Environment Agency

Evidence

Material comparators for end-of-waste decisions

Materials applied to land: non-waste wood

Report – SC130040/R5

Version 2

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Executive summary

This report details work carried out to characterise wood, a key non-waste comparator. This information will inform end-of-waste assessments for waste-derived materials intended to replace wood products that are 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 non-waste wood as an ordinary comparator and a literature review was used to identify any existing published data.

A limited number of suitable pre-existing datasets were found during the literature review.

Sixteen samples of non-waste wood were collected from various suppliers 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.

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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 non-waste wood 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 16 non-waste wood samples and some existing data published by WRAP.

Six other reports cover ordinary material comparators applied to land:

- manufactured fertilisers
- non-waste biochar
- PAS 100 compost
- peat
- soil improver
- straw

2 Definition

For the purpose of this project, non-waste wood applied to land is defined as bark and woodchip products which are used in horticulture as ornamental mulches. Bark and wood chip products are also used in playgrounds and horse ménages.

2.1 Properties

Non-waste wood when applied to land can:

- be decorative
- control moisture loss
- suppress weeds
- reduce soil erosion

Non-waste wood has a low nutritive value and nutrient availability, and may consume nitrogen during breakdown in the soil.

3 Comparator sub-types

To provide primary data for this project, 16 non-waste wood samples were taken from a variety of locations across England and from a variety of sub-types. Thirteen of the 16 samples were bark and three were wood chips (Figure 3.1). The breakdown of the samples by species is shown in Figure 3.2.

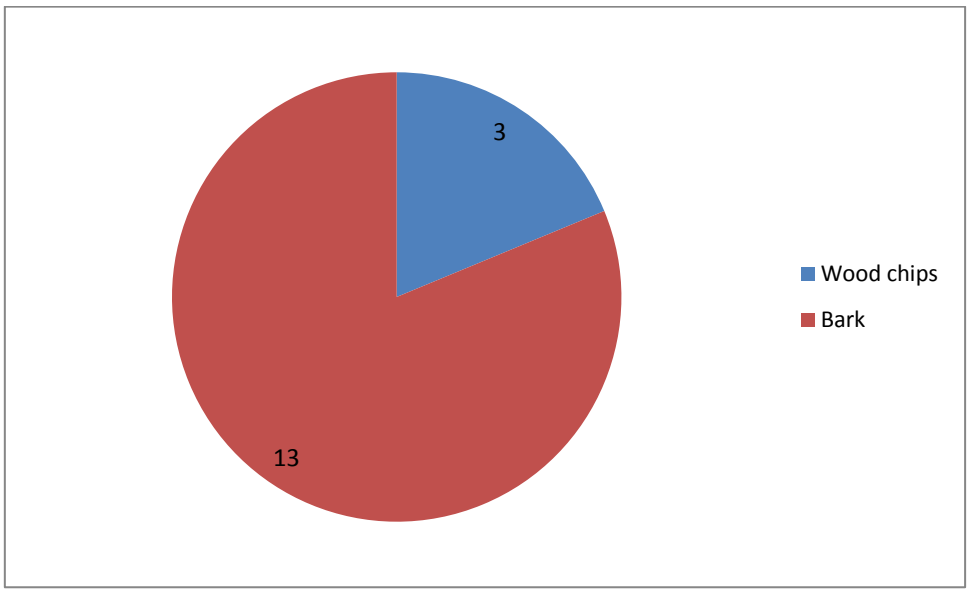

Figure 3.1 Non-waste wood sub-types (wood chip or bark)

