CHEMICAL ENGINEERING TRANSACTIONS

VOL. 59, 2017

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Zhuo Yang, Junjie Ba, Jing Pan

ISBN 978-88-95608- 49-5; **ISSN** 2283-9216

DOI: 10.3303/CET1759189

Evaluation of Industrial Exhaust SO_2 on Health Risk of Population

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The method of health risk assessment was used to evaluate the health risks caused by SO_2 pollution in the urban area of Suzhou. SO_2 is a non-carcinogenic chemical. The health risk of the population was calculated by the method of non-carcinogenic health risk assessment, and the results could provide the theoretical basis for the evaluation of environmental pollution and occupational hazards. According to the monitoring data of SO_2 concentration in the atmosphere of Suzhou city and the respiratory disease mortality rate of the population from 1993 to 2002, we conduct statistical analysis and calculations. The results showed that there was a positive correlation between the mortality of respiratory diseases and the daily exposure dose of SO_2 in the atmosphere. In 2002, the annual health risk caused by SO_2 pollution in the atmosphere was $0.0078 * 10^{-6}$. Compared with the respiratory disease and lung cancer mortality, the mortality rate caused by SO_2 is very small in respiratory diseases and lung cancer deaths. Therefore, it can be considered that the health hazard of SO_2 pollution is relatively small. According to the analysis of the physical examination data of workers exposed to SO_2, the results showed that the health risk of workers exposed to SO_2 should not be ignored. Labor protection needs to be strengthened.

1. Introduction

The potential health hazard effects of harmful chemical factors in the environment can be determined using quantitative hazard analysis. Since the 1980s, the concept and method of health risk assessment have been developed rapidly. The method of health risk assessment can help government agencies and management to make decisions more rationally. Health risk refers to the probability that an adverse factor in the environment leads to an adverse health response in the exposed population under certain conditions (Pohl et al., 2017; Valet et al., 2016; De Falco et al., 2016; Grimaz and Capellari, 2016; Jentry et al., 2017; Alhamdani et al., 2017; Phneah et al., 2017). The health risk assessment is the process of comprehensive qualitative and quantitative evaluation of the adverse health effects of harmful environmental factors on specific populations (Johansson et al., 2016).

SO_2 has a strong stimulating effect. In addition to the stimulation of the conjunctiva, it is easy to be absorbed by the upper respiratory tract and the mucous membrane of the bronchial mucosa (Carotenuto et al., 2016; Di et al., 2016; Dong et al., 2015; Sakai et al., 2015; Wang et al., 2016; Zhang et al., 2016). Therefore, it mainly affects the upper airway and bronchial airway above, resulting in the site of the smooth muscle and peripheral nerve receptors are stimulated to produce reflex contraction. The lumen of the trachea and bronchi becomes narrow, and airway resistance and secretions are increased. In severe cases, it can cause local inflammation or necrotic tissue. The adsorption of SO_2 on inhalable particles is considered to be an allergen, which can lead to asthma, such as Japanese yokkaichiasthma. SO_2 is absorbed by the alveolar blood circulation through the rapid distribution of the body, the harm is multifaceted. SO_2 is absorbed by the alveolar blood circulation through the rapid distribution of the body, and the harm is multifaceted. For example, SO_2 can be combined with vitamin B_1 in the blood, and destroy the normal situation of vitamin B_1 and vitamin C in the body, resulting in the imbalance of vitamin C in the body, thus affecting the metabolism and growth (Kojima et al., 2016).

Please cite this article as: Shurong Han, 2017, Evaluation of industrial exhaust so2 on health risk of population, Chemical Engineering Transactions, 59, 1129-1134 DOI:10.3303/CET1759189

2. Evaluation of SO_2 on health risk of population

2.1 Materials and methods

Source of data: (1) Monitoring data of state controlled air quality monitoring points in Suzhou city in 1993 ~2002, which provided by Suzhou environmental quality monitoring station. (2) Respiratory disease mortality and lung cancer mortality among urban residents in 1993~2002 were provided by the Suzhou Center for Disease Control and Prevention.

