Environment Agency

Evidence

Material comparators for end-of-waste decisions

Materials for fuels: charcoal

Report – SC130040/R8

Version 2

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Executive summary

This report details the work undertaken to characterise charcoal, a key comparator. This information will inform end-of-waste assessments for waste-derived materials intended to replace charcoal as a fuel.

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 the Environment Agency 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 charcoal 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.

Eleven samples of charcoal 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 other materials and wastes can be assessed.

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 the Environment Agency 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.'

The purpose of this report is to provide an evidence base of the composition and characteristics of charcoal which is defined as an ordinary material comparator that is currently permitted for use as a fuel.

This report provides the results from the primary analysis of 11 charcoal samples.

Three other reports cover ordinary material comparators for fuel:

- biomass
- coal
- natural gas

2 Definition

2.1 Material properties relevant to use

Charcoal is an easy to handle and convenient fuel, which burns without producing much smoke other than during lighting.

Charcoal is a dark grey or black solid and is made by heating wood or other biological materials in the absence of oxygen. It is often used for outdoor domestic cooking, for example, on barbeques. Charcoal is produced in the UK but the majority is imported. The current source of most of Britain's charcoal is South-East Asia, Central and South Africa and Latin America (Surrey County Council 2012).

Charcoal can be split into two types as described below.

2.1.1 Lumpwood

Lumpwood charcoal is mainly produced from hardwood. Softwood can be used to make charcoal, but this tends to be less dense and burns more quickly. Restaurant charcoal used in the restaurant trade is screened to a larger grade and will burn longer and hotter than normal barbecue charcoal.

2.1.2 Briquettes

Charcoal briquettes are manufactured ovoids that are made from charcoal fines bound with vegetable starch.

3 Comparator sub-types

Eleven charcoal samples were obtained from a variety of suppliers across England to provide a cross-section of charcoal types. Figures 3.1 and 3.2 show breakdowns of the samples by sub-type and origin respectively.

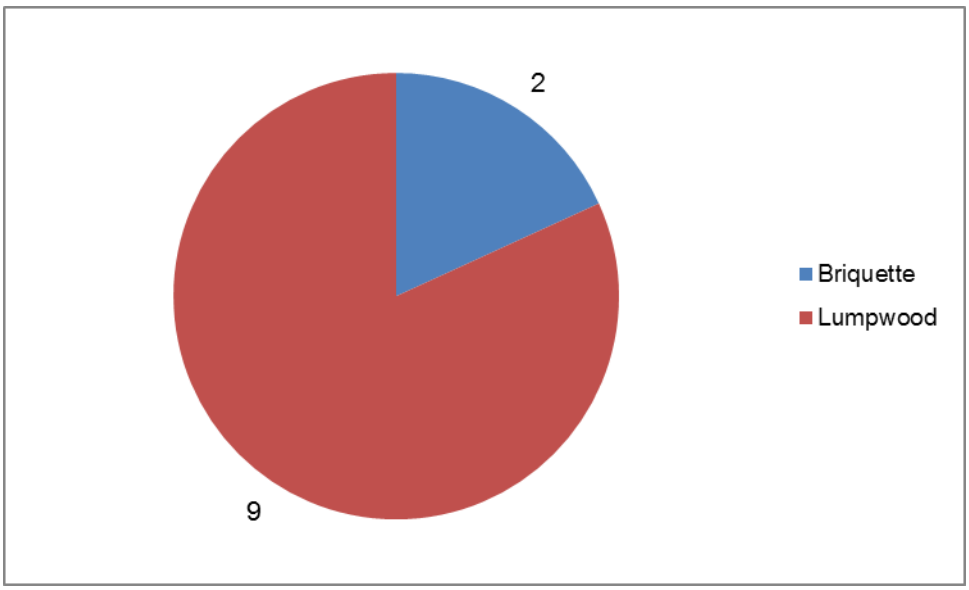

Figure 3.1 Number of charcoal samples by sub-type

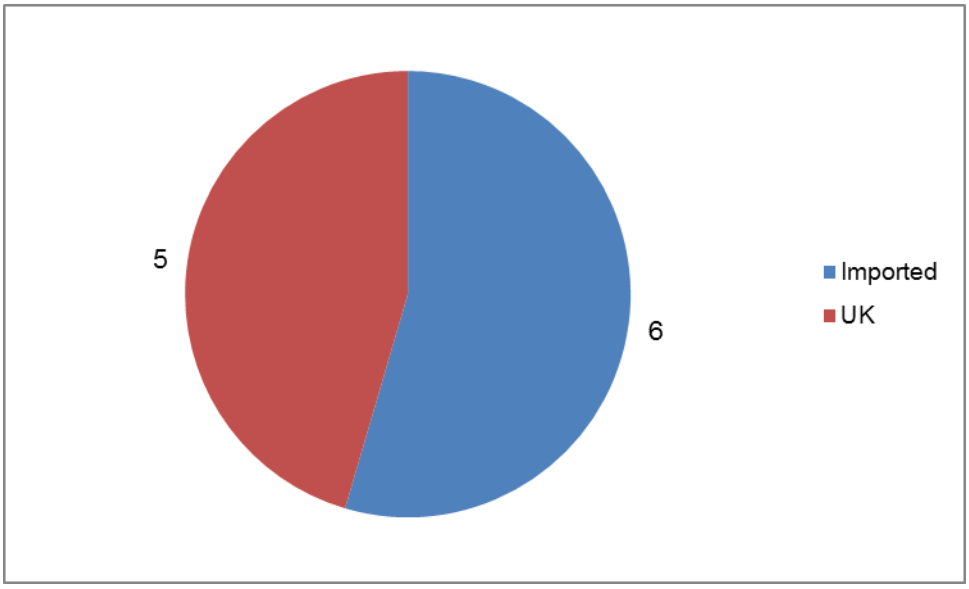

Figure 3.2 Number of charcoal samples by origin

4 Material sources and sampling procedure

An internet search was used to produce a list of charcoal suppliers. Charcoal samples were requested from all these suppliers to ensure a cross-section of charcoal types were sampled. Samples were collected from those willing to participate.

No sampling standards for charcoal were identified during the literature review. Charcoal samples were taken in accordance with BS 4845-2:1979 (BSI 1979).

5 Analytical parameters

The main parameters determined, together with units of measurement, are summarised in Tables 5.1 to 5.5.

Testing was carried out in accordance with in-house methods documented by the Environment Agency's National Laboratory Service (NLS) 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, 'SAL' refers to Scientific Laboratories Ltd and 'ESG' refers to Environmental Scientifics Group Limited.

