B−14.1.2 A Study on the Analysis of Life Cycle Emissions of Other Greenhouse Gases for Technology Assessment (Final Report)

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Total Budget for FY1994−FY1996 23,162,000 Yen (FY1996; 7,127,000 Yen)

[Abstract]

The essential data for the life cycle analysis of the emissions of the trace greenhouse gases, such as methane, nitrous oxide, halocarbons, were accumulated and analyzed. The emission factor and amount on nitrous oxide from the production of adipic acid and nitric acid were experimentally determined to be 1.3(N_2O.mol/adipic-acid.mol) and ca. 15 Gg・N_2O /yr, respectively.

In addition, data bases on the treatment plants for municipal solid waste (MSW), night soil (NS, including sludge) and sewage were compiled. The numbers of plants, the treated volume and the consumption of energy were in 1981fy and 1990fy as follows: [MSW], 1842 and 1780 plants(pt.), 25.9 and 36.5 Mton・MSW, 1,061 and 1,779 GWh, 80 and 78 ML (oil), 3.3 and 2.0 Mm^3(town gas), 0.16 and 0.32 Gg(LPG) ; [NS], 1487 and 1166 pt., 20 and 26.9 GL・NS, 1440 and 1,400 GWh, 194 and 167 ML(oil), 0.7 and 0.9 Mm^3(t. gas), 0.2 and 0.2 Gg(LPG). The main energy sources of these plants are electricity and oil, and each amount is approximately 1% of the domestic (home) use [187 TWh(EL), 15 GL(oil)] in 1990 fy in Japan.

The outline of the results of this study is as the followings; 1) the scale of sewage plants does not much influenced the energy use for the treatment, 2) the energy used for the bulky waste treatment is mainly composed with electricity which is about 320 GWh to the amount of 3.5 Mton in 1990fy. 3) the expenses for these waste treatment in Japan is also analyzed and the total amount is 90 billion yen in 1981fy and 150 in 1990fy, and 4) the total emission of greenhouse gases from the combustion treatments was roughly compared with one from the landfill disposal and the former was about one seventh of emission to the later on the basis of the adjusted radiative forcing.

Key Words; Emission, Life cycle analysis, Night soil treatment, Adipic acid, CH_4, N_2O

1. Introduction

The contribution of the trace greenhouse gases (GHGs), such as Methane (CH_4), nitrous oxide(N_2O), halocarbons(CFCs), ozone(O_3), to the global warming is considered to be increasing numerically and relatively during the last two decades[1-3]. In addition, the emission of these trace GHGs can be easily reduced, compared with CO_2 emission which is directly connecting the energy uses, if the sources and the emissions of them could be clear. They, however, are obscure in detail parts, especially from waste and sewage treatments.

One of the most important parts in the life cycle analysis or assessment is the accurate estimate of the energy consumption, which emits CO_2 directly or indirectly, in each processes. Therefore, we compiled the database for about 5000 waste treatment plants in Japan for 1981-1990. Then, the data were analyzed from the energy and fuel use and the expenses in these plants.

2. Estimate the emission of N_2O from the plants for adipic acid production.

Adipic acid which is primarily used in the manufacture of nylon 6.6 polyamide via reaction with 1,6-hexamethylenediamene are reported to be a important source of N_2O[4]. The emission factor was experimentally estimated and determined to be 1.3 (N_2O.mol/adipic acid.mol), which is slightly higher than the reported one[4]. The amount on nitrous oxide from the production of adipic acid were estimated to be ca. 15 Gg·N_2O/y in Japan. N_2O emission from the adipic acid production can be eliminated by the change of production processes and the catalytic dissociation or thermal decomposition.

3. Reduction techniques for the CFCs emission.

The methods which had been recently developed for decomposition of CFCs are categorized about ten kinds and each of them have the own advantage. However, the method which use the cement kiln is seemed to be most proper in many cases, because of, the lower energy consumption for treatment, the lower expenses for the plant construction and the operation, and the easy handling of the products after the decomposition. In some cases, the incinerators for the waste treatment is also useful for the decomposition of CFCs in the waste and in the atmosphere around the plant.

