream and most is transferred to the sludge which results from the process of wastewater treatment. The natural cycle is completed when the nutrients are returned to the soils, replenishing those removed by the plants. Returning the nutrients transferred via food from rural to urban areas to rural agricultural land also completes the urban/rural cycle. It is for this reason that use of Biosolids in agriculture is considered the most sustainable option of sludge management.

Benefits of Biosolids

Biosolids is rich in both the macro and micro nutrients required for healthy plant and animal growth. It contains nitrogen, phosphorus and potassium. It

can also provide magnesium, zinc, copper, calcium, nickel, boron, manganese and cobalt.

Because of its organic matter content, Biosolids can provide good tilth to heavy soils and improve the structure of sandy soils. By improving the relationship between soil microorganisms and the plant root, the addition of Biosolids to soil can assist plants to attain full health at optimal growth rates.

Potential constraints on agricultural use of Biosolids

The everyday activities of man in modern society result in the discharge of many substances to the wastewater stream. Untreated wastewater sludge may contain:

- bacteria, viruses, parasites and other potentially disease-causing microorganisms
- heavy metals, sources of which include pipework materials, storm water run-off from roads, industrial processes and cosmetics
- a variety of organic micropollutants, arising principally from industrial processes, detergent use and irresponsible waste disposal.

These contaminants can be either eliminated or substantially reduced by:

- environmental legislation
- prevention/limitation of discharges to sewer
- treatment of wastewater sludge.

Only wastewater sludge which has undergone one of the recommended treatment processes to attain an adequate standard can be classified as Biosolids (see Part 2, Paragraph 1.5). The precautionary principle is observed by limitation and control of Biosolids application to land.

Control of discharges to sewer is most desirable for the purposes of producing a quality Biosolids product. Maximisation of sewage effluent quality is regarded as central to the sustainability of the Biosolids use programme (see Part 5, Paragraphs 2.1 – 2.3 and 3.1 – 3.9).

Who is the Biosolids producer?

A Local Authority, wastewater treatment plant operator and any other organisation involved in treating wastewater sludge to a standard sufficiently high for its safe and beneficial use, can be regarded as a Biosolids producer.

The role of the Biosolids producer

Essential functions of the Biosolids producer in organising the Biosolids use programme include:

- liaising with customers in the provision of a product which will be beneficial as a source of nutrients and as a soil conditioner
- ensuring the Biosolids product provided is of a consistently high quality
- guaranteeing a reliable and ready source of Biosolids
- ensuring that the Biosolids product is applied to land in accordance with the recommendations provided in this Code of Good Practice
- building the confidence of customers and consumers in the value of the Biosolids product.

By regulating the use of Biosolids so as to take account of relevant legislation (see Appendix 2) and to abide by the relevant Codes of Practice, the Biosolids producer holds the key to the sustainability of the Biosolids use programme.

part two

Achieving the Biosolids product

1. Treatment

General

1.1 Treatment of wastewater sludge by one or more of the processes described in Paragraph 1.5 below will produce Biosolids, a pasteurised product.

1.2 Treatment can have the added benefit of making the Biosolids product **easier** to handle, store, transport and spread.

Treatment requirements

1.3 Wastewater sludge must receive the appropriate treatment to reach the standards necessary to be classified as Biosolids. The Biosolids product may then be spread on agricultural land in accordance with the requirements of this Code of Good Practice.

1.4 Untreated wastewater sludge should not be landspread or injected into soil.

Treatment processes

1.5 Treatment by one or more of the following recommended processes will satisfy the requirements for production of Biosolids when process conditions as outlined in Appendix 3, Table 1, are maintained:

- Mesophilic anaerobic digestion with pre- or post- sanitation
- Thermophilic anaerobic digestion
- Thermophilic aerobic digestion
- Composting (windrows or aerated piles)
- Alkaline stabilisation
- Thermal drying

2. Guarantee of quality product

General

2.1 Biosolids must be recognised as a product of a consistently high standard which can be used safely and beneficially in agriculture. This can be achieved by reaching defined standards of chemical, physical and microbiological quality and by controlling the rates of Biosolids application to land.

Microbial reduction

2.2 Treatment by at least one of the approved processes will ensure that the Biosolids product attains the following microbial standards:

Faecal coliform < 1,000 MPN (Most Probable Number).g^{-1} dry solids
Salmonella sp. < 3 MPN.$4g^{-1}$ dry solids

The Biosolids can then be classified as a pasteurised product.

Heavy metals

2.3 Some soils are naturally high in heavy metals. But metals also enter soil from a variety of other sources, including the air, artificial fertilisers and animal slurries. Care must be taken that additional metal applied to soil by the landspreading of Biosolids will not prove adverse to soil, plant, animal or human health. This can be ensured by:

- observing planting, harvesting and grazing constraints (Part 4, Paragraphs 4.1 – 4.6)
- restricting rates of Biosolids application to land (Part 4, Paragraphs 5.1 – 5.6)
- controlling the annual average addition of metal to land over a 10-year period (Part 4, Paragraph 5.7)
- not applying Biosolids to land in which heavy metals are already present in high concentrations (Part 4, Paragraph 5.7).

2.4 The rates of metal addition resulting from the controls such as those outlined above can provide many of the micronutrient requirements essential for healthy plant and animal development (see Appendix 6, Table 3).

Organic micropollutants

2.5 Levels of organic micropollutants in wastewater sludge are very low. The constraints outlined in Paragraph 2.3 on landspreading of Biosolids will ensure that applications of organic micropollutants are extremely low and will not be detrimental to soil, plant, animal or human health.

2.6 The Biosolids use programme should incorporate regular monitoring of a number of organic micropollutants as specified in Appendix 7. This will establish data against which a constant check on concentrations of these substances can be made (see Part 5, Paragraph 1.6).

Certificate of Analysis of the Biosolids product

2.7 A comprehensive analysis of the Biosolids product must be made on a regular basis (see Part 5, Paragraph 1.15). The results will be presented in a Certificate of Analysis.

2.8 Every potential customer may obtain a Certificate of Analysis of the Biosolids which he/she is going to use.

2.9 In general, this Certificate of Analysis should provide information on the:

- date on which the sample was taken
- origin of the wastewater sludge from which the Biosolids was produced
- treatment process used to achieve the Biosolids product
- presence of faecal coliform or *Salmonella* sp.
- nutrient status of the Biosolids
- concentration of heavy metals in the Biosolids
- concentration of organic micropollutants in the Biosolids.

Parameters to be measured and listed in the Certificate of Analysis include those listed in Appendix 7, Table 1. All analysis is to be done using standard methods.

part three

Promoting the Biosolids product

1. Setting up the Biosolids use programme

Programme of Evaluation

1.1 A wastewater treatment plant manager wishing to set up a programme of Biosolids use should undertake a strategic exercise to evaluate the viability and sustainability of such a programme within that locality.