Table 5.1 Analysis: physical properties

Parameter/ determinand	Test method used	Unit
Particle size distribution (PSD)	SAL determination of percentage particles. 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).	%
Bulk density	The test portion is filled into a standard container of a given size and shape, and is weighed afterwards. The density is calculated from the net weight per standard volume and reported.	kg/m^3

Table 5.2 Proximate analysis (composition) and calorific value

Parameter/ determinand	Test method used	Unit
Moisture content	ESG documented in-house method based on ISO 687 and ISO11722	%
Ash content	ESG documented in-house method based on ISO 1171:2010	%
Volatile matter	ESG documented in-house method based on ISO 562:2010	%
Fixed carbon	Parameter by calculation	%
Net calorific value (LHV)	ESG documented in-house method based on ISO 1928	kJ/kg
Gross calorific value (HHV)	ESG documented in-house method based on ISO 1928	kJ/kg

Table 5.3 Ultimate (elemental) analysis

Parameter/ determinand	Test method used	Unit
Carbon	ESG documented in-house method by Exeter CE440 elemental analyser	%
Hydrogen	ESG documented in-house method by Exeter CE440 elemental analyser	%
Nitrogen	ESG documented in-house method by Exeter CE440 elemental analyser	%
Oxygen	Calculated	%
Sulphur	ESG documented in-house methods by instrumental analysis using Eltra Helios sulphur analyser	%
Chlorine	ESG documented in-house method based on method described in Vol. 115 of the *Analyst* (November 1990) using wavelength dispersive X-ray fluorescence (XRF)	%
Fluorine	Following calorific value test (see Table 5.2) – the washings from the bomb calorimeter are submitted for analysis.	%
Bromine	Following calorific value test (see Table 5.2) – the washings from the bomb calorimeter are submitted for analysis by ion-selective electrode.	%

Table 5.4 Analysis: metals

Parameter/ determinand	Test method used	Unit
Aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, thallium, tin, titanium, vanadium, zinc	LE I metals (ICP-OES) 01– digestion block aqua regia extracted under reflux; determined by inductively coupled plasma optical emission spectrometry (ICP-OES)	mg/kg
Chromium VI	Hexavalent chromium by spectrophotometry	mg/kg

Table 5.5 Analysis: organic contaminants

Parameter/ determinand	Test method used	Unit
Polycyclic aromatic hydrocarbons (PAHs) (USEPA16)[1]	Organics dichloromethane (DCM) extracted; hexane exchange determined by gas chromatography–mass spectrometry (GCMS) (scan mode)	μg/kg
Benzene, toluene, ethylbenzene and xylenes (BTEX)	Organics DCM extracted; hexane exchange determined by GCMS (scan mode)	μg/kg
Polychlorinated biphenyls (PCBs)	LE O HRMS3 – dioxins; furans – toluene accelerated solvent extraction (ASE); three-stage clean-up; determined by high resolution GCMS	μg/kg
Dioxins and furans	LE O HRMS3 – dioxins; furans – toluene ASE; three-stage clean-up; determined by high resolution GCMS	μg/kg

Notes: [1] List of 16 PAHs classified by the US Environmental Protection Agency (USEPA) as priority pollutants.

6 Existing data

No relevant existing datasets relating to charcoal were identified during the literature review.

7 Primary data

7.1 Statistical analysis of data

All ‘less than’ values were taken as the measured value. The mean, median, minimum, maximum and 90th percentile were calculated for each analyte.

Box plots can be used to graphically represent groups of quantitative data. 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. The top of the box is 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 times the interquartile range.

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

A box and whisker plot of potassium concentration in charcoal is shown in Figure 7.1. This diagram demonstrates the issue of outliers in the dataset.

It is important to provide a reasonable sized dataset for comparison purposes. Where there is sufficient sample size (≥10) to calculate a 90th percentile of the data, the 90th percentile has been calculated.

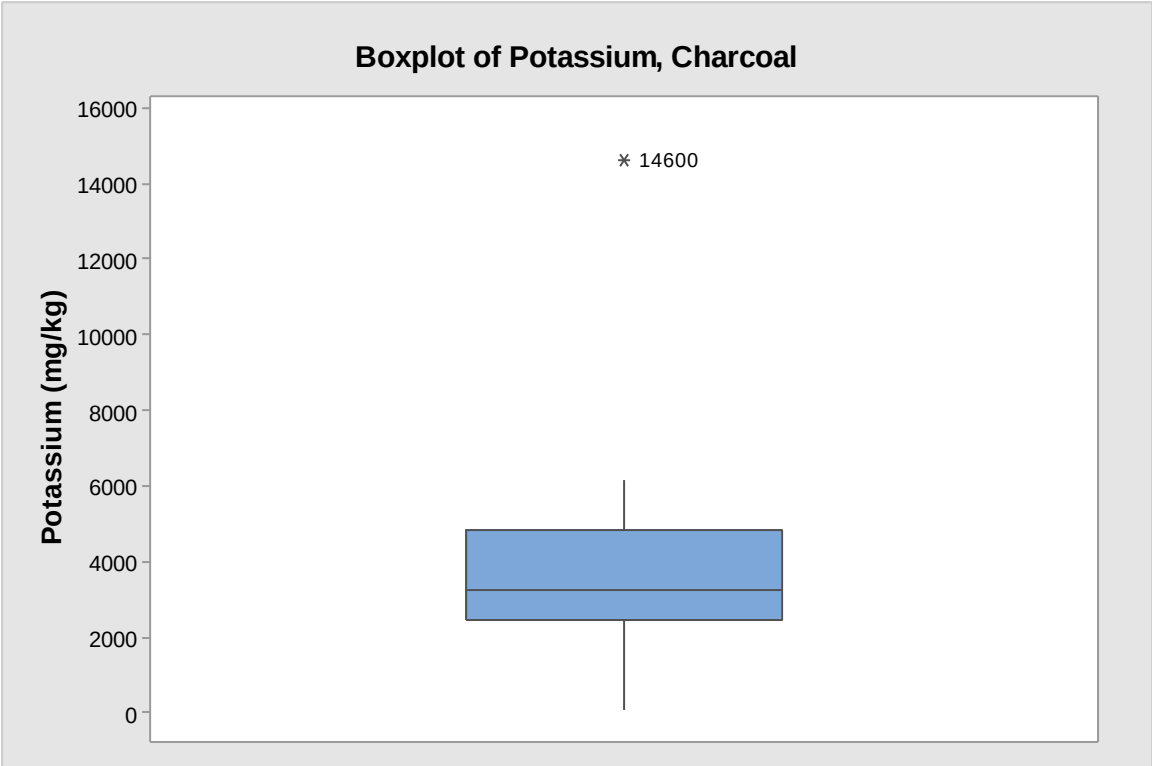

Figure 7.1 Boxplot of potassium, charcoal

7.2 Using the data tables

Data are presented in tables summarising:

- physical properties
- metals
- organic contaminants
- calorific value, proximate (composition) and ultimate (elemental) analysis

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 (LOD) for some analytes was elevated above the target limit of detection.

