B–16.1.1 The Study of Wastewater Treatment to Control the Global Warming Gas

Contact Person Dr. Ryuichi Sudo
Department of Civil Engineering,
Faculty of Engineering, Tohoku University,
Aoba Sendai 980-77, Japan
Tel : +81-22-217-7469
Fax: +81-22-217-7471

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Abstract

The purpose of this research project was conducted to investigate the amount of the greenhouse effect gases emitted from the conventional wastewater treatment facilities, conventional and new developed on-site night soil treatment facilities, combined gray and night soil treatment facilities, and pig farm wastewater treatment facilities. Through three years' research, the emission inventory of these greenhouse effect gases such as CO_2, CH_4, N_2O was determined in each facility and process. The establishment and estimation of wastewater systems for the control of the greenhouse effect gases was also discussed in this study.

Key words Greenhouse effect gas, wastewater treatment, on-site treatment facility, pig farm wastewater, anaerobic submerged filter

1. Introduction

It is well-known fact that a great amount of the greenhouse effect gases may be emitted from wastewater treatment facilities and waste disposal facilities. Although most sources of these gases were considered to come from the industrial and natural activities, it is important to grasp the quantitative amount of greenhouse effect gases from each sources (Inamori et al, 1993; Sudo,1991, 1993, Japanese Environment Agency, 1994).

The purpose of this research project was conducted to investigate the amount of the greenhouse effect gases emitted from the conventional wastewater treatment facilities, conventional and new developed on site night soil treatment facilities, combined gray and night soil treatment facilities, and pig farm wastewater treatment facilities. Through three years' research, the emission inventory of these greenhouse effect gases such as CO_2, CH_4, N_2O was determined in each facility and process. In addition, the relationship between the treatment efficiency and gas production, and the reduction countermeasures were also discussed for the estimation and establishment of wastewater treatment systems for the control of the greenhouse effect.

2. Research method

In order to grasp the amount of greenhouse effect gases from wastewater treatment systems, three traditional facilities such as conventional activated sludge process plant, on-site treatment facility (both black wastewater, and combined gray and black wastewater treatment facility), and pig farm wastewater treatment facility were selected.

2.1 Survey of the pig farm wastewater treatment facility

The pig farm surveyed is located at the suburb of Sendai city. There were 2000 pigs in this farm, and 5t/day of the manure and urine was released. Activated sludge process was used to treat the wastewater from pig farm. Fig.1 shows the simplified diagram of treatment process. The treatment efficiency as nitrification or denitrification was insufficient. Thus, many of the incompleted wastewater was thrown to the field around. The survey of the amount of the greenhouse effect gases from the field, pig houses including wastewater treatment process was carried out. The amount of the greenhouse effect gas was measured in pig houses (pits), aerobic reactor, anaerobic reactor, and the disposal fields (farmland). The survey began from February 1993.

2.2 Survey of the on-site treatment facility

The numbers of the on-site treatment facility installed in Japan increased to 300,000 unit every year. By Mar 31, 1991, the total number of the on-site treatment facility had reached to 6,840,000 units, in which night soil treatment facilities were 6,640,000, combined gray and night soil treatment facilities were 210,000. 85 % of the treatment population of one unit of the on-site treatment facility is less than 20 persons.

Six plants of the conventional aeration type night soil treatment facilities, and two plants of anaerobic biological contact aeration type gray and night soil treatment facilities were selected to determine the amount of the greenhouse effect gases from these on-site treatment facilities. Of the six plants of night soil treatment facilities, four were extended aeration type, the rest were new developed submerged filter with settling tank type. Fig.2 shows the flow chart of each treatment process.