Methods: (1) According to the monitoring data of SO_2 in the atmosphere of Suzhou, the daily exposure dose of SO_2 was obtained. (2) The correlation analysis was carried out with statistical software to obtain the relationship between SO_2 daily average growth rate and lung cancer mortality and total mortality. (3) Based on the formula $R=(D/RFD)*10^{-6}$ of the health risk assessment of non-carcinogenic pollutants, the health risk of SO_2 in the urban air pollutants was calculated. (4) The health risk of exposure to SO_2 was compared with respiratory disease, lung cancer mortality and total mortality.

2.2 Results

1. According to the monitoring data of the national control air quality monitoring point in Suzhou from 1993 to 2002, the average annual concentration of SO_2 is shown in Table 1 and Figure 1.

Table 1: Annual Concentration of SO2 in the Atmosphere of Suzhou City from 1993 to 2002 (mg/m³).

Yeas	SO_2
2002	0.044
2001	0.045
2000	0.045
1999	0.043
1998	0.045
1997	0.045
1996	0.063
1995	0.070
1994	0.067
1993	0.064

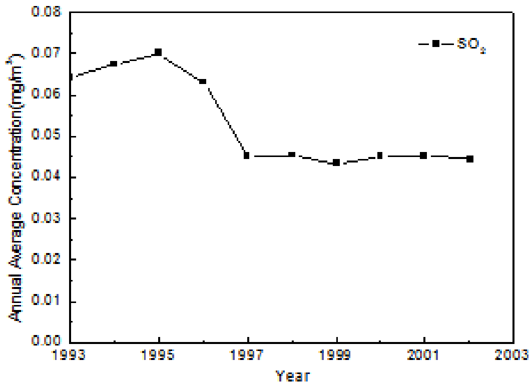

Figure 1: Annual Concentration of SO2 in the Atmosphere of Suzhou City from 1993 to 2002.

The main route of exposure to SO_2 in the population is inhalation of SO_2 in the atmosphere.

The daily exposure dose D (mg / kg.d) was calculated by the weight W = 70 kg and the daily air volume L = 20 m^3 / d.

$$D=C*L/W=C*20/70 \tag{1}$$

Among them, C is the daily average concentration of pollutants in mg/m^3.

Therefore, we can get the annual average exposure dose of SO_2 in Suzhou urban population in 1993 ~2002, as shown in Table 2.

Table 2: Annual exposure dose of SO2 in Suzhou urban population from 1993 to 2002 (mg / kg.d).

Yeas	SO_2
2002	0.0126
2001	0.0129
2000	0.0129
1999	0.0123
1998	0.0129
1997	0.0129
1996	0.0180
1995	0.0200
1994	0.0191
1993	0.0183

2. The mortality rate, mortality rate and total mortality rate of respiratory diseases in Suzhou urban population from 1993 to 2002 are shown in Table 3 and Figure 2.

Table 3: Respiratory disease, lung cancer and total mortality (/ 100,000) in urban areas from 1993 to 2002.

Yeas	Urban population	Deaths from respiratory diseases	Respiratory disease mortality rate	Deaths from lung cancer	Lung cancer mortality rate	Total mortality rate
2002	2122800	2088	98.36	617	29.07	127.43
2001	2090789	1789	85.57	695	33.24	118.81
2000	2065231	2200	106.53	680	32.93	139.46
1999	2056930	2198	106.86	680	33.06	139.92
1998	2046201	2586	126.38	623	30.45	156.83
1997	2039331	2296	112.59	616	30.21	142.80
1996	2033966	2549	125.32	708	34.81	160.13
1995	1853053	2309	124.61	526	28.39	153.00
1994	2020610	2574	127.04	312	15.44	142.48
1993	1985703	2674	134.66	525	26.44	161.10