7.3 Primary data tables

Primary data are shown in Tables 7.1 to 7.17.

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Table 3.1 Primary data for charcoal: physical properties

Sample ID	Dry solids @ 30°C	PSD 2–20 mm	PSD 20–50 mm	PSD >50 mm	Loose bulk density
	%	%	%	%	kg/m^3
Charcoal 01	95.8	49.5	<0.1	<0.1	–
Charcoal 02	97.4	17.0	<0.1	<0.1	–
Charcoal 03	97.3	15.0	<0.1	<0.1	–
Charcoal 04	98.1	30.0	<0.1	<0.1	–
Charcoal 05	75.8	10.7	<0.1	<0.1	–
Charcoal 06	94.5	5.4	<0.1	<0.1	–
Charcoal 07	93.0	4.0	<0.1	<0.1	–
Charcoal 08	94.8	8.7	<0.1	<0.1	–
Charcoal 09	96.5	7.6	<0.1	<0.1	123
Charcoal 10	96.4	12.9	<0.1	<0.1	–
Charcoal 11	97.2	19.8	<0.1	<0.1	–
Mean	94.3	17.3	0.1	0.1	123
Median	96.4	14.0	0.1	0.1	123
Minimum	75.8	4.0	0.1	0.1	123
Maximum	98.1	49.5	0.1	0.1	123
No. of samples	11	10	10	10	1
90th percentile	97.4	32.0	0.1	0.1	n/a
LOD	0.5	n/a	n/a	n/a	n/a

Notes: – Particle size reduced, loose bulk density test not conducted

Table 7.2 Primary data for charcoal: metals (mg/kg DW)

(a)

Sample ID	Al	Sb	As	Ba	Be	Bo	Cd	Ca	Cr	Cr VI	Co	Cu	Fe	Pb	Li
Charcoal 01	1620.0	<1.00	<0.50	29.4	<0.1	13.80	<0.200	10000	3.430	<0.6	1.390	4.38	1360	<1.00	<1.00
Charcoal 02	<50.0	<1.00	<0.50	2.5	<0.1	14.90	<0.200	6950	<0.500	<0.6	<0.100	<1.00	<200	<1.00	<1.00
Charcoal 03	81.7	<1.00	<0.50	21.6	<0.1	23.50	0.298	32600	<0.500	<0.6	<0.100	7.60	<200	<1.00	1.20
Charcoal 04	<50.0	<1.00	<0.50	11.8	<0.1	10.80	<0.200	25600	<0.500	<0.6	0.233	1.74	<200	<1.00	<1.00
Charcoal 05	<50.0	<1.00	<0.50	20.3	<0.1	10.40	<0.200	4040	0.589	<0.6	0.236	3.26	<200	6.91	<1.00
Charcoal 06	206.0	<1.00	<0.50	21.9	<0.1	11.10	<0.200	5440	3.880	<0.6	0.198	4.14	227	3.82	<1.00
Charcoal 07	<50.0	<1.00	<0.50	5.5	<0.1	8.79	<0.200	3690	0.676	<0.6	<0.100	1.46	<200	<1.0	<1.00
Charcoal 08	<50.0	<1.00	<0.50	9.7	<0.1	18.60	<0.200	4520	<0.500	<0.6	<0.100	2.15	<200	<1.0	<1.00
Charcoal 09	78.8	<1.00	<0.50	32.9	<0.1	2.93	<0.200	2990	1.800	<0.6	<0.100	<1.00	<200	<1.0	<1.00
Charcoal 10	116.0	<1.00	<0.50	51.0	<0.1	4.34	<0.200	17400	0.546	<0.6	0.115	2.70	<200	1.63	<1.00
Charcoal 11	9130.0	2.45	1.16	165.0	<0.1	317.00	2.840	24300	9.510	<1.2	5.530	119.00	9460	36.20	3.57
Mean	1043.9	1.13	0.56	33.8	0.1	39.65	0.449	12503	2.039	0.7	0.746	13.49	1150	5.05	1.25
Median	78.8	1.00	0.50	21.6	0.1	11.10	0.200	6950	0.589	0.6	0.115	2.70	200	1.00	1.00
Minimum	50.0	1.00	0.50	2.5	0.1	2.93	0.200	2990	0.500	0.6	0.100	1.00	200	1.00	1.00
Maximum	9130.0	2.45	1.16	165.0	0.1	317.00	2.840	32600	9.510	1.2	5.530	119.00	9460	36.20	3.57
No. of samples	11.0	11	11	11	11	11	11	11	11	11	11	11	11	11	11
90th percentile	1620.0	1.00	0.50	51.0	0.1	23.50	0.298	25600	3.880	0.6	1.390	7.60	1360	6.91	1.20
LOD	50	1	0.5	0.5	0.1	1	0.2	60	0.5	0.6	0.1	1	200	1	1

(b)

