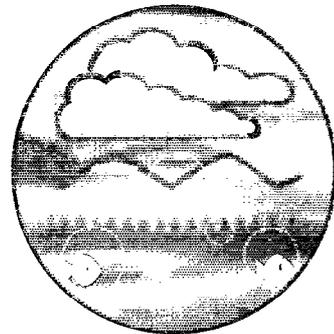
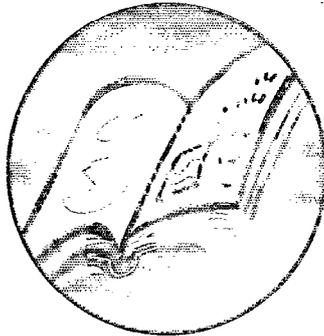
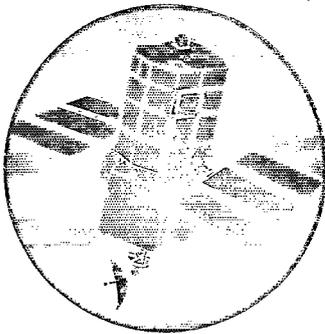


UK Sewage Sludge Survey Regional Presentation



Research and Development

Project Record
P2/065/1



ENVIRONMENT AGENCY



All pulps used in production of this paper is sourced from sustainable managed forests and are elemental chlorine free and wood free

UK Sewage Sludge - Regional Presentation

R&D Project Record P2/065/1

A Gendebien, C Carlton-Smith, M Izzo and J E Hall

Research Contractor:

WRc plc

Further copies of this report are available from:
Environment Agency R&D Dissemination Centre, c/o
WRc, Frankland Road, Swindon, Wilts SN5 8YF



tel: 01793-865000 · fax: 01793-514562 · e-mail: publications@wrcplc.co.uk

Publishing Organisation:

Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol BS32 4UD

Tel: 01454 624400

Fax: 01454 624409

HO-06/98-B-BCPR

© Environment Agency 1999

All rights reserved. No part of this document may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior permission of the Environment Agency.

The views expressed in this document are not necessarily those of the Environment Agency. Its officers, servant or agents accept no liability whatsoever for any loss or damage arising from the interpretation or use of the information, or reliance upon views contained herein.

Dissemination status

Internal: Released to Regions
External: Released to the Public Domain

Statement of use

This report summarises the findings of the UK Sewage Sludge Survey. The report will provide Environment Agency staff and others with information relating to the current and future status of sludge production recycling and disposal in the UK.

Research contractor

This document was produced under R&D Project P2-065 by:

WRc plc
Henley Road
Medmenham
Marlow
Buckinghamshire
SL7 2HD

Tel: 01494 636500 Fax: 01491 636501

WRc Report No.: EA 4574/1

Environment Agency Project Leader

The Environment Agency's Project Leader for R&D Project P2-065 was:
Dr Nina Sweet - Environment Agency, Head Office

FOREWORD

This Project Record is the companion volume to R&D Technical Report P165 on the UK sewage sludge survey based on the year 1996/7. TR P165 presents the results of the survey on a national basis whilst this Project Record supplies more detail by including information on sewage sludge production, treatment and disposal for each water company in England and Wales, each region in Scotland, and for Northern Ireland.

CONTENTS	Page
FOREWORD	i
LIST OF TABLES	iv
LIST OF FIGURES	xiii
EXECUTIVE SUMMARY	1
KEY WORDS	4
1. INTRODUCTION	5
2. CURRENT AND FUTURE SLUDGE PRODUCTION, RECYCLING AND DISPOSAL	7
2.1 Water Companies in England and Wales	7
2.2 Scottish Authorities	8
2.3 Northern Ireland	9
3. TREATMENT OF SLUDGE USED IN AGRICULTURE	17
3.1 Water Companies in England and Wales	17
3.2 Scottish Water Authorities	20
3.3 Northern Ireland Divisions	20
4. QUALITY OF SEWAGE SLUDGE	25
4.1 England and Wales	25
4.2 Scotland	25
4.3 Northern Ireland	25
5. AGRICULTURAL APPLICATION AND SOIL QUALITY	31
5.1 Water companies in England and Wales	31
5.2 Scottish Authorities	35
5.3 Northern Ireland	36
REFERENCES	39

APPENDICES

APPENDIX A	SURVEY DATA FOR EACH LOCAL REGION: ENGLAND AND WALES	41
APPENDIX B	SURVEY DATA FOR EACH LOCAL REGION: SCOTLAND	101
APPENDIX C	NORTHERN IRELAND	121
APPENDIX D	SUMMARY OF DATA AVAILABLE	129

LIST OF TABLES

Table 2.1	Total annual quantity of sludge disposed of to different outlets in the year of the survey (1996/7) in England and Wales	10
Table 2.2	Total annual quantity of sludge disposed of to different outlets in the year of the survey (1996/7) in Scotland	11
Table 2.3	Total annual quantity of sludge disposed of to different outlets in the year of the survey (1996/7) in Northern Ireland	11
Table 2.4	Annual sludge production per works size in England and Wales (1996/7)	12
Table 2.5	Annual sludge production per works size in Scotland (1996/7)	13
Table 2.6	Annual sludge production per works size in Northern Ireland (1996/7)	13
Table 2.7	Predicted sludge production and disposal in 2005 for England and Wales	14
Table 2.8	Predicted sludge production and disposal in 2005 in Scotland	14
Table 2.9	Predicted sludge production and disposal in 2005 in Northern Ireland	15
Table 3.1	Treatment of sludge (%) recycled in agriculture in England and Wales (1996/7)	17
Table 3.2	Treatment applied to liquid sludge recycled in agriculture in England and Wales (1996/7)	19
Table 3.3	Treatment applied to dewatered sludge recycled in agriculture in England and Wales (1996/7)	19
Table 3.4	Future trends (by 2005/6) in treatment of sludge used in agriculture in England and Wales (%)	21
Table 3.5	Treatment of sludge (%) recycled in agriculture in Scotland (1996/7)	22
Table 3.6	Treatment applied to liquid sludge recycled in agriculture in Scotland (1996/7)	22

Table 3.7	Treatment applied to dewatered sludge used in agriculture in Scotland (1996/7)	23
Table 3.8	Future trends (by 2005/6) in treatment of sludge used in agriculture in Scotland (%)	23
Table 3.9	Treatment of sludge (%) in Northern Ireland (1996/7)	24
Table 3.10	Treatment of sludge used in agriculture in Northern Ireland (1996/7)	24
Table 3.11	Future trends (by 2005/6) in treatment of sludge used in agriculture in Northern Ireland (%)	24
Table 4.1	Quality of sludge in England and Wales for main outlets	26
Table 4.2	Quality of sludge used in agriculture in 1996/7 in England and Wales	27
Table 4.3	Quality of sludge in Scotland for main outlets	27
Table 4.4	Quality of sludge used in agriculture in Scotland in 1996/7	28
Table 4.5	Quality of sludge in Northern Ireland for main outlets in 1996/7	28
Table 4.6	Quality of sludge used in agriculture in 1996/7 in Northern Ireland	29
Table 5.1	Area of agricultural land utilised for sewage sludge recycling in England and Wales 1996/97	32
Table 5.2	Utilisation of sludge application method (% of area receiving sludge)	32
Table 5.3	Spreading method by land use in England and Wales (%)	34
Table 5.4	Average application rate by application method and land use in England and Wales (tds ha^{-1})	34
Table 5.5	Land use for sludge recycling in Scotland (1996/7)	35
Table 5.6	Spreading method by land use in Scotland (%)	35
Table 5.7	Mean application rate by spreading method and land use in Scotland (tds ha^{-1})	36
Table 5.8	Area of agricultural land utilised for sewage sludge recycling in Northern Ireland (1996/97)	37
Table 5.9	Spreading method employed in Northern Ireland (1996/7)	37
Table 5.10	Quality of agricultural soil used in Northern Ireland for sludge recycling (1996/7)	38
Table AW1	Current and future sludge quantities by outlets (tds a^{-1}), Anglian Water	43
Table AW2	Annual sludge production by works size (tds a^{-1}), Anglian Water (1996/7)	43

Table AW3	Current and future treatment of sludge recycled in agriculture (tds a ⁻¹), Anglian Water	44
Table AW4	Current treatment of sludge sent to other outlets (tds a ⁻¹), Anglian Water (1996/7)	44
Table AW5	Sludge treatment according to works size (tds a ⁻¹), Anglian Water (1996/7)	45
Table AW6	Quality of sludge according to outlet, Anglian Water (1996/7)	45
Table AW7	Quality of sludge used in agriculture, Anglian Water (1996/7)	46
Table AW8	Land use and sludge application rate, Anglian Water (1996/7)	46
Table AW9	Spreading methods and application rate by land use, Anglian Water (1996/7)	47
Table AW10	Quality of agricultural soil used for sludge recycling, Anglian Water (1996/7)	47
Table NW1	Current and future sludge quantities by outlets, Northumbrian Water (1996/7)	49
Table NW2	Annual sludge production by works size, Northumbrian Water (1996/7)	49
Table NW3	Current and future treatment of sludge recycled in agriculture, Northumbrian Water (tds a ⁻¹)	50
Table NW4	Current treatment of sludge sent to other outlets, Northumbrian Water (tds a ⁻¹)	50
Table NW5	Sludge treatment according to works size, Northumbrian (1996/7) (tds a ⁻¹)	51
Table NW6	Quality of sludge according to outlet, Northumbrian Water (1996/7)	51
Table NW7	Quality of sludge used in agriculture, Northumbrian Water (1996/7)	52
Table NW8	Sludge application rate by land use, Northumbrian Water (1996/7)	52
Table NW9	Spreading methods and application rate by land use, Northumbrian Water (1996/7)	53
Table NW10	Quality of agricultural soil, used for sludge recycling, Northumbrian Water (1996/7)	53
Table NWW1	Current and future sludge quantities by outlets, North West Water (tds a ⁻¹)	55
Table NWW2a	Annual sludge production by works size, North West Water (1995/6)	55

Table NWW2b	Annual sludge production by works size, North West Water (1996/7)	55
Table NWW3	Current and future treatment for sludge recycled in agriculture, North West Water (tds a ⁻¹)	56
Table NWW4	Current treatment of sludge sent to other outlet, North West (tds a ⁻¹)	56
Table NWW5	Sludge treatment according to works size, North West Water (1996/7)	57
Table NWW6	Quality of sludge according to outlet, North West Water (1996/7)	57
Table NWW7	Quality of sludge used in agriculture, North West Water (1996/7)	58
Table NWW8	Land use and sludge application rate, North West Water (1996/7)	58
Table NWW9	Spreading methods and application rate, North West Water (1996/7)	59
Table NWW10	Quality of agricultural soil used for sludge recycling, North West Water (1996/7)	59
Table STW1	Current and future sludge quantities by outlets, Severn Trent Water (tds a ⁻¹)	61
Table STW2a	Annual sludge production by works size, Severn Trent Water (1995/6)	61
Table STW2b	Annual sludge production by works size, Severn Trent Water (1996/7)	61
Table STW3	Current and future treatment of sludge recycled to agriculture, Severn Trent Water	62
Table STW4	Current treatment of sludge sent to other outlets, Severn Trent Water (tds a ⁻¹)	62
Table STW5a	Sludge treatment according to works size, Severn Trent Water (1995/6)	63
Table STW5b	Sludge treatment according to works size, Severn Trent Water (1996/7)	63
Table STW6a	Quality of sludge according to outlet, Severn Trent Water (1995/6)	63
Table STW6b	Quality of sludge according to outlet, Severn Trent Water (1996/7)	64
Table STW7	Quality of sludge used in agriculture, Severn Trent Water (1996/7)	64

Table STW8	Sludge application rate by land use , Severn Trent Water (1996/7)	65
Table STW10	Quality of agricultural soil used for sludge recycling, Severn Trent Water (1996/7)	65
Table SW1	Current and future sludge quantities by outlets, Southern Water (tds a ⁻¹)	67
Table SW2a	Annual sludge production by works size, Southern Water (1995/6)	67
Table SW2b	Annual sludge production by works size, Southern Water (1996/7)	67
Table SW3	Current and future treatment for sludge recycled to agriculture, Southern Water	68
Table SW4	Current treatment of sludge sent to other outlets, Southern Water (tds a ⁻¹)	68
Table SW5a	Sludge treatment according to works size, Southern Water (1995/6)	69
Table SW5b	Sludge treatment according to works size, Southern Water (1996/7)	69
Table SW6a	Quality of sludge according to outlet, Southern Water (1995/6)	70
Table SW6b	Quality of sludge according to outlet, Southern Water (1996/7)	70
Table SW7	Quality of sludge used in agriculture, Southern Water (1996/7)	71
Table SW8	Land use and sludge application rate, Southern Water (1996/7)	71
Table SW9	Spreading method and application rate, Southern Water (1996/7)	71
Table SW10	Quality of agricultural soil used for sludge recycling, Southern Water (1996/7)	72
Table SWW1	Current and future sludge quantities by outlets, South West Water (tds a ⁻¹)	73
Table SWW2a	Annual sludge production by works size, South West Water (tds a ⁻¹) (1995/6)	73
Table SWW2b	Annual sludge production by works size, South West Water (tds a ⁻¹) (1996/7)	73
Table SWW3	Current and future treatment of sludge recycled to agriculture, South West Water (tds a ⁻¹)	74
Table SWW4	Current treatment of sludge sent to other outlets (tds a ⁻¹)	74
Table SWW5a	Sludge treatment according to works size, South West Water (tds a ⁻¹) (1995/6)	75

Table SWW5b	Sludge treatment according to works size, South West Water (tds a ⁻¹) (1996/7)	75
Table SWW6	Quality of sludge according to outlet, South West Water (1996/7)	76
Table SWW7	Quality of sludge used in agriculture, South West Water (1996/7)	76
Table SWW8	Land use and sludge application rate, South West Water (1996/7)	77
Table SWW9	Spreading methods and application rate, South West Water (1996/7)	77
Table SWW10	Quality of agricultural soil used for sludge recycling, South West Water (1996/7)	78
Table TW1	Current and future sludge quantities by outlets, Thames Water (tds a ⁻¹)	79
Table TW2a	Annual sludge production by works size (tds a ⁻¹), Thames Water (1995/6)	79
Table TW2b	Annual sludge production by works size (tds a ⁻¹), Thames Water (1996/7)	79
Table TW3	Current and future treatment for sludge recycled to agriculture, Thames Water (tds a ⁻¹)	80
Table TW4	Current treatment of sludge sent to other outlets (tds a ⁻¹)	80
Table TW5a	Sludge treatment according to works size (tds a ⁻¹), Thames Water (1995/6)	81
Table TW5b	Sludge treatment according to works size (tds a ⁻¹), Thames Water (1996/7)	81
Table TW6a	Quality of sludge according to outlet, Thames Water (1995/6)	82
Table TW6b	Quality of sludge according to outlet, Thames Water (1996/7)	82
Table TW7	Quality of sludge used in agriculture, Thames (1996/7)	83
Table TW8	Land use and sludge application rate by land use, Thames Water (1996/7)	83
Table TW9	Spreading method and application rate, Thames Water (1996/7)	83
Table TW10	Quality of agricultural soil used for sludge recycling, Thames Water (1996/7)	84
Table WW1	Current and future sludge quantities by outlets, Welsh Water (tds a ⁻¹)	85

Table WW2	Annual sludge production by works size (tds a ⁻¹), Welsh Water (1996/7)	85
Table WW3	Current and future treatment for sludge recycled to agriculture (tds a ⁻¹), Welsh Water	86
Table WW5	Sludge treatment according to works size (tds a ⁻¹), Welsh Water (1996/7)	86
Table WW6/7	Quality of sludge used in agriculture, Welsh Water (1996/7)	87
Table WW8	Sludge application rate by land use, Welsh Water (1996/7)	87
Table WW9	Spreading method and application rate, Welsh Water (1996/7)	87
Table WW10	Quality of agricultural soil used for sludge recycling, Welsh Water (1996/7)	88
Table WXW1	Current and future sludge quantities by outlets, Wessex Water (tds a ⁻¹)	89
Table WXW2a	Annual sludge production by works size (tds a ⁻¹), Wessex Water (1995/6)	89
Table WXW2b	Annual sludge production by works size (tds a ⁻¹), Wessex Water (1996/7)	89
Table WXW3	Current and future treatment of sludge recycled to agriculture (tds a ⁻¹), Wessex Water	90
Table WXW4	Current treatment of sludge sent to other outlets (tds a ⁻¹)	90
Table WXW5a	Sludge treatment according to works size (tds a ⁻¹), Wessex Water (1995/6)	91
Table WXW5b	Sludge treatment according to works size (tds a ⁻¹), Wessex Water (1996/7)	91
Table WXW6a	Quality of sludge according to outlet, Wessex Water (1995/6)	92
Table WXW6b	Quality of sludge according to outlet, Wessex Water (1996/7)	92
Table WXW7	Quality of sludge used in agriculture, Wessex Water (1996/7)	93
Table WXW8	Land use and sludge application rate, Wessex Water (1996/7)	93
Table WXW9	Spreading method and application rate, Wessex Water (1996/7)	93
Table WXW10	Quality of agricultural soil used for sludge recycling, Wessex Water (1996/7)	94
Table YW1	Current and future sludge quantities by outlets, Yorkshire Water (tds a ⁻¹)	95
Table YW2a	Annual sludge production by works size (tds a ⁻¹), Yorkshire Water (1995/6)	95

Table YW2b	Annual sludge production by works size (tds a ⁻¹), Yorkshire Water (1996/7)	95
Table YW3	Current and future treatment of sludge recycled to agriculture (tds a ⁻¹), Yorkshire Water	96
Table YW4	Current treatment of sludge sent to other outlets (tds a ⁻¹)	96
Table YW5a	Sludge treatment according to works size (tds a ⁻¹), Yorkshire Water (1995/6)	97
Table YW5b	Sludge treatment according to works size (tds a ⁻¹), Yorkshire Water (1996/7)	97
Table YW6a	Quality of sludge according to outlet, Yorkshire Water (1995/6)	98
Table YW6b	Quality of sludge according to outlet, Yorkshire Water (1996/7)	98
Table YW7	Quality of sludge used in agriculture, Yorkshire Water (1996/7)	99
Table YW8	Land use and sludge application rate by land use, Yorkshire Water (1996/7)	99
Table YW9	Spreading method employed, Yorkshire (1996/7)	100
Table YW10	Quality of agricultural soil used for sludge recycling, Yorkshire Water (1996/7)	100
Table WoS1	Current and future sludge quantities by outlets, West of Scotland (tds a ⁻¹)	103
Table WoS2	Annual sludge production by works size, West of Scotland (1996/7)	103
Table WoS3	Current and future treatment of sludge recycled to agriculture, West of Scotland	104
Table WoS4	Current treatment of sludge sent to other outlets (tds a ⁻¹)	104
Table WoS5	Sludge treatment according to works size, West of Scotland (1996/7)	105
Table WoS6	Quality of sludge according to outlet, West of Scotland (1996/7)	105
Table WoS7	Quality of sludge recycled to agriculture, West of Scotland (1996/7)	106
Table WoS8	Land use and sludge application rate, West of Scotland (1996/7)	106
Table WoS9	Spreading method and application rate, West of Scotland (1996/7)	106
Table WoS10	Quality of agricultural land used for sludge recycling, West of Scotland (1996/7)	107
Table EoS1	Current and future sludge quantities by outlets, East of Scotland (tds a ⁻¹)	109

Table EoS2	Annual sludge production by works size, East of Scotland (1996/7)	109
Table EoS3	Current and future sludge treatment for sludge recycled to agriculture, East of Scotland	110
Table EoS4	Current treatment for sludge sent to other outlets (tds a ⁻¹)	110
Table EoS5	Sludge treatment according to works size, East of Scotland (1996/7)	111
Table EoS6	Quality of sludge according to outlet, East of Scotland (1996/7)	111
Table EoS7	Quality of sludge recycled to agriculture, East of Scotland (1996/7)	112
Table EoS8	Land use and sludge application rate, East of Scotland (1996/7)	112
Table EoS9	Spreading method employed, East of Scotland (1996/7)	113
Table EoS10	Quality of agricultural land used for sludge recycling, East of Scotland (1996/7)	113
Table NoS1	Current and future sludge quantities by outlets, North of Scotland (tds a ⁻¹)	115
Table NoS2	Annual sludge production by works size, North of Scotland (1996/7)	115
Table NoS3	Current and future treatment of sludge recycled to agriculture , North of Scotland	116
Table NoS4	Current treatment of sludge sent to other outlets	116
Table NoS5	Sludge treatment according to works size, North of Scotland (1996/7)	117
Table NoS6	Quality of sludge according to outlet, North of Scotland (1996/7)	117
Table NoS7	Quality of sludge recycled to agriculture, North of Scotland (1996/7)	118
Table NoS8	Land use and sludge application rate, North of Scotland (1996/7)	118
Table NoS9	Spreading method and application rate, North of Scotland (1996/7)	118
Table NoS10	Quality of agricultural land used for sludge recycling, North of Scotland (1996/7)	119
Table NI 1	Current and future sludge quantities by outlets, Northern Ireland (tds a ⁻¹)	123
Table NI 2	Annual sludge production per works size in Northern Ireland (1996/7)	123

Table NI 3	Current and future treatment for sludge recycled to agriculture in Northern Ireland (tds a ⁻¹)	124
Table NI 4	Current treatment of sludge sent to other outlets (1996/7)	124
Table NI 5	Sludge treatment according to works size in Northern Ireland (1996/7)	125
Table NI 6	Quality of sludge in Northern Ireland for main outlets (1996/7)	125
Table NI 7	Quality of sludge used in agriculture in Northern Ireland (1996/7)	126
Table NI 8	Area of agricultural land utilised for sewage sludge recycling in Northern Ireland (1996/97)	126
Table NI 9	Spreading method employed in Northern Ireland (1996/7)	127
Table NI 10	Quality of agricultural soil used in Northern Ireland for sludge recycling (1996/7)	127
Table D1	Number of sludge centres and percentage of data supplied for the different parameters in each local area	131
Table D2	Number of land units and percentage of land sludged for which data was supplied for different parameters	132

LIST OF FIGURES

Figure 2.1	Sludge production, disposal and recycling in all regions (1996/97)	16
Figure 3.1	Major treatment processes of sludge recycled to agriculture in the UK (1996/7)	18
Figure 5.1	Type of agricultural land utilised for sludge recycling, all regions (1996/7)	33

EXECUTIVE SUMMARY

Production and disposal of sewage sludge

The results of the UK survey of sludge production, treatment and disposal for the year 1996/7 are presented in two separate reports. On a national basis in R&D Technical Report P165 and on a regional basis in this Project Record which summarises the data for each water company in England and Wales, each region in Scotland, and for Northern Ireland. The previous survey report carried out for the then Department of the Environment for the year 1990/1, published in 1993, did not include information for separate companies so direct comparison between the two surveys cannot be made on a regional basis. The main regional findings from the 1996/7 survey data were as follows:

Most sludge was disposed of by Thames Water (271 000 tonne dry solids [tds] per annum) followed by Severn Trent Water (162 000 tds), North West Water (133 000 tds), Anglian Water (130 000 tds), Yorkshire Water (96 600 tds) and Southern Water (62 900 tds). The remaining four companies disposed of less than 40 000 tds each. Sludge production is directly related to the population and the quantity of industrial effluent discharged in the catchment of the water company. These two inputs are expressed in combination as population equivalent (pe). Average sludge production on a *per capita* basis in the UK is considered to be about 54 g pe d.

