

## Supplementary material

### Atmospheric short-chain-chlorinated paraffins in Melbourne, Australia – first extensive southern hemisphere observations

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## Introduction

The supplementary material included here provides details of: locations used in the study, ancillary measurements, SCCP measurement methodology, SCCP results and physical and chemical properties of SCCPs. These are the first observations of ambient SCCP concentrations from Australia and the second from the southern hemisphere. As a result, attention was given to evaluating the methods used in the collection of SCCPs from the atmosphere. Issues addressed include partitioning of SCCPs in the particulate and gas phases, collection efficiency of the gas phase, comparison of active and passive sampling, quantification of possible contamination by the pump in the PUF sampler, repeatability of ambient measurement and an international laboratory inter-comparison study. Some measurements via passive sampling are included in this supplementary material due to the paucity of comparisons of active and passive sampling in the literature.

## Site Locations

Table S1 shows some characteristics and the locations of the 10 dwellings. Due to the noise from the samplers, some occupants chose to have the sampling conducted when the dwelling was vacant; this is indicated in Table S1. Fig. 1 inset shows a map of Melbourne in relation to Bass Strait, and includes locations of the dwellings used in the indoor air observations and the ambient air site at Aspendale. It also shows the location of the EPAV (Environment Protection Authority of Victoria) site at Box Hill and the Bureau of Meteorology site at Moorabbin Airport, both sites contributing ancillary data to this study.

## Ancillary Measurements

The carbon monoxide concentrations and wind speed and direction were recorded at the Bureau of Meteorology at Moorabbin Airport and the EPA site at Box Hill respectively, see Fig. 1. The wind speed and

direction are combined and resolved as north–south wind speed and east–west vector wind speed where the positive sign is for winds from the north and the east.

### **Collection of SCCPs from the atmosphere**

The active samples were collected with high volume samplers from Lear Siegler Australasia Pty. Ltd at a flow rate of 225 l min<sup>-1</sup> either over a period of about seven days, giving sample volumes of about 2200 m<sup>3</sup> or over monthly periods giving sample volumes of about 9000 m<sup>3</sup>. Since the mass of SCCPs collected during weekly sampling was at least 20 times the blank level, the sampling periods of one month or one week were considered to give results that are comparable. The particulate phase fraction of SCCPs was collected on 104 mm diameter quartz fibre filters that were pre-cleaned by baking for 30 hours at 150 °C. The gaseous fraction of SCCPs was collected downstream of the particulate phase on a section of (PUF) PUF-1 60 mm diameter and 40 mm length, a 10 mm layer of XAD-2 resin and a second section of PUF, PUF-2; all were packed in a glass container. The PUF sections were pre-cleaned by extraction in organic solvents. The filter holders were cleaned with iso-propanol wipes and left to dry before the filter and PUF sample were loaded into the sampler. After the completion of sampling the quartz fibre filters were wrapped in aluminium foil that was previously cleaned, by heating to 150 °C for 30 hours in a muffle furnace, to remove any traces of organic material. Both the PUF's in the glass containers, and the quartz fibre filters were wrapped in pre-cleaned aluminium foil, sealed in a metal tin and taken back to CSIRO laboratories at Aspendale where they were stored at -10 °C.

Passive samples were collected on sorbent impregnated polyurethane foam disks (SIP), 140 mm diameter and 13.5 mm thick. Before use, they were cleaned with organic solvents to remove any vestige of SCCPs. They were impregnated with XAD-2 resin by dipping the disks into a slurry of XAD-2 resin in hexane in a manner similar to that described previously.<sup>[1]</sup> During the sampling period the SIP disks were held in a water-proof enclosure (Tisch Environmental TE-200-PAS) which was positioned about 2.5 metres from the ground. After use they were wrapped in pre-cleaned aluminium foil and stored at -10 °C until they were ready for chemical analysis.

