Examining Organic and Elemental Carbon Presence in Beauty Salon Service Rooms

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Supplementary material

Table S1. Analysis of indoor air quality in Poland from 1995 till now (starting from oldest one to the newest).

No.	Reference	Location	Measurement period	Analysed compounds	Mass conc.
1.	(Pastuszka, 1995)	The area of Upper Silesia	6-7 days cycle	The concentration of PM10and TSP and the fractional distribution of bioaerosols	-
2.	(Górny et al., 1995)	Selected cities of Upper Silesia	Spring and winter period	Dust and metal concentration	Katowice (TSPin) – 100 µg/m^3 Bytom (TSPin) – 102 µg/m^3 Sosnowiec (TSPin), – 82 µg/m^3 Sosnowiec (TSPin), flat where residents do smoke cigarettes – 344 µg/m^3 Knurów (TSPin), flat where residents smoke cigarettes – 226 µg/m^3 Chorzów (TSPin) – 93 µg/m^3 Chorzów (TSPin) flat with heating stove – 226 µg/m^3
3.	(Karwowska, 2003)	Educational institutions (kindergartens, primary schools, middle schools)	Winter season	Microbiological contamination, i.e. fungi, bacteria: Coli sp., Staphylococcus sp., mesophiles, hemolytic	-
4.	(Kondej & Jankowska, 2004b, 2004a)	Production and office room in the grinding plant	Working shift	Total and respirable PM concentration	- TSP - 1,792 mg/m^3 in the production facility -TSP- 0.922 mg/m^3 in the office - Respirable PM - 0.380 mg/m^3 in the production facility - Respirable PM - 0.099 mg/m^3 in the office
5.	(Stryjakowska-Sekulska et al., 2007)	University premises in Poznań (library, reading rooms, corridor, toilets, canteen, dean's office, chemical laboratory)	IX-X 2012 and IX-X 2013; twice a day: morning and afternoon	fungi, blood bacilli, and fungi, among others: aspergillus, blackening beetle, others	-

No.	Reference	Location	Measurement period	Analysed compounds	Mass conc.
6.	(Wójcik et al., 2010)	Hen houses – 3 laboratories for incubating chickens	Winter season (3.01-7.02); Summer season (22.05-29.06). Samples were taken at: 7.00 a.m., 1.00 p.m., 9.00 p.m.	Microbiological contamination: bacteria and fungi without distinction into specific types	-
7.	(Gołofit-Szymczak & Górny, 2010)	Four air-conditioned office buildings	Winter season (October-March)	Microbial contamination in indoor air (bacteria and fungi)	-
8.	(Kalwasińska et al., 2012)	University library in Toruń	Winter season 10.2009-03.2010; measurements twice a day, i.e. in the morning before starting work and in the afternoon	Microbial contamination (bacteria and fungi) in indoor and outdoor air of a library	-
9.	(Dumala & Dudzińska, 2013)	Five schools in Lublin	During the heating season March 15, 2012 - March 29, 2012; Outside the heating season May 10, 2012 - May 29, 2012, air sampling before and during classes.	Microbial contamination (bacteria and fungi) in the indoor air	-
10.	(Gładyszewska-Fiedoruk & Krawczyk, 2013)	Fifteen doctor's offices for 6 types of medical practices	Seasons: summer, autumn and winter	Temperature, humidity, CO_2 concentration, air flow rate	-
11.	(Zwoździak et al., 2013)	Wrocław primary school	Winter and Summer Season 2009/2010	PM_1, $PM_{2.5}$, PM_{10} concentration	-
12.	(Polednik, 2013)	Primary school classes in Lublin	Heating and non-heating season. Before and after lectures	PM1 mass and number concentration, air humidity, temperature, and CO_2	PM_1 winter: 280±57 μg/m^3 summer: 211.82±68 μg/m^3
13.	(Telejko, 2015)	Three computer labs at the university	10.2014-02.2015	CO_2 concentration, temperature, air humidity	-
14.	(Mainka & Zajusz-Zubek, 2015)	Rural and municipal kindergartens in Upper Silesia	Winter and spring season	Concentration of $PM_{2.5}$ and $PM_{2.5}$ – bound elements	.
15.	(Mainka et al., 2015)	Kindergartens in Gliwice	Winter period	VOCs in $PM_{2.5}$ and PM_{10}, bacterial and fungal bioaerosols, carbon dioxide (CO_2) concentrations	-
16.	(Polednik et al., 2016)	Air-conditioned hall of the Lublin University of Technology	Spring season (4-11.04.2012; 11-19.04.2012)	PM_1 mass and number concentration, temperature, CO2 concentration, air humidity	AC off - 45.4 μg/m^3 AC on/off – 25.6 μg/m^3