Fifty per cent of sludge was recycled to agricultural land and this outlet is usually considered to be the BPEO (Best Practicable Environmental Option) where suitable land is accessible. Welsh Water sent all of its sludge to agricultural land and other companies making major use of the outlet were South West Water and Wessex Water (both 84%), Anglian Water (77%), Southern Water (65%) and Thames Water (53%). This reflects the extent of accessible farmland available to these companies. Two companies made use of 'dedicated sites' these were Anglian Water (13% of sludge) and Severn Trent Water (14%).

Dumping at sea accounted for 18% of sludge disposed in England and Wales. In terms of quantity, most was dumped by Thames Water (72 300 tds) and North West Water (59 400 tds) whilst the 19 500 tds dumped by Northumbrian Water accounted for 50% of that company's sludge. The sea disposal outlet has been used to take sludge from large conurbations on the coast without access to agricultural land.

Legislation has stopped sea disposal at the end of 1998. An obvious alternative is incineration or other thermal destruction process although this does not achieve complete disposal as an ash representing 30 - 40% of sludge dry matter is left which, if no use can be found for it, requires disposal to landfill. In 1996/7, incineration and landfill each accounted for 9% of sludge production. These two outlets were most used by Severn Trent Water and Yorkshire Water, together taking about 50% of sludge production for these companies.

Six per cent of sludge was used in land reclamation and for Thames Water, which made most use of land reclamation, the outlet accounted for 53 600 tds of sludge or 20% of sludge disposed. Where it is feasible, the use of sludge in land reclamation is an attractive 'green' option making beneficial use of the soil building properties of sludge associated with its content of organic matter and slowly released plant nutrients (nitrogen and phosphorus). Other

outlets including 'within curtilage', use in forestry or as compost accounted for 4% of sludge in England and Wales and are of local importance.

Most sludge (59%) was produced at 119 large STWs with a pe of more than 150 000. Medium STWs (pe 10 000 - 150 000) numbered 475 and produced 33% of the sludge. Four per cent of sludge was produced at 881 small (less than 10 000 pe) STWs, most of which belong to Anglian Water (383), Wessex Water (149), Welsh Water (144), North West Water (54) and Severn Trent Water (37).

The survey indicated an increase in sludge production in England and Wales from 968 000 tds in 1996/7 to 1 224 000 tds in 2005 (increase of 26%). This prediction seems high but is estimated on the basis of implementation of the UWWTD Directive. There will be little change for Anglian, Severn Trent and Thames Water but for the others, substantial increases in sludge production are predicted as waste water currently discharged to marine waters down outfalls has to be treated. The increases are: Northumbrian Water (119%), North West Water (30%), Southern (22%), South West (193%), Welsh (188%), Wessex (62%) and Yorkshire Water (38%). This extra sludge will be accommodated by use in agriculture (increase of 28%), treatment by incineration or other thermal process (increase of 324%) whilst the destination of 14% of the sludge in 2005 is classified as 'others' which in effect means undecided at the moment.

In Scotland, the water industry made a major transition from local authority control to three water authorities in April 1996; namely North of Scotland, West of Scotland and East of Scotland. In 1996/7, Scottish water authorities relied heavily (76 %) on sea disposal although, as decreed in 1991, this has been phased out at the end of 1998. This is especially a problem in the West and East of Scotland which use the sea outlet for 93% and 52% of their sludge respectively. The other favoured outlet in 1996/7 was agriculture taking 19% of sludge altogether but 84% of sludge in the North of Scotland area. Landfill was a minor outlet for sludge in Scotland (4% total) although 4900 tds sludge (16%) was dumped in landfill by the East of Scotland water authority. The West of Scotland water authority sent 1200 tds of sludge to land reclamation. There was no incineration of sludge in Scotland in 1996/7.

In Scotland, the majority of sludge (75%) was produced/treated at a limited number of large works (Table 2.5). North of Scotland water authority had no large STW but 41 of the 58 small STW in Scotland, the rest being with East of Scotland water authority.

The quantity of sludge for disposal in Scotland is expected to increase to 198 000 tds by 2005 which would be 41% more than in 1996/7. At the time of the survey, reports in the media *E. coli* 0157 food poisoning outbreaks and unregulated landspreading of abattoir wastes, although unconnected with sludge recycling, had led to a negative public perception of sludge use in agriculture, leaving the water authorities undecided about their future sludge management. However, the data collected during this survey seemed to indicate that by 2005 agricultural recycling will still remain the favoured option for the North and East of Scotland Authorities while West of Scotland Authority is planning to divert most sludge towards energy recovery. East of Scotland is also looking into other outlets such as land reclamation.

The water executive in Northern Ireland is divided into four divisions; Western, Eastern, Northern and Southern divisions. In Northern Ireland, in 1996/7, the total quantity of sludge

amounted to 32 000 tds. Fifty five percent of sludge was recycled to agriculture and 45% was disposed to sea. The majority of sludge (65%) was treated at medium sized works.

The Western Division recycled sludge mainly to agriculture and had no sea disposal. The Southern Division also reported recycling most sludge to agriculture. The Northern Division still relied heavily on sea disposal due to the limited availability of suitable agricultural land. The Eastern Division also relied mainly on sea disposal while 20% was recycled to agriculture.

It is estimated that the quantity of sludge produced in the province will increase by 40% to around 44 000 tds by the year 2005. Northern Ireland has planned to redirect sludge currently dumped at sea as well as the increased production mainly to incineration. Agriculture will, however, continue to be a main outlet in the Western and Southern Divisions where storage facilities will be upgraded.

Treatment of sludge used in agriculture .

Twenty two per cent of sludge used in agriculture in England and Wales was untreated; those making most use of untreated sludge were Anglian Water (54%), Wessex Water (43%) and Yorkshire water (28%). The use of untreated sludge in agriculture is likely to be associated with small STWs in rural areas close to farmland. Some farmers prefer untreated sludge because it contains more organic matter than some treated sludges. Fifty seven per cent of sludge was treated by mesophilic anaerobic digestion before landspreading, the next most used treatment process being storage of dewatered sludge cake (11%). At least 60% of sludge used in agriculture was liquid.

It was estimated that by 2005, the use of untreated sludge in agriculture will have ceased, 46% of sludge will be treated by mesophilic anaerobic digestion and 37% will receive a 'high level' pasteurisation treatment process including 18% which will be thermally dried. The latter process can be applied to stabilised or unstabilised sludge and produces a dry product of about 90% ds in the form of granules or pellets. The process minimises the volume of sludge for disposal and the product gives to operator flexibility since it can be stored, used on the land or as fuel or sent to landfill as circumstances require.

In Scotland, in 1996/7, 22% of sludge recycled in agriculture was untreated, 31% was stored as unstabilised cake and 15% stored as liquid sludge. Thirty three percent of sludge was anaerobically digested; 11% liquid sludge and 22% followed by dewatering. Fifty three percent of sludge recycled in agriculture was dewatered.

In the future in Scotland there is still some uncertainty regarding treatment options (18% classified as other) but thermal drying is expected to treat up to 57% of the total quantity of sludge going to agriculture by 2005/6, while anaerobic digestion will decrease substantially down to less than 10%. Thermal drying is also expected to treat a large proportion of sludge used in other outlets such as for power generation in the West of Scotland Water Authority.

In Northern Ireland in 1996/7, all sludge recycled in agriculture was treated to some degree, varying from mesophilic anaerobic digestion (51%), liquid storage (24%) or cake storage (25%). Seventy-five per cent of sludge used in agriculture was liquid.

Future strategy for Northern Ireland is still being developed, however, it was indicated that sludge from Belfast will be incinerated and at least 75% of the sludge recycled to agriculture will be treated by mesophilic anaerobic digestion.

Sludge and soil quality and application to agricultural land

Sludges recycled to land were low in PTE content and soil analysis for PTEs where sludge had been applied gave results close to background levels.

The total area of land to which sludge was applied in 1996/7 in England and Wales was 73 000 ha which was less than 1% of the total area of agricultural land. It covers around 16 000 land units (areas of land receiving sludge) some of which were being treated several times that year. Fifty-nine percent of the area treated with sludge in England and Wales in 1996/7 was arable land. There were regional differences in the proportions applied to arable and pasture and between surface application and injection, reflecting climate, local agriculture and sludge treatment practice. Sludge was predominantly applied to arable land in most regions except in Welsh and North West Water, where pasture represented up to 80% of the area receiving sludge. The larger areas used for sludge recycling (more than 10 000 ha per annum) were located in Thames Water, Severn Trent Water, and Anglian Water. The most common spreading method was injection to plough depth which was used for 57% of sludge applied to land. It was the main method of application in Anglian Water, South West Water, Thames Water and Wessex Water. For Northumbrian Water, Welsh Water and Yorkshire Water, the splash plate was the most used method of application. In these companies, liquid digested sludge was the main type of sludge used in agriculture. The average application rates of sludge in England and Wales was 3.4 tds ha⁻¹ for arable land and 2.9 tds ha⁻¹ for pasture.

The total area of land to which sludge was applied in 1996/7 in Scotland was 4200 ha. This includes around 600 land units divided between arable (67%), and pasture (33%). The most common spreading methods were splash plate and injection to plough depth both for arable and pasture land. The average application rates of sludge for 1996/7 was 3.9 tds ha⁻¹ for arable land and 1.9 tds ha⁻¹ for pasture.

The total area receiving sludge in 1996/7 in Northern Ireland was 1200 ha. Application rates were only supplied for the Western and Southern Divisions. In the Western Division, spreading rates were in the range of 8.6 tds ha⁻¹ of dewatered sludge, while in the Southern Division, the rate of application was an average of 1.9 tds ha⁻¹ for liquid digested sludge and 2.2 tds ha⁻¹ for liquid stored sludge.

KEY WORDS

Sewage sludge, Survey, UK, Production, Treatment, Quality, Disposal, Regional

1. INTRODUCTION

The history of sludge surveys and the background to this survey are described in Environment Agency R&D Technical Report P165 which describes the results on a national basis whilst this report presents the information regionally.

The report includes interpretative sections comparing regions under the headings of current and future sludge production, recycling and disposal; sludge treatment; quality of sewage sludge; and agricultural application and sludge quality. Tables of detailed information about sewage sludge production, treatment and disposal in each company or region are given in four appendices at the end of the report.

The data are from the year 1996/7 and its validity is confirmed by data submitted by seven water companies for the previous year 1995/6 which are in reasonable agreement.

In the last two years, events influencing management of sewage sludge have moved quickly due to implementation of the Urban Waste Water Treatment Directive 91/271/EEC (CEC 1991) including closure of sea dumping at the end of 1998, and to doubts about the security of the agricultural outlet following calls to phase out recycling of untreated sludge and concerns about pathogens in the agricultural environment. Consequently, the plans for future treatment and disposal of sludge made in February 1998 and included in this report must be regarded as tentative.

2. CURRENT AND FUTURE SLUDGE PRODUCTION, RECYCLING AND DISPOSAL

2.1 Water Companies in England and Wales

Quantities of sludge and disposal outlets for the year 1996/7 are shown in Table 2.1 and Figure 2.1. Most sludge was disposed of by Thames Water (271 000 tonne dry solids [tds] per annum) followed by Severn Trent Water (162 000 tds), North West Water (133 000 tds), Anglian Water (130 000 tds), Yorkshire Water (96 600 tds) and Southern Water (62 900 tds). The remaining four companies disposed of less than 40 000 tds each, as specified in Table 2.1. Sludge production is directly related to the population and the quantity of industrial effluent discharged in the catchment of the water company. These two inputs are expressed in combination as population equivalent (pe). Average sludge production on a *per capita* basis in the UK is considered to be about 54 g pe d. Fifty per cent of sludge was recycled to agricultural land and this outlet is usually considered to be the BPEO (Best Practicable Environmental Option) where suitable land is accessible. Welsh Water sent all of its sludge to agricultural land and other companies making major use of the outlet were South West Water and Wessex Water (both 84%), Anglian Water (77%), Southern Water (65%) and Thames Water (53%). This reflects the extent of accessible farmland available to these companies. Two companies made use of 'dedicated sites', these were Anglian Water (13% of sludge) and Severn Trent Water (14%). Dumping at sea accounted for 18% of sludge disposed in England and Wales. In terms of quantity, most was dumped by Thames Water (72 300 tds) and North West Water (59 400 tds) whilst the 19 500 tds dumped by Northumbrian Water accounted for 50% of that company's sludge. The sea disposal outlet has been used to take sludge from large conurbations on the coast without access to agricultural land. Legislation has stopped sea disposal at the end of 1998. An obvious alternative is incineration or other thermal destruction process although this does not achieve complete disposal as an ash representing 30 - 40% of sludge dry matter is left which, if no use can be found for it, requires disposal to landfill. In 1996/7, incineration and landfill each accounted for 9% of sludge production. These two outlets were most used by Severn Trent Water and Yorkshire Water, together taking about 50% of sludge production for these companies. Table 2.1 shows that 6% of sludge was used in land reclamation and for Thames Water, which made most use of land reclamation, the outlet accounted for 53 600 tds of sludge or 20% of sludge disposed. Where it is feasible, the use of sludge in land reclamation is an attractive 'green' option making beneficial use of the soil building properties of sludge associated with its content of organic matter and slowly released plant nutrients (nitrogen and phosphorus). Other outlets including 'within curtilage', use in forestry or as compost accounted for 4% of sludge in England and Wales and are of local importance.

Sludge production according to size of sewage treatment works (STW) is reported in Table 2.4. Most sludge (59%) was produced at 119 large STWs with a pe of more than 150 000. Medium STWs (pe 10 000 - 150 000) numbered 475 and produced 33% of the sludge. Four per cent of sludge was produced at 881 small (less than 10 000 pe) STWs, most of which belong to Anglian Water (383), Wessex Water (149), Welsh Water (144), North West Water (54) and Severn Trent Water (37).

Table 2.7 reports an estimated increase in sludge production in England and Wales from 968 000 tds in 1996/7 to 1 224 000 tds in 2005 (increase of 26%). This prediction seems high but is estimated on the basis of implementation of the UWWTD Directive. There will be little change for Anglian, Severn Trent and Thames Water but for the others, substantial increases in sludge production are predicted as waste water currently discharged to marine waters down outfalls has to be treated. The increases are: Northumbrian Water (119%), North West Water (30%), Southern (22%), South West (193%), Welsh (188%), Wessex (62%) and Yorkshire Water (38%). This extra sludge will be accommodated by use in agriculture (increase of 28%), treatment by incineration or other thermal process (increase of 324%) whilst the destination of 14% of the sludge in 2005 is classified as 'others' which in effect means undecided at the moment.

2.2 Scottish Authorities

In Scotland, the water industry made a major transition from local authority control to three water authorities in April 1996; namely North of Scotland, West of Scotland and East of Scotland.

In 1996/7, Scottish water authorities relied heavily (76 %) (Table 2.2 and Figure 2.1), on sea disposal although, as decreed in 1991, this has been phased out at the end of 1998. This is especially a problem in the West and East of Scotland which use the sea outlet for 93% and 52% of their sludge respectively. The other favoured outlet in 1996/7 was agriculture taking 19% of sludge altogether but 84% of sludge in the North of Scotland area. Landfill was a minor outlet for sludge in Scotland (4% total) although 4900 tds sludge (16%) was dumped in landfill by the East of Scotland water authority. The West of Scotland water authority sent 1200 tds of sludge to land reclamation. There was no incineration of sludge in Scotland in 1996/7.

In Scotland, the majority of sludge (75%) was produced/treated at a limited number of large works (Table 2.5). North of Scotland water authority had no large STW but 41 of the 58 small STW in Scotland, the rest being with East of Scotland water authority.

The quantity of sludge for disposal in Scotland is expected to increase to 198 000 tds by 2005 which would be 41% more than in 1996/7 (Table 2.8). North of Scotland Authority is faced with a five-fold increase in sludge produced from compliance with the Urban Wastewater Treatment Directive. At the time of the survey, reports in the media *E. coli* 0157 food poisoning outbreaks and unregulated landspreading of abattoir wastes, although unconnected with sludge recycling had led to a negative public perception of sludge use in agriculture, leaving the water authorities with uncertainties about their future sludge management. However, the data collected during this survey seemed to indicate that by 2005 agricultural recycling will still remain the favoured option for the North and East of Scotland Authorities while West of Scotland Authority is planning to divert most sludge towards energy recovery. East of Scotland is also looking into other outlets such as land reclamation (Table 2.8).

2.3 Northern Ireland

The water executive in Northern Ireland is divided into four divisions; Western, Eastern, Northern and Southern divisions. Information in Appendix C presents the situation for the whole of the region. In Northern Ireland, in 1996/7, the total quantity of sludge amounted to 32 000 tds. Fifty five percent of sludge was recycled to agriculture and 45% was disposed to sea (Table 2.3 and Figure 2.1). The majority of sludge (65%) was treated at medium sized works (Table 2.6).

The Western Division recycled sludge mainly to agriculture and had no sea disposal. The Southern Division also reported recycling most sludge to agriculture. The Northern Division still relied heavily on sea disposal due to the limited availability of suitable agricultural land. The Eastern Division also relied mainly on sea disposal while 20% was recycled to agriculture.

In the future (Table 2.9), the quantities of sludge produced will increase by 40% to around 44 000 tds by the year 2005. Northern Ireland has planned to redirect sludge currently dumped at sea as well as the increased production mainly to incineration. Agriculture will, however, continue to be a main outlet in the Western and Southern Divisions where storage facilities will be upgraded.

Table 2.1 Total annual quantity of sludge disposed of to different outlets in the year of the survey (1996/7) in England and Wales

Region	Agriculture		Dedicated site		Incineration		Landfill		Land reclamation		Sea disposal		Other		Total
	tds a ⁻¹	(%)	tds a ⁻¹	(%)	tds a ⁻¹	(%)	tds a ⁻¹	(%)	tds a ⁻¹	(%)	tds a ⁻¹	(%)	tds a ⁻¹	(%)	tds a ⁻¹
Anglian	100 700	(77)	16 300	(13)			1 700	(1)			9 800	(8)	100+	(<1)	130 300
Northumbrian	2 700	(7)					3 200	(8)			19 500	(50)	13 800#	(36)	39 200
North West	39 400	(30)			14 100	(11)	17 800	(13)			59 400	(45)	2 300*	(2)	133 000
Severn Trent	56 900	(35)	22 500	(14)	41 300	(25)	37 700	(23)	3 300	(2)			900+	(1)	162 700
Southern	40 600	(65)			4 300	(7)	9 600	(15)			8 200	(13)	200*		62 900
South West	12 400	(84)								(<1)	2 300	(16)			14 700
Thames	144 100	(53)							53 600	(20)	72 300	(27)	1 100#	(<1)	271 200
Welsh	23 300	(100)													23 300
Wessex	28 400	(84)					1 800	(5)	3 800	(11)					34 000
Yorkshire	31 400	(32)			31 100	(32)	14 300	(15)	2 000	(2)	5 300	(5)	12 500*	(13)	96 600
England and Wales	480 000	(50)	38 800	(4)	90 800	(9)	86 100	(9)	62 700	(6)	176 900	(18)	31 100	(4)	968 000

Notes:

- * Within curtilage
- + Forestry
- # Mainly horticultural compost

Table 2.2 Total annual quantity of sludge disposed of to different outlets in the year of the survey (1996/7) in Scotland

Region	Agriculture		Landfill		Land reclamation		Sea disposal		Total
	tds a ⁻¹	(%)	tds a ⁻¹	(%)	tds a ⁻¹	(%)	tds a ⁻¹	(%)	tds a ⁻¹
East of Scotland	9 700	(32)	4 900	(16)			15 700	(52)	30 300
West of Scotland	4 500	(6)			1 200	(1)	71 300	(93)	77 000
North of Scotland	8 200	(84)	100	(1)			1 500	(15)	9 800
Scotland	22 400	(19)	5 000	(4)	1 200	(1)	88 500	(76)	117 100

Note: % of each local region

Table 2.3 Total annual quantity of sludge disposed of to different outlets in the year of the survey (1996/7) in Northern Ireland

Region	Agriculture		Sea disposal		Total
	tds a ⁻¹	%	tds a ⁻¹	%	tds a ⁻¹
Northern Ireland	17 500	(55)	14 500	(45)	32 000

Table 2.4 Annual sludge production per works size in England and Wales, all outlets (1996/7)

