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Estimating the emission of some trace gases in China*

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Abstract— The emission of CO_2, SO_2, NO_x from burning coal would play important roles in emission of trace gases in China. The estimation for emission of CO_2 from burning fossil fuel and from cement production were 577 $TgCO_2$-C and 28 $TgCO_2$-C in 1988. The estimation for the emission of N_2O was 0.18 Tg N_2O-N. As for methane, the total amount of emission was about 33 Tg CH_4 in 1988 in China. The emission of SO_2, NO_x from burning coal and oil have been estimated.
Keywords: trace gases; coal combustion; China.

1 Introduction

Human activities are now altering the chemistry of the atmosphere on a global scale. The rates of growth of trace gases have increased significantly since pre-industrial time. The variation of components and concentrations of trace gases in the atmosphere may influence the sustaining living environment of human being. Some serious environmental problems may be related to the characters of trace gases in the air. Obviously, the trace gases can be emitted from two major sources: anthropogenic sources and natural sources. These gases are belived to be emitted from combustion of fossil fuel and biomass as well as from industrial productive processes. Some of them are emitting from biological procedures.

It is important to estimate the emission of trace gases in China. Now, we focus on the estimation for the emission of some greenhouse gases.

2 The emission of CO_2

For a long time, coal combustion is the main energy consumption in China. In 1987 and 1988 the coal consumption were 76.2% and 76.1% of the total energy consumed. But in the period of 1953 to 1961 the coal consumption was 94.3%–91.3% of the total energy consumed (National Statistic Agency of China, 1989). Therefore, the emission of CO_2 from burning coal would play an important role on the emission of CO_2 in China. It was reported that 70% of the domestic energy

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consumed in rural area in China was from agricultural biomass burning. Besides, CO_2 can be emitted from biodegradation and cement productive procedures.

Now, the estimation for the emission of CO_2 from different sources in China was discussed as follows.

2.1 The emission of CO_2 from burning fossil fuel

Based on the total amount and structure of energy consumption in China, the amount of burning coal, burning oil and burning gas can be calculated. Then the emission of CO_2 from fossil fuel can be estimated by the method suggested by Rotty *et al.* (Rotty, 1986). But some coefficients are different from that of EPA in the case of China.

The amount of emission of CO_2 is expressing in the following equation.

$$CO_2 = (P)_i\ (FO)_i\ (C)_i,$$

where, i is the type of fuel, it is including coal, oil and gas; P is the amount of consumed fuel; FO is the oxidative fraction of fuel; C is the amount of carbon in a unit fuel.

2.1.1 The emission of CO_2 from consumed coal

CO_2s is the emission of CO_2 in TgC; Ps is the consumed coal per year in Tg ($\pm 11.2\%$); FOs is the effect oxidative fraction (0.982); Cs is the carbon contain in ton per ton of standard coal (0.707).

2.1.2 The emission of CO_2 from burning oil

CO_2l is the emission of CO_2 in TgC; Pl is the consumed oil per year in Tg(8%); FOl is the effect oxidative fraction (0.918); Cl is the carbon contain in ton per ton of standard oil (0.85).

2.1.3 The emission of CO_2 from burning gas.

CO_2g is the emission of CO_2 in TgC; Pg is the consumed gas in 10^5J per year ($\pm 10\%$); FOg is the effect oxidative fraction (0.98); Cg is the carbon contain in TgC per consumed gas in 10^5 J.

The estimated emission of CO_2 from burning coal, burning oil and burning gas are shown in Table 1.

2.2 The emission of CO_2 from agricultural biomass burning

It was reported that 70% of the domestic energy consumption in country side in China was from agricultural biomass burning. The structure of energy consumption in rural area in China is given in Table 2 (Chou, 1989).

There are many uncertain factors during the estimation for emission of biomass burning. For example, the humidity of biomass, the temperature of burning, the type of oven. All remarkably influence the emission of CO_2.

Table 1 The emission of CO_2 from burning fossil fuel in China

(Unit: TgC)

Year	Emission of CO_2 from fossil fuel	Emission of CO_2 from burning		
		Coal	Oil	Gas
1985	482.09	403.54	71.62	6.92
1986	509.06	425.48	75.95	7.63
1987	546.23	458.32	80.44	7.47
1988	577.41	486.07	85.46	7.88

Table 2 The structure of energy consumption in rural area in China in 1987*

	Weight	Equal to standard coal, TgC	Structure, %
Coal	243.2 Tg	173.5	29.9
Coal tar	9.8 Tg	9.3	1.6
Petroleum	20.0 Tg	28.5	4.6
Electric power	103.8×10^9 kWh	41.2	7.1
Wood burning	232.3 Tg	132.6	22.8
Straw burning	391.5 Tg	196.3	33.7
Total		581.6	100.0

* from energy report, Chou YJ, 1989

2.3 The emission of CO_2 from industrial processes

A lot of CO_2 can be emitted during the production of cement. Cement is made by burning lime and clay. CaO is remained as one of the components in cement and CO_2 is released into the atmosphere. Cement is a mixture. It contains about 62% of CaO. Then, the emission of CO_2 during the production of cement can be estimated by the production of cement. In 1986, the emission of CO_2 from cement production was 22.6 $TgCO_2$-C. In 1987 and 1988 the emissions of CO_2 were 25.4 and 28.6 $TgCO_2$-C respectively.