No.	Reference	Location	Measurement period	Analysed compounds	Mass conc.
17.	(Polednik & Polednik, 2016)	Church	Three masses with a duration of 60 minutes, in various weather conditions	Mass concentration and number concentration of PM in the church during the mass	During Mass PM_1 – 632 μg/m^3 PM_{10} – 665 μg/m^3 TSP – 709 μg/m^3
18.	(Lenart & Olszowski, 2016)	University	Winter season, 83 observations with 90-minute measurements	Indoor-outdoor relation for PM_{10} mass concentration	$PM_{10\ outdoor}$ – 52 μg/m^3 $PM_{10\ indoor}$ – 44 μg/m^3
19.	(Rogula-Kozłowska, 2016)	Two underground chambers of the health resort in the Wieliczka Salt Mine	7-20.07.2015	Concentration and composition of PM in the internal air of the underground spa chamber	eg. $PM_{0.65-1}$ 1.13-11.47 μg/m^3
20.	(Błaszczyk et al., 2017)	Two kindergartens in Silesia (urban and rural environment)	Spring season	$PM_{2.5}$ inside and outside the tested objects and the concentration of 15 PAHs, analysis of the mutagenic and carcinogenic potential of PM-bound PAHs	$PM_{2.5\ outdoor}$ - 16-69.5 μg/m^3 $PM_{2.5\ indoor}$ - 20.0-41.9 μg/m^3
21.	(Mainka et al., 2016)	Two kindergartens in Gliwice	Winter season (9/12/2013 - 17/01/2014) and spring season (24/03 - 17/04/2014)	Monoaromatic hydrocarbons: benzene, toluene, ethylbenzene, xylene, BTEX	-
22.	(Majewski et al., 2016)	Two teaching rooms in two Universities in Gliwice and Warsaw	Spring season 04 – 05.2015	PM_1 concentration and PM_1-bound mercury	Gliwice: $PM_{1\ indoor}$:9.9-50.1 μg/m^3 $PM_{1\ outdoor}$:7.7-26.4 μg/m^3 Warszawa: $PM_{1\ indoor}$: 4-24.8 μg/m^3 PM1 $_{outdoor}$ or: 5.7-37.8 μg/m^3
23.	(Kociszewska et al., 2017)	Two lecture halls at two universities: Warsaw University of Life Sciences and the Silesian University of Technology	Spring season 04 – 06.2016	PM_1 concentration and the content of the PM-bound OC and EC	Gliwice: $PM_{1\ indoor}$:14.35 μg/m^3 $PM_{1\ outdoor}$: 22.59 μg/m^3 Warszawa: $PM_{1\ indoor}$:9.08 μg/m^3 $PM_{1\ outdoor}$: 13.19 μg/m^3
24.	(Kobza et al., 2018)	Dental offices	Working shift	Bioaerosols in the air of indoor spaces	-
25.	(Brągoszewska et al., 2018)	Kindergartens and early school classes	Summer/winter period	Bioaerosols in offices	-
26.	(Kuskowska et al., 2019)	athletic gym, school gym, fitness room, fencing room, wrestling rooms 1, 2, and 3, and tennis court, Warsaw	March 2017 and October 2017	PM_1, $PM_{2.5}$, PM_4, PM_{10}, and PM_{100} mass concentration	i.e. in wrestling rooms 1, 2, and 3, reaching 114.7, 142.3, and 508.4 μg/m^3 for PM100
27.	(Rogula-Kopiec et al., 2019a)	selected beauty salons and outdoors in Silesia	Summer and Winter season 2016	PM_4, PMtot OC, and EC / indoor & outdoor	$PM_{4\ indoor}$ 170.2 ± 72.8 μg/m^3 TPM_{indoor} 272.5 ± 128.7 μg/m^3 $PM_{4\ outdoor:}$ 105.0 ± 94.7 μg/m^3 $TPM_{outdoor:}$ 147.1 ± 114.0 μg/m^3

No.	Reference	Location	Measurement period	Analysed compounds	Mass conc.
28.	(Pytel et al., 2021)	Four spa salons located in Gdynia (Poland)	January 2019 to April 2019,	TVOCs compounds	-
29.	(Rogula-Kopiec et al., 2023)	selected beauty salons and outdoors in Silesia	Summer season 2023	9 compounds from BTEX group	
30.	(Melaniuk-Wolny & Widziewicz-Rzońca, 2024)	The Silesian University of Technology sports halls "Nowa Hall', "Konarskiego Hall", "OSiR Hall"	April 28, 2022, to June 7, 2022	$PM_{2.5in}$ and $PM_{2.5}$ out, CO_2, RH%, Temp.	The average median concentration of indoor $PM_{2.5}$ - 16.7 μg/m³, while outdoor levels - 12.2 μg/m³
31	(Rogula-Kozłowska, Bralewska, Rogula-Kopiec, et al., 2020)	Two Polish fire stations belonging to the State Fire Service - FSN in North Poland and FSS in South Poland	Each station, over a 7 d period	Respirable PM (PM4) and 15 polycyclic aromatic hydrocarbons (PAH; in gaseous and particulate phases)	PM4 (μg/m³) in Common room FSN(36) and FSS(93) PM4 (μg/m³) in changing room FSN(72) and FSS(151) PM4 (μg/m³) in truck bay FSN(131) and FSS(194)
32	(Rogula-Kozłowska, Bralewska, & Jureczko, 2020)	Changing room and garage in a fire station located in the Upper Silesian agglomeration (Poland)	November 2018	Benzene, toluene, ethylbenzene, xylene, and styrene (BTEXS) concentrations	∑BTEXS Changing Room: 925.1 μg/m³ Garage: 893.1 μg/m³ Outdoor: 139.6 μg/m³
33	(Mach et al., 2023)	Selected fire stations garage in Poland	24.06 to 08.07 (2020), i.e., full 336 hours	The concentrations of PM10 and PM-bound metals were analyzed with a temporal resolution of 4 h	PM_{10} – max. conc. 19.35 μg/m³, mean conc. 10.66 μg/m³
34	(Bralewska et al., 2022)	typical Polish sports centre inside and outside the building	non-heating (05/18/2017–06/21/2017) and heating (10/16/2017–11/20/2017) seasons	VOC, NO_2, SO_2 levels inside the sports hall	CO_2in (761–815 ppm), VOC_{in} (129.4–193.3 μg/m³), NO_{2in} (20.2–21.3 μg/m³), and SO_{2in} (0.9–1.4 μg/m³)

