The occupant perception and investigation of indoor air quality at home in Seoul

Jong-Ryeul Sohn, Young-Whan Kim, Sang-Hoon Byeon, Dal-Woong Choi

Department of Environmental Health, College of Health Sciences, Korea University, Seoul, Korea

ABSTRACT

Indoor Air Quality (IAQ) in workplace and residential environments has been a concern of people. Recently, Ministry of Environment in Korea has recognized the potential risk on the health effects related to indoor air pollution at home. Therefore, the purpose of this study was to measure the indoor air pollutants of IAQ at different homes and investigate the perception of IAQ recognition at home through a questionnaire survey in Seoul.

We estimated the IAQ of six selected homes based on site region and housing type. The indoor air pollutants and parameters, such as room temperature (RT), room humidity (RH), respirable suspended particulate matter (PM_{10}), formaldehyde (HCHO), total bacteria counts (TBC), carbon monoxide (CO) and carbon dioxide (CO_2), were monitored in summer and winter. In monitoring results, the PM_{10} concentrations and TBC of two homes were higher than the standard in public places (150 $\mu g/m^3$ and 500 CFU/m^3, respectively). The level of HCHO exceeded the Korean standard (0.1 ppm) at all the monitored homes. In statistics analysis, we found a correlation between the building age and the concentration of CO and TBC (significant at $p < 0.01$) in summer. The correlation between RT, RH and HCHO was significant at the 0.05 level. Finally, the important air pollutants of IAQ in homes were HCHO and TBC. In addition, we performed a questionnaire survey of 500 people about their awareness of the importance of IAQ in our homes during the same period. In the results obtained, most respondents recognized the importance of IAQ at homes.

From the results obtained, it can be concluded that the IAQ of the six selected homes was perceived as acceptable. Further, it is recommended that the government should suggest guidelines and control of IAQ problems, and the occupants need to make efforts to reduce the exposure to sources of undesirable pollutants.

INTRODUCTION

Recently, Indoor Air Quality (IAQ) in workplace and residential environments has caught the attention of people and scientists. Many studies have been performed on IAQ related to workplace, shopping centre, schools, hospitals, etc. It has been found that IAQ is very important to us because we are spending more than 80% of our time indoors. The cause of indoor air pollution is a combinatory effect of physical, chemical and biological factors in the environment. The sources of indoor pollutants are known from outdoor environment such as industrial activities and traffic conditions, building materials and equipments, furnishings and human activities.

Indoor air pollutants from various sources have affected the IAQ and our health. Especially, IAQ of residential houses has become an issue of public concern in Seoul because indoor air pollution in homes can have great impact on the health and well-being of people during their lifetime.

Therefore, the purpose of this study was to measure the indoor air pollutants of IAQ at different homes and investigate the perception of IAQ recognition at home from a questionnaire survey in Seoul. We have suggested an alternative idea to reduce the exposure to air pollutants in residential homes.

METHODS

Site Description

Residential homes in Seoul are mainly of two types: private houses and apartments. So we selected homes on the basis of housing type, location and building age as specified characteristic to evaluate the potential indoor air quality. The general description of the sampling site is shown in Table 1.

Table 1 Description of sampling site for measuring indoor air quality

Sampling site	Site	Type of home	Building age	Floor area (m^2)
Home 1	Residential area, high population, high traffic flow	Private House	1–5	90
Home 2	Residential area, high population, high traffic flow	Private House	6–10	90
Home 3	Residential area, high population, high traffic flow	Private House	11–20	90
Home 4	Residential area, high population, high traffic flow	Apartment	1–5	85
Home 5	Residential area, high population, high traffic flow	Apartment	6–10	85
Home 6	Residential area, high population, high traffic flow	Apartment	11–20	85

Sampling and Analysis

In this study, indoor air pollutants of selected homes were measured such as room temperature (RT), relative humidity (RH), carbon monoxide (CO), carbon dioxide (CO_2), formaldehyde (HCHO), respirable suspended particulate matter (PM_{10}), total bacteria count (TBC). Sampling equipments were placed at 1.5 m above floor level at indoor locations. A combined IAQ monitor (BACCUA, Italy) was used for measuring indoor RT, RH, CO, CO_2. A SKC formaldehyde monitoring kit was used for HCHO measurements. PM_{10} was measuring using PM_{10} Mini-vol air sampler (Airmetrics, PAS-201, USA). Biotest Centrifugal Air Sampler (Biotest, RCS sampler, UK) for Agar strips was used for sampling bacteria at 4 ml/min. Agar strips were incubated at 35°C for 48 h. RT, RH, CO, CO_2, HCHO and PM_{10} were continuously monitored for 24 h.

