EFFECTS ON THE RESPIRATORY TRACT OF INDOOR AND OUTDOOR AEROSOL

Fernanda ODUBER[a], Amaya CASTRO[a], Ana I. CALVO[a], Carlos BLANCO-ALEGRE[a], Olivier PUJOL[b], Roberto FRAILE[a]

[a] *Department of Physics, IMARENAB University of León, 24071 León, Spain*
[b] *Université de Lille 1, UFR de physique, Laboratoire d'Optique Atmosphérique, F-59655 Villeneuve d'Ascq Cedex, France*
rfral@unileon.es

INTRODUCTION

Evidences show that, depending on size, the atmospheric particles can reach different regions of the respiratory tract, and that long or short-term exposure can cause serious respiratory and cardiovascular diseases and even death. Residence for a long time in an area with high particle concentrations produces a greater number of particles retained in the respiratory tract. There is a relationship between the increase of PM_{10} levels and the rate of deaths from cardiovascular and respiratory causes. In this work, the influence of particulate matter on the respiratory health was studied by means of the calculation of the inhalable, thoracic, tracheobronchial and respirable fractions following the standard ISO 7708:1995, in two indoor and two outdoor locations in Northwestern Spain.

STUDY AREA

Fig. 1. Location of sampling sites

Table 1. Description of the sampling locations

Indoor		Outdoor	
Case 1. Báscones de Valdivia, Palencia	**Case 2.** Gymnasium of the University of León	Ordoño II Secondary School, León (urban)	
February 6-8, 2014. Living room (41 m³). Biomass burning in an open fireplace	July15- 21, 2012 Sportive activities in a gym: 15 m x 27 m x 10.6 m	**Case 3.** August 1- October 23, 2012 Summer-autumn transition	**Case 4.** August 19- 21, 2012. During a vigorous forest fire in Castrocontrigo (León Province), 70 km far from León city, under an intense thermal inversion

METHODOLOGY

Particle size spectra were continuously monitored in 31 discrete channels (size ranges between 0.1 and 10 µm latex particle size) using a laser spectrometer probe (Passive Cavity Aerosol Spectrometer Probe, PMS Model PCASP-X)

Fig. 2. Optical particle counter (PCASP-X)

RESULTS

Tables show inhalable, thoracic, tracheobronchial and respirable mass fractions in healthy adults and high risk population (children, frail or sick people) deposited in the respiratory tract for two indoors and two outdoors locations.

Indoor, Case 1

Table 2. Combustion phases: **F1**: Ignition, 1.5 kg of oak chips, 400 g of branches of pruning of the vine and two sheets of newspaper; **F2**: Refuelling, 5 kg of wood; **F3** and **F4**: 3.5 kg/refuelling; **BG**: background, **CL:** cleaning process; **Max. burning:** maximum during the combustion process and **Max. cleaning:** maximum during the cleaning process.

	Inhalable Fraction	Thoracic Fraction	Tracheobronchial Fraction		Respirable Fraction	
			Healthy adult	High risk	Healthy adult	High risk
Activity code	µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}
F1	217 ± 13	110 ± 40	63 ± 14	83± 30	50 ± 30	25 ± 17
F2	283 ± 16	140 ± 50	80 ± 13	100 ± 20	60 ± 40	35± 30
F3	94 ± 2	38 ± 7	27 ± 4	32 ± 5	11 ± 4	5 ± 3
F4	79.3 ± 1.8	32 ± 6	24 ± 4	28 ± 5	8 ± 4	4 ± 3
BG	65 ± 5	30 ± 16	24 ± 10	28 ± 14	7 ± 6	2.0 ± 1.4
CL	180.1 ± 1.5	57 ± 5	45.7 ± 1.7	52.1 ± 0.4	11 ± 6	5 ± 4
Max. burning	483	370	168	255	211	128
Max. cleaning	4541	3330	1470	2335	1860	995

Outdoor, Case 3

Table 4. Different situations during the summer-autumn transition: a) months, b) weekdays/weekend, c) hourly intervals for weekdays and weekend.

		Inhalable Fraction	Thoracic Fraction	Tracheobronquial Fraction		Respirable Fraction	
				Healthy adult	High risk	Healthy adult	High risk
		µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}
a)	August	41± 46	27 ± 30	17 ± 19	21 ± 23	10 ± 11	6 ± 7
	September	45 ± 36	29 ± 23	18 ± 14	21 ± 17	12 ± 9	8 ± 6
	October	28 ± 20	19 ± 13	7 ± 5	9 ± 6	12 ± 8	9 ± 7
b)	Weekdays	42 ± 43	27 ± 27	16 ± 16	19 ± 19	11 ± 11	7 ± 7
	Weekend	36 ± 32	24 ± 22	14 ± 12	17 ± 15	11 ± 9	7 ± 6
c)	Weekdays						
	0000-0500	36 ± 42	19 ± 22	11 ± 12	12 ± 14	9 ± 10	7 ± 8
	0500-1000	53 ± 40	31 ± 24	17 ± 13	21 ± 16	14 ± 11	10 ± 8
	1000-1500	38 ± 28	27 ± 20	16 ± 12	20 ± 15	11 ± 8	6 ± 5
	1500-2000	44 ± 57	30 ± 39	19 ± 25	24 ± 31	11 ± 15	7 ± 9
	2000-0000	41 ± 39	26 ± 24	16 ± 15	19 ± 18	10 ± 9	6 ± 6
	Weekend						
	0000-0500	42 ± 42	24 ± 25	14 ± 14	16 ± 16	11 ± 11	8 ± 8
	0500-1000	42 ± 41	25 ± 24	14 ± 14	17 ± 16	11 ± 11	8 ± 8
	1000-1500	26 ± 18	16 ± 11	9 ± 6	11 ± 7	7 ± 5	6 ± 4
	1500-2000	32 ± 23	18 ± 14	10 ± 7	11 ± 8	9 ± 6	7 ± 5
	2000-0000	35 ± 10	20 ± 10	11 ± 5	13 ± 7	9 ± 4	7 ± 3

