Environment Agency

Evidence

Material comparators for end-of-waste decisions

Materials applied to land: straw

Report – SC130040/R4

Version 2

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This report is the result of research commissioned and funded by the Environment Agency.

Published by:
Environment Agency, Horizon House, Deanery Road, Bristol, BS1 5AH

www.gov.uk/government/organisations/environment-agency

ISBN: 978-1-84911-322-9

Further copies of this report are available from our publications catalogue:
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Dissemination Status:
Publicly available

Keywords:
End of waste, Straw, Laboratory analysis

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Project Number:
SC130040/R4

Executive summary

This report details work carried out to characterise straw, a key non-waste comparator. This information will inform end-of-waste assessments for waste-derived materials intended to replace straw that is applied to land.

The Waste Framework Directive (Article 6) provides criteria for identifying when a waste material has become a product and no longer needs to be regulated as a waste. Through Article 6 the case law requires us to consider the environmental and human health impacts from materials in comparison with their non-waste material alternatives.

> *... "It should be enough that the holder has converted the waste material into a distinct, marketable product, which can be used in exactly the same way as a [non-waste material], and with no worse environmental effects..."*

Market research was used to define straw as an ordinary comparator and a literature review was used to identify any existing published data.

No suitable pre-existing datasets were found during the literature review.

Ten samples of straw were collected from various growers across England. Analytical data from these samples are presented in this report.

We recommend comparing the concentrations of analytes in the comparators dataset to the concentrations in the waste-derived material, paying attention to the higher values. This comparison does not constitute a pass/fail test or an end of waste view. It will provide an indication of whether the waste material contains similar levels of analytes to non-waste materials and whether an end-of-waste application may be appropriate or that further analysis or improved treatment processes may be warranted.

Acknowledgements

The authors would like to thank the following individuals and organisations for their assistance in producing this report:

- Paul Murray, Environment Agency, Advisor, Environment and Business
- Sue Hornby, Environment Agency, Senior Advisor, Environment and Business
- Jenny Scott, Environment Agency, Legal Advisor
- Bianca Prince, National Laboratory Service, Key Account Manager
- Will Fardon, National Laboratory Service

Contents

1 Introduction

To define end-of-waste criteria, the Environment Agency requires a set of ordinary material comparator data for use as a benchmark against which to assess other materials and wastes.

Article 6 of the Waste Framework Directive provides criteria for identifying when a waste material has become a product and no longer needs to be regulated as a waste. Through Article 6 the case law requires the environmental and human health impacts from materials to be considered in comparison with their non-waste material alternatives. In particular the Court of Appeal judgement in OSS Group Ltd v Environment Agency (2007) contained the statement:

> 'It should be enough that the holder has converted the waste material into a distinct, marketable product, which can be used in exactly the same way as a [non-waste material], and with no worse environmental effects.'

The purpose of this report is to provide an evidence base of the composition and characteristics (beneficial and potentially unbeneficial) of straw which is defined as an ordinary material comparator that is currently permitted for beneficial application to land. The report presents the results from the primary analysis of 10 straw samples.

Six other reports cover ordinary material comparators applied to land:

- manufactured fertilisers
- non-waste biochar
- non-waste wood
- PAS 100 compost
- Peat
- Soil improver

2 Definition

Straw is used in horticulture. It is applied directly to soil as mulch/crop protection. Straw is often used to:

- protect strawberries
- cover plants in cold weather
- mulch other crops

It is also used in mushroom growing and as animal bedding.

Many different types of straw are available:

- winter wheat/barley straw
- spring wheat/barley straw
- oat straw

- oilseed rape straw
- rye straw
- linseed straw

Wheat straw is primarily used in strawberry growing.

2.1 Properties

Straw acts as a weed suppressor. It can also help to retain water and reduce soil erosion. When ploughed into land, it generally has a small beneficial effect on soil organic matter content and the workability of the soil. Conversely straw may lock up nitrogen when it is worked into the soil following harvest or winter protection.

3 Comparator sub-types

All straw samples collected were wheat straw.

4 Material sources

An internet search was used to produce a list of strawberry, carrot and mushroom growers. Straw samples were requested from a number of growers across England.

5 Sampling procedure

Samples were taken in accordance with BS EN 12579 (BSI 2000).