### **Chemical Analysis of SCCPs**

The SCCP concentrations in the air samples captured on the (polyurethane foam) PUF, XAD-2 Resin and quartz filters were measured at the National Measurement Institute (NMI) by Low Resolution Mass Spectrometry. The PUF and filters were extracted together by a two stage solvent extraction using ethyl acetate:methanol (1:1, stage 1), followed by toluene (stage 2). After extraction, concentration and splitting, the samples underwent a cleanup process that included silica gel and Gel Permeation Chromatography cleanup (USEPA 3640A). Two isotopically labeled standards were then added to sample extracts immediately before analysis, to serve as internal standards for quantification. Qualitative/quantitative analysis for SCCPs was performed with a high-resolution gas chromatograph/low-resolution mass spectrometer/computerised data

system, operated in Negative Chemical Ionisation mode using methane as reagent gas. Simultaneous selective ion monitoring (two characteristic ions) and full scan (50–500 amu) ion monitoring were performed for SCCP analysis. The identification of the compounds was confirmed when target ions were detected in the correct abundance ratio within established retention time windows. Quantification was based on the use of external standards (either C<sub>10</sub>-C<sub>13</sub> SCCP 55.5% or C<sub>10</sub>-C<sub>13</sub> SCCP 63% depending on the best chromatographic match with the samples) that were injected immediately before each batch of samples.

The NMI participated in the recent international fifteen laboratories inter-comparison of SCCP analyses<sup>[2]</sup> and achieved satisfactory results for its results for total SCCPs.

### **Partitioning between gas and particulate phases and gas collection efficiency**

During this study three samples, one each in autumn, winter and spring, were collected at Aspendale as part of the monthly active sampling to determine the percentage of SCCPs that were in the gas and particulate phases. The filters from the autumn and winter samples were analysed separately from the corresponding gas samples, consisting of PUF-1, XAD-2 resin and PUF-2 sections. During spring individual chemical analysis was carried out on each sample section including the filter, PUF-1, XAD-2 resin and PUF-2. This was done to estimate the gas and particulate fractions, and to measure the gas collection efficiency.

Table S2 presents the results the collection efficiency of the gas fraction on PUF-1 the XAD-2 resin and PUF-2 at a flow rate of 225 l min<sup>-1</sup>. The results show that 91.4% of the gas was collected on PUF-1, 6.8% on the XAD-2 resin and 1.8% on PUF-2. This shows that the gas fraction of SCCPs is collected completely by the PUF/XAD-2 resin arrangement, and that greater than 95% is collected on PUF-1. Therefore, breakthrough is not a significant issue.

Table S2 also presents the results of the gas and particulate partitioning measurements. The results show that the percentage of gas was 89.1%, 90.0% and 89.4% in autumn, winter and spring respectively, when the average temperatures were 293.5, 285.2 and 287.4 K. In two previous studies in Lancaster, England, the gaseous and particulate percentages were found to be 91 and 9%<sup>[3]</sup> and 95 and 5%<sup>[4]</sup> at average temperatures of 282.5 K and 288.8 K respectively. In a comprehensive SCCP partitioning study in Beijing,<sup>[5]</sup> a variation in gas and particulate percentages was observed in summer and winter, with gas and particulate phases of 94% and 6% respectively in summer when the average temperature was 299.2 K and 33% and 67% respectively during winter<sup>[5]</sup>, when the average temperature was 271.3 K.<sup>[5]</sup> The average temperatures recorded during sampling, suggest that above 283.3 K at least 89 to 95% of SCCPs exist in the gas phase and only 5 to 11% in the particulate phase (Table S2). However, at temperatures of 271.3 K and below, the gas phase fraction is a maximum of 67%, significantly less than at the higher temperatures of the other measurements in Table S2. The gas phase fraction of SCCPs between 271.3 and 283.3 K is uncertain and needs to be better quantified.

It is important to quantify the gas phase/particulate phase partitioning because when passive sampling is employed to measure SCCPs since passive sampling does not collect the particulate fraction. Sampling at temperatures less than 283.1 K has significant consequences when only gas phase SCCP measurements are made and may lead to lower observed concentrations compared to the actual concentrations. This is particularly true for passive sampling, where the particulate fractions of SCCPs are not measured.

