

# STUDY ON MSW GENERATION AND ITS ENVIRONMENT POLLUTION SITUATIONS IN CHINA

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## ABSTRACT

The factors influencing the municipal solid waste generation in China was studied in this article, the results showed that the MSW generation amount in this country was evidently affected by the population structure, economics development status, energy consumption structure and MSW management system, on the other hand, the environment pollution caused by municipal solid waste in China was still explored here, it indicated that the inappropriate treatment and disposal of MSW in China was one of the main pollution source to the water, air and worldwide environment.

**Key Words :** MSW generation, MSW pollution

With the development of social economics and the people's living standards, the solid waste, especially the municipal solid waste, has being aggrandized dramatically because of the social production and the living activities in China, and this has been far exceeding the environmental attenuation capacity and this results in hindering the sustainable development. Statistically, the total amount of municipal solid waste generation was 0.12 billion tons in China in 1995 (China Statistic Almanac 1996), and the figure increased to 0.138 billion tons in the next year in China (China Statistic Almanac 1997). It's reported that the annual growth rate of municipal solid waste in China is 8% to 10% and this is much higher than that in the developed countries with an annual growth rate of 3.2% to 4.5% and it's still much higher than that in the developing countries with an increasing rate of 2% to 3%. In China, most of the municipal solid waste was disposed in simply dumping method because the economics began to develop was rather late in China, and its threatening to the environment has caused high appre-

ciation in this country now. But how to solve the MSW pollution problem is still a tuff question in China. According to this, the authors are trying to find out the factors that affect the municipal solid waste generation and its pollution to the environment in China in this article.

## ANALYSIS ON THE MSW GENERATION SOURCES

### Population influence

The city scales expand year after year and the non-agriculture population in the cities grows rapidly with the improvement of the urbanization and the increase of the city numbers after the innovation and open policy issued in China. There are almost over 1.2 billion people in China by the end of the year 1995, and the people living in the 640 cities have occupied 22.5% of the total population. Thereinto, about 10 cities have the population over 2 million people, and 22 cities have the population between 1 million and 2 million, and another 43 cities have the population between 0.5 million and 1 million, and 192 cities have the pop-

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ulation between 0.2 million and 0.5 million, and the last 373 cities have the population below 0.2 million. It's estimated that the cities and towns in China will reach 700~800 and 20,000 respectively in the year 2000, the population in cities will reach 0.45 billion and there will be 40 million farmers turning to non-agriculture, and the level of urbanization will be 35%.

Because of the increase of the cities, the enlargement of the city scale, the growth of the non-agriculture population, the open of the market, the farmers turning to work in the cities and the development of the tourism in China, the MSW generation amount increases rapidly and this aggravates the work of the municipal environment sanitary management.

The relationship between the MSW generation amount and the non-agriculture population in China was listed in figure 1. It can be concluded from the figure that the MSW generation amount increases with the growth of the population in cities, and this trend will continue in the next several years with the quickening of the urbanization. It can be seen that the increase of the population in cities is the main factor which influences the MSW generation.

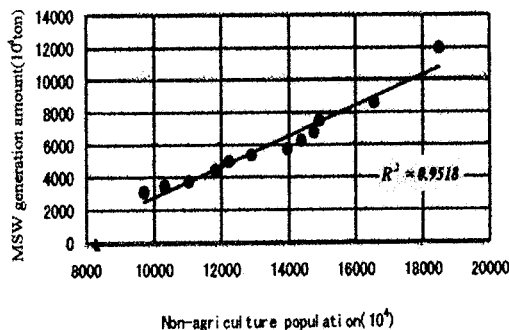


Fig.1 The relationship between MSW generation amount and the

### Economics development influence

The relationship between MSW generation amount and GDP in China was showed in figure 2. It can be seen from this figure that the MSW generation amount influenced by the economics development. At the beginning of the innovation and

open policy issued, the MSW generation amount sharply rose with the increase of GDP, and the increase of the MSW generation amount slowed down to steady level when the GDP reached a specific value. And this situation is similar with that in the industrial developed countries during their rapid growing times.