RESULTS

Measuring Results

Table 2 shows the measuring results of indoor air pollutants and parameters at the six selected homes. Figures 1 and 2 show the 24 h average concentration of PM_{10}, HCHO, CO_2 and TBC at six selected home. As shown Figures 1 and 2, PM_{10} concentrations of Homes 1, 2, 3 (private house) in summer were below the Korean IAQ standard (0.15 mg^3/m^3), but those at apartment in winter were above the standard. The presence of PM_{10} concentrations in homes were from outdoor sources such as heavy traffic flow, construction activity and from indoors such as tobacco smoking, gas cooking appliances and household cleaning. The levels of

HCHO concentrations were much above the Korean IAQ standard (0.1 ppm) in all the homes. The high HCHO concentrations were due to decorative wall and painting in old homes and new style decoration and furniture in new homes. Thus, from the results we could confirm that HCHO in indoors was the most important pollutant compared to the other pollutants at home. The level of TBC at homes 3 and 6 were above the guidelines of Hong Kong and Singapore (500 CFU/m^3), which was due to inadequate ventilation, home age and hygienic quality of home.

Table 3 shows the correlation coefficient between pollutant factors at home in summer. In Table 3, we found a correlation between the building age and the concentration of CO and TBC (significant at $p < 0.01$) in summer. That was due to outdoor infiltration caused by poor ventilation. The correlation between HCHO, RT and RH was significant at the 0.05 level. It can be found that the production rate of HCHO at home was related to RT and RH.

Consequently, we can be found that the problems of IAQ pollutants at the selected homes were HCHO and TBC in comparison with other researchers (Baek *et al*., 1997; Lee *et al*., 2001). It was likely to be caused by the variety of materials used and the poor ventilation system of homes.

Therefore, we would like to recommend the inspection of construction materials used in indoor work and the installation of a room-sized air cleaner for improving the IAQ of homes.

Table 2 Measurement results of indoor air pollutants and parameters at the six selected homes

	Sampling point		Room temp. (°C)	Relative humid. (%)	CO (ppm)	CO_2 (ppm)	HCHO (ppm)	PM_{10} (μg/m^3)	Bacteria (CFU/m^3)
Standard			17–28	40–70	10.0	1000	0.10	150	500*
Private Houses	Home 1	Summer	25.0	67	3.7	532	0.46	119	362
		Winter	24.6	43	4.4	842	0.68	143	520
	Home 2	Summer	25.0	75	4.7	559	0.34	128	584
		Winter	22.0	45	5.1	855	0.51	147	822
	Home 3	Summer	26.0	80	5.2	628	0.26	147	898
		Winter	24.0	46	5.6	955	0.44	169	960
	Home 4	Summer	23.0	60	3.6	558	1.80	149	240
		Winter	24.0	33	4.0	852	2.20	172	368
Apartments	Home 5	Summer	25.0	68	4.9	579	0.67	166	608
		Winter	25.4	38	6.4	898	1.20	192	728
	Home 6	Summer	26.0	74	5.6	595	0.51	177	984
		Winter	25.0	34	7.2	938	0.78	192	1150

*The guideline of Singapore(Korea was not the standard).