Region	Store			Small			Medium			Large		
	(tds)	%	(n)	(tds)	%	(n)	(tds)	%	(n)	(tds)	%	(n)
Anglian	31 400	24	47	17 300	13	383	40 200	31	98	39 700	31	10
Northumbrian				800	2	8	18 900	48	12	19 500	50	2
North West				2 000	2	54	25 700	19	32	105 400	79	22
Severn Trent				1 000	1	37	50 300	31	65	111 400	69	23
Southern				1 200	2	8	47 600	76	44	14 200	23	8
South-West				3 000	20	14	11 700	80	31			
Thames				1 800	1	13	53 300	19	60	216 100	80	34
Welsh				5 500	24	144	17 800	76	19			
Wessex	8 800	26	46	4 200	12	149	15 200	45	33	5 700	17	5
Yorkshire	100	<1	1	2 900	3	71	33 600	35	81	60 300	62	15
England and Wales	40 300	4	94	39 500	4	881	314 300	33	475	572 400	59	119

% of each local region
n number of treatment centres
Store lagoon or stockpile
Small <10,000 pe
Medium 10,000 pe - 150,000 pe
Large >150,000 pe

Table 2.5 Annual sludge production per works size in Scotland, all outlets (1996/7)

Region	Small		Medium		Large	
	(tds)	%	(tds)	%	(tds)	%
East of Scotland	900	3	13 600	45	15 700	52
West of Scotland			4 500	6	72 400	94
North of Scotland	5 200	53	4 600	47		
Scotland	6 100	5	22 700	19	88 200	75

Small <10,000 pe
 Medium 10,000 pe - 150,000 pe
 Large >150,000 pe

Table 2.6 Annual sludge production per works size in Northern Ireland, all outlets (1996/7)

Region	Small		Medium		Large	
	(tds)	%	(tds)	%	(tds)	%
Northern Ireland	2 000	6	20 900	65	9 100	29

Small <10,000 pe
 Medium 10,000 pe - 150,000 pe
 Large >150,000 pe

Table 2.7 Predicted sludge production and disposal in 2005 for England and Wales

Region	Estimated Quantities by 2005 (tds)	Proportion (%) going to					
		A	DS	I	L	LR	Others
Anglian	136 000	52	12		1	1	35*
Northumbrian	86 000						100 ^s
North West	173 000	46		44	10		
Severn Trent	167 000	39	13	33	12	2	1 [@]
Southern	77 000	100					
South-West	43 000	100					
Thames	264 000	59		35		6	
Welsh	67 000 ⁺	100					
Wessex	55 000	30			5		65 [#]
Yorkshire	155 000	23		43	7	23	3 [@]
England and Wales	1 224 000	50	3	24	5	5	14

A agriculture DS dedicated site I incineration L landfill LR land reclamation
 * Production of aggregates
 s Gasification and power generation
 @ Other uses include mainly land reclamation
 + A proportion of sludge may also be gasified
 # Not specified but probably includes land reclamation

Table 2.8 Predicted sludge production and disposal in 2005 in Scotland

Region	Estimated Quantities by 2005 (tds)	Proportion (%) going to					
		A	DS	I	L	LR	Others
North of Scotland	56 000	100					
West of Scotland	82 000	4					96*
East of Scotland	59 000	73				25	2 [@]
Scotland	198 000	52				8	40

A agriculture DS dedicated site I incineration L landfill LR land reclamation
 * Other uses include energy production
 @ Other uses include recycling to forestry

Table 2.9 Predicted sludge production and disposal in 2005 in Northern Ireland

Region	Estimated Quantities by 2005 (tds)	Proportion (%) going to				
		A	DS	I	L	LR
Northern Ireland	44 000	48		52		

A agriculture DS dedicated site I incineration L landfill LR land reclamation

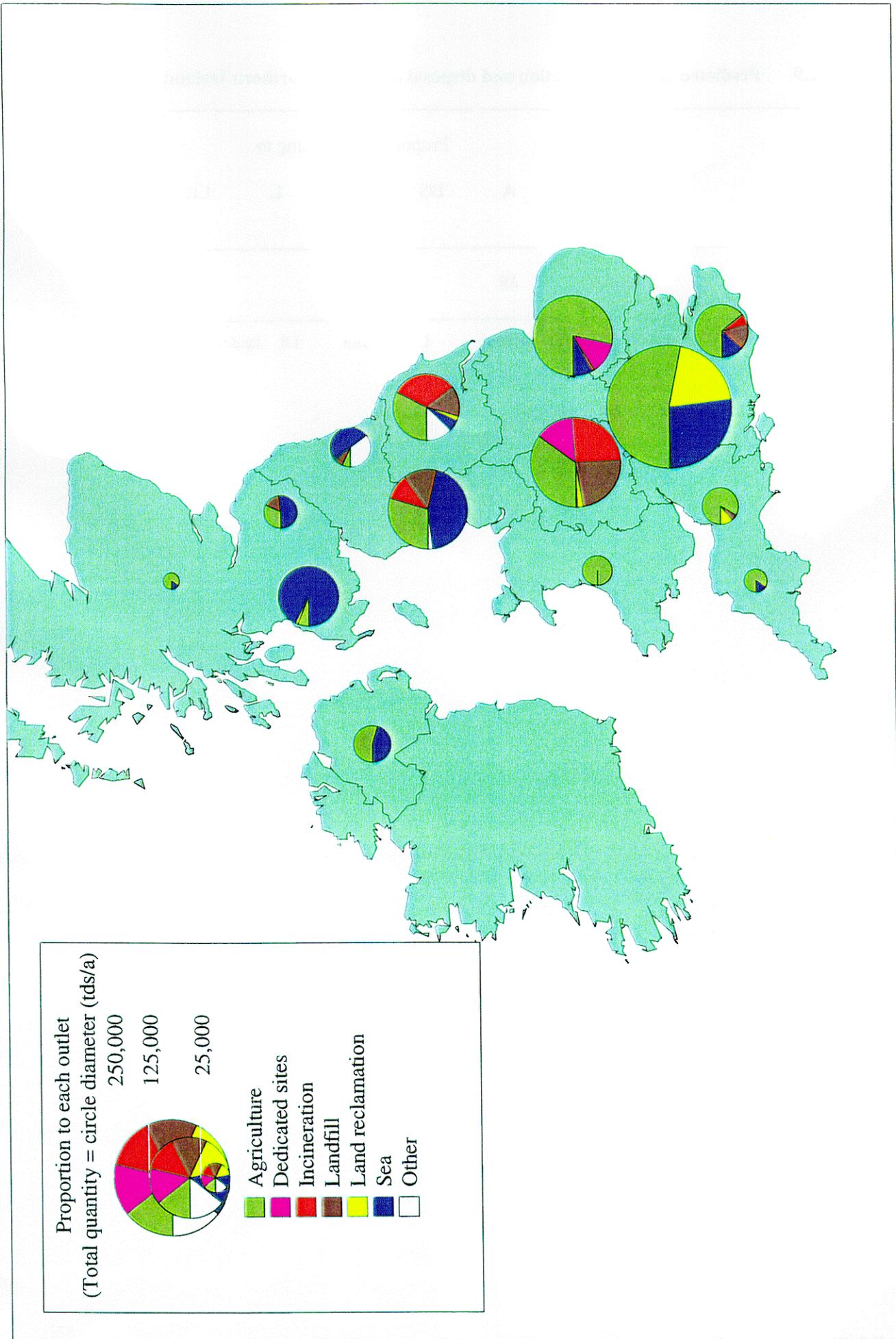


Figure 2.1. Sludge production, disposal and recycling in all regions (1996/97)

3. TREATMENT OF SLUDGE USED IN AGRICULTURE

3.1 Water Companies in England and Wales

Table 3.1 and Figure 3.1 present the information on the treatment of sludge used in agriculture by the companies. More detail is given in Tables 3.2 and 3.3 according to whether the sludge was in liquid or dewatered form, as defined by the treatment groups. Twenty two per cent of sludge used in agriculture was untreated; those making most use of untreated sludge were Anglian Water (54%), Wessex Water (43%) and Yorkshire water (28%). The use of untreated sludge in agriculture is likely to be associated with small STWs in rural areas close to farmland. Some farmers prefer untreated sludge because it contains more organic matter than some treated sludges. Fifty seven per cent of sludge was treated by mesophilic anaerobic digestion before landspreading, the next most used treatment process being storage of dewatered sludge cake (11%). At least 60% of sludge used in agriculture was liquid.

Table 3.1 Treatment of sludge (%) recycled in agriculture in England and Wales (1996/7)

	MAD	MAD/DEW	TAD	TAD/DEW	Lime	LIQ/STO	CAKE/STO	COM	THE	None
Anglian	16	14			3	7	4			54
Northumbrian	85	15	<1							
North West	75	2			8	1	5			9
Severn Trent	69	18					7			7
Southern	8	28			7	3	46	<1		7
South West	44	7				2	35		<1 ^{SW1}	12
Thames	26	44			10		7	3		9
Welsh	39	12		1	15	5	9			19
Wessex	37	10					7		4 ^{WXW1}	43
Yorkshire	51		<1			9	11			28
England and Wales	35	22	<1	<1	6	3	11	<1	<1	22

Notes:

PAS	Pasteurisation
MAD	Mesophilic anaerobic digestion
MAD/DEW	Anaerobic digestion and dewatering and storage
TAD	Thermophilic aerobic digestion
TAD/DEW	TAD and dewatering and storage
COM	Composting and/or co-composting
LIME	Lime stabilization
LIQ/STO	Liquid storage
CAKE/STO	Unstabilised, dewatered and stored
THE	Thermal drying of treated and untreated sludge
^{SW1}	Thermal drying of untreated sludge
^{WXW1}	Thermal drying of treated sludge

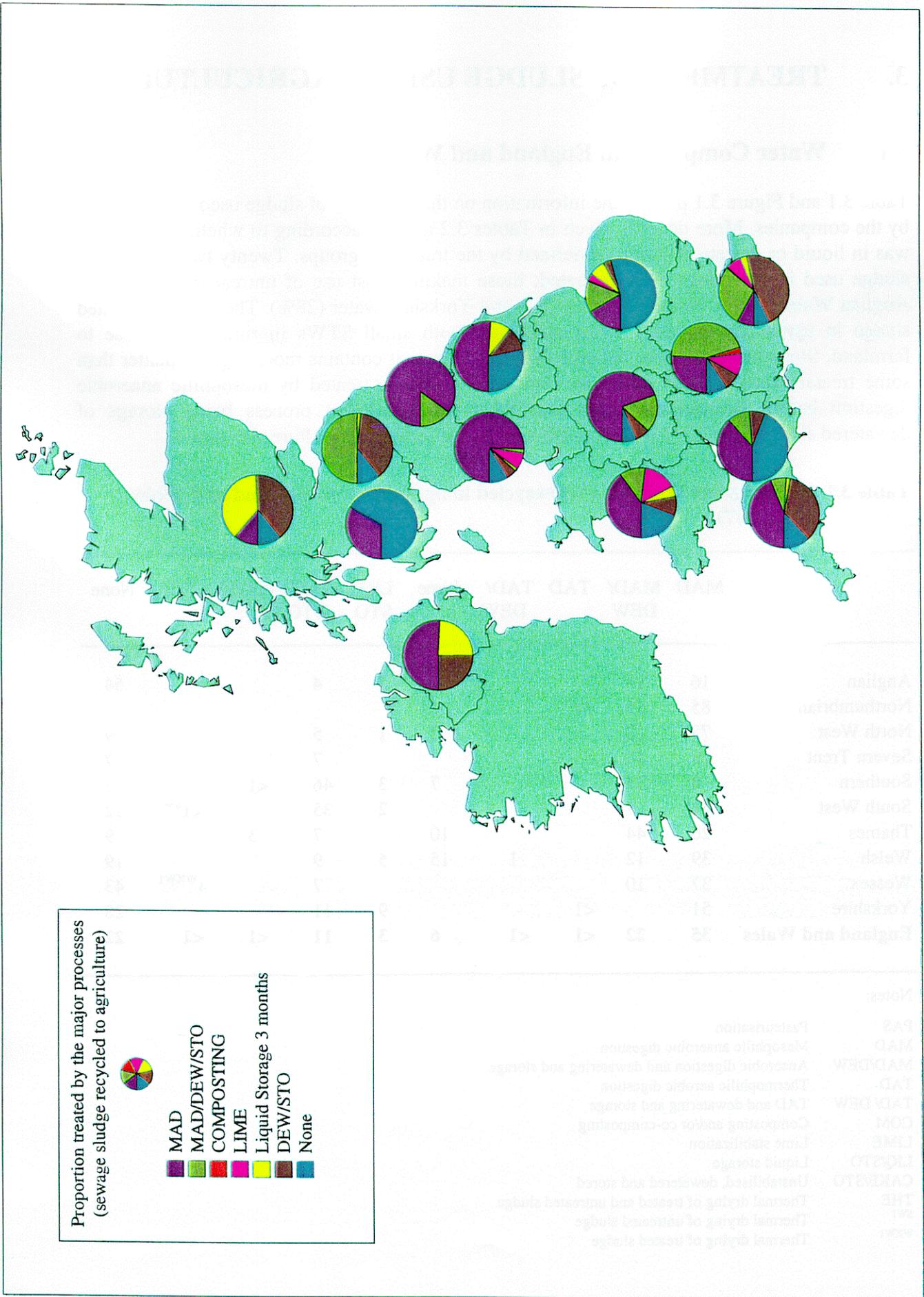


Figure 3.1 Major treatment processes of sludge recycled to agriculture in the UK (1996/7)

Table 3.2 Treatment applied to liquid sludge recycled in agriculture in England and Wales (1996/7)

	Liquid sludge (%)				
	MAD	TAD	Lime	Stored	None
Anglian	21			9	70
Northumbrian	100	<1			
North West	85		4	1	10
Thames	73				27
Welsh	51		19	6	24
Wessex	46				54
Severn Trent	91				9
Southern	44			17	39
South West	77			3	21
Yorkshire	57			11	32
England and Wales	57	<1	3	4	36

Notes:

MAD Mesophilic anaerobic digestion
TAD Thermophilic aerobic digestion
LIME Lime stabilization
Stored Liquid storage for 3 months

Table 3.3 Treatment applied to dewatered sludge recycled in agriculture in England and Wales (1996/7)

	Cake sludge (%)					
	MAD	TAD	COM	LIME	Stored	THE
Anglian	66		2	15	17	
Northumbrian	100					
North West	19			37	44	
Thames	68		4	16	11	
Welsh	54	6			40	
Wessex	48				34	18
Severn Trent	73				27	
Southern	34			9	57	
South West	17				81	2
Yorkshire					100	
England and Wales	59	>1	2.5	11	27	0.5

Notes:

MAD Mesophilic anaerobic digestion, dewatered and stored
TAD Thermophilic aerobic digestion, dewatered and stored
COM Composting or co-composting
LIME Lime stabilization and dewatered (%ds >25)
Stored Unstabilised, dewatered and stored
THE Thermal drying

Looking to the future (Table 3.4), it is seen that the use of untreated sludge in agriculture will cease, 46% of sludge will be treated by mesophilic anaerobic digestion and 37% will receive a 'high level' pasteurisation treatment process including 18% which will be thermally dried. The latter process can be applied to stabilised or unstabilised sludge and produces a dry product of about 90% ds in the form of granules or pellets. The process minimises the volume of sludge for disposal and the product gives to operator flexibility since it can be stored, used on the land or as fuel or sent to landfill as circumstances require.

3.2 Scottish Water Authorities

In Scotland, in 1996/7, 22% of sludge recycled in agriculture was untreated, 31% was stored as unstabilised cake and 15% stored as liquid sludge. Thirty three percent of sludge was anaerobically digested; 11% liquid sludge and 22% followed by dewatering. No lime stabilisation nor other more advanced treatment was applied (Table 3.5 and Figure 3.1).

Fifty three percent of sludge recycled in agriculture was dewatered. Twenty four percent of liquid sludge was anaerobically digested while 30% was stored, unstabilised and 46% was untreated (Table 3.6). Forty one percent of dewatered sludge applied to agriculture (Table 3.7) was anaerobically digested while 59% was stored and unstabilised.

The situation was variable according to water authorities (Figure 3.1). West of Scotland still had a substantial proportion of sludge going to agriculture untreated (67%), while the other two water authorities had both reduced these proportions down to 11%.

In the future (Table 3.8) all sludge recycled to agriculture will be at least dewatered. There are still some uncertainties regarding the level of treatment (18% classified as other) but thermal drying is expected to treat up to 57% of the total quantity of sludge going to agriculture by 2005/6, while anaerobic digestion will decrease substantially down to less than 10%. Most of the sludge used in agriculture by the East of Scotland (95%) and North of Scotland (30%) water authorities will be thermally dried. Thermal drying will also be the main sludge treatment for other outlets. Most of the sludge produced by the West of Scotland water authority will be thermally dried and used as fuel in electrical power generation.

3.3 Northern Ireland Divisions

In Northern Ireland in 1996/7, all sludge recycled in agriculture was treated to some degree, varying from mesophilic anaerobic digestion (51%), liquid storage (24%) or cake storage (25%) (Table 3.9 and Figure 3.1). Seventy-five per cent of sludge used in agriculture was liquid (Table 3.10).

In the Western Division, all sludge recycled to agriculture was treated by dewatering and storage as cake before being spread on land. In the other divisions, most sludge was liquid digested sludge or stored liquid sludge.

Future strategy for Northern Ireland is still being developed, however, current information (Table 3.11) indicates that, in the future, liquid storage of sludge going to agriculture will be reduced (down to 3% in 2005/6) and anaerobic digestion will account for 75%.

Table 3.4 Future trends (by 2005/6) in treatment of sludge used in agriculture in England and Wales (%)

	PAS	MAD	MAD/ DEW/ STO	TAD	COM	CO- COM	LIME	LIQ/ STO	CAKE/ STO	THE	Other	None
Anglian	49				14	1	7			28*		
North West	100											
Northumbrian ^{NW1}	na	na	na	na	na	na	na	na	na	na	na	na
Severn Trent			92						8			
Southern			63							37		
South West ^{SW1}		13	2						10	6*	68	
Thames		29	48		3		10		7	3		
Welsh		48								52*		
Wessex					7					93		
Yorkshire ^{YW1}		42		<1				8	10	14	25	
England and Wales	19	16	30	<1	2.6	<	3.3	0.5	3.9	18	7	

Notes:

PAS	Pasteurisation	LIME	Lime stabilization
MAD	Mesophilic anaerobic digestion	MAD/DEW/STO	Anaerobic digestion and dewatering and storage
TAD	Thermophilic aerobic digestion	CO-COM	Co-composting
COM	Composting	CAKE/STO	Unstabilised, dewatered and stored
LIQ/STO	Liquid storage	THE	Thermal drying
NW1	By 2005/6, Northumbrian is hoping to have diverted all its sludge from other outlets to gasification.		
SW1	Large uncertainties due to lack of response		
YW1	Large uncertainties due to lack of response. Probably move dewatered anaerobic digested and thermally dried sludge		
na	Not applicable		
*	Thermal drying of untreated sludge		

Table 3.5 Treatment of sludge (%) recycled in agriculture in Scotland (1996/7)

	MAD	MAD/ DEW/ STO	Lime	LIQ/ STO	CAKE/ STO	THE	None
North of Scotland	11			38	40		11
West of Scotland	33						67
East of Scotland		50		1	38		11
Scotland	11	22		15	31		22

Notes:

PAS	Pasteurisation
MAD	Mesophilic anaerobic digestion
MAD/DEW/STO	Anaerobic digestion and dewatering and storage
LIQ/STO	Liquid storage
CAKE/STO	Unstabilised, dewatered and stored
THE	Thermal drying of treated or untreated sludge

Table 3.6 Treatment applied to liquid sludge recycled in agriculture in Scotland (1996/7)

	Liquid sludge (%)		
	MAD	Stored	None
North of Scotland	19	63	18
West of Scotland	33		67
East of Scotland		12	88
Scotland	24	30	46

Notes

MAD	Mesophilic anaerobic digestion
TAD	Thermophilic aerobic digestion
Stored	Liquid storage

Table 3.7 Treatment applied to dewatered sludge used in agriculture in Scotland (1996/7)

	Cake sludge (%)	
	MAD	Stored
North of Scotland		100
West of Scotland		
East of Scotland	57	43
Scotland	41	59

Notes

MAD Anaerobic digestion and dewatering and storage

TAD TAD and dewatering and storage

Stored Unstabilised, dewatered and stored

Table 3.8 Future trends (by 2005/6) in treatment of sludge used in agriculture in Scotland (%)

	PAS	MAD	MAD/ DEW/S TO	CO/ COM	LIME	LIQ/ STO	CAKE/ STO	THE/ TR	THE/ UTR	Other*	None
North of Scotland			11	1	9		15	30			33
West of Scotland		100									
East of Scotland	4	1						70	25		
Scotland	2	3	6	<1	4.5		8	46	11	18	

Notes:

* Uncertain

PAS Pasteurisation

MAD Mesophilic anaerobic digestion

MAD/DEW/STO Anaerobic digestion and dewatering and storage

CO-COM Co-composting

LIME Lime stabilization

LIQ/STO Liquid storage

CAKE/STO Unstabilised, dewatered and stored

THE/TR Thermal drying of treated sludge

THE/UTR Thermal drying of untreated sludge

Table 3.9 Treatment of sludge (%) in Northern Ireland (1996/7)

Outlet	PAS	MAD	TAD	LIME	LIQ/ STO	CAKE/ STO	None
Agriculture		51			24	25	
Sea		5					95

Notes:

PAS	Pasteurisation	LIME	Lime stabilization
MAD	Mesophilic anaerobic digestion	TAD	Thermophilic aerobic digestion
LIQ/STO	Liquid storage	CAKE/STO	Unstabilised, dewatered and stored

Table 3.10 Treatment of sludge used in agriculture in Northern Ireland (1996/7)

	Liquid MAD or stored	Cake stored
Northern Ireland	75	25

Table 3.11 Future trends (by 2005/6) in treatment of sludge used in agriculture in Northern Ireland (%)

	PAS	MAD	TAD	COM	LIME	LIQ/ STO	CAKE/ STO	THE	None
Northern Ireland		75				3	22		

Notes:

PAS	Pasteurisation	LIME	Lime stabilization
MAD	Mesophilic anaerobic digestion	TAD	Thermophilic aerobic digestion
COM	Composting	THE	Thermal drying
LIQ/STO	Liquid storage	CAKE/STO	Unstabilised, dewatered and stored

4. QUALITY OF SEWAGE SLUDGE

The quality of sludge is described in detail for each sludge producer in their respective appendices. Sludge quality is expressed as weighted average values and percentiles (10, 50 and 90%-ile) for nutrients and potentially toxic elements (PTE).

