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LANDFILL WASTE WARTER TREATMENT BY APPLICATION OF PULSED HIGH VOLTAGE

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ABSTRACT: In this study, using the plasma generated from the pulsed discharge process, we examined the possibility of simultaneous degradations of dye substance and COD component in the landfill waste water. Furthermore, the possibility of sterilization by the plasma was investigated in the experiments. Experiments were performed to investigate the effects of voltage, repetition rate, charging time and O_2 coexistence on the sterilization and degradations of COD and dye substance. The experimental results show that the sterilization and simultaneous degradations of the dye substance and COD are possible by the plasma and the dye substance is easily decomposed by the plasma from COD. The degradations of the dye substance and COD were enhanced by the presence of O_2, while the effect on the dye substance degradation is larger than COD degradation. The results reveal that sterilization is possible by plasma, and E. coli is completely dead as compared with the bacteria is difficult to kill completely by the plasma.

Keywords: Landfill Waste Water, Plasma, COD, Dye Substance, Sterilization

1. INDRODUCTION

Many of the common final disposal site in Japan, non-combustible residue and ash comprised incineration of waste are mainly reclaimed. Many contaminants, such as SS, BOD, COD, dye substance, nitrogen content and salts etc. are contained in the effluent of these landfills [1]-[2]. In many disposal sites, the BOD value of the water meet the water quality standard value, but the COD does not reach the water quality standard value in many cases. The factor of COD component is dye substance, such as humic acid, fulvic acid etc.. These substances are difficult to decompose biologically, as so-called non-biodegradable organic matter.

Currently, landfill waste water treatment has been used physical treatment and biological treatment. However, biological treatments there are the following problems. That are, the processing time is long, the maintenance of micro-organisms is difficult, and can be not respond to change long-term leaching of water quality. Physical treatment methods commonly use aggregation, precipitation method etc., but there are the problems of sludge generation and high cost required to process.

In this study, using the plasma generated from the pulsed discharge process, we examined the possibility of simultaneous degradations of dye substance and COD component in the landfill waste water. Furthermore, the possibility of sterilization by the plasma was also investigated in the experiments. The pulsed discharges produce ozone, free radicals, ultraviolet radiation, and shockwaves in water, and can be utilized for a more effective water treatment [3]-[5].

Since the breakdown voltage in water is much higher than that in air, a large power supply and expensive pulse forming network are required. In this study, a pulsed discharge reactor is used to produce plasma in gas phase and wastewater is sprayed into the plasma for treatment. This system combines the advantage of using small, simple, and inexpensive power supply and pulse forming network for electrical discharges in air and directly utilizing ozone, as well as free radicals and ultraviolet radiations for treating the wastewater.

The experiments reported here were designed to investigate the effects of charging voltage, repetition rate, discharging time and O_2 coexistence on the sterilization and degradations of COD and dye substance.

2. EXPERIMENTS

The experimental apparatus is shown in fig.1. The apparatus is combined of pulsed power generator, pump, O_2 cylinder, electrode and oscilloscope. The discharge chamber comprised of parallel electrodes enclosed in a vinyl chloride container (140mm×140mm×350mm). The size of frog electrode is 80mm in length, a width of 60mm, 12 mm needle length is fixed to equal 72 present on the surface. The plate electrode is made of stainless steel and sizes of width and length are 60mm, 80mm respectively. A showerhead for injecting droplets into the chamber is set at the lower part in the chamber. The experiments were carried out by using the real landfill waste water in this study. Waste water is sprayed into the reactor from a showerhead at a flow rate of 180ml/min. The sprayed water solution is collected in a container connected to the reactor and is circulated to the reactor by a pump.

