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MEASUREMENTS OF INDOOR CARBON MONOXIDE LEVELS USING PASSIVE SAMPLERS IN KOREA

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Indoor carbon monoxide (CO) concentrations and personal CO exposures were measured in Korea where CO poisoning caused from the usage of Yeontan or coal briquette as domestic fuel for cooking and space heating has been a serious problem. Thirty-five homes were selected from an urban and rural area for the survey conducted in January 1989. Newly developed passive CO samplers were placed in a kitchen and living room for the indoor measurement and were worn by a housewife for the personal exposure monitoring. Daily averages of indoor CO concentrations were 23.4 ppm in the kitchen and 11.8 ppm in the living room. The average personal CO exposures of 18.1 ppm was between the two indoor CO concentrations. The indoor concentrations and personal exposures to CO were different in types of the space heating systems and two areas. House ventilating methods and socio-economic conditions were also important factors in determining the indoor and personal CO levels in Korea.

INTRODUCTION

One hundred thousand poisoning cases and two thousand deaths in a year due to accidental exposures to CO are reported in Korea[1], where approximately 70 percent of households use coal briquettes or Yeontan as domestic fuel for cooking and space heating. CO, a combustion product of Yeontan, is discharged into a house through flues of the heating system which is inadequately maintained and/or installed. An ondol is a traditional and common method for floor heating and cooking in Korea. There are two basic types of ondols using Yeontan. One is a traditional ondol and the other is an ondol boiler. In the traditional ondol, flues are installed from the cooking stoves in kitchens, under floors, through the living area, to the outside. Indoor

air is warmed up with the combustion gas vented through the flues. In the ondol boiler, hot water or steam made with the boiler is used instead of the combustion gas as the medium for the floor heating. The pipes for the hot water or steam are positioned under the floors. "Saemaul" boiler is a subtype of the ondol boiler using a cooking stove for producing hot water.

Since most of the research has focused on medical treatments and follow-up studies on the patients suffered from the CO poisoning, there are few studies on personal CO exposures and indoor CO concentrations. A preliminary field study using newly developed passive CO monitors was conducted to investigate the distribution of personal CO exposures and to seek determinant factors of indoor CO pollution in Korea.

MATERIALS & METHODS

Thirty five participants in two cities, Seoul and Togo, were selected from homes using Yeontan. Seoul is the largest city in Korea and Togo is a rural area located at about 130 km south of Seoul. Twenty five participants were chosen from three districts in Seoul where socio-economic conditions differed.

The sampling was conducted, in January 1989, using three passive CO samplers in each home for 24 hours. Two samplers for the indoor measurements were placed in a kitchen and living room. One sampler for monitoring the personal exposure was carried by a housewife. Some outdoor samplers were placed at the outside of several participant's houses. CO levels inside and outside of each house were monitored with a portable electrochemical CO analyzer prior to the passive sampler measurements in order to determine appropriate sampling points.

The passive CO sampler consisted of a glass tube with one side sealed by a rubber cap[2]. The CO adsorbent packed in the glass tube was made from Zn-Y-zeolite. The sampling rate of CO was controlled with a narrow diameter polyethylene tube inserted into the center of the adsorbent layer through a septum fixed to the other end of the glass tube. Analysis of the samplers was carried out by thermal desorption of CO, followed by gas chromatography with a flame ionization detector.

Participants' activities were recorded during the measurements, such as the time spent, locations, and the usage of gas appliances. We also collected information on participant's smoking habits and house characteristics.

RESULTS & DISCUSSION

Characteristics of house structures and types of ondols of 35 homes are summarized Table 1. There are more Korean style homes in Seoul, which were less spacious and mostly made of wood. Ten homes have the traditional

ondol, 10 use the Saemaul boiler and the rest are users of the ondol boiler. In Togo, 2 homes have the traditional ondol and 8 use the ondol boiler.

Cumulative frequency distributions for indoor CO concentrations and personal exposure levels are presented in Figure 1 and a summary of statistics is shown in Table 2. The mean CO concentrations in the kitchen and living room were 23 ppm and 12 ppm, respectively. The average personal CO exposure of 18 ppm was between the averages of the two indoor measurements. Half of the participants were exposed to high levels of CO exceeding the ambient air quality standard in the USA and Japan which is a 24-hour average of 10 ppm. Average outdoor CO concentrations measured by the electrochemical analyzer were 5.5 ppm in Seoul and 1.3 ppm in Togo.

When comparing indoor CO concentrations by types of ondols, houses with the ondol boiler had lower mean concentrations than houses using the traditional ondol. Living room CO concentrations in Seoul, for example, were 11.1 ppm and 9.5 ppm for the traditional ondol and the ondol boiler respectively (Table 3). In Togo, they were 14.2 ppm and 4.7 ppm (Table 4). Houses with the Saemaul boiler were the most polluted by CO among the three ondol systems in Seoul (Table 3). The Saemaul boiler system, which has been recently adopted, does not help to improve indoor air quality in terms of CO.

The average personal CO exposures were highest for the wives using the traditional ondol in Togo, while in Seoul the average CO levels were highest among wives using the Saemaul boiler (Table 3 & 4). When comparing averages of the personal CO exposures by the type of ondols and by areas, they did not necessarily correspond to the extent of indoor air pollution by CO. In Seoul, the mean personal CO exposures of the traditional ondol users and the ondol boiler users were 11 ppm and 19 ppm, whereas indoor CO concentrations in the traditional ondol houses were higher than those in the ondol boiler houses. These suggest that the personal CO exposures depend not only on the indoor CO concentrations but also on other factors, such as daily activities, outdoor CO concentrations and house ventilation.