4.1 England and Wales

Comparison of the quality of sludge between outlets for England and Wales as a whole (Table 4.1) seems to confirm that sludge going to agriculture and used as horticultural compost was of better quality than sludge going to other outlets such as landfill. The information on the quality of sludge incinerated has to be taken with caution as only limited data were provided on ash, liquid and cake sludge. Similarly, results on quality of sludge for forestry, horticultural compost and within curtilage were based on a limited set of data, generally less than 10 samples.

For agricultural outlet (Table 4.2), there was a high level of monitoring for PTEs, including the non-statutory elements (Mo, Se, As and F), and also for nutrients N and P, but only relatively few samples were analysed for ammonia. As described in R&D Technical Report P165 (the national presentation of this survey) median values of PTEs in sludge used in agriculture were lower in 1996/7 than in 1990/1 and well below the sludge quality limits in EC Directive 86/278/EEC. This shows continuing reduction in PTEs in the sludge used in agriculture.

4.2 Scotland

The quality of sludge in Scotland is presented in Tables 4.3 and 4.4 and for each individual company in Appendix B. Compared to the average quality values in the England and Wales region, the quality of sludge recycled to agriculture is similar. The quality of sludge disposed of to sea had a higher level of zinc and chromium compared with sludge recycled to agriculture or disposed of to landfill.

4.3 Northern Ireland

The quality of sludge in Northern Ireland is presented in Tables 4.5 and 4.6. None of the Northern Ireland regions reported information on the non-statutory PTEs. The sludge produced was comparatively low in PTEs.

Table 4.1 Quality of sludge in England and Wales for all outlets (1996/7)

Outlet	Weighted average concentration (mg kg ⁻¹ ds)								
	Agriculture	Dedicated site	Incineration ²	Sea disposal	Landfill	Land reclamation	Forestry	Horticultural compost	Within curtilage
n ¹	1 158	69	5	24	28	19	24	47	6
% ds	15	6	47	3	22	56	28	32	14
Tot N	43 900	55 800		51 600	41 900	17 000	27 500	34 700	34 000
NH ₃ -N	7 800	6 700	3000	5 000	2 500	4 200		4 000	14 900
Tot P	22 600	27 200		28 700	17 800	17 800	16 900	6 000	41 100
Zinc	802	938	643	886	1314	729	2 243	427	653
Copper	565	472	537	526	487	451	625	281	394
Nickel	59	68	74	49	106	99	84	8	36
Cadmium	3.4	6.5	4.0	3.6	4.5	15.4	6.9	1.9	2.9
Lead	221	361	301	538	256	266	550	170	193
Mercury	2.3	2.6	0.6	2.1	2.6	2.4	3.3	1.0	2.1
Chromium	163	226	153	219	686	243	158	105	814
Molybdenum	8	9	42	10	12	6	9	5	10
Selenium	2.0	1.7	2.5	1.4	2.2	1.7	1.1	1.5	1.2
Arsenic	6	6	17	7	10	8	8	2	7
Fluorine	224	295	506	263	339	167	377	144	225

Notes:

1 Maximum number of samples, usually lower for NH₃ and non statutory PTEs

2 Based on return from 5 works - mixture of ash, cake and liquid sludge

Table 4.2 Quality of sludge used in agriculture in England and Wales (1996/7)

Parameters	Concentration (mg kg ⁻¹ ds)			(n)	EC Directive 86/278/EC
	10%ile	median	90%ile		
%ds	2	5	19	1317	
Tot N	21 900	35 600	61 400	1202	
NH ₃ -N	1 400	5 000	15 500	231	
Tot P	10 800	19 400	35 600	1201	
Zinc	347	559	1080	1223	2500-7000
Copper	199	376	751	1223	1000-1750
Nickel	11	20	65	1219	300-700
Cadmium	0.8	1.6	3.5	1049	20-40
Lead	39	96	293	1218	750-1200
Mercury	0.5	1.4	4.2	1200	16-25
Chromium	12	24	161	1220	
Molybdenum	2	5	10	883	
Selenium	0.5	1.6	2.9	879	
Arsenic	0.7	2.5	10	861	
Fluorine	83	161	301	820	

Table 4.3 Quality of sludge in Scotland for main outlets (1996/7)

Parameter Outlet	Weighted average concentration (mg kg ⁻¹ ds)			
	Agriculture	Sea disposal	Landfill	Land reclamation
n ¹	69	15	4	1
% ds	11	5	17	29
Tot N	40 200	39 400	49 718	44 000
NH ₃ -N	10 700	6 300		ns
Tot P	14 500	21 800	12 239	ns
Zinc	644	1 256	567	713
Copper	620	333	168	395
Nickel	31	40	19	49
Cadmium	1.4	1.6	1.2	2.0
Lead	271	208	134	236
Mercury	2.5	1.2	1.1	2.4
Chromium	81	309	51	126
Molybdenum	2.9	3.4	10.6	ns
Selenium	0.86	0.75	ns	ns
Arsenic	3.2	6.6	4.2	ns
Fluorine	91	44	ns	ns

Notes:

1 Maximum number of samples, usually lower for NH₃ and non-statutory PTEs

ns Not supplied

Table 4.4 Quality of sludge used in agriculture in Scotland (1996/7)

Parameter	Sludge concentration (mg kg ⁻¹ ds)			n
	10%ile	Median	90%ile	
%ds	1.8	4.5	24.5	69
Tot N	5 700	35 800	65 900	55
NH ₃ -N				
Tot P	900	10 300	34 500	47
Zinc	318	508	883	50
Copper	157	254	720	59
Nickel	8	20	38	56
Cadmium	0.6	1.2	3.1	57
Lead	69	170	299	59
Mercury	0.71	2.0	5.24	49
Chromium	15	37	97	59
Molybdenum	0.99	3.65	7.24	40
Selenium	0.25	1.08	2.26	25
Arsenic	0.64	3.67	5.42	35
Fluorine	39	65	112	25

Table 4.5 Quality of sludge in Northern Ireland for main outlets (1996/7)

Parameter**	Weighted average concentration* (mg kg ⁻¹ ds)	
	Agriculture	Sea disposal
n ¹	27	4
% ds	14	2
Tot N	25 100	-
Tot P	27 400	-
Zinc	668	900
Copper	583	861
Nickel	38	80
Cadmium	2.1	3.0
Lead	156	131
Mercury	2.4	3.6
Chromium	50	122

Notes:

* Data for Eastern Division not available

¹ Maximum number of samples

** Data for non statutory PTEs not available

Table 4.6 Quality of sludge used in agriculture in Northern Ireland (1996/7)

Parameter**	Sludge concentration* (mg kg ⁻¹ ds)			n
	10%ile	Median	90%ile	
%ds	2.4	4.9	16.2	27
Tot N	18 400	26 500	32 800	22
NH ₃				ns
Tot P	6 400	16 900	52 800	22
Zinc	419	745	1 169	27
Copper	121	350	1 015	27
Nickel	13	22.5	82	27
Cadmium	0.7	1.4	3.6	27
Lead	36	106	211	27
Mercury	0.9	2	3.6	27
Chromium	2.4	29	79	27

Notes:

* Data for Eastern Division not available

** Data for non statutory PTEs not available

5. AGRICULTURAL APPLICATION AND SOIL QUALITY

5.1 Water companies in England and Wales

The total area of land to which sludge was applied in 1996/7 in England and Wales was 73 000 ha which was less than 1% of the total area of agricultural land. It covers around 14 000 land units (areas of land receiving sludge) some of which were being treated several times that year.

It was not possible within the scope of this survey to compare directly sludge type and spreading method, nor sludge quality and soil quality. Some general observations are as follows.

Although the majority of companies reported that the soil data for the current survey were mainly background, i.e. levels prior to sludge application, it was not possible for all of them to differentiate between background levels and concentrations after sludge application. The soil quality for each individual company is presented in the appendices. The level of return for non-statutory parameters was low (around 20%). The quality of agricultural soil used for sewage sludge for each individual company is expressed as 10, 50 and 90 percentile for all PTEs. The results of the survey suggest that PTE levels in soils receiving sludge in 1996/7 were similar to the background concentrations that would be found in unsludged soil. This is not surprising since PTE concentrations in sludge are now at a level that would require many repeated applications of sludge to the land before an increase in soil PTE concentration would be detected.

Fifty-nine percent of the area treated with sludge in England and Wales in 1996/7 was arable land (Table 5.1). There are of course regional differences in the proportions applied to arable and pasture (Figure 5.1) and between surface application and injection, reflecting climate, local agriculture and sludge treatment practice.

Sludge was predominantly applied to arable land in most regions except in Welsh and North West Water, where pasture represented up to 80% of the area receiving sludge. The larger areas used for sludge recycling (more than 10 000 ha per annum) were located in Thames Water, Severn Trent Water, and Anglian Water.

The most common spreading method was injection to plough depth which was used on 57% of total area of sludge treated soils (Table 5.2). This was the main method of application in Anglian Water, South West Water, Thames Water and Wessex Water. For Northumbrian Water, Welsh Water and Yorkshire Water, the splash plate was the most common method of application. In these companies, liquid digested sludge was also the most common type of sludge used in agriculture. A comparison between spreading methods for each land use is presented in Table 5.3. Injection remained the most widely used method of sludge application to the land. Subsurface soil injection of sludge, if properly operated, should minimise both odour nuisance and the possibility of disease transmission. However, not all land is suitable for injection because of unfavourable soil conditions, topography or crop. In particular, upland regions to the north and west of the UK are likely to be unsuitable for injection.

Table 5.1 Area of agricultural land utilised for sewage sludge recycling in England and Wales (1996/97)

Region	Arable			Pasture			Total	
	Land area (ha)	Land units (n)	%	Land area (ha)	Land units (n)	%	Land area (ha)	Land units (n)
Anglian	8 100	755	77	2 500	330	23	10 600	1 085
Northumbrian	700	132	70	300	75	30	1 000	207
North West	2 000	500	21	7 400	2 205	79	9 400	2 705
Severn Trent	6 600	876	47	7 400	1 466	53	14 000	2 432
Southern	3 300	794	86	500	141	14	3 800	935
South-West	2 100	447	69	1 000	227	31	3 100	674
Thames	10 600	2655	75	3 500	1 026	25	14 100	3 681
Welsh	1 000	320	20	4 100	1 279	80	5 100	1 599
Wessex	4 400	1087	72	1 700	489	28	6 100	1 576
Yorkshire	4 400	605	76	1 400	330	24	5 800	935
England and Wales	43 300	7851	59	29 700	6 289	41	73 000	14 140

Table 5.2 Utilisation of sludge application method (% of area receiving sludge)

	SP	SA	MS	INJ	SINJ	O	U
Anglian			2	92		1	5
Northumbrian	100						
North West	30	21	3	7		40	
Severn Trent	NI	NI	NI	NI	NI	NI	NI
Southern	10		73	18			
South-West	30		25	45			
Thames	19	8	28	46		<1	
Welsh	51		11	34		4	
Wessex	9	4		37	16	34	<1
Yorkshire	47		6	27		14	6
England and Wales	9	3	9	57	1	6	11

Notes:

SP Splash plate applicator from tanker

SA Umbilical fed surface application

MS Application from solid manure spreader

INJ Injection to plough depth

SINJ Shallow injection (<=10 cm)

O Other methods

U Unspecified/no data

NI No information was supplied from Severn Trent Water

Units: % of total land hectare that received sludge in the region during year.

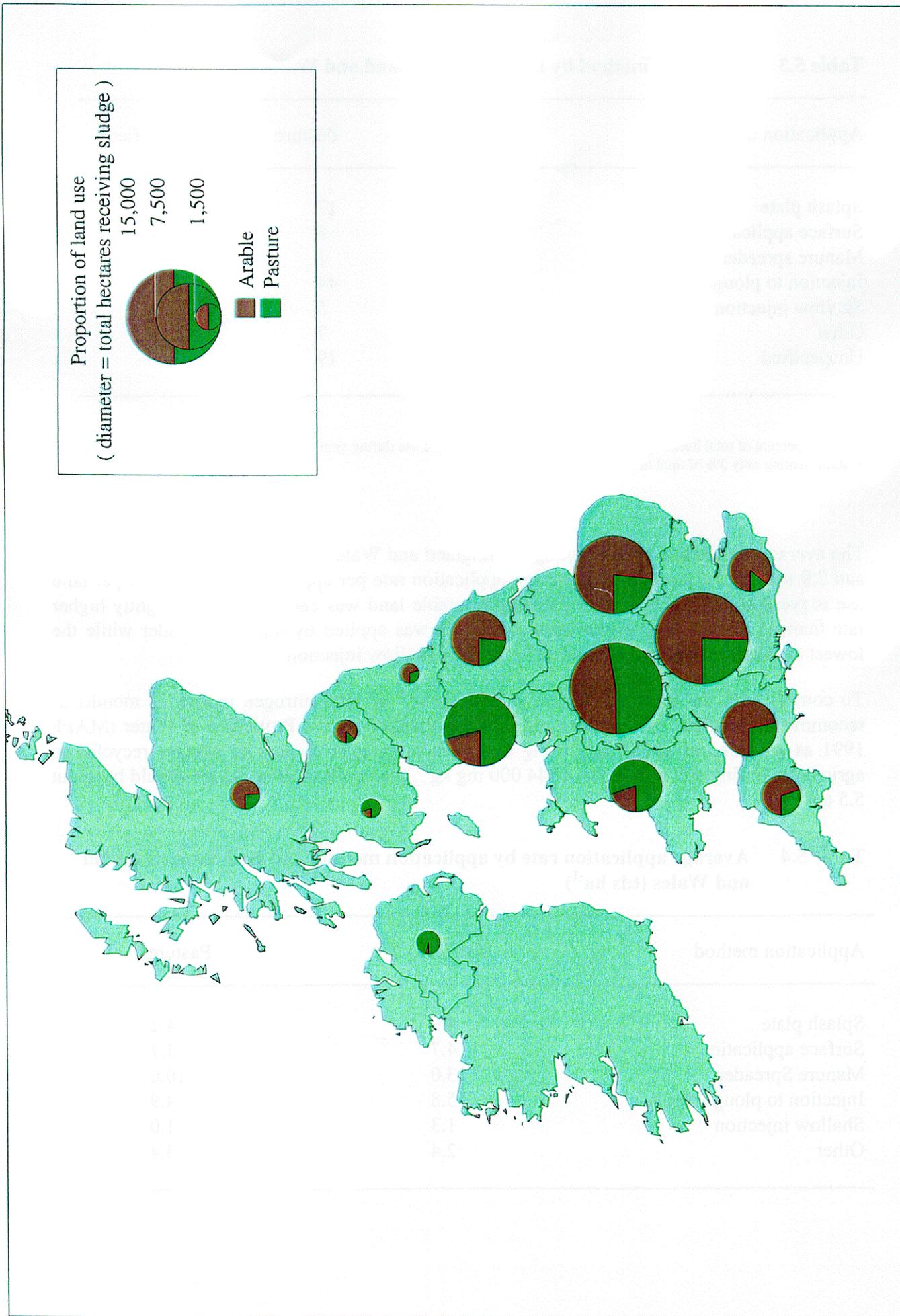


Figure 5.1 Type of agricultural land utilised for sludge recycling, all regions (1996/7)

Table 5.3 Spreading method by land use in England and Wales (%)

Application method	Arable	Pasture	Unspecified*
Splash plate	6	17	54
Surface application	<1	8	
Manure spreader	13	1	10
Injection to plough depth	65	44	32
Shallow injection	<1	5	
Other	7	7	4
Unspecified	8	19	

Notes:

Units are percent of total hectareage that received sludge for that land use during year

* Representing only 3% of total hectareage

The average application rates of sludge in England and Wales was 3.4 tds ha⁻¹ for arable land and 2.9 tds ha⁻¹ for pasture. The average application rate per application method and per land use is presented in Table 5.4. Application to arable land was carried out at a slightly higher rate than on pasture. The higher application rate was applied by manure spreader while the lowest application rates were reported for deep or shallow injection.

To comply with the recommendation of 250 kg ha⁻¹ of total nitrogen in any 12 months as recommended in the Code of Good Agricultural Practice for the Protection of Water (MAFF 1991 as amended in 1998), and using the average nitrogen content of sludges recycled to agriculture in England and Wales of 44 000 mg kg⁻¹, the application of sludge should be about 5.5 tds ha⁻¹.

Table 5.4 Average application rate by application method and land use in England and Wales (tds ha⁻¹)

Application method	Arable	Pasture
Splash plate	4.9	4.2
Surface application	4.7	3.7
Manure Spreader	13.0	10.0
Injection to plough depth	5.8	4.9
Shallow injection	1.3	1.0
Other	2.4	3.4

5.2 Scottish Authorities

The total area of land to which sludge was applied in 1996/7 in Scotland was 4200 ha (Table 5.5). This includes around 600 land units divided between arable (67%), and pasture (33%). Arable land use dominates in East and North of the Scottish regions while in the West, most sludge was applied to grassland (Table 5.5 and Figure 5.1). Some of these units were receiving sludge several times that year.

The most common spreading methods were splash plate applicator from tanker and injection to plough depth both for arable and pasture land (Table 5.6). The average application rates of sludge for 1996/7 were 3.9 tds ha⁻¹ for arable land (ranging between 1.4 to 9.3 tds ha⁻¹) and 1.9 tds ha⁻¹ for pasture (ranging between 1.1 to 50 tds ha⁻¹) (Table 5.7).

Table 5.5 Area of agricultural land utilised for sewage sludge recycling in Scotland (1996/7)

Local region	Arable			Pasture			Total	
	ha	n	%	ha	n	%	ha	n
Scotland East	1122	156	87	169	32	13	1291	188
Scotland North	1523	198	74	537	56	26	2060	254
Scotland West	170	24	20	682	131	80	852	155
Scotland	2815	378	67	1388	219	33	4203	597

Table 5.6 Spreading method by land use in Scotland (%)

Application method	Arable	Pasture
Splash plate	55	28
Surface application	-	7
Manure spreader	14	<1
Injection to plough depth	31	65

Note: Units are percent of total hectareage that received sludge during that year

Table 5.7 Average application rate by application method and land use in Scotland (tds ha⁻¹)

Application method	Arable	Pasture
Splash plate	1.4	1.1
Surface application		2.2
Manure spreader	9.3	50
Injection to plough depth	5.4	2.2

The quality of agricultural land used for sewage sludge recycling for each local region is shown in Appendix B. Soil PTE concentrations even at the 90%ile were well below the permissible limits for sludge application.

5.3 Northern Ireland

The total area receiving sludge in 1996/7 (Table 5.8) in Northern Ireland was 1200 ha. This does not include the area in the Eastern Division for which only qualitative information was supplied. The agricultural outlet in the Eastern Division is not the main outlet, however, the quantity of sludge recycled to land represented 34% of the whole quantity recycled in Northern Ireland. In the Western Division, agricultural land used for sludge recycling was a mixture of arable and grassland while in the Southern and Northern Divisions, sludge was mainly used on grassland.

Sludge recycled to agriculture in Northern Ireland was always surface applied (Table 5.9). In the Western Division sludge was applied by manure spreader while in the other three divisions, splash plate was the spreading method utilised.

Application rates were only supplied for the Western and Southern Divisions. In the Western Division, spreading rates are in the range of 8.6 tds ha⁻¹ of dewatered sludge, while in the Southern Division, the rate of application was an average of 1.9 tds ha⁻¹ for liquid digested sludge and 2.2 tds ha⁻¹ for liquid stored sludge.

In the three Divisions, the soil PTE concentrations, even at the 90%ile were well below the permissible limits for sludge application, except for nickel in one catchment of the Southern and Northern Division, this high concentration of metal in the soil being of geochemical origin (Table 5.10).

Table 5.8 Area of agricultural land utilised for sewage sludge recycling in Northern Ireland (1996/97)

Land use	Land area*		Land unit*
	(ha)	(%)	(n)
Arable	50	4	16
Pasture	1 156	96	579
Total	1 206		595

Note:

* Data for Eastern Division not supplied.

Table 5.9 Spreading method employed in Northern Ireland (1996/7)

Application method	Area* (%)
Splash plate	85
Manure spreader	15

Notes:

Units are percent of total hectareage that received sludge during that year

* Data for Eastern Division not supplied but sludge is applied mainly by splash plate

Table 5.10 Quality of agricultural soil used in Northern Ireland for sludge recycling (1996/7)

Parameter	pH range	UK Code of Practice	Soil concentration* (mg kg ⁻¹ ds)			n
			10%ile	Median	90%ile	
Zn	p1	200	49	84	118	77
	p2	200	54	85	119	169
	p3	200	25	83	128	309
	p4	300	50	92	167	35
Cu	p1	80	20	30	79	77
	p2	100	18	32	71	169
	p3	135	8	31	79	309
	p4	200	13	23	55	35
Ni	p1	50	16	33	85	76
	p2	60	17	33	96	169
	p3	75	10	34	114	309
	p4	110	14	21	66	35
Cd	p5	3	0.16	0.35	1.0	590
Pb	p5	300	12	24	43	595
Hg	p5	1	0.04	0.1	0.3	561
Cr	p5	400	22	54	100	592

Notes:

* Data for Eastern Division not supplied

- p1 Soil pH 5.0 to <5.5
- p2 Soil pH 5.5 to <6.0
- p3 Soil pH 6.0 to 7.0
- p4 pH>7.0
- p5 pH>5.0

REFERENCES

CEC (1991) Council Directive of 21 May 1991 concerning urban wastewater treatment (91/271/EEC). *Official Journal* L135, 40-52.

MAFF (1998) The Water Code - Revised 1998. Code of Good Agricultural Practice for the Protection of Water. MAFF and Welsh Office, Agriculture Department, October 1998.