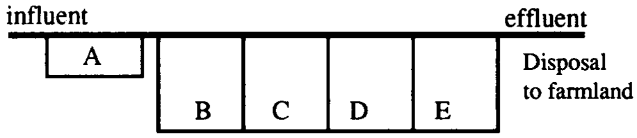

Fig. 1 Diagram of pig farm waste water treatment process
A : settling tank, B: 1st anaerobic tank, C: 1st aeration tank,
D : 2st anaerobic tank, E: 2st aeration tank

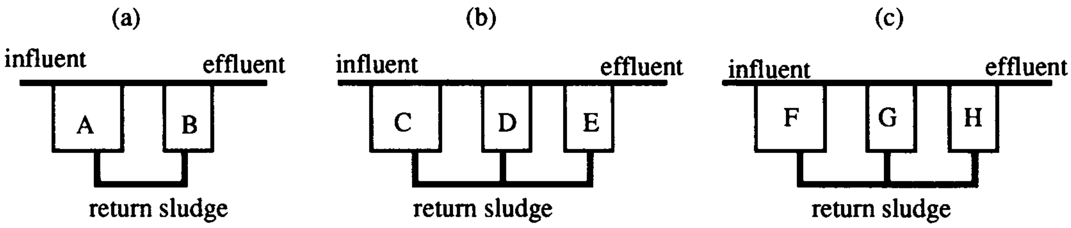

Fig. 2 Diagram of processes of on-site treatment facilities

(a) conventional extended aeration type, (b) new developed submerged filter type, (c) combined gray and night soil treatment facility
A : aeration tank, B: settling tank, C : primary settling tank, D - submerged filter tank,
E : final settling tank, F:anaerobic tank, G: submerged filter tank, H: final settling tank .

The effective capacity of the six-person on-site treatment facility was 3.832m^3, in which the volume of the anaerobic tank was 2.006m^3, aeration tank 1.265m^3, settling tank 0.561m^3. The survey was carried out between December 1993 and March 1994.

2.3 Survey of the wastewater treatment process

The survey was carried out at Y treatment plant which is located in the suburb of Sendai city, Miyagi prefecture, its treatment capacity was 4500 m^3/day, the population utilizing the treatment plant was 11,900. Conventional standard activated sludge process was used in this treatment plant. The treatment process consisted of primary settling tank (6.5x30x3.0m), two aeration tanks (6.5x68x5.5m) and final settling tank (6.5x42x3.0m). Fig. 3 shows the simplified diagram of this treatment process. The composition of CO_2, N_2O and CH_4 from each processes was determined. The study was carried out between November,1994 and April 1995.

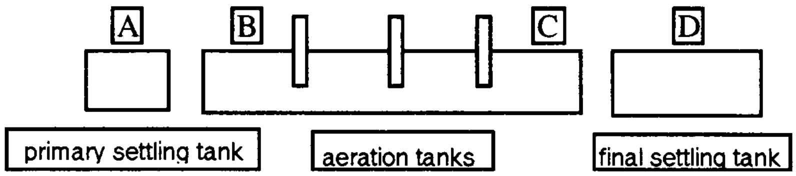

Fig. 3 Diagram of Y-water treatment system
A: primary settling tank B:1st aeration tank
C: 2nd aeration tank. D: final settling tank

2.4 Sampling and Analytical method

Gas sampling was collected using gas trap equipment, and the Shimazu GAS 8A was used for the analysis of O_2, N_2 and CH_4, and for the analysis of N_2O and CO_2, Shimazu GAS 9A was used. Related water quality such as SS, Water temperature, BOD, COD, TN, TP was also determined by Standard Methods.

3. Results and discussion

3.1 Greenhouse effect gases from pig farm wastewater treatment facilities

As have been mentioned, there were 2000 pigs in this farm, the facility received about 10m^3 wastewater per day. The amount of the greenhouse effect gas from pit, aerobic reactor, anaerobic reactor and farmland was measured. Fig.4 shows the amount of gases emitted from each treatment process. The average amount of CH_4 and CO_2 gases from these areas was estimated to be 554 g-CH_4/day, 270 g-CO_2/day, respectively. The dominant source of CH_4 gas was found in the anaerobic reactor (fermentation tank) , and the dominant sources of CO_2 was in aerobic reactor. N_2O was not recognized in pig farm process. It was calculated that the amount of CO_2 and CH_4 per capital was 270 and 277 g/day/capital, respectively.

