Journal of Environmental Sciences Vol. 8, No. 3, pp. 292–298, 1996 ISSN 1001-0742

Emission of landfill gas in Qingdao, China

Gao Jixi, Shen Yingwa, Cao Hongfa, Shu Jianmin

Institute of Ecology, Chinese Research Academy of Environmental Sciences, Beijing 100012, China

Abstract—— A study on landfill gas emission in Qingdao, China was carried out. The results showed that the generation of landfill gas with maximum methane concentration occurred several months after the refuse was disposed and the steady emission of landfill gas could remain two years. The variation of landfill gas production was associated with temperature. In June, the emission of landfill gas rose gradually from morning to evening, but in September, it rose in the morning, and then fell in the afternoon. From June to August, the emission of landfill gas showed rising trend, but it declined quite quickly from September to December. In different seasons, the outflow rate of landfill gas varied from depth to depth in the refuse site. When earth temperature was higher in summer, the emission of landfill gas did not correspond with the depth of refuse sites, but when temperature fell in winter, and the temperature became a limited factor to the gas production, the outflow of landfill gas increased with increasing in depth of refuse piling.

Keywords: landfill gas; emission; China

1 Introduction

Greenhouse effect is one of main global environmental problems. The problems caused by greenhouse gases such as global climate change have been paid much attention in the world. The main compositions of greenhouse gases is CO_2 and CH_4, and landfill refuse sites are main sources producing these gases. According to some researches abroad, the amount of gases produced in landfill site are not only very large, but it can keep constant for 15 to 20 years.

Moreover, as most of the garbage in our country and some other developing countries was disposed with landfill, it not only occupied a lot of land but also polluted environment seriously. Thus it is quite necessary to restore the landfill sites. The gases produced in the landfill is a subject of much concern in the rehabilitation because of the gases have adverse effects on vegetation (Spreull, 1987; Flower, 1981; Farquhar, 1973; Shu, 1995). So understanding the rules of landfill gas emission is very important to rehalitation of landfill sites and elimination of environmental pollution.

In this subject we takes Qingdao City of China as an example to study the emission of landfill gas.

2 The location and characteristics of the landfill site

The landfill site was selected in Qingdao City, China, which is a sea beach refuse site, situated in the middle part of the east coast of Jiaozhou Bay in Qingdao. Its total landfill area is 64.3 ha with a depth of 8.3—9.8m, and the total filling amount of refuse was roughly 4 million tons. The garbage of the landfill mainly consisted of inorganic materials, which account for 77%. In the inorganic materials, major components were coal ash and cinder, and the contents of gas and metal were very low. In organic materials, the main contents were leaves and discarded vegetables from kitchen. Besides, a little paper and textile materials were contained (Table 1).

Table 1 Composition of refuse in Qingdao City

Composition	Component	Fresh weight, %	Dry weight, %
Organic	Paper	1.5	1.1
	Plastics	0.5	0.4
	Textiles	0.8	0.6
	Plant and kitchen materials	29.5	20.7
	Total amount	32.3	22.8
Inorganic	Ash	67.0	76.1
	Glass	0.4	0.5
	Metals	0.3	0.4
	Total amount	67.7	77.0

3 Methods

The emission rate of landfill gas is generally detected with gas flow meter in developed countries, but in Qingdao, the flow rate of landfill gas could not be detected in this method because the flow rate of gas was too small. Therefore, a new method was designed in this study. The monitoring equipment is shown in Fig. 1. It consists of a bag, a rubber cap, a glass tube and a perforated vent pipe. The length of the pipe is 1.5 m with a diameter of 5 cm (in some cases, the length of the pipe is 1.0 m, or 2.0m). Of which the length of the perforated part is one third, and the diameter of the small hole is 1 cm. To prevent backfilling materials to block up the small holes, selected little gravel was used around the perforated part of the vent pipe before backfilling wastes. When sampling, the bag is