APPENDIX A

SURVEY DATA FOR EACH LOCAL REGION: ENGLAND AND WALES

ANGLIAN WATER

Table AW1 Current and future sludge quantities by outlets (tds a⁻¹), Anglian Water

Outlet	1996/7	2000/1	2005/6
Agriculture	100 700	124 500	71 000
Dedicated site	16 300	14 000	16 000
Incineration			
Sea disposal	9 800		
Landfill	1 700	1 000	1 000
Land reclamation		1 000	1 000
Forestry	100	1 000	1 000
Horticultural compost		500	1 000
Within curtilage		2 000	
Other		10 000*	45 000*
Total	128 600	154 000	136 000

* Aggregate production and gasification

Table AW2 Annual sludge production by works size (tds a⁻¹), Anglian Water (1996/7)

Outlet	Store		Small		Medium		Large	
	tds a ⁻¹	n	tds a ⁻¹	n	tds a ⁻¹	n	tds a ⁻¹	n
Agriculture	31 300	46	17 200	350	36 900	89	15 300	6
Dedicated site					1 700	1	14 600	2
Sea disposal							9 800	2
Landfill	100	1			1 600	2		
Forestry			100	18	<100	4		

Table AW3 Current and future treatment of sludge recycled in agriculture (tds a⁻¹), Anglian Water

Treatment	1996/97	2000/1	2005/6
Pasteurisation		10 000	35 000
Mesophilic anaerobic digestion	16 500	50 000	
MAD and dewatering and storage	14 600		
Composting	400	1 000	10 000
Co composting		1 000	1 000
Lime stabilization	3 300	5 000	5 000
Liquid storage for three months	7 400	1 000	
Dewatered and stored	3 700	500	
Thermal drying		6 000	20 000
None	54 800	50 000	
Total	100 700	124 500	71 000

Table AW4 Current treatment of sludge sent to other outlets (tds a⁻¹), Anglian Water (1996/7)

Treatment	Dedicated site	Sea disposal	Landfill	Forestry
Pasteurisation				
Mesophilic anaerobic digestion	9 500			
MAD and dewatering and storage			1 000	
Composting				
Co composting				
Lime stabilization				
Liquid storage for three months				
Dewatered and stored			700	
Thermal drying				
None	6 800	9 800		100
Total	16 300	9 800	1 700	100

Table AW5 Sludge treatment according to works size (tds a⁻¹); all outlets in Anglian Water (1996/7)

Treatment	Store	Small	Medium	Large
Mesophilic anaerobic digestion	10 700	400	5 400	9 500
MAD and dewatering and storage	4 600	300	5 400	5 400
Composting		300	100	
Lime stabilization	3 300			
Liquid storage for three months	6 100	800	600	
Dewatered and stored	1 500	300	2 500	
None	5 300	15 200	26 200	24 800

Table AW6 Quality of sludge according to outlet, Anglian Water (1996/7)

Parameter	Weighted average (mg kg ⁻¹ ds)				
	Agriculture	Dedicated site	Sea disposal	Landfill	Forestry
% ds	9	4	4	23	6
Nitrogen	37 500	56 100	68 100	34 000	25 700
NH ₃ -N	ns	ns	ns	ns	ns
Phosphorous	19 700	24 200	25 200	22 400	14 900
Zinc	711	703	467	963	460
Copper	472	401	401	566	313
Nickel	46	45	28	109	17
Cadmium	2.2	2.1	1.3	2.2	1.5
Lead	157	156	100	63	89
Mercury	2.2	1.8	1.3	1.9	1.0
Chromium	87	130	117	143	56
Molybdenum	7.5	10.3	5.6	8.2	5.0
Selenium	1.9	1.3	2.4	2.5	1.5
Arsenic	2.3	2.2	9.7	1.0	3.0
Fluorine	194	215	232	178	157

ns not supplied

Table AW7 Quality of sludge used in agriculture, Anglian Water (1996/7)

Parameter	Concentration (mg kg ⁻¹ ds)			Number of samples n
	10%ile	Median	90%ile	
% ds	2.01	5.19	11.1	503
Nitrogen	18 850	31 730	58 380	503
NH ₃ -N				ns
Phosphorous	11 425	16 954	27 242	503
Zinc	321	498	886	503
Copper	212	372	707	503
Nickel	11	18	45	499
Cadmium	0.75	1.3	2.5	328
Lead	33	67	170	498
Mercury	0.4	1.08	4.3	479
Chromium	11	17	100	500
Molybdenum	2.1	4.4	9	482
Selenium	0.8	1.7	2.9	498
Arsenic	0.4	1.7	3.6	481
Fluorine	93	170	289	440

ns not supplied

Table AW8 Land use and sludge application rate, Anglian Water (1996/7)

Landuse	Total area		Land unit (n)	Mean application rate (tds ha ⁻¹)	Applications (n)
	(ha)	(%)			
Arable	8 100	77	755	1.4	4 878
Pasture	2 500	23	330	1.0	2 070
Total	10 600		1 085		6 948

Table AW9 Spreading methods and application rate by land use, Anglian Water (1996/7)

Application method	Area (%)	Mean application rate (kg ha ⁻¹)	
		Arable	Pasture
Manure spreader	2	11.6	9.6
Injection to plough depth	92	1.1	0.9
Other	1	2.6	
Not specified	5	2.7	2.2

Table AW10 Quality of agricultural soil used for sludge recycling, Anglian Water (1996/7)

Parameter	pH class	10%ile	Median	90%ile	(n)
Zn	p1	52	77	85	5
	p2	29	57	91	28
	p3	28	64	112	224
	p4	28	58	101	821
Cu	p1	14	20	21	5
	p2	8	13	26	28
	p3	7	15	27	224
	p4	6	14	23	822
Ni	p1	19	21	28	5
	p2	4	15	31	28
	p3	7	21	32	223
	p4	7	18	32	820
Cd	p5	0.06	0.16	0.32	465
Pb	p5	12	22	40	1081
Hg	p5	0.03	0.08	0.20	629
Cr	p5	12	32	61	1076
Mo	p5	0.50	1.00	2.22	875
Se	p5	0.12	0.25	0.55	929
As	p5	4.5	10.0	20.5	1073
F	p5	15	34	101	577

p1 soil pH 5.0 to <5.5
p2 soil pH 5.5 to <6.0
p3 soil pH 6.0 to 7.0
p4 soil pH >7.0
p5 soil pH >5.0

NORTHUMBRIAN WATER

Table NW1 Current and future sludge quantities by outlets, Northumbrian Water (1996/7)

Outlet	1996/7	2000/1	2005/6
Agriculture	2 700	16 000	
Dedicated site			
Incineration			
Sea disposal	19 500		
Landfill	3 200	3 200	
Land reclamation			
Forestry			
Horticultural compost	12 400	12 400	
Within curtilage			
Other	1 400	36 400	86 000
Total	39 200	68 000	86 000

Table NW2 Annual sludge production by works size, Northumbrian Water (1996/7)

Outlet	Small		Medium		Large	
	tds a ⁻¹	n	tds a ⁻¹	n	tds a ⁻¹	n
Agriculture	800	7	2 000	7		
Dedicated site			1 400	1		
Sea disposal					19 500	2
Landfill			3 200	3		
Horticultural compost	100	1	12 300	1		

Table NW3 Current and future treatment of sludge recycled in agriculture, Northumbrian Water (tds a⁻¹)

Treatment	1996/97	2000/1	2005/6*
Pasteurisation			
Mesophilic anaerobic digestion	2 300	2300	
MAD and dewatering and storage	400	400	
Thermophilic aerobic digestion	10	10	
Composting			
Lime stabilization			
Liquid storage			
Unstabilised, dewatered and stored			
Thermal drying		13 300	
None			
Total	2 710	16 010	

* By 2005/6, al sludge produced should be diverted to gasification and power generation

Table NW4 Current treatment of sludge sent to other outlets, Northumbrian Water (tds a⁻¹)

1996/97	Horticultural compost	Landfill	Sea disposal	Other*
Pasteurisation				
Mesophilic anaerobic digestion				1 400
Anaerobic digestion and dewatering and storage	100	1 300		
Thermophilic aerobic digestion				
Composting	12 300			
Lime stabilization				
Liquid storage				
Unstabilised, dewatered and stored		1 900		
Thermal drying				
None			19 500	
Total	12 400	3 200	19 500	1 400

* Other includes disposal outside curtilage, not used for cropping nor grazing

Table NW5: Sludge treatment according to works size, all outlets in Northumbrian Water (1996/7) (t ds a⁻¹)

Treatment	Small	Medium	Large
Mesophilic anaerobic digestion	800	3 000	
MAD and dewatering and storage	100	1 700	
Thermophilic aerobic digestion	10		
Composting		12 300	
Dewatered and stored		1 900	
None			19 500

Table NW6: Quality of sludge according to outlet, Northumbrian Water (1996/7)

Outlet	Weighted average (mg kg ⁻¹ ds)				
	Agriculture	Dedicated site	Sea disposal	Landfill	Horticultural compost
% ds	8	4	4	25	32
Tot N	58 500			37 000	31 000
NH ₃ -N					
Tot P	33 600			21 100	5 100
Zinc	676	900	212	3 387	401
Copper	410	330	261	406	200
Nickel	45	72	30.2	106	2.42
Cadmium	1.93	4	1.00	10.2	2.01
Lead	246	180	134	237	170
Mercury	1.08	0.76	1.41	1.38	0.90
Chromium	29.9	100	31.0	213	105
Molybdenum	7.45	10	10.0	6.39	4.99
Selenium	1.09		0.71	1.44	1.40
Arsenic	6.37		2.00	2.71	2.00
Fluorine	129			178	136

Table NW7 Quality of sludge used in agriculture, Northumbrian Water (1996/7)

	Concentration (mg kg ⁻¹ ds)			Number of samples
	10%ile	Median	90%ile	(n)
% ds	2.8	3.3	4.1	14
Nitrogen	41 000	55 000	77 350	14
NH ₃ -N				ns
Phosphorous	22 300	33 100	48 180	14
Zinc	343	575	1 016	14
Copper	196	320	526	14
Nickel	3.2	20.5	81.3	14
Cadmium	1.27	2	2	14
Lead	74.1	180	338	14
Mercury	0.5	1.1	2.36	14
Chromium	2.6	27.5	71.4	14
Molybdenum	2	2	4.7	14
Selenium	0.4	1.1	2.21	14
Arsenic	1	3	5.4	14
Fluorine	84.9	140	293	14

ns not supplied

Table NW8 Sludge application rate by land use, Northumbrian Water (1996/7)

Landuse code	Total area		Land unit (n)	Mean application rate (tds ha ⁻¹)	Application rate (n)
	(ha)	(%)			
Arable	700	70	132	7.8	186
Pasture	300	30	75	8.0	116
Total	1 000		207		302

Table NW9 Spreading methods and application rate by land use, Northumbrian Water (1996/7)

Application method	Total area (%)	Mean application rate (kg/ha)	
		Arable	Pasture
Splash plate applicator from tanker	100	7.8	8.0

Table NW10 Quality of agricultural soil, used for sludge recycling, Northumbrian Water (1996/7)

	pH group	10%ile	Median	90%ile	(n)
Zn	p1	36	56	83	14
	p2	37	55	78	48
	p3	29	52	80	8
	p4	16	50	80	12
Cu	p1	5	12	21	14
	p2	7	13	27	48
	p3	6	14	34	8
	p4	7	13	33	12
Ni	p1	7	17	28	14
	p2	9	17	24	48
	p3	8	17	34	8
	p4	8	17	33	12
Cd	p5	0.9	1	2	207
Pb	p5	24	50	110	207
Hg	p5	0.07	0.1	0.2	207
Cr	p5	9	21	42	207
Mo	p5	0.3	1	3	207
Se	p5				0
As	p5	2	5	10	207
F	p5	26	44	91	207

p1 soil pH 5.0 to <5.5
p2 soil pH 5.5 to <6.0
p3 soil pH 6.0 to 7.0
p4 soil pH >7.0
p5 soil pH >5.0

NORTH WEST WATER

Table NWW1 Current and future sludge quantities by outlets, North West Water (tds a⁻¹)

Outlet	1995/6*	1996/7	2000/1	2005/6
Agriculture	35 500	39 400	121 300	79 600
Dedicated site				
Incineration		14 100	32 700	76 700
Sea disposal		59 400		
Landfill		17 800	18 400	16 900
Land reclamation				
Forestry				
Horticultural compost				
Within curtilage		2 300		
Other				
Total	35 500	130 700	172 400	173 200

Data for 1995/6 only supplied for agricultural outlet

Table NWW2a Annual sludge production by works size, North West Water (1995/6)

Outlet	Small	Medium	Large
Agriculture	1 100	27 800	6 600
Incineration			
Sea disposal			
Landfill			
Within curtilage			

Data for 1995/6 only supplied for agricultural outlet

Table NWW2b Annual sludge production by works size, North West Water (1996/7)

Outlet	Small	Medium	Large
Agriculture	1 200	21 300	17 000
Incineration			14 100
Sea disposal	800	500	58 200
Landfill	50	1 600	16 200
Within curtilage		2 300	

Table NWW3 Current and future treatment for sludge recycled in agriculture, North West Water (tds a⁻¹)

	1995/96	1996/97	2000/1	2005/6
Pasteurisation				
Mesophilic anaerobic digestion	30 600	29 800	53 400	79 550
MAD and dewatering and storage	-	800	46 300	
Thermophilic aerobic digestion				
Composting				
Lime stabilization	1 000	3 000	1 100	
Liquid storage for three months	-	500	400	
Dewatered and stored	1 300	1 900	3 700	
Thermal drying				
None	2 400	3 400	16 400	
Total	35 300	39 400	121 300	79 550

Table NWW4 Current treatment of sludge sent to other outlet, North West (tds a⁻¹)

1996/97	Incineration	Sea disposal	Landfill	Within curtilage
Pasteurisation				
Mesophilic anaerobic digestion		58 200	<100	700
Anaerobic digestion and dewatering and storage				
Thermophilic aerobic digestion				
Composting				
Lime stabilization				
Liquid storage for three months				
Unstabilised, dewatered and stored			17 800	
Thermal drying				
None	14 100	1 200	<100	1 600
Total	14 100	59 400	17 800	2 300

Table NWW5 Sludge treatment according to works size, all outlets in North West Water (1996/7)

Treatment	Small	Medium	Large
Mesophilic anaerobic digestion	400	16 000	72 300
Anaerobic digestion and dewatering and storage			800
Lime stabilization		3 000	
Liquid storage for 3 months		500	
Unstabilised, dewatered and stored		2 000	17 600
None	1 600	4 100	14 700

Table NWW6 Quality of sludge according to outlet, North West Water (1996/7)

Outlet	Weighted average (mg kg ⁻¹ ds)				
	Agriculture	Incineration	Sea disposal	Landfill	Within curtilage
% ds	7	5	3	30	5
Tot N	50 000			41 600	38 300
NH ₃ -N					24 900
Tot P	19 100			13 300	18 900
Zinc	1 000		1 200	800	800
Copper	709		639	456	505
Nickel	63		56	57	51
Cadmium	3		4	4	5
Lead	380		1 196	441	241
Mercury	2		1.9	0.7	4
Chromium	165		503	287	46
Molybdenum	11			9	6
Selenium	1.3			0.7	1.1
Arsenic	6		3	4	4
Fluorine	211		55	153	95

Table NWW7 Quality of sludge used in agriculture, North West Water (1996/7)

	Concentration (mg kg ⁻¹ ds)			Number of samples (n)
	10%ile	Median	90%ile	
%ds	3	5	9	49
Tot N	33 150	46 100	66 000	49
NH ₃ N				ns
Tot P	7 100	15 100	23 900	49
Zn	397	747	1 562	49
Cu	180	459	1 106	49
Ni	13	21	96	49
Cd	1	2	5	49
Pb	114	219	481	49
Hg	1	2	5	49
Cr	15	38	168	49
Mo	3	7	15	49
Se	0	1	1	49
As	2	3	10	48
F	52	92	395	49

ns not supplied

Table NWW8 Land use and sludge application rate, North West Water (1996/7)

Landuse code	Total area		Land unit (n)	Mean application rate (tds ha ⁻¹)	Applications (n)
	(ha)	(%)			
Arable	2 000	21	500	4.8	500
Pasture	7 400	79	2 205	3.7	2 205
Total	9400		2 705		2 705

Table NWW9 Spreading methods and application rate, North West Water (1996/7)

Application method	Total area %	Mean application rate (kg ha ⁻¹)	
		Arable	Pasture
Splash plate applicator from tanker	30	2.8	4.1
Umbilical fed surface application	21	4.1	4.1
Application from solid manure spreader	3	10.6	60.9
Injection to plough depth	7	4.7	4.4
Other	39	4.0	3.5

Table NWW10 Quality of agricultural soil used for sludge recycling, North West Water (1996/7)

	pH class	10%ile	Median	90%ile	(n)
Zn	5.0 > 5.5	33	60	96	584
	5.5 < 6.0	35	62	105	926
	6.0 to 7.0	29	59	106	1 082
	> 7.0	29	59	118	113
Cu	5.0 > 5.5	10	20	35	584
	5.5 < 6.0	10	21	38	925
	6.0 to 7.0	8	19	38	1 082
	> 7.0	8	18	38	113
Ni	5.0 > 5.5	6	13	21	584
	5.5 < 6.0	7	14	24	926
	6.0 to 7.0	6	13	24	1 081
	> 7.0	5	13	25	113
Cd	5.0 > 7.0	0.16	0.50	1.60	2 702
Pb	5.0 > 7.0	23	48	89	2 704
Hg	5.0 > 7.0	0.06	0.14	0.40	2 660
Cr	5.0 > 7.0	10	20	36	2 703
Mo	5.0 > 7.0	0.19	0.88	1.60	2 377
Se	5.0 > 7.0	0.07	0.20	0.59	218
As	5.0 > 7.0	4.2	9.8	22	218
F	5.0 > 7.0	19	29	50	238

SEVERN TRENT WATER

Table STW1 Current and future sludge quantities by outlets, Severn Trent Water (tds a⁻¹)

Outlet	1995/6	1996/7	2000/1	2005/6
Agriculture	54 100	56 900	65 000	65 000
Dedicated site	22 400	22 600	22 100	22 100
Incineration	51 600	41 300	55 000	55 000
Sea disposal				
Landfill	28 200	37 700	20 000	20 000
Land reclamation	11 400	3 300	4 000	4 000
Forestry	600	900	1 000	1 000
Horticultural compost Within curtilage Other				
Total	168 300	162 700	167 100	167 100

Table STW2a Annual sludge production by works size, Severn Trent Water (1995/6)

Outlet	Small	Medium	Large
Agriculture	1 100	34 200	18 800
Dedicated site	1 100	8 200	13 100
Incineration			51 600
Landfill		5 400	22 800
Land reclamation		2 500	8 900
Forestry			600

Table STW2b Annual sludge production by works size, Severn Trent Water (1996/7)

Outlet	Small	Medium	Large
Agriculture	700	35 100	21 100
Dedicated site	200	8 200	14 100
Incineration		900	40 400
Landfill		4 700	33 000
Land reclamation		1 400	1 900
Forestry			900

Table STW3 Current and future treatment of sludge recycled to agriculture, Severn Trent Water

	1996/7	2000/1	2005/6
Pasteurisation			
Mesophilic anaerobic digestion	39 500		
MAD and dewatering and storage	10 000	60 000	60 000
Thermophilic aerobic digestion			
Composting			
Lime stabilization			
Liquid storage for three months			
Unstabilised, dewatered and stored	3 700	5 000	5 000
Thermal drying			
None	3 700		
Total	56 900	65 000	65 000

Table STW4 Current treatment of sludge sent to other outlets, Severn Trent Water (tds a⁻¹)

1996/97	Dedicated site	Incineration	Land reclamation	Landfill	Forestry
Pasteurisation					
Mesophilic anaerobic digestion	15 400	900	<100		
Anaerobic digestion and dewatering and storage	5 400	40 400	2 600	33 000	900
Thermophilic aerobic digestion					
Composting					
Lime stabilization					
Liquid storage for three months					
Unstabilised, dewatered and stored	1 600	<100	700	4 700	
Thermal drying					
None	100			<100	
Total	22 500	41 300	3 300	37 700	900

Table STW5a · Sludge treatment according to works size, all outlets in Severn Trent Water (1995/6)

Treatment	Small	Medium	Large
Mesophilic anaerobic digestion MAD and dewatering and storage	50	32 700	21 600
Dewatered and stored	1 400	12 400	86 100
None	700	3 400	

Table STW5b · Sludge treatment according to works size, all outlets in Severn Trent Water (1996/7)

Treatment	Small	Medium	Large
Mesophilic anaerobic digestion Anaerobic digestion and dewatering and storage		34 900	20 900
Unstabilised, dewatered and stored	300	10 400	90 600
None	600	3 200	

Table STW6a · Quality of sludge according to outlet, Severn Trent Water (1995/6)

Outlet	Weighted average (mg kg ⁻¹ ds)					
	Agriculture	Dedicated site	Incineration	Landfill	Land reclamation	Forestry
% ds	8	7	3	3	32	31
Tot N	53 800	60 100	50 500	57 900	34 500	16 500
NH ₃ -N						
Tot P	20 800	20 600	21 500	23 000	11 900	10 000
Zinc	1 031	840	3 435	1 453	668	2 611
Copper	748	542	810	762	409	598
Nickel	72	90	190	198	23	72
Cadmium	4.4	6.9	6.0	10.1	3.7	6.2
Lead	243	398	219	253	116	597
Mercury	2.8	3.2	3.5	3.4	1.9	2.8
Chromium	157	131	660	311	60	200
Molybdenum	10.5	8.0	5.5	7.9	10.7	5.9
Selenium	1.2	1.7	1.0	1.6	0.8	0.7
Arsenic	7.3	6.3	7.6	8.9	4.3	9.7
Fluorine	289	322	351	427	212	325

Table STW6b Quality of sludge according to outlet, Severn Trent Water (1996/7)

