B-16.2 Study on the Estimation of the Release Suppression Effect of Greenhouse Effect Gases for the Appropriate Wastewater Treatment and Waste Disposal, and for the Social System Introduced Recycling

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ABSTRACT

For this study green house effect gas nitrous oxide(N_2O) produced in the domestic wastewater treatment process control technique has been carried out. N_2O can in principal be emitted from both biological nitrification and denitrification in the biological wastewater treatment process, perceiving digestion reaction, it was examined emitted mechanisms using batch cultivation system in this study firstly. As a results, it was effective keeping up low nitrate concentration in water to control N_2O emission, there is necessity for connecting anaerobic operation to keep in the reactor as typical nitrogen, phosphorus and nutrients removal process.

The effect on N_2O emission control as mainly investigated using intermittent aeration process and continuous aeration process that are one of the nitrogen and phosphorus removal processes and general wastewater treatment process, in this experiment. As a result, it was proved that nitrate concentration was maintained lower and N_2O emission was about 1/20 only in the intermittent aeration process compare with continuous aeration process.

Life-cycles of several kinds of beverage containers were examined and energies consumed during whole their life-cycles was analyzed for deriving better way of their recycling. With respect to PET beverage bottles and PSP food trays, possible alternatives for their recycling were described and evaluated in terms of energy consumption and saving. The life-cycle energy analysis was also carried out concerning an incineration facilities for municipal waste with power generation plant to balance its accounts of life-cycle energy and carbon dioxide.

KEY WORDS

Global warming gas control, Wastewater treatment, Waste, Recycle, Energy recovery, LCA,

1. INTRODUCTION

It is supposed that greenhouse gas have been emitted in great quantities from domestic and industrial wastewater treatment plant, but there are no exact evidence. The real situation for the greenhouse effect gases control method is not systematized. In this study, especially, a potentially important nitrous oxide(N_2O) has been examined. General domestic sewage is treated by biological process, and N_2O is emitted in nitrification under aerobic condition because most of these treatment processes are aerobic condition, biological nitrification is most important mechanism in this investigation.

Use of bottles and wrapping materials for food has been steadily increasing in Japan. Total amount of the materials is not very large, comparing with those which are used in other industries such as construction. It is a critical point from the viewpoint of sustainability in resources that lengths of life-cycles of such bottles and other products for wrapping last as short as a week. Life-cycles of several kinds of beverage containers were examined and energies consumed during whole their life-cycles was analyzed for deriving better way of their recycling. With respect to PET beverage bottles and PSP food trays, possible alternatives for their recycling were described and evaluated in terms of energy consumption and saving. The life-cycle energy analysis was also carried out concerning an incineration facilities for municipal waste with power generation plant to balance its accounts of life-cycle energy and carbon dioxide.

2. RESULTS and DISCUSSION

2.1 N_2O Emission Control in Domestic Sewage Treatment

2.1.1 Examination Using Batch Cultivation System

Nitrification proceeds sequentially through the following reactions,

$$\text{organic nitrogen} \Rightarrow NH_4\text{-}N \Rightarrow NH_2OH \Rightarrow NO_2\text{-}N/NO_3\text{-}N$$

and N_2O is thought to generate from the $NH_2OH \Rightarrow NO_2\text{-}N$ reaction. We have thought that $NO_3\text{-}N$ accumulation in water have a effect on nitrification and N_2O emission since the end products of nitrogen are $NO_3\text{-}N$ in nitrification reaction. A effect on N_2O products by nitrate coexisted in the reaction have been conducted in this study. In the experiment, the beginning condition was set up as 2000mg/l of MLSS, 30mg/l of $NH_4\text{-}N$, 0,15,30 and 60mg/l of $NO_3\text{-}N$ using 2l of flask. A change on standing of N_2O concentration of air phase and $NH_4\text{-}N$, $NO_3\text{-}N$ concentration of liquid phase were calculated at pH 7.0 adjusted by using HEPES as a buffer.

