Indoor air quality in Lahore, Pakistan

Ian Colbeck[1], Zaheer A.Nasir[2], Zulfiqar Ali[3] and Sidra Safdar[3]
[1]School of Biological Sciences, University of Essex, Colchester, Essex, CO4 3SQ, UK
[2]Department of Civil, Environmental and Geomatic Engineering, University College London, WC1E 6BT, UK
[3]Department of Zoology, University of the Punjab, Lahore, Pakistan
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Presenting author email: colbi@essex.ac.uk

Lim et al. (2012) have estimated that globally 3.2 million people died from air pollution in 2010. They suggest that over 2.1 million premature deaths and 52 million years of healthy life lost in 2010 were due to fine particle air pollution in Asia. In addition indoor air pollution from solid fuel usage kills 3.5 million people annually.

Very few studies have been conducted in Pakistan regarding indoor air quality (Colbeck et al. 2010). It is not recognized as an environmental hazard at government level. Lahore (31.55°N and 74.34°E) is the second biggest city of Pakistan and the provincial capital of Punjab. It is one of the most densely populated cities of the world with an estimated population of 10,000,000.

The current study was undertaken to monitor the concentration of fine particulate matter ($PM_{2.5}$) in different residential settings within Lahore and to identify the major sources of pollution.

Twenty four houses were selected as study sites. Two real time aerosol monitors (TSI DustTrak 8520) were run in parallel; one in the kitchen and another in the living room. Fine particulate concentration in all study sites was monitored for 72 hours each in the kitchens and living rooms beginning from January 2012 to January 2013. There were nine small houses ($\leq$ 2510.6 m^2), nine medium sized houses (> 2510.6 m^2 to 5021.2 m^2) and six large sized houses (> 5021.2 m^2). The number of occupants varied from 3 to 13individuals in the different households.

The results are summarised in Table 1. The average concentrations of $PM_{2.5}$ were higher in the kitchens as compared to the living rooms. The highest mean concentration (1003 µg/m³) occurred in a kitchen in which a window faced a furniture factory; this was probably a source of fine PM throughout the day. The lowest average concentration (63 µg/m³) was in a kitchen that was not in use. In the living rooms the highest value of $PM_{2.5}$ (984 µg/m³) was observed in a house in a semi-urban industrial area, the head of the family was a smoker and there were 13 occupants. The lowest value (68 µg/m³) was found in a house with only 6 occupants and they spent most of their time outdoors resulting in low concentrations of PM. No significant difference was observed between the day and night averages.

Cooking, cleaning, smoking, and space heating were observed to be the major sources from the indoors environment while outdoor sources also played an important role especially in houses located in industrial and semi-urban areas and near high traffic roads.

Table 1. Average $PM_{2.5}$ concentrations (µg/m³) in kitchens and living rooms in Lahore.

Number of occupants	KITCHEN			LIVING ROOM		
	24 hr avg	Day	Night	24 hr avg	Day	Night
12	1003	1091	885	463	372	489
4	249	254	264	206	217	207
6	227	207	248	141	118	161
8	347	387	283	198	204	185
7	189	186	192	148	142	153
6	363	336	485	237	207	314
3	185	150	226	166	133	205
7	187	219	145	172	186	140
8	63	68	53	120	118	117
6	74	58	93	68	58	70
7	237	276	131	117	119	112
12	136	136	136	177	194	154
6	211	145	377	123	131	108
8	201	217	172	216	235	170
5	135	138	129	135	134	133
7	336	361	297	333	341	340
6	194	228	151	193	287	154
13	433	377	525	517	370	653
5	314	238	388	344	282	767
4	439	306	551	474	343	585
8	858	717	977	984	848	1096
6	753	658	849	921	895	985
3	516	408	647	701	558	388
13	383	395	323	439	500	388

Colbeck, I., Nasir, Z.A. and Ali, Z. (2010) *Environmental Science and Pollution Research* **17**, 49-63.

Lim, S.S. et al. (2013) *The Lancet* **380**, 2224-2260.