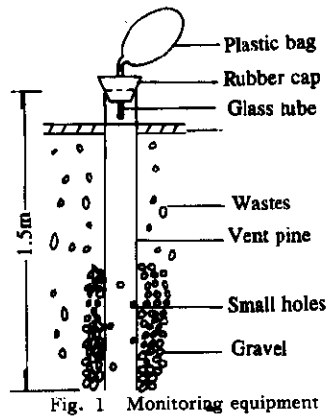

Fig. 1 Monitoring equipment

connected with the vent pipe through the glass tube and the cap. At the same time, recording the time for landfill gas to fill up the bag. The air in the bag was exhausted out completely when the bag was connected with the vent pipe. The emission rate was calculated in following formula: $F=V/T$, there F is the outflow rate of landfill gas, L/min; V is the bag volume, m^3; T is the time, min.

In the study, four refuse sites with ages of six months, one year, two years and the three years were selected. Each refuse site was repeated 3 times, and 3 samples were taken for every time.

4 Results and discussion

4.1 Emission of landfill gas in different ages of refuse sites

Emission of landfill gas in refuse sites with ages of six months, one year, two years and three years was studied. The results showed that the highest outflow rate of landfill gas with maximum methane concentration occurred in half a year refuse sites, then followed by one year sites. The average rate was 1.36L/min and 2.78 L/min respectively in half a year and one year sites in June. The outflow rates of gas in two-year and three-year sites were much lower. In two year sites, the emission rate was only about 5 percent of the rate in six month sites, in three-year refuse sites, only 30% of the samples could be detected with a maximum of 0.053L/min and a minimum of 0.03 L/min.

So it can be concluded from the above results that in Qingdao refuse site, the appearance of landfill gas with maximum methane concentration occurred very quickly after the refuse was disposed. The emission rate reached maximum value in about six months. The steady production of the gas could remain about two years, and the gas production rate got down very quickly after two-year. This result is very different from the situation in developed countries. It was reported that occurrence of landfill gas with maximum methane concentration usually took about one or two years after the refuse was disposed in developed countries, and the steady generation of the gas could last for 15 to 20 years.

The difference of landfill gas production between Qingdao and developed countries may result from the difference of refuse composition. In developed countries, the contents of organic materials in refuse are very high, and most of the organic materials are paper and plastic which are not easy to be decomposed. Therefore, the gas production occurs slowly, but it consists longer. In Qingdao, the contents of organic materials in refuse are very low, and most of the organic matters are leaves and discarded vegetables from kitchen which are easy to be decomposed, so the landfill gas occurs quickly after the refuse is buried, but it last a short period.

4.2 Variation of landfill gas daily production

The study was carried out on the sites with ages of six months and one year separately in June and September. The monitoring of landfill gas was taken once every two hours from 8:00 am to 20:00 pm in the June and 8:00 am to 18:00 pm in September. The results showed that the landfill gas flux varied greatly within a day(Fig. 2). In June, the gas out-

flow rose gradually from 8:00 am to 20:00 pm, but in September, it went up in the morning, and then fell from 12:00 pm to 18:00 pm. It seemed that the variation of gas outflow corresponded with the daily change of earth temperature. In June, the earth temperature showed increasing trend from morning to evening, but in September, the earth temperature declined from noon to night, thus resulting in falling of landfill gas production. Except earth temperature, atmospheric pressure and wind may also effect the outflow rate of landfill gas. Alan Yong(Alan, 1990) reported that landfill gas emission has a close relationship with atmospheric pressure.