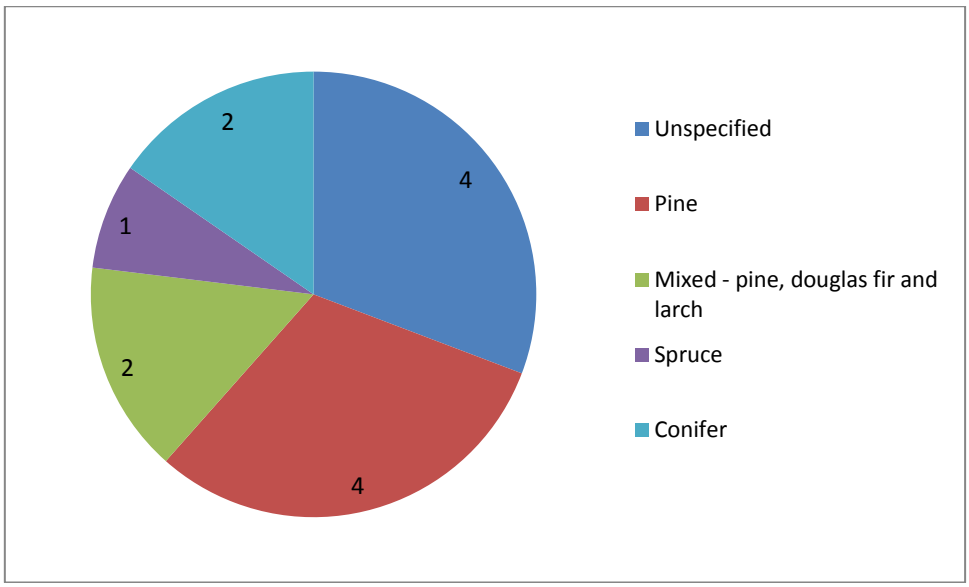

Figure 3.2 Non-waste wood sub-types (species)

4 Material sources

An internet search was used to produce a list of non-waste wood suppliers. Non-waste wood samples were requested from a random selection of these suppliers.

5 Sampling procedure

Non-waste wood samples were taken in accordance with BS EN 12579 (BSI 2000) from a number of suppliers across England to give a geographical spread.

6 Analytical parameters

The main parameters determined are summarised in Tables 6.1 to 6.11. 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: particle size distribution

Parameter/ determinand	Test method used	Unit
Particle size distribution	SAL determination of percentage stones. The particle size distribution calculates the percentage of a sample which is distributed via sieving between 2 and 20 mm, between 20 and 50 mm, and over 50 mm. The determination is performed on the >2 mm fraction of the sample (that is, the fraction of the sample that does not pass through the 2 mm sieve).	%

Table 6.3 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 6.4 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 6.5 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)

Parameter/ determinand	Test method used	Unit
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 6.6 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 6.7 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 6.8 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 6.9 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)
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 6.10 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)

Parameter/ determinand	Test method used	Unit
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)
Visible contaminants (>2 mm)	SAL determination of percentage stones – the % >2 mm fraction of the soil sample (that is, the fraction of the sample which does not pass through the 2 mm sieve)	%

Table 6.11 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

A limited number of the existing datasets related to non-waste wood identified during the literature review had sufficient provenance to be included in this project. These data are presented in Tables 7.1 and 7.2, and are taken from WRAP (2005) which reported on seven key elements of interest (Cr, Ni, Zn, Cu, As, Cd and Pb) and a set of 11 further elements (Al, B, Ba, Ca, Fe, Mg, Mn, Na, P, Si and Sr) where the amount extracted from the wood samples was related to the dry weight of wood.

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.

Table 7.1 Key elements of interest: amount in 1 kg of dry wood (mg/kg)

Species	Country	Test method	As	Cd	Cr	Cu	Ni	Pb	Zn
Spruce	Scotland supplier 2	ICP-AES	0.01	0.07	0.05	0.72	0.03	0.22	3.03
	Wales	ICP-AES	0.03	0.09	0.08	0.78	0.02	0.1	1.98
	Northern Ireland	ICP-AES	0	0.04	0.03	1.36	0.03	1.21	1.7
Pine	Scotland supplier 2	ICP-AES	0.04	0.05	0.13	0.76	0.03	0.15	2.8
	England	ICP-AES	0	0.08	0.5	0.56	0.24	0.11	1.72
Douglas fir	Scotland supplier 2	ICP-AES	0.06	0.33	0.2	16.98	0.13	0.71	21.09
	England	ICP-AES	0.08	0.19	0.2	4.1	0.09	1.04	3.97
Larch	Scotland supplier 2	ICP-AES	0.08	0.2	0.37	4.79	0.28	1.36	17.6
	England	ICP-AES	0	0.1	0.03	0.87	0.02	4.67	1.18
Pine bark	Scotland supplier 1	ICP-AES	0.06	0.06	0.18	3.07	0.21	0.33	4.52
	Scotland supplier 2	ICP-AES	0.07	0.05	0.99	3.61	0.27	0.34	4.35
Spruce	Scotland supplier 1	ICP				1.44			7.61
	Scotland supplier 2	ICP				0.87			11.3
	Wales	ICP				0.8			8.43
	Northern Ireland	ICP				1.2			35.89
Pine	Scotland supplier 1	ICP				1.85		3.24	8.56
	Scotland supplier 2	ICP				0.68			13.86
	England	ICP				1.26			12.19
Douglas fir	Scotland supplier 1	ICP				0.68			3.73
	Scotland supplier 2	ICP				2.88			16.71
	England	ICP				5.94		0.85	20.38
Larch	Scotland supplier 1	ICP				0.83			2.66
	Scotland supplier 2	ICP				2.42			26.67
	England	ICP				1.4		7.92	5.13
Spruce bark	Scotland	ICP				8.23	2.74		85.02