Table S2 Summary presenting the types of windows, ventilation systems, and cubature for each beauty salon (C1, C2, C3, H1, H2, H3, N1, N2, N3).

Beauty Salon ID	Type of Windows	Type of Ventilation	Cubature [m³]
C1	Fixed	Air Conditioning	92.5
C2	Tilt	Air Conditioning	105
C3	Opening	Air Purifier + Air Conditioning	150
H1	Fixed	Gravimetric	50
H2	Fixed	Gravimetric	40
H3	Tilt	Gravimetric	75
N1	Opening	Air Purifier + Air Conditioning	220
N2	Tilt	Gravimetric	82.8
N3	Fixed	Air Conditioning	45

Table S3. Summary statistics presenting mean, median, maximum, and minimum concentrations of $PM_{2.5}$ and $PM_{2.5}$-bound OC and EC concentrations inside tested beauty salons together with results from the Shapiro-Wilk test (p - values).

	$PM_{2.5}$	OC	EC	$PM_{2.5}$	OC	EC	$PM_{2.5}$	OC	EC
µg/m³	**N1**			**H1**			**C1**		
average	28.55	51.59 (p=0.0000)	1.51 (p=0.0396)	8.20	36.28 (**p=0.0747**)	0.28 (p=0.0195)	54.78	56.04 (**p=0.4148**)	1.04 (**p=0.2460**)
max	81.09	78.94	4.81	13.66	58.22	1.02	64.09	66.83	1.49
min	2.02	16.39	BLD	4.42	20.44	BDL	46.97	44.98	0.76
median	26.23	54.73	0.76	8.82	33.28	0.03	55.66	57.90	1.04
µg/m³	**N2**			**H2**			**C2**		
average	10.28	46.26 (**p=0.1711**)	21.07 (p=0.0273)	47.43	47.34 (p=0.0248)	1.05 (0.0403)	37.53	53.54 (**p=0.4340**)	1.11 (**p=0.7374**)
max	14.53	65.99	46.87	66.30	69.91	3.55	43.05	59.07	1.46
min	8.52	27.86	BDL	41.12	38.38	0.01	32.54	46.05	0.60
median	9.64	43.80	19.88	45.35	43.69	0.51	37.94	53.11	1.14
µg/m³	**N3**			**H3**			**C3**		
average	39.95	69.41 (p=0.0000)	1.25 (**p=0.6256**)	59.10	53.08 (**p=0.1864**)	1.08 (**p=0.4077**)	32.44	60.11 (**p=0.2804**)	0.87 (**p=0.1640**)
max	62.04	227.36	2.66	142.17	93.87	2.38	64.60	87.82	1.54
min	24.44	33.72	0.01	3.49	26.19	0.01	8.38	39.37	0.44
median	36.46	53.80	1.20	50.05	49.09	1.02	23.55	54.81	0.73
µg/m³	**BG**								
average	10.97	39.23 (p=0.0193)	0.47 (**p=0.1768**)						
max	37.35	96.84	1.02						
min	1.72	15.99	0.01						
median	5.35	17.34	0.25						

Note: BDL – below detection level, for EC < 0.0011 µg/m³

Normality testing - p-values from the Shapiro-Wilk test inform about the probability distribution of data in each test group, p>0.05 suggests normal distribution (bolded font).

Table S4 Analysis parameters according to the EUSAAR 2 protocol (Cavalli et al., 2010).

Gas phase/stream	Temperature [˚C]	Duration [s]
He	200	120
He	300	150
He	450	180
He	650	180
He/O_2	500	120
He/O_2	550	120
He/O_2	700	70
He/O_2	850	80

During the analysis, clean and certified gases from Air Liquide were used. The validation parameters for the method used were as follows:

- Total uncertainty of EC measurement in dust: 5%;
- EC detection limit: 0.1 µg/cm²;
- Limit of detection (LOD) EC: 0.1 µg/cm²;
- Total uncertainty of OC measurement in dust: 5%;
- OC detection limit: 0.94 µg/cm²;
- Limit of detection (LOD) OC: 0.47 µg/cm².