Indoor, Case 2

Table 3. Different activities in the gymnasium: **I**: Before sport activities, **II:** Sports activities without using magnesia alba in the morning (tatamis), **III:** Sports activities without using magnesia alba in the morning (pit and tatamis); **IV:** Sports activities using magnesia alba in the morning (pit and tatamis); **V:** Vacant period; **VI:** Sports activities without using magnesia alba in the afternoon (tatamis); **VII:** Sports activities without using magnesia alba in the afternoon (pit and tatamis); **VIII:** Sports activities without using magnesia alba in the afternoon (pirouettes); **IX:** Cleaning activities; **X:** After sport activities (0h-2h); **XI:** After sport activities (2h-4h); **XII:** Maximum of magnesia alba concentration; **XIII:** weekend; **XIV:** outdoors.

	Inhalable Fraction	Thoracic Fraction	Tracheobronquial Fraction		Respirable Fraction	
			Healthy adult	High risk	Healthy adult	High risk
Activity code	µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}
I	10 ± 1	8 ± 2	3 ± 1	4 ± 1	5 ± 3	4 ± 3
II	100 ± 30	70 ± 19	50 ± 15	60 ± 18	20 ± 6	11 ± 4
III	300 ± 30	200 ± 20	180 ± 18	200 ± 20	60 ± 8	20 ± 3
IV	400 ± 3	300 ± 9	200 ± 2	300 ± 5	70 ± 9	30 ± 5
V	170 ± 2	120 ± 8	90 ± 2	110 ± 4	30 ± 6	12 ± 4
VI	100 ± 1	70 ± 3	50 ± 1	60 ± 2	20 ± 3	8 ± 2
VII	160 ± 3	110 ± 13	80 ± 7	100 ± 11	30 ± 7	10 ± 2
VIII	190 ± 0	130 ± 0	100 ± 0	110 ± 0	30 ± 0	12 ± 0
IX	40 ± 0	30 ± 2	18 ± 1	22 ± 1	10 ± 2	6 ± 2
X	18 ± 1	14 ± 3	8 ± 1	10 ± 1	6 ± 3	4 ± 3
XI	11 ± 0	10 ± 1	4 ± 1	6 ± 1	6 ± 2	4 ± 2
XII	600 ± 10	400 ± 40	300 ± 10	400 ± 30	130 ± 30	50 ± 14
XIII (*)	3	3	1	1	2	2
XIV (*)	17	10	7	8	3	2

(*) One day sampling

Outdoor, Case 4

Table 5. August 19, 20 and 21, 2012, during a vigorous forest fire in Castrocontrigo.

	Inhalable Fraction	Thoracic Fraction	Tracheobronquial Fraction		Respirable Fraction	
			Healthy adult	High risk	Healthy adult	High risk
Day	(µg m^{-3})	(µg m^{-3})	(µg m^{-3})	(µg m^{-3})	(µg m^{-3})	(µg m^{-3})
19 /08/ 2012	26 ± 13	18 ± 9	11 ± 6	14 ± 7	7 ± 3	4 ± 2
20 /08/ 2012	43 ± 31	29 ± 21	18 ± 13	22 ± 16	11 ± 8	7 ± 5
21 /08/ 2012	46 ± 24	31 ± 16	18 ± 9	22 ± 11	14 ± 7	9 ± 5
Maximum of Day (hour)						
19 /08/ 2012 (0800 UTC)	47	27	19	22	8	5
20 /08/ 2012 (1900 UTC)	121	63	47	54	16	9
21 /08/ 2012 (1200 UTC)	111	75	32	46	43	29

CONCLUSIONS

We found that indoor air pollution causes a higher deposition of small particles in the tracheobronchial and alveolar areas than polluted outdoor air.

Case1.- There are two dangerous process: a) with an initial cold environment we had difficulties for the first ignition. During this phase, the respirable fraction (211 µg m^{-3}) of the healthy people exposed to the biomass burning in an open fireplace was comparable to that of people working in mining, leather and textile industries, and b) an inadequate clean with burning embers becomes in a very polluting process (1860 µg m^{-3}). As a consequence of the high number of particles smaller than 0.5 µm that are inhaled (98.5%), a large amount of particulate matter was deposited in the alveolar zone. The ignition and the first refueling phases are very dangerous for the respiratory tract with 50 and 60 µg m^{-3} corresponding to the respirable fraction, respectively.

Case 2.- The particle size distributions are different when different gymnastic activities are practiced in the gym. Sport activities using magnesia alba cause a large deposition of small particles at the alveolar level (maximum of 130 µg m^{-3}).

Case 3.- As summer progresses to autumn the particle number increases,. The main raisons for the increase in the particle number are the traffic intensification after summer holidays, the lower dispersion caused by the thin boundary layer and the start of the use of the domestic heating devices in autumn. For the respirable fraction in healthy adults, the higher values are obtained in September and October (12 µg m^{-3}), and between 0500 to 1000 UTC on weekdays on Monday, Friday and Saturday (14 µg m^{-3}).

Case 4.- The population was exposed to high levels of pollution caused by the plume of smoke over the city. High risk people as children, frail and sick people might have retained up to 54 µg m^{-3} in the tracheobronchial region (episode average of 19 µg m^{-3}) and 29 µg m^{-3} in the alveolar region (episode average of 7 µg m^{-3}).

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