Sample ID	Mg	Mn	Hg	Mo	Ni	P	K	Se	Ag	Na	Sr	Tl	Sn	Ti	V	Zn
Charcoal 01	954	42.30	<0.2	<1	1.290	556.0	4220	<1	<1	403.0	58.4	<1	<1.00	94.80	4.910	10.90
Charcoal 02	74.9	<2.00	<0.2	<1	<0.600	30.4	115	<1	<1	59.1	62.3	<1	<1.00	<3.00	<0.100	<2.00
Charcoal 03	985	14.90	<0.2	<1	<0.600	590.0	3790	<1	<1	84.4	379.0	<1	<1.00	<3.00	0.183	21.50
Charcoal 04	1790	3.29	<0.2	<1	0.878	405.0	6160	<1	<1	49.3	123.0	<1	<1.00	<3.00	<0.100	3.66
Charcoal 05	448	328.00	<0.2	<1	1.240	462.0	2470	<1	<1	96.8	18.7	<1	<1.00	<3.00	0.220	39.60
Charcoal 06	603	102.00	<0.2	<1	2.510	277.0	3120	<1	<1	141.0	16.1	<1	<1.00	9.55	0.637	14.40
Charcoal 07	207	40.20	<0.2	<1	0.612	137.0	2550	<1	<1	166.0	3.7	<1	<1.00	<3.00	<0.100	12.50
Charcoal 08	666	41.90	<0.2	<1	0.869	363.0	4860	<1	<1	140.0	17.1	<1	<1.00	<3.00	<0.100	13.30
Charcoal 09	1100	70.60	<0.2	<1	0.871	52.5	662	<1	<1	49.4	3.9	<1	<1.00	<3.00	0.235	8.20
Charcoal 10	753	8.42	<0.2	<1	<0.600	287.0	3270	<1	<1	36.3	179.0	<1	<1.00	7.28	0.249	8.92
Charcoal 11	3520	947.00	<0.2	<1	9.900	1440.0	14600	<1	<1	956.0	129.0	<1	4.78	645.00	37.60	176.00
Mean	1009	145.51	0.2	1	1.815	418.2	4165	1	1	198.3	90.0	1	1.34	70.69	4.04	28.27
Median	753	41.90	0.2	1	0.871	363.0	3270	1	1	96.8	58.4	1	1.00	3.00	0.22	12.50
Minimum	74.9	2.00	0.2	1	0.600	30.4	115	1	1	36.3	3.7	1	1.00	3.00	0.10	2.00
Maximum	3520	947.00	0.2	1	9.900	1440.0	14600	1	1	956.0	379.0	1	4.78	645.00	37.60	176.00
No. of samples	11	11	11	11	11	11	11	11	11	11	11	11	11	11.00	11	11
90^{th} percentile	1790	328	0.2	1	2.510	590	6160	1	1	403	179	1	1	94.8	4.91	39.6
LOD	20	2	0.2	1	0.6	10	50	1	1	10	1	1	1	3	0.1	2

DW = dry weight

Table 7.3 Primary data for charcoal: heptachlorodibenzo-*p*-dioxin

Sample ID	1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin ng/kg (ITEQ)	1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin ng/kg (DW)	Heptachlorodibenzo-*p*-dioxin ng/kg (DW) sum of isomers
Charcoal 01	<0.0300	<3.00	<3.0
Charcoal 02	<0.0300	<3.00	<3.0
Charcoal 03	0.2150	21.50	51.9
Charcoal 04	<0.0300	<3.00	<3.0
Charcoal 05	<0.0300	<3.00	<3.0
Charcoal 06	<0.0300	<3.00	<3.0
Charcoal 07	<0.0300	<3.00	<3.0
Charcoal 08	<0.0300	<3.00	<3.0
Charcoal 09	<0.0300	<5.00	<3.0
Charcoal 10	<0.0300	<3.00	<3.0
Charcoal 11	0.0446	4.46	9.85
Mean	0.0481	5.00	8.07
Median	0.0300	3.00	3
Minimum	0.0300	3.00	3
Maximum	0.2150	21.50	51.9
No. of samples	11	11	11
90th percentile	0.0446	5.00	9.85
LOD	0.03	3	3

ITEQ = International Toxicity Equivalents

Table 7.4 Primary data for charcoal: hexachlorodibenzo-*p*-dioxin

Sample ID	1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	Hexachlorodibenzo-*p*-dioxin
	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (DW) sum of isomers
Charcoal 01	<0.09	<0.9	<0.070	<0.70	<0.2	<1	<0.7
Charcoal 02	<0.09	<0.9	<0.070	<0.70	<0.2	<1	<0.7
Charcoal 03	<0.09	<0.9	0.262	2.62	<0.2	<1	6.03
Charcoal 04	<0.09	<0.9	<0.070	<0.70	<0.2	<1	<0.7
Charcoal 05	<0.09	<0.9	<0.070	<0.70	<0.2	<1	<0.7
Charcoal 06	<0.09	<0.9	<0.070	<0.70	<0.2	<1	<0.7
Charcoal 07	<0.09	<0.9	<0.070	<0.70	<0.2	<1	<0.7
Charcoal 08	<0.09	<0.9	<0.070	<0.70	<0.2	<1	<0.7
Charcoal 09	<0.09	<0.9	<0.070	<0.70	<0.2	<1	<0.7
Charcoal 10	<0.09	<0.9	<0.070	<0.70	<0.2	<1	<0.7
Charcoal 11	<0.09	<0.9	<0.070	<0.70	<0.2	<1	<0.7
Mean	0.09	0.9	0.087	0.87	0.2	1	1.18
Median	0.09	0.9	0.070	0.70	0.2	1	0.7
Minimum	0.09	0.9	0.070	0.70	0.2	1	0.7
Maximum	0.09	0.9	0.262	2.62	0.2	1	6.03
No. of samples	11	11	11	11	11	11	11
90th percentile	0.09	0.9	0.070	0.70	0.2	1	0.7
LOD	0.09	0.9	0.07	0.7	0.2	1	0.7

Table 7.5 Primary data for charcoal: pentachlorodibenzo-*p*-dioxin

Sample ID	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin ng/kg (ITEQ)	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin ng/kg (DW)	Pentachlorodibenzo-*p*-dioxin ng/kg (DW) sum of isomers
Charcoal 01	<0.20	<0.40	<0.40
Charcoal 02	<0.20	<0.40	<0.40
Charcoal 03	<0.20	<0.40	<0.40
Charcoal 04	<0.20	<0.40	<0.40
Charcoal 05	<0.20	<0.40	<0.40
Charcoal 06	<0.20	<0.40	<0.40
Charcoal 07	<0.20	<0.40	<0.40
Charcoal 08	1.47	2.94	3.8
Charcoal 09	<0.20	<0.40	<0.40
Charcoal 10	<0.20	<0.40	<0.40
Charcoal 11	<0.20	<0.40	<0.40
Mean	0.32	0.63	0.71
Median	0.20	0.40	0.4
Minimum	0.20	0.40	0.4
Maximum	1.47	2.94	3.8
No. of samples	11	11	11
90^{th} percentile	0.20	0.40	0.4
LOD	0.2	0.4	0.4

Table 7.6 Primary data for charcoal: tetrachlorodibenzo-*p*-dioxin

Sample ID	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin ng/kg (ITEQ)	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin ng/kg (DW)	Tetrachlorodibenzo-*p*-dioxin ng/kg (DW) sum of isomers
Charcoal 01	<0.3	<0.3	<0.3
Charcoal 02	<0.3	<0.3	<0.3
Charcoal 03	<0.3	<0.3	<0.3
Charcoal 04	<0.3	<0.3	<0.3
Charcoal 05	<0.3	<0.3	<0.3
Charcoal 06	<0.3	<0.3	<0.3
Charcoal 07	<0.3	<0.3	<0.3
Charcoal 08	<0.3	<0.3	<0.3
Charcoal 09	<0.3	<0.3	<0.3
Charcoal 10	<0.3	<0.3	<0.3
Charcoal 11	<0.3	<0.3	<0.3
Mean	0.3	0.3	0.3
Median	0.3	0.3	0.3
Minimum	0.3	0.3	0.3
Maximum	0.3	0.3	0.3
No. of samples	11	11	11
90^{th} percentile	0.3	0.3	0.3
LOD	0.3	0.3	0.3