6 Analytical parameters

The main parameters determined are summarised in Table 6.1 to 6.10. All laboratory work was carried out by the Environment Agency's National Laboratory Service (NLS).

Testing was carried out in accordance with relevant NLS documented in-house methods which meet the requirements of the performance standards of the Environment Agency's monitoring certification scheme (MCERTS). Specific tests used are outlined in the tables. Other test methods are available.

In the tables, 'LE' refers to the NLS Leeds laboratory and SAL refers to Scientific Analysis Laboratories Ltd.

Table 6.1 Analysis: beneficial properties

Parameter/ determinand	Test method used	Unit
pH	LE I pH and EC 01 pH and conductivity – water extracted, determined by specific electrode from ‘‘as received’ sample	–
Conductivity	LE I pH and EC 01 pH and conductivity – water extracted, determined by specific electrode from ‘‘as received’ sample	µS/cm
Dry solids @ 30°C	LE P soil preparation 01 – sample air dried at <30ºC in a controlled environment until constant weight is achieved	%
Dry solids @ 105°C	LE I dry solids and LoI 01 dry solids (105ºC) and loss on ignition (500ºC) – thermally treated, determined by gravimetry	%
Loss on ignition (LoI) @ 500°C (organic matter content)	LE I dry solids and LoI 01 dry solids (105ºC) and loss on ignition (500ºC) – thermally treated, determined by gravimetry	%
Carbon, organic as C	LE I TOC 01 – combusted with oxygen, thermal conductivity detection	%
Nitrogen as N	LE I nutrients (Kone) 01 NH_4, TON, NO_2 – 2M KCl extraction, determined colorimetrically by discrete analyser on ‘‘as received’ sample	mg/kg (DW)
Carbon	LE I TOC 01 TC % TN – combusted with oxygen, thermal conductivity detection	mg/kg (DW)
C:N	Calculated value, carbon divided by nitrogen as N	n/a

EC = electrical conductivity; TOC = total organic carbon; TON = total organic nitrogen; TN = total nitrogen; DW = dry weight

Table 6.2 Analysis: primary nutrients

Parameter/ determinand	Test method used	Unit
Total nitrogen (N) Kjeldahl test	Parameter by calculation	mg/kg (DW)
Total P	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Total K	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Ammoniacal nitrogen as N	LE I nutrients (Kone) 01 NH_4, TON, NO_2 – 2M KCl extraction, determined colorimetrically by discrete analyser on ‘as received’ sample	mg/kg (DW)
Nitrate as N	Parameter by calculation	mg/kg (DW)

ICP-OES = inductively coupled plasma optical emission spectrometry

Table 6.3 Analysis: secondary nutrients

Parameter/ determinand	Test method used	Unit
Ca	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Mg	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Total sulphur	SAL determination of total sulphur – dried and ground aliquot of the sample is weighed into a ceramic crucible. The sample is then oxidised in the analyser's combustion chamber and any organic sulphur present is converted to sulphur dioxide. The sulphur dioxide in the combustion gases is measured by an infra-red detector.	%

Table 6.4 Analysis: trace nutrients

Parameter/ determinand	Test method used	Unit
B	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Cu	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Fe	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Mn	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Mo	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Zn	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Chloride	LE I halides chloride, bromide and sulphate – water extracted determined directly by ion chromatography on 'as received' sample	mg/kg (DW)

Table 6.5 Analysis: other elements found in plants which may not be essential for growth

Parameter/ determinand	Test method used	Unit
Co	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Na	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Ni	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)

Se	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)

Table 6.6 Analysis: Potentially Toxic Elements (PTEs)

Parameter/ determinand	Test method used	Unit
Cd	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Cr	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Cu	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Hg	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Ni	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Pb	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Zn	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)

Table 6.7 Analysis: other potential contaminants

Parameter/ determinand	Test method used	Unit
V	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)

Table 6.8 Analysis: metals

Parameter/ determinand	Test method used	Unit
Al	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Ag	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
As	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Ba	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Be	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Li	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)

Parameter/ determinand	Test method used	Unit
Sb	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Sn	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES.	mg/kg (DW)
Sr	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Ti	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)
Tl	LE I metals (ICP-OES) 01 – digestion block aqua regia extracted under reflux, determined by ICP-OES	mg/kg (DW)