Table S5. Concentrations of PM2.5, OC and EC in outdoor air, Silesia region, Poland

No.	Reference	Location	$PM_{2.5}$ (μg/m³)	OC (μg/m³)	EC (μg/m³)
1	This study	Bytom	10,97±5,35	39,23±24,41	0,47±0,44
2	(Błaszczak et al., 2016)	Złoty Potok	24,92	8,58	1,48
3		Racibórz	31,56	12,08	1,96
4	(Rogula-Kopiec et al., 2019b)	Bytom 1	105,0±94,7*	41,8±26,1*	2,7±1,5*
5		Bytom 2	26,2±6,8*	15,6±5,1*	1,7±0,3*
6		Bytom 3	24,8±5,8*	14,8±5,8*	1,7±0,3*
7		Bytom 4	19,4±7,5*	10,5±2,5*	0,8±0,5*
8	(Rogula-Kozłowska et al., 2014)	Katowice Spring	33,02	4,03	9,83
9		Katowice Summer	17,29	2,81	3,37
10		Katowice Autumn	38,26	3,33	2,49
11		Katowice Winter	82,97	12,29	20,38
12	(Błaszczak et al., 2023)	Zabrze, heating season	34,85±21,08	14,59±10,54	3,07±1,62
13		Zabrze, non-heating season	10,50±3,62	3,96±1,39	0,73±0,42

- Whenever noted ± it means average ± standard deviation
  *PM_4

Table S6. Summary statistics regarding mean, median, and ranges of $PM_{2.5}$ concentrations [μg/m³] indoor beauty salons and in the background the 10-day mean, maximum, minimum, and median concentrations of PM2.5 indoors beauty salons: N (nails), H (hairdressing), C (cosmetic studios), and BG (background)

measure	$PM_{2.5}$ μg/m³			
	N1	**N2**	**N3**	**BG**
mean	28.55	10.28	39.95	10.97
max	81.09	14.53	62.04	37.35
min	2.02	8.52	24.44	1.72
median	26.23	9.64	36.46	5.35
	H1	**H2**	**H3**	**BG**
mean	8.20	47.43	59.10	10.97
max	13.66	66.30	142.17	37.35
min	4.42	41.12	3.49	1.72
median	8.82	45.35	50.05	5.35
	C1	**C2**	**C3**	**BG**
mean	54.78	37.53	32.44	10.97
max	64.09	43.05	64.60	37.35
min	46.97	32.54	8.38	1.72
median	55.66	37.94	23.55	5.35

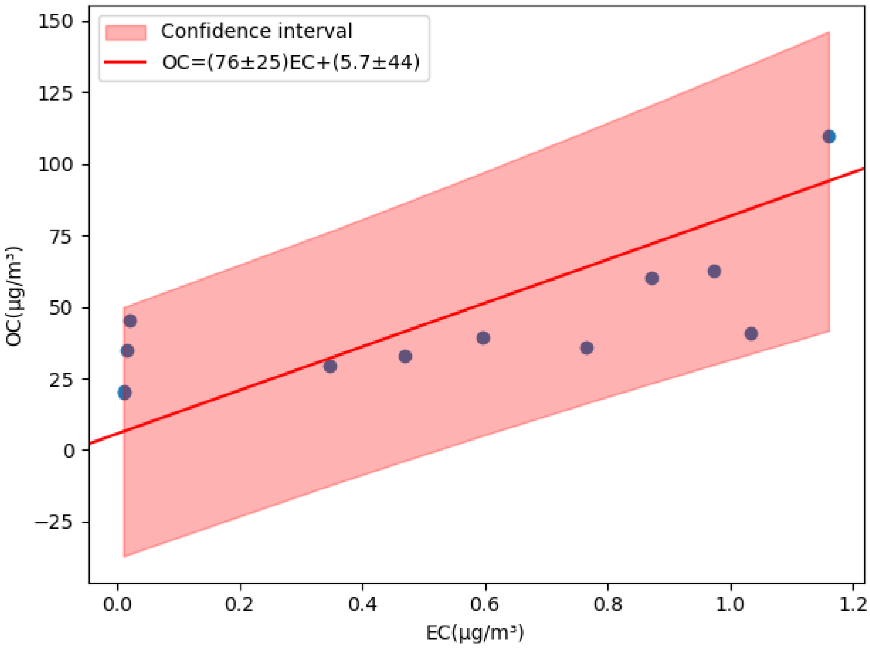

Figure S1. The ratio of the primary OC to EC for the BG site with the regression line according to the method (Saylor et al., 2006) obtained using York regression (York et al., 2004)