Outlet	Weighted average (mg kg ⁻¹ ds)					
	Agriculture	Dedicated site	Incineration	Landfill	Land reclamation	Forestry
% ds	6.6	6.9	4.5	3.5	22.2	30.9
Tot N	59 600	63 500	57 900	50 900	31 000	27 750
NH ₃ -N						
Tot P	23 200	21 700	42 800	23 600	14 500	17 250
Zinc	1 183	1 177	691	1 647	1 609	2 506
Copper	741	567	432	835	528	672
Nickel	94	86	191	247	101	94
Cadmium	4.6	8.1	3.0	8.4	6.0	7.4
Lead	246	568	153	241	453	618
Mercury	3.7	3.8	3.7	4.0	2.9	3.6
Chromium	193	154	218	337	124	173
Molybdenum	9.0	8.3	3.4	7.3	9.6	9.3
Selenium	1.7	2.0	1.7	1.9	1.4	1.0
Arsenic	7.4	5.5	5.3	9.0	7.0	9.2
Fluorine	256	324	274	287	320	407

Table STW7 Quality of sludge used in agriculture, Severn Trent Water (1996/7)

	10%ile	Median	90%ile	(n)
%ds	2.8	5	11.2	86
Tot N	25 000	39 000	73 600	86
NH ₃ -N				ns
Tot P	9 000	17 100	27 200	86
Zn	428	682	1 408	86
Cu	199	372	886	86
Ni	11	22	86	86
Cd	3	3	5	86
Pb	44	131	369	86
Hg	0.6	2	5	86
Cr	13	30	175	86
Mo	2.6	5	10	86
Se	0.5	1.1	2.2	86
As	2.3	4.2	9.4	86
F	126	229	360	86

ns not supplied

Table STW8 Sludge application rate by land use , Severn Trent Water (1996/7)

Landuse	Total area		Land unit (n)	Mean application rate (tds ha-1)	Application (n)
	(ha)	(%)			
Arable	6 600	47	876	ns	909
Pasture	7 600	53	1 466	ns	1 506
Total	14 200		2 432		2 415

ns - data not supplied

Table STW10 Quality of agricultural soil used for sludge recycling, Severn Trent Water (1996/7)

Parameter	pH class	10%ile	Median	90%ile	(n)
Zn	p1	51	90	124	86
	p2	51	86	121	314
	p3	50	83	124	1 427
	p4	54	90	131	502
Cu	p1	11	19	35	86
	p2	13	21	36	314
	p3	12	21	36	1 427
	p4	11	22	38	502
Ni	p1	9	20	27	86
	p2	9	19	29	314
	p3	8	19	32	1 427
	p4	8	19	32	1 427
Cd	p5	0.5	1.3	1.7	2 287
Pb	p5	14	29	56	2 332
Hg	p5	0.05	0.10	0.26	2 235
Cr	p5	12	27	47	2 332
Mo	p5	1	1	2	2 285
Se	p5	0.1	0.2	0.5	2 283
As	p5	5	10	21	2 287
F	p5	105	188	282	2 288

p1 soil pH 5.0 to <5.5
 p2 soil pH 5.5 to <6.0
 p3 soil pH 6.0 to 7.0
 p4 soil pH >7.0
 p5 soil pH >5.0

SOUTHERN WATER

Table SW1 Current and future sludge quantities by outlets, Southern Water (tds a⁻¹)

Outlet	1995/6	1996/7	2000/1	2005/6
Agriculture	34 550	40 600	68 800	77 200
Dedicated site	4 300			
Incineration	8 900	4 300		
Sea disposal	1 200	8 200		
Landfill		9 600		
Land reclamation				
Forestry				
Horticultural compost				
Within curtilage	6 300	200		
Other				
Total	55 250	62 900		

Table SW2a Annual sludge production by works size, Southern Water (1995/6)

Outlet	Small	Medium	Large
Agriculture	3 000	28 200	3 350
Incineration			4 300
Sea disposal		8 900	
Landfill		1 200	
Within curtilage		4 100	2 200

Table SW2b Annual sludge production by works size, Southern Water (1996/7)

Outlet	Small	Medium	Large
Agriculture	1 200	32 100	7 300
Incineration			4 300
Sea disposal		5 900	2 400
Landfill		9 600	
Within curtilage			200

Table SW3 Current and future treatment for sludge recycled to agriculture, Southern Water

1996/97	1996/7	2000/1	2005/6
Pasteurisation			
Mesophilic anaerobic digestion	3 200	47 300	48 700
Anaerobic digestion and dewatering and storage	11 400		
Thermophilic aerobic digestion			
Composting	200		
Lime stabilization	2 900		
Liquid storage for three months	1 300		
Unstabilised, dewatered and stored	18 800		
Thermal drying		21 500*	28 500*
None	2 900		
Total	40 600	68 800	77 200

* treated sludge

Table SW4 Current treatment of sludge sent to other outlets, Southern Water (tds a⁻¹)

1996/97	Incineration	Sea disposal	Landfill	Within curtilage
Pasteurisation				
Mesophilic anaerobic digestion				
MAD and dewatering and storage			2 300	200
Thermophilic aerobic digestion				
Composting			1 500	
Lime stabilization				
Liquid storage for three months				
Dewatered and stored	4 300		5 900	
Thermal drying				
None		8 200		
Total	4 300	8 200	9 600	200

Table SW5a Sludge treatment according to works size, all outlets in Southern Water (1995/6)

Treatment	Small	Medium	Large
Mesophilic anaerobic digestion	400	1 800	
MAD and dewatering and storage	300	8 000	3 600
Composting			
Lime stabilization			
Liquid storage for 3 months	400	400	
Dewatered and stored	800	15 200	6 300
Other		6 300	
None	1 100	10 800	

Table SW5b Sludge treatment according to works size, all outlets in Southern Water (1996/7)

Treatment	Small	Medium	Large
Mesophilic anaerobic digestion		3 200	
Anaerobic digestion and dewatering and storage	300	10 700	2 900
Composting		1 600	
Lime stabilization		2 900	
Liquid storage for 3 months	200	1 100	
Unstabilised, dewatered and stored	400	19 600	8 900
Other			
None	400	8 400	2 400

Table SW6a Quality of sludge according to outlet, Southern Water (1995/6)

Outlet	Weighted average (mg kg ⁻¹ ds)				
	Agriculture	Incineration	Sea disposal	Landfill	Within curtilage
% ds	29	23	3	28	33
Tot N	29 600	43 000		24 700	25 400
NH ₃ -N					
Tot P	12 600	17 000		7 900	10 300
Zinc	638	435	592	456	2 039
Copper	502	558	595	323	470
Nickel	45	25	48	29	34
Cadmium	0.8	0.6	0.8	0.5	0.9
Lead	194	64	110	217	219
Mercury	2.3	1.6	1.5	2.1	3.6
Chromium	479	52	44	49	85
Molybdenum	10.5	8.2		3.3	21.1
Selenium	1.5	1.4		0.7	2.8
Arsenic	5.6	2.2		1.9	2.8
Fluorine	204	51		62	573

Table SW6b Quality of sludge according to outlet, Southern Water (1996/7)

Outlet	Weighted average (mg kg ⁻¹ ds)				
	Agriculture	Incineration	Sea disposal	Landfill	Within curtilage
% ds	23	25	3	31	33
Tot N	37 600	43 000	44 500	34 200	32 000
NH ₃ -N	3 900	3 000		3 50	2 800
Tot P	16 400	15 300		14 000	18 800
Zinc	745	447	578	1 544	1 036
Copper	586	501	360	409	844
Nickel	37	24	34	25	68
Cadmium	0.9	0.7	0.6	1.5	2.0
Lead	197	70	104	272	222
Mercury	2.5	1.2	1.2	2.1	3.9
Chromium	333	44	44	2 270	186
Molybdenum	10.8	5.4		15.7	27.8
Selenium	1.2	1.0		1.1	0.4
Arsenic	4.0	1.9		12.3	2.9
Fluorine	108	56		512	108

Table SW7 Quality of sludge used in agriculture, Southern Water (1996/7)

	10%ile	Median	90%ile	(n)
%ds	3.9	20.1	30.9	47
N	26 600	35 000	52 600	47
NH ₃ -N	1 300	2 800	7 500	47
P	9 400	15 300	23 800	47
Zn	449	627	1 158	47
Cu	378	535	899	47
Ni	14	26	99	47
Cd	0.3	0.6	2.1	47
Pb	82	185	366	47
Hg	1.1	2.3	4.9	47
Cr	14	26	204	47
Mo	2.7	4.6	27.3	47
Se	0.4	0.9	2.3	47
As	1.7	2.5	4.3	47
F	69	96	167	47

Table SW8 Land use and sludge application rate, Southern Water (1996/7)

Landuse	Total area		Land unit (n)	Mean application rate (tds ha ⁻¹)	Applications (n)
	(ha)	(%)			
Arable	3 258	86	794	7.3	887
Pasture	518	14	141	5.9	141
Total	3 776		935		1 028

Table SW9 Spreading method and application rate, Southern Water (1996/7)

Application method	Total area (%)	Mean application rate	
		Arable	Pasture
Splash plate applicator from tanker	10	5.6	4.4
Application from solid manure spreader	73	7.1	6.9
Injection to plough depth	18	8.6	7.3

Table SW10 Quality of agricultural soil used for sludge recycling, Southern Water (1996/7)

	pH class	10%ile	Median	90%ile	(n)
Zn	p1	40	63	88	29
	p2	46	73	107	84
	p3	41	64	96	375
	p4	42	69	107	445
Cu	p1	11	18	22	29
	p2	13	20	30	84
	p3	11	18	32	375
	p4	9	15	24	445
Ni	p1	9	16	26	29
	p2	8	18	32	84
	p3	9	17	27	375
	p4	7	18	30	445
Cd	p5	0.2	0.4	1	935
Pb	p5	18	30	51	935
Hg	p5	0.06	0.26	0.45	935
Cr	p5	16	33	53	935
Mo	p5	0.7	1.4	1.9	935
Se	p5	0.05	0.3	0.4	935
As	p5	3.3	7.6	17	935
F	p5	13	34	123	935

p1 soil pH 5.0 to <5.5
p2 soil pH 5.5 to <6.0
p3 soil pH 6.0 to 7.0
p4 soil pH >7.0
p5 soil pH >5.0

SOUTH WEST WATER

Table SWW1 Current and future sludge quantities by outlets, South West Water (tds a⁻¹)

Outlet	1995/6	1996/7	2000/1	2005/6
Agriculture Dedicated site	12 100	12 400	43 000	43 000
Incineration Sea disposal Landfill	2 300	2 300		
Land reclamation Forestry Horticultural compost Within curtilage Other	<100	<100	<100	<100
Total	14 400	14 700	43 000	43 000

Table SWW2a Annual sludge production by works size, South West Water (tds a⁻¹) (1995/6)

Outlet	Small	Medium
Agriculture	2 500	9 600
Sea disposal Landfill		2 300
Land reclamation		<100

Table SWW2b Annual sludge production by works size, South West Water (tds a⁻¹) (1996/7)

Outlet	Small	Medium
Agriculture	3 000	9 400
Sea disposal Landfill		2 300
Land reclamation		<100

Table SWW3 Current and future treatment of sludge recycled to agriculture, South West Water (tds a⁻¹)

Treatment	1996/7	2000/1	2005/6
Pasteurisation			
Mesophilic anaerobic digestion	5 400	5 500	5 500
MAD and dewatering and storage	900	1 000	1 000
Thermophilic aerobic digestion			
Composting			
Lime stabilization			
Liquid storage for three months	200	200	200
Unstabilised, dewatered and stored	4 300	4 500	4 500
Thermal drying of treated sludge			
Thermal drying of untreated sludge	100	2 500	2 500
Other		27 800	27 800
None	1 500	1 500	1 500
Total	12 400	43 000	43 000

Table SWW4 Current treatment of sludge sent to other outlets (tds a⁻¹)

1996/97	Land reclamation	Sea
Pasteurisation		
Mesophilic anaerobic digestion	<100	2 300
Anaerobic digestion and dewatering and storage		
Thermophilic aerobic digestion		
Composting		
Lime stabilization		
Liquid storage for three months		
Unstabilised, dewatered and stored		
Thermal drying of treated sludge		
Thermal drying of untreated sludge		
None		
Total	<100	2 300

Table SWW5a Sludge treatment according to works size, all outlets in South West Water (tds a⁻¹) (1995/6)

Treatment	Small	Medium
Mesophilic anaerobic digestion	900	6 900
Anaerobic digestion and dewatering and storage	400	1 500
Liquid storage for 3 months	200	
Unstabilised, dewatered and stored	300	3 200
Thermal drying of untreated sludge		700
None	700	1 000

Table SWW5b Sludge treatment according to works size, all outlets in South West Water (tds a⁻¹) (1996/7)

Treatment	Small	Medium
Mesophilic anaerobic digestion	1 400	6 300
Anaerobic digestion and dewatering and storage	500	400
Liquid storage for 3 months	200	
Unstabilised, dewatered and stored	400	4 000
Thermal drying of untreated sludge		100
None	600	900

Table SWW6 Quality of sludge according to outlet, South West Water (1996/7)

Outlet	Weighted average (mg kg ⁻¹ ds)		
	Agriculture	Sea disposal	Land reclamation
% ds	13	3	3
Tot N	39 400	48 400	35 700
NH ₃ -N			
Tot P	14 800	20 100	18 400
Zinc	591	742	935
Copper	336	343	308
Nickel	34	45	25
Cadmium	2.0	2.0	2.2
Lead	169	284	155
Mercury	1.8	2.9	1.8
Chromium	73	59	42
Molybdenum	10	32	9
Selenium	2.2	2.5	
Arsenic	5.7	5.0	
Fluorine			

Table SWW7 Quality of sludge used in agriculture, South West Water (1996/7)

	10%ile	Median	90%ile	(n)
%ds	2	5	26	40
Tot N	29 800	39 700	52 800	40
NH ₃ -N				ns
Tot P	8 800	15 150	20 900	40
Zn	363	626	899	40
Cu	136	246	472	40
Ni	16	29	58	40
Cd	2.0	2.0	2.0	40
Pb	99	150	299	40
Hg	0.9	1.8	3.2	40
Cr	26	46	114	40
Mo	5.0	5.6	11.4	20
Se	2.2	2.2	2.2	1
As	5.7	5.7	5.7	1
F				

ns not supplied

Table Sww8 Land use and sludge application rate, South West Water (1996/7)

Landuse	Area spread		Land unit (n)	Mean application rate (tds ha ⁻¹)	Applications (n)
	(ha)	(%)			
Arable	2 100	69	447	3.3	658
Pasture	1 000	31	227	2.4	363
Not supplied	<100		13	2.2	20
Total	3 100		687		1 041

Table Sww9 Spreading methods and application rate, South West Water (1996/7)

Spreading method	Total area (%)	Mean application rate (kg ha ⁻¹)	
		Arable	Pasture
Splash plate applicator from tanker	29	2.3	2.6
Application from solid manure spreader	25	5.5	5.0
Injection to plough depth	44	2.2	1.8

Table SWW10 Quality of agricultural soil used for sludge recycling, South West Water (1996/7)

	pH group	10%ile	Median	90%ile	(n)
Zn	p1	40	125	661	67
	p2	49	110	383	98
	p3	42	120	464	359
	p4	56	135	431	91
Cu	p1	10	46	144	67
	p2	11	36	156	98
	p3	12	33	129	359
	p4	14	42	130	91
Ni	p1	9	36	201	67
	p2	9	29	72	98
	p3	10	32	113	359
	p4	15	29	105	91
Cd	p5	0.5	2.0	6.0	615
Pb	p5	18	55	213	615
Hg	p5	0.1	0.2	0.7	614
Cr	p5	11	31	118	615
Mo	p5	0.5	5	21	606
Se	p5	1	1.1	2.0	74
As	p5	25	83	279	75
F	p5				ns

p1 soil pH 5.0 to <5.5
p2 soil pH 5.5 to <6.0
p3 soil pH 6.0 to 7.0
p4 soil pH >7.0
p5 soil pH >5.0
ns not supplied

THAMES WATER

Table TW1 Current and future sludge quantities by outlets, Thames Water (tds a⁻¹)

Outlet	1995/6	1996/7	2000/1	2005/6
Agriculture	133 500	144 100	145 500	155 000
Dedicated site				
Incineration			92 000	92 000
Sea disposal	82 700	72 300		
Landfill				
Land reclamation	83 700	53 600	16 000	16 000
Forestry				
Horticultural compost	600	1 100	1 000	1 000
Within curtilage	1 700	<100		
Other				
Total	302 200	270 100	254 500	264 000

Table TW2a Annual sludge production by works size (tds a⁻¹), Thames Water (1995/6)

Outlet	Small	Medium	Large
Agriculture	1 600	29 800	102 100
Sea disposal			82 700
Land reclamation		400	83 300
Horticultural compost		600	
Within curtilage		1 700	

Table TW2b Annual sludge production by works size (tds a⁻¹), Thames Water (1996/7)

Outlet	Small	Medium	Large
Agriculture	1 800	52 200	90 200
Sea disposal			72 300
Land reclamation		<100	53 600
Horticultural compost		1 100	
Within curtilage		100	

Table TW3 Current and future treatment for sludge recycled to agriculture, Thames Water (tds a⁻¹)

Treatment	1996/7	2000/1	2005/6
Pasteurisation			
Mesophilic anaerobic digestion	37 000	37 000	45 500
MAD and dewatering and storage	63 800	65 000	75 000
Thermophilic aerobic digestion			
Composting	4 000	4 000	4 000
Lime stabilization	15 000	15 000	15 000
Liquid storage for three months			
Dewatered and stored	10 600	10 600	10 600
Thermal drying			5 000
None	13 700	14 000	
Total	144 100	145 600	155 000

Table TW4 Current treatment of sludge sent to other outlets (tds a⁻¹)

1996/97	Horticultural compost	Land reclamation	Sea disposal	Within curtilage
Pasteurisation				
Mesophilic anaerobic digestion		4 500	71 200	
Anaerobic digestion and dewatering and storage		49 100		
Thermophilic aerobic digestion				
Composting	1 100			
Lime stabilization				
Liquid storage for three months				
Unstabilised, dewatered and stored				
Thermal drying				
None			1 200	100
Total	1 100	53 600	72 300	100

Table TW5a Sludge treatment according to works size (tds a⁻¹), all outlets in Thames Water (1995/6)

Treatment	Small	Medium	Large
Mesophilic anaerobic digestion		6 200	137 200
MAD and dewatering and storage		5 900	128 500
Composting		1 100	2 200
Lime stabilization			8 300
Unstabilised, dewatered and stored	900	7 300	10 300
None	700	12 200	15 700

Table TW5b Sludge treatment according to works size (tds a⁻¹), all outlets in Thames Water (1996/7)

Treatment	Small	Medium	Large
Mesophilic anaerobic digestion		8 300	104 500
MAD and dewatering and storage		6 800	106 200
Composting		1 100	4 000
Lime stabilization		15 000	
Dewatered and stored	1 000	9 500	
None	700	12 700	1 500

Table TW6a Quality of sludge according to outlet, Thames Water (1995/6)

Outlet	Weighted average (mg kg ⁻¹ ds)				
	Agriculture	Sea disposal	Land reclamation	Horticultural compost	Within curtilage
% ds					
Tot N					
NH ₃ -N					
Tot P					
Zinc	705	895	534	793	575
Copper	585	548	354	42	721
Nickel	63	50	101	98	22
Cadmium	5.1	3.4	12.8	1.5	3.8
Lead	233	388	253	197	86
Mercury	3.0	3.0	2.4	2.6	2.7
Chromium	131	85	280	140	40
Molybdenum	6.5		4.6	6.5	4.6
Selenium	2.4		1.2	3.3	2.2
Arsenic	4.0		6.0	1.6	3.4
Fluorine	246		97	271	172

Table TW6b Quality of sludge according to outlet, Thames Water (1996/7)

Outlet	Weighted average (mg kg ⁻¹ ds)				
	Agriculture	Sea disposal	Land reclamation	Horticultural compost	Within curtilage
% ds	25	2	59	38	6
Tot N	40 332		15 383	78 000	45 000
NH ₃ -N	8 665		4 079	4 000	31 000
Tot P	19 409		17 069	13 000	18 000
Zinc	663	912	684	681	825
Copper	620	564	450	1 192	604
Nickel	61	50	99	72	37
Cadmium	4.8	4.1	16.5	1.3	2.1
Lead	221	391	259	207	275
Mercury	2.1	2.7	2.4	2.0	1.9
Chromium	116	79	251	127	52
Molybdenum	5.2		5.4	4.4	4.0
Selenium	2.6		1.7	2.6	2.0
Arsenic	6.7		8.2	2.8	4.7
Fluorine	253		153	230	156

Table TW7 Quality of sludge used in agriculture, Thames (1996/7)

	10%ile	Median	90%ile	(n)
%ds	3	5	27	91
Tot N	29 000	45 000	60 965	91
NH ₃ -N	4 000	8 000	17 000	91
Tot P	11 000	17 000	25 000	91
Zn	475	641	896	91
Cu	310	604	920	91
Ni	18	34	81	91
Cd	0.9	1.9	5.5	91
Pb	60	115	312	91
Hg	0.8	1.8	2.8	91
Cr	23	50	213	91
Mo	3.0	3.8	6.9	91
Se	1.2	2.1	3.4	91
As	1.5	3.0	6.8	91
F	101	137	239	91

Table TW8 Land use and sludge application rate by land use, Thames Water (1996/7)

Landuse	Area spread		Land unit (n)	Mean application rate (tds ha ⁻¹)	Applications (n)
	(ha)	(%)			
Arable	10 600	75	2 655	5.1	5 383
Pasture	3 500	25	1 026	3.6	2 143
Total	14 100		3 681		7 526

Table TW9 Spreading method and application rate, Thames Water (1996/7)

Spreading method	Total area (%)	Mean application rate (tds ha ⁻¹)	
		Arable	Pasture
Splash plate applicator from tanker	19	4.5	4.9
Umbilical fed surface application	8	5.4	3.6
Application from solid manure spreader	28	10.7	8.5
Injection to plough depth	46	1.3	1.7
Other	0	2.0	1.5

Table TW10 Quality of agricultural soil used for sludge recycling, Thames Water (1996/7)

	pH group	10%ile	Median	90%ile	(n)
Zn	p1	24	44	71	55
	p2	25	43	87	192
	p3	32	59	103	1308
	p4	42	69	105	2142
Cu	p1	5	10	19	55
	p2	5	11	28	192
	p3	7	14	31	1308
	p4	8	16	29	2142
Ni	p1	6	11	26	55
	p2	5	12	23	192
	p3	6	17	32	1308
	p4	10	21	35	2142
Cd	p5	0.20	0.43	1.07	3697
Pb	p5	20	34	61	3697
Hg	p5	0.05	0.08	0.22	3697
Cr	p5	17	33	59	3697
Mo	p5	0.2	0.5	2.4	282
Se	p5	0.1	0.2	0.5	301
As	p5	3.0	7.9	15	308
F	p5	19	39	93	320

p1 soil pH 5.0 to <5.5
p2 soil pH 5.5 to <6.0
p3 soil pH 6.0 to 7.0
p4 soil pH >7.0
p5 soil pH >5.0

WELSH WATER

Table WW1 Current and future sludge quantities by outlets, Welsh Water (tds a⁻¹).