The voltage and current are observed by an

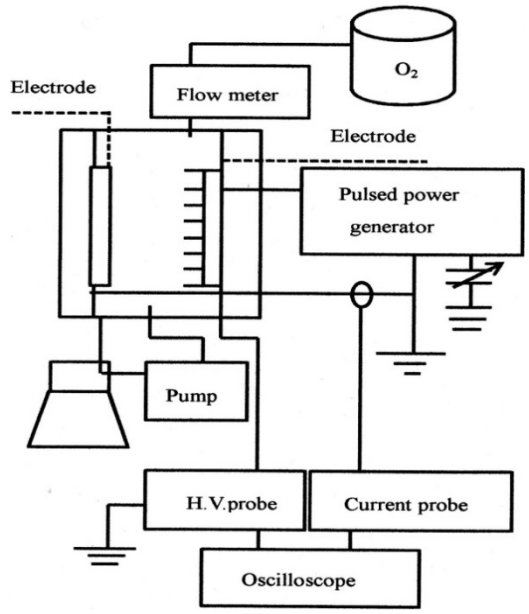

Fig.1 Schematic diagram of the experimental apparatus

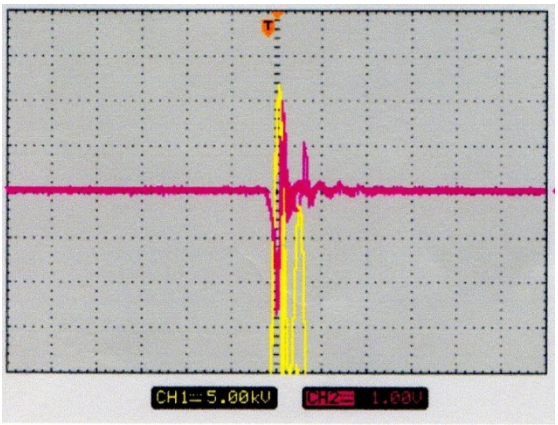

Fig.2 Typical waveforms of pulse voltage and discharge current

oscilloscope (Iwatsu, DS-5110) via a 1/1000 high voltage probe (North Star, PVM-2), a 0.1V/A current probe (Person, 6600). Discharging power varies with discharge repetition rate of and charging voltage of the capacitor.

Discharging power varies with the changes of repetition rate and charging voltage. The sterilization and degradations of COD and dye substance were examined for the various discharging power and O_2 coexistence (table 1). The effects of O_2 presence and reptition ratio on the sterilization was also examined in this experiment (table 2). The ratio of decolorization of dye substance was measured with a UV and visible-light absorption spectrometer (Shimadzu, Uvmini-1240). The concentration of COD was measured with a CODMn and E. coli and bacteria were measured with DD chiekka-(Asone).

Table 1 Experimental conditions

No.	Voltage	Repetition rate	O_2
	(kV)	(pps)	(ℓ/min)
1	32	100	0.5
2	37	100	0.5
3	42	100	0.5
4	42	65	0.5
5	42	80	0.5
6	42	100	0
7	42	100	0.1
8	42	100	0.25
9	42	100	0.5
COD:366mg/ℓ, capacity:500mℓ			
flow rate:180mℓ/min, cromaticity:1200°			

Table 2 Experimental conditions

No.	Voltage	Repetition rate	O_2
	(kV)	(pps)	(ℓ/min)
A	35	65	0
B	35	80	0
C	35	100	0
E	40	50	0
F	40	50	0.5
G	40	50	1
E. coli :97CFU/ml, capcity:500mℓ			
flow rate:220mℓ/min, bacteria:115CFU/ml			

3. RESULTS AND DISCUSSION

3.1 Effects of repetition rate and charging voltage on the ratios of COD decomposition and decolorization

The pulse energy changes with the changes of repetition rate and charging voltage and current. Fig.3 shows the effect of charging voltage on the ratios of COD decomposition and decolorization. When increasing the charging time from 0min to

30min, the COD decomposition ratios increases from 0% to 2%, 2%, 29% for the charging voltages of 32kV, 37kV and 42kV respectively. The COD decomposition ratios increase to 7%, 14% with the change of the charging time from 30 to 120minutes at the charging voltages of 32kV, 37kV, respectively. However, at the charging voltage of 42kV, the COD decomposition ratio increases from 29 to 36% in the same charging time. These results show that a constant voltage is required for the degradation of COD components by plasma. The results carried out at the charging voltage of 42kV also show that the component of COD can be roughly divided in to indecomposable component and easily decomposable component. The easily decomposable component is decomposed in the initial treatment time and the indecomposable component remains in the process late. The ratio of decolorization increases with the increases of charging time and voltage. When increasing the charging time from 0min to 120min,