1.2 Factors which this Programme of Evaluation shall include are:

Type, quality and quantity of wastewater sludge generated in the locality
Availability of land in the locality
Crops grown in the locality and methods of fertilisation
Availability of other organic fertilisers
Suitability of area for landspreading of organic wastes
Soil type, quality, trafficability, nutrient status
Local climate
Local topography
Presence of nitrate in groundwater
Vulnerability of both ground and surface waters
Hydraulic capacity of the soil
Background concentration of heavy metals in soil
Accessibility by road

1.3 The Programme of Evaluation should also attempt to anticipate local demand for the Biosolids product. The Biosolids producer should choose/design the treatment process to answer the fertiliser requirements of the potential customer base. Providing an answer to local fertiliser needs will help to guarantee continued demand for the Biosolids product.

2. Choosing the spreadlands

2.1 A detailed guide to choosing spreadlands can be found in the BATNEEC Guidance Note for the Pig Production Sector (EPA, 1996) and the (draft) Code of Practice for the Protection of Groundwater from the Landspreading of Organic Wastes (EPA/GSI, 1997).

2.2 The Biosolids producer is obliged to walk all proposed spreadlands prior to deciding whether they are suitable for inclusion in the Biosolids use programme.

2.3 While use of Biosolids in agriculture is the best practice generally, it may be that the Programme of Evaluation will show that it is not practicable in a particular locality.

2.4 For further guidance on safe application of Biosolids, see also Part 4, Paragraphs 7.1 – 7.7.

3. Liasing with the customer

General

3.1 Communication with the customer is an important component of developing a culture of beneficial use of Biosolids. It allows the customer to make best use of the Biosolids product and to develop an appreciation of its fertiliser and soil conditioner qualities. It also enables the customer to provide any information which may be requested of him.

Certificate of Analysis

3.2 Every customer may obtain a Certificate of Analysis of the Biosolids product as detailed in Part 2, Paragraphs 2.7 – 2.9.

Nutrient Management Plans

3.3 Provision of sound agronomic advice should be an integral part of the Biosolids use programme. The Biosolids producer will provide a full Nutrient Management Plan for all spreadlands in accordance with Part 4, Paragraphs 6.1 – 6.8. A copy of the Nutrient Management Plan relating to his/her lands, in addition to soil testing and other monitoring data, should be given to the customer.

Code of Good Practice

3.4 The Biosolids producer will provide the customer with a copy of the Code of Good Practice for Use of Biosolids in Agriculture. This can form the basis for discussions between the producer and customer of their obligations and requirements.

Promotional activities

3.5 In areas with existing Biosolids use programmes, promotional activities should be maintained to sustain and increase the existing customer base and increase public awareness and acceptability of Biosolids recycling.

part four

Code of Good Agricultural Practice

1. Storage requirements

1.1 Availability of adequate and sound storage is a strategic necessity to the Biosolids use programme, allowing best use to be made of spreading windows and optimising transportation. The Biosolids producer must provide storage at the Biosolids production plant, although this may be supplemented by on-farm storage at farms participating in the Biosolids use programme.

Volume of storage

1.2 The volume of storage provided must be sufficient to store Biosolids produced between the months of October and February during which time conditions will generally not be suitable for landspreading (see Paragraph 7.2).

Low-solids storage

1.3 Liquid Biosolids storage provided at the Biosolids production plant should be an overground tank. This tank may be constructed from concrete or steel. Concrete tanks should be constructed in accordance with S123: "Minimum specification: Slatted livestock units; Reinforced concrete tanks". Steel tanks should be constructed on an impermeable concrete base. All tanks must be certified by the manufacturer as watertight for a 10-year period, after which a certificate of integrity should be obtained once every 5 years from a qualified engineer.

High-solids storage

1.4 Biosolids with a dry solid content of > 25% can be stockpiled at the wastewater treatment plant on a hardstanding area constructed according to S108: "Minimum specification for manure pits". Such hardstanding areas must be covered by a roof and walls to prevent leachate generation as a result of rainwater ingress. Any self-generated leachate should be subject to collection and controlled disposal.

Location of storage facilities

1.5 Storage facilities should be located so as not to cause a risk of either surface or groundwater pollution. The (draft) Code of Practice for the Protection of Groundwater from the Landspreading of Organic Wastes (EPA/GSI, 1997) can provide guidance to siting storage facilities.

1.6 Storage facilities should not be readily accessible either to the public or livestock and secure fencing must be provided around any tank or hardstanding area in which Biosolids is stored.

Off-site storage

1.7 Should a customer so desire, he/she may provide on-farm storage of Biosolids prior to landspreading. The Biosolids producer should be satisfied that any storage facility used to hold Biosolids is structurally sound and constructed to the requirements of Paragraphs 1.3 and 1.4 above.

1.8 A header tank can be used for transferring liquid Biosolids from the transportation vehicle to the spreading equipment at the site of application. A header tank is not subject to the same design and location requirements as a storage tank and should not be used for long-term storage purposes. However, a clean header tank will enhance the image of the Biosolids use programme and care should be taken not to position it adjacent to a river nor to overfill it during the landspreading operation.

2. Transportation

Transportation equipment

2.1 Liquid Biosolids must be transported in a closed tanker. Biosolids of a dry solids content > 25% may be transported in a covered skip or trailer.

2.2 Whatever vehicle is chosen, its type and size should be suitable for the planned task.

Route planning

2.3 Routes should be chosen in such a way as to minimise nuisance to the public. Low-level bridges and other obstacles can be avoided by forward planning. At the site of landspreading, care must be taken that the transport vehicle does not create a traffic hazard when entering or exiting fields or when parked at the roadside.

Management

2.4 A clean, well-run vehicle will promote the image of the Biosolids use programme. The carrying of mud from the site of landspreading on to the public road should be avoided. Tanks and wheels should be washed before leaving the Biosolids production plant and farm.

Spillages

2.5 Should a spillage occur during transportation, it must be cleaned up immediately. Spillages cannot be allowed to enter watercourses and ditches. In the event of a spillage on the public road, both the Local Authority headquarters and the Gardaí must be contacted as soon as possible.

3. Methodologies for landspreading of Biosolids

Landspreading equipment

3.1 The bandspreader is recommended as the most suitable equipment for landspreading of liquid Biosolids. Fitting of flow-meters, Global Positioning Systems and other recording and monitoring equipment is strongly encouraged.

3.2 Shallow soil injection may be used for landspreading of Biosolids on land under permanent pasture in areas in which groundwater is not subject to elevated nitrate levels.

3.3 Biosolids of a dry solids content > 25% may be applied to land using a muck-spreader.

3.4 Thermally dried Biosolids, which is of a very high dry solids content and has the appearance of artificial fertiliser granules, may be applied with a conventional fertiliser spreader.

