RESPIRABLE DUST WEIGHT CONCENTRATION AND QUARTZ CONCENTRATION IN RESPIRABLE DUST WEIGHT CONCENTRATION IN TAEBACK AND KANGNEUNG COLLIERIES

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ABSTRACT

In order to evaluate the working environment of underground coal mines, the respirable dust and the concentration of quartz in respirable dust were measured at the area of Taeback and Kangneung collieries. The quartz concentration was measured by Fourier transform infrared spectrophotometry. The results were compared according to the area and work site (drilling, coal face).

The distribution of data of respirable dust and quartz concentration in respirable dust were well fitted to the log-normal distribution. The geometric mean values of respirable dust were 1.34 mg/m³ (SD, 2.81) on drilling site and 2.55 mg/m³ (SD, 2.61) on coal face at Taeback collieries. At Kangneung collieries, they were 2.44 mg/m³ (SD, 3.63) on drilling site and 4.24 mg/m³ (SD, 2.37) on coal face. The geometric mean values of quartz concentration in respirable dust were 4.24% (SD, 2.59) on drilling and 1.39% (SD, 2.22) on coal face at Taeback collieries. At Kangneung collieries, they were 2.55% (SD, 3.08) on drilling and 1.24% (SD, 2.33) on coal face. There was no significant difference in the mean value of respirable dust between two areas. But the mean concentration of quartz in respirable dust showed significant difference between work site (p<0.05) but no difference between area (p>0.05).

INTRODUCTION

In Korea, raw prevalence rate of occupational disease was 2.2% in 1986. Among them, about 57.3% was pneumoconiosis. Eighty-eight percent of penumoconiosis was coal worker's pneumoconiosis.[7] So the environmental management of coal mine is important. Coal vein is narrow, so application of mechanical mining is difficult. Zahorski reported differences of prevalence and incidence rate of C.W.P. according to areas, and similar report was reported by Gilson about prevalence rate.[12,4] Seaton reported that small concentration of quartz in coal dust is important for pathogenesis of coal workers pneumoconiosis.[11]

Now there are a few systemically analyzed data about quartz concentration in respirable dust of coal mines in Korea. We planned to evaluate the work environment of coal mines located at Kangneung and Taeback by measurement of respirable dust weight concentration and quartz concentration in respirable dust.

METHOD AND MATERIALS

We selected 70 sampling points at collieries in the Taeback area and 35 sampling points at collieries in the Kangneung area. For the measurement of respirable dust weight concentration, we got 52 samples from Taeback area and 33 samples from Kangneung area. For the measurement of quartz concentration in respirable dust weight concentration, we got 65 samples from Taeback area and 35 samples from Kangneung area. Casella personal air sampler (England) and MSA Fixt-Flo (Model 1, U.S.A.) were used for sampling of respirable dust. For the analysis of quartz concentration in respirable dust weight concentration, Fourier transform infrared spectrophotometer (Analet Instrument FX-6160, U.S.A.) was used. We got the standard respirable quartz from NBS (National Bureau of Standards, standard reference material number, 1878, particle size <5 μm).

The mean air flow rate of personal dust sampler was 1.80 l/min (SD, 0.13;1.5-2.0). Sampling was conducted at coal face and drilling site. The zone of sampling point was respirable zone of worker. Fixed site sampling method was used. Three samplers were used at the same time. Sampling was conducted during one shift and the available mean sampling time was 214 (SD, 42; 60-354) minutes. Membrane filter was dried at desiccator for 24 hours and the weight was measured for 5 times. Accuracy of measurement was 0.24%. The pretreatment of sample was conducted by muffle furnace for ashing at 650°C for 2 hours.