Nitrification rate and a change on standing of $NH_4\text{-}N$ in each series were shown in figure 1 and 2. Nitrification reaction from $NH_4\text{-}N$ to $NO_3\text{-}N$ was progressed almost 100% in all of 4 series not depend upon nitrate concentration added in the beginning step and $NH_4\text{-}N$ was almost 0mg/l in an end of experiment. Also nitrification rates were not different for all of series and reaction of all series were almost finished in 9 hours after beginning of experiment. As a result, nitrification reaction of $NH_4\text{-}N$ was done completely for the range of nitrate

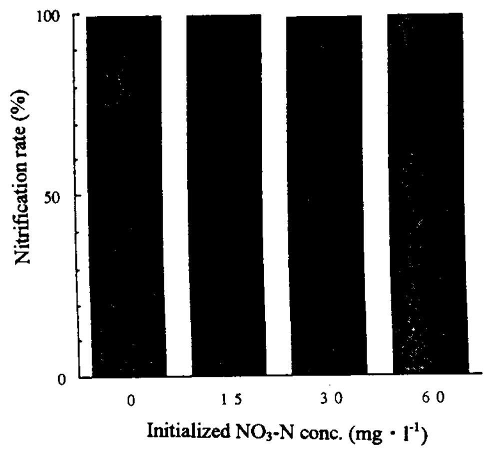

Fig.1 Nitrification rate

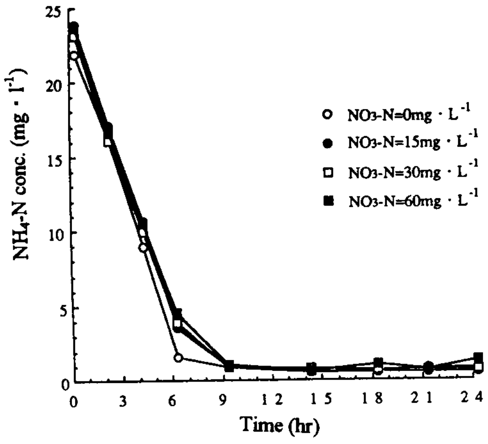

Fig.2 The change of NH_4-N conc. on the elapsed time

concentration in the water. It was found that in the comparison of N_2O emission volume against 1mg of MLSS at the end of experiment, in figure 3, N_2O emission rate was in proportion to coexisted NO_3-N concentration. Conversion rate from NH_4-N consumed to N_2O(figure 4) in the reaction was greater as increasing of NO_3-N concentration coexisted in the beginning nitrate was about 1.5% the series whose initial concentration in 60mg/l but there was no difference between 15 and 30 mg/l of initial concentration, and it was maintained about 1/3 only compare with the series of 50mg/l. It was found that from this results, greater NO_3-N concentration in the water N_2O emission volume is increased by nitrification. Another words, to control N_2O emission, NO_3-N concentration existed in nitrification should be kept lower in any case.

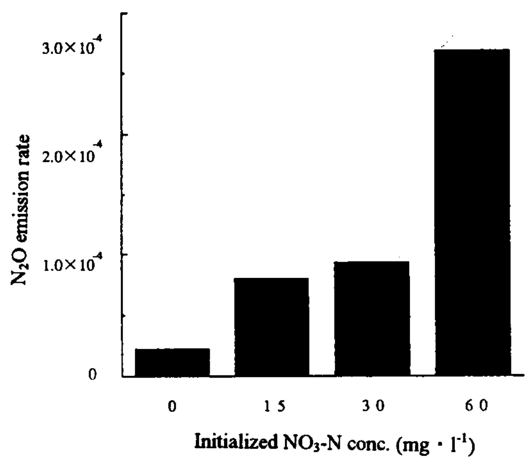

Fig.3 N_2O emission rate per 1mg of MLSS

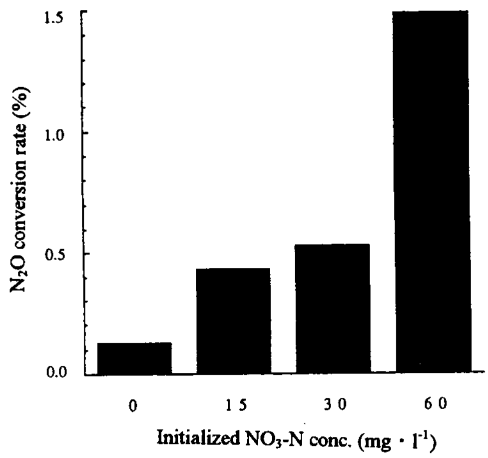

Fig.4 Conversion rate of NH_4-N to N_2O(N base)

2.1.2 Examination for Facilities of Wastewater Treatment Plant

Figure 5 shows volume of N_2O emission converted from $1m^3$ of influent wastewater. There was big different between intermittent and continuous aeration process as emitted

