STUDY ON DUST PARTICLE SIZE IN AUTOPSIED LUNGS OF UNDERGROUND COALMINERS

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INTRODUCTION

Some scholars suggested that particle less than 5 μ m was most harmful. Others thought that particle less than 5–7 μm had the selective effect on the lungs. Some countries adopted the respirable dust concentration as dust standard.[1] But both the measurement of particle size distribution of dust after death from the lungs of coalminers and the experimental study on dust retained in the respirable organ of animals failed to reach a consensus about hygienic evaluation of different fractions of particle sizes. Dust 40–60 μm in diameter were found at autopsy.[2] Professor Chen Hongquan[3] observed particle size distribution of dust at autopsy, using biological microscope and scanning electron microscope and suggested that the particles with dia. below 2, 5 and 10 μm made up 65.2, 88.4 and 95% of total number. Author[4] thought that dust more than 5–7 μm must be considered when working out limit standard of dust and monitoring dust in production environment.

In this paper, our results of study on particle size distribution of dust in underground coalminers' lungs were reported.

MATERIALS AND METHODS

Subjects

120 histological sections were at random sampled from the lung sections of 60 autopsies (2 sections per case), who had been exposed to coal dust or with Coal Workers' Pneumoconiosis for this study, most of them had been coal mining workers and the few had been rock drifting workers. In view of the difference of physical and chemical properties of coal mineral dusts, 120 sections were divided into two dust groups which were treated with digestion and microincineration, respectively.

Hydrogen Peroxide Digestion

The specimen were digested in 70 ± 5 centigrade temperature H_2O_2 for 3 hrs and treated with concentrated HCl and observed by polarizing microscope.

Microincineration

Thin sections with their waxembedding material were moved by washing in xylene, dried and microincinerated in a muffle furnace at 540 centigrade temperature for 4 hrs, treated with concentrated HCl.

Size-Groups by Particle Size

Dusts were divided into down to 2, 2–5, 5–7, 7–10 and over 10 μm size-groups by geometric projection diameter. Fractions of particle numbers and masses of dust were calculated.

RESULTS

Number Distribution of Particle Sizes of Dust in lungs

The observations of the treated specimens which were divided into many parts equally were performed using the X 400 light microscope and Polarizing microscope. 500 particles were measured per section. Results were in Table I. The % of particle numbers was similar in the small particles of two dust-groups, significantly different in two dust-groups of particle 7–10 μm and over 10 μm in dia.($t > t_{0.01}$ $P < 0.01$). In mineral dust-group, numbers of particle 7–10 μm in dia. made up 7.7 % of all mineral particle numbers. In coal dust-group, number of particle in 7–10 μm dia. only constituted 4.4 % of all coal particle numbers, number of dust > 10 μm covered 0.4% and 0.2% respectively in mineral dust-group and in coal dust-group. It was clear that large particle mineral dust predominated over that of coal dust.

To account of different definitions of the respirable dust in the inspirable dust curve recommended by some countries and organisms[5] Table I was changed into Table II. Grain size distribution >7 μm fraction had significant difference in mineral dust-group and coal dust group ($t > t_{0.01}$, $P < 0.01$).

Mass Distribution of Dust Particle Size in Lungs

Accumulative distribution derived from number distribution of particle size was plotted on logarithmic normal log-probability graph paper so as to attain number distribution N(D) which was necessary to account and more minute than the measuring of groups by means of geometric projection using microscope. Total mass of particles with dia. ranging from D_1 to D_2 is given by

$$m_{1,2} = \int_{D_1}^{D_2} \rho \, \alpha_v \, D^3 \, N(D) \, dD$$

Table I
Number Distribution of Particle Sizes of Two Dust-Groups

Types of Dusts	Number of Samples	% of Number Distribution of Particle Sizes (μm)				
		<2	2-5	>5	7-10	>10
Mineral	53	55.6	25.8	10.5	7.7	0.4
Coal	57	57.6	26.5	11.2	4.4	0.2

Table II
Numbers of Particle Sizes of Two Dust-Groups

Types of Dusts	Number of Samples	% of Particle Sizes (μm)			
		<5	5-7	7-10	>10
Mineral	53	72.9	18.6	8.1	0.4
Coal	57	79.1	15.9	4.7	0.3
Mean		76.0	17.2	6.4	0.4

Here: ρ: Particle Density
α_v: Volume Shape Factor of Particle
D: Geometrical Projective Diameter of Particle.