For analysis of quartz, we made 7 mm pellet with 80 mg of KBr by the manual of FT-IR of Analet Co. For the compensation of sample loss, correction factor (C.F.) was used as

below.

$$C.F. = \frac{C3}{C1 + C2}$$

C1: the initial weight of KBr (80 mg)
C2: the weight of standard sample or treated sample
C3: the weight of pellet

Standard calibration curve was calculated with the standard respirable quartz (NBS, standard reference material number, 1878, particle size < 5 μm) at the wave length of 799 cm^{-1} (Figure 1).[3] The measurable range of quartz was 9.7-196 μg with the sensitivity of 90-112%.[2]

Percent concentration of quartz was calculated

$$\text{as Quartz (\%)} = \frac{S2}{S1 \times 1000} \times 100$$

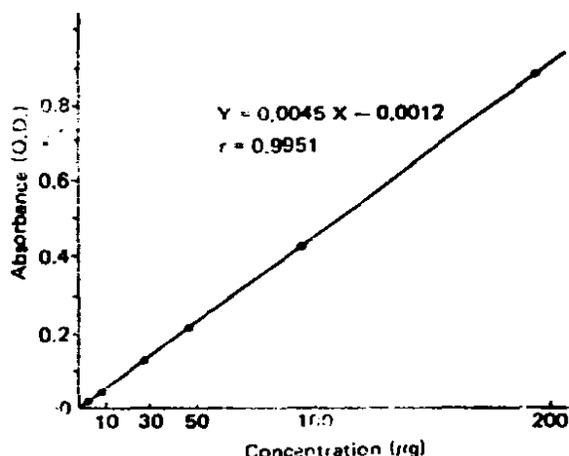S1: the weight of corrected sample (mg)
S2: the weight of quartz in sample (μg)

The distribution of respirable dust weight concentration and the quartz concentration in respirable dust weight concentration were tested for normality by chi-square test.

RESULTS

Respirable dust concentration was measured by the time weighted average concentration (mg/m^3, TWA) with unit of 0.01 mg. The mean concentrations were calculated by arithmetic and geometric means (Table I). Among all of the respirable dust weight concentrations, 40% of samples were less than 2 mg/m^3. The distribution showed skewness to right (Figure 2). When we converted the data into logarithm, histogram showed normal distribution (p>0.1) (Figure 3). So we used the geometric mean value for t-test. There was no geographical difference between Taeback and Kangneung. But there was significant difference between the drilling and coal face in Taeback (Table II). Quartz concentration was calculated as percent concentration in respirable dust.

Table III shows the quartz concentration in Taeback and Kangneung area. The histogram showed skewness to right

Figure 1. Standard calibration curve for quartz determination by Fourier transform infrared spectrophotometry.
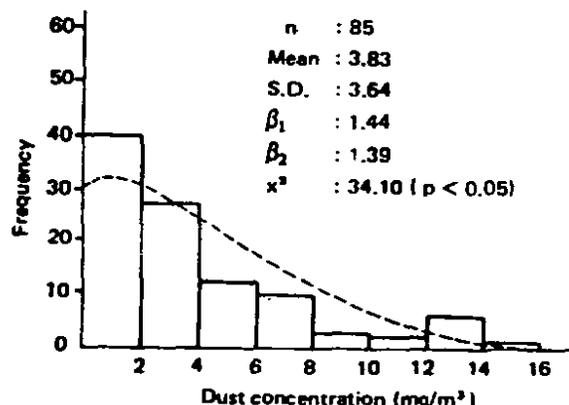

Figure 2. Histogram and expected distribution curve of respirable dust concentrations in Taeback and Kangneung areas.

Table I
Respirable Dust Weight Concentration in Taeback and Kangneung Areas

Area	Site	Cases	Respirable dust concentration (mg/m3)					
			Arithmetic		Geometric		Min.	Max.
			Mean	S.D.	Mean	S.D.		
Taeback	Drilling	23	2.00	1.56	1.34	2.81	0.12	5.55
	Coal face	29	3.74	3.14	2.55	2.61	0.30	11.49
Kangneung	Drilling	16	4.55	4.51	2.44	3.63	0.25	12.88
	Coal face	17	5.77	4.53	4.24	2.37	0.50	14.76

S.D.: Standard Deviation, Min: Minimum, Max.: Maximum

n   : 85
Mean : $\log^{-1}$ 0.37 = 2.34
S.D. : $\log^{-1}$ 0.47 = 2.95
β_1 : - 0.45
β_2 : - 0.27
x^2 : 3.46 (p > 0.1)