### Active versus passive sampling

SCCP concentrations were measured in parallel using active and passive sampling techniques over a 12-month period in 2013. The observations are presented in Fig. 2. The active and passive samplers were co-located at the Aspendale site within 5 metres from each other. The active samples were collected at monthly periods, and the passive samples were collected over three 3-monthly periods one 6-monthly period and one 12-monthly period.

The active samples are converted to atmospheric concentrations using:

$$C_A = \frac{N_{PUF}}{Ft} \quad (1)$$

where  $C_A$  = atmospheric concentration of SCCPs from the active sample ( $\text{ng m}^{-3}$ ),  $N_{PUF}$  = SCCP mass on the sampler ( $\text{ng sampler}^{-1}$ ),  $t$  = time (days),  $F$  = volumetric flow rate through the active sampler,  $\text{m}^3$  per day where the volume is at STP.

As the active and passive samples were collected over the same time period and at the same location, it is possible to use this data to determine the absorption rate of SCCPs by the passive samplers, a quantity not readily available from theoretical considerations. The absorption rate was calculated from (2) as suggested in a previous study.<sup>[6]</sup>

$$R_{PUF} = \frac{N_{PUF}}{C_A t} \quad (2)$$

where  $R_{PUF}$  = absorption rate of SCCPs by the PUF disk ( $\text{m}^3 \text{day}^{-1}$ ),  $N_{PUF}$  = SCCP mass on the sampler ( $\text{ng sampler}^{-1}$ ),  $C_A$  = atmospheric concentration of SCCPs from the active sample ( $\text{ng m}^{-3}$ ),  $t$  = time (days).

The absorption rates were calculated for the 3 and 6 monthly sampling periods and the results averaged give an uptake rate of  $3.4 \pm 1.2 \text{ m}^3 \text{day}^{-1}$ , where the uncertainty is the standard error of the mean. Table S3 gives passive uptake rates for SCCPs calculated from this and a previous study. The estimation from the study in China, Japan and South Korea is  $4.2 \text{ m}^3 \text{day}^{-1}$ , and is not significantly different from this study<sup>[6]</sup>. In another study<sup>[3]</sup>, the uptake rate is established as  $17.1 \text{ m}^3 \text{day}^{-1}$ ; about a factor of 4 higher than the other two studies. However, in that study<sup>[3]</sup> the active concentration  $C_A$  was assumed, rather than measured over the period of passive sampling. Therefore, the estimate is less well constrained because of the uncertainty of using an estimated rather than measured concentration in the uptake estimate.

## Contamination study

During this study sampling was conducted inside 10 dwellings. The question arose whether SCCPs were present in the pump exhaust. For the samples collected indoors, where the pump exhausted directly in the room, any SCCPs in the pump exhaust had the potential to increase the SCCPs mass on the filter/PUF sampler.

In order to quantify any possible increase in SCCPs concentration due to the exhaust, a sampling procedure using four POPs samplers, was carried out in March 2010 at the Aspendale site in suburban Melbourne.

Fig. S1 shows the arrangement of the four samplers. Sampler 1, a blank, was located about 30 metres from samplers 2 and 3 (Fig. S1). The pump exhaust from sampler 2 was directed to the inlet of sampler 3. The exhaust was placed close to the inlet but not physically connected to it, so that air could flow into the sampler in a normal way. Thus ambient air could also be sampled. This ensured that sampler 3 was sampling a mixture of pump exhaust and ambient air. Sampler 2 was sampling ambient air, as was sampler 4, which was located about 50 metres from samplers 2 and 3. The blank was left in the sampler for the 7-day period, but the pump was not turned on.