If composition of particles and mechanism of producing particle are same, ρ and α_v are not related to particle size, so the formula above is changed into:

$$m_{1,2} = \rho \alpha_v \int_{D_1}^{D_2} D^3 \ N\ (D)\ dD$$

But relation between N(D) and D measured really showed that distributions of N(D) was different within the range of particle sizes considered. For the sake of convenience, integral method of numerical value was used. So:

$$m_{1,2} = \rho \alpha_v \sum_{D_i=D_1}^{D_2} D_i^3 \ N\ (D_i)$$

Within the given range of Particle size ($D_1 - D_2$), the per cent of particle mass in total particle mass is:

$$F_{1,2} = \frac{m_{1,2}}{m_t} = \frac{\rho \alpha_v \sum_{D_i=D_1}^{D_2} D_i^3 \ N\ (D_i)}{\rho \alpha_v \sum_{D_i=D_{min}}^{D_{max}} N\ (D_i)\ D_i^3}$$

$$= \frac{\sum_{D_i=D_1}^{D_2} D_i^3 \ N\ (D_i)}{\sum_{D_i=D_{min}}^{D_{max}} D_i^3 \ N\ (D_i)}$$

Where D_{min} and D_{max} are the smallest and largest particle diameters. M_t is total mass. The calculated results were shown in Table III and Figure 1. It was seen in Table III that masses of Particle greater than 5, 7 or 10 μm in size made up respectively 83.7 ± 3.3, 66.3 ± 6.1 and 14.2 ± 7.7

Table III
Mass Percent of Particle Sizes in Two Dust-Groups

Types of Coal	Number of Samples	% Mass of Particle Sizes (μm) <5	5-7	7-10	>10
Mineral	53	16.3	17.4	52.1	14.2
Coal	57	22.5	11.3	55.5	12.5
Mean		19.4	14.3	53.8	12.5

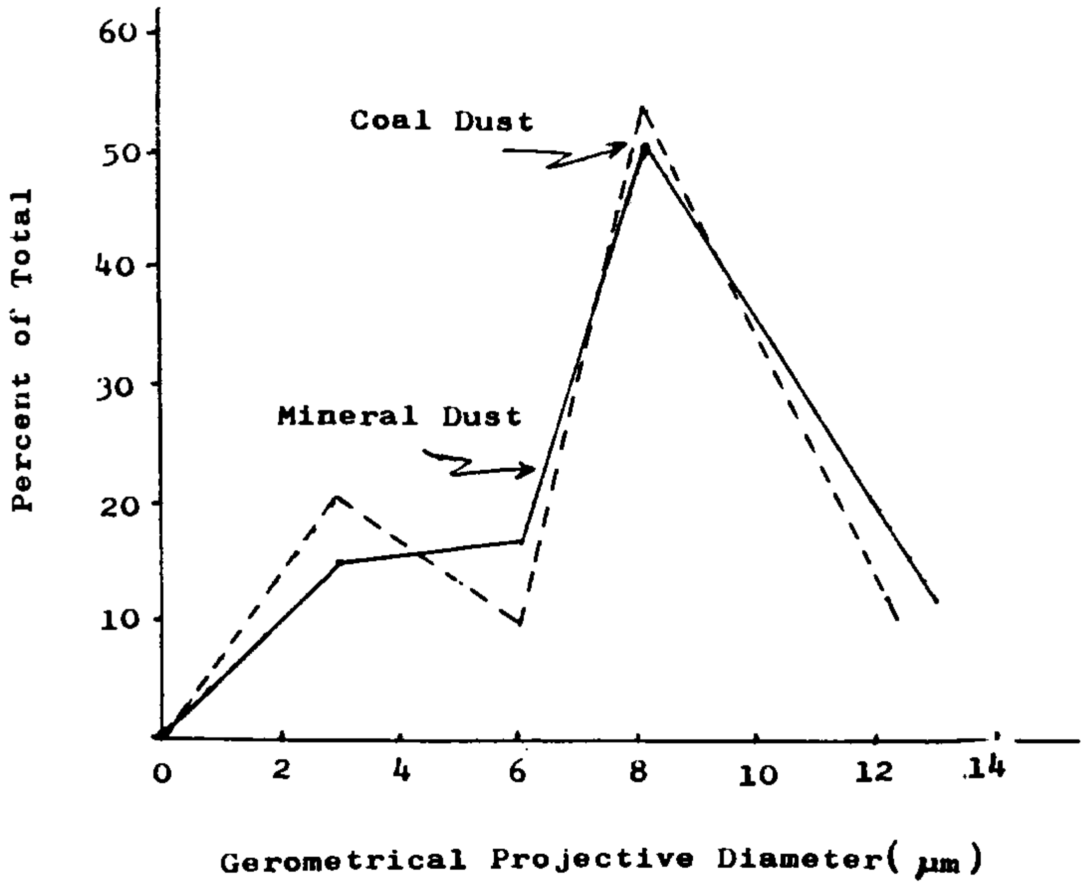

Figure 1. Mass percent of particle sizes of two types of dusts.

percent of the total mass in mineral dust in autopsic lung tissue and in coal dust in lung, masses of particle with more than 5, 7 or 10 μm in dia. accounted for 77.6 ± 7.2, 45.3 ± 10.4 and 10.8 ± 8.4 % of total mass, respectively. Significance tests showed that particle fractions over 5 μm and 7 μm of two types of dusts were significantly different ($t > t_{0.01}$, $P < 0.05$)and that fractions >10 μm of two types of dust had statistical significance($t > t\ 0.05$, $P < 0.05$).