Species	Country	Test method	As	Cd	Cr	Cu	Ni	Pb	Zn
Pine bark	Scotland supplier 1	ICP				2.68			25.44
	Scotland supplier 2	ICP				2.42			15.12

Source: WRAP (2005, Tables 11 and 14)

Table 7.2 Further elements of interest: amount in 1 kg of dry wood (mg/kg)

Species	Country	Test method	Al	B	Ba	Ca	Fe	Mg	Mn	Na	P	Si	Sr
Spruce	Scotland supplier 1	IAAS	170	62	453	10,799	381	1,954	1,646	668	221	283	159
	Scotland supplier 2	ICP	123	65	275	11,585	246	1,955	2,607	869	94	340	94
	Wales	ICP	101	67	184	6,366	176	1,340	1,005	813	92	276	59
	Northern Ireland	ICP	67	67	329	11,964	90	1,570	1,495	748	322	232	127
Pine	Scotland supplier 1	ICP	87	52	121	13,305	179	4,628	2,487	810	283	139	69
	Scotland supplier 2	ICP	203	68	85	16,056	127	3,718	930	651	735	161	85
	England	ICP	189	74	32	16,813	84	3,468	1,366	1,471	2,312	179	21
Douglas fir	Scotland supplier 1	ICP	81	51	233	5,938	89	1,230	721	1,230	848	174	42
	Scotland supplier 2	ICP	122	58	108	3,025	115	382	108	1,584	202	144	58
	England	ICP	637	212	467	25,470	1040	3,396	5,306	4,033	2,335	1,358	106
Larch	Scotland supplier 1	ICP	127	67	290	5,505	79	1,754	599	1,694	260	236	79
	Scotland supplier 2	ICP	133	61	212	3,455	158	1,091	297	970	97	176	67
	England	ICP	64	93	140	6,408	93	874	4,602	757	157	175	35

Source: WRAP (2005, Tables 17 and 18)
IAAS = indirect atomic absorption spectroscopy

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 chloride concentration in non-waste wood shown in Figure 8.1 demonstrates the issue of outliers in the dataset.