Responsibility for landspreading

3.5 In general, the Biosolids producer will be responsible for landspreading of the Biosolids product. However, it is quite acceptable for a customer to carry out the landspreading operation on his/her own land provided that the customer is made aware of his/her requirements under the Code of Good Practice for the Use of Biosolids in Agriculture.

3.6 The farmer may store Biosolids in tanks which are also used for the storage of other organic slurries. Where the proportion of other organic slurries exceeds 50% of the volume of the Biosolids, the landspreading operation shall be the farmer's responsibility and not that of the Biosolids producer.

3.7 The person carrying out the landspreading operation must be provided with a map of the site where the Biosolids is to be applied. This map should indicate:

- buffer zones and other prohibited areas
- areas of rock outcrop
- any hazards to be avoided
- maximum permissible rates of application in accordance with the Nutrient Management Plan.

Use of contractors

3.8 Contractors may be employed to carry out the landspreading operation on behalf of the Biosolids producer or on behalf of the landowner on the understanding that they must operate in strict accordance with the Code of Good Practice for the Use of Biosolids in Agriculture.

4. Planting, harvesting and grazing constraints

General

4.1 The constraints on planting, harvesting and grazing when Biosolids is used in agriculture are outlined in Paragraphs 4.2 – 4.6 and are summarised in Appendix 5, Table 1.

Crops to which Biosolids can be applied

4.2 Biosolids can be applied to soil prior to planting cereals, oil seed rape, grass (both permanent pasture and silage), fodder beet and forestry.

4.3 When used as a fertiliser on growing crops, it may be applied to cereals, oil seed rape, grass (both permanent pasture and silage) and forestry only.

4.4 Upland forestry is frequently characterised by artificially drained, thin, poor and acidic soils. For the purposes of preventing potential water pollution, Biosolids should not be applied to forestry plantations in upland areas. It may, however, be used to fertilise lowland forestry, provided all other landspreading considerations in this Paragraph and in Paragraphs 7.1 – 7.7 are satisfied.

Constraints on crop harvesting

4.5 No animal fodder, including kale, fodder beet or silage, may be harvested until at least 3 weeks after application of Biosolids.

Constraints on grazing

4.6 Cattle should not be turned out onto pasture which has been fertilised with Biosolids until 3 – 6 weeks after the date of application. The interval between application and commencement of grazing will depend on the level of incorporation of Biosolids into the soil, generally as influenced by length of sward and rainfall events.

5. Application rates for Biosolids

General

5.1 The target rate of application of Biosolids must be limited to that corresponding to the lowest of the following:

- the maximum permissible rate of application of nutrients
- the maximum permissible rate of application of metals
- the maximum permissible hydraulic loading.

This target rate, which must not exceed this lowest limit, will be determined by site-specific soil and crop conditions and by the quality of the Biosolids product.

5.2 Whatever target rate is found to be suitable should be applied uniformly over the landspreading site.

Nutrients

5.3 Integral to the use of all fertilisers is the balancing of crop nutrient requirements and available nutrients in the soil. The use of Biosolids as a fertiliser should always be done in accordance with a Nutrient Management Plan (see Paragraphs 6.1 – 6.8).

5.4 To protect both soil and water from pollution by nitrates, maximum rates of Biosolids application must be observed in accordance with the following extract from the Code of Good Agricultural Practice to Protect Waters from Pollution by Nitrates (Department of the Environment and Department of Agriculture, Food and Forestry, 1996).

> In areas supporting high stocking rates and, provided surface and groundwaters are in good condition, i.e. nitrate concentrations do not exceed 20 $mg.l^{-1}$ and there is no evidence of eutrophication caused by nitrates, the maximum quantity of slurry and other organic manure applied to land, including that deposited by the grazing animal, should be such as to ensure that the nitrogen contained therein does not exceed 250 kg per hectare per annum. In all other areas, the nitrogen applied from these organic fertilisers should not exceed 210 kg per hectare per annum. Lower application rates than those indicated should be observed in areas where the County Council indicates that this is necessary because of the nitrate level in waters, or because the phosphorus content of the slurry or other organic manure is causing, or is likely to cause, water pollution.
>
> (Department of the Environment and Department of Agriculture, Food and Forestry, 1996)

5.5 Recommended levels of soil phosphorus have been established by Teagasc for the agronomic requirements of individual crops. Any increase in soil phosphorus above these levels will not result in improved crop yield and may contribute to pollution of surface water. Biosolids should not be applied to land with soil phosphorus concentrations above these levels.

5.6 Biosolids should be applied in conjunction with agronomic levels of soil phosphorus as specified by Teagasc.

Heavy metals

5.7 The fertiliser benefits of Biosolids can best be optimised by restricting the potential application of metals to soils. Therefore limit values are set for:

- the concentration of certain metals in soils (see Appendix 6, Table 1)
- the rates of addition of certain metals to soils (see Appendix 6, Table 2)
- the concentration of lead in Biosolids (see Paragraph 5.8).

These limits must be observed by all Biosolids use programmes.

5.8 The concentration of lead in Biosolids to be surface applied to permanent pasture for grazing should be no greater than 750 $mg.kg^{-1}$ dry solids.

5.9 Because soil pH and clay content are major factors in determining the availability of elements to plants, Biosolids may not be applied to any soil with a pH of less than 5.0 or a clay content of less than 10%. It is also desirable that the pH of soil to which Biosolids has been applied should be maintained above this level.

Hydraulic loading

5.10 Regardless of the Biosolids dilution factor, the maximum hydraulic loading per single application should not exceed the hydraulic capacity of the soil as determined by the Programme of Evaluation and, in general, should not exceed 50 m^3 per hectare.

6. Nutrient Management Planning

6.1 The objective of a Nutrient Management Plan is to balance the application of nutrients with crop requirements while taking account of nutrients already present and available in the soil so as to allow optimum crop growth without adverse environmental impact. Oversupply of nutrients may result in either soil or water pollution and may be detrimental to plant health. Balancing the nutrient requirements of the crop with nutrients in the soil is the key to good agricultural practice.

6.2 Nutrient management planning is the cornerstone of the Biosolids use programme and landspreading of Biosolids on any site must be done in accordance with a Nutrient Management Plan prepared specifically for that site.

6.3 Nutrient Management Plans should be so designed as to take account of all fertilisers being spread, whether produced on or off the farm. If Biosolids is applied to grazing ground, account must be taken of the organic nitrogen load supplied by actively grazing livestock.

6.4 The nutrient content of Biosolids should be based on analysis of the Biosolids product. Typical nutrients contained in Biosolids are provided in Appendix 4. The nutrient status of the soil will be evident from soil analysis and cropping and fertilisation history.

6.5 Crop nutrient requirements are as recommended by Teagasc. When the recommended nutrient requirements of a crop are not met by either Biosolids or other organic fertilisers, the additional nutrients may be obtained from artificial fertiliser.