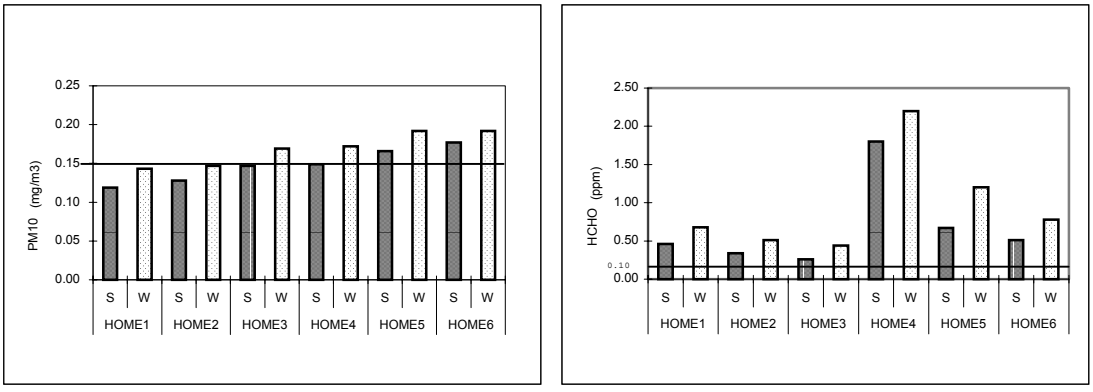

Figure 1 The measurement data of indoor air pollutants (PM_{10}, HCHO) for summer and winter at six different homes in Seoul (s, summer; w, winter).

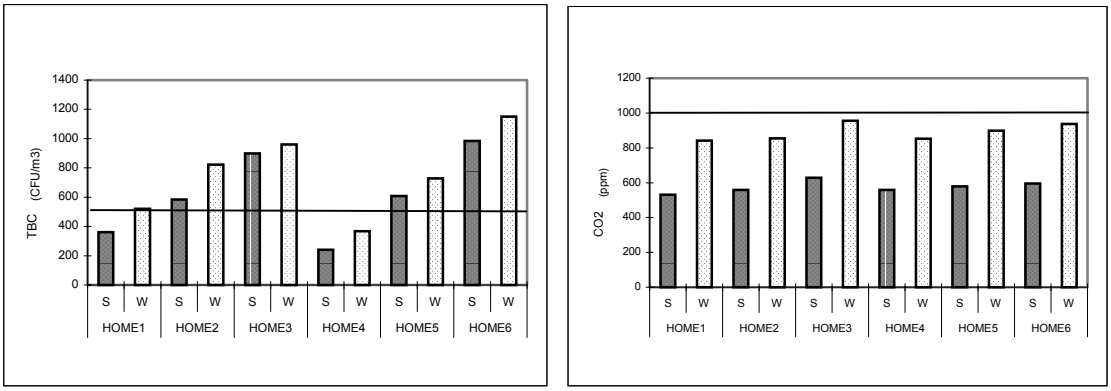

Figure 2 The measurement data of indoor air pollutants (TBC, CO_2) for summer and winter at six different homes in Seoul.

Table 3 Correlation coefficient between pollutant factors at home in summer

	BA	RT	RH	CO	CO_2	HCHO	PM_{10}	TBC
BA	1	0.811	0.835*	0.941**	0.898*	–0.555	0.570	0.984**
RT		1	0.876*	0.813	0.583	–0.907*	0.216	0.881*
RH			1	0.786	0.690	–0.845*	0.062	0.843
CO				1	0.790	–0.599	0.642	0.968*
CO_2					1	–0.312	0.584	0.824*
HCHO						1	0.154	–0.647
PM_{10}							1	0.561
TBC								1

BA, building age; RT, room temperature; RH, room humidity.
**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

Results of Questionnaire survey

We performed a questionnaire survey of 500 people about their awareness of the importance of IAQ in our homes.

In the questionnaire survey of occupants' perception on IAQ (Figures 3 and 4), most respondents recognized the indoor air pollution and indicated discomfort such as fatigue, headache, eye ache.

Therefore, it appears that the IAQ in homes may have potential risk and problems for the health of the occupants.

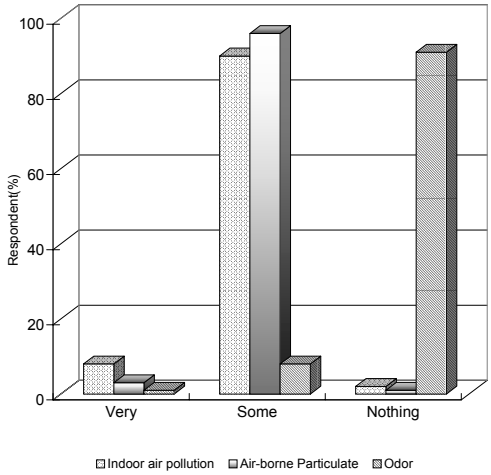

Figure 3 The questionnaire survey of occupant perception on the indoor air quality at six different homes in Seoul.

