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INDOOR AIR POLLUTION IN JAPANESE BUILDINGS

Satoru Muramatsu
Department of Public Health Tokyo Medical and Dental University,
Suginami Minami Health Center, Tokyo, JAPAN

Abstract

Under the provisions of the Law for Maintenance of Sanitation in Buildings, the "Building Sanitation Control Standards" came into force subsequently.

Air quality standard, one of this Standards is composed of the following 6 itemes: Suspended particles, Carbondionide, Carbon monoxide,Temperature, Relative humidity and Air velocity. Since the enactment of the law, we have serveyed actual conditions of indoor environment for these 13 years, and found the percentage of buildings which failed to come up to the standards.

Introduction

In Japan, the law for Maintenance of Sanitation in Buildings was enacted in 1970 and under the provisions of this law, the "Building Sanitation Control Standards" came into force subsequently.

Air quality standard, one of the Sanitation Control Standards is composed of the following 6 items:

Suspended particles: not more than 150μg/m^3
CO_2 : not more than 1,000ppm
CO : 10ppm(except special cases)
Temperature, Relative humidity and air blow(Velocity)

Since the evactment of the law, we have surveyed actual conditions of indoor environment for these 13 years, and found the percentage of buildings which failed to come up to the standards are as follows:

45.1% with regard to Dust(Suspended particles)
17.8% with regard to CO_2
3.3% with regard to CO
40.2% with regard to Relative humidity
at the average value of annual reports taken in Tokyo for the just 12 years.

With this paper, I would like to report on some of the findings we obtained from our air pollution survey conducted mainly in 1978 in Tokyo together with some discussion[1].

Object of survey

The buildings we choses as the object of our survey one those of occupying over 3,000m^2 in floor space and one of utilized by large of people. And the number of such buildings are over 16,000 throghout the country and among which 3,400 are in Tokyo.

We planned to check 100 buildings in Tokyo, but actually 94 of business office buildings and others.

Measurement of indoor air quality

The ratio of space of air conditioning to total floor space of a building is about 60-70%.

Of we want to count one measuring point aloocates for one air conditioned space(500m^2), the measuring point per building comes to 5-17 points, averaging 8 points. To these points, we add 1-2 points for each air intake.

We took the measurement 3 times(at 10-12A.M., 1-3P.M., and 3-5P.M.) a day in ordinary business hours(9A.M.-5P.M.) at one measuring point. Then, we figured out Daily arithmetical average.

Measuring items and measuring points

a)We selected 3 Items Dust, CO_2 and CO in order to determine the purity of air. The measuring apparatuses we employed are as follows:

For Dust(Suspended particles):Light scatter detector type and "ROKEN" Spectra Analytical filter paper type[2)]
For CO_2 :"KITAGAWA"Detection tube type and Interferometer
For CO :"KITAGAWA"Detection tube type and Electro chemical detector type "ECOLIZER"

b)We classified the air-filtering devices of air conditioners into the following 3 items:

a. Un-woven cloth(Unit type a automatically renewal type)
b. Electrostatic dust collector
c. Others

Number of occupants, smokers, and their ratio

At the measuring points, we counted the number of persons the number of smokers at the time we actually surveyed the room. Then we figured out the smokers ratio by the following equation.

$$\text{Smokers ratio}(\%) = \frac{\text{Number of smokers}}{\text{Number of room-occupants}} \times 100$$

In those building which we surveyed, people were smoking frully in their rooms. So, we observed the relationship between the smokers ratio and content-ratio of cigaret smoke contained in the suspended pantides in the air.

Result

1.Result of our survey: with respect to the indoor air quality Standard.

1)Number of the buildings air qualified

Unsatisfied buildings which exceeded the standard for both suspended particles and CO_2(even at one of all the measuring points) are shown in the Table 1.

Table 1. Qualified rate for both suspended particles and CO_2

Item	No. of Buildings	%
Building qualified	35	37.2
Building disqualified	59	62.8
Breakdown of disqualification		
Dust(Suspended particles)	40	67.8
CO_2	7	11.9
Dust & CO_2	12	20.3

Note: Standard values
Suspende particles:not more than 150μg/m^3
CO_2: not more than 1,000ppm

2)Concentration of polluted air in the buildings disqualified

Figs 1 & 2 show the relationship between the average measured value and the disqualified rate.