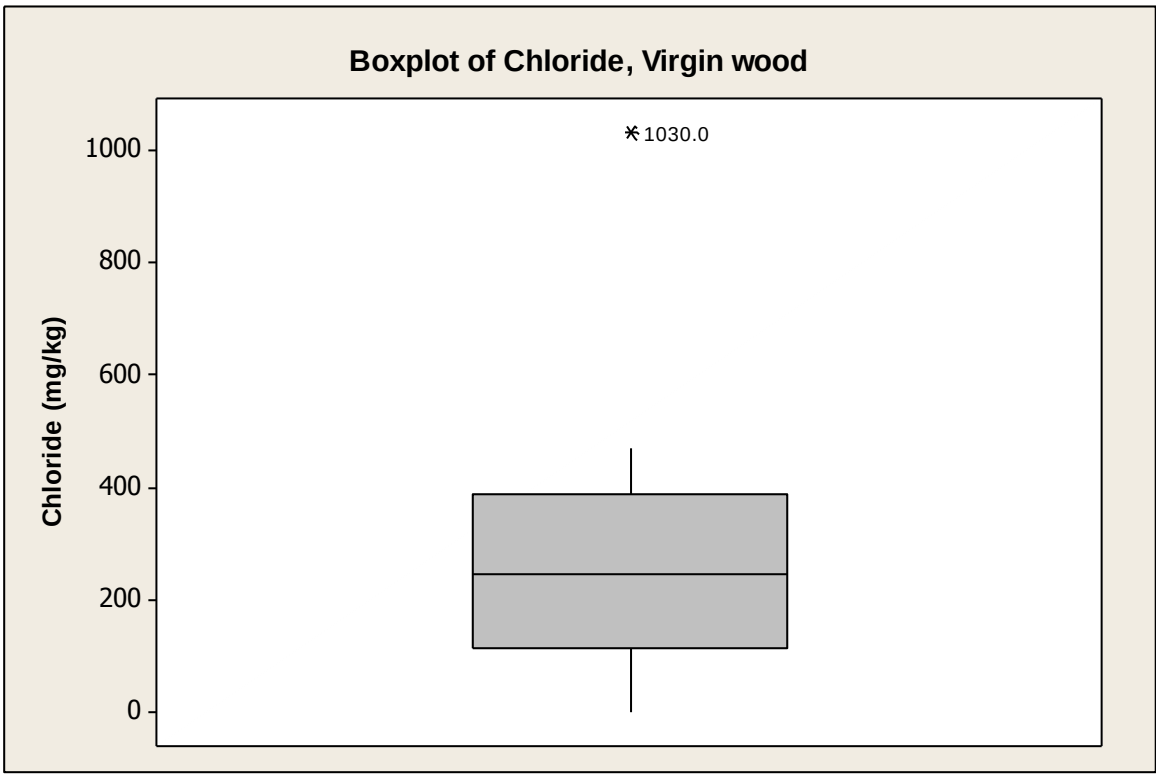

Figure 8.1 Box plot of chloride concentration in virgin wood

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)
- particle size distribution (Table 8.2)
- primary, secondary and trace nutrients (Table 8.3)
- other elements found in plants which may not be essential for growth, Potentially Toxic Elements (PTEs) and other potential contaminants (Table 8.4)
- other metals and analytes (Table 8.5)
- GCMS semi-volatile screen (Table 8.6a,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 8.6. Table 8.7 provides a statistical analysis of the combined dataset of those elements for which existing data were identified (see Section 7).

Table 8.1 Primary data for non-waste wood: beneficial properties

Sample ID	pH	Conductivity	Dry solids @ 30°C	Dry solids @ 105°C	LoI @ 500°C (organic matter content)	Carbon, organic as C	Nitrogen as N	Carbon	C:N [1]
		µS/cm	%	%	%	%	mg/kg (DW)	mg/kg (DW)	
Wood 01	4.40	0.95	39.8	37.4	95.6	38.3	10,800	456,000	42.2
Wood 02	6.15	0.29	31.3	34.1	94.4	36.9	9,400	464,000	49.4
Wood 03	4.93	0.17	81.4	80.4	99.5	49.0	3,560	461,000	129
Wood 04	6.15	0.47	61.5	55.7	93.7	44.0	4,230	379,000	89.6
Wood 05	6.36	0.35	88.3	81.4	99.3	44.4	1,380	441,000	320
Wood 06	6.74	0.23	64.0	55.7	96.3	41.0	4,390	401,000	91.3
Wood 07	4.42	0.42	71.8	67.1	97.6	46.9	4,070	473,000	116
Wood 08	5.09	0.44	61.6	78.7	98.5	44.7	6,030	444,000	73.6
Wood 09	5.80	0.03	55.5	63.5	99.7	44.9	540	464,000	859
Wood 10	6.41	0.18	47.9	74.0	94.6	46.1	4,240	345,000	81.4
Wood 11	5.54	0.37	50.8	65.3	96.3	46.0	4,410	456,000	103
Wood 12	4.72	0.57	59.0	71.6	99.4	45.3	2,780	496,000	178
Wood 13	5.08	0.24	53.2	68.2	98.8	43.8	3,730	477,000	128
Wood 14	4.90	0.20	52.6	80.6	98.8	42.0	4,510	427,000	947
Wood 15	4.87	0.16	43.8	84.4	95.7	29.2	5,420	439,000	81.0
Wood 16	5.38	0.30	75.3	98.3	95.9	45.5	5,130	451,000	87.9
Mean	5.43	0.34	58.6	68.5	97.1	43.0	4,664	442,125	211
Median	5.24	0.30	57.3	69.9	97.0	44.6	4,315	453,500	97.4
Minimum	4.40	0.03	31.3	34.1	93.7	29.2	540	345,000	42.2
Maximum	6.74	0.95	88.3	98.3	99.7	49.0	10,800	496,000	947
No. of samples	16	16	16	16	16	16	16	16	16
90th percentile	6.39	0.52	78.4	82.9	99.5	46.5	7,715	475,000	589
LOD	0.20	10	0.5	0.5	0.5	0.3	200	1,000	n/a