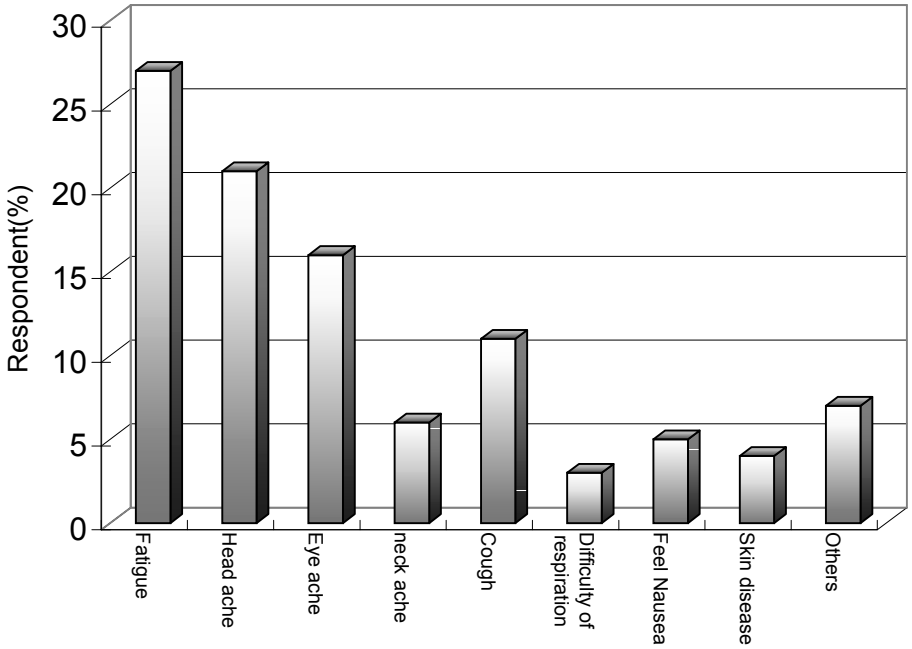

Figure 4 The questionnaire survey about the healthy condition of occupants at homes in Seoul.

CONCLUSIONS

We performed a questionnaire survey of 500 people about their awareness of the importance of IAQ in our homes. And we measured the IAQ of housing of six homes as site region and housing types. We obtained the following results.

The average PM_{10} concentrations and TBC of two homes exceeded those measured in a private house compared with the Korea standard. All average concentrations of HCHO in the six selected homes were high in comparison with the EPA and Korean standards. In statistics analysis using SPSS, the building age and concentration of CO and TBC were very significant at the 0.01 level; we also obtained correlation coefficients significant at the 0.05 level between RT, RH and HCHO.

So it appeared that IAQ of homes may have the potential risk and problems of health for the occupants. Therefore, it can be concluded that the IAQ of the six selected homes was perceived as acceptable; further, it is recommended that the government should suggest guidelines and control of IAQ problems, and the occupants must make efforts to reduce the exposure to sources of undesirable pollutants.

ACKNOWLEDGEMENTS

The study is supported by Institute for Health Sciences, College of Health Sciences, Korea University. The authors thank Mr Kim, Mr Lee and Miss Chun for assistance during sampling tasks, and Mr Chung for assistance in HPLC analysis.

REFERENCES

Baek, S.O., Kim, Y.S. and Perry, R. (1997). Indoor air quality in homes, offices and restaurants in Korea urban areas—indoor/outdoor relationships. *Atmospheric Environment* **31**, 529–544.

Chan, L.Y., Kwok, W.S. and Chan, C.Y. (2000). Human exposure to respirable suspended particulate and airborne lead in different roadside microenvironments. *Chemosphere* **41**, 93–99.

Chao, Y.H., Tung, C.W. and Burnett, J. (1998). Influence of different indoor activities on the indoor particulate levels in residential buildings. *Indoor Built Environment* **7**, 110–121.

Moschandreas, D.J. and Relwani, S.M. (1992). Perception of environmental tobacco smoke odors: an olfactory and visual response. *Atmospheric Environment* **26B**, 263–269.