2. Relationship between the 'number of room occupants',and 'concentration of suspended particles'.

As to the smokers ratio, we got 3.2% at minimum, 13.6% at maximum ,while 6.2% is the average at 86 office buildings we examined.

In the next place, we examined the percentage cigaret smoke contaned in suspended particulate materials by means of Spectra analytical filter paper type dust measuring opparatus. It was proved that the particulate materials in all building servey contened about 52% of cigaret smoke in average.

Also, we examined the relationship between the presence of smokers and the content-rate of cigaret smoke, which proved that the content-rate of the cigaret smoke insuspended particles is 43% even though there was no smoker around the measuring point.

3. Amount of suspended particles and concentration of CO_2 depending on the media used for filter of air-cleaning-devices.

The status of the air-cleaning device which installed as central air-conditioners in the building is shows in the Table 2.

Table 3 shows the amount of indoor suspended particles and average concentartion of CO_2 by the kind of air-filtering materials

Table 2. Air purification devices

Kind		No. of Building
with Un-woven cloth	with Unit type	16
	with Automatic renewal type	40
Electrostatic type		13
Other		25
Total		94

Table 3. Average concentration of suspended particles and CO_2

Kind \ Items	Amount suspended particles ($\mu g/m^3$) $^{Ma*}_{\sigma}$	CO_2 (ppm) $^{Ma*}_{\sigma}$
With un-woven cloth with Unit type	117 (73)	726 (200)
with Automatic renewal type	88 (57)	698 (199)
Electrostatic Type	105 (76)	683 (113)

*Means arithmetical average

4.Concentration of indoor air contamination

In oder to know the total concentration of polluted air in the 94 buildings, we measured at 693 points indoors and 131 points near the air intake. Table 4 shows its average values.

5. Rerationship between CO_2 and concentration of suspended particles.

Above relationship between CO_2(Y,ppm) and concentration of suspended particles(X,$\mu g/m^3$) can be shown by the following equation:

$$Y=5.1024 + 135.2$$
$$\gamma=0.474(p<0.01)$$

Table 4. Average concentration of air purity

Air purity \ Average concentration	Indoor concentration		Outdoor concentration	
	Ma* (σ)	Mg** (σg)	Ma* (σ)	Mg** (σg)
Amount of suspended particles	$\mu g/m^3$ 114 (73)	$\mu g/m^3$ 93 (1.99)	$\mu g/m^3$ 36 (24)	$\mu g/m^3$ 31 (1.76)
CO_2	715ppm (175)	696ppm (1.26)	381ppm (69)	374ppm (1.23)
CO	3.1ppm (1.4)	2.9ppm (1.54)	2.5ppm (1.7)	2.1ppm (1.78)

Note: n=94 Indoor measuring points: 693
outdoor measuring points : 131
*Means arithmetical average. **Means geometric average

Discussion

1.Each buildings disquolification rate against Sanitation Control Standards.

From the average values of the 'amount of suspended particles' and the 'concentration of CO_2' and the disquolification rate, we might be able to say as the following:

1)Suspended particles

When its average value was 100$\mu g/m^3$, its disqualification rate came to 20%, and when the value was 150$\mu g/m^3$ the rate came to almost 45%, and when the value was 160$\mu g/m^3$ the rate was 50%, which means that half the member of the whole measuring points did not satisfy the standards.

2)When its average value was 800ppm, its disqualification rate came to 20%, and when the value was 1,000ppm, the rate came to 40%.

2.Relationship between smoking rate and contens-rate of cigaret smoke contained in suspended particles.

The principal cause of high concentration of contaminated indoor air was probably, cigaret smoking.

Cause of that, we examined the smokers rate at the 88 buildings out of the 94 buildings we surveyed, its average was 6.2%.