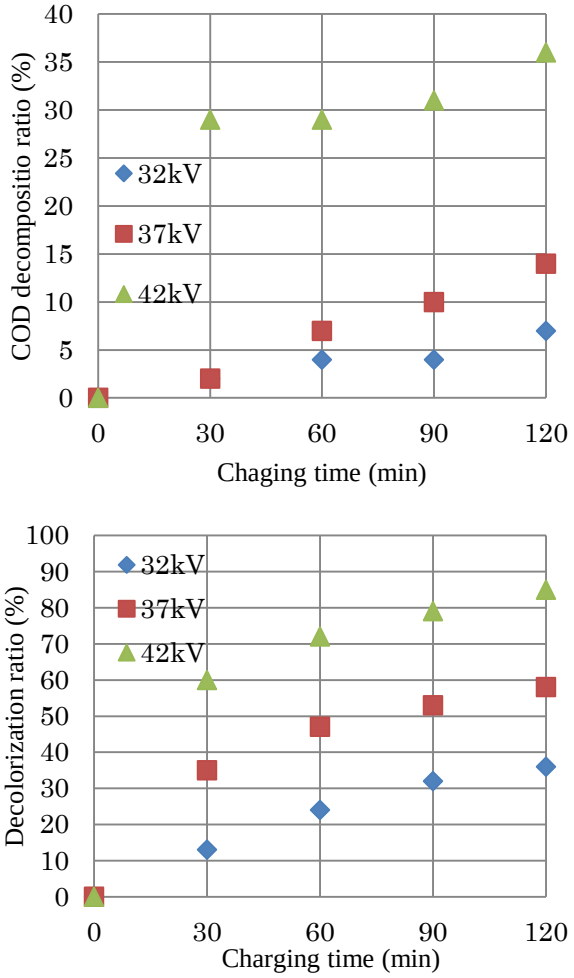

Fig.3 Effect of charging voltage on the ratios of COD decomposition and decolorization

the ratio of decolorization increases from 0% to 82 % at the charging voltage of 42kV. This maximum decolorization ratio of 82 % is much higher than that for the maximum decolorization ratio of 35% at the charging voltage of 32kV. Comparison of the effect of charging voltage on the ratios of COD decomposition and decolorization shows that simultaneous degradation of the dye substance and COD are possible by the plasma and the dye substance is easily decomposed by the plasma from COD. Fig.4 shows the effect of repetition rate on the ratios of COD decomposition and

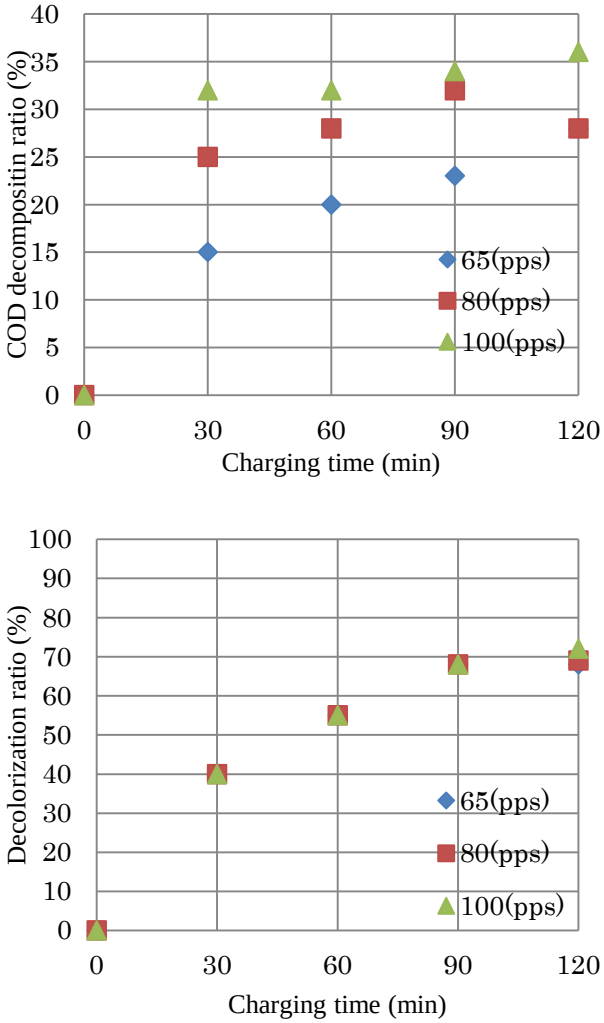

Fig.4 Effect of repetition rate on the ratios of COD decomposition and decolorization