Table S4 shows the results of the sampling procedure designed to measure any effect on SCCPs concentration due to the exhaust from the sampling pump. Table 4 shows that at  $<0.06 \text{ ng m}^{-3}$  the blank is low, but not zero. It shows, in Table 4, that at the blank is low, and less than 1% of the sample concentrations. The SCCPs concentration measured on the ambient plus exhaust sample was  $10.5 \text{ ng m}^{-3}$  compared to  $15.7 \text{ ng m}^{-3}$  measured on the co-located ambient sample. The fourth sampler measured  $11.1 \text{ ng m}^{-3}$  in ambient air, a concentration close to that measured on the ambient plus exhaust sample. These results show that there was no increase in concentration due to contamination from the pump exhaust, even when the sampler was directly sampling exhaust from a co-located sampler. The result in the ambient plus exhaust sample is consistent with  $\frac{1}{3}$  of the volume sampled being exhaust and  $\frac{2}{3}$  of the volume sampled being ambient air with a SCCP concentration of  $15.7 \text{ ng m}^{-3}$  as observed by the co-located sampler. The concentrations of the SCCPs measured inside and outside of the 10 dwellings can then be assumed to be entirely free of contamination from exhaust from the sampling pump.

## Repeatability

During the period of this study, five samples were collected in duplicate to assess the repeatability of the results. The samples were collected over the same time periods by samplers located within one metre of each other, and are presented in Table S5. The repeatability was assessed as a Pearson correlation coefficient with a value of 0.93 which is significant at the 1% level for a single sided test.

### **Inter-comparison study**

The extraction and chemical analysis of SCCPs is quite complex, and the techniques were newly developed in Australia therefore an inter-comparison was conducted with an established laboratory, the Norwegian Institute for Air Research, (NILU) Kjeller, Norway. To achieve this, four samples and two blanks were collected using two co-located PUF samplers over a period of about 7 days. Two samples and one blank were collected from each sampler. After sampling was complete the filters and PUF samples were stored at  $-10\text{ }^{\circ}\text{C}$  until they were ready to be shipped to the laboratories for analysis. One set of two samples and one blank were sent to NMI where they were extracted and analysed with the techniques described previously. The other set of two co-located samples and blanks were sent to NILU where they were extracted and analysed using the techniques they have employed previously to analyse SCCPs.<sup>[7, 8]</sup>

The data in Table S6, presented previously<sup>[9]</sup>, show the results of the inter-comparison. The blank concentrations were low compared with the samples. The concentrations of the samples analysed at NILU were  $4.8\text{ ng m}^{-3}$  and  $12.7\text{ ng m}^{-3}$ , while the corresponding results from NMI were  $6.3\text{ ng m}^{-3}$  and  $4.8\text{ ng m}^{-3}$ . The concentrations reported by NMI are reported as equivalent to 55.5% whereas the NILU results are for the total SCCPs concentration for the sample. The differences in the SCCPs concentrations include contributions due to differences in: sampling, storage, extraction and the analytical techniques used by the two laboratories. The results in Table S6 have differences greater than expected from the repeatability of a single laboratory as determined previously. The results in Table S6 are consistent with a previous inter-comparison<sup>[2]</sup> where the ratios of concentrations of SCCPs determined by individual laboratories on an unknown SCCP mixture (when standards of individual SCCPs were provided) ranged from 0.7 to 4.1 times the target concentration and the CVs of results between laboratories was 56%. Overall, the SCCPs determined in this study are consistent with the international accepted standards for SCCP measurements. Table S7 presents the concentrations of SCCPs measured using active and passive sampling in Melbourne during 2013. Table S8 gives some details of the 10 dwellings employed to measure concentrations of SCCPs measured indoors and outdoors in Melbourne during summer 2009.

Table S9 provides the details of SCCP air concentrations from measurements in background, rural and urban/industrial sites and indoor environments which are cited in previous studies. Table S10 provides the details of SCCP soil and air concentrations in the Pearl River Delta, as used in this paper. Table S11 lists selected physical properties of some individual SCCPs.

### **Soil Moisture Values**

Soil moisture values are taken from the Australian Bureau of Meteorology at [www.bom.gov.au/water/landscape](http://www.bom.gov.au/water/landscape). Soil moistures are measured in % saturation at the root zone, 0 – 1 metre soil

depth. This study uses % soil moisture in correlations with various parameters and gas concentrations. The correlations are given in Table 2 of the main document. The soil moistures are employed for the particular sampling periods, and are the average values of six sites that were chosen to spatially represent the Melbourne area. The latitude and longitude of the six sites are shown in Table S12.