6.6 Restrictions on the use of Biosolids as specified in Paragraphs 4.1 – 4.6 and 5.1 – 5.10 must be taken account of when drawing up the Nutrient Management Plan.

6.7 A set of Ordnance Survey maps should accompany the Nutrient Management Plan. These maps should be at least as detailed as those of a scale of 1:10,560 and should indicate the location of the landspreading areas and all sensitive features, including dwelling houses and sensitive buildings, watercourses, rock outcrops, buffer zones and sources of water supply on the lands or in their vicinity.

6.8 It may be the case that the customer is also accepting organic waste from a party other than the Biosolids producer. In this event, the Biosolids producer must take responsibility for the production of a Nutrient Management Plan which takes account of the nutrients supplied by all organic fertilisers in question.

7. Best landspreading practices

7.1 The following guidelines for best landspreading practices have been taken into account in the preparation of this Code of Good Practice:

- Code of Practice for Landspreading of Organic Wastes (Teagasc)
- Code of Good Agricultural Practice to Protect Waters from Pollution by Nitrates (Department of the Environment and Department of Agriculture, Food and Forestry, 1996)
- BATNEEC Guidance Note for the Pig Production Sector (EPA, 1996)
- Draft Code of Practice for Protection of Groundwater from the Landspreading of Organic Wastes (EPA/GSI, 1997).

Recommendations contained in these guidelines have been drawn up taking account of agronomic considerations, prevention of water pollution and minimisation of nuisance and should be followed at all times.

7.2 Landspreading of Biosolids should be carried out as early as practicable in the growing season so as to maximise the uptake of nutrients by crops and minimise pollution risks. As a general practice, Biosolids applications to land should be avoided during the non-growing season which varies throughout the country, depending on local climatic conditions, between the months of October and February.

Exceptions to this general rule are permitted where the Nutrient Management Plan (see Paragraph 6.1 above) establishes that landspreading of Biosolids can be carried out during this period in accordance with the Code of Good Practice without risk of causing water pollution or where exceptional weather conditions arise.

7.3 In general, Biosolids should not be spread on ground without an active crop cover. However, it may be spread on fallow land prior to sowing, provided the Biosolids is immediately incorporated into the soil.

7.4 In general, Biosolids should not be applied to land which:

- has a shallow depth to bedrock
- has gravel or cracked soil overlying pipe or mole drains
- has a surface gradient of greater than 11%
- is prone to flooding.

7.5 Spreading in unsuitable weather conditions can cause loss of nutrients to both surface and ground water. Avoid spreading Biosolids if heavy rain is forecast within 48 hours. Do not apply Biosolids to:

- waterlogged land
- frozen or snow-covered land
- free-draining sites where the water table is within 1 metre of the land surface at the time of application.

7.6 The following buffer strips must be observed when landspreading Biosolids:

	Buffer zone (m)
Sensitive buildings (hospitals, schools and churches)	200
Dwelling houses[1]	100
Karst features	30
Lakes and main river channels[1]	20
Small watercourses[1]	10
Public roads[1]	10
Domestic wells[1]	50
Public water supplies[1, 2]	50 – 300

[1] Specified distances to be increased if the gradient is greater than 6%.
[2] The appropriate distance depends on vulnerability and direction of groundwater flow.

7.7 When landspreading, the Biosolids producer should take account of any factors which may improve the public acceptability of the Biosolids use programme. Ultimately, the success of the Biosolids use programme will depend on the public image which Biosolids has developed as a fertiliser.

part five

Maintaining the quality of the Biosolids product

1. Monitoring and Recording

General

1.1 A regulated programme of monitoring complemented by comprehensive record-keeping is essential to guaranteeing the traceability of the Biosolids production process and the quality of the Biosolids product. The results of monitoring as indicated in Paragraphs 1.2 – 1.14 and as summarised in Appendix 7 must be recorded as recommended in Paragraphs 1.15 – 1.25. A copy of all such records should be kept at the Biosolids production plant site office for at least a 10-year period and should be made available on request.

Monitoring of the Biosolids treatment process

1.2 Regular monitoring of all significant process parameters specified in Appendix 7, Table 1, will ensure the Biosolids product is receiving a consistently adequate standard of treatment. Process parameters should be measured and recorded.

Microbiological monitoring

1.3 The absence of certain microorganisms will also indicate the quality of the Biosolids product. Microbiological analysis of both liquid and dewatered Biosolids should be carried out at the sampling frequencies and by the methods specified in Appendix 7, Tables 2 and 4 respectively.

1.4 Samples for microbiological analysis should be representative of the Biosolids product and taken at random, with the minimum of delay between sampling and analysis.

Monitoring of Biosolids quality

1.5 The Biosolids product must be analysed for the range of parameters specified in Appendix 7, Table 1, as frequently as indicated in Appendix 7, Table 2. Analysis of Biosolids should be performed only by approved laboratories. Recommended methods for analysis of each parameter are listed in Appendix 7, Table 4.

1.6 The Biosolids product must be analysed for the micropollutants specified in Appendix 7, Table 1 at the beginning of the Biosolids use programme and at least as often thereafter as is indicated in Appendix 7, Table 2. Recommended methods for analysis of each micropollutant are listed in Appendix 7, Table 4.

part five

1.7 It may be necessary to increase the range and frequency of Biosolids analysis in the event of a new discharge to or any other change in the wastewater stream which might change the character of the Biosolids.

1.8 In the case of a wastewater treatment plant which does not receive industrial discharges, the Biosolids quality may be relatively constant over time. If, having monitored the Biosolids quality over a period of two years, the Biosolids producer does not observe any significant changes in the parameters specified in Appendix 7, Table 1, the frequency of Biosolids analysis may be reduced as indicated in Appendix 7, Table 2.

1.9 Biosolids samples taken for analysis must be representative of the Biosolids product, particularly in respect of solids concentration. Samples from Biosolids of both a low and high solids content must be composites of daily samples taken over a period of at least one week. Whether the Biosolids is of a low or high solids content, in the case of samples taken for microbial analysis, recommendations in Paragraph 1.4 should be followed.

Soil monitoring

1.10 For the purposes of nutrient management planning, shallow soil samples must be analysed for pH, phosphorus and potassium at least once every three years. These should be composite samples taken at least every 2 – 4 hectares and to a depth of 10 cm. However, where soil types are similar and cropping and treatment of the land were unchanged during the previous 5 years or more, a composite sample from an area of up to 12 hectares is acceptable.

1.11 Soil must be analysed for heavy metal concentrations at the beginning of the Biosolids use programme and not less than once every five years thereafter. One deep soil sample must be taken at least every five hectares to a depth of 25 cm, where practicable, and should be a composite sample representative of the entire five hectares.