The changes of the living standards and the consumption structure not only influence the generation of the municipal garbage but also influence the composition of the garbage. After the innovation and open policy issued, the residential living standards increased year after year which can be seen in table 1, and total income of the citizens increased by 4.7 times form 1985 to 1995. At the same time, the composition of the garbage generated in the cities and towns made corresponding changes. The changes of different components in the garbage from Hangzhou city such as decomposable wastes, coal cinder and reusable waste are shown in figure 3 for the last ten years. It can be seen from the figure that the decomposable wastes and reusable waste of the garbage continuously increase, but the cinder content of the MSW continuously decrease. To compare with that in 1985, the reusable wastes in the garbage increased by 3.8 times in 1994 and the decomposable wastes content increased by 52%, on the contrary, the inorganic contents such as cinder and soil decreased by 39%.

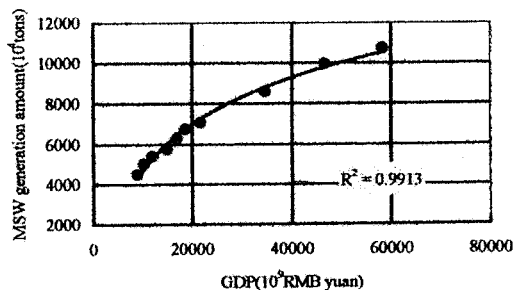


Fig.2 The relationship between MSW generation amount and GDP in China

It can be seen from the data in table 2 that the composition of the garbage changed with the different areas in the same city. The reusable wastes content (82%) of the garbage from advanced residential quarters such as plastics, paper, metal, textile and glass is obviously higher than that from the ordinary residential quarters which is only 47%, on the contrary, the kitchen wastes and

**Tab.1** The statistics of the city scale and population in China

Year	1986	1987	1988	1989	1990	1991	1993	1995
Number of cities	353	381	434	450	467	479	570	640
Construction area(Km <sup>2</sup> )	10127	10816	12094	11170	12855	14011	16588	19264
Heating area(104m <sup>2</sup> )	9907	15282	13883	19385	21263	27651	44164	64645
Spreading rate of gas used area(%)	28.52	32.6	39.4	38.6	42.2	47.1	57	70
Non-agriculture population(104persons)	22906	25155	29545	31205	~	29589	33780	37789
Agriculture population(104persons)	12233	12893	13969	14377	14752	14921	16550	18490
Rate of non-agriculture population(%)	53.41	51.25	47.28	46.07	~	50.43	48.99	48.93
Average income(RMB/a)	1234	~	~	1387.8	~	1713.1	2583.2	4288.1

**Tab.2** MSW composition in different areas in a city in 199

	MSW composition (dry base, %)										Wet base calorific value(kj/kg)	
	metal	glass	plastics	paper	textile	wood	kitchen wastes	cinder	brick and tile	water content	High	Low
ordinary residential quarters	1.96	12.8	14.6	15.1	2.86	11.2	32.6	1.92	6.74	53.9	3869	2036
advanced residential quarters	8.75	18.4	15.6	35.1	4.16	1.5	16.3	~	0.22	33.2	7100	5682
college area	7.18	25.2	12.7	17.6	4.64	13.6	11.7	10.7	0.79	36.2	4934	3462
commercial area	6.69	11.5	18.5	38.5	6.24	12.5	2.7	~	0.31	346	8136	6598
hotel	4.79	25.1	18.2	44.4	2.43	0.2	4.7	~	0.30	10.3	10337	9120
hospital	1.25	26.1	14.1	38.9	3.55	1.0	13.3	1.71	~	39.4	5436	3923
park	6.56	9.52	12.4	12.2	1.63	14.8	5.5	22.3	12.8	26.0	5996	4698

**Tab.3** MSW composition in different countries

year	country	city	paper	glass	metal	plastics	rubber	wood	vegetable	textile	other
1984	USA	New York	44.8	11.9	8.0	5.1	~	4.0	22.0	4.0	~
1982	UK	London	37.0	10.8	6.0	5.2	~	~	28.0	3.4	~
1986	Singapore	Singapore	43.0	1.0	3.0	6.0	~	~	5.0	9.0	32.0
1986	Thailand	Bangkok	18.0	2.0	2.0	10.0	1.0	23.0	30.0	4.0	~
1986	Indonesia	Jakarta	8.0	0.1	1.0	4.0	~	4.0	79.0	2.0	1.0
1986	Phillipins	Manila	17.0	5.0	2.0	4.0	2.0	6.0	43.0	4.0	17.0