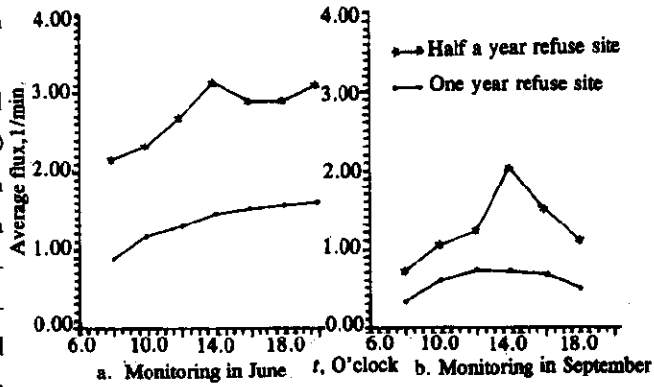

Fig. 2 Daily variation of landfill gas

Comparing the emission of landfill gas at six months refuse sites with that at one year sites, Fig. 2 reveals that the outflow of landfill gas varied more quickly in half a year sites than in one year sites. This may result from the difference of emission rates between one year and half a year sites. In the half a year refuse sites,, the rate of landfill emission was higher than that in one year sites.

4.3 Study on the monthly variation of landfill gas emission

The monitoring of variation of landfill gas production was began in June, 1991, ended in January, 1992. Half a year refuse sites and one year refuse sites were chosen as the monitoring fields. The results showed that the outflow rate of landfill gas increased gradually from June to August, but it declined quite quickly from September to December. The variation of landfill gas in six months sites and one year sites showed the same trends. The highest emission of landfill gas occurred in September. Two months later, however, the outflow of landfill gas became too small to be measured in one year refuse sites. Up to December, the outflow rate of landfill gas in six months refuse sites also became very low, but it still could be measured in January next year(Fig. 3).

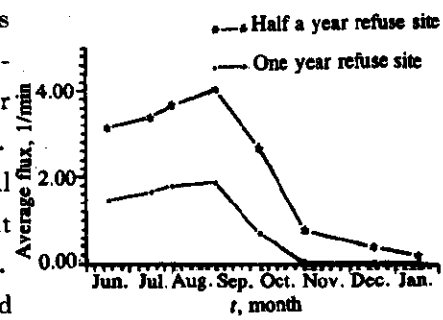

Fig. 3 Monthly variation of landfill gas

Similar to the results observed above in 4.2, we thought that the variation of landfill gas emission was associated with the variation of seasonal temperature. In Summer, the temperature was high, so, the emission rate of landfill gas was high too. In autumn, with the falling of temperature, the gas production became low too. When temperature fallen to minimum in winter, the outflow of landfill gas also dropped to lowest point.

4.4 Study on the emission of landfill gas at different depth in the landfill

The study was carried out in half a year refuse sites from August 1991 to January 1992. The three depth of 1.0m, 1.5m, and 2.0m was used. The results showed that the emission rate of landfill gas at different depth was different in different months. In August, the highest outflow of landfill gas occurred at depth of 1.5m, and the lowest were occurred at depth of 1.0m. In October, the highest outflow of landfill gas occurred at depth of 2.0 m, and the lowest occurred at depth of 1.0m. Up to December, the emission of landfill gas at depth of 1.0m was too low to be measured, and the outflow rate of landfill gas at depth of 1.5m and 2.0 m began to decline quickly. Up to January, 1992, the outflow rate of landfill gas at depth of 1.5m became very low, but the outflow of landfill gas depth of 2.0 m kept the same rate as in December.