1.12 It may be necessary to take and analyse deep soil samples more frequently should the most recent deep soil sample indicate that the cumulative soil metal loadings are approaching maximum permissible limits (see Appendix 6, Table 1) or if modelling predicts that these maximum permissible cumulative limits may be exceeded during the following five years.

1.13 All soil samples should be taken in accordance with Teagasc guidelines. Analysis of soil nutrient, metal and micropollutant levels should be done by the methods specified in Appendix 7, Table 5 and should be carried out only by an approved laboratory.

1.14 Where possible, arrangements should be made for keeping records of all deep soil sample analyses for a period of at least 30 years. This will assist evaluation of long-term trends.

Certificate of Analysis

1.15 Results of the Biosolids analysis should be presented in a Certificate of Analysis as described in Part 2, Paragraphs 2.7 – 2.9. This Certificate should indicate the date on which the sample was taken, the origin of the sludge from which the Biosolids was produced and analysis of the parameters specified in Appendix 7, Table 1.

1.16 Where possible, arrangements should be made for keeping copies of all Certificates of Analysis for a period of at least 30 years. This will assist evaluation of long-term trends.

Landspreading agreements

1.17 When the customer wishes to use Biosolids as a fertiliser and the land and crop in question are suitable for Biosolids application, the Biosolids producer must request the customer to sign a landspreading agreement.

1.18 The landspreading agreement indicates that the Programme of Evaluation has been completed and that both the customer and the Biosolids producer are in agreement that the customer's land may be fertilised with Biosolids when spreading conditions permit.

Nutrient management planning

1.19 Nutrient management plans should be revised every year, taking account of the most recent Certificate of Analysis, soil testing results, crop type and any other relevant changes.

Integrity of storage

1.20 It will be necessary to check the integrity of storage tanks which have been constructed for a period of 10 years or longer. This must be done by a qualified engineer once every five years. The tanks may not continue to be used unless they are certified as structurally sound.

Recording the movement of Biosolids

1.21 Every shipment of Biosolids off site must be recorded in a log book at the Biosolids production plant site office. The log book should contain details of:

- date of drawing
- volume drawn
- identification of Biosolids transporter
- destination (i.e. name and address of receiving customer)
- identification of site to which Biosolids is applied
- identification of spreader, if different from transporter
- where deposited, if not spread.

1.22 Where possible, arrangements should be made for keeping all log book records for a period of at least 30 years. This will assist evaluation of long-term trends.

Certificate of Acceptance/Certificate of Spreading

1.23 It is most important that the destination of every load of Biosolids transported from the wastewater treatment plant is confirmed. On delivery of the Biosolids product, the customer must sign:

- a Receipt of Acceptance, where the Biosolids is stored in the customer's holding tank, or
- a Receipt of Spreading, where the Biosolids is applied to the customer's land.

Public relations

1.24 As good public relations are fundamental to the success of the Biosolids use programme, it is good practice to maintain a log book in which liaison with the public, whether customers or otherwise, are recorded. In the case of customers, the entries may include dates and details of agronomic advice given or of visits paid by the customer to the Biosolids producer. For the general public, the entries may record any query or comment made to either the Biosolids producer or the customer in relation to the Biosolids use programme.

Mandatory reporting

1.25 Under Directive 86/278/EEC on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture, the government is required to submit a consolidated report on the Biosolids use programme to the European Commission once every four years.

2. Control

Industrial discharges

2.1 Industry may use the municipal sewerage system for discharge of trade effluents. Any such industry must comply with effluent discharge requirements for the heavy metals and organic micropollutants listed in Appendix 7, Table 1 and for any other potential contaminant of Biosolids as required by the Local Authority or the Environmental Protection Agency.

2.2 Any industry discharging trade effluent to the municipal sewerage system should carry out analyses of this effluent at least every six months or as frequently as requested by the Local Authority or the Environmental Protection Agency.

2.3 Where the concentration of a potential contaminant of Biosolids is so high as to hinder the sustainability of the Biosolids use programme, the industry in question must be requested to reduce the concentration of the contaminant to an acceptable level before discharge.

3. Future developments

General

3.1 The sustainability of the Biosolids use programme can be guaranteed only by continued efforts to improve the quality and management of the Biosolids product.

3.2 The quality of Biosolids is dependent on the quality of the wastewater stream and hence, monitoring and improving the quality of effluent discharges to the sewerage system must be one of the primary objectives of the Biosolids use programme.

3.3 The higher the biochemical oxygen demand of the wastewater stream, the greater the volume of sludge generated by wastewater treatment and the greater the volume of Biosolids produced. High nutrient loadings may require tertiary treatment of the wastewater stream, further increasing the volume of Biosolids generated. Smaller volumes of Biosolids can be managed more easily and to a higher standard than can larger volumes. This provides an additional incentive to improving the quality of effluent discharges to the sewerage system.

Design of sewerage systems

3.4 Sewerage systems should be designed with a view to preventing avoidable contamination of Biosolids. This includes consideration of separate sewerage systems and minimisation of entry to the sewerage system of rainwater runoff from roads.

Industrial discharges

3.5 Before a licence to discharge to a sewer is granted to an industry, it is essential to ensure that the new trade effluent is properly assessed for its potential impact on the quality of the Biosolids and that any necessary conditions are applied before discharge is permitted.

3.6 The Integrated Pollution Control Licensing system may allow significant potential for an effective programme of continual reduction of contaminant discharges from industry. A full mass-balance of process inputs and outputs can highlight the eventual destination of trade effluent constituents.

3.7 From time to time, the Minister and/or the Local Authority may consider it necessary to establish standards for the parameters listed in Appendix 7, Table 1 and for any other relevant parameters in trade effluents discharging to the municipal sewerage system.

Domestic discharges

3.8 Some domestic products contain heavy metals or other contaminants which may impact adversely on the quality of Biosolids. Where there is a potential for such adverse impact, the Local Authority should encourage the use of suitable alternatives to such products. Alternatively, it may urge the manufacturer of these products to reduce the concentration of such contaminants and/or to investigate the possibility of their substitution.

3.9 It is important to ensure that any substances introduced as substitutes have been assessed for their effects on the environment and on human health and have been found to be both biodegradable and safe.

Additional parameter control

3.10 Over many years and in all areas of environmental management, scientific research has focused on a priority list of substances of potential concern. The purpose of this research is to generate data which are used, as appropriate, either to dispel concern or to amend environmental management programmes. Once sufficient data have been gathered on one substance, priority research moves on to the next candidate on the list.

The same approach has also been taken with research into the beneficial use of Biosolids. An example of a group of substances which has received extensive study in the past is heavy metals. As a result of data generated, Biosolids use programmes worldwide include controls on the permissible increase in soil metal concentrations due to application of Biosolids. An example of a group of substances under current study is the detergent group. In acknowledgement of this research, this Code of Good Practice requires monitoring of nonylphenol (See Appendix 7, Table 1) in both Biosolids and soil.