The important sources and the emission of CO_2 in China are given in Table 3.

3 The estimation for the emission of N_2O

Recent increases in the atmospheric levels of nitrous oxide have caused concern in

Table 3 The main sources and the emissions of CO_2 in China

(Unit: TgC)

Year	Burning fossil fuel	Burning wood	Cement production
1986	509.1	–	22.6
1987	546.2	92	25.4
1988	577.4	2	28.7

view of its greenhouse properties and its contribution to ozone depletion. Increases are predominantly due to growth in fossil fuel burning, fertilizer consumption and land used. It is known that fossil fuel burning, biomass burning, fertilizer used and microbial processes in soil. All of these processes have been identified as the sources N_2O. Some reports indicated that small amount of N_2O can be emitted from living soy bean, maize and plants. But the mechanism of formation of N_2O do not know yet. Now the emissions of N_2O from different sources in China have been estimated as follows.

3.1 The emission of N_2O from burning fossil fuel

Linak (Linak, 1990) reported that the ratio of $N_2O/CO_2=0.0000203$ during combustion coal. Therefore the emission of N_2O from burning coal can be estimated. In 1987, 0.0227 Tg N_2O-N was emitted and in 1988 the emission of N_2O was 0.0242 Tg N_2O-N.

3.2 The emission of N_2O from biomass burning

Crutzen (Crutzen, 1979) reported that the biomass burning is one kind of important sources of N_2O. But the emissions of N_2O are varied in different burning type and burning conditions. He indicated that about $0.005-0.009$ of N contained in biomass are converted to N_2O. The biomass fuel consumptions are 215 Tg of wood burning and 290 Tg of straw burning in 1990 in China. The emission of N_2O from biomass burning was estimated to be 0.02 Tg N_2O-N. Now, we do not know more detail about the mechanism of emission of N_2O yet.

3.3 The emission of N_2O from fertilizer used in the crop land

Different kinds of fertilizer contain different amount of N. It seems that about 0.1% of N in the fertilizer may convert to N_2O. The emission of N_2O from fertilizer was estimated to be 0.0402 Tg N_2O-N in 1986.

3.4 The emission of N_2O from agricultural soil and forest soil

During the processes of nitrification and denitrification of nitrite and nitrate in soil, N_2O can be produced and emitted into the air. Keller (Keller, 1986)

reported that the mean value of emission coefficients of N_2O in farmland and forest soil are 0.46% kg/(ha · a) and 1.1 kg/ha · a, respectively. So, the emission of N_2O from farmland was 0.067 Tg N_2O-N and the estimated emission of N_2O from forest land was 0.036 Tg N_2O-N in 1986.

The main sources and emissions of N_2O in China are given in Table 4.

Table 4 The main sources and emissions of N_2O in China

(Unit: Tg)

Year	From burning fossil fuel	From burning biomass	From fertilizer	From farmland forest soil
1986	0.021	0.02	0.040	0.103
1987	0.023	0.02	–	0.101
1988	0.024	0.02	–	0.104
1990	0.025	0.02	–	–

4 Estimation for the emission of CH_4 in China

Methane is one important trace gases in the atmosphere. In addition to its greenhouse properties, it influences numerous chemical species and processes in the atmosphere. Methane is released into the air by a variety of processes, such as enteric fermentation by ruminants, rice paddy, biomass burning, coal mining operations and leakage of natural gas and so on.

The harvest area of rice in Asian-Pacific Region is about 90% of the total harvest area in the world. China is the largest rice productive country in Asian-Pacific Region. Wang *et al.* (Wang, 1990) have measured the emission flux of methane from rice paddy in Zhejiang, Sichuan and Jiangsu provinces. He estimated that the emission of methane from rice paddy was 23 Tg CH_4 in 1988 in China.

Domestic ruminants can release methane. The emission factor for cow and waterbuffalo is 55kg CH_4 per head per year; for camel is 58; for goat and sheep is 5. From the amount of domestic animal, the emission of CH_4 from animal can be estimated. It was about 5.5 Tg methane in 1988 in China.

It was reported that 8 m^3 of methane was emitted from coal mining production of 1 ton coal in China. About 92% of coal mine methane was released into the atmosphere. So 4.6 Tg CH_4 was emitted into the atmosphere during coal mining operations in 1988 in China.

The total emission of methane from different sources was about 33 Tg CH_4 in China in 1988.

5 The emission of SO_2 and NOx from burning coal and oil

The emission factors of SO_2 and NOx from burning coal and oil have been determined in the Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences. Therefore the emission of SO_2 and NOx from burning coal and oil can be estimated. The results are given in Table 5.

Table 5 The emission of SO_2, NOx from burning coal and oil in China

(Unit: 10^4 ton)

Year	Emission of SO_2 from burning		Emission of NOx from burning	
	Coal	Oil	Coal	Oil
1986	563.8	41.6	159.9	27.6
1987	607.3	44.1	172.3	29.3
1988	641.4	46.9	182.0	31.1

6 Conclusions

The emission of CO_2 from burning coal and burning oil in China have been estimated by the method of Rotty and Marland. The amount of emission of CO_2 from burning fossil fuel was 577 TgC in 1988. The estimation for emission of N_2O was 0.18 Tg N_2O-N. As for methane, the total amount of emission was about 33 Tg CH_4 in 1988 in China. The emissions of SO_2, NOx from burning coal and oil have been estimated.

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