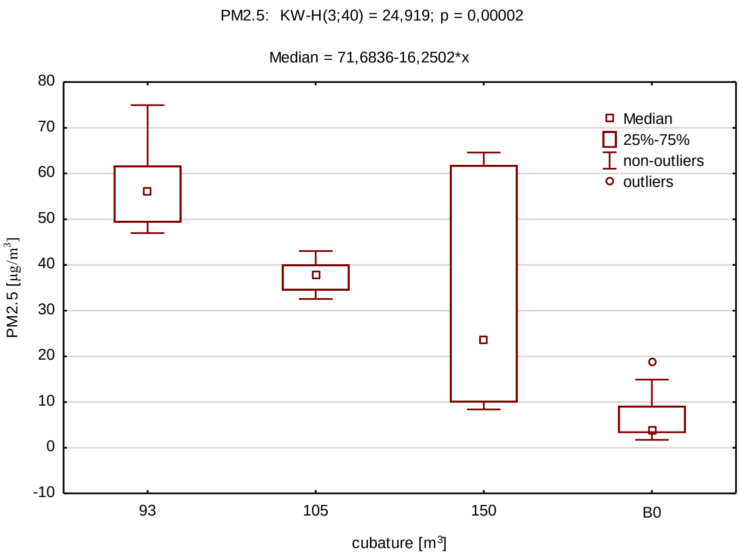

Figure S2 The 10-day median, 25%, and 75% percentile concentrations of $PM_{2.5}$ inside cosmetic studios of different cubature: and in the B0 (background) *The differences between indoor and outdoor (BG - background) concentrations are statistically significant (n = 10; Kruskal Wallice test; p < 0.05)

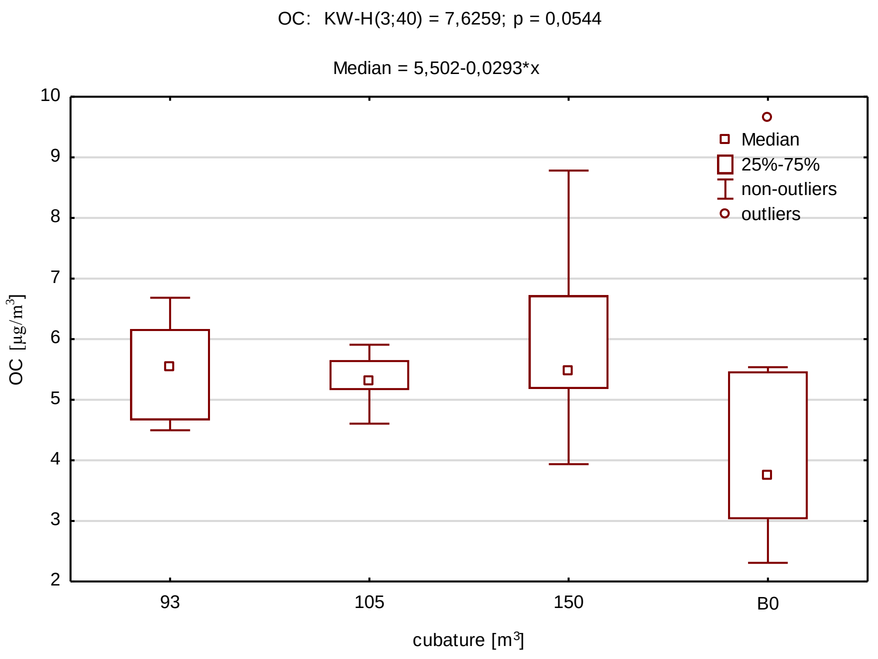

Figure S3 The 10-day median, 25%, and 75% percentile concentrations of OC inside cosmetic studios of different cubatures: and in the B0 (background) *The differences between indoor and outdoor (B0 - background) concentrations are statistically significant (n = 10; Kruskal Wallice test; p < 0.05)