4. Energy consumption in the waste treatment.

The data concerned the waste treatment in Japan was compiled for 1981-1990 from the data book[5]. The raw data sets collected by Ministry of Health and Welfare were validated from the relations between the plant capacity, the treated volume and the bill for electricity (EL) or fuels. Some data for treated volume were corrected on the basis of the bill, and a few were excluded from the data set because of the poor consistency.

The amounts of EL and fuels consumed in the incineration plants for municipal solid waste (MSW) , the treatment plants for night soil (NS, including sludge from septic tanks) , the community size sewage plants and the bulky waste treatment plans in Japan are estimated and analyzed from the types and the capacity of plants in this decade.

4.1 Energy consumption in the treatment plants for municipal solid waste in Japan.

The numbers of plants, the treated volume and the consumptions of them were in 1981fy and 1990fy as follows: 1842 and 1780 plants(pt.), 25.9 and 36.5 Mton, 1,061 and 1,779 GWh, 80 and 78 ML (oil), 3.3 and 2.0 Mm^3 (town gas), 0.16 and 0.32 Gg(LPG). The main energy sources of these plants are electricity and oil, the total energy was 1.8 and 2.4 Pcal, which is about 4% of the utilizable energy produced by MSW combustion.

These amounts and the ratios to the treated volumes in different type facilities are listed Table 1. The much variations in the ratios are observed in different types. The trends of energy consumption for ten years are; those had been increased by more 30%. However, the energy use in big plants for MSW had been decreased as shown in Fig.1, and that is considered to be the influence of the increase of self-power-generation there. The ratios of consumption to treated volume were changed widely as 30-90 kWh/ton and 1-13 L(oil)/ton for MSW.

4.2 Energy consumption in the treatment plants for night soil and sludge in Japan.

The numbers of plants, the treated volume and the consumptions of them for NS were in 1981fy and 1990fy as follows: 1487 and 1166 pt., 20 and 26.9 GL, 1440 and 1,400 GWh, 194 and 167 ML(oil), 0.7 and 0.9 Mm^3 (t. gas), 0.2 and 0.2 Gg(LPG). The main energy sources of these plants are electricity and oil, the amount of electricity is similar to one for MSW, but oil is twice. Each amount is approximately 1% of the domestic (home) use that are 187 TWh(EL), 15 GL(oil) in 1990 fy in Japan.

These amounts and the ratios to the treated volumes in different type facilities are listed Table 2. The more variations in the ratios are observed in different types for NS. The trends of energy consumption for ten years are; although the number of plants for NS had been decreased by near 20%, the treated amounts increased by 35%. The ratios of consumption to treated volume were changed widely as 30-100 kWh/kL and 5-20 L(oil)/kL.

4.3 Energy consumptions in the community size sewage plants in Japan

These plants are operated in the area where the public sewerage system is not served yet. The total designed population for these plants was about 1 million, 1% of Japanese. The energy consumption in there which is listed in Table 3 is compared with that in some sewerage plants and the scale of sewage plants does not much influenced the energy use for the treatment.

4.4 Energy consumption in the treatment plans for bulky waste in Japan

The number of them is about 700 plants in Japan. The energy used for the bulky waste treatment is mainly composed with electricity which is about 320 GWh to 3.5 Mton of the treated amount in 1990fy, in similar ratio to the MSW.

5. The trend and the contents of the expenses in the MSW treatment plants.

The amounts of the expenses used in MSW treatment plants had been increased continuously for the period of 1981-90, as about 90 billion yen to 150. The major items in the expenses are the charges for the others (composed with those for periodical inspection, operation and maintenance by contract, and so on) > electricity > expendables > chemicals . The differences in [expenses (except others) / treated amount] with the process types are much and the compost plants, the highest one, consumed the expenses of 4000 yen/ton by four times, compared with fixed batch type incineration plants (lowest one, 1000 yen/ton).

6. Comparison of the expense between the incineration and the landfill for MSW treatment.

The total expenses including the construction of plants or facilities and the operation for the incineration and the direct landfill for MSW are roughly estimated. They are resulted to be 14-18 k·yen (10-14 k·yen for construction and 4 k·yen for operation) for the incineration and 8-25 k·yen (7-24 k·yen for construction and 1 k·yen for operation) for the landfill, where the expenses for the collection, the transportation and the personal are excluded. The expenses for the two kinds of treatments are seemed to be similar.