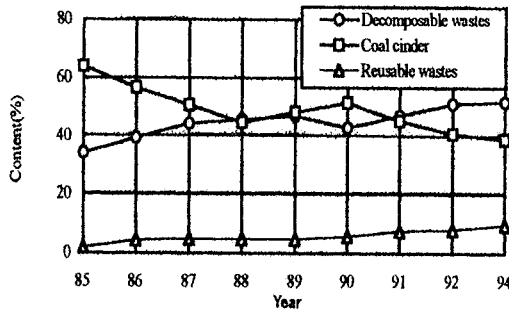


Fig.3 Changes of different components in the garbage from Hangzhou city

construction wastes content of the garbage from the advanced residential quarters is clearly lower than that from the ordinary residential quarters, and it's close to composition of garbage in the developed countries which can be seen in table 3. Nevertheless, kitchen wastes content is relatively high owing to the relatively lower residential living standards, so the water content in the garbage is rather high to make the calorific value of the garbage relatively low.

With the improvement of the living standards, the changes of the consumption consciousness and the development of the packing industry, the commodity packing forms and quantity increases rapidly, once-used commodities are widely used in hotels and restaurants. But the packing materials are become garbage once the commodities are consumed. Actually most of the materials in the garbage such as metal, glass, paper and especially the plastics are packing materials. For example, the amount of the kitchen wastes is reduced because the vegetables are selected and washed before they are sold in the supermarket, but the amount of the packing materials in the garbage is increased because of the packing commodities. The once-used commodities will be become wastes after they are used only once, so it not only increases the waste generation amount but also wastes the natural resources greatly. Although the packing industry in China hasn't developed as much as that in the developed countries presently, it can be seen that the packing wastes in the garbage has been increased steadily with the spreading of the packing commodities and once-used commodities, and it has brought a lot of pressure on the environment. In the recent years, the

white pollution caused by the waste plastics which has caused much attention by the society is a typical case.

### Energy structure influences

The another important factor which influence the MSW composition is fuel consumption structure. Coal is the major fuel in China, and 75% of the irreplaceable energy is coal. Coal is not only widely used in industry but also in family, most of the families use coal as their main fuel to cook and heat, therefore, there are a lot of coal cinder in the municipal garbage, and this makes the relatively small organic material content of the garbage.

Nevertheless, with the spreading of central heating and gasification in the cities in recent years, the consumption structure of the residential fuel has had a great change, and it still causes the change of the MSW composition. The data of the MSW composition in some cities was listed in table 4 and table 5. It can't be easily seen the clear differences of the MSW composition among the different areas from the data listed, but the residential fuel structure has caused great influence on the garbage composition. The inorganic component in garbage from the area where coal is the main fuel is clearly higher than that from the areas where gas is the main fuel, on the contrary, the content of organic component and reusable wastes from the gas used areas is evidently higher than that from the coal used areas. On the other hand, residential living standards in the coal-used areas is always lower than that in the gas-used areas. Kitchen wastes has become the main component because of the decrease of the cinder in the garbage, therefore, the water content of garbage increases accordingly.

The spreading rate of coal gas in cities has increased from 38.6% in 1989 to 68.4% in 1995 (calculated in population), the country-wide centralized heating area has increased from 193.86 million m<sup>2</sup> in 1989 to 610.40 million m<sup>2</sup> in 1995. The popularization efficiency of centralized heating area in Northern China was 20% in 1995 and it's planned to reach 30% in the year 2000, and it will be 45% in the economic developed cities. Therefore, the organic materials content and calorific value of municipal garbage will make further increase, and this will cause much influence on development of MSW treatment and disposal technology.

Tab.4 MSW composition in different cities where using gas as the fuel

unit: %

Area		Cities in South China			Cities in North China					
city		Nanning	Nanjing	Shanghai	Chongqing	Taiyuan	Jilin	Tianjin	Shenyang	Harbin
organic component		46.01	64.77	80.30	69.91	83.22	62.04	78.98	86.94	63.92
inorganic component		45.76	18.33	7.54	19.91	4.12	27.26	5.88	9.34	20.22
wastes	paper	2.77	9.61	3.47	2.90	6.97	~	~	1.91	11.04
	metal	1.06	1.93	2.00	1.19	1.13	~	~	0.41	0.66
	plastics	1.22	1.49	1.86	2.12	1.60	~	~	0.27	1.73
	glass	2.36	1.89	1.74	1.95	1.37	~	~	0.71	2.07
	cloth	0.82	1.98	3.09	2.01	1.59	~	~	0.42	0.36
	sub-total	8.23	16.90	12.16	10.18	12.66	10.70	15.14	3.72	15.86