Notes: [1] Calculated value

Table 8.2 Primary data for non-waste wood: particle size distribution

Sample ID	Supplied grade (mm)	Fraction (% DW)		
		2–20 mm	20–50 mm	>50 mm
Wood 01	Unknown	67.5	0.10	0.10
Wood 02	Unknown	46.4	0.10	0.10
Wood 03	30-60	35.4	58.5	0.10
Wood 04	Unknown	78.9	0.10	0.10
Wood 05	Unknown	95.1	0.10	0.10
Wood 06	Unknown	68.2	28.5	0.10
Wood 07	3–18	100	0.00	0.00
Wood 08	5–35	100	0.00	0.00
Wood 09	5–40	100	0.00	0.00
Wood 10	5–35	74.4	0.10	0.10
Wood 11	5–75	100	0.00	0.00
Wood 12	15–65	100	0.00	0.00
Wood 13	10–50	100	0.00	0.00
Wood 14	5–35	100	0.00	0.00
Wood 15	1–10	56.8	0.10	0.10
Wood 16	Unknown	99.7	0.10	0.10
Mean		82.7	5.48	0.06
Median		97.4	0.10	0.10
Minimum		35.4	0.00	0.00
Maximum		100	58.5	0.10
No. of samples		16	16	16
90th percentile		100	14.3	0.10
LOD		0	0	0