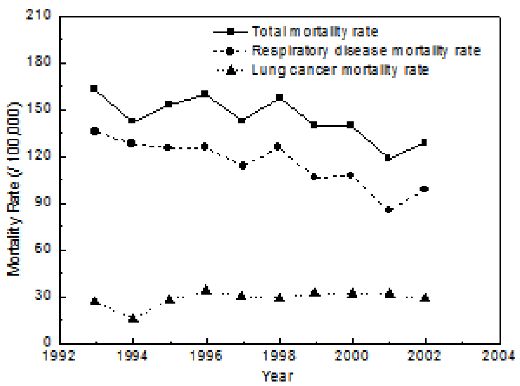

Figure 2: Respiratory disease, lung cancer and total mortality (/100,000) in urban areas from 1993 to 2002.

The mortality of the respiratory system, the death rate of lung cancer and the total mortality and SO_2 daily precipitation were analyzed by statistical software.

According to the level of α=5, the results showed that the mortality of respiratory diseases was positively correlated with the daily exposure dose of SO_2. The grade correlation coefficient r=0.650 ($p < 0.05$), it shows that with the daily exposure dose of SO_2 increases, the population respiratory disease mortality was also increased. However, there was no significant difference in the mortality of respiratory diseases, lung cancer mortality, and total mortality and SO_2 daily exposure dose.

3. Dangerous characterization

Hazard characterization is a measure of the health risk of a group of individuals exposed to specific contaminants in the environment by some means.

Based on the formula $R=(D/RFD)*10^{-6}$ of the health risk assessment of non-carcinogenic pollutants, the health risk of SO_2 in the urban air pollutants was calculated. Among them, R is the lifetime health risk of individuals exposed to non-carcinogenic contaminants. D is the daily exposure dose per unit weight of non-carcinogenic pollutants (mg/kg.d). RFD is the reference dose for non-carcinogenic contaminants (mg/kg.d).

Calculation of individual lifetime health risk caused by SO_2: the RFD=0.023mg/kg.d and Table 2 data is introduced into the formula $R=(D/RFD)*10^{-6}$, the population exposure to SO_2 individual lifetime health risk R can be obtained. The individual lifetime health risk R is divided by the average life expectancy (70 years), and the individual annual health risk Ra can be obtained. The results are shown in Table 4. The change trend of SO_2 daily average concentration and individual lifetime health risk is shown in Figure 3.

Table 4: Lifetime and annual health risk for individuals exposed to SO2 in Suzhou urban area.

Yeas	D (mg / kg.d)	R (10^{-6})	Ra (10^{-6} a^{-1})
2002	0.0126	0.5466	0.0078
2001	0.0129	0.5590	0.0080
2000	0.0129	0.5590	0.0080
1999	0.0123	0.5342	0.0076
1998	0.0129	0.5590	0.0080
1997	0.0129	0.5590	0.0080
1996	0.0180	0.7826	0.0112
1995	0.0200	0.8696	0.0124
1994	0.0191	0.8323	0.0119
1993	0.0183	0.7950	0.0114

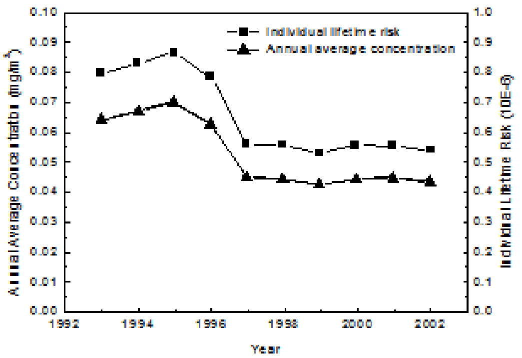

Figure 3: The change trend of SO2 daily average concentration and individual lifetime health risk.