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**Table S1. Physical characteristics of the 10 dwellings employed in the study**

Dwelling	Attached Garage	Occupied	Age of dwelling years	Construction	Latitude degrees	Longitude degrees
1	No	No	49	Brick veneer	37.783	145.330
2	No	No	65	Double brick	37.897	145.076
3	No	Yes	16	Double brick	37.896	145.049
4	Yes	Yes	4	Weatherboard	38.167	145.191
5	No	No	7	Brick veneer	37.874	145.126
6	No	No	75	Double brick	37.889	145.005
7	No	No	76	Double brick	37.904	145.010
8	Yes	Yes	31	Brick veneer	38.024	145.109
9	No garage	Yes	75	Double brick	37.916	145.002
10	Yes	Yes	12	Brick veneer	37.902	145.011

**Table S2. Percentage of SCCPs in gas and particulate phases**

Concentrations of SCCPs in particles and gas are ng m<sup>-3</sup>. NM, not measured; NG, not given

Season	Particle	PUF 1	Resin	PUF 2	Total gas	Total	Gas %	Particle %	Temp <sup>⌘</sup> K
Autumn <sup>*</sup>	1.01	NM	NM	NM	8.29	9.30	89	11	293.5
Winter <sup>*</sup>	0.27	NM	NM	NM	2.43	2.70	90	10	285.2
Spring <sup>*</sup>	0.40	3.09	0.23	0.06	3.38	3.78	89	11	287.4
Winter <sup>[5]</sup>	NG	NG	NG	NG	NG	NG	67	33	271.3
Summer <sup>[5]</sup>	NG	NG	NG	NG	NG	NG	94	6	299.2
Summer <sup>[4]</sup>	NG	NG	NG	NG	NG	NG	95	5	Unknown
Spring <sup>[3]</sup>	NG	NG	NG	NG	NG	NG	91	9	282.4

\*This study

⌘Average temperature during sampling period

**Table S3. Calculated passive uptake rates for SCCPs**

Location	Absorption rate m <sup>3</sup> day <sup>-1</sup>	Notes	Reference
China, Japan, South Korea	4.2	Calculated from comparison of total mass collected on active sampler and total mass on passive sampler	[6]
Aspendale, Melbourne	3.2 ±0.9	Calculated from comparison of total mass collected on active sampler and total mass on passive sampler	This study

**Table S4. Concentrations of SCCPs measured in a blank sample, ambient air sample and ambient air plus exhaust air sample during March 2010**

Sample number	Sample type	SCCPs ng m <sup>-3</sup>	Location
1	Blank	<0.06	30m away from 2&3
2	Ambient	15.7	Co-located
3	Ambient plus exhaust	10.5	Co-located
4	Ambient	11.1	50m away from 2&3

**Table S5. Co-located paired SCCP samples**

Sample	Month	year	Sample A ng m <sup>-3</sup>	Sample B ng m <sup>-3</sup>	Repeatability <sup>II</sup>
1	February	2013	16.3	21.6	28.0
2	May	2013	9.0	5.9	41.9
3	August	2013	1.0	2.7	89.6
4	September	2013	3.0	3.8	25.7
5	March	2010	15.7	11.1	34.3
Average			7.9	9.0	38.3
Blank <sup>#</sup>			0.5		

$$^{\text{II}} \text{ Repeatability} = \frac{\text{abs}(\text{Sample A} - \text{Sample B}) \times 100}{\text{mean}(\text{of A \& B})}$$

<sup>#</sup>based on an average blank level and a typical air volume.