Table 8.3 Primary data for non-waste wood: 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
Wood 01	<10,800	799	3,470	<5	<8.00	8,380	1,320	<0.05	13.6	5.90	1,900	529	<2	95.6	331
Wood 02	<9,390	1,110	4,090	9.02	<9.58	10,700	2,040	<0.05	16.7	9.29	4,610	825	<2	136.0	323
Wood 03	<3,560	498	1,970	10.4	<4.00	4,830	517	<0.05	11.3	22.0	628	203	<2	30.9	91.6
Wood 04	<4,230	574	2,090	14.7	<5.00	11,300	1,430	<0.05	12.2	7.68	1,910	374	<2	57.0	471
Wood 05	<1,380	105	722	<2	<3.00	754	135	0.09	4.46	2.94	137	175	<2	6.18	<3
Wood 06	<4,390	842	3,490	14.6	<5.00	12,200	807	<0.05	13.0	33.7	965	42.5	<2	73.7	26.2
Wood 07	<4,070	445	1,550	<3	<4.00	4,680	545	<0.05	8.92	6.35	2,840	403	<1	41.2	223
Wood 08	<6,030	616	2,390	<3	<5.00	2,740	586	<0.05	13.6	5.24	<200	689	<1	39.6	468
Wood 09	<540	61.5	385	<4	<4.78	324	78.2	<0.05	1.27	1.08	<200	60	<1	3.27	7.70
Wood 10	<4,240	780	2,560	<4	<6.00	11,000	1,640	<0.05	11.9	10.9	5,920	496	<1	64.8	260
Wood 11	<4,410	747	3,460	<4	<6.00	7,970	1,390	<0.05	14.5	7.72	1,780	960	<1	120.0	339
Wood 12	<2,780	659	2,510	<3	<5.00	3,150	754	<0.05	12.8	4.76	1,260	915	<1	30.2	407
Wood 13	<3,730	559	1,750	<4	<6.00	4,880	622	<0.05	9.16	5.34	1,170	276	<1	33.6	1,030
Wood 14	<4,510	582	1,960	<4	<6.00	6,160	913	<0.05	11.5	5.99	1,420	423	<1	34.7	212
Wood 15	<5,420	784	2,770	<2	<7.00	7,350	1,450	<0.05	11.6	10.7	3,100	769	<1	85.0	230
Wood 16	<5,130	334	1,570	<3	<4.00	4,420	391	<0.05	12.3	3.70	<200	943	<1	26.9	186
Mean	4,663	593	2,296	5.61	5.52	6,302	914	0.05	11.2	8.96	1,765	505	1.38	54.9	288
Median	4,315	599	2,240	4.00	5.00	5,520	781	0.05	12.1	6.17	1,340	460	1.00	40.4	245
Minimum	540	62	385	2.00	3.00	324	78	0.05	1.27	1.08	137	42.5	1.00	3.27	3.00
Maximum	10,800	1,110	4,090	14.7	9.58	12,200	2,040	0.09	16.7	33.7	5,920	960	2.00	136.0	1,030
No. of samples	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
90th percentile	7,710	821	3,480	12.5	7.50	11,150	1,545	0.05	14.1	16.5	3,855	929	2.00	108	470
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 8.4 Primary data for non-waste wood: 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
Wood 01	1.77	1.69	177	0.57	2.85	5.90	2.64	<2	3.34	95.6	2.61
Wood 02	1.71	1.62	345	0.67	22.5	9.29	4.68	<2	7.81	136	3.77
Wood 03	0.37	1.48	250	<0.3	5.41	22.0	3.92	<2	3.29	30.9	1.14
Wood 04	0.90	1.37	516	0.38	4.97	7.68	6.35	<2	4.17	57.0	3.90
Wood 05	<0.3	1.00	173	<0.25	0.49	2.94	1.80	<2	0.94	6.18	0.22
Wood 06	0.49	1.27	447	<0.3	7.90	33.7	5.25	<2	4.25	73.7	1.49
Wood 07	1.02	1.32	276	0.42	2.18	6.35	7.38	<0.2	2.35	41.2	2.64
Wood 08	0.28	1.43	210	0.36	<0.5	5.24	<1	<0.2	0.80	39.6	0.26
Wood 09	<0.1	1.14	33.7	<0.2	<0.5	1.08	<1	<0.2	<0.6	3.27	<0.1
Wood 10	2.01	<1	233	0.44	8.03	10.9	11.9	<0.2	6.02	64.8	10.3
Wood 11	1.23	1.48	195	0.93	2.17	7.72	3.51	<0.2	4.38	120	2.32
Wood 12	0.63	1.40	142	0.36	2.13	4.76	3.13	<0.2	2.53	30.2	2.07
Wood 13	0.51	1.13	285	0.40	1.98	5.34	3.32	<0.2	1.62	33.6	1.53
Wood 14	1.21	1.18	183	0.39	2.68	5.99	3.60	<0.2	2.58	34.7	2.38
Wood 15	1.62	1.35	180	0.75	3.07	10.7	5.94	<0.2	4.83	85.0	4.07
Wood 16	0.73	<1	102	0.65	0.73	3.70	<1	<0.2	0.99	26.9	0.23
Mean	0.93	1.30	234	0.46	4.26	8.96	4.15	0.88	3.16	54.9	2.44
Median	0.82	1.34	203	0.40	2.43	6.17	3.56	0.20	2.94	40.4	2.20
Minimum	0.10	1.00	33.7	0.20	0.49	1.08	1.00	0.20	0.60	3.27	0.10
Maximum	2.01	1.69	516	0.93	22.5	33.7	11.9	2.00	7.81	136	10.3
No. of samples	16	16	16	16	16	16	16	16	16	16	16
90th percentile	1.74	1.55	396	0.71	7.97	16.5	6.87	1[2]	5.43	108	3.99
LOD	0.1	1	10	0.2	0.5	1	1	0.2	0.6	2	0.1

Notes: [1] All units mg/kg (DW).
[2] The PAS 100 limit for Hg has been used due to sample clean-up problems