4. According to the non-carcinogenic pollutant health risk assessment formula $R'=(D/RFD)*10^{-6}$, the health risk of workers in SO_2 of Suzhou City is calculated. Among them, R' is the lifetime health risk of individuals exposed to SO_2. D is the occupational exposure to SO_2 workers per unit weight daily exposure dose, and the unit is mg/kg.d. RFD is the reference dose for SO_2 (mg/kg.d), and RFD=0.023 mg/kg.d. The calculation results are shown in Table 5.

Table 5: The exposure dose of workers is based on the average concentration of SO2 in each year.

Yeas	1997	1998	1999	2000	2001	2002
Operating point SO2 average concentration	4.1	3.5	2.8	6.8	7.5	8.2
$D'_{occupation}$ (mg)	196800	168000	134400	326400	360000	393600
D'_{total} (mg)	217817	189017	155417	347417	381017	414617
D' (mg/kg.d)	0.1218	0.1057	0.0869	0.1943	0.213	0.2318
R' (10^{-6})	5.296	4.596	3.778	8.448	9.261	10.08
Ra' (10^{-6} a^{-1})	0.0757	0.0657	0.054	0.1207	0.1323	0.144

The change trend of SO_2 concentration and individual lifetime health risk is shown in Figure 4.

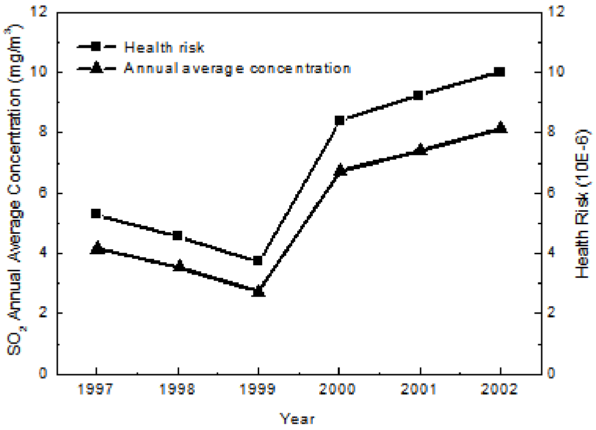

Figure 4: The change trend of SO2 concentration and individual lifetime health risk

After calculation and analysis, the average individual annual risk and peak individual annual risk of SO_2 workers were 18.46 times and 37.69 times of the urban population. It shows that workers exposed to SO_2 are facing serious health risks relative to the general population. Therefore, the occupational health of workers exposed SO_2 risk cannot be ignored, and the labor protection needs to be strengthened.

2.3 Discussion

It can be seen from Figure 1 that the annual mean concentration of SO_2 in the atmosphere of Suzhou from 1993 to 2002 is kept at a low level since the highest peak in 1995. Compared with the average daily concentration in 1993 (0.064mg/m^3), the average daily concentration (0.044 mg/m^3) in 2002 decreased by 31%, and it is 37% lower than the highest value (0.070mg/m^3 in 1995).

After consulting the information, at present, Suzhou has not used the method of health risk assessment to evaluate the health effects of SO_2 in the atmosphere. Professor Chen Bingheng of School of Public Health, Fudan University, Shanghai, made a quantitative assessment of the health effects of SO_2 pollution in the urban area of Shanghai by the method of health risk assessment (Ku et al., 2017). The results show that the concentration of atmospheric SO_2 in Shanghai has been declining since 1990, and the damage to the residents has also been declining. This trend is consistent with the Suzhou urban area. The concentration of SO_2 in urban area of Shanghai in 1999 (annual average concentration is 0.044mg/m^3) is the same as that of SO_2 in Suzhou in 2002. At this concentration, Shanghai city cannot estimate the number of excess deaths caused by SO_2 pollution. The result of the evaluation is consistent with this, that is, the health hazard caused by SO_2 pollution in the atmosphere is relatively small.

3. Conclusions

In this study, health risk assessment method was used to evaluate the health risk caused by SO_2 pollution in Suzhou urban area. The results showed that the health risk of SO_2 in the urban area from 1993 to 2002 was relatively small. However, the health risk of workers exposed to SO_2 is larger, so it should not be ignored.

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