Outlet	1996/7	2000/1	2005/6
Agriculture	23 300	66 600*	67 100*
Dedicated site			
Incineration			
Sea disposal			
Landfill			
Land reclamation			
Forestry			
Horticultural compost			
Within curtilage			
Other			
Total	23 300[#]	66 600	67 100

[#] A small quantity was also reported to be sent to another unspecified outlet.

* A proportion of sludge may also be gasified for energy production

Table WW2 Annual sludge production by works size (tds a⁻¹), Welsh Water (1996/7).

Outlet	Small	Medium
Agriculture	5 500	17 900

Table WW3 Current and future treatment for sludge recycled to agriculture (tds a⁻¹), Welsh Water

	1996/7	2000/1*	2005/6*
Pasteurisation			
Mesophilic anaerobic digestion	9 200	36 500	32 100
Anaerobic digestion and dewatering and storage	2 800		
Thermophilic aerobic digestion			
TAD and dewatering and storage	300		
Composting			
Lime stabilization	3 500		
Liquid storage for three months	1 100		
Unstabilised, dewatered and stored	2 100		
Thermal drying of treated sludge			
Thermal drying of untreated sludge		28 200	35 000
None	4 400	1 900	
Total	23 300	66 600	67 100

* A proportion of sludge may also be gasified

Table WW5 Sludge treatment according to works size (tds a⁻¹), all outlets in Welsh Water (1996/7)

Treatment	Small	Medium
Mesophilic anaerobic digestion	3 300	5 900
Anaerobic digestion and dewatering and storage	800	2 000
TAD and dewatering and storage	300	
Lime stabilization	<100	3 400
Liquid storage for 3 months	800	300
Unstabilised, dewatered and stored		2 100
None	300	4 100

Table WW6/7 Quality of sludge used in agriculture, Welsh Water (1996/7)

Outlet	Concentration (mg kg ⁻¹ ds)				Number of sample (n)
	Weighted average	10%ile	Median	90%ile	
% ds	8	2	5	15	163
Tot N	57 138	30 600	50 250	88 520	58
NH ₃ -N					ns
Tot P	16 655	8 000	14 400	24 060	57
Zinc	1 035	291	575	1 141	79
Copper	291	95	238	418	79
Nickel	45	8.2	21	56	79
Cadmium	2.45	1.0	2.0	3.7	79
Lead	245	46	155	436	79
Mercury	1.70	0.3	1.5	4.3	79
Chromium	76	8.0	26	105	79
Molybdenum					ns
Selenium					ns
Arsenic					ns
Fluorine					ns

ns not supplied

Table WW8 Sludge application rate by land use, Welsh Water (1996/7)

Landuse	Area spread		Land unit (n)	Mean application rates (tds ha ⁻¹)	Applications (n)
	(ha)	(%)			
Arable	1 000	20	320		338
Pasture	4 100	80	1279	5.8	1 351
Total	5 100		1599		1 683

Table WW9 Spreading method and application rate, Welsh Water (1996/7)

Spreading method	Total area (%)	Mean Application rate (tds ha ⁻¹)
Splash plate applicator from tanker	51	4.5
Solid manure spreader	11	10
Injection to plough depth	34	6.8
Other	4	4.5

Table WW10 Quality of agricultural soil used for sludge recycling, Welsh Water (1996/7)

Parameter	pH class	10%ile	Median	90%ile	(n)
Zn	p1	47	79	131	151
	p2	49	78	130	356
	p3	48	77	141	792
	p4	53	84	154	283
Cu	p1	8	17	37	151
	p2	9	16	28	356
	p3	9	16	27	792
	p4	10	18	38	283
Ni	p1	9	18	29	151
	p2	10	19	30	356
	p3	10	20	31	792
	p4	10	18	32	283
Cd	p5	0.4	1.0	1.0	1 583
Pb	p5	22	42	109	1 584
Hg	p5	0.10	0.10	0.27	1 579
Cr	p5	16	28	50	1 584
Mo	p5				ns
Se	p5				ns
As	p5				ns
F	p5				ns

ns not supplied
p1 soil pH 5.0 to <5.5
p2 soil pH 5.5 to <6.0
p3 soil pH 6.0 to 7.0
p4 soil pH >7.0
p5 soil pH >5.0

WESSEX WATER

Table WXW1 Current and future sludge quantities by outlets, Wessex Water (tds a⁻¹)

Outlet	1995/6	1996/7	2000/1	2005/6
Agriculture	28 600	28 400	46 400	16 600
Dedicated site				
Incineration				
Sea disposal				
Landfill	4 300	1 800	2 900	2 800
Land reclamation	9 000	3 800		
Forestry				
Horticultural compost				
Within curtilage				
Other			8 700	36 000
Total	41 900	34 000	58 000	55400

Table WXW2a Annual sludge production by works size (tds a⁻¹), Wessex Water (1995/6)

Outlet	Store	Small	Medium	Large
Agriculture	5 900	3 800	15 900	3 000
Landfill	<100	100	1 800	2 400
Land reclamation				9 000

Table WXW2b Annual sludge production by works size (tds a⁻¹), Wessex Water (1996/7)

Outlet	Store	Small	Medium	Large
Agriculture	8 800	4 200	13 500	1 900
Landfill	100		1 700	
Land reclamation				3 800

Table WXW3 Current and future treatment of sludge recycled to agriculture (tds a⁻¹), Wessex Water

Treatment	1996/7	2000/1	2005/6
Pasteurisation			
Mesophilic anaerobic digestion	10 500	4300	
MAD and dewatering and storage	2 800	1200	
Thermophilic aerobic digestion			
Composting			1 100
Lime stabilization			
Liquid storage for three months			
Dewatered and stored	2 000	3 800	
Thermal drying of treated sludge	1 000	13 500	15 500
Thermal drying of untreated sludge		14 000	
None	12 100	9 638	
Total	28 400	46 400	16 600

Table WXW4 Current treatment of sludge sent to other outlets (tds a⁻¹) Wessex Water

1996/97	Dedicated site	Incineration	Sea disposal	Landfill	Land Reclamation
Pasteurisation					
Mesophilic anaerobic digestion					
MAD and dewatering and storage					
Thermophilic aerobic digestion					
Composting					
Lime stabilization					
Liquid storage for three months					
Dewatered and stored				1 703	
Thermal drying of treated sludge					3 787
None				67	
Total				1 770	3 787

Table WXW5a Sludge treatment according to works size (tds a⁻¹), all outlets in Wessex Water (1995/6)

Treatment	Store	Small	Medium	Large
Mesophilic anaerobic digestion	2 100		7 100	1 400
Anaerobic digestion and dewatering and storage	200	50		2 100
Unstabilised, dewatered and stored	500		2 200	
Thermal drying of treated sludge	200		1 800	9 000
None	2 900	3 500	6 600	

Table WXW5b Sludge treatment according to works size (tds a⁻¹), all outlets in Wessex Water (1996/7)

Treatment	Store	Small	Medium	Large
Mesophilic anaerobic digestion	1 900	100	6 900	1 600
Anaerobic digestion and dewatering and storage	2 500			300
Unstabilised, dewatered and stored	1 700	300	1 700	
Thermal drying of treated sludge			1 000	3 800
None	2 800	3 800	5 600	

Table WXW6a Quality of sludge according to outlet, Wessex Water (1995/6)

Outlet	Weighted average (mg kg ⁻¹ ds)		
	Agriculture	Landfill	Other
% ds	13	28	95
Tot N	35 616	40 530	35 643
NH ₃ -N			
Tot P	39 546	30 077	41 054
Zinc	842	929	991
Copper	523	434	378
Nickel	60	36	41
Cadmium	3.5	5.9	7.9
Lead	231	167	300
Mercury	2.5	2.7	3.4
Chromium	255	438	197
Molybdenum	23	49	
Selenium			
Arsenic	10	12	
Fluorine			

Table WXW6b Quality of sludge according to outlet, Wessex Water (1996/7)

Outlet	Weighted average (mg kg ⁻¹ ds)		
	Agriculture	Landfill	Land reclamation
% ds	12	29	94
Tot N	46 756	43 000	36 677
NH ₃ -N			
Tot P	39 832	28 050	38 894
Zinc	825	898	1 073
Copper	495	327	328
Nickel	61	21	52
Cadmium	3.7	2.5	12.3
Lead	189	123	324
Mercury	2.3	1.1	3.5
Chromium	235	86	184
Molybdenum	7.3		7.3
Selenium			
Arsenic	13		13
Fluorine			

Table WXW7 Quality of sludge used in agriculture, Wessex Water (1996/7)

	10%ile	Median	90%ile	(n)
%ds	3	6	9	229
Tot N	22 500	33 000	57 750	221
NH ₃ -N				ns
Tot P	18 800	27 400	42 667	221
Zn	438	649	1 120	222
Cu	266	403	709	222
Ni	13	18	57	222
Cd	1.1	1.7	4.4	222
Pb	52	95	280	222
Hg	0.5	1.3	3.5	222
Cr	15	25	184	222
Mo	7.3	7.3	7.3	1
Se				ns
As	13	13	13	1
F				ns

ns not supplied

Table WXW8 Land use and sludge application rate, Wessex Water (1996/7)

Landuse	Area spread		Land unit (n)	Mean application rate (tds ha ⁻¹)	Applications (n)
	(ha)	(%)			
Arable	4 383	72	1 087	1.6	3 160
Pasture	1 728	28	489	1.6	1 073
Total	6 111		1 576		4 233

Table WXW9 Spreading method and application rate, Wessex Water (1996/7)

Application method	Total area (%)	Mean application rate (tds ha ⁻¹)	
		Arable	Pasture
not specified	0.3	1.4	1.3
Splash plate applicator from tanker	8	4.4	2.4
Umbilical fed surface application	4	2.2	2.5
Application from solid manure spreader		5.5	
Injection to plough depth	35	1.1	1.8
Shallow injection (<=10 cm)	15	1.3	1.0
Other	32	1.3	1.0

Table WXW10 Quality of agricultural soil used for sludge recycling, Wessex Water (1996/7)

	pH class	10%ile	Median	90%ile	(n)
Zn	p1	15	42	89	127
	p2	16	44	101	190
	p3	20	47	111	546
	p4	40	80	119	712
Cu	p1	5	10	23	127
	p2	5	11	24	190
	p3	6	11	26	546
	p4	8	12	25	712
Ni	p1	1.6	7	24	127
	p2	3	9	27	190
	p3	3	11	30	546
	p4	11	21	36	712
Cd	p5	0.2	0.5	1.3	1 576
Pb	p5	15	26	44	1 576
Hg	p5	0.05	0.08	0.15	1 576
Cr	p5	8	23	43	1 576
Mo	p5	0.8	1.4	1.8	3
Se	p5				ns
As	p5	6	9	15	22
F	p5				ns

p1 soil pH 5.0 to <5.5
p2 soil pH 5.5 to <6.0
p3 soil pH 6.0 to 7.0
p4 soil pH >7.0
p5 soil pH >5.0
ns not supplied

YORKSHIRE WATER

Table YW1. Current and future sludge quantities by outlets, Yorkshire Water (tds a⁻¹)

Outlet	1995/6	1996/7	2000/1	2005/6
Agriculture	33 500	31 500	32 300	34 100
Dedicated site				
Incineration	32 500	31 100	68 200	68 200
Sea disposal	5 900	5 300		
Landfill	20 300	14 400	10 000	3 000
Land reclamation	5 300	2 000	31 500	50 100
Forestry				
Horticultural compost				
Within curtilage	14 100	12 500		
Other				
Total	111 600	96 800	142 000	155 400

Note: Landfill and Land reclamation data for future dates revised since National Presentation

Table YW2a Annual sludge production by works size (tds a⁻¹), Yorkshire Water (1995/6)

Outlet	Small	Medium	Large
Agriculture	5 600	22 900	5 000
Dedicated site			
Incineration			32 500
Sea disposal			5 900
Landfill	100	3 800	16 400
Land reclamation	<100	500	4 800
Within curtilage	3 100	5 100	5 900

Table YW2b Annual sludge production by works size (tds a⁻¹), Yorkshire Water (1996/7)

Outlet	Small	Medium	Large
Agriculture	2 500	22 000	6 900
Dedicated site			
Incineration		5 700	25 400
Sea disposal			5 300
Landfill		450	13 900
Land reclamation		900	1 200
Within curtilage	300	4 500	7 700

Table YW3 Current and future treatment of sludge recycled to agriculture (tds a⁻¹), Yorkshire Water

Treatment	1996/7	2000/1	2005/6
Pasteurisation			
Mesophilic anaerobic digestion	16 100	15 000	15 000
Thermophilic aerobic digestion	<100		
Composting			
Lime stabilization			
Liquid storage for three months	3 000		
Unstabilised, dewatered and stored	3 500		
Thermal drying			5 000
Other		17 200*	14 100*
None	8 900		
Total	31 500	32 300	34 100

Table YW4 Current treatment of sludge sent to other outlets (tds a⁻¹), Yorkshire Water

1996/7	Incineration	Land reclamation	Landfill	Within curtilage	Sea
Pasteurisation					
Mesophilic anaerobic digestion		900		1100	
Thermophilic aerobic digestion					
Composting					
Lime stabilization					
Liquid storage for three months				400	
Unstabilised, dewatered and stored		1 100	14 400	1 300	
Thermal drying					
Other	31 100				
None				9 700	5 300
Total	31 100	2 000	14 400	12 500	5 300

Table YW5a Sludge treatment according to works size (tds a⁻¹), all outlets in Yorkshire Water (1995/6)

Treatment	Small	Medium	Large
Mesophilic anaerobic digestion	1 900	14 400	9 800
Thermophilic aerobic digestion	<100		
Liquid storage for 3 months	800	700	
Unstabilised, dewatered and stored	500	7100	16 400
Other	100	1 700	32 500
None	5 500	7 800	11 800

Table YW5b Sludge treatment according to works size (tds a⁻¹), all outlets in Yorkshire Water (1996/7)

Treatment	Small	Medium	Large
Mesophilic anaerobic digestion	<100	16 600	1 400
Thermophilic aerobic digestion	<100		
Liquid storage for 3 months	100	1 000	2 300
Unstabilised, dewatered and stored	500	3 300	16 500
Other		5 700	25 400
None	2 300	7 000	14 700

Table YW6a Quality of sludge according to outlet, Yorkshire Water (1995/6)

Outlet	Weighted average (mg kg ⁻¹ ds)						
	Agriculture	Dedicated site	Incineration	Sea disposal	Landfill	Land reclamation	Within curtilage
% ds	6.7	7.4	19	8.3	43	34	19
Tot N	38 600	36 100	1 000	36 000	4 400	24 900	29 900
NH ₃ -N	8 900	4 400		1 700	900	900	1 800
Tot P	45 800	19 900	148 000	4 900	132 100	36 000	25 300
Zinc	797	668	628	389	662	995	498
Copper	389	248	415	179	487	364	305
Nickel	58	35	88	19	78	82	23
Cadmium	2.1	1.6	4.8	1.3	4.6	5.8	1.6
Lead	214	210	276	155	323	349	159
Mercury	2.3	1.5	0.3	1.0	0.3	1.4	1.2
Chromium	154	197	202	260	175	643	172
Molybdenum	11	10	73	10	55	10	10
Selenium	2.2	1.9	3.8	1.7	3.0	0.8	1.3
Arsenic	10	11	22	10	21	16	10
Fluorine	271	307	656	317	590	198	190

Table YW6b Quality of sludge according to outlet, Yorkshire Water (1996/7)

Outlet	Weighted average (mg kg ⁻¹ ds)						
	Agriculture	Dedicated site	Incineration	Sea disposal	Landfill	Land reclamation	Within curtilage
% ds	7.2	7.3	92	8.5	23	23	22
Tot N	38 800	37 000	1 000	33 600	39 400	39 900	32 300
NH ₃ -N	8 800	6 700		5 000	1 800	6 400	4 100
Tot P	48 400	45 400	139 500	38 900	12 900	43 100	52 700
Zinc	730	787	692	822	491	598	561
Copper	376	390	552	325	204	357	291
Nickel	57	68	80	89	35	100	26
Cadmium	1.9	3.7	5.0	4.4	1.7	1.9	1.5
Lead	200	252	371	287	269	172	169
Mercury	2.3	1.6	0.3	1.3	1.9	1.5	1.2
Chromium	353	577	179	249	252	218	1 196
Molybdenum	11	10	54	10	17	10	10
Selenium	2.3	1.7	3.0	1.4	3.3	2.4	1.3
Arsenic	10	16	21	20	10	10	10
Fluorine	284	365	639	320	314	294	392

Table YW7 Quality of sludge used in agriculture, Yorkshire Water (1996/7)

	10%ile	Median	90%ile	(n)
%ds	3	5	10	95
Tot N	22 300	31 800	44 500	93
NH ₃ -N	1000	3 100	13 300	93
Tot P	21 100	35 100	57 700	93
Zn	313	535	870	92
Cu	174	312	549	92
Ni	12	23	65	92
Cd	0.6	1.2	2.5	93
Pb	46	108	273	92
Hg	0.4	1.3	4.7	93
Cr	17	35	196	92
Mo	10	10	10	93
Se	0.5	1.5	3.1	93
As	10	10	10	93
F	80	140	310	93

Table YW8 Land use and sludge application rate by land use, Yorkshire Water (1996/7)

Landuse	Area spread		Land unit (n)	Mean application rate (tds ha ⁻¹)	Applications (n)
	(ha)	(%)			
Arable	4 400	76	605	5.8	605
Pasture	1 400	24	330	5.1	330
Total	5 800		935		935

Table YW9 Spreading method employed, Yorkshire (1996/7)

Spreading method	Total area (%)	Mean application rate (tds ha ⁻¹)	
		Arable	Pasture
Not specified	6	5.9	5.4
Splash plate applicator from tanker	47	5.6	5.3
Application from solid manure spreader	6	10.6	7.1
Injection to plough depth	27	6.4	1.9
Other	14	4.3	4.6

Table YW10 Quality of agricultural soil used for sludge recycling, Yorkshire Water (1996/7)

Parameter	pH group	10%ile	Median	90%ile	(n)
Zn	p1	67	112	162	31
	p2	54	110	161	155
	p3	38	102	159	615
	p4	26	92	176	136
Cu	p1	17	31	62	31
	p2	15	32	50	155
	p3	11	28	51	615
	p4	8	23	54	136
Ni	p1	10	20	34	31
	p2	10	20	31	155
	p3	7	20	32	613
	p4	6	15	30	136
Cd	p5	0.10	0.27	0.69	946
Pb	p5	29	64	101	946
Hg	p5	0.06	0.12	0.27	946
Cr	p5	13	33	55	946
Mo	p5	0.48	1.14	2.38	946
Se	p5	0.24	0.50	0.85	946
As	p5	5	9	20	946
F	p5	30	49	87	946

p1 soil pH 5.0 to 5.5
p2 soil pH 5.5 to 6.0
p3 soil pH 6.0 to 7.0
p4 soil pH >7.0
p5 soil pH >5.0

APPENDIX B

SURVEY DATA FOR EACH LOCAL REGION: SCOTLAND

WEST OF SCOTLAND

Table WoS1 Current and future sludge quantities by outlets, West of Scotland (tds a⁻¹)

Outlet	1996/7	2000/1	2005/6
Agriculture	4 500	2 800	3 000
Dedicated site			
Incineration			
Sea disposal	71 300		
Landfill			
Land reclamation			
Forestry	1 200		
Horticultural compost			
Within curtilage			
Other		76 200*	80 000*
Total	77 000	79 000	83 000

* Other include energy production

Table WoS2 Annual sludge production by works size, West of Scotland (1996/7)

Outlet	Medium	Large
Agriculture	4 500	
Sea disposal		71 300
Land reclamation		1 200

Table WoS3 Current and future treatment of sludge recycled to agriculture, West of Scotland

Treatment	1996/7	2000/1	2005/6
Pasteurisation			
Mesophilic anaerobic digestion	1 500	2 800	3 000
MAD and dewatering and storage			
Thermophilic aerobic digestion			
TAD and dewatering and storage			
Composting			
Co-composting			
Lime stabilization			
Liquid storage for three months			
Dewatered and stored			
Thermal drying			
Other			
None	3 000		
Total	4 500	2 800	3 000

Table WoS4 Current treatment of sludge sent to other outlets (tds a⁻¹)

Treatment 1996/97	Sea disposal	Land Reclamation
Pasteurisation		
Mesophilic anaerobic digestion		
MAD and dewatering and storage		1 200
Thermophilic aerobic digestion		
TAD and dewatering and storage		
Composting		
Co-composting		
Lime stabilization		
Liquid storage for three months		
Dewatered and stored		
Thermal drying		
Other		
None	71 300	
Total	71 300	1 200

Table WoS5 Sludge treatment according to works' size, all outlets in West of Scotland (1996/7)

Treatment	Medium	Large
Mesophilic anaerobic digestion MAD and dewatering and storage	1 500	1 200
None	3 000	71 300

Table WoS6 Quality of sludge according to outlet, West of Scotland (1996/7)

Parameter	Weighted average (mg kg ⁻¹ ds)		
	Agriculture	Sea disposal	Land reclamation
% ds	4	5	29
N	83 800	39 400	44 000
NH ₃ -N	23 000		
P	36 600	21 900	
Zinc	470	1 256	713
Copper	228	333	395
Nickel	29	40	49
Cadmium	0.9	1.6	2.0
Lead	203	208	236
Mercury	1.2	1.2	2.4
Chromium	55	309	126
Molybdenum	1.0		
Selenium	0.1		
Arsenic	1.2	6.6	
Fluorine	132		