Table 7.7 Primary data for charcoal: octachlorodibenzo-*p*-dioxin

Sample ID	Octachlorodibenzo-*p*-dioxin ng/kg (ITEQ)	Octachlorodibenzo-*p*-dioxin ng/kg (DW)
Charcoal 01	0.0219	21.9
Charcoal 02	<0.0030	<4.0
Charcoal 03	0.2530	253.0
Charcoal 04	<0.0030	<4.0
Charcoal 05	<0.0030	<4.0
Charcoal 06	0.0303	30.3
Charcoal 07	0.0128	12.8
Charcoal 08	<0.0030	<4.0
Charcoal 09	0.0290	29.0
Charcoal 10	<0.0030	<4.0
Charcoal 11	0.0178	17.8
Mean	0.0345	35.0
Median	0.0128	12.8
Minimum	0.0030	4.0
Maximum	0.2530	253.0
No. of samples	11	11
90th percentile	0.0303	30.3
LOD	0.003	4

Table 7.8 Primary data for charcoal: heptachlorodibenzofuran

Sample ID	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1,2,3,4,7,8,9-Heptachlorodibenzofuran	Heptachlorodibenzofuran
	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (DW) sum of isomers
Charcoal 01	0.0356	3.56	<0.008	<0.9	4.27
Charcoal 02	<0.0200	<2.00	<0.008	<0.9	<0.90
Charcoal 03	0.0751	7.51	<0.008	<0.9	9.76
Charcoal 04	<0.0200	<2.00	<0.008	<0.9	<0.90
Charcoal 05	<0.0200	<2.00	<0.008	<0.9	<0.90
Charcoal 06	<0.0200	<2.00	<0.008	<0.9	<0.90
Charcoal 07	<0.0200	<2.00	<0.008	<0.9	<0.90
Charcoal 08	<0.0200	<2.00	<0.008	<0.9	<0.90
Charcoal 09	<0.0200	<4.00	<0.008	<0.9	<0.90
Charcoal 10	<0.0200	<2.00	<0.008	<0.9	<0.90
Charcoal 11	0.0425	4.25	<0.008	<0.9	7.67
Mean	0.0285	3.03	0.008	0.9	2.63
Median	0.0200	2.00	0.008	0.9	0.9
Minimum	0.0200	2.00	0.008	0.9	0.9
Maximum	0.0751	7.51	0.008	0.9	9.76
No. of samples	11	11	11	11	11
90^{th} percentile	0.0425	4.25	0.008	0.9	7.67
LOD	0.02	2	0.008	0.9	0.3

Table 7.9 Primary data for charcoal: hexachlorodibenzofuran

Sample ID	1,2,3,4,7,8-Hexachlorodibenzofuran	1,2,3,4,7,8-Hexachlorodibenzofuran	1,2,3,6,7,8-Hexachlorodibenzofuran	1,2,3,6,7,8-Hexachlorodibenzofuran	1,2,3,7,8,9-Hexachlorodibenzofuran	1,2,3,7,8,9-Hexachlorodibenzofuran	2,3,4,6,7,8-Hexachlorodibenzofuran	2,3,4,6,7,8-Hexachlorodibenzofuran	Hexachlorodibenzofuran
	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (DW) sum of isomers
Charcoal 01	<0.07	<0.7	<0.04	<0.40	<0.08	<0.80	<0.20	<2.0	<0.40
Charcoal 02	<0.07	<0.7	<0.04	<0.40	<0.08	<0.80	<0.20	<2.0	<0.40
Charcoal 03	<0.07	<0.7	0.158	1.58	0.149	1.49	0.331	3.31	14.8
Charcoal 04	<0.07	<0.7	<0.04	<0.40	<0.08	<0.80	<0.20	<2.0	<0.40
Charcoal 05	<0.07	<0.7	<0.04	<0.40	<0.08	<0.80	<0.20	<2.0	<0.40
Charcoal 06	<0.07	<0.7	<0.04	<0.40	<0.08	<0.80	<0.20	<2.0	<0.40
Charcoal 07	<0.07	<0.7	<0.04	<0.40	<0.08	<0.80	<0.20	<2.0	<0.40
Charcoal 08	<0.07	<0.7	<0.04	<0.40	<0.08	<0.80	<0.20	<2.0	<0.40
Charcoal 09	<0.07	<0.7	<0.04	<0.40	<0.08	<0.80	<0.20	<2.0	<0.40
Charcoal 10	<0.07	<0.7	<0.04	<0.40	<0.08	<0.80	<0.20	<2.0	<0.40
Charcoal 11	<0.07	<0.7	<0.04	<0.40	<0.08	<0.80	<0.20	<2.0	1.67
Mean	0.07	0.7	0.051	0.51	0.086	0.86	0.212	2.12	1.82
Median	0.07	0.7	0.04	0.40	0.08	0.80	0.20	2.0	0.4
Minimum	0.07	0.7	0.04	0.40	0.08	0.80	0.20	2.0	0.4
Maximum	0.07	0.7	0.158	1.58	0.149	1.49	0.331	3.31	14.8
No. of samples	11	11	11	11	11	11	11	11	11
90th percentile	0.07	0.7	0.04	0.40	0.08	0.80	0.20	2.0	1.67
LOD	0.07	0.7	0.04	0.4	0.08	0.8	0.2	2	0.4

