

하 권 철

**Characteristics of Airborne Asbestos and Radon Concentrations  
in the Underground Spaces in Gyungnam Province**

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The purpose of this research is to characterize airborne asbestos and radon concentrations as trace toxic air pollutant in the underground spaces in Gyungnam province. Air samples of asbestos and radon were taken in the three underground spaces for ten months from April 2003 to January 2004. The IAQ(Indoor Air Quality) of underground spaces were controlled using central ventilation (supply/exhaust) system. The levels of geometric means of airborne asbestos and radon concentrations in three sampling spaces

were below the standards of Korean Ministry of Environment. However, one sample of airborne asbestos in underground spaces "C", which was used fire proofing fibrous material, was in excess of the standard. There are significantly statistical differences in levels of trace toxic air pollutants by sampling spaces(p<0.05).

**Key Words:** Asbestos, Radon, Indoor Air Quality, Underground Space

I. 서 론

1970 (Indoor Air Quality, IAQ), 21  
(Tight Building Syndrome-TBS, (indoor environment)  
Sick Building Syndrome-SBS,  
(Indoor Environmental Quality, IEQ),  
, 가 (Building-Related Disease, BRD),  
(Hines  
, 1993; McCarthy , 1998; Spengler ,  
가 가 1991). 가

: 2004 11 24 , : 2004 12 27

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가

ACGIH  
 AI( , confirmed  
 human carcinogen) ( , 1989, , 2002; ACGIH, 2004).  
 가 ,  
 가 70 가  
 ASHRAE(American Society of Heating,  
 Refrigerating, Air Conditioning Engineers)  
 (acceptable air quality)  
 “ ,  
 (80%) ,  
 ” Po-218  
 (ASHRAE, 1999). (non-indus-  
 trial environments) 가 ,  
 가 20% .  
 (NCRP)  
 13 5  
 ~ 2 .  
 가 .  
 가 ,  
 가 가  
 ( , 1989; ,  
 2002; EPA, 2004).  
 (Wolkoff, 1992; Harrje, 1991).  
 1970 (防火)  
 , , ,  
 가  
 가  
 (Mesothelioma, 1993; Ryan , 1994).  
 ),  
 (Asbestosis)가  
 가 ,  
 가 20~30 .

## II. 연구 대상 및 방법

### 1. 연구 대상

가 3  
 ( 2 , 1 ) 2003 4  
 2004 1 10

### 2. 연구 방법

가 (NIOSH)  
 (EPA)

#### 1) 덕면

NIOSH “NIOSH 7400”  
 (membrane filter, SKC)  
 (Gilian, HFS, USA) 2.5 /min  
 6

(Zeiss, Axiostar plus)  
 5 μm  
 가 3:1

가 (Gilian, USA)  
 가 (Hines,  
 lcc  
 ( /cc)  
 (NIOSH, 1994).

#### 2) 박돈

EPA E-PERM  
 Electret Radon Monitor System(RAD Elec  
 Inc.) 48

E-PERM  
 Picocuries per liter(pCi/ )  
 Becquerels per cubic meter(Bq/m<sup>3</sup>)  
 (EPA, 2004). 1 curie(Ci)  
 1 pCi 1 0.037  
 , 1 Bq  
 1  
 1 pCi/ 37 Bq/m<sup>3</sup>  
 1 Bq/m<sup>3</sup>

Windows(Version 4.0, Jandel Corp., USA),  
 Excel 2000(Microsoft Corp., USA)  
 (Seifert, 1992; Mulhausen  
 , 1998).

“C”  
 , 가  
 1980  
 가

### III. 결과 및 고찰

20~31m<sup>3</sup> ASHRAE 62-1999  
 가  
 1 m<sup>2</sup> 7 m<sup>3</sup>  
 (ASHRAE 1999).

#### 1. 지하생활공간의 특징 및 실내공기 질 관리

$$\text{Airborne Radon Concentration(pCi/ℓ)} = \frac{IV - FV}{CF \times D} - BG$$

( 1)

IV, FV : Initial and Final Electret Voltages  
 D : Exposure Period(days)

CF(Calibration Factor) : 1.69776+ 0.00057420  
 ×(IV+FV)/2

B : Environmental Gamma Background  
 Radiation(11.8 μR/h)

G : 0.087 pCi/ (S chamber E-PERM  
 1 μR/h

가 )

(Log-

Normal Distribution)

(Geometric Mean,

GM) (Geometric Standard  
 Deviation, GSD)

가 3 ( 2  
 , 1 )  
 , ( ),  
 ( 1).