In addition to those parameters specified in Appendix 7, the levels of certain other substances in sludge and Biosolids should also be measured from time to time. The selection of appropriate parameters should reflect current national or international priorities. Data generated should be appropriate to a full environmental analysis of the potential impact of the substances in question on soil, plant, animal and human health.

Continuous programme assessment

3.11 Comprehensive records developed over the life of the Biosolids use programme will allow invaluable long-term assessment of the soil-plant-Biosolids relationship. Monitoring of trends in this relationship, either by the Biosolids producer or by an educational or scientific institution, should form the basis for regular review of the scientific data from which the guidelines in this Code of Good Practice were developed.

Remember

- The quality of Biosolids depends on the quality of the wastewater stream

appendix 1

Glossary

Aerobic	In the presence of oxygen.
Anaerobic	In the absence of oxygen.
Heavy metal	A term used to describe metals with a high atomic mass, some of which can be harmful to ecological and human health.
MPN	Most Probable Number
Municipal	Pertaining to the urban situation.
Organic micropollutants	A term used to describe a huge number of compounds which are discharged into the sewerage system with wastewater from homes, industries, storm sewers, etc. Several of these have been singled out for monitoring and regulation in Biosolids on the basis of their rate of occurrence and potential hazard to human health and to the environment.
p.e.	Population equivalent 1 p.e. is the organic biodegradable load having a 5-day biochemical oxygen demand of 60 g of oxygen per day.
Precautionary principle	A principle enshrined in Agenda 21, the declaration of the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, 1992, which reflects our incomplete knowledge of ecosystems.
Wastewater sludge	Sludge arising from the process of wastewater treatment.

appendix 2

Relevant legislation

Legislation with which this Code of Good Practice complies

Council Directive 76/464/EEC on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community,
- adopted by the Local Government (Water Pollution) Act, 1977
  the Local Government (Water Pollution) Amendment Act, 1990
  Statutory Instrument No. 245 of 1994

Council Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances
- adopted by the Local Government (Water Pollution) Act, 1977
  Statutory Instrument No. 108 of 1978
  Statutory Instrument No. 390 of 1979
  Statutory Instrument No. 33 of 1982
  the Local Government (Water Pollution) Amendment Act, 1990
  Statutory Instrument No. 245 of 1994
  the Waste Management Act, 1996

Council Directive 86/278/EEC on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture,
- adopted by Statutory Instrument No. 183 of 1991
  the Waste Management Act, 1996

Council Directive 91/271/EEC concerning urban waste water treatment,
- adopted by Statutory Instrument No. 419 of 1994

Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agriculture

Legislation taken into account in the preparation of this Code of Good Practice

Council Directive 78/659/EEC on the quality of fresh waters needing protection or improvement in order to support fish life,
- adopted by the Local Government (Water Pollution) Act, 1977
  Statutory Instrument No. 293 of 1988

Council Directive 83/513/EEC on cadmium discharges to the aquatic environment
- adopted by Statutory Instrument No. 294 of 1985

Council Resolution 88/C 30/01 on a community action programme to combat environmental pollution by cadmium

Council Resolution 97/C 321/01 on the drafting, implementation and enforcement of Community environmental law

appendix 3

Recommended treatment processes for Biosolids production

Table 1
Recommended Treatment Process Conditions for Production of Biosolids

Process	Description
Mesophilic anaerobic digestion with pre- or post- pasteurisation	Mean retention period of at least 12 days primary digestion in temperature range 35° +/- 3°C or of at least 20 days primary digestion in temperature range 25°C +/- 3°C. Pasteurisation phase must achieve a retention period of at least 1 hour at a temperature ≥ 70°C or 2 hours at a temperature ≥ 55°C.
Thermophilic anaerobic digestion	Mean retention period of at least 48 – 72 hours in temperature range 50 – 55°C. Must include a retention period of at least 1 hour at a temperature greater than 70°C followed by a minimum retention period of at least 2 hours at a temperature ≥ 55°C or of at least 4 hours at a temperature ≥ 50°C.
Thermophilic aerobic digestion	Mean retention period of at least 7 days. All sludge to be subject to a temperature ≥ 55°C for at least 4 hours. Must achieve a reduction in volatile solids of ≥ 38%.
Composting: 1. Windrows 2. Static pile or in-vessel	 To be held at 55°C for at least 15 days, during which time a temperature of ≥ 55°C must be maintained over 5 turnings of the windrow. A temperature of ≥ 55°C must be achieved and maintained uniformly for at least 3 days.
Alkaline stabilisation	1. Addition of lime to raise pH to greater than 12.0 with an accompanying rise in temperature to 70°C for 30 minutes. 2. Addition of lime to raise pH to greater than 12.0 and to maintain the pH above 12 for 72 hours and to achieve a temperature ≥ 52°C for at least 12 hours. At the end of the 72 hour period, air dry to a dry solid content of ≥ 50%.
Thermal drying	Drying by direct or indirect contact with hot gases. Moisture content of the dried Biosolids to be ≤ 10%. Either the temperature of the Biosolids > 80°C or the wet bulb temperature of the gas in contact with the Biosolids as the Biosolids leaves the drier > 80°C.

appendix 4

Composition and fertiliser value of Biosolids

Table 1
Composition of Irish Wastewater Sludges
(Note: These are untreated sludges. Nitrogen and phosphorus composition may change with treatment. Heavy metal content will remain unchanged.)

		Range	Mean	Number of samples
Dry solids[1]	%	1 – 65	22	20
Nitrogen[1]	mg/kg DS[3]	8.5 – 58100	27558	12
Phosphorus[1]	mg/kg DS	1.5 – 21100	10386	13
Potassium[1]	mg/kg DS	0.7 – 89,600	31467	3
Magnesium[1]	mg/kg DS	--	0.4	2
Copper[1]	mg/kg DS	25 – 2,481	641	24
Nickel[1]	mg/kg DS	2.6 – 389	54	24
Iron[1]	mg/kg DS	1,200 – 96,075	20,190	7
Zinc[1]	mg/kg DS	32 – 2070	562	25
Cadmium[1]	mg/kg DS	0.1 – 13.6	2.8	22
Chromium[1]	mg/kg DS	28 – 509	165	4
Lead[1]	mg/kg DS	8.1 – 850	150	24
Mercury[1]	mg/kg DS	0.1 – 2.0	0.6	4
Manganese[2]	mg/kg DS	65 – 3,018	340	N/A
Boron[2]	mg/kg DS	19 - 236	72	N/A
Cobalt[2]	mg/kg DS	1 – 48	14	N/A

[1] Samples from 25 Irish wastewater treatment plants taken for the *Strategy Study on Options for the Treatment and Disposal of Sewage Sludge in Ireland* (Weston-FTA, 1993). The smallest wastewater treatment plant in this survey served a population of 350; the largest served a population of 29,527.