While, the fact that the cigaret smoke itself contained in the suspended particles was 43% even without any smoker in the room. Based on this surprising results, about 2/3 air ventilated is re-circulating in the building and thus contaminating whole of the building with the smoke of cigaret.

3.Concentration of polluted indoor by the kinds of air-cleaning devices.

The air-cleaning devices installed in the buildings which we surveyed yielded same results as those abtained by other reports[3].

It can be said that the indoor environment is significiantly affected by the factors controled by the owners such effected by the number of people in the room, especially the number of smokers, air volume ventilated and maintenance of facilities rather than the capacity of air-cleaning device itself.

4. Concentration of contaminated indoor air

According to our survey average value(Ma) and standard deviation (σ) of the all measuring points, Ma+σ(84%) contained 180μg/m^3 of suspended particles and 890ppm of CO_2 and this fact proves that there are many buildings which exceed the standard for suspended particles. The quility of average outdoor at the time of own survey was as follow: 31μg/m^3 suspended perticlate, 374ppm CO_2, against these relative low level of pollution, the levels of indoor were remarkably higher then these of outdoor. These high level of pollution should mostly generate from indoor saurse itself.

5. Relationship between CO_2 and cencentration of suspended particles.

According to our observation, the suspended particles and CO_2 exceed their standards simultaneously and such cases are being new increrseing. We can reduce from regression analysis that when the amount of suspended particles in the room rasches 150μg/m^3, the amounts of CO_2 reaches 900ppm. While when CO_2 reaches 1,000ppm, the suspended particles should be around 170μg/m^3 supassing its standard.

Conclusions

We have got following conclusion one of the results of our servey condercted as the 94 building located in Tokyo.

1) If average value of suspended particles is 100μg/m^3, disqualification rate comes to 20%, while if the average value is 150μg/m^3, the disqualification rate increases up to 45%.

2) If average value of concentration of CO_2 is 800ppm, the disqualification rate comes to 20%. If the value is 1,000ppm, the rate becomes over 50%.

3) Content-rate of cigaret smoke contained in the suspended particles was as high as about 50% regardless of presence of smokers in the room, which shows the strong influence of smoking throghout whole indoor environment of building.

4) We note that un-woven cloth which widely used in air cleaning devices, however this does not remove dusts efficiently.

5) Average values of the all measuring points are as follows.

Amounts of suspended particles : 114μg/m^3
CO_2 : 715ppm
Concentration at the air intake:
Amount of suspended particles : 36μg/m^3
CO_2 : 381ppm

Reference

(1) S.M uramatsu, Studies on Indoor air pollution(I). Actual indoor air pollution and its evaluation. Japanese Jaurnal of Public Health, 1982, 1,31-36.

(2) K.Kimura, Roken-Type Spectra Analytical filter paper dust meter(I) Sience of Labor 1973, 137-150.

(3) S.Muramatsu, Plan for air cleaning devices according to the Low for Maintenance of Sanitation in Buildings' Jaurnal of HASS 1978, 3, 39-48.

(4) J.Repace, Indoor air quality. An Emerging Public Health progrem. The Environmental Form 1980,5, 15-19.

FIG.1. DISQUALIFIED RATE FOR SUSPENDED PARTICLES

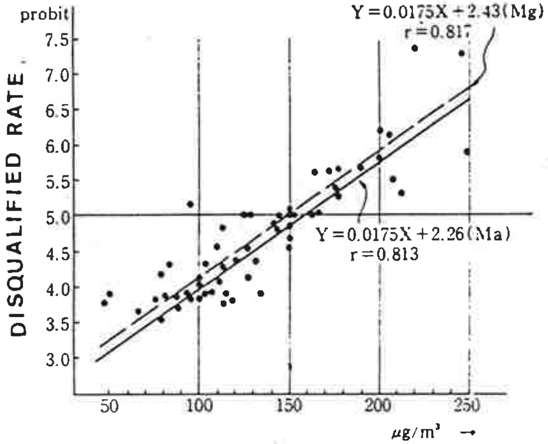

FIG.2. DISQUALIFIED RATE FOR CO_2