7. Comparison of the GHGs emission between the incineration and the landfill for MSW treatment.

The total emission of greenhouse gases from the combustion treatments was roughly compared with one from the landfill disposal. The former was estimated to be 0.27·c(CO_2)/ton·waste, against 1.78·c(CO_2)/ton·waste for the later, after the adjustment by the radiative force*, as shown in Fig.2. Then, it was confirmed that the incineration with proper way can reduced the adjusted GHGs emission by about one seventh, compared with the direct landfill disposal.

* Adjusted value for CH_4 on the basis of radiative force → 21·CO_2.

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Table 1. The electricity and oil consumed indifferent type facilities for MSW treatment.

Type of plants	No.plants	Treated volume Total kton	Treated volume For each kton/pt	Electricity[a] Total GWh	Electricity[a] Per treated[b] kWh/ton	Oil[a] Total ML	Oil[a] Per treated[b] L/ton
[1981fy] ;Upper line / [1990fy] ;Lower line							
Fully continuous combustion type							
	304	17,531	57.7	799	70.4	24.0	2.68
	379	27,173	71.7	1,286	47.3	18.1	0.67
Semi continuous combustion type							
	119	1,306	11.0	72	69.0	6.2	6.31
	249	3,799	15.3	296	78.0	7.4	1.96
Mechanical batch combustion type							
	979	5,629	5.8	137	21.5	41.8	9.99
	861	5,110	5.9	186	36.4	45.8	8.97
Fixed grade-bar batch combustion type							
	348	994	2.9	9.2	13.8	6.3	13.4
	214	266	1.2	2.3	8.7	3.2	12.1
High speed composting type							
	11	56	5.1	2.7	72.2	0.02	0.35
	23	58	2.5	4.0	69.5	0.8	13.0
Others							
	81	374	4.6	41	35.8	2.3	4.85
	54	116	2.1	3.9	33.2	2.9	24.8
General total							
	1,842	25,891		1,061		80.4	
	1,780	36,523		1,779		78.2	

Table 2. The electricity and oil consumed in different type facilities for NS treatment.

Type of plants	No.plants	Treated volume Total ML	Treated volume For each ML/pt	Electricity[a] Total GWh	Electricity[a] Per treated[b] kWh/kL	Oil[a] Total ML	Oil[a] Per treated[b] L/kL
[1981fy] ;Upper line / [1990fy] ;Lower line							
Anaerobic digestion process							
	579	10, 201	17. 6	480	54. 7	72. 6	5. 56
	391	8, 823	22. 6	279	32. 2	41. 1	5. 43
Aerobic digestion process							
	394	3, 038	7. 7	508	48. 1	55. 0	8. 66
	345	7, 094	20. 6	396	70. 3	40. 0	9. 10
Conventional nitrification–denitrification process							
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	227	7, 267	34. 6	510	99. 3	48. 6	7. 95
High loading nitrification–denitrification process							
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	116	2, 169	18. 7	134	67. 8	12. 6	6. 72
Others–1[c]							
	252	6. 877	33. 5	422	62. 5	66. 7	6. 64
	87	1, 594	18. 3	83	39. 4	24. 6	26. 3
Others–2[c]							
	262			30		0. 3	
	—			—		—	
General total							
	1, 487	20, 116		1, 440		194. 3	
	1, 166	26, 947		1, 402		166. 9	

Note, [a]; Calculated from the bills for electricity and oil.
[b]; Avaraged value from those of individual facilities.
[c]; Others–1; Types else above. Others–2: Facilities without volume data.

Table 3. The electricity and oil consumed in small size sewage treatment plants.
[1990 fy]

	Total	Treatment methods A	B	C	D
Number of community	419				
Number of plants	385	272	50	15	48
Designed service populat. 10^4	81.6	41.4	34.3	4.3	1
Designed max.sewage, km³/day	291.1	142.7	121.5	11.1	15
Used electricity, Gwh	35.8	21.2	12.4	0.83	1.37
Used electricity (Cal.)	45.4	25.5	15.4	1.4	3.1
Used oil, ML	2.09	0.82	0.73	0	0.54
Used tap water, km³	151.2	48.1	45.6	25.3	32.2

[Total used electricity(Cal.)／Designed max.sewage·year]
=0.43 kwh/m³ (1990fy) , [=0.42 kwh/m³ (1985fy)]

A: Long term aeration process, B: Conventional activated sluge process.
C: Biological contact aeration process, D: Others.