Table 6.9 Analysis: other analytes

Parameter/ determinand	Test method used	Unit
Bromide	LE I halides chloride, bromide and sulphate – water extracted determined directly by ion chromatography on 'as received' sample	mg/kg (DW)
Cr VI	LE I Cr (VI) 01 chromate – alkaline extracted determined by comparator disc colorimetry on 'as received' sample	mg/kg (DW)
Fluoride	LE I fluoride – 1M H_2SO_4 extraction, determined by ion selective electrode on 'as received' sample.	mg/kg (DW)
Nitrite as N	LE I nutrients (Kone) 01 NH_4, TON, NO_2 – 2M KCl extraction, determined colorimetrically by discrete analyser on 'as received' sample.	mg/kg (DW)
Sulphate	LE I halides chloride, bromide and sulphate - water extracted determined directly by Ion Chromatography on 'as received' sample.	mg/kg (DW)
Total oxidised nitrogen as N	LE I nutrients (Kone) 01 NH_4, TON, NO_2 – 2M KCl extraction, determined colorimetrically by discrete analyser on 'as received' sample.	mg/kg (DW)

Table 6.10 Analysis: GCMS semi-volatile screen

Parameter/ determinand	Test method used	Unit
Various	NLS O SV screens – solvent extracted, determined by GCMS (scan mode)	mg/kg (DW)

O SV = organic semi-volatile; GCMS = gas chromatography–mass spectrometry

7 Existing data

No suitable existing data were identified during the literature review.

Some data were also found in the Phyllis2 database (http://www.ecn.nl/phyllis2/Browse/Standard/ECN-Phyllis) and other online sources. However, these data did not meet the quality assurance criteria required for this project and are not reproduced here.

8 Primary data

8.1 Statistical analysis of data

The mean, median, minimum and maximum values for each analyte were calculated. When the sample size was sufficient (that is, ≥10), the 90th percentile was also calculated. All analytical values determined as 'less than (<)' values were taken as the values themselves.

Box plots are used to graphically represent groups of quantitative data (Figure 8.1). The sample minimum, lower quartile (Q1), median (Q2), upper quartile (Q3) and sample maximum are used. The median is indicated by the horizontal line that runs across the box (Figure 8.1). The top of the box is the 75th percentile (upper quartile or Q3). The bottom of the box is the 25th percentile (lower quartile or Q1). The interquartile range is represented by the height of the box (Q3 – Q1). A smaller interquartile range indicates less variability in the dataset while a larger interquartile range indicates a variable dataset. Whiskers extend out of the box to represent the sample minimum and maximum. Outliers are plotted as asterisks and are defined as data points that are 1.5× the interquartile range. The box and whisker plot of strontium concentration in straw shown in Figure 8.1 demonstrates the issue of outliers in the dataset.