Relationship between the Mass and the Number Distribution of Dust Particle Sizes in Autopsic Lungs

The mass and the number distributions of dust particle sizes in the lung tissue were studied. (Figure 2). Figure 2 illustrated that number of dust < 5 μm amounted to 76.0% of total number, but its mass was only 19.4%, of total mass; that number of dust >5 μm made up only 24.0% , but its mass accounted for 80.6% of total mass and that number of dust † 7 μm was 6.8% total number, its mass was 66.3% total mass and that number of dust >1O μm was 0.4% of total number, its mass constituted 12.5%, total mass.

Some scholars had observed 37297 airborne particles of samples from the gold mine and come to the conclusion that number of particle <1 μm made up 92/% of total number and its mass only 10.5% weight of sample, which was correspondence with our results.

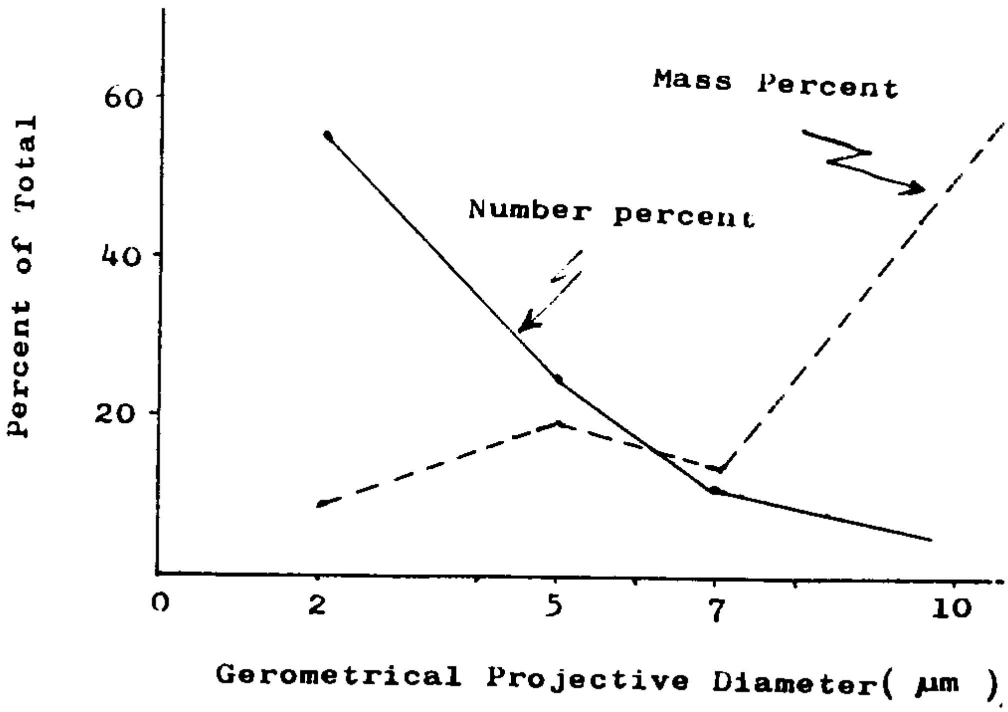

Figure 2. Comparison of percent content of particle sizes of dusts in autopsic lungs.

DISCUSSION

Some scholars[2] had injected the same weight of quartz 0.8–2.0µm and 5–10 µm in dia. into two groups of rats (A group and B group), respectively and observed 19 small dust focuses and 3 large dust focuses in A group and 47 small dust focuses and 15 large dust focuses in B group. It may be seen that quartz 5–7 µm.in dia. caused the more and the larger dust focus than quartz 0.8–2.0 µm in dia.. Hence, the respirable dust concentration was only part of dust concentration.

Other articles[6,7,8] and our study confirmed that the level of pathological change and categories by X-ray were closely relative to mass and content of dust retained in lungs. Such research has shown that CWP is related to exposure to respirable dust, partially dust 2 µm or larger in size, is the most important factor associated with CWP. So we think that when drawing up the dust hygiene standard and monitoring dust concentration, we considered not only the respirable dust concentration but also the total dust concentration.

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