Frequency

−1.0 − 0.7 − 0.4 − 0.1 0.2   0.5   0.8   1.1   1.4
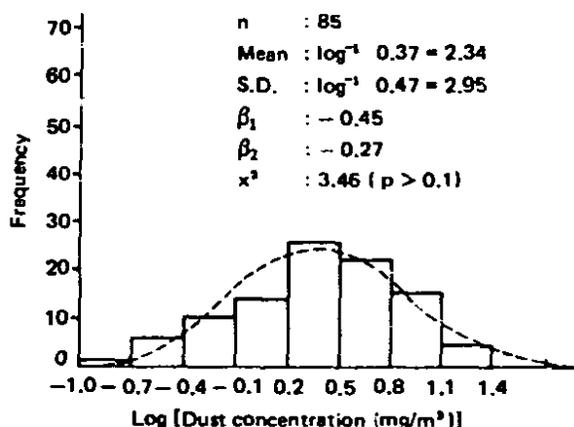Log [Dust concentration (mg/m³)]

Figure 3. Histogram and expected distribution curve of logarithms of respirable dust concentrations in Taeback and Kangneung areas.

(Figure 4). So, it was converted into logarithmic data (Figure 5) and the logarithmic distribution showed normal distribution (p > 0.1). There was no geographical difference of quartz concentration but there was difference between drilling and coal face in both areas (p < 0.05) (Table IV).

DISCUSSION

The TLV of coal dust is 2 mg/m³ in the case of less than 5% of quartz concentration.[1] Table I and Figure 1 reveal that many samples are over the TLV of ACGIH. Zahorski reported that the more narrower of coal seam, the more prevalence rate of coal workers' pneumoconiosis.[12] Saric reported that the dust is more produced from more crumbly coal.[10] The coal seam of South Korea is thin, crumbly anthracite.[8] So, we think that the higher concentration of respirable dust concentrations are partly due to the character of coal seam in comparison with other countries.[6,5]

The distribution of respirable coal dust and quartz concen-

Table II

Comparison between Drilling and Coal Face at Taeback and Kangneung Collieries by Logarithms of Respirable Dust Weight Concentration

| | | Area | | t-value |
		Taeback	Kangneung	
Site	Drilling	0.13 ± 0.45	0.39 ± 0.56	−1.61
	Coal face	0.41 ± 0.42	0.63 ± 0.38	−1.80
t-value		−2.32*	−1.45	

* p < 0.05

Table III

Quartz Concentration in Respirable Dust Weight Concentration

| Area | Site | Cases | Quartz concentration (%) | | | | | |
| | | | Arithmetic | | Geometric | | Min. | Max. |
			Mean	S.D.	Mean	S.D.		
Taeback	Drilling	31	6.18	5.52	4.24	2.59	0.58	24.12
	Coal face	34	1.89	1.54	1.39	2.22	0.40	5.85
Kangneung	Drilling	18	3.54	2.12	2.55	3.08	0.06	7.14
	Coal face	17	2.05	3.37	1.24	2.33	0.46	14.72

S.D.: Standard Deviation, Min: Minimum, Max.: Maximum

tration in respirable coal dust (Figure 3, Figure 5) revealed log normal distribution as Lazarus had reported.[9]

Goldstein reported different respirable dust and quartz concentration in respirable dust weight concentration according to different quality of coal.[6] Saric also reported that even if the quality was the same, quartz concentration was different according to colliery.[10] He reported that even in the same colliery, there was much variation in quartz concentration. The quality of coal and geologic epoch of Taeback and Kangneung are the same. So, we think that there is no significant regional difference of respirable coal dust and quartz concentration. But we think that the difference of quartz concentration between drilling and coal face is due to rock drilling (Table IV).

SUMMARY

We evaluated the two collieries of Taeback and Kangneung. Respirable dust weight concentrations were measured. Quartz concentration in respirable dust weight concentrations were analyzed by Fourier transform infrared spectrophotometer.

The data of respirable dust and quartz concentration distributed as log normal. In Taeback colliery, geometric mean respirable dust weight concentrations were 1.34 (SD, 2.81; range, 0.12-5.55) mg/m^3 at drilling, 2.55 (SD, 2.61; range, 0.30-11.49) mg/m^3 at coal face.

