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Study on Model of Indoor Air Pollution Forecast for Decoration Under Natural Ventilation Condition[1]

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Objective To establish the model of indoor air pollution forecast for decoration. **Methods** The model was based on the balance model for diffusing mass. **Results** The data between testing concentration and estimating concentration were compared. The maximal error was less than 30% and average error was 14.6%. **Conclusion** The model can easily predict whether the pollution for decoration exceeds the standard and how long the room is decorated.

Key words: Air pollution indoor; Model; Natural ventilation

INTRODUCTION

People's living standard has been raised by a rapid improvement of economy. The residence where people live becomes more beautiful and comfortable. Therefore, great deal of flag, dope and artifical board used in the process of family decoration, resulting in serious indoor air pollution. Formaldehyde, benzene, ammonia are released from the building materials[1]. From a report of Beijing Appraisal Center of Chemistry, the building materials cause severe indoor air pollution and ten thousands of persons are poison pre year only in Beijing. The first question is how to predict whether the pollution for decoration exceeds the standard. The second question is how long the room decorated. The third question is what kind of materials should be used.

METHODS

Many scholars in the world have done a great deal in researching indoor air pollutants, and have put forward many emission models[2]. Particularly, the releasing density of materials of indoor decoration mathematics model has given the great help for the study of pollutant emanating model[3]. The model of conservation mass is put forward by Dockery and Spengler[4]. The model can describe the case of indoor air pollution in China, which has been verified by scholars from Institute of Public Health of Shanghai Medical College. The formula is as following:

$$dQ=(1-F)qC_0dt-qC_idt-KQdt+Sdt$$

After reducing this model, and if the osmosis from the outdoor is not considered, we can get the following formula:

$$C_i= Se^{kt}/q$$

Where, C_i is the predicted concentration of the indoor pollution ($mg\cdot m^{-3}$), S is the intensity of discharge of the indoor pollution, ($mg.h^{-1}$), K is the constant of attenuation, t is time (h), q is the flux of the indoor air ($m^3\cdot h^{-1}$).

The function shows that the concentration of the indoor pollution is direct related with the intensity of discharge of the indoor pollution, and inversely related with the flux of the indoor air. Furthermore, the intensity of discharge of the indoor pollution becomes weak along with time.

Study on Parameters of the Model

Parameters of the source Study on the source of decorative materials was based on formaldehyde released from the decorative materials. We researched the change in the concentration of formaldehyde from the boards from the market of

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structural materials in Beijing in different periods of time (Fig. 1).

Diffusing Parameter

The best diffusion method for indoor pollutant is ventilation[5]. The change rate is high and the indoor concentration is low. According to the principle of ventilation, the two aspects of action determine the indoor change rate indoor. The heat pressure action formula is as following:

$$P_n = H(\rho_e - \rho_i)$$

Where, P_n is heat pressure ($kg{\cdot}m^{-2}$), H is distance of axis between inlet and outlet (m), ρ_e is outdoor density ($kg{\cdot}m^{-3}$), ρ_i is indoor density ($kg{\cdot}m^{-3}$).

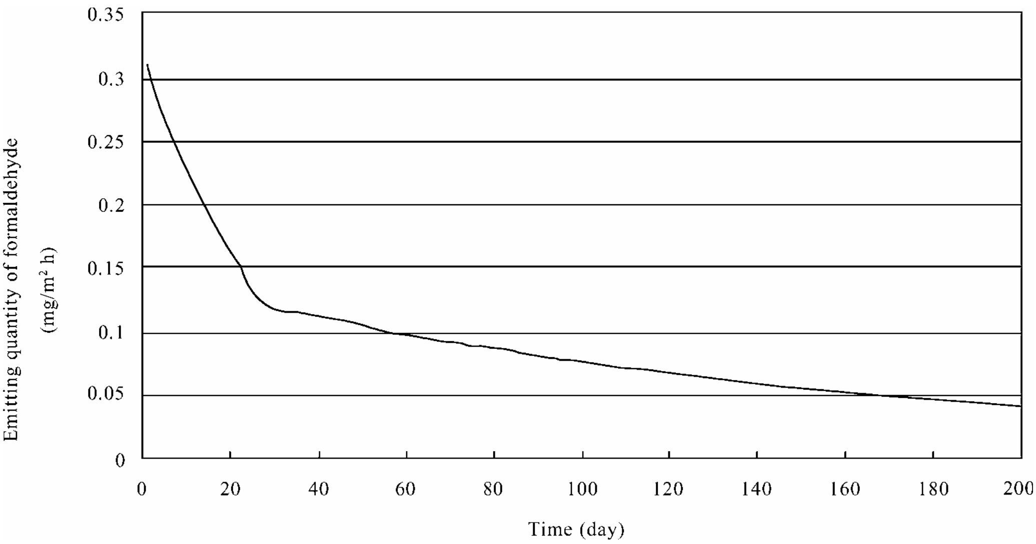

FIG. 1. Emitting quantity of formaldehyde in different periods of time (1-200 days).