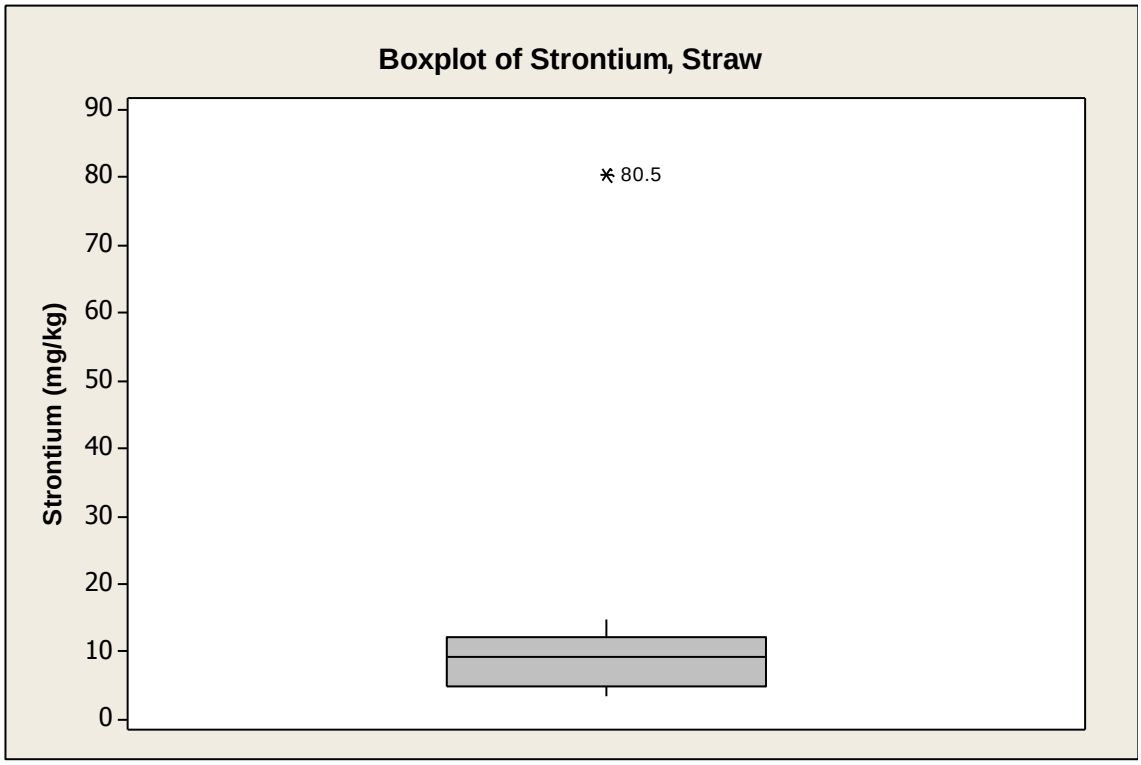

Figure 8.1 Box plot of strontium concentration in straw

Outliers can adversely affect the statistical analysis by:

- giving serious bias or influence to estimates that may be of less interest
- increasing the error variance and reducing the power of statistical tests
- decreasing normality (if non-random) and altering the odds of type I and II errors

8.2 Using the data tables

The analytical data are presented in the following tables:

- beneficial properties (Table 8.1)
- primary, secondary and trace nutrients (Table 8.2)
- other elements found in plants which may not be essential for growth, Potentially Toxic Elements (PTEs) and other potential contaminants (Table 8.3)
- other metals and analytes (Table 8.4)
- GCMS semi-volatile screen (Table 8.5a,b)

We recommend comparing the concentrations of analytes in the comparators dataset to the concentrations in the waste-derived material, paying attention to the higher values. This comparison does not constitute a pass/fail test or an end of waste view. It will provide an indication of whether the waste material contains similar levels of analytes to non-waste materials and whether an end-of-waste application may be

appropriate or that further analysis or improved treatment processes may be warranted.

Due to difficulties encountered during sample preparation the limit of detection for some analytes was higher than the target limit of detection.

8.3 Primary data tables

Primary data are shown in Tables 8.1 to 8.5.

Table 8.1 Primary data for straw: beneficial properties

Sample ID	pH	Conductivity	Dry solids @ 30°C	Dry solids @ 105°C	LoI @ 500°C (organic matter content)	Carbon	Carbon, Organic as C	Nitrogen as N	C:N [1]
		µS/cm	%	%	%	%	mg/kg (DW)	mg/kg (DW)	
Straw 01	8.56	1.97	91.5	86.9	93.2	40.3	401,000	1,000	401
Straw 02	7.76	2.50	91.6	85.8	90.3	40.2	409,000	6,160	66.4
Straw 03	8.12	1.60	83.8	81.7	92.6	38.4	382,000	8,420	45.4
Straw 04	7.03	1.94	95.8	86.3	90.1	39.6	414,000	6,280	65.9
Straw 05	6.83	2.76	90.8	85.8	87.9	38.1	378,000	6,590	57.4
Straw 06	7.72	1.86	76.8	83.5	93.9	38.9	356,000	6,630	53.7
Straw 07	7.94	1.99	95.8	86.6	93.1	38.2	426,000	14,600	29.2
Straw 08	7.06	1.29	89.1	82.1	90.3	38.8	382,000	12,600	30.3
Straw 09	7.90	2.73	97.3	87.7	92.8	39.4	420,000	8,190	51.3
Straw 10	8.01	3.02	97.0	87.2	90.1	38.4	412,000	10,500	39.2
Mean	7.69	2.17	91.0	85.4	91.4	39.0	398,000	8,097	84.0
Median	7.83	1.98	91.6	86.1	91.5	38.9	405,000	7,410	52.5
Minimum	6.83	1.29	76.8	81.7	87.9	38.1	356,000	1,000	29.2
Maximum	8.56	3.02	97.3	87.7	93.9	40.3	426,000	14,600	401
No. of samples	10	10	10	10	10	10	10	10	16
90th percentile	8.16	2.79	97.0	87.3	93.3	40.2	420,600	12,800	100
LOD	0.2	10	0.5	0.5	0.5	0.3	1,000	200	n/a