In Kangneung colliery, they were 2.44 (SD, 3.63; range, 0.25-12.88) mg/m^3 at drilling, 4.24 (SD, 2.37; range, 0.50-14.76) mg/m^3 at coal face. As a quartz concentration in
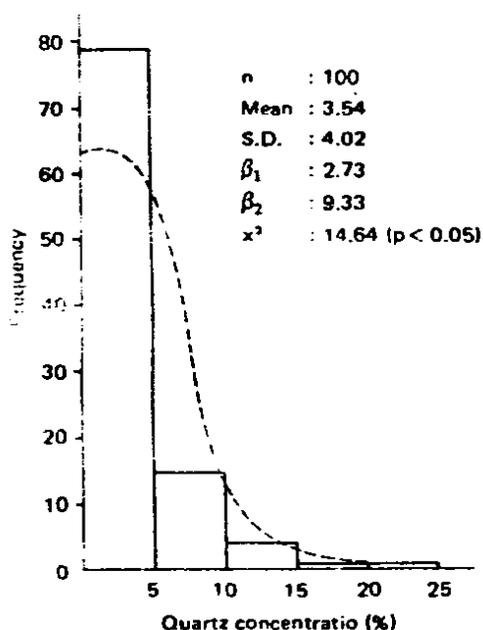

Figure 4. Histogram and expected distribution curve of percent quartz in respirable dust concentrations in Taeback and Kangneung areas.
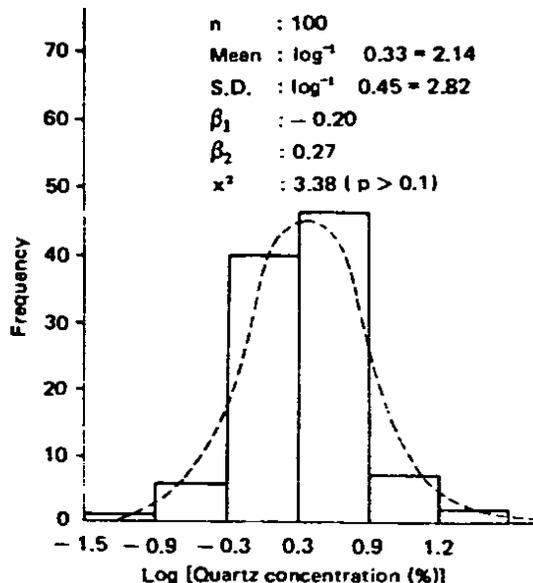

Figure 5. Histogram and expected distribution curve of logarithms of percent quartz in respirable dust in Taeback and Kangneung areas.

Table IV

Comparison between Drilling and Coal Face at Taeback and Kangneung Areas
by Logarithms of Quartz Concentration in Respirable Dust

		Area		t-value
		Taeback	Kangneung	
Site	Drilling	0.63 ± 0.41	0.41 ± 0.49	1.69
	Coal face	0.14 ± 0.35	0.09 ± 0.37	0.48
t-value		5.11*	2.13*	

* $p < 0.05$

respirable dust weight concentration, geometric mean value of Taeback colliery were 4.24 (SD, 2.59; range 0.58-24.12)% at drilling, 1.39 (SD, 2.22; range, 0.40-5.85)% at coal face.

In Kangneung colliery, they were 2.55 (SD, 3.08; range, 0.06-7.14)% at drilling, 1.24 (SD, 2.33; range 0.46-14.72)% at coal face.

There was no statistically significant difference between two collieries of respirable dust weight concentration and quartz concentration. But there was statistically significant difference in quartz concentration between drilling and coal face at both collieries (p < 0.05).

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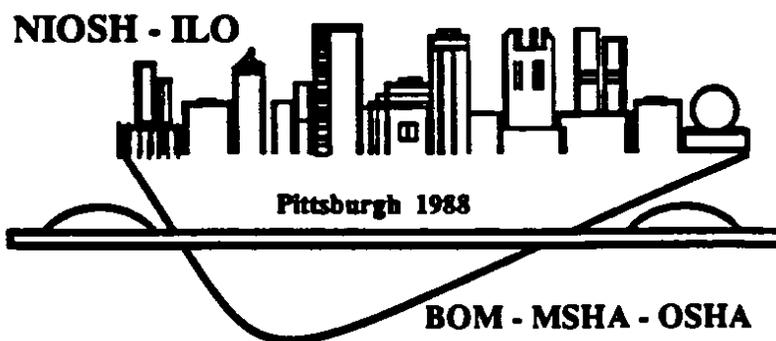
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