Table 8.5 Primary data for non-waste wood: 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
Wood 01	770	<10	1.31	155	0.032	<6	<10	35.8	<3	<20	33.6	<0.8	<20	332	20.5	<0.3	<8
Wood 02	1,200	<10	1.39	182	0.051	<6	<10	49.5	<3	<20	38.7	<1	<20	<0.9	21.6	<0.3	9.58
Wood 03	753	<10	1.61	18.8	<0.01	<6	<10	10.9	<3	<20	4.43	<0.3	<20	<2	20.8	<0.1	<4
Wood 04	1,570	<10	1.45	107	0.088	<6	<10	27.5	<3	<20	50.3	<0.3	<30	<2	34.7	<0.2	<5
Wood 05	<100	<10	<1	9.92	<0.01	<6	<10	<5	<3	<20	2.38	<0.3	<20	<3	219	<0.1	<3
Wood 06	539	<10	1.23	12.9	<0.01	<6	<10	26.8	<3	<20	8.41	<0.3	<30	<2	9.40	<0.2	<5
Wood 07	717	<1	1.26	24.6	0.100	<1	<1	10.2	<1	<1	<3	<0.3	<30	8.75	25.8	<0.1	<4
Wood 08	180	<1	0.85	36.6	<0.1	<1	<1	13.3	<1	<1	<3	<0.3	<30	<0.3	<5	<0.2	<5
Wood 09	<50	<1	0.50	9.12	<0.1	<1	<1	1.51	<1	<1	<3	<0.4	<40	<0.3	11.3	0.22	<5
Wood 10	3,190	<1	3.81	61.2	0.157	4.06	<1	26.4	<1	<1	76.6	<0.4	<40	<0.3	60.1	<0.2	<6
Wood 11	964	<1	0.93	90.4	<0.1	1.74	<1	24.2	<1	<1	<3	<0.4	<40	<0.3	<5	<0.2	<6
Wood 12	864	<1	2.12	45.1	<0.1	1.57	<1	11.4	<1	<1	3.40	<0.3	<30	3.31	19.1	<0.2	<5
Wood 13	806	<1	1.04	19.6	<0.1	<1	<1	9.21	<1	<1	<3	<0.4	<40	6.73	40.5	<0.2	<6
Wood 14	883	<1	1.18	30.7	<0.1	1.03	<1	13.6	<1	<1	10.1	<0.4	<40	<0.3	13.6	<0.2	<6
Wood 15	1,670	<1	1.21	109	<0.1	2.23	<1	22.3	<1	<1	34.9	<0.5	<50	0.98	5.83	<0.2	<7
Wood 16	332	<1	<0.5	58.7	<0.1	<1	<1	14.9	<1	<1	<3	<0.3	35.7	4.28	41.0	<0.1	<4
Mean	912	4.38	1.34	60.7	0.079	3.23	4.38	18.9	1.75	8.13	17.6	0.42	32.2	23.0	34.6	0.19	5.54
Median	788	1.00	1.22	40.9	0.1	1.99	1	14.3	1	1	3.92	0.35	30	2	20.7	0.2	5
Minimum	50.0	1.00	0.50	9.12	0.01	1	1	1.51	1	1	2.38	0.30	20	0.30	5	0.1	3
Maximum	3,190	10.0	3.81	182	0.157	6	10.0	49.5	3.00	20.0	76.6	1	50	332	219	0.3	9.58
No. of samples	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
90th percentile	1,620	10	1.87	132	0.1	6	10	31.7	3	20	44.5	0.65	40	7.74	50.6	0.26	7.5
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 8.6 Primary data for non-waste wood: GCMS semi-volatile screen [1,2]

(a)

Sample ID	1-phenanthrenecarboxylic acid, 1,2,3,4,4a,9,10,10a – octahydro – 1,4a,- dimethyl-7-(1-methylethyl)-, (1R-(1.alpha,4a.beta,10a.alpha)-	1-phenanthrenecarboxylic acid, 1,2,3,4,4a,9,10,10a – octahydro-1,4a-dimethyl-7-(1-methylethyl)-, methylester,-(1S-(1.alpha,4a.alpha,10a.alpha)-	1-phenanthrenecarboxaldehyde, 7-ethenyl – 1,2,3,4,4a,4b,5,6,7,9,10,10a – dodecahydro – 1,4a,7-trimethyl-, (1R-(1.alpha,4a.beta, 4b.alpha,7.beta,10a.alpha)-	1-naphthalenepropanol,alpha – ethenyldecahydro-,alpha,5,5,8a-tetramethyl-2-methylene – (1S(1.alpha(S*). 4a.beta,8a.alpha))-	1-docosene	(5.alpha, 9.alpha, 10.beta) – kaur – 15-ene	(1S-(1.alpha(R*),4a.beta,8a.alpha)) – alpha – ethenyldecahydro – alpha.,5,5,8a-tetramethyl-2-methylene-1-naphthalenepropanol	(1R-(1.alpha,4a.beta,10.alpha)) – 1,2,3,4,4a,9,10,10a-octahydro – 1,4a – dimethyl-7-(1-methylethyl)-1-phenanthrenecarboxaldehyde	(1R-(1.alpha,4a.beta,4b.alpha,7.alpha,10a.alpha)-7-ethenyl – 1,2,3,4,4a,4b,5,6,7,8,10,10a – dodecahydro – 1,4a,7 – trimethyl 1-phenanthrenecarboxylic acid	(1R-(1.alpha, 4a.beta,10a.alpha)) – 1,2,3,4,4a,9,10,10a-octahydro – 1,4a – dimethyl-7-(1-methylethyl)-1-phenanthrenecarboxylic acid, methyl ester
Wood 01										
Wood 02						17				
Wood 03										17
Wood 04							98	26	11	29
Wood 05										
Wood 06										
Wood 07				26						
Wood 08				25						
Wood 09										
Wood 10										
Wood 11										
Wood 12										
Wood 13	2400	64	57							
Wood 14										
Wood 15	51		32							
Wood 16					48					