Notes: [1] calculated value

Table 8.2 Primary data for straw: primary, secondary and trace nutrients [1]

Sample ID	Primary nutrients					Secondary nutrients			Trace nutrients							
	Total nitrogen (N) Kjeldahl test	Total P	Total K	NH_3 as N	Nitrate as N	Ca	Mg	Total sulphur	B	Cu	Fe	Mn	Mo	Zn	Chloride
Straw 01	<1,000	870	4,960	<2	<2.74	3,950	882	0.14	4.45	4.42	414	20.9	1.01	25.7	1,210
Straw 02	<6,160	826	11,100	<2	<2.85	4,280	1,260	0.11	2.78	4.49	<200	10.1	1.72	13.5	676
Straw 03	<8,420	993	6,220	3.65	<4.00	1,880	576	0.05	2.84	3.39	<200	16.6	<1	9.09	521
Straw 04	<6,280	1,280	18,300	<2	<2.89	2,010	536	<0.05	1.48	3.53	<200	7.70	6.73	13.7	753
Straw 05	<6,590	1,250	8,220	2.70	<3.00	2,840	1,020	<0.05	3.72	2.55	<200	13.4	<1	8.81	2,370
Straw 06	<6,630	1,570	9,670	7.51	<3.78	1,560	692	<0.05	3.97	5.88	<200	17.8	1.10	9.84	829
Straw 07	<14,600	1,200	9,780	2.72	<2.71	3,480	949	<0.05	3.28	2.80	<200	16.7	1.03	9.65	1,820
Straw 08	<12,600	1,420	6,850	45.9	<3.00	3,310	943	<0.05	4.02	3.30	<200	37.4	<1	15.8	1,380
Straw 09	<8,190	1,750	10,800	<2	<3.00	3,160	833	<0.05	4.28	2.50	<200	30.4	<1	20.7	1,260
Straw 10	<10,500	1,230	12,400	<2	<2.87	1,830	751	<0.05	1.46	3.78	<200	12.0	1.17	19.8	1,000
Mean	8,097	1,239	9,830	7.25	3.08	2,830	844	0.07	3.23	3.66	221	18.3	1.68	14.7	1,182
Median	7,410	1,240	9,725	2.35	2.95	3,000	858	0.05	3.50	3.46	200	16.7	1.02	13.6	1,105
Minimum	1,000	826	4,960	2.00	2.71	1,560	536	0.05	1.46	2.50	200	7.70	1.00	8.81	521
Maximum	14,600	1,750	18,300	45.9	4.00	4,280	1,260	0.14	4.45	5.88	414	37.4	6.73	25.7	2,370
No. of samples	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
90th percentile	12,800	1,588	12,990	11.3	3.80	3,983	1,044	0.11	4.30	4.63	221	31.1	2.22	21.2	1,875
LOD	n/a	10	50	2	n/a	60	20	0.05	1	0.1	1	2	1	2	3

Notes: [1] All units mg/kg (DW) apart from total sulphur for which the units are % (DW).

Table 8.3 Primary data for straw: other elements found in plants which may not be essential for growth, PTEs and other potential contaminants [1]