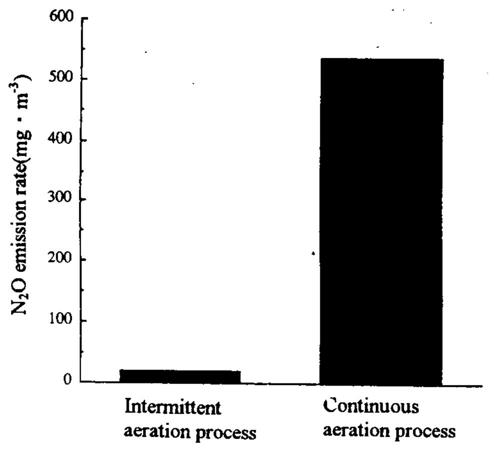

Fig.5 N_2O emission rate per 1m^3 of treated sewage

volume were 20mg and 536mg. In continuous aeration process, nitrogen concentration of treated water was relatively higher than that of the other process and it was almost existed as NOx-N as well as nitrogen removal rate, was up to 80%, but was less than 10% for this process. Conversion rate of N_2O from influent nitrogen was shown in figure 5 as 1.2% of influent nitrogen was converted into N_2O. This result was coincided with results of batch cultivation system and was found NO_3-N concentration of aeration tank in treated plant should be kept lower to control N_2O emission.

2.2 Recycle of Beverage Bottles and Assumption of Life-Cycle Energy for Waste Incineration Facilities

2.2.1 Life-Cycle Energy of Beverage Bottles

Life-cycle energy was calculated from various statistical, published and/or industrial data for four beverage containers, i.e., PET bottle, glass bottle, steal can and aluminum can. The result showed that there are much differences among the containers in consumed-energy distribution over each life stage of them, in particular, so between the aluminum can and the glass bottle. The aluminum can dissipates more than 80% of its life-cycle energy in its former life stages, i.e., mining and refining processes. A large portion of the energy, therefore, can be saved by collecting the post-consumer cans and providing them to the can production. On the other hand, the glass bottle dissipates most of its life-cycle energy in the bottle production stage or the latter stages. Thus, reuse of the post-consumer bottles for refilling contributes to the energy saving much more than recycling of them in fragments

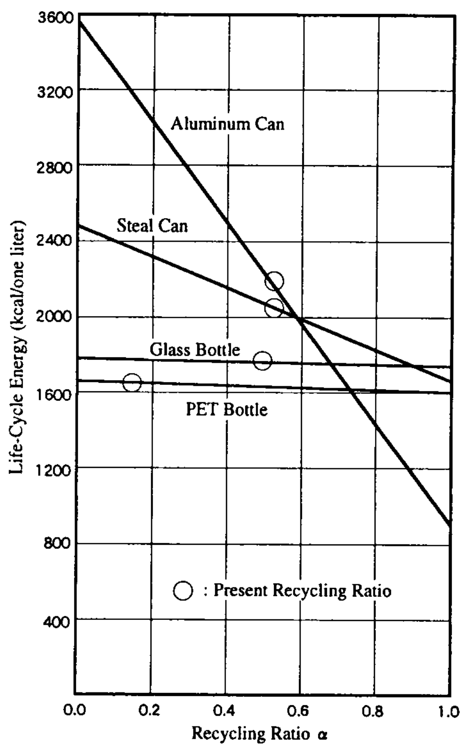

Fig.6 Life-cycle energy depending upon recycling ratio of beverage containers

for re-producing the bottles. The energy saving efficiency of the former was estimated to be six or seven times of that of the latter.

It is practically impossible to collect and use 100% of the post-consumer containers for recycling or reuse. The life-cycle energy of each container carrying one liter of beverage was calculated, depending upon its recycling ratio, which is represented in Figure 6. The containers collected separately from other wastes were supposed to be recycled to the production process of the same kind of containers, but the exception was PET bottles for which an incineration with energy recovery was assumed. The containers collected together with other wastes were supposed to be sent to the land reclamation. The circles in the figure indicates the present ratios of recycling in Japan. The figure describes that, supposing that the recycling ratios are maintained as they are, there are only small differences among the life-cycle energies for the four beverage containers.

2.2.2 Evaluation of Recycling Alternatives for PET Bottle and PSP Tray

Most of wasted plastics are being disposed of and buried at land reclamation in Japan. Some alternative ways other than the disposal, however, has been proposed because of the facts that only limited areas are available for the reclamation, and that the plastics have an usable and high inherent energy. Evaluation were here made on such proposals in terms of total saved energy associated with the alternatives, in conjunction with a model case of Tokyo Metropolitan Area.

Four alternative ways recycling post-consumer PET bottles and PSP trays were taken into consideration. Those are, at present, relatively realizable alternatives, that is, incineration together with other household wastes for energy recovery, incineration of the plastics only for energy recovery, and two material recyclings. In both the recyclings the collected materials are provided to the production of the bottle or tray, but there is a difference between these two in a way collecting the wastes from consumers.