Presence of smokers in homes was not a major determinant factor of the CO concentrations (Table 5). We could not detect the contributions of smoking to indoor CO levels and personal exposure.

CONCLUSIONS

The types of heating systems were found to be one of the determinant factors of indoor CO concentrations and personal CO exposures. Indoor CO levels for homes with traditional ondols were higher than those with ondol boilers in both areas. Particularly kitchen CO concentrations of the traditional

ondol house in Togo exceeded 50 ppm. In Seoul the houses with the Saemaul boiler, which is a subtype of the ondol boiler, had the highest indoor CO concentrations. The personal CO exposures were between indoor CO concentrations in the living room and kitchen in most cases.

REFERENCES

1.Song DB (1985) Epidemiology of Carbon monoxide poisoning in Korea. J of Korean Med Assoc, 28:1059-1063.

2.Hishinuma M, Yanagisawa Y(1989) Passive sampler for carbon monoxide using a solid adsorbent. The 82nd Annual Meeting of Air Pollution Control Association, Anaheim, CA.

Figure 1.

Cumulative frequency distributions of CO concentrations by location.

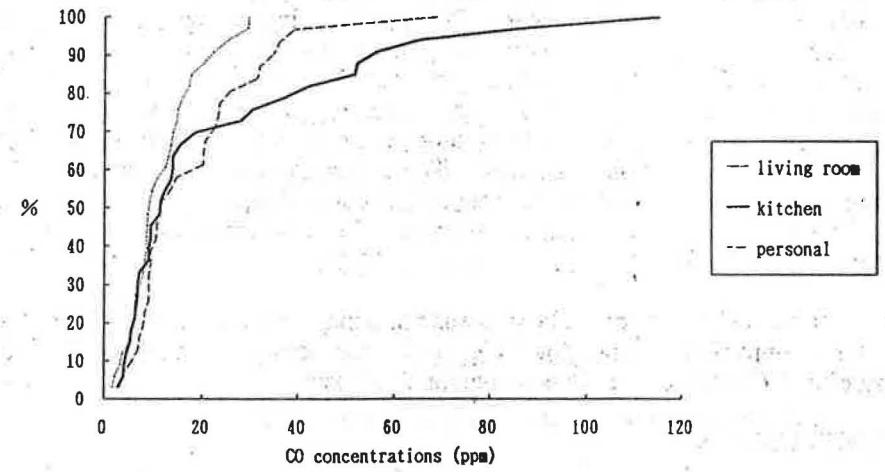

TABLE 1. CHARACTERISTICS OF SUBJECTS' HOUSE BY THE AREA.

	SEOUL	TOGO
	# OF HOUSES	# OF HOUSES
TYPE OF HEATING		
TRADITIONAL ONDOL	10(40%)	2(20%)
ONDOL BOILER		
SAEMAUL	10(40%)	0(0%)
OTHER	5(10%)	8(80%)
STRUCTURE		
KOREAN STYLE	16(64%)	2(20%)
WESTERN STYLE	2(8%)	4(40%)
KOREAN-WESTERN MIXED STYLE	7(28%)	4(40%)
	MEAN(S.D.)	MEAN(S.D.)
TOTAL FLOOR SPACE*	37.3(29.4)	80.9(36.6)
KITCHEN SPACE*	5.3(4.0)	4.0(2.0)
LIVING ROOM SPACE*	6.9(3.3)	5.3(1.7)

*SQUARE METER

TABLE 2. SUMMARY STATISTICS OF CO CONCENTRATIONS. (PPM)

	MEAN	S.D	RANGE	N
LIVING ROOM	11.8	7.2	1.7 - 29.8	33
KITCHEN	23.4	26.2	2.8 - 115.1	33
PERSONAL	18.1	13.8	3.0 - 69.5	31

TABLE 3. MEAN CO CONCENTRATIONS(PPM) BY TYPE OF HEATING IN SEOUL.

	TRADITIONAL ONDOL	ONDOL BOILER SAEMAUL	OTHERS
LIVING ROOM	11.1 (N=10)	18.1 (N=10)	9.5 (N=4)
KITCHEN	16.7 (N=9)	29.5 (N=10)	11.4 (N=4)
PERSONAL	10.8 (N=10)	25.0 (N=9)	18.9 (N=3)

TABLE 4. MEAN CO CONCENTRATIONS BY TYPE OF HEATING IN TOGO.

	TRADITIONAL ONDOL	ONDOL BOILER
LIVING ROOM	14.2 (N=2)	4.7 (N=7)
KITCHEN	57.6 (N=2)	21.0 (N=8)
PERSONAL	50.6 (N=2)	10.0 (N=7)

TABLE 5. MEAN CO CONCENTRATIONS(PPM) BY PRESENCE OF SMOKERS IN HOMES.

	SMOKERS YES(24)*	SMOKERS NO(11)*
	MEAN (S.D)	MEAN (S.D)
LIVING ROOM	12.6 (8.0)	10.3 (4.8)
KITCHEN	23.1 (26.1)	24.1 (26.6)
PERSONAL	15.4 (8.5)	23.7 (19.8)

*(NUMBER OF DATA)