Sample ID	Other elements found in plants which may not be essential for growth									PTEs	Other potential contaminants
	Co	Se	Na	Cd	Cr	Cu	Pb	Hg	Ni	Zn	V
Straw 01	0.13	1.23	235	<0.2	0.94	4.42	1.48	<0.2	<0.7	25.7	0.87
Straw 02	<0.1	1.20	149	<0.2	0.58	4.49	<1	<0.2	<0.7	13.5	0.15
Straw 03	<0.1	1.11	82.1	<0.2	<0.5	3.39	<1	<0.2	<0.6	9.09	<0.1
Straw 04	<0.1	1.32	61.6	<0.2	<0.5	3.53	<1	<0.2	<0.6	13.7	<0.1
Straw 05	<0.1	1.26	51.8	<0.2	0.63	2.55	<1	<0.2	<0.6	8.81	0.16
Straw 06	<0.1	1.20	150	<0.2	<0.6	5.88	<1	<0.2	<0.7	9.84	<0.1
Straw 07	<0.1	<1	66.9	0.207	<0.5	2.80	<1	<0.2	<0.6	9.65	0.18
Straw 08	<0.1	<1	119	0.332	0.73	3.30	1.03	<0.2	<0.6	15.8	0.34
Straw 09	<0.1	<1	53.0	0.297	<0.6	2.50	<1	<0.2	<0.7	20.7	0.23
Straw 10	<0.1	<1	55.6	0.222	0.91	3.78	<1	<0.2	<0.6	19.8	0.18
Mean	0.10	1.13	102	0.226	0.65	3.66	1.05	0.2	0.64	14.7	0.24
Median	0.10	1.16	74.5	0.200	0.60	3.46	1.00	0.2	0.60	13.6	0.17
Minimum	0.10	1.00	51.8	0.200	0.50	2.50	1.00	0.2	0.60	8.81	0.10
Maximum	0.13	1.32	235	0.332	0.94	5.88	1.48	0.2	0.70	25.7	0.87
No. of samples	10	10	10	10	10	10	10	10	10	10	10
90th percentile	0.10	1.27	159	0.301	0.91	4.63	1.08	0.2	0.70	21.2	0.39
LOD	0.1	1	10	0.2	0.5	1	1	0.2	0.6	2.0	0.1

Notes: [1] All units mg/kg (DW).

Table 8.4 Primary data for straw: other metals and analytes [1]

Sample ID	Metals													Other analytes		
	Al	Sb	As	Ba	Be	Li	Ag	Sr	Tl	Sn	Ti	Cr VI	Fluoride	Bromide	Sulphate	Nitrite as N	TON as N
Straw 01	346	<1	0.70	42.2	<0.1	<1	<1	11.1	<1	<1	6.71	<0.7	23.1	0.62	796	0.26	<3
Straw 02	<50	<1	0.52	37.0	<0.1	<1	<1	14.7	<1	<1	<3	<0.7	<20	0.91	429	0.15	<3
Straw 03	<50	<1	<0.5	22.5	<0.1	<1	<1	3.47	<1	<1	<3	<0.4	<20	<0.3	174	<0.1	<4
Straw 04	<50	<1	0.52	38.9	<0.1	<1	<1	3.89	<1	<1	<3	<0.7	<20	1.32	325	0.11	<3
Straw 05	<50	<1	<0.5	82.6	<0.1	<1	<1	80.5	<1	<1	<3	<0.7	<20	<0.3	644	<0.1	<3
Straw 06	<60	<1	<0.6	30.1	<0.1	<1	<1	7.51	<1	<1	<3	<0.9	<30	<0.3	571	0.22	<4
Straw 07	<50	<1	3.66	55.6	<0.1	<1	<1	10.6	2.90	<1	<3	<0.7	<20	<3	883	0.29	<3
Straw 08	53.5	<1	3.71	66.8	<0.1	<1	<1	10.4	2.95	<1	<3	<0.8	<20	<3	151	<0.1	<3
Straw 09	<60	<1	3.99	49.8	<0.1	<1	<1	7.91	3.29	<1	<3	<0.7	<20	<3	635	<0.1	<3
Straw 10	<50	<1	3.53	39.9	<0.1	<1	<1	5.24	2.75	<1	<3	<0.7	<20	3.48	475	0.13	<3
Mean	82.0	1	1.82	46.5	0.1	1	1	15.5	1.79	1.00	3.37	0.70	21.3	1.62	508	0.16	3.2
Median	50.0	1	0.65	41.1	0.1	1	1	9.16	1.00	1.00	3.00	0.70	20.0	1.12	523	0.12	3
Minimum	50.0	1	0.50	22.5	0.1	1	1	3.47	1.00	1.00	3.00	0.40	20.0	0.30	151	0.10	3
Maximum	346	1	3.99	82.6	0.1	1	1	80.5	3.29	1.00	6.71	0.90	30.0	3.48	883	0.29	4
No. of samples	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
90th percentile	88.6	1	3.74	68.4	0.1	1	1	21.3	2.98	1	3.37	0.81	23.8	3.05	805	0.26	4
LOD	50	1	0.5	0.5	0.1	1	1	1	1	1	3	0.3	20	0.3	5	0.1	3

Notes: [1] All units mg/kg (DW).