[2] 200 samples from 45 Irish wastewater treatment plants published in O'Riordan , E.G., Dodd, V.A., Tunney, H. and Fleming, G.A. (1986), "The chemical composition of Irish sewage sludges". In the *Irish Journal of Agricultural Research*, No. 25.

[3] DS = dry solids

Table 2
Total and Available Phosphorus in Biosolids produced by Various Recommended Treatment Processes

Biosolids type	% DS[1]	Total P applied	Available P (1st cropping year)
Digested low-solids	4	3% of DS = 1.2 kg/tonne	60% of total P = 0.7 kg/ tonne
Digested high-solids	25	3.5% of DS = 8.8 kg/tonne	35 – 50% of total P = 3.0 – 4.4 kg/tonne
Composted[2]	65	1.0% of DS = 6.5 kg/tonne	20% of total P = 1.3 kg/tonne
Lime stabilised	60	0.4% of DS = 2.4 kg/tonne	46% of total P = 1.1 kg/tonne
Thermally dried	94	3.7% of DS = 34.8 kg/tonne	9 – 50% of total P = 3.1 – 17.4 kg/tonne

[1] DS = dry solids

[2] Wood chips used as bulking agent

Table 3
Total and Available Nitrogen in Biosolids produced by Various Recommended Treatment Processes

Biosolids type	% DS[1]	Total N applied	Available N (1st cropping year)
Digested low-solids	4	5% of DS = 2.0 kg/tonne	60% of total N = 1.2 kg/ tonne
Digested high-solids	25	3.0% of DS = 7.5 kg/tonne	15% of total N = 1.1 kg/tonne
Composted[2]	65	1.6% of DS = 10.4 kg/tonne	10% of total N[3] = 1.0 kg/tonne
Lime stabilised	60	0.7% of DS = 4.2 kg/tonne	15% of total N = 0.6 kg/tonne
Thermally dried	94	3.7% of DS = 34.8 kg/tonne	20% of total N = 7.0 kg/tonne

[1] DS = dry solids

[2] Wood chips used as bulking agent

[3] Ammonium-N only

appendix 5

Planting, harvesting and grazing constraints

Table 1
Planting, harvesting and grazing constraints to be observed when using Biosolids as a fertiliser

Crops to which Biosolids can be applied while growing	Crops to which Biosolids can be applied prior to sowing/setting
Cereals	Cereals
Oil seed rape	Oil seed rape
Grass[1]	Grass
Forestry[2]	Sugar beet
	Animal fodder[1]
	Forestry[2]

1 No harvesting or grazing until at least 3 weeks after application.

2 Not to be applied to upland forestry.

appendix 6

Limits to heavy metal application

Table 1
Maximum permissible concentrations of certain heavy metals in soil

Metal	Maximum permissible concentration (mg/kg dry solids)	
	pH 5.0 – 6.0 and/or clay content 10 – 15%	pH > 6.0 and clay content > 15%
Zinc	100	150
Cadmium	1.0	1.5
Nickel	50	80
	For pH > 5.0 and clay content ≥ 15%	
Copper	80	
Lead	80	
Mercury	1	
Chromium	100	

Table 2
Maximum permissible annual average rates of addition of certain heavy metals to soils over a 10-year period

Metal	Maximum permissible average annual rate of addition of metal over a 10-year period (kg/hectare/year)
Zinc	7.5
Cadmium	0.05
Nickel	3.0
Copper	7.5
Lead	4.0
Mercury	0.1
Chromium	3.5

Table 3
Typical maximum permissible number of applications of Biosolids as determined by soil metal concentrations

		Cd	Cu	Ni	Pb	Zn	Cr
Case 1: Biosolids @ 2% DS; 2.8% N; 1% P							
Concentration in Biosolids	(mg/kg DS)	2.8	641	54	150	562	165
Background level in soil[1]	(mg/kg soil)	0.61	21	24.8	24.2	71.8	46.6
Amount in Biosolids application of 50 t/ha	(kg/ha)	0.003	0.64	0.05	0.15	0.56	0.17
Total concentration in 25 cm soil sample in year 1	(mg/kg soil)	0.61	21.2	24.8	24.2	72.0	46.7
Permissible number of applications at 50 t/ha[2]		452	299	1516	1209	163	1051
Case 2: Biosolids @ 6% DS; 2.8% N; 1% P							
Concentration in Biosolids	(mg/kg DS)	2.8	641	54	150	562	165
Background level in soil[1]	(mg/kg soil)	0.61	21	24.8	24.2	71.8	46.6
Amount in Biosolids application of 50 t/ha	(kg/ha)	0.008	1.9	0.16	0.45	1.69	0.5
Total concentration in 25 cm soil sample in year 1	(mg/kg soil)	0.61	21.6	24.9	24.3	72.3	46.8
Permissible number of applications at 50 t/ha[2]		150	99	505	403	54	350
Case 3: Biosolids @ 25% DS; 2.8% N; 1% P							
Concentration in Biosolids	(mg/kg DS)	2.8	641	54	150	562	165
Background level in soil[1]	(mg/kg soil)	0.61	21	24.8	24.2	71.8	46.6
Amount in Biosolids application of 50 t/ha	(kg/ha)	0.025	5.77	0.49	1.35	5.06	1.49
Total concentration in 25 cm soil sample in year 1	(mg/kg soil)	0.62	22.8	25.0	24.6	73.6	47.1
Permissible number of applications at 50 t/ha[2]		50	33	168	134	18	116

[1] Average background metal concentrations in Irish agricultural soils

[2] Assuming no loss or dissipation of metal during spreadland lifetime

appendix 7

Monitoring requirements

Table 1
Parameters to be included in Certificate of Analysis of Biosolids

Parameter	Units of measurement
Dry solids	(%)
Organic matter	(TOC as % of dry solids)
pH	
Total nitrogen	(% dry solids)
Ammonium-nitrogen	(% dry solids)
Total phosphorus	(% dry solids)
Total potassium	(% dry solids)
Faecal coliform	(MPN.g^{-1} dry solids)
Salmonella sp.	(MPN.g^{-1} dry solids)
Zinc	(mg.kg^{-1} dry solids)
Copper	(mg.kg^{-1} dry solids)
Nickel	(mg.kg^{-1} dry solids)
Cadmium	(mg.kg^{-1} dry solids)
Lead	(mg.kg^{-1} dry solids)
Mercury	(mg.kg^{-1} dry solids)
Chromium	(mg.kg^{-1} dry solids)
Polychlorinated biphenyls (PCB)	(mg.kg^{-1} dry solids)
Polychlorinated dibenzodioxins/dibenzofurans (PCDD/F)	(ng TEQ.kg^{-1} dry solids)
Polyaromatic Hydrocarbons (PAH)	(mg.kg^{-1} dry solids)
Nonylphenol	(mg.kg^{-1} dry solids)