decolorization. As the repetition rate of the applied voltage increases from 65 to 100 pps, the decomposition ratio of COD increase 8% in the range of the charging time, however, the variation in decolorization ratio show similar tendency for the change of the repetition rate from 65 to 100pps. These results show that the COD decomposition ratio is affected by the increase in the repetition tare and the decolorization is not affected by most to changes in the repetition rate.

3.2 Effect of O_2 coexistence on the ratios of COD decomposition and decolorization

Fig.5 shows the effect of O_2 coexistence on the ratios of COD decomposition and decolorization at the charging voltage of 42kV and repetition rate of 100 pps for the variation of O_2 gas flow from 0 to 0.5ℓ/min. When increasing the charging time from 0 to 120 minutes at the O_2 gas flow of 0ℓ/min, the decomposition ratio of COD increases from 0 to

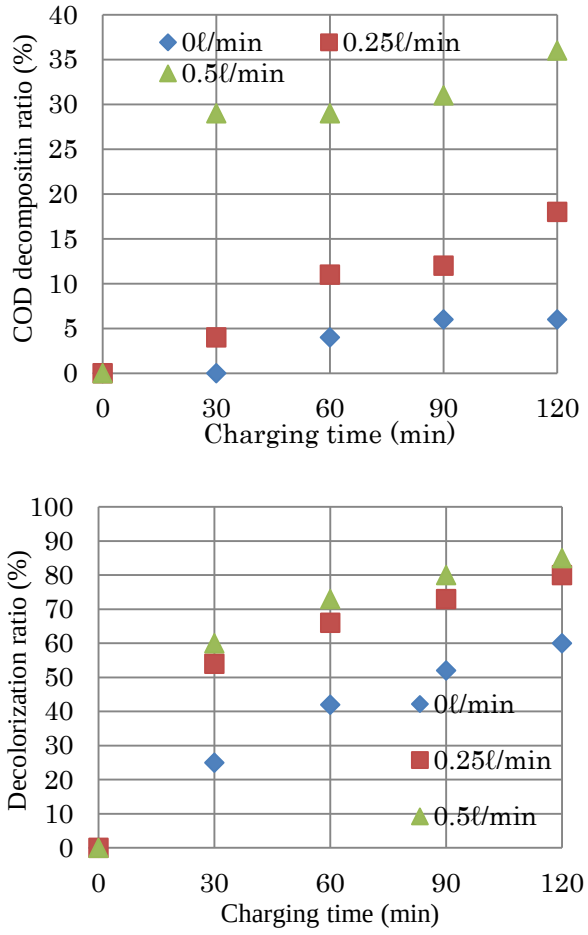

Fig.5 Effect of O_2 coexistence on the ratios of COD decomposition and decolorization

5%. However, The decomposition ratio of COD increases from 0 to 36% as the increasing of O_2 gas flow rate 0 to 0.5ℓ/min. This means that the variation of the O_2 gas flow rate from 0 to 0.5ℓ/min results in the increase of 31% of the COD decomposition ratio. On the other hand, when increasing the charging time from 0 to 120 minutes at the O_2 gas flow rate of 0 ℓ/min, the decolorization ratio increases from 0 to 50 %. When increasing the O_2 gas flow from 0 to 0.5 ℓ/min, the maximum decolorization ratio increases from 50 to 82%. A basic mechanism of non-thermal plasma in electrical discharge processing for the treatment of wastewater is considered to be the formation of a strong electric field and strong non-thermal plasma where high-energy collisions of molecules with electrons generate various active species such as OH, O, H, O_3, etc.

$$O_2 + e \rightarrow 2O + e \quad (1)$$
$$H_2O + e \rightarrow HO + H + e \quad (2)$$
$$O + O_2 \rightarrow O_3 \quad (3)$$
$$HO + HO \rightarrow H_2O_2 \quad (4).$$

Comparison of the effect of O_2 flow rate on the ratios of COD decomposition and decolorization shows that the O_2 coexistence enhances decomposition rates of COD and dye substance by the generate O and O_3, and effect of O_2 coexistence on the decolorization is higher than that decomposition of COD.