Table 8.5 Primary data for straw: GCMS semi-volatile screen [1,2]

(a)

Sample ID	1-hexacosene	1,19-eicosadiene	13-octadecanal	14,16-hentriacontanedione	1-nonadecene	1-octadecene	4,22-stigmastadiene-3-one	beta.-sitosterol	boscalid	camasterol	campesterol	cyclooctacosane	eicosane	ergosta-4,22-dien--3-one	ergosterol	gamma.-sitosterol	hentriacontane
Straw 01		12				79			11		14					57	
Straw 02		91					12		20							30	92
Straw 03	53	31					16									32	13
Straw 04				120			12				14	134				43	
Straw 05				110			24				14	400				45	
Straw 06							26				13				11	30	19
Straw 07		14			66		22				13					34	
Straw 08		23				30										26	
Straw 09							29				15		33			54	58
Straw 10			26		158			42		11			36	19			

(b)

Sample ID	heptacosane	heptacosyl acetate	hexadecane	hexatriacontane	lup-20(29)-ene-3-one	nonacosane	octacosane	octacosyl acetate	octadecanal	octadecane	oxirane,heptadecyl-	pentatriacontane	squalene	stigmast -3,6- dione, (5.alpha.)- cane	stigmast-4-en-3-one	stigmasten-4-en-3-one	stigmasterol	tetracosane
Straw 01			22				82	154	73		27	17			40		15	
Straw 02		14				50	25	90							27			
Straw 03					13						11		12		42		22	49
Straw 04					10	31									29		25	
Straw 05	20			28	11	85									59		21	
Straw 06					25									16	48		21	21
Straw 07					25	30									41		27	
Straw 08		61			15										33		18	
Straw 09					15	30									70		18	
Straw 10					11											53	14	

Notes: [1] Analytes >10 mg/kg (DW) only; analytes not detected or those with <10mg/kg (DW) have not been reported.
[2] The full GCMS screen data with <10 mg/kg values will be included in the comparator spreadsheet tool. The compounds identified at concentrations greater than the detection level during the GCMS screen are believed to be, in the vast majority of cases, naturally occurring substances within the sample matrix, rather than pollutants.

9 Conclusions

Data are presented for 10 samples of straw. Physical properties and chemical analyses are provided. These data can be used by companies and individuals to assist in the process of applying for end-of-waste status for their products, either by confirming their product's comparable composition or identifying problems to be rectified before such status can be achieved.

References

BSI, 2000. *BS EN 12579:2000. Soil improvers and growing media. Sampling.* London: British Standards Institution.

List of abbreviations

AAS	atomic absorption spectrometry
1M	1 molar
2M	2 molar
Ag	Silver
Al	Aluminium
As	Arsenic
B	Boron
Ba	Barium
Be	Beryllium
C	Carbon
Ca	Calcium
CaO	Calcium oxide
Cd	Cadmium
Chromium VI	Chromium Hexavalent
Co	Cobalt
Cr	Chromium
Cu	Copper
DW	dry weight
EC	electrical conductivity

Fe	Iron
GCMS	gas chromatography–mass spectrometry
H_2SO_4	Sulphuric acid
Hg	Mercury
ICP-AES	inductively coupled plasma atomic emission spectroscopy
ICP-OES	inductively coupled plasma optical emission spectrometry
K	Potassium
KCL	Potassium chloride
LE	Leeds laboratory of NLS
Li	Lithium
LOD	limit of detection
LoI	loss on ignition
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
Na	Sodium
NH_3 as N	Ammoniacal nitrogen
NH_4	Ammonium
Ni	Nickel
NLS	National Laboratory Service [Environment Agency]
NO_2	Nitrogen dioxide
O SV	Organic semi volatile
P	Phosphorus
PAS	Publically Available Standard
Pb	Lead
PTEs	Potentially Toxic Elements
SAL	Scientific Analysis Laboratories Limited
Sb	Antimony
Se	Selenium
Sn	Tin
Sr	Strontium
TC	total carbon
Ti	Titanium

Tl	Thallium
TN	total nitrogen
TOC	total organic carbon
TON	total organic nitrogen
V	Vanadium
Zn	Zinc

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