**Table S6. Concentrations of SCCPs measured in two ambient samples and one blank sample analysed at NMI and NILU**

Sample On	Sample Off	Sample type	SCCPs NMI ng m <sup>-3</sup>	Uncertainty ng m <sup>-3</sup>	SCCPs NILU ng m <sup>-3</sup>	Uncertainty ng m <sup>-3</sup>
01/10/2010 18:18	08/10/2010 17:50	Blank	<0.86		0.14	
13/09/2010 12:47	24/09/2010 10:35	Ambient	6.3	±2.5	4.8	±1.9
24/09/2010 12:35	01/10/2010 17:12	Ambient	4.7	±1.9	12.7	±5.1

**Table S7. Concentrations of short chain chlorinated paraffins observed at Aspendale during 2013**

Date on	Date off	SCCPs ng m <sup>-3</sup>
<i>Active samples</i>		
07/01/13	08/02/13	28.4
08/02/13	05/03/13	18.9
05/03/13	02/04/13	9.3
02/04/13	30/04/13	3.3
30/04/13	31/05/13	7.4
31/05/13	28/06/13	4.2
28/06/13	30/07/13	2.2
30/07/13	03/09/13	1.9
03/09/13	01/10/13	3.4
01/10/13	04/11/13	5.7
04/11/13	03/12/13	18.6
03/12/13	06/01/14	20.5
annual median		6.6
annual average		10.4
st deviation		8.8
maximum		28.4
minimum		1.8
<i>Passive samples</i>		
07/01/13	03/04/13	11.7
28/06/13	01/10/13	3.6
01/10/13	06/01/14	13.0
28/06/13	06/01/14	9.7

07/01/13	06/01/14	8.4
annual average		8.4

**Table S8. Concentration of SCCPs measured indoors and outdoors of 10 dwellings**

Dwelling	Date on	Date off	SCCPs ng m <sup>-3</sup> indoors	SCCPs ng m <sup>-3</sup> outdoors	Indoor : outdoor ratio	Occupied during sampling	Age years
1	31/12/08	07/01/09	21.0	45.7	0.46	No	49
2	02/01/09	09/01/09	25.9	35.1	0.74	No	65
3	08/01/09	15/01/09	25.9	56.4	0.46	Yes	16
4	12/01/09	19/01/09	28.2	30.1	0.94	Yes	4
5	20/01/09	27/01/09	23.4	70.2	0.33	No	7
6	21/01/09	28/01/09	43.4	82.0	0.53	No	75
7	29/01/09	05/02/09	60.6	81.6	0.74	No	76
8	30/01/09	06/02/09	32.1	28.2	1.14	Yes	31
9	09/02/09	16/02/09	17.3	35.2	0.49	Yes	75
10	10/02/09	17/02/09	21.7	28.4	0.76	Yes	12
Average			30.0	49.3	0.61		
Median			25.9	40.5	0.63		
Maximum			60.6	82.0			
Minimum			17.3	28.2			

**Table S9. Concentrations of SCCPs in background, rural and urban sites from previous studies**

Site	Min ng m <sup>-3</sup>	Max ng m <sup>-3</sup>	Mean ng m <sup>-3</sup>	SD ng m <sup>-3</sup>	No. obs	Sampling type	Reference	
<b>Background</b>								
Egbert, Canada, 1990	0.065	0.924	0.543		120	Hi-vol filter+PUF	[10]	
Alert, Canada, 1992	<0.001	0.0085				Hi-vol filter+PUF	[11]	
Alert, Canada, 1994 –1995	0.0011	0.0072				Not given	[12]	
Svalbard, Norway, 1999	0.009	0.057	0.019	0.008	5	Hi-vol filter+PUF	[7]	
Fildes Peninsula, Antarctica, 2013	0.0096	0.0208	0.0149	4.1	24	Hi-vol filter+PUF	[13]	
Bear Island, Norway, 2000	1.8	10.6	6.0	3.4	7	Hi-vol filter+PUF	[8]	
Range — background	<0.001	0.924						
<b>Rural</b>								
Lancaster, U.K., 1997	0.0054	1.085	0.320	0.320	26	Hi-vol filter+PUF	[4]	
Lancaster, U.K. 1997/98			0.099			Not given	[14]	
Lancaster, U.K., 2003	<0.18	3.40	1.10	1.00	20	Hi-vol filter+PUF	[3]	
Various sites, U.K., 2003*	0.15	2.24	0.60	0.56	20 sites	Passive PUF	[3]	
Sites CNU5 and CNU18, China, 2008#	8	60	43.7		18 sites	18 sites	Passive PUF	[6]
Site JAU2 and JAU11, Japan, 2008#	0.35	0.94	0.70		12 sites	12 sites	Passive PUF	[6]
Sites SKR1 and SKR5, South# Korea, 2008#	0.79	1.08	0.87		7 sites	7 sites	Passive PUF	[6]
Range — rural	0.005	60						
<b>Urban/industrial</b>								
Various sites, U.K., 2003*	0.55	6.37	2.03	1.93	20 sites	Passive PUF	[3]	