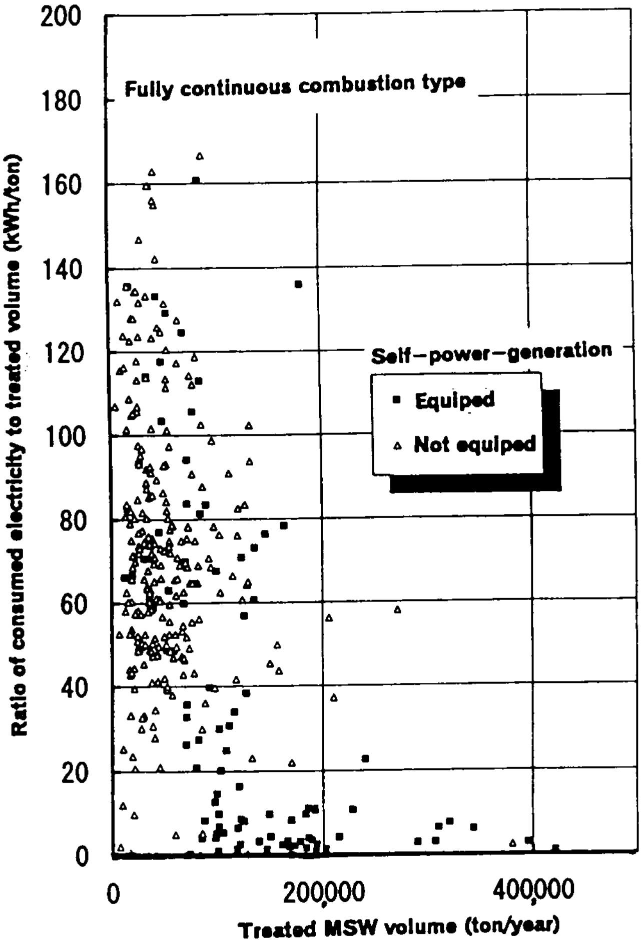
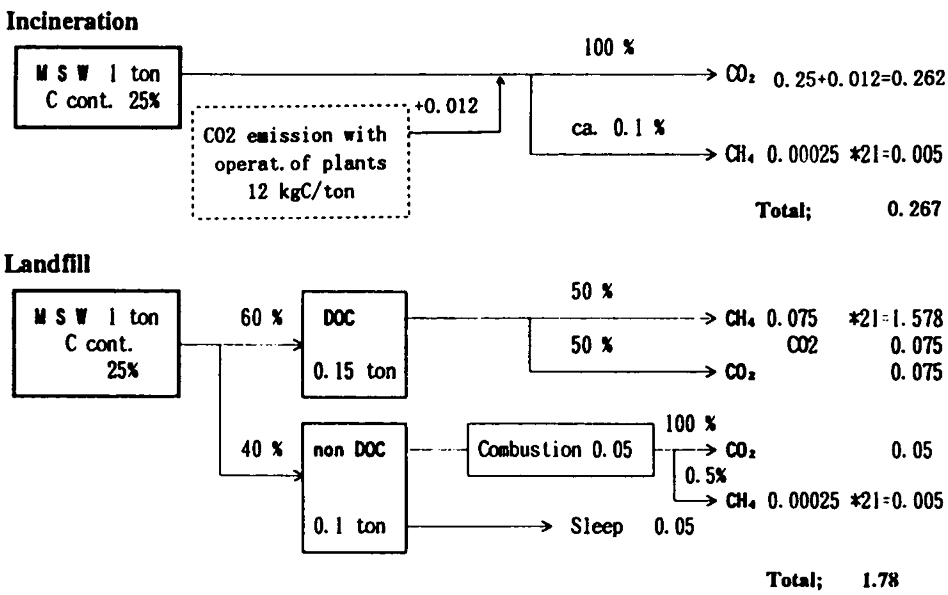


Fig.1 Consumed electricity to the treated MSW volume in individual facilities in 1990fy.



[RATIO; Landfill/Incineration(1.78/0.267) ≒ 7 times]

Fig.2 Comparison of the force of greenhouse gases emission to waste disposal methods (Trial)