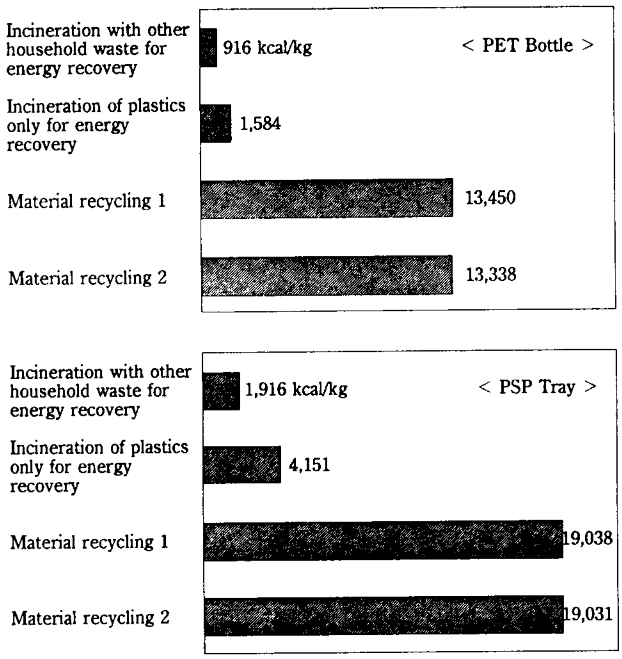

Fig.7 Total energy saved by recycling alternatives of the study

Figure 7 compares total saved energies for the alternatives of the study. The two material recyclings were much superior to other two alternatives, i.e., incineration for energy recovery. And the way of waste collection was elucidated not to effect much on the result, since no significant difference in the saved energy was observed between the two material recyclings. Accordingly, the same superiority of the material recycling can be expected in other smaller city or rural area, where the efficiency of waste collection is somewhat worse.

2.2.3 Life-Cycle Analysis of an Incineration Plant for Municipal Waste with Power Generation

Recently many incineration systems for municipal waste have been equipped with power generation plants. The motivation for this is that the recovery of energy through power generation is expected to decrease the demand for power generated from fossil fuels thereby reducing emissions of carbon dioxide, a primary greenhouse gas. It should be recognized, however, that the installation of power generators and related equipment in incineration systems result in the consumption of some additional amounts of energy and resources and their associated environmental burdens. A life cycle analysis of a municipal waste incineration system with a power generation plant was made to estimate net amounts of energy production/consumption and carbon dioxide emissions during all stages of the plant's life.

The study revealed that the production of construction materials such as iron and concrete requires the greatest portion of total requirements and thus emitted the most carbon dioxide among all life stages of the system. Figure 8 represents the energy balance of a waste incineration system with a power generation plant. The energy used for producing and maintaining the power generator and related components is indicated separately from that for the others. The energy generated by the system is large compared with not only that required for producing, installing and operating the portions of power generation unit but also that required for the whole incineration system. In addition, the power generated by waste incineration lessens demand for power from fossil fuel power plants, thereby reducing in the net emission of carbon dioxide to the atmosphere.

Most recent incineration facilities with large capacity have power generation plants in Japan, but the proportion of such facilities is presently still less than 20 %, including those plants generating some limited amount of power due to various other reasons. The spread of power generation from municipal waste should be facilitated by investigation of economic, social and regulatory mechanisms.

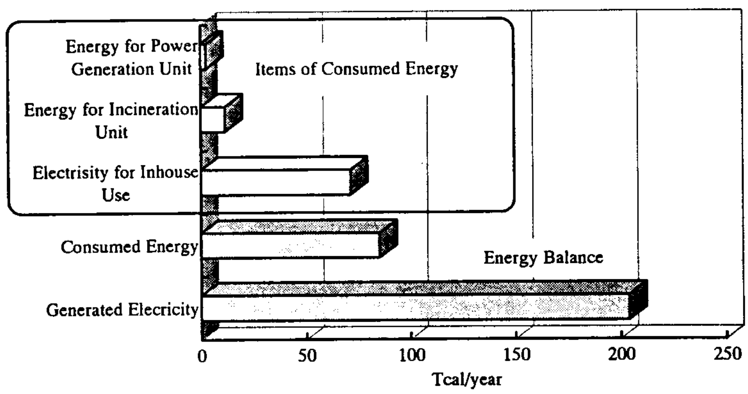

Fig.8 Energy balance around an incineration system for municipal waste with power generation plants