Table 7.10 Primary data for charcoal: pentachlorodibenzofuran

Sample ID	1,2,3,7,8-Pentachlorodibenzofuran	1,2,3,7,8-Pentachlorodibenzofuran	2,3,4,7,8-Pentachlorodibenzofuran	2,3,4,7,8-Pentachlorodibenzofuran	Pentachlorodibenzofuran
	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (ITEQ)	ng/kg (DW)	ng/kg (DW) sum of isomers
Charcoal 01	<0.03	<0.5	<0.20	<0.40	<0.4
Charcoal 02	<0.03	<0.5	<0.20	<0.40	<0.4
Charcoal 03	<0.03	<0.5	1.41	2.81	7.43
Charcoal 04	<0.03	<0.5	<0.20	<0.40	<0.4
Charcoal 05	<0.03	<0.5	<0.20	<0.40	<0.4
Charcoal 06	<0.03	<0.5	<0.20	<0.40	<0.4
Charcoal 07	<0.03	<0.5	<0.20	<0.40	<0.4
Charcoal 08	<0.03	<0.5	<0.20	<0.40	<0.4
Charcoal 09	<0.03	<0.5	<0.20	<0.40	<0.4
Charcoal 10	<0.03	<0.5	<0.20	<0.40	<0.4
Charcoal 11	<0.03	<0.5	<0.20	<0.40	<0.4
Mean	0.03	0.5	0.31	0.62	1.04
Median	0.03	0.5	0.20	0.40	0.4
Minimum	0.03	0.5	0.20	0.40	0.4
Maximum	0.03	0.5	1.41	2.81	7.43
No. of samples	11	11	11	11	11
90th percentile	0.03	0.5	0.20	0.40	0.4
LOD	0.03	0.5	0.2	0.4	0.4

Table 7.11 Primary data for charcoal: tetrachlorodibenzofuran

Sample ID	2,3,7,8-Tetrachlorodibenzofuran ng/kg (ITEQ)	2,3,7,8-Tetrachlorodibenzofuran ng/kg (DW)	Tetrachlorodibenzofuran ng/kg (DW) sum of isomers
Charcoal 01	<0.09	<0.9	<0.9
Charcoal 02	<0.09	<0.9	<0.9
Charcoal 03	<0.09	<0.9	<0.9
Charcoal 04	<0.09	<0.9	<0.9
Charcoal 05	<0.09	<0.9	<0.9
Charcoal 06	<0.09	<0.9	<0.9
Charcoal 07	<0.09	<0.9	<0.9
Charcoal 08	<0.09	<0.9	<0.9
Charcoal 09	<0.09	<0.9	<0.9
Charcoal 10	<0.09	<0.9	<0.9
Charcoal 11	<0.09	<0.9	<0.9
Mean	0.09	0.9	0.9
Median	0.09	0.9	0.9
Minimum	0.09	0.9	0.9
Maximum	0.09	0.9	0.9
No. of samples	11	11	11
90^{th} percentile	0.09	0.9	0.9
LOD	0.09	0.9	0.9

Table 7.12 Primary data for charcoal: octachlorodibenzofuran

Sample ID	Octachlorodibenzofuran ng/kg (ITEQ)	Octachlorodibenzofuran ng/kg (DW)
Charcoal 01	<0.0040	<3.00
Charcoal 02	<0.0040	<3.00
Charcoal 03	0.0114	11.4
Charcoal 04	<0.0040	<3.00
Charcoal 05	<0.0040	<3.00
Charcoal 06	<0.0040	<3.00
Charcoal 07	<0.0040	3.67
Charcoal 08	<0.0040	<3.00
Charcoal 09	<0.0040	<6.00
Charcoal 10	<0.0040	<3.00
Charcoal 11	<0.0040	<3.00
Mean	0.0047	4.10
Median	0.0040	3.00
Minimum	0.0040	3.00
Maximum	0.0114	11.40
No. of samples	11	11
90^{th} percentile	0.0040	6.00
LOD	0.004	3

Table 7.13 Primary data for charcoal: PCBs (μg/kg DW)

(a)

Sample ID	PCB-018	PCB-028	PCB-031	PCB-047	PCB-049	PCB-051	PCB-052	PCB-077	PCB-081	PCB-099	PCB-101	PCB-105	PCB-114	PCB-118
Charcoal 01	0.0521	0.0381	<0.0200	0.0201	0.0283	0.0082	0.0571	<0.0030	<0.002	0.0271	0.0662	0.0089	<0.002	0.0292
Charcoal 02	0.0109	<0.0200	<0.0200	<0.0100	<0.0050	<0.0040	<0.0060	<0.0030	<0.002	<0.0030	<0.0050	<0.0030	<0.002	0.0087
Charcoal 03	0.0292	0.0220	0.0252	<0.0100	0.0056	<0.0040	0.0120	<0.0030	<0.002	<0.0030	0.0172	<0.0030	<0.002	0.0050
Charcoal 04	0.0577	0.0374	0.0221	0.0134	0.0203	<0.0040	0.0273	<0.0030	<0.002	0.0146	0.0297	<0.0030	<0.002	0.0209
Charcoal 05	0.0574	0.0802	0.0498	0.0293	0.0132	0.0125	0.0343	<0.0030	<0.002	<0.0030	0.0484	<0.0030	<0.002	0.0428
Charcoal 06	0.0183	<0.0200	<0.0200	0.0277	0.0423	<0.0040	0.0488	0.0043	<0.002	0.0240	0.0354	0.0127	<0.002	0.0399
Charcoal 07	0.0178	<0.0200	<0.0200	<0.0100	0.0191	<0.0040	0.0140	0.0031	<0.002	0.0097	0.0239	<0.0030	<0.002	0.0234
Charcoal 08	0.0534	<0.0200	<0.0200	0.0160	<0.0050	<0.0040	0.0115	0.0044	<0.002	0.0037	0.0060	<0.0030	<0.002	0.0204
Charcoal 09	0.0675	<0.0200	<0.0200	0.0317	0.0340	0.0093	0.0457	0.0033	<0.002	0.0221	0.0340	<0.0030	<0.002	0.0230
Charcoal 10	<0.010	<0.0200	<0.0200	<0.0100	<0.0050	<0.0040	0.0067	<0.0030	<0.002	<0.0080	<0.0050	<0.0030	<0.002	0.0062
Charcoal 11	<0.010	<0.0200	<0.0200	0.0112	<0.0050	<0.0040	<0.0060	<0.0030	<0.002	<0.0030	<0.0050	0.0056	<0.002	0.0061
Mean	0.0349	0.0289	0.0234	0.0172	0.0166	0.0056	0.0245	0.0033	0.002	0.0110	0.0251	0.0047	0.002	0.0205
Median	0.0292	0.0200	0.0200	0.0134	0.0132	0.0040	0.0140	0.0030	0.002	0.0080	0.0239	0.0030	0.002	0.0209
Minimum	0.0100	0.0200	0.0200	0.0100	0.0050	0.0040	0.0060	0.0030	0.002	0.0030	0.0050	0.0030	0.002	0.0050
Maximum	0.0675	0.0802	0.0498	0.0317	0.0423	0.0125	0.0571	0.0044	0.002	0.0271	0.0662	0.0127	0.002	0.0428
No. of samples	11	11	11	11	11	11	11	11	11	11	11	11	11	11
90th percentile	0.0577	0.0381	0.0252	0.0293	0.0340	0.0093	0.0488	0.0043	0.002	0.0240	0.0484	0.0089	0.002	0.0399
LOD	0.01	0.02	0.02	0.01	0.005	0.004	0.006	0.003	0.002	0.003	0.005	0.003	0.002	0.004