Site	Min ng m <sup>-3</sup>	Max ng m <sup>-3</sup>	Mean ng m <sup>-3</sup>	SD ng m <sup>-3</sup>	No. obs	Sampling type	Reference
Various sites, China, 2008 <sup>#</sup>	13.5	517	143	106	18 sites	Passive PUF	[6]
Various sites, Japan, 2008 <sup>#</sup>	0.3	14.8	2.9	3.4	12 sites	Passive PUF	[6]
Various sites, South Korea, 2008 <sup>#</sup>	0.6	9.4	2.5	2.4	7 sites	Passive PUF	[6]
Melbourne, Australia, 2008 - 2013	1.9	82.0	24.3	24.1	27	Hi-vol filter+PUF	This study
Pearl River Delta, China, summer, 2009/2010	2.01	106	29.5	28.4	14 sites	Passive PUF	[15]
Pearl River Delta, China, winter, 2009/2010	0.95	26.5	5.2	3.8	14 sites	Passive PUF	[15]
Beijing, China, Winter, 2011	1.9	33	7.7	6.7	14	Hi-vol filter+PUF	[5]
Beijing, China, Summer, 2011	112	332	200	57	23	Hi-vol filter+PUF	[5]
Melbourne, Australia, 2008–2013	1.9	82.8	24.4	24.1	27	Hi-vol filter+PUF	This study
<hr/>							
Range — urban/industrial	0.6	517					
<hr/>							
<b>Indoor air</b>							
Lancaster, UK, workshop, 2003* Lab, office house	0.2	11.9	3.6	5.5	4	Passive PUF	[3]
Stockholm, Sweden, 2006/07	2	147	49	35	44	Low-vol filter+PUF	[16]
Melbourne, Australia, 2009	17	61	30	13	10	Hi-vol filter+PUF	This study
<hr/>							
Range	0.2	61					

\*Calculated from reference [3], assuming a sampling rate of 17 m<sup>3</sup> day<sup>-1</sup>.<sup>[3]</sup>

<sup>#</sup>calculated from Figs 2 and 3.<sup>[6]</sup>

N: number of samples or sites

**Table S10. Soil and air concentrations of SCCPs, ratios and references**

Values are either mean  $\pm$  two standard deviations or mean (range) or when indicated by the superscript §, the median

Location	Soil ng g <sup>-1</sup>	Air ng m <sup>-3</sup>	Soil/Air ratio m <sup>3</sup> g <sup>-1</sup>	Reference
Pearl River Delta <sup>[6]</sup>	12.1 $\pm$ 4.4 (2008)	18.2 $\pm$ 9.1 (2008)	1.0 $\pm$ 0.3	Wang, Y. et al. (2013)