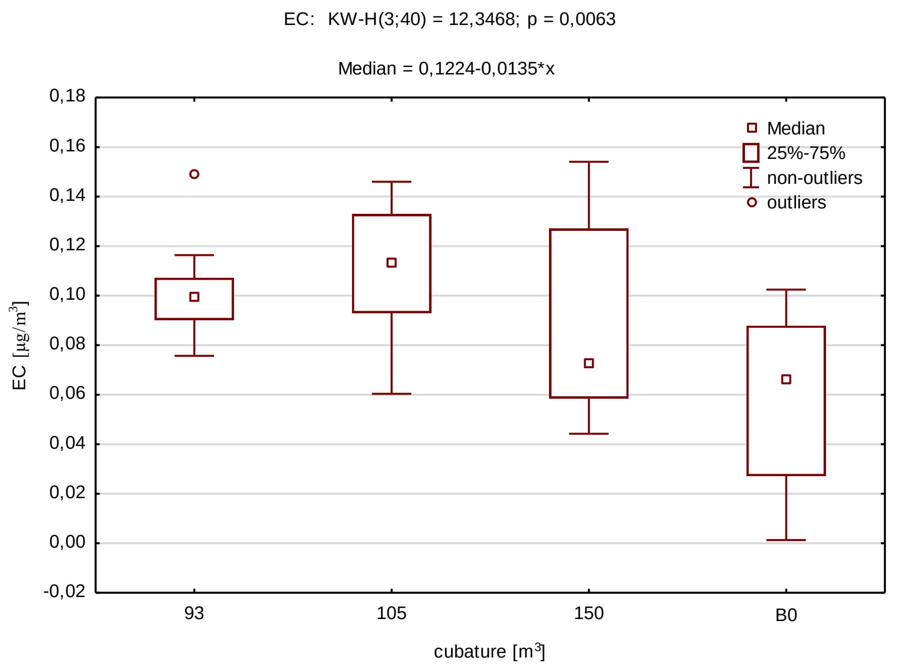

Figure S4 The 10-day median, 25%, and 75% percentile concentrations of EC inside cosmetic studios of different cubatures: and in the B0 (background) *The differences between indoor and outdoor (B0 - background) concentrations are statistically significant (n = 10; Kruskal Wallice test; p < 0.05)

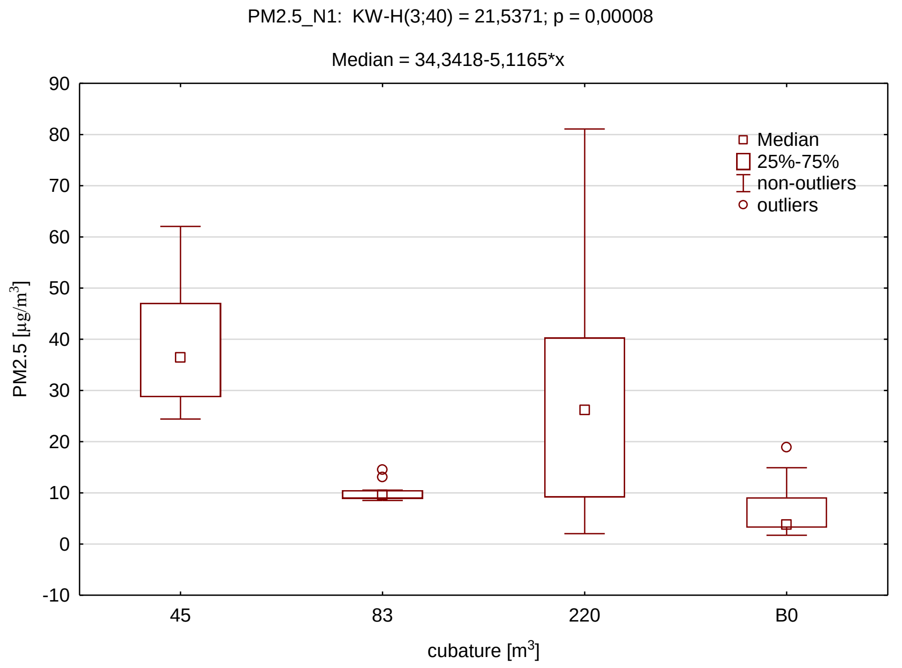

Figure S5 The 10-day median, 25%, and 75% percentile concentrations of $PM_{2.5}$ inside nail salons of different cubature: and in the B0 (background) *The differences between indoor and outdoor (B0 - background) concentrations are statistically significant (n = 10; Kruskal Wallice test; p < 0.05)

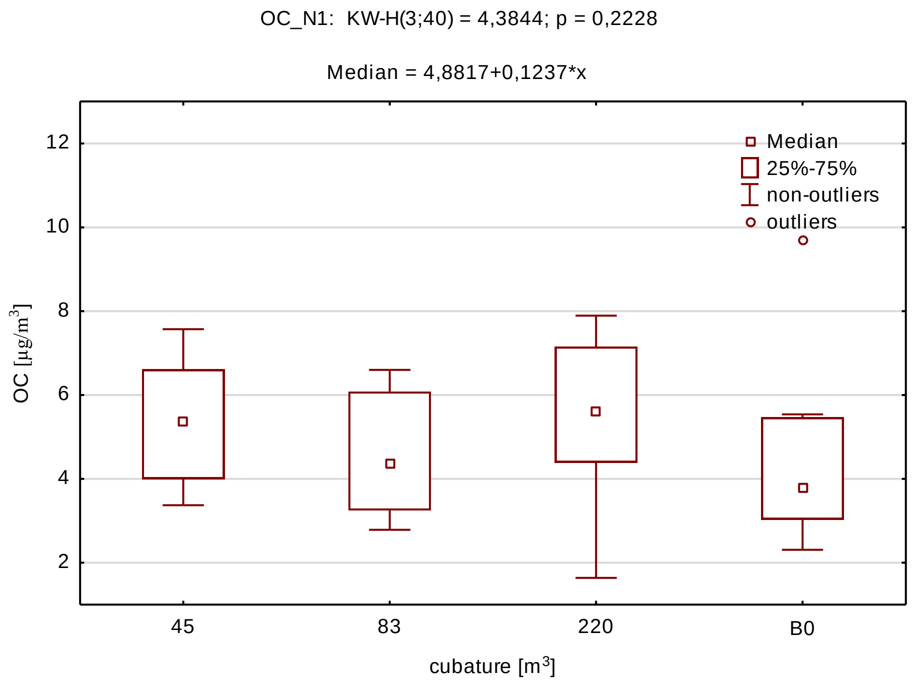

Figure S6 The 10-day median, 25%, and 75% percentile concentrations of OC inside nail salons of different cubatures: and in the B0 (background) *The differences between indoor and outdoor (B0 - background) concentrations are statistically significant (n = 10; Kruskal Wallice test; p < 0.05)