The wind pressure action formula is following:

$$P_w = \frac{KV^2 P_e}{2g}$$

Where, P_w is wind pressure ($kg{\cdot}m^{-2}$), V is wind speed, P_e is outdoor density, K is air dynamical coefficient, g is acceleration of gravity ($m{\cdot}s^{-2}$).

From the formulas, heat and wind pressure action can be known if the indoor air change rate is determined by the formulas, which it need some parameters, but the parameters is random. Besides, the air change rate is influenced by building shapes, number of windows, opened or closed windows, different temperature, indoor and outdoor wind speed, the frequency of wind direction. If there are more parameters in the model, the model is difficult to use it. It is considered that the air change rate can be determined by meteorologic parameters (wind speed, frequency of wind direction and different temperature Figs. 2 and 3).

The air change rate was detected between Nov. 2002 and Mar. 2003. The efficiency data were 148. The testing shapes of chamber were office and residence. According to the weather in those days, the windows of testing chamber were chosen making a choice of opening (one window was opened, about 0.5 m^2) and closing. The office volume was 52.1 m^3, 53.6 m^3 and 55.8 m^3 ; the residency volume was 38.4 m^3 and 21.6 m^3; the height was 4 m, 15 m, 21 m, 29 m, 40 m. The relation between the air change rate and outdoor wind speed is as following:

According to the testing, the relation between air change rate and different temperature is as following:

Validation

Many factors including different weather condition, different condition and background indoor concentration[4], can be influence application of the model. For reducing deviation, the model should be checked. The verification formula is as following:

$$r = \frac{Q_i - p_i}{Q_i}$$

Where, r is deviation value, Q_i is testing concentration, p_i is prediction concentration.

RESULTS

The model was verified in residences decorated for 6 months. The major indoor pollutant was formaldehyde. The residences were distributed 14 dwelling areas. The verification results are listed in Tables 1 and 2.

The tables show that the deviation is not over 30% in the 15 of the 20 residences, and from 33% to 52% in the 5 residences. According to native custom, reducing concentration of indoor pollutant was used to ventilate (window opened, about 0.5 m^2). Table 2 shows that the deviation is from 3% to 12% in 3 of 4 residences, and 38% in 1 residence.

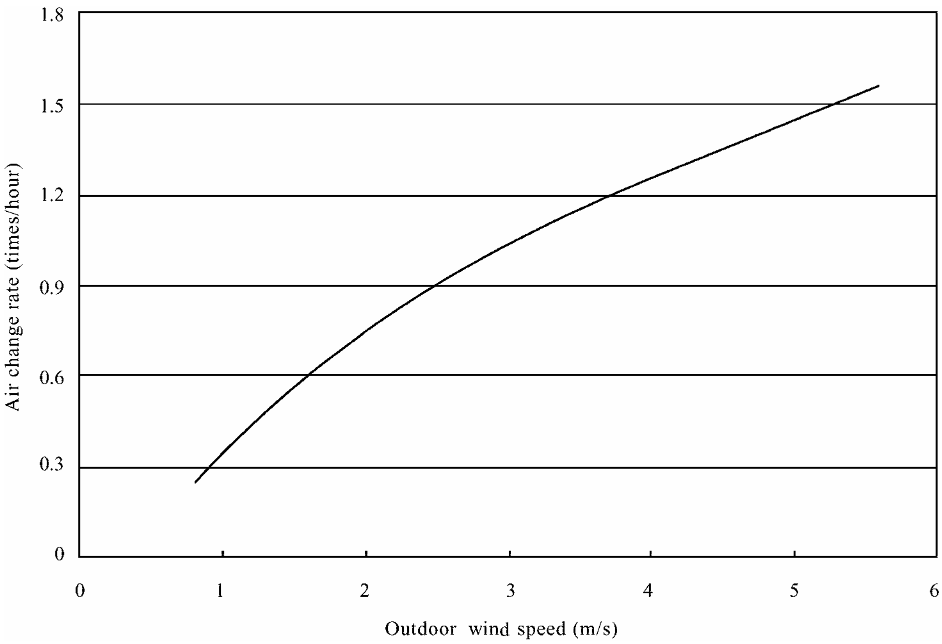

FIG. 2. Relation between the air change rate and outdoor wind speed (20 different temperature).