Table 2
Minimum Frequency of Analysis of Certain Parameters required to be Monitored in Biosolids

Parameter	Frequency of analysis[1]		
	< 50,000 p.e.	50,000 – 100,000 p.e.	> 100,000 p.e.
pH	Every 12 months[2]	Every 12 months	Every 6 months
Total nitrogen	Every 12 months[2]	Every 12 months	Every 6 months
Ammonium-nitrogen	Every 12 months[2]	Every 12 months	Every 6 months
Total phosphorus	Every 12 months[2]	Every 12 months	Every 6 months
Total potassium	Every 12 months[2]	Every 12 months	Every 6 months
Faecal coliform	Every week	Every week	Every week
Salmonella sp.	Every week	Every week	Every week
Zinc	Every 12 months[2]	Every 12 months	Every 6 months
Copper	Every 12 months[2]	Every 12 months	Every 6 months
Nickel	Every 12 months[2]	Every 12 months	Every 6 months
Cadmium	Every 12 months[2]	Every 12 months	Every 6 months
Lead	Every 12 months[2]	Every 12 months	Every 6 months
Mercury	Every 12 months[2]	Every 12 months	Every 6 months
Chromium	Every 12 months[2]	Every 12 months	Every 6 months

continued ...

Table 2 … continued
Minimum Frequency of Analysis of Certain Parameters required to be Monitored in Biosolids

Parameter	Frequency of analysis[1]		
	< 50,000 p.e.	50,000 – 100,000 p.e.	> 100,000 p.e.
Polychlorinated biphenyls (PCB)	Every 5 years	Every 2 years[3]	Every 12 months
Polychlorinated dibenzodioxins/dibenzofurans (PCDD/F)	Every 5 years	Every 2 years[3]	Every 12 months
Polyaromatic Hydrocarbons (PAH)	Every 5 years	Every 2 years[3]	Every 12 months
Nonylphenol	Every 5 years	Every 2 years[3]	Every 12 months

[1] To be analysed more frequently if there is a significant change in the quality of the wastewater stream.

[2] Can be reduced to every 2 years for a wastewater treatment plant into which industry does not discharge and if no significant changes are observed in the parameter values over a period of 2 years.

[3] Can be reduced to every 5 years for a wastewater treatment plant into which industry does not discharge. Should be analysed more frequently if there is a significant change in the quality of the wastewater stream.

Table 3
Minimum Frequency of Soil Sampling and Analysis

Parameter	Depth of sample (cm)	Frequency
Organic matter	10	Every 2 years
pH	10	Every 2 years
Clay content	10	Every 2 years
Total phosphorus	10	Every 2 years
Total potassium	10	Every 2 years
Zinc	25	Every 5 years
Copper	25	Every 5 years
Nickel	25	Every 5 years
Cadmium	25	Every 5 years
Lead	25	Every 5 years
Mercury	25	Every 5 years
Chromium	25	Every 5 years
Polychlorinated biphenyls (PCB)	25	Every 5 years
Polychlorinated dibenzodioxins/dibenzofurans (PCDD/F)	25	Every 5 years
Polyaromatic Hydrocarbons (PAH)	25	Every 5 years

Table 4
Recommended Analytical Methodology to be used for Parameters to be Monitored in Biosolids

Parameter	Standard Test Number[1]	Analytical methods
Dry solids	Standard Methods 2540B	Total solids dried at 103 – 105°C
Organic matter	Standard Methods 5310B	Combustion-Infrared Method
	BS Method	Gravimetric Analysis
pH	Standard Methods 4500-H^+	pH metre
Total nitrogen		Digestion with sulphuric acid and hydrogen peroxide followed by distillation
	BS Method	Colorimetric analysis
Ammonium-nitrogen	BS Method	Digestion and Colorimetric Analysis
Total phosphorus	Standard Methods 4500-P	Digestion and Colorimetric Analysis
Total potassium	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
Faecal coliform	Standard Methods 9221E or 9222D	Faecal Coliform Procedure: Multiple Tube or Membrane Filter
Salmonella sp.	Standard Methods 9260D	Quantitative *Salmonella* Procedures
Zinc	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
Copper	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
Nickel	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method

continued ...

Table 4 ... continued
Recommended Analytical Methodology to be used for Parameters to be Monitored in Biosolids

Parameter	Standard Test Number	Analytical methods
Cadmium	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
	Standard Methods 3030D and 3113B[2]	Electrothermal Atomic Absorption Spectrometry
Lead	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
Chromium	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
Mercury	Standard Methods 3112	Cold Vapour Atomic Absorption
Polychlorinated biphenyls (PCB)	Standard Methods 6630C	Liquid-Liquid Extraction Gas Chromatography
Polychlorinated dibenzodioxins/dibenzofurans (PCDD/F)	Standard Methods 6630B	Liquid-Liquid Extraction Gas Chromatography
Polyaromatic hydrocarbons (PAH)	Standard Methods 6640B	Liquid-Liquid Extraction Chromatography
Nonylphenol	Standard Methods 5530B and C	Cleanup and Chloroform Extraction

[1] As specified by *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association, American Water Works Association and Water Environment Federation), unless otherwise indicated.

[2] Used for measuring cadmium at very low concentrations only (< 1mg.kg^{-1}).

Table 5
Recommended Analytical Methodology to be used for Parameters to be Monitored in Soil

Parameter	Test Number[1]	Analytical methods
Dry solids	Standard Methods 2540B	Total solids dried at 103 – 105°C
pH	Standard Methods 4500-H^+	pH metre
Clay content	BS 1377, 1990, Part 2	Hydrometer Method
Total phosphorus	Standard Methods 4500-P	Digestion and Colorimetric Analysis
Total potassium	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
Zinc	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
Copper	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
Nickel	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
Cadmium	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
	Standard Methods 3030D and 3113B	Electrothermal Atomic Absorption Spectrometry[1]
Lead	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method
Chromium	Standard Methods 3030D and 3111 or 3120B	Acid Digestion and Flame Atomic Adsorption Spectrometry or Inductively Coupled Plasma Method

continued ...

Table 5 … continued
Recommended Analytical Methodology to be used for Parameters to be Monitored in Soil

Parameter	Test Number[1]	Analytical methods
Mercury	Standard Methods 3112	Cold Vapour Atomic Absorption
Polychlorinated biphenyls (PCB)	Standard Methods 6630C	Liquid-Liquid Extraction Gas Chromatography
Polychlorinated dibenzodioxins/dibenzofurans (PCDD/F)	Standard Methods 6630B	Liquid-Liquid Extraction Gas Chromatography
Polyaromatic hydrocarbons (PAH)	Standard Methods 6640B	Liquid-Liquid Extraction Chromatography

[1] As specified by *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association, American Water Works Association and Water Environment Federation), unless otherwise indicated.

[2] Used for measuring cadmium at very low concentrations only (< $1 mg.kg^{-1}$).