Table WoS7 Quality of sludge recycled to agriculture, West of Scotland (1996/7)

Parameter	Concentration (mg kg ⁻¹ ds)			Number of samples (n)
	Min	Mean	Max	
%ds	2.1	3.1	6.7	9
N	9 900	55 340	111 000	9
NH ₃ -N	21 800	23 750	25 500	3
P	9 900	33 739	46 000	9
Zn	352	580	804	9
Cu	114	236	292	9
Ni	13	32	44	9
Cd	0.1	1.0	1.9	9
Pb	56	171	276	9
Hg	0.6	1.7	2.2	9
Cr	49	60	75	9
Mo	1.0	1.0	1.0	3
Se	0.05	0.05	0.05	3
As	0.3	1.8	4.6	5
F	108	136	186	3

Table WoS8 Land use and sludge application rate, West of Scotland (1996/7)

Landuse code	Area spread	Land unit (n)	Mean application rate (tds ha ⁻¹)	Applications (n)
	(ha)			
Arable	200	24	8.8	24
Pasture	700	131	2.2	137
Total	900	155		161

Table WoS9 Spreading method and application rate, West of Scotland (1996/7)

Application method	% of total area	Mean application rate (tds ha ⁻¹)	
		Arable	Pasture
Splash plate applicator from tanker	46		0.7
Umbilical fed surface application	20		2.2
Injection to plough depth	33	8.8	9.1

Table WoS10 Quality of agricultural land used for sludge recycling, West of Scotland (1996/7)

Parameter	pH class	10%ile	Median	90%ile	(n)
Zn	5.0 < 5.5	36	60	106	24
	5.5 < 6.0	31	56	94	65
	6.0 to 7.0	34	60	110	65
	> 7.0	74	78	81	2
Cu	5.0 < 5.5	8	15	24	24
	5.5 < 6.0	6	15	27	65
	6.0 to 7.0	7	15	24	65
	> 7.0	13	18	22	2
Ni	5.0 < 5.5	9	16	39	24
	5.5 < 6.0	12	19	29	65
	6.0 to 7.0	13	21	31	65
	> 7.0	25	29	32	2
Cd	5.0 +	0.05	0.1	1.0	157
Pb	5.0 +	17	27	61	157
Hg	5.0 +	0.1	0.1	0.5	149
Cr	5.0 +	25	41	60	157
Mo	5.0 +	1.0	1.0	3.9	36
Se	5.0 +	0.2	0.4	1.0	36
As	5.0 +	3.5	6.0	9.0	36
F	5.0 +	30	83	253	36

Note: Soil pH 5.0+ equivalent to all pH values; 5.0 and above

EAST OF SCOTLAND

Table EoS1 Current and future sludge quantities by outlets, East of Scotland (tds a⁻¹)

Outlet	1996/7	2000/1	2005/6
Agriculture	9 700	40 700	43 400
Dedicated site			
Incineration			
Sea disposal	15 800		
Landfill	4 900	2 000	
Land reclamation		1 800	14 700
Forestry		1 000	1 000
Horticultural compost			
Within curtilage			
Other			
Total	30 400	45 500	59 100

Table EoS2 Annual sludge production by works size, East of Scotland (1996/7)

Outlet	Small	Medium	Large
Agriculture	1 000	8 700	
Sea disposal			15 750
Landfill		4 900	

Table EoS3 Current and future sludge treatment for sludge recycled to agriculture, East of Scotland

Treatment	1996/7	2000/1	2005/6
Pasteurisation		1 500	2 000
Mesophilic anaerobic digestion		300	300
MAD and dewatering and storage	4 900		
Thermophilic aerobic digestion			
TAD and dewatering and storage			
Composting			
Co-composting			
Lime stabilization			
Liquid storage for three months	100		
Unstabilised, dewatered and stored	3 700	500	
Thermal drying of treated sludge		28 200	30 300
Thermal drying of untreated sludge		10 200	10 900
Other			
None	1 000		
Total	9 700	40 700	43 400

Table EoS4 Current treatment for sludge sent to other outlets (tds a⁻¹)

Treatment	Sea disposal	Landfill
Pasteurisation		
Mesophilic anaerobic digestion		
Anaerobic digestion and dewatering and storage		2 700
Thermophilic aerobic digestion		
TAD and dewatering and storage		
Composting		
Co-composting		
Lime stabilization		
Liquid storage for three months		
Unstabilised, dewatered and stored		2 200
Thermal drying of treated sludge		
Thermal drying of untreated sludge		
Other		
None	15 750	
Total	15 750	4 900

Table EoS5. Sludge treatment according to works size, all outlets in East of Scotland (1996/7)

Treatment	Small	Medium	Large
MAD and dewatering and storage	100	7 400	
Liquid storage for 3 months	100		
Dewatered and stored	500	5 400	
None	200	850	15 750

Table EoS6. Quality of sludge according to outlet, East of Scotland (1996/7)

Outlet	Weighted average (mg kg ⁻¹ ds)		
	Agriculture	Sea disposal ¹	Landfill
% ds	12	4	17
N	20 400		49 600
NH ₃ -N	ns		
P	11 400		12 200
Zinc	844		564
Copper	920		165
Nickel	41		19
Cadmium	1.4		1.2
Lead	390		131
Mercury	1.3		1.0
Chromium	139		52
Molybdenum	2.0		
Selenium	ns		
Arsenic	ns		
Fluorine	ns		

Notes:

¹ no quality data

ns not supplied

Table EoS7 Quality of sludge recycled to agriculture, East of Scotland (1996/7)

Parameter	Concentration (mg/kg ⁻¹ ds)			Number of samples (n)
	10%ile	Median	90%ile	
%ds	3.5	5.6	23.4	25
N	1 600	9 800	31 700	15
NH ₃ -N				ns
P	5 300	13 400	20 300	7
Zn	301	492	866	9
Cu	105	235	1 906	18
Ni	9	20	49	18
Cd	0.7	1.0	2.4	18
Pb	100	212	545	18
Hg	0.2	1.3	2.3	8
Cr	26	61	372	18
Mo	1.2	4.0	6.0	7
Se				ns
As				ns
F				ns

ns - not supplied

Table EoS8 Land use and sludge application rate, East of Scotland (1996/7)

Landuse	Area spread		Land unit (n)	Mean application rate (tds ha ⁻¹)	Applications (n)
	(ha)	(%)			
Arable	1 100	85	156	4.8	179
Pasture	200	15	32	2.4	32
Total	1300		188		211

Table EoS9 : Spreading method employed, East of Scotland (1996/7)

Application method	Area %	Mean application rate (tds ha ⁻¹)	
		Arable	Pasture
Splash plate applicator from tanker	63	2.6	2.5
Application from solid manure spreader	15	7.8	
Injection to plough depth	22	7.4	

Table EoS10 : Quality of agricultural land used for sludge recycling, East of Scotland (1996/7)

Parameter	pH class	10%ile	Median	90%ile	(n)
Zn	5.0 < 5.5	2.8	5.8	48	44
	5.5 < 6.0	2.9	7.2	74	44
	6.0 to 7.0	2.2	43	118	84
	> 7.0	29	54	74	7
Cu	5.0 < 5.5	2.5	4.8	15	44
	5.5 < 6.0	3.3	7.7	20	44
	6.0 to 7.0	2.6	6.8	26	84
	> 7.0	12	17	18	7
Ni	5.0 < 5.5	0.6	1.3	13	44
	5.5 < 6.0	0.8	1.5	20	44
	6.0 to 7.0	0.6	14	28	84
	> 7.0	0.9	13	20	7
Cd	5.0 +	0.1	0.3	1.0	182
Pb	5.0 +	4	22	53	189
Hg	5.0 +	0.08	0.2	0.9	68
Cr	5.0 +	16	29	57	182
Mo	5.0 +	0.4	1.0	3.5	25
Se	5.0 +	0.2	0.3	3.0	10
As	5.0 +	5	8	50	10
F	5.0 +	119	500	500	3

Note: Soil pH class 5.0 + includes all soils at pH 5.0 and above

NORTH OF SCOTLAND

Table NoS1 Current and future sludge quantities by outlets, North of Scotland (tds a⁻¹)

Outlet	1996/7	2000/1*	2005/6*
Agriculture	8 200	53 800	56 200
Dedicated site			
Incineration			
Sea disposal	1 500		
Landfill	<100		
Land reclamation			
Forestry			
Horticultural compost			
Within curtilage			
Other			
Total	9 800	53 800	56 200

* A five-fold increase following compliance with the Urban Wastewater Treatment Directive

Table NoS2 Annual sludge production by works size, North of Scotland (1996/7)

Outlet	Small	Medium
Agriculture	4 100	4 200
Sea disposal	1 000	500
Landfill	100	

Table NoS3 Current and future treatment of sludge recycled to agriculture , North of Scotland

Treatment	1996/7	2000/1	2005/6
Pasteurisation			
Mesophilic anaerobic digestion	900	5 000	6 400
MAD and dewatering and storage			
Thermophilic aerobic digestion			
TAD and dewatering and storage			
Composting			
Co-composting		500	500
Lime stabilization		4 200	4 800
Liquid storage for three months	3 100		
Dewatered and stored	3 300	8 300	8 700
Thermal drying of treated sludge		17 000	17 000
Thermal drying of untreated sludge			
Other		18 800	18 800
None	900		
Total	8 300	53 800	56 200

Table NoS4 Current treatment of sludge sent to other outlets

Treatment - 1996/7	Sea disposal	Landfill
Pasteurisation		
Mesophilic anaerobic digestion		
MAD and dewatering and storage		
Thermophilic aerobic digestion		
TAD and dewatering and storage		
Composting		
Co-composting		
Lime stabilization		
Liquid storage for three months		
Dewatered and stored		<100
Thermal drying of treated sludge		
Thermal drying of untreated sludge		
Other		
None	1 500	
Total	1 500	<100

Table NoS5 : Sludge treatment according to works size, all outlets in North of Scotland (1996/7).

Treatment	Small	Medium
Mesophilic anaerobic digestion	300	700
Liquid storage for 3 months	400	2 700
Unstabilised, dewatered and stored	2 600	700
None	1 900	500

Table NoS6 : Quality of sludge according to outlet, North of Scotland (1996/7)

Outlet	Weighted average (mg·kg ⁻¹ ds)		
	Agriculture	Sea disposal	Landfill
% ds	14	1.5	13
N	37 900	50 000	59 000
NH ₃ -N	8 500	6 250	
P	5 100	5 700	12 000
Zinc	555	318	792
Copper	490	112	429
Nickel	20	15	
Cadmium	1.9	1.3	0.8
Lead	172	89	363
Mercury	4.3	1.6	10.2
Chromium	29	21	19
Molybdenum	4.4	3.4	11
Selenium	1.3	0.8	
Arsenic	4.2	2.0	4.2
Fluorine	71	44	

Table NoS7 Quality of sludge recycled to agriculture, North of Scotland (1996/7)

Parameter	Concentration (mg kg ⁻¹ ds)			Number of samples (n)
	10%ile	Median	90%ile	
%ds	1.0	3.9	25.2	35
N	27 600	47 100	65 700	31
NH ₃ -N	3 600	7 500	21 600	22
P	800	6 000	17 000	31
Zn	314	508	870	32
Cu	175	269	881	32
Ni	7.1	17.5	36.4	29
Cd	0.8	1.7	3.8	30
Pb	66	161	248	32
Hg	0.9	2.4	7.8	32
Cr	9.0	23.5	53.4	32
Mo	1.1	4.0	7.3	30
Se	0.8	1.2	2.4	22
As	1.4	3.7	5.6	30
F	39	59	81	22

Table NoS8 Land use and sludge application rate, North of Scotland (1996/7)

Landuse	Area spread			Mean application rate (tds ha ⁻¹)	Applications rate (n)
	(ha)	(%)	(n)		
Arable	1 500	74	198	2.9	302
Pasture	500	26	56	1.5	151
Total	2 000		254		453

Table NoS9 Spreading method and application rate, North of Scotland (1996/7)

Application method	% of total area	Mean application rate (tds ha ⁻¹)	
		Arable	Pasture
Splash plate applicator from tanker	37	0.8	1.0
Application from solid manure spreader	8	10.5	50.0
Injection to plough depth	55	3.3	1.2

Table NoS10 Quality of agricultural land used for sludge recycling, North of Scotland (1996/7)

	pH class	10%ile	Median	90%ile	(n)
Zn	5.0 < 5.5	28	56	69	12
	5.5 < 6.0	20	55	73	84
	6.0 - 7.0	21	53	76	157
	> 7.0	9	9	9	1
Cu	5.0 < 5.5	7	12	27	12
	5.5 < 6.0	5	18	29	84
	6.0 - 7.0	6	17	30	157
	> 7.0	5	5	5	1
Ni	5.0 < 5.5	8	20	24	12
	5.5 < 6.0	5	19	32	84
	6.0 - 7.0	5	18	31	157
	> 7.0	5	5	5	1
Cd	5.0 +	0.07	0.20	0.45	253
Pb	5.0 +	9	24	59	253
Hg	5.0 +	0.06	0.10	0.18	253
Cr	5.0 +	12	34	52	253
Mo	5.0 +	0.14	0.50	1.00	253
Se	5.0 +	0.14	0.35	0.67	253
As	5.0 +	3	6	10	253
F	5.0 +	36	73	120	238

Note: Soil pH class 5.0 + includes all soils at pH 5.0 and above

APPENDIX C
NORTHERN IRELAND

Table NI 1 : Current and future sludge quantities by outlets, Northern Ireland (tds a⁻¹)

Outlet	1996/7	2000/1	2005/6
Agriculture	17 500	19 100	21 100
Dedicated site			
Incineration		14 600	23 200
Sea disposal	14 600		
Landfill			
Land reclamation			
Forestry			
Horticultural compost			
Within curtilage			
Other			
Total	32 100	33 700	44 300

Table NI 2 : Annual sludge production per works size (tds a⁻¹) in Northern Ireland (1996/7)

Outlet*	Small	Medium	Large
Agriculture	1 847	15 692	
Sea disposal	163	5 245	9 151
Total	2 010	20 937	9 151

* All divisions included

Table NI 3 Current and future treatment for sludge recycled to agriculture in Northern Ireland (tds a⁻¹)

Treatment	1996/7	2000/1	2005/6
Pasteurisation			
Mesophilic anaerobic digestion	8 900	8 100	15 700
MAD and dewatering and storage		3 800	
Thermophilic aerobic digestion			
TAD and dewatering and storage			
Composting			
Co-composting			
Lime stabilization			
Liquid storage for three months	4 200	2 800	700
Dewatered and stored	4 400	4 500	4 600
Thermal drying of treated sludge			
Thermal drying of untreated sludge			
Other			
None			
Total	17 500	19 100	21 100

Table NI 4 Current treatment of sludge sent to other outlets (tds a⁻¹) in Northern Ireland (1996/7)

Treatment	Sea disposal
Pasteurisation	
Mesophilic anaerobic digestion	800
MAD and dewatering and storage	
Thermophilic aerobic digestion	
TAD and dewatering and storage	
Composting	
Co-composting	
Lime stabilization	
Liquid storage for three months	
Dewatered and stored	
Thermal drying of treated sludge	
Thermal drying of untreated sludge	
Other	
None	13 800
Total	14 600

Table NI 5 Sludge treatment according to works size, all outlets in Northern Ireland (1996/7)

Treatment	Sludge quantity (%)		
	Small	Medium	Large
Mesophilic anaerobic digestion MAD and dewatering and storage	49	42	
Liquid storage for 3 months Unstabilised, dewatered and stored	43	16	
None	8	21	100

Table NI 6 Quality of sludge in Northern Ireland for main outlets (1996/7)

Parameter**	Weighted average concentration* (mg.kg ⁻¹ .ds)	
	Agriculture	Sea disposal
n	27	4
% ds	14	2
Tot N	25 100	
Tot P	27 400	
Zinc	668	900
Copper	583	861
Nickel	38	80
Cadmium	2.1	3.0
Lead	156	131
Mercury	2.4	3.6
Chromium	50	122

* Data for Eastern Division not supplied

** Data for non statutory PTEs not available

Table NI 7 Quality of sludge used in agriculture in Northern Ireland (1996/7)

Parameter**	Sludge concentration*			n
	10%ile	Median	90%ile	
%ds	2.4	4.9	16.2	27
N	18 400	26 500	32 800	22
P	6 400	16 900	52 800	22
Zn	419	745	1169	27
Cu	121	350	1015	27
Ni	13	22.5	82	27
Cd	0.7	1.4	3.6	27
Pb	36	106	211	27
Hg	0.9	2	3.6	27
Cr	2.4	29	79	27

* Data for Eastern Division not supplied

** Data for non statutory PTEs not available

Table NI 8 Area of agricultural land utilised for sewage sludge recycling in Northern Ireland (1996/97)

Landuse	Land area*		Land unit*
	(ha)	(%)	
Arable	50	4	16
Pasture	1156	96	579
Total	1206		595

Note:

* Data for Eastern Division not supplied. A small proportion of sludge is recycled to agriculture

Table NI 9 Spreading method employed in Northern Ireland (1996/7)

Application method	Area* (%)
Splash plate applicator from tanker	85
Application from solid manure spreader	15

Note: * Data for Eastern Division not supplied but sludge is applied mainly by splash plate applicator from tanker

Table NI 10 Quality of agricultural soil used in Northern Ireland for sludge recycling (1996/7)

Parameter	pH range	UK Code of Practice	Soil concentration* (mg kg ⁻¹ ds)			n
			10%ile	Median	90%ile	
Zn	p1	200	49	84	118	77
	p2	200	54	85	119	169
	p3	200	25	83	128	309
	p4	300	50	92	167	35
Cu	p1	80	20	30	79	77
	p2	100	18	32	71	169
	p3	135	8	31	79	309
	p4	200	13	23	55	35
Ni	p1	50	16	33	85	76
	p2	60	17	33	96	169
	p3	75	10	34	114	309
	p4	110	14	21	66	35
Cd	p5	3	0.16	0.35	1	590
Pb	p5	300	12	24	43	595
Hg	p5	1	0.04	0.1	0.3	561
Cr	p5	400	22	54	100	592

Notes:

* Data for Eastern Division not supplied

p1 Soil pH 5.0 to <5.5

p2 Soil pH 5.5 to <6.0

p3 Soil pH 6.0 to 7.0

p4 pH >7.0

p5 pH >5.0

APPENDIX D

SUMMARY OF DATA AVAILABLE

Table D1 Number of sludge centres and percentage of data supplied for the different parameters in each local area, all outlets (1996/7)

Local region	No. of sample (n)	NGR %	pe %	ds %	N %	NH ₃ N %	P %	Zn %	Cu %	Ni %	Cd %	Pb %	Hg %	Cr %	Mo %	Se %	As%	F %
Anglian	521	100	91	100	100	0	100	100	100	100	65	100	95	100	96	102	98	90
Northumbrian	22	100	100	100	82	0	82	100	100	100	100	100	95	100	91	86	77	82
North West	108	100	98	100	49	2	49	58	58	58	58	56	51	58	50	48	49	50
Severn Trent	115	100	95	90	89	0	89	89	89	89	89	89	89	89	89	89	89	89
Southern	60	100	100	100	100	93	93	100	100	100	100	100	100	100	93	93	93	93
South-West	45	100	98	100	100	0	100	100	100	100	100	100	100	100	56	11	11	0
Thames	107	0	100	100	95	95	95	100	100	100	100	100	100	100	94	94	94	94
Welsh	163	100	0	100	36	0	35	48	48	48	48	48	48	48	0	0	0	0
Wessex	233	87	78	100	96	0	96	97	97	97	97	97	96	97	1	0	1	0
Yorkshire	166	96	100	100	89	88	89	94	94	94	95	94	92	94	92	92	92	92
England and Wales	1540	91	83	100	87	20	86	90	90	90	78	90	87	90	66	65	64	61
East of Scotland	29	97	97	100	62	0	34	41	72	72	72	72	38	72	24	0	0	0
North of Scotland	49	86	78	96	67	47	67	69	69	61	65	69	69	69	65	47	65	47
West of Scotland	13	100	100	100	92	23	85	100	100	100	100	100	100	100	23	23	54	23
Scotland	91	91	87	98	69	29	59	65	75	70	73	75	64	75	46	29	43	29
Northern Ireland*	48	44	90	65	46	6	46	65	0	0	0	0						

* Data for the Eastern Division not supplied for quality of sludge

Table D2 **Number of land units and percentage of land sludged for which data was supplied for different parameters**

Local region	Land unit (n)	Areas %	pH %	Zn %	Cu %	Ni %	Cd %	Pb %	Hg %	Cr %	Mo %	Se %	As %	F %
Anglian	1 085	100	100	99	100	99	43	100	58	99	81	86	99	53
Northumbrian	207	100	100	100	100	100	100	100	100	100	100	0	100	100
North West	2 706	100	100	100	100	100	100	100	98	100	88	8	8	9
Severn Trent	2 415	100	97	97	97	97	95	97	93	97	95	95	95	95
Southern	935	100	100	100	100	100	100	100	100	100	100	100	100	100
South West	687	100	100	90	90	90	90	90	89	90	88	11	11	0
Thames	3 697	100	100	100	100	100	100	100	100	100	8	8	8	9
Welsh	1 604	100	99	99	99	99	99	99	98	99	0	0	0	0
Wessex	1 576	100	100	100	100	100	100	100	100	100	0	0	1	0
Yorkshire	972	97	97	97	97	97	97	97	97	97	97	97	97	97
England and Wales	15 884	100	97	99	99	99	97	99	97	99	53	21	23	21
East of Scotland	189	100	100	100	100	100	96	100	36	96	13	5	5	2
North of Scotland	254	100	100	100	100	100	100	100	100	100	100	100	100	94
West of Scotland	157	100	100	100	100	100	100	100	95	100	23	23	23	23
Scotland	600	100	100	100	100	100	99	100	77	99	45	43	43	40
Northern Ireland*	595	100	100	100	100	100	99	100	94	99	0	0	0	0

* Data not supplied for the Eastern Division