가

(ETS)

#### 2. 석면 농도분포의 특성

“A”가 가 12 ~ 14  
 , 가 가  
 “C”가 가  
 “B”가 가 W-test(Shapiro and Wilk test)

Sigma Plot 4.0 for Windows(Version 4.0,  
 Jandel Corp., USA) Sigma Stat. for

“A” ”B”

(Mulhausen , 1998).

Table 1. Characteristics of sampling space underground spaces in Gyeongnam Province

Sampling space	A	B	C
Area, m <sup>2</sup>	16,746	3,143	7,665
Length/width, m	517/23~33	170/20	330/11
Occupants(manager)	350(17)	120(3)	400(7)
Customer per day	30,000	3000	20,000
No. of shop	407	85	212
No. of exit	18	6	14
Ventilation system	Central	Central	Central
Fans(horse power)	40HP x 4, 30HP x 2	25HP x 2, 10HP x 2	50HP X 3
Supply air(m <sup>3</sup> /h)	339,880	114,920	162,000
Exhaust air(m <sup>3</sup> /h)	298,800	87,500	135,000
Open year	1999	1980	1988



Table 3. Geometric mean, geometric standard deviation, and range of radon concentrations by sampling space (standard : 4 pCi/ )

Sampling site	No. of sample	Radon concentration, pCi/		
		GM	GSD	Range
A	11	1.053	1.467	0.475~1.742
B	11	0.423	2.142	0.301~1.005
C	11	0.603	2.638	0.047~1.981

( , 1989).

가 (p<0.05).  
가 5.

#### IV. 결 론

3 가 가 가  
가 가 가  
가  
2003 4 2004 1

가 , ,  
가 가  
가 가  
2004  
“ ”  
1. 가  
ASHRAE  
2. 가  
3. 가  
0.01 f/cc  
2003 7  
“A”, “B”, “C” 0.0019 f/cc, 0.0006  
f/cc, 0.0025 f/cc  
가 “C” 가  
0.012 f/cc  
4. “A”, “B”,  
“C” 1.05 pCi/ , 0.42 pCi/ ,  
0.60 pCi/

#### 감사의 글

#### REFERENCES

12 ,  
1989.  
(ETS)  
2003;13(2)152~159  
2002.  
American Conference of Governmental  
Industrial Hygienists(ACGIH), 2004  
Threshold Limit Values for Chemical  
and Physical Agents, and Biological  
Exposure Indices, ACGIH, Cincinnati,  
Ohio.  
American Society of Heating, Refrigerating

- and Air-Conditioning Engineers (ASHRAE), ASHRAE 62-1989: Standards for Acceptable Indoor Air Quality, ASHRAE, 1999.
- Harrje, D.T., Building Dynamics and Indoor Air Quality. In: *Indoor Air Pollution: A Health Perspective*, pp. 68-81. J.M. Samet and J.D. Spengler, Eds. The Johns Hopkins University Press, London, 1991.
- Hines, A.L., *Indoor Air Quality and Control*, New Jersey: PTR Prentice Hall, 1993.
- McCarthy, J.F.; Bearg, D.W.; Spengler, J.D., Assessment of Indoor Air Quality. In: *Indoor Air Pollution: A Health Perspective*, 1998. pp. 82-108.
- Mulhausen, J.R., Damiano, J. A Strategy for Assessing and Managing Occupational Exposures, AIHA Press. 1998.
- National Institute for Occupational Safety and Health (NIOSH): NIOSH Manual of Analytical Method (NMAM), 4th Ed., 1994. Edited by P.M. Eller, DHHS/NIOSH
- Ryan, P.B., Lambert, W.E.: Personal Exposure to Indoor Air Pollution. In: *Indoor Air Pollution: A Health Perspective*, 1994. pp. 109-127.
- Seifert, B., Organic Indoor Pollutants: Sources, Species, and Concentrations. In: *Chemical, Microbiological, Health and Comfort Aspects of Indoor Air Quality-State of the Art in SBS*, pp. 25-36. H. Knoppel and P. Wolkoff, Eds. ECSC, EEC, Brussels and Luxembourg. Printed in the Netherlands, 1992.
- Spengler, J.D., Sources and Concentrations of Indoor Air Pollution. In: *Indoor Air Pollution: A Health Perspective*, J.M. Samet and J.D. Spengler, Eds. The Johns Hopkins University Press, London, 1991. pp. 33-67.
- US Environment Protection Agency(EPA), 2004. Available from URL:<http://www.epa.gov/iaq>
- Wolkoff, P., The Dynamics of the Indoor Environment and Some Strategical Aspects of Indoor Measurements. In: *Chemical, Microbiological, Health and Comfort Aspects of Indoor Air Quality-State of the Art in SBS*, pp. 15-24. H. Knoppel and P. Wolkoff, Eds. ECSC, EEC, Brussels and Luxembourg. Printed in the Netherlands, 1992.