**Table S11. Physical properties of SCCPs**

SCCP	Molecular weight	HL Pa m <sup>3</sup> mol <sup>-1</sup>	V <sub>p</sub> 25°C Pa	K <sub>ow</sub>	Sw μg l <sup>-1</sup>	Boil pt °C
1,10 dichlorodecane	211				257	275
1,10 dichlorododecane	239	499	5.0×10 <sup>-1</sup>			168
1,12 Dichlorododecane	239	648	6.8×10 <sup>-2</sup>		22.4	
Trichlorododecane	273			5.85		
1,2,9,10 Tetrachlorodecane	280	17.7	2.8×10 <sup>-2</sup>	5.93	328	
Tetrachlorodecane	280			6.04-6.20	141	
1,2,10,11 Tetrachloroundecane	294	6.3	1.0×10 <sup>-2</sup>		575	
1,2,11,12 Tetrachlorododecane	308		3.5×10 <sup>-3</sup>			
Pentachlorodecane (a+b)	314	4.9				
Pentachlorodecane (c+d)	314	2.6				
Pentachloroundecane (a+b)	328	1.46			546	
Pentachloroundecane (c+d+e)	328	0.68			962	
Pentachlorododecane (a+b)	342		5.4×10 <sup>-3</sup>		449	
Pentachlorododecane (c+d)	342		4.0×10 <sup>-3</sup>		657	
Pentachlorododecane	342	1.37	1.6×10 <sup>-3</sup> –1.9×10 <sup>-3</sup>			
Hexachlorodecane	349		1.1×10 <sup>-3</sup> –2.2×10 <sup>-3</sup>			
Hexachloroundecane	363		2.4×10 <sup>-4</sup> –4.9×10 <sup>-4</sup>			
Hexachlorododecane	377		1.1×10 <sup>-3</sup> –2.2×10 <sup>-3</sup>			
Hexachlorododecane	377	1.37	1.4×10 <sup>-3</sup> –5.2×10 <sup>-3</sup>			

K<sub>ow</sub> of SCCPs ranges from 5.16 to 8.12<sup>[17]</sup> (Drouillard 1996 MSc thesis, Env Canada)

Vapour Pressure SCCPs: 2.8×10<sup>-7</sup> – 0.066 Pa (Drouillard 1996 MSc thesis, Env Canada)

Water solubility: 0.49 – 1260  $\mu\text{g l}^{-1}$  (Drouillard 1996 MSc thesis, Env Canada)

Vapour Pressure SCCPs:  $2.8 \times 10^{-7}$  – 0.028 Pa<sup>[18]</sup> (Env Canada)

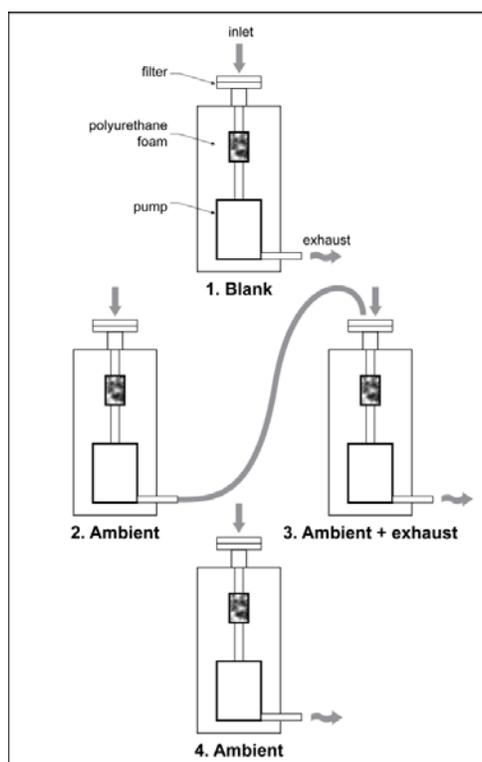
Henry's Law Constant: 0.68 – 17.7 Pa m<sup>3</sup> mol<sup>-1</sup> [18].

Water solubility: 6.4 – 2370  $\mu\text{g l}^{-1}$  [18].

K<sub>ow</sub>: 4.39 – 8.69.

**Table S12. Locations of sites employed for soil moisture**

Soil moisture site	Latitude	Longitude
1	37.75	144.80
2	37.95	145.05
3	37.95	144.65
4	37.65	145.10
5	38.15	145.15
6	38.00	145.25



**Fig. S1.** The arrangement of samplers used in the exhaust study to identify and quantify any potential contamination.