(b)

Sample ID	1-phenanthrenemethanol, 1,2,3,4,4a,9,10,10a-octahydro-1,4a-dimethyl-7-(1-methylethyl)-, (1S-(1.alpha, 4a.alpha, 10a.beta))-	1,22-docosanediol	1,3,6,10-cyclotetradecatetraene,3,7,11-trimethyl-14-(1-methylethyl)-	13-docosenamide	3,7,11-trimethyl-14-(1-methylethyl)-1,3,6,10 -cyclotetradecatetraene	9,12-octadecadienoic acid	α-amyrin	campesterol	friedelan-3-one	γ-sitosterol	kaur -15-ene, (5.alpha,9.alpha,10.beta)-	*n*-hexadecanoic acid	*n*-tetracosanol-1	stigmast-4-en-3-one	stigmastanol	thunbergol
Wood 01									21	30					23	
Wood 02										240						
Wood 03					19					35				97		
Wood 04					20	84				116		18		54		
Wood 05																45
Wood 06							19			33						
Wood 07			36							16				39		27
Wood 08	15													25	29	
Wood 09																
Wood 10																
Wood 11				17				13		57				19		
Wood 12										40				25		
Wood 13			310											16		730
Wood 14										49				10		
Wood 15			13							25	14			20		
Wood 16		16								19			121	25		53

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.

Table 8.7 Primary data for non-waste wood: combined data summary

	Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	Mg	Mn	Na	Ni	P	Pb	Sr	Zn
Mean	612.7	0.8	40.5	134.5	8,190.6	0.3	1.7	2.8	5.0	1,173.0	1,447.5	1,077.6	691.2	2.0	601.8	3.2	46.4	28.9
Median	332	0.85	14.5	107	6,408	0.36	0.93	0.99	2.94	504.5	1,320	721	447	0.97	559	3.13	31.25	16.71
Minimum	64	0	1.27	9.12	324	0.04	0.1	0.03	0.56	79	78.2	42.5	33.7	0.02	61.5	0.1	1.51	1.18
Maximum	3,190	3.81	212	467	25,470	0.93	16	22.5	33.7	5,920	4,628	5,306	4,033	7.81	2,335	11.9	159	136
No. of samples	27	25	29	29	29	23	21	25	43	26	29	29	29	26	29	27	28	43
90th percentile	1,348	1.546	69.2	297.8	13,855	0.7	2.01	6.9	10.4	2,970	3,410.4	2,511	1,493.6	4.6	900.4	6.8	97.6	82.74

Notes: All results are mg/kg (DW)

9 Conclusions

Data are presented for 16 samples of non-waste wood bark and chippings. 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.

Published data were identified and collected but their analytical quality could not be confirmed and the majority were rejected.

Data from existing published sources have been combined with data from this project and the statistical analysis is shown in Table 8.7.

References

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

ENVIRONMENT AGENCY, 2013. *Material comparators for end-of-waste decisions: manufactured fertilisers.* Bristol: Environment Agency.

WRAP, 2005. *Assessment of types and levels of naturally occurring contaminants in non-waste wood sources.* Banbury: WRAP.

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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