(b)

Sample ID	PCB-123	PCB-126	PCB-128	PCB-138	PCB-153	PCB-156	PCB-157	PCB-167	PCB-169	PCB-170	PCB-180	PCB-189
Charcoal 01	<0.002	<0.003	0.0151	0.0523	0.0572	<0.0020	<0.003	<0.003	<0.003	0.0217	0.0212	<0.0020
Charcoal 02	<0.002	<0.003	<0.0030	<0.0050	0.0095	<0.0020	<0.003	<0.003	<0.003	<0.0030	<0.0040	<0.0020
Charcoal 03	<0.002	<0.003	<0.0030	<0.0050	0.0102	<0.0020	<0.003	<0.003	<0.003	<0.0030	<0.0040	<0.0020
Charcoal 04	<0.002	<0.003	<0.0030	0.0458	0.0453	<0.0020	<0.003	<0.003	<0.003	<0.0030	<0.0040	<0.0020
Charcoal 05	<0.002	<0.003	<0.0030	0.0599	0.0540	<0.0020	<0.003	<0.003	<0.003	0.0231	0.0450	<0.0020
Charcoal 06	<0.002	<0.003	<0.0030	0.0503	0.0662	0.0099	<0.003	<0.003	<0.003	0.0265	0.0416	0.0026
Charcoal 07	<0.002	<0.003	0.0079	0.0188	0.0195	0.0022	<0.003	<0.003	<0.003	<0.0030	0.0227	<0.0020
Charcoal 08	<0.002	<0.003	0.0083	0.0099	<0.0060	<0.0020	<0.003	<0.003	<0.003	<0.0030	0.0150	<0.0020
Charcoal 09	<0.002	<0.003	0.0083	0.0258	0.0457	<0.0020	<0.003	0.004	<0.003	<0.0030	0.0269	<0.0020
Charcoal 10	<0.002	<0.003	0.0054	0.0137	0.0246	<0.0020	<0.003	<0.003	<0.003	0.0037	0.0075	<0.0020
Charcoal 11	<0.002	<0.003	0.0043	0.0070	0.0126	0.0023	<0.003	<0.003	<0.003	<0.0030	<0.0040	<0.0020
Mean	0.002	0.003	0.0058	0.0267	0.0319	0.0028	0.003	0.003	0.003	0.0087	0.0178	0.0021
Median	0.002	0.003	0.0043	0.0188	0.0246	0.0020	0.003	0.003	0.003	0.0030	0.0150	0.0020
Minimum	0.002	0.003	0.0030	0.0050	0.0060	0.0020	0.003	0.003	0.003	0.0030	0.0040	0.0020
Maximum	0.002	0.003	0.0151	0.0599	0.0662	0.0099	0.003	0.004	0.003	0.0265	0.0450	0.0026
No. of samples	11	11	11	11	11	11	11	11	11	11	11	11
90^{th} percentile	0.002	0.003	0.0083	0.0523	0.0572	0.0023	0.003	0.003	0.003	0.0231	0.0416	0.0020
LOD	0.002	0.003	0.003	0.005	0.006	0.002	0.003	0.003	0.003	0.003	0.004	0.002

Table 7.14 Primary data for charcoal: PAHs (μg/kg DW)

(a)

Sample ID	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene
Charcoal 01	67.4	20.9	<400	<400	<400	<400	<100	<400
Charcoal 02	12.9	<20.0	<400	<400	<400	<400	<100	<400
Charcoal 03	137.0	28.9	<400	<400	<400	<400	<100	<400
Charcoal 04	164.0	50.6	444	<400	<400	<400	<100	<400
Charcoal 05	81.2	37.7	<400	<400	<400	<400	<100	<400
Charcoal 06	55.9	<20.0	<400	<400	<400	<400	<100	<400
Charcoal 07	101.0	<40.0	<700	<700	<700	<700	<200	<700
Charcoal 08	99.7	<20.0	<400	<400	<400	<400	151	<400
Charcoal 09	2.2	<20.0	<300	<300	<300	<300	<100	<300
Charcoal 10	22.5	37.6	<400	<400	<400	<400	<100	<400
Charcoal 11	27.3	32.4	<400	<400	<400	<400	<100	<400
Mean	70.1	29.8	422	418	418	418	114	418
Median	67.4	28.9	400	400	400	400	100	400
Minimum	2.2	20.0	300	300	300	300	100	300
Maximum	164.0	50.6	700	700	700	700	200	700
No. of samples	11	11	11	11	11	11	11	11
90th percentile	137.0	40.0	444	400	400	400	151	400
LOD	0.1	1	20	20	20	20	6	20

(b)

Sample ID	Chrysene	Dibenzo(ah)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
Charcoal 01	<600	<60	<400	<200	<600	325	<400	<400
Charcoal 02	<600	<60	<400	<200	<600	324	<400	<400
Charcoal 03	<600	<60	<400	<200	<600	977	516	<400
Charcoal 04	<600	<60	<400	1010	<600	906	937	<400
Charcoal 05	<600	<60	<400	280	<600	287	<400	<400
Charcoal 06	<600	<60	<400	<200	<600	998	<400	<400
Charcoal 07	<1000	<100	<700	<400	<1000	1870	<700	<700
Charcoal 08	<600	<60	<400	<200	<600	2030	566	<400
Charcoal 09	<500	<50	<300	<200	<500	338	<300	<300
Charcoal 10	<600	<60	<400	<200	<600	735	<400	<400
Charcoal 11	<600	<60	<400	<200	<600	837	<400	<400
Mean	627	63	418	299	627	875	493	418
Median	600	60	400	200	600	837	400	400
Minimum	500	50	300	200	500	287	300	300
Maximum	1000	100	700	1010	1000	2030	937	700
No. of samples	11	11	11	11	11	11	11	11
90^{th} percentile	600	60	400	400	600	1870	700	400
LOD	30	3	20	10	30	10	20	20