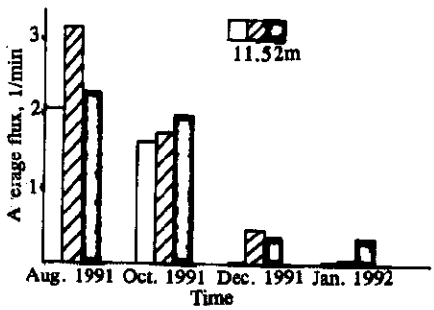

Fig. 4 Average gas flux in different depth in the landfill

The results showed that the effects of depth on landfill gas emission depended on temperature. In August, the earth temperature was very high, and the temperature from depth of 1.0 m to 2.0 m was similar, so the outflow rate of landfill gas in three depth all was very high, and their difference was resulted from position difference. Up to December, the earth temperature began to decline, but the earth temperature of upper layer decreased more quickly than that of lower layer, so the outflow rate of landfill gas at depth of 1.0 m and 1.5m decreased more rapidly than that of 2.0m. So we conclude that the effects of depth on landfill gas emission hinged on earth temperature. When the earth temperature was high in summer, the outflow rate of landfill gas did not correspond with the depth; when the temperature fell in winter, and the temperature became the limited factor to gas production, the qutflow rate of landfill gas correspond with the depth, the deeper, the higher gas outflow. The monitoring results on earth confirmed the conclusion. In August, all the earth temperature from 1.0m to 2.0 m exceeded 30℃. However, up to December, the earth temperature was only 16℃ at the depth 1.0m, but it was more than 25℃ at the depth of 2.0m.

From the results mentioned above, we can deduce that the landfills of refuse in most cities in China have large amount of gases produced after the garbage was disposed. With the increase of population and improvement of people's living condition, the volume of domestic garbage produced in China is increasing dramatically. According to statistics, the amount of domestic garbage produced in 1980 is 73 million ton, and it will raise to 120 million ton by 1995. It estimated that the amount will increase to 190 million ton by the year of 2000(Gao, 1994). As most of the garbage is disposed with landfill, if all the landfill gases including methane are discharged to atmosphere directly, they are bound to increase greenhouse effect and cause environmental problems. Besides, some elements in landfill gases have adverse effects to plants, animals and human being. For example, H_2S can damage eyes and respiratory organs; CH_4 is liable to cause explosive accidents. Therefore, we should pay much attention to the landfill gas. In order to protect environment, we suggest that the landfill gas, es-

pecially methane, should be collected and used rather than be discharged to atmosphere.

With regard to rehabilitation of landfill sites, and the period of maximum production of landfill gas occurs in the first two years after the garbage was filled, and the emission of landfill gas slows down very quickly after this period, it is more suitable to restore the landfill sites with plants after the garbage was disposed two years. But after that, the gas still should be piped out and collected, or else it not only effects plant growth but is likely to arouse explosive accidents.

5 Conclusions

The results showed that the emission of landfill gas in Qingdao refuse site was very different from the results obtained in developed countries. The appearance of landfill gas with maximum methane concentration occurred very quickly after the refuse was disposed in Qingdao, but it remained stable only for two years. This difference is resulted from the difference of refuse composition and characteristics.

The emission of landfill gas in Qingdao refuse site varied greatly in a day. In summer, the gas outflow increased from morning to evening, and in fall, it increased in the morning, but decreased in the afternoon.

In a year, the emission of landfill gas showed rising trend from June to August, and arrived to maximum in September. After that, the emission of landfill gas declined very quickly. Up to November, the emission rate became very low.

The emission rate of landfill gas was correspond with the depth in winter. But in summer, the effects of depth on emission rate was small.

The generation of landfill gas in Qingdao refuse site was very sensitive to temperature variation. The flux of gas increased with increasing of temperature to some extent.

The ideal time for landfill site rehabilitation is two years after the domestic garbage was disposed. In order to decrease global greenhouse effects and protect environment, the landfill gas should be collected and used rationally.

Acknowledgements——This paper was part of a joint project of CRAES, Qingdao Environmental Protection Agency and Liverpool University, UK. The authors would like to thank Professor Dun Wanru and Yue Xilian in Qingdao Institute of Environmental Protection, and Professor A. D. Bradshow and Professor Brain Moss in Liverpool University for their technical assistance and cooperation to enable a successful progress of the study.

References

Alan Young, Waste Management & Research, 1990; 8:379

Flower FB. Journal of Arboriculture, 1981; 7(2):43

Farquhar GJ, Rovers FA. Water, Air and Soil Pollution, 1973; 2:485

Gao Jixi, Cao Hongfa, Shu Jianmin. Environmental Pollution & Control, 1994; 4:30

Shu Jianmin, Shen Yingwa, Gao Jixi. Research of Environmental Sciences, 1995; 3:13

Sprell WJ, Susan Cullum. Waste Management & Research, 1987; 5(1)

(Received February 10, 1995)