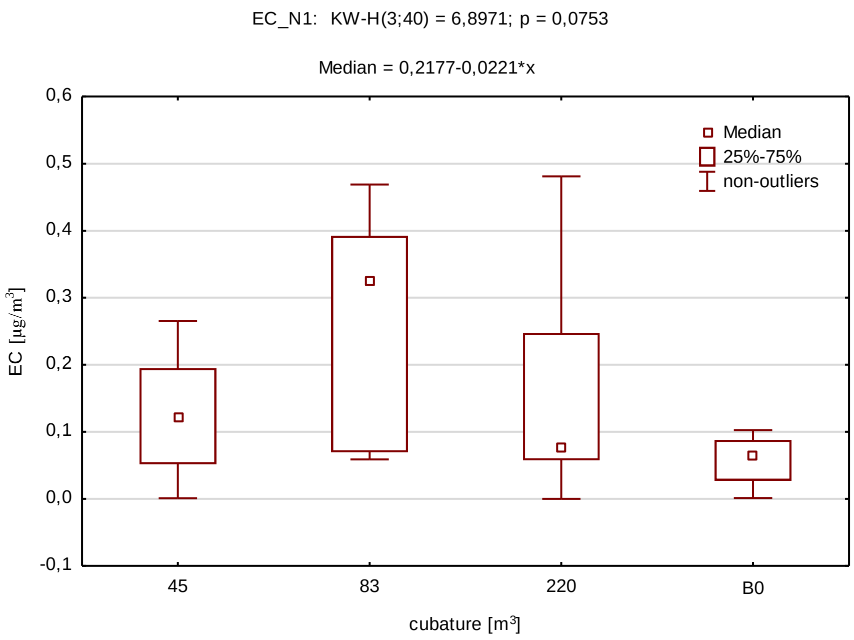

Figure S7 The 10-day median, 25%, and 75% percentile concentrations of EC inside nail salons of different cubatures: and in the B0 (background) *The differences between indoor and outdoor (B0 - background) concentrations are statistically significant (n = 10; Kruskal Wallice test; p < 0.05)

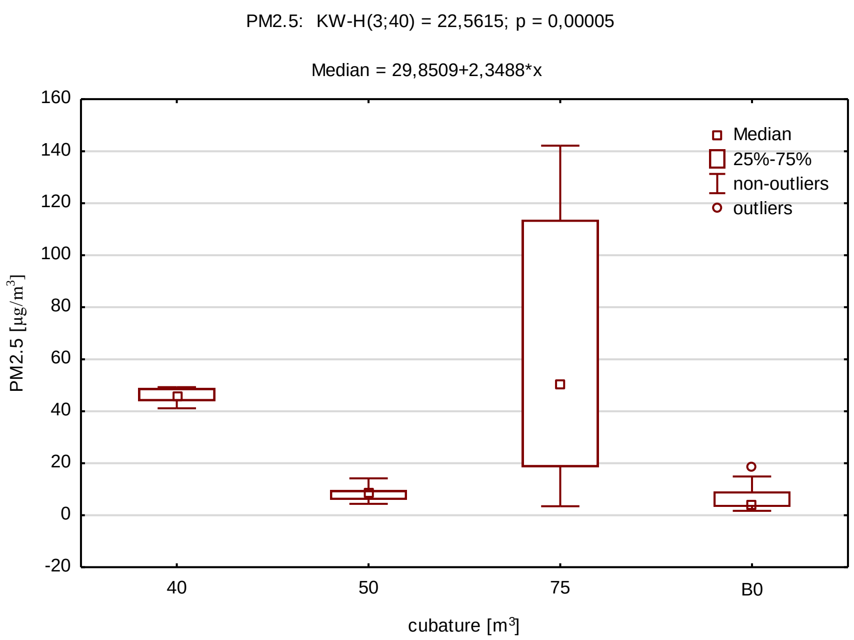

Figure S8 The 10-day median, 25%, and 75% percentile concentrations of $PM_{2.5}$ inside hairdresser salons of different cubature: and in the B0 (background) *The differences between indoor and outdoor (B0 - background) concentrations are statistically significant (n = 10; Kruskal Wallice test; p < 0.05)