Table 7.15 Primary data for charcoal: BTEX

Sample ID	1,2-Dimethylbenzene [o-Xylene]	Benzene	Dimethylbenzene	Ethylbenzene	Toluene [Methylbenzene]
	µg/kg (DW)	µg/kg (DW)	µg/kg (DW) sum of (1,3- 1,4-isomers)	µg/kg (DW)	µg/kg (DW)
Charcoal 01	64.60	5.51	329.0	32.30	<10.0
Charcoal 02	7.91	24.60	19.7	5.49	34.7
Charcoal 03	18.60	121.00	49.5	15.90	117.0
Charcoal 04	289.00	44.10	1220.0	999.00	298.0
Charcoal 05	<5.00	8.89	11.8	3.92	<20.0
Charcoal 06	<5.00	<5.00	<10.00	<2.00	<10.0
Charcoal 07	<3.00	<3.00	<6.00	<2.00	<9.0
Charcoal 08	<5.00	<5.00	<10.00	<3.00	<20.0
Charcoal 09	<5.00	<5.00	<10.00	<3.00	<20.0
Charcoal 10	<7.00	<7.00	<10.00	<4.00	<20.0
Charcoal 11	<4.00	<4.00	<8.00	<2.00	<10.0
Mean	37.65	21.19	153.1	97.51	51.7
Median	5.00	5.51	10.0	3.92	20.0
Minimum	3.00	3.00	6.0	2.00	9.0
Maximum	289.00	121.00	1220.0	999.00	298.0
No. of samples	11	11	11	11	11
90th percentile	64.60	44.10	329.0	32.30	117.0
LOD	1	1	2	0.5	3

Table 7.16 Primary data for charcoal: calorific value and proximate analysis (composition)

Sample ID	Calorific value (gross)	Calorific value (net)	Total moisture	Ash	Volatile matter	Fixed carbon
	kJ/kg	kJ/kg	%	%	%	%
Charcoal 01	28504	28089	8.9	5.9	5.7	79.5
Charcoal 02	27091	26475	7.4	8.2	15.7	68.7
Charcoal 03	28001	27312	8.0	4.2	17.5	70.3
Charcoal 04	26143	25446	9.8	6.0	19.5	64.7
Charcoal 05	20649	19376	36.8	1.6	10.7	50.9
Charcoal 06	29194	28303	9.5	1.6	11.3	77.6
Charcoal 07	30003	29130	9.0	1.8	8.8	80.4
Charcoal 08	29322	28468	9.3	2.3	8.3	80.1
Charcoal 09	30528	29614	8.8	1.8	10.9	78.5
Charcoal 10	26919	25803	8.8	8.1	31.4	51.7
Charcoal 11	20530	19646	9.7	17.7	23.6	49.0
Mean	26989	26151	11.5	5.4	14.9	68.3
Median	28001	27312	9.0	4.2	11.3	70.3
Minimum	20530	19376	7.4	1.6	5.7	49.0
Maximum	30528	29614	36.8	17.7	31.4	80.4
No. of samples	11	11	11	11	11	11
90^{th} percentile	30003	29130	9.8	8.2	23.6	80.1
LOD	100	100	0.1	0.1	1.1	n/a

Table 7.17 Primary data for charcoal: ultimate analysis

Sample ID	Bromine	Carbon	Chlorine	Fluorine	Hydrogen	Nitrogen	Oxygen	Sulphur
	mg/kg	%	%	mg/kg	%	%	%	%
Charcoal 01	<100	79.86	0.04	<100.0	0.91	0.36	4.0	0.05
Charcoal 02	<100	72.84	0.09	14	2.01	0.80	8.6	0.06
Charcoal 03	<100	74.06	0.05	<10.0	2.28	0.89	10.5	0.06
Charcoal 04	<100	70.03	0.01	18.7	2.11	0.49	11.5	0.04
Charcoal 05	<100	54.06	0.01	138.3	1.74	0.27	5.5	0.02
Charcoal 06	<100	79.05	0.01	<10.0	1.97	0.52	7.3	0.02
Charcoal 07	<100	81.31	0.01	<10.0	1.82	0.52	5.5	<0.02
Charcoal 08	<100	80.74	0.01	<10.0	1.49	0.70	5.5	<0.02
Charcoal 09	<100	81.19	0.01	<10.0	2.15	0.29	5.7	0.06
Charcoal 10	<100	67.07	0.01	34.8	3.94	1.67	10.1	0.27
Charcoal 11	<100	55.71	0.09	<10.0	2.15	1.13	13.3	0.22
Mean	100	72.36	0.03	33.3	2.05	0.69	8.0	0.08
Median	100	74.06	0.01	10.0	2.01	0.52	7.3	0.05
Minimum	100	54.06	0.01	10.0	0.91	0.27	4.0	0.02
Maximum	100	81.31	0.09	138.3	3.94	1.67	13.3	0.27
No. of samples	11	11	11	11	11	11	11	11
90^{th} percentile	100	81.19	0.09	100.0	2.28	1.13	11.5	0.22
LOD	100	0.41	0.01	10	0.06	0.1	n/a	0.02

References

BSI, 1979. *BS 4845-2:1979. Methods for sampling manufactured domestic solid smokeless fuels in small consignments of mass 50 kg to 5000 kg either in bulk or in bags. Sampling of solid smokeless fuels other than coke.* London: British Standards Institution.

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List of abbreviations

1M	1 molar
2M	2 molar
Ag	Silver
Al	Aluminium
As	Arsenic
B	Boron
ASE	accelerated solvent extraction
Ba	Barium
Be	Beryllium
BTEX	Benzene, toluene, ethylbenzene, xylene
C	Carbon
Ca	Calcium
Cd	Cadmium
Chromium VI	Chromium Hexavalent
Co	Cobalt
Cr	Chromium
Cu	Copper
DCM	dichloromethane
DW	dry weight
Fe	Iron
GCMS	gas chromatography–mass spectrometry
Hg	Mercury
HR	high resolution
ICP-OES	inductively coupled plasma optical emission spectrometry
ITEQ	International Toxicity Equivalents
K	Potassium
LE	Leeds laboratory of NLS
Li	Lithium
LOD	limit of detection
LoI	loss on ignition
MCERTS	Environment Agency's Monitoring Certification Scheme
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
P	Phosphorus
PAH	polycyclic aromatic hydrocarbon
Pb	Lead
PCB	polychlorinated biphenyl
PSD	particle size distribution
PTEs	Potentially Toxic Elements
SAL	Scientific Analysis Laboratories Limited
Sb	Antimony
Se	Selenium
Sn	Tin
Sr	Strontium
TC	total carbon
TC	total carbon
Ti	Titanium
Tl	Thallium
TN	total nitrogen
TN	total nitrogen
TOC	total organic carbon
TON	total organic nitrogen
USEPA	United States Environmental Protection Agency
V	Vanadium
Zn	Zinc

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