3.2 Greenhouse effect gas from on-site treatment facility

The result obtained from the survey was shown in Fig. 5. The amount of CO_2 emitted from the aeration tanks of both conventional aeration type and new developed type (night soil treatment facility) was quite small. However, the clear relationship between the CO_2 emission and the treatment efficiency was not recognized. Only a small amount of N_2O was emitted from the aeration tank of the aeration type (night soil treatment facility). It was found that the production of CH_4 at a rate of 8 ml/day/plant was

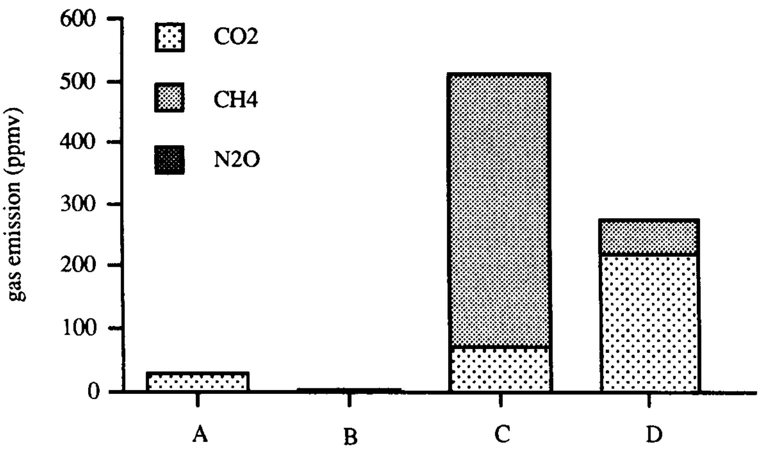

Fig. 4 The greenhouse effect gases emited from pig farm wastewater process
A: 1st aeration tank B: 2nd aeration tank
C: 1st anaerobic tank D: pig house No.2000