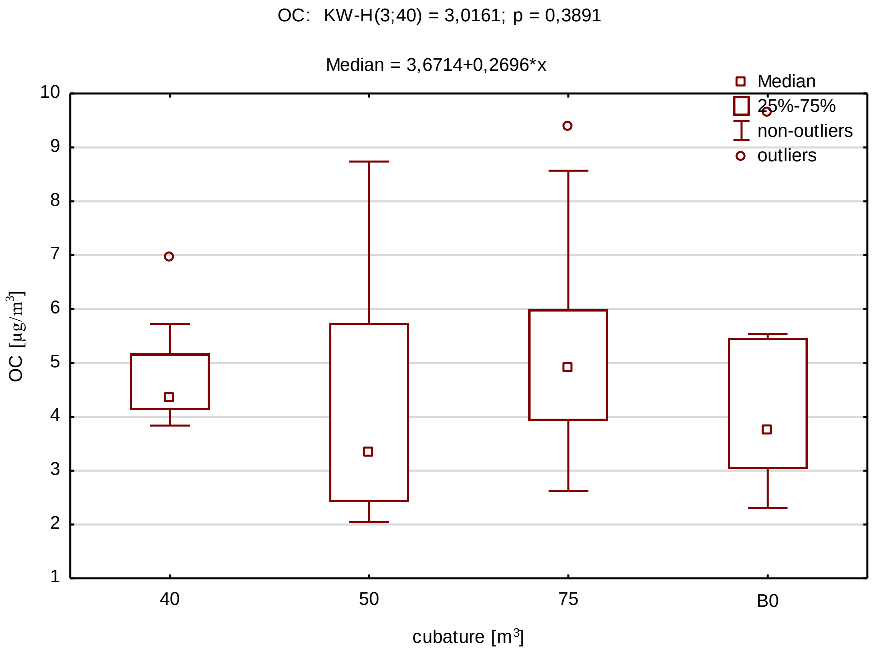

Figure S9 The 10-day median, 25%, and 75% percentile concentrations of OC inside hairdresser salons of different cubature: and in the B0 (background) *The differences between indoor and outdoor (B0 - background) concentrations are statistically significant (n = 10; Kruskal Wallice test; p < 0.05)

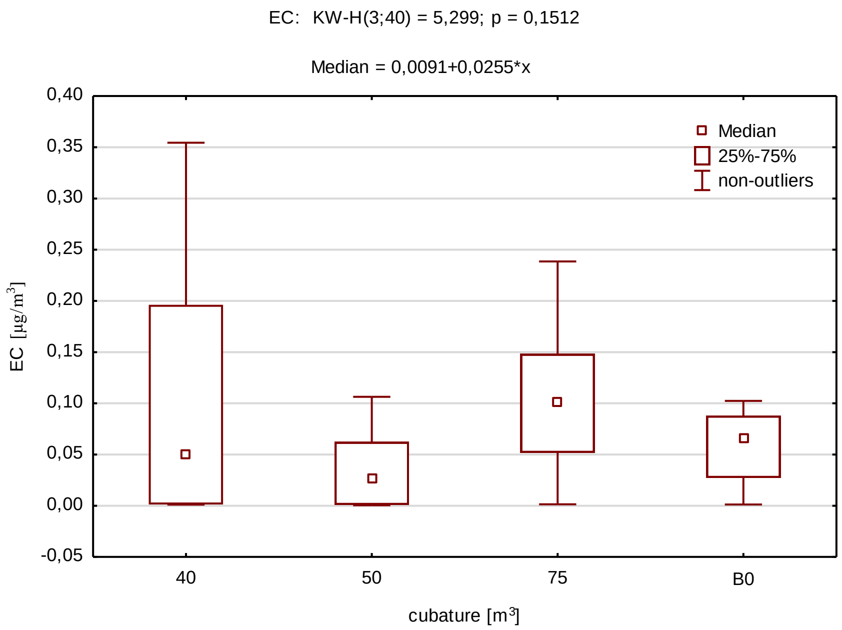

Figure S10 The 10-day median, 25%, and 75% percentile concentrations of EC inside hairdresser salons of different cubature: and in the B0 (background) *The differences between indoor and outdoor (B0 - background) concentrations are statistically significant (n = 10; Kruskal Wallice test; p < 0.05)

Gravimetric analysis procedure

The PM2.5 particles were collected on quartz filters with a diameter of 37 mm from Whatman (QMA, ø25 mm; GE Medical Systems, Life Sciences, Warsaw). Prior to and following exposure, the filters were conditioned in a weighing room within a laminar flow chamber at a constant temperature of 20°C (±2°C) and a constant air humidity of 50% (±10%) for a minimum of 48 hours. Subsequently, the filters were weighed using a Radwag scale with a resolution of 1 µm. Following each weighing, the balance was checked and calibrated in accordance with the instructions provided. For PM collection, Whatman quartz fibre filters (QMA, ø25 mm; GE Medical Systems, Life Sciences, Warsaw, Poland) were employed with Gilian Plus sampling pumps (Sensidyne, St. Petersburg, FL).

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