Maximum decomposition rate of COD is about 35% and the maximum decomposition rate of the dye is about 85%. This indicates that the maximum decomposition rate of the dye is about 2.4 times the COD maximum decomposition rate. The factor of COD in landfill drainage is dye substance, such as humic acid, fulvic avid etc.. The dye substance is polymeric materials, and has a complex molecular structure. The pulsed discharges produce ozone, free radicals, ultraviolet radiation, and shockwaves in water, and can be utilized for a more effective water treatment. While the many physical and chemical phenomena occurred with electrical discharges are connected with the discharge energy. Experimental results described above indicate that the plasma and active substance generated from the discharge process of the experimental conditions of this paper can destroy the molecular structure of these polymer organic material, contributes to reduce the concentration of dye, and that it is difficult to completely decompose these polymer organic material to CO_2 and H_2O.

3.3 The possibility of sterilization in the landfill waste water treatment by the plasma

Fig.6 shows the experimental results carried out in the experimental condition 2, which investigated the possibility of sterilization in the landfill waste water treatment by the pulasma. It can be seen from the figure that the charging time over 20minutes, the survival ratio of E. coli is 0%, and bacteria survived even 60 minutes. In addition, when increasing the charging time from 0 to 60minutes, the survival ratio of bacteria is lower at the experimental conditions of A and F than that the other experimental conditions. These results indicate that the bacteria are difficult to kill by

plasma completely and survival ratio was affected by the changes of repetition rate and O_2 gas flow rate.

4. CONCLUSIONS

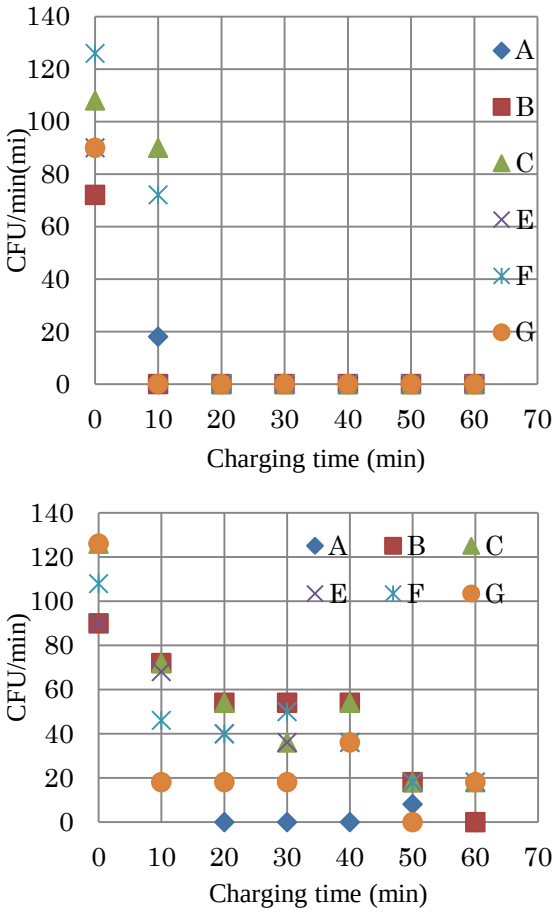

Fig.6 The effect of sterilization by using plasma

The effects of the repetition rate, charging voltage and O_2 coexistence on the ratios of COD decomposition and decolorization have been investigated by pulsed discharge in water droplet spray. The comparisons of the experimental results have clarified that the sterilization and simultaneous degradations of the dye substance and COD are possible by the plasma and the dye substance is easily decomposed by the plasma from COD.

The degradations of the dye substance and COD were enhanced by the presence of O_2, while the effect on the dye substance degradation is larger than COD degradation. The effects of repetition rate and O_2 coexistence on the sterilization has also investigated. It was found that sterilization is possible by the plasma, and E. coli is completely dead as compared with the bacteria is difficult to kill completely by the plasma.

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