Tab.5 MSW composition in different cities where coal is the main fuel

unit: %

Area		Cities in South China				Cities in North China				
city		Nanning	Nanjing	Shanghai	Chongqing	Taiyuan	Jilin	Tianjin	Shenyang	Harbin
organic component		17.02	26.28	31.96	16.80	10.86	4.80	22.26	37.97	30.86
inorganic component		78.60	68.20	60.70	79.54	86.38	93.70	69.52	60.79	66.02
wastes	paper	1.61	3.18	2.00	0.75	1.57	~	~	0.35	1.70
	metal	0.64	0.34	2.70	0.94	0.30	~	~	0.17	0.50
	plastics	1.09	0.47	1.35	0.68	0.17	~	~	0.09	0.24
	glass	0.43	0.72	1.06	0.84	0.21	~	~	0.24	0.49
	cloth	0.61	0.81	0.23	0.42	0.51	~	~	0.21	0.72
	sub-total	4.38	5.52	7.34	3.66	2.76	2.10	9.12	1.06	3.15

### Management system influences

The administrative department of municipal garbage in China is Ministry of Construction, in different cities the Environment and Sanitary Department is in charge of the collection, transportation, treatment and disposal of the municipal garbage. The frame of the MSW administrative organs in Beijing is listed in figure 2, and a triple administrative system including city, districts and streets is implemented by the Environment and Sanitary Department in many cities. It can be seen that the management, supervision and operation of the collection, transportation and disposal of garbage in China is implemented and accomplished by only one administrative organ. Because the work to collect, transport, treat and dispose the municipal garbage is relatively complex and heavy, the main administrative department will consider the policy, regulation and administration remarkably simple.

Except the Environment and Sanitary Department, the Supply and market corp. under Ministry of domestic trade is in charge of the waste materials reclaim work, and the Environment Protection Department is responsible for the environment management work in the process of garbage collection, treatment and disposal.

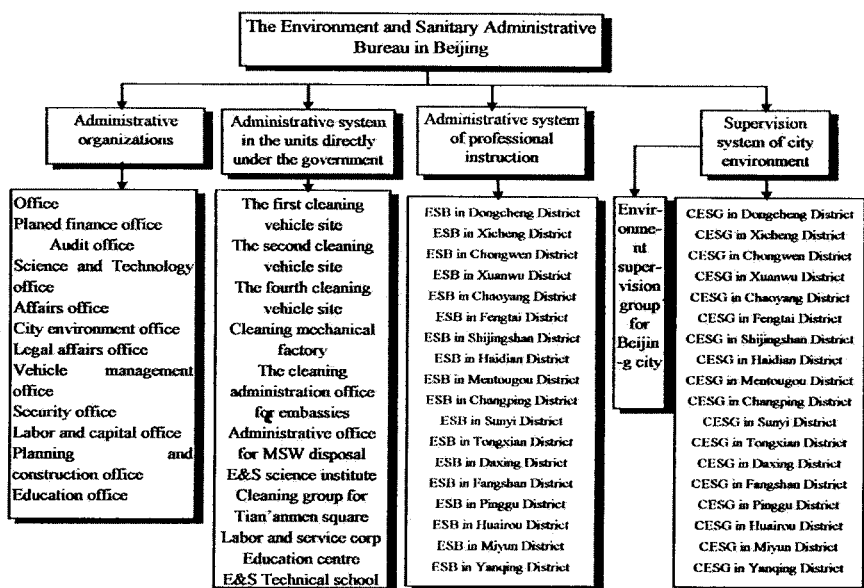
In brief, it's unfavorable to change the difficult position of the municipal garbage management with existing administrative system. It's the main problems that the politics and the industry are not separated for the garbage management, the management, supervision and operation of the garbage are implemented by only one department, so the efficient mechanism can't be formed at this situation, and it limits the development of the municipal garbage development. There are two many workers and staff in the waste materials reclaim depot and city environment and sanitary management department, and the duty and responsibility for different departments are not clear, reasonable management system hasn't been formed, and manpower and material resources are not used appropriately.