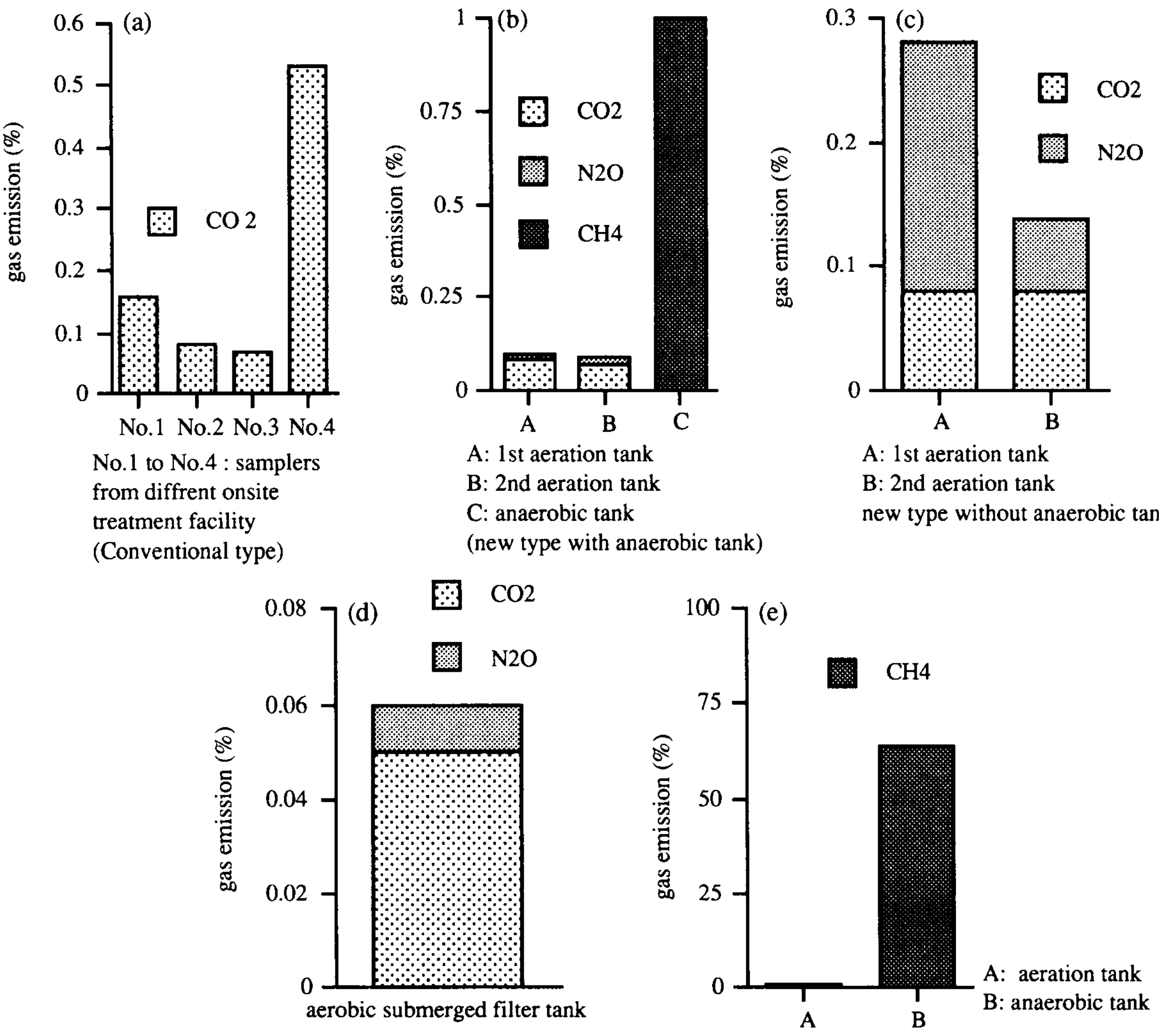

Fig. 5 The green house gases emission from each on-site treatment facility
(a) conventional extended aeration process (conventional type),
(b) new developed submerged filter process with anearobic tank,
(c) new developed submerged filter process without anearobic tank,
(d) (e) combined gray and black water treatment process using submerged filter

obtained from the settlement tank of the new developed type (night soil treatment facility), the production rate of CH_4 from the anaerobic contact aeration type (gray and night soil treatment facility) was 1,221ml/day/plant, and if converted by treatment population, the amount should be 174 ml-CH_4/day/person. It can be seen that the emission of CH_4 from the anaerobic submerged filter was quite high. This suggests that proper countermeasures should be taken in the future.

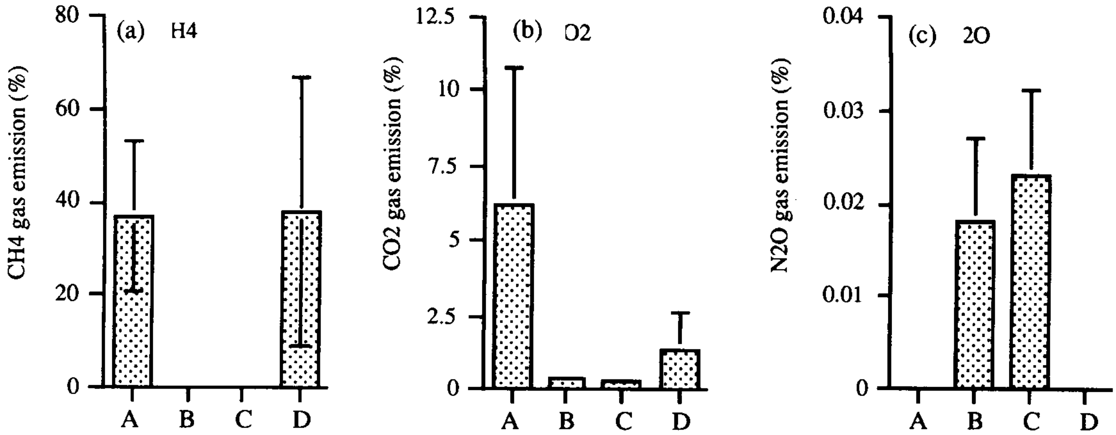

Fig. 6 The greenhouse effect gases fromwastewater treatment system
A: primary settling tank B: 1st aeration tank,
C : 2nd aeration tank, D: final settling tank

3.3 Greenhouse effect gases from wastewater treatment facilities

The amount of CO_2, N_2O, CH_4 emitted from each treatment process was shown in Fig.6. It can be seen from this figure that little N_2O emission was detected, but CH_4 emission from primary settling tank was quite high, and the emission from final settling tank was also detected. Furthermore the amount of CH_4 released from final settling tank was also as high as that in first settling tank. This is because the sludge in the final settling tank was excessive and it might contribute to the emission of CH_4. It was found that there was correlation between BOD loading and CH_4 concentration. The CH_4 emission increased with the increase of BOD loading (Fig.7). The emission factors for CH_4 and CO_2 were estimated to be 0.09-0.32, and 0.04-0.08 g/day/person, respectively.