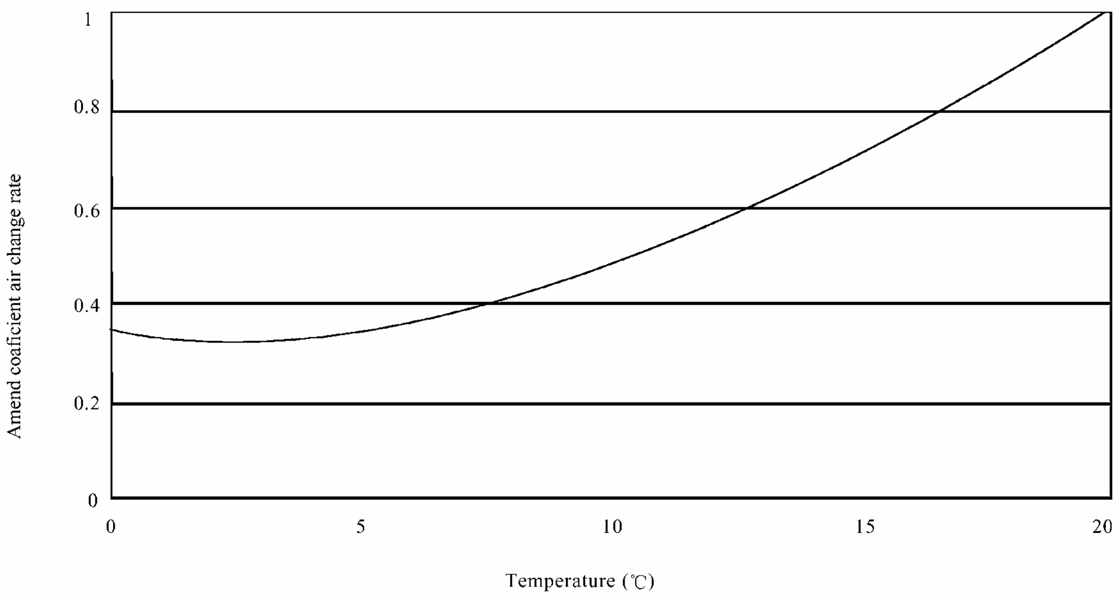

FIG. 3. Relation between air change rate and different temperature.

TABLE 1

Verification of Model of Air Pollution Indoor for Decoration

Number	Address	Volume of Chamber (m^3)	Surface Area of Decorated Chamber (m^2)	Time	Different Temperature (℃)	Wind Direction (°)	Wind Speed (m·s)	Predicting Concentration ($mg·m^3$)	Testing Concentration ($mg·m^3$)	Deviation (%)
1	Area A	22.7	22.7	10-14	1.8	17	1.4	0.08	0.09	11
2		35.1	15.9	10-15	2.2	234	1.3	0.102	0.12	15
3		45.9	24.8	10-20	2.8	300	1.3	0.138	0.15	8
4	Area B	35.1	20.8	10-16	4.5	267	0.4	0.154	0.23	33
5		29.7	15.5	10-16	3.6	276	0.6	0.121	0.09	34
6		35.1	17.2	10-16	1.1	293	1.2	0.108	0.12	10
7		29.7	27.1	10-16	1.7	270	0.6	0.22	0.21	4
8	Area C	35.1	14.1	10-15	7.2	261	0.7	0.089	0.09	1
9	Area D	52.2	45.1	10-17	1.9	315	0.4	0.137	0.09	52
10	Area E	41.3	27.4	10-17	1.2	244	0.5	0.091	0.10	9
11	Area F	41.6	21.4	10-15	4.9	210	1.3	0.14	0.1	40
12		41.6	6.4	10-15	1.6	215	2.2	0.043	0.06	28
13		43.2	24.8	10-20	2.4	270	0.5	0.127	0.14	9
14	Area G	42.4	18.8	10-17	3.4	300	0.9	0.112	0.1	12
15	Area H	50.4	13.2	10-18	1.0	0	1.2	0.078	0.08	2
16	Area I	37.5	15.9	10-18	0.5	371	1.1	0.13	0.1	30
17	Area J	47.7	18.8	10-19	1.6	83	2.0	0.102	0.09	13
18	Area K	36.4	6.2	10-18	0	309	0.7	0.037	0.03	23
19	Area L	34.5	7.2	10-19	1.6	83	2	0.049	0.06	18
20	Area M	30.6	29.5	10-20	7.1	84	0.9	0.224	0.2	12

TABLE 2

The Verification of Model of Indoor Air Pollution for Decoration (Window Opened, About 0.5 m^2)

Number	Address	Volume of Chamber (m^3)	Surface Area of Decorated Chamber (m^2)	Time	Different Temperature (℃)	Wind Direction (°)	Wind Speed ($m·s^{-1}$)	Predicting Concentration ($mg·m^{-3}$)	Testing Concentration ($mg·m^{-3}$)	Deviation (%)
1	Area M	30.6	29.5	10-20	7.1	84	0.9	0.16	0.18	11
2	Area F	43.2	24.8	10-20	2.4	270	0.5	0.116	0.12	3
3	Area J	47.7	18.8	10-19	1.6	83	2.0	0.075	0.1	12
4	Area L	34.5	7.2	10-19	1.6	83	2	0.048	0.08	38

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