## POLLUTION SOURCES ANALYSIS

### Influences on water

There are a lot of pathogen bacteria in the municipal garbage, and there also a lot of acid and base organic pollutants generated during decomposition of the waste, moreover, the heavy metals will be dissolved from the waste, so the garbage is a pollution source combined with organic materials, heavy metals and pathogen bacteria. The water in the garbage and rain permeated into the waste while piling up both can generate high concentration leachate with the three pollutants mentioned above, and it can cause serious pollution to the surface water and ground water if the leachate goes into the water body nearby or permeates into the ground without any control. The pollution accidents caused by the landfill leachate occurred repeatedly in China. For examples:

- The Waste Transportation River which is the canal to transport garbage to Shanghai Old Harbor landfill has become black with the waste floating on the water, the light wastes float with the wind and the leachate from the landfill has become a main pollution source to the ground water in this area. The internal rivers in many cities such as Fuzhou and Suzhou have polluted seriously by the garbage.
- In the Summer in 1983, the malaria was prevalent both in Hamajing and Wangchengpo garbage deposit sites in Guiyang city, and the results of the later drinking water sampling tests nearby showed that the number of colon bacillus in the drinking water was 770 times more than that of the drinking water standards and bacteria content was 2600 times more than the standards. In order to eliminate the groundwater pollution, the local government invested 200,000RMB to do the project and closed the two garbage deposit sites.
- The results to analyze the groundwater near the Hanjiawazi landfill in Harbin city indicated that indexes such as SS, color, Mn, Fe, phonel, Hg and bacteria exceed the drinking water standards, thereinto, the content of Fe, Mn, Hg was 1.7times, 4times and 29 times of the standards respectively, and total number of bacteria and colon bacillus exceeded the



Annotation: ESB-Environment and Sanitary Bureau  
CESG-City environment supervision group

Fig.4 The frame of the MSW administrative organs in Beijing

standards by 4.3 times and 410 times respectively.

- The groundwater was polluted seriously because the municipal garbage from Heping District in Shenyang city was deposited in a waste sand quarry near Liaohe river. The analysis results of the samples drawn from the different finished landfills from 1949 in 1990 indicated were: ① muddy groundwater and odor smell; ② oil content of 0.001~0.14mg/l; ③ phenol content of 0.001~0.014mg/l; ④ COD 3.4~130.4mg/l; ⑤ NH<sub>3</sub>-N 1.0~300mg/l, NO<sub>2</sub>-N 0.016~0.827mg/l, NO<sub>3</sub>-N 3.32~78.64mg/l; ⑥ total bacterial 145~849/ml.

### Influences on air

Plenty of methane can be generated in the deposit sites or landfills because of the decomposition of the waste. 90% of the landfill gas are methane and carbon dioxide in active landfills.

Thereinto, methane is a colorless, smellless and light gas, it can be culminated in depression or buildings during its diffusion in the air. Methane is a nonhazardous gas, but it's a flammable and explosive gas, and the explosion limit of methane is 5~15% in the presence of oxygen and the most violent explosion limit is about 9.5%. Most of the municipal garbage in China is disposed in open-air deposit sites and simple landfills, no landfill gas collection and drainage systems are constructed in these deposit sites, a great quantity of released gas is discharged to the air without any control. Thus the air nearby was polluted and the hidden danger such as explosion and fire is existing. The landfill gas explosion accident occurred in Yangfang town, Changping county of Beijing city was a typical case. The landfill gas explosion accidents in other areas in China were occurred repeatedly.

The odor gas such as ammonia and H<sub>2</sub>S and other volatile gas can be still generated from landfills. Certainly, the composition of the landfill gas changes with the different landfill structure, different waste and climate conditions. Moreover, some reports showed that dioxin was detected in the landfill leachate and released gas in the recent years.

### **Influences on the worldwide environment**

Methane is one of the main components in landfill gas and it's a kind of greenhouse gas, and its contribution to greenhouse effect is about 21 times of carbon dioxide, and the total discharged amount of methane generated from municipal garbage occupies almost 6~18% of the total methane discharge amount all over the world, so it's an unignorable factor in controlling the global warming. So some students in USA even said that it's more important to control the landfill gas to discharge into the atmosphere than all the regulations and laws issued by the government and local governments to prevent the global warming.

### **CONCLUSIONS**

Municipal solid waste pollution problem is a serious environment problem in China at the moment, so the authors tried to find the main factors that influence the municipal solid waste generation, and the results showed that the MSW generation amount in this country was evidently affected by the population structure, economics

development status, energy consumption structure and MSW management system, on the other hand, the environment pollution caused by municipal solid waste in China was still explored, and it indicated that the inappropriate treatment and disposal of MSW in China was one of the main pollution source to the water, air and the worldwide environment. So different factors must be taken into consideration to solve the solid waste pollution problems in China in the coming future, and efforts must be imposed to solve this problem in China as well, and the authors are certain of that it will be beneficial both to China and to the whole world to solve the MSW problem in China.

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