From above discussion, it can be seen that the CH_4 emission from anaerobic processes may be one of the main factors contributing to the greenhouse effect in this three wastewater treatment systems, whereas the CO_2 emission is mainly from aerobic processes. However, the emission of N_2O was not detected in this survey. Further studies are needed on the emission of greenhouse effect gases from other wastewater treatment systems including RBC, wetland system, biological treatment process, UASB, and so on (Sudo, 1993).

In waste management, new technologies such as reduction and resource recovery, utilization of incineration heat, recovery of greenhouse effect gases should be positively promoted. Public awareness activities related to reduction, resource recovery and energy recovery should be also promoted (Inamori et al, 1991). The control of the greenhouse effect to be solved in the field of wastewater systems can be listed as below: 1) effective use of waste and wastewater to the air-condition and heating system in buildings; 2) development of technologies to reduce the N_2O production during nitrification and denitrification; 3) effective use of CH_4 to electric power; 4) use wastewater to agriculture and field land for harvesting; 5) culture of microorganisms to decompose and assimilate the CH_4, and so forth.

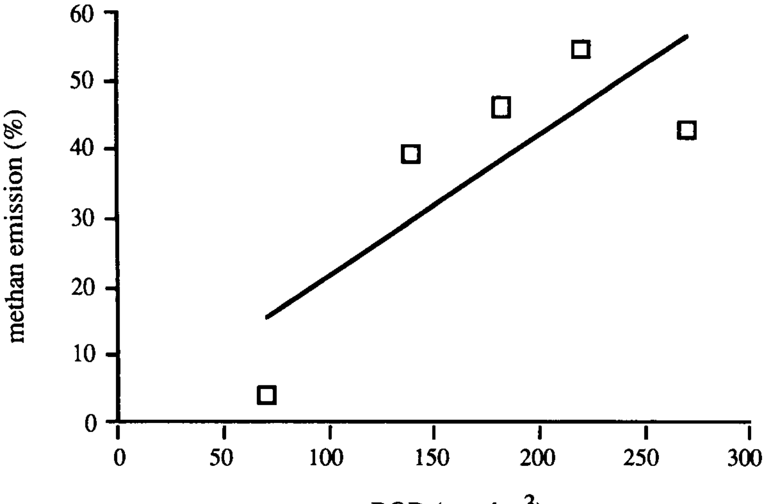

Fig.7 The corralation between BOD loading and CH_4 in primary settling tank.

((methane gas emission) =0.207x(BOD)+1.106 r=0.81)

4. Conclusions

Through three years' research, the emission inventory of these greenhouse effect gases such as CO_2, CH_4, N_2O was determined in each facilities and their processes.

1) The average amount of CH_4 and CO_2 gases from these areas was estimated to be 554 g-CH_4/day, 270 g-CO_2/day, and the dominant source of CH_4 gas was found in the anaerobic reactor, and the dominant sources of CO_2 was from aerobic reactor. It was calculated that the amount of CO_2 and CH_4 per capital in pig farm was 135 and 277 g/day/capital, respectively.

2) The amount of CO_2 emitted from the aeration tanks of both conventional type and new contact aeration type (night soil treatment facility) was quite small, and the clear relationship between the CO_2 emission and the treatment efficiency was not recognized; Only a small amount of N_2O was emitted from the aeration tank of the aeration type; The production of CH_4 at a rate of 8 ml/day/plant was obtained from the settling tank of the contact aeration type facility; The production rate of CH_4 from the anaerobic contact aeration type (gray and night soil treatment facility) was estimated to be 1,221ml/day/plant.

3) The emission factors for CH_4 and CO_2 were estimated to be 0.09-0.32, and 0.04-0.08 g/day/person in wastewater treatment facilities, and the correlation between BOD loading and CH_4 emission was recognized.

Further studies are needed on the emission of greenhouse effect gases from other wastewater treatment systems including RBC, wetland system, biological treatment process, UASB, and so on. Meanwhile, in waste management, new technologies such as reduction and resource recovery, utilization of incineration heat, recovery of greenhouse effect gases should be positively promoted. Public awareness activities related to reduction, resource recovery and energy recovery should be also promoted.

5. References

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