Treatment and Recycling Process for Biosolids by Radiation

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1. Introduction

The volume of sludge is increasing rapidly on a yearly basis in Korea. Liquid sewage sludge generated in Korea has been treated as reuse (7%), landfill (5%), incineration (12%) and ocean dump (72%) in 2003 [1]. Ocean dump is the main treatment of sewage sludge up to date but incineration and landfill will be increased because Korean government will restrict ocean dump in the near future. Desirable treatment of sewage sludge is still a sensitive issue though many scientists have vigorously studied the safe and environmentally sound treatment of sewage sludge and reducing sludge cake [2, 3, 4].

Therefore reduction of moisture content in sludge and recycling by radiation is the main objective in this work.

Here we studied the radiation technique as a pre-treatment process to enhance sludge dewaterability, to disinfect micro-organisms, and to remove the toxic organics in sewage sludge simultaneously. The improvement of sludge compost after irradiation was also observed to develop the method for recycling of sludge.

2. Methods and Results

2.1 Materials

Sewage digested sludge was collected from sewage treatment plant in D-city, Korea. Total solid concentration of sludge was 3.9~4.8% (w/w) and organic content was about 54% (TVS/TS). All samples were examined in 24 hr after collection to minimize the alteration of sludge and the experiment was executed at room temperature.

2.2 Electron beam irradiation

The electron accelerator (1.5MeV, ELV-4 Model) was used from EB Tech. Co. in Korea. All samples were poured into a flat glass tray (Pyrex. Co., U.S.A.) at the thickness below 5mm and then irradiated.

2.3 Enhancement of sludge dewaterabiligy

Moisture content in sludge cake was largely reduced by about 10% (w/w) after irradiation at the maximum dose of 20 kGy (Figure 1). It suggests that a high energy of radiation might cause the disruption of sludge particles into smaller ones, which induced the removal of the interstitial water from sludge [5, 6]. Zeta potential was increased by 1 ~ 4mV when irradiated at 6, 10, 20 and 30kGy respectively. When sludge was irradiated, viscous polymers of sludge could be disrupted and it would induce the lower negative zeta potential than that of unirradiated one. The reduced repulsive force between particles could induce the effective dehydration of sludge after irradiation.

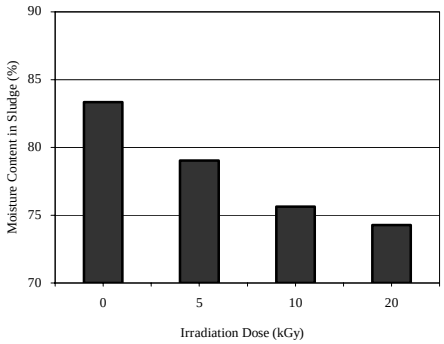

Figure 1. Moisture content in sludge as a function of irradiation dose.

2.4 Disinfection

Disinfection of sludge by electron beam irradiation was evaluated by measuring bacteria and *E. Coli* before and after irradiation. Over 99% of bacteria and *E. Coli* were reduced at the low dose of 1 kGy (Table 1), which means that irradiation could be a very effective tool enhancing the dewaterability as well as sterilizing the micro-organisms in sludge. SEM images of Figure 2 showed the alteration of cell wall of *E. Coli*. Unirradiated *E. Coli* showed the clear bacillus structure but electron beam brought the damage to it and changed its external structure significantly.

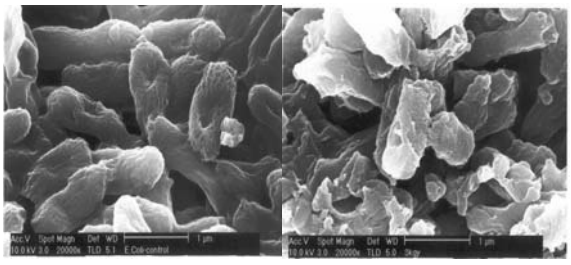

Figure 2. SEM images of *E. Coli* before (left) and after (right) irradiation at the dose of 3 kGy.

Table 1. Reduction of the bacteria and the colony forming unit of *E. coli* as a function of irradiation dose.

Irradiation Dose	Bacteria		*E. Coli*	
	CFU/ml	Reduction (%)	CFU/ml	Reduction (%)
0 kGy	1,300,000,000	0.00	375,000	0.00
1 kGy	1,040,000	99.92	1,050	99.72
3 kGy	460,000	99.96	330	99.91
6 kGy	220,000	99.98	290	99.95
10 kGy	77,000	99.99	185	99.92

2.4 Decomposition of Organic Contaminants in Sludge

The fundamental study on decomposition of PAHs was carried out to reduce the organic toxicity of sludge by radiation (Figure 3). According to increasing dose rate up to 25 kGy, naphthalene, acenaphthylene, acenaphthene, fluorene, and phenanthene were decomposed over 99%, anthracene, fluoranthene, pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene were decomposed over 90 %, and benz(a)anthracene and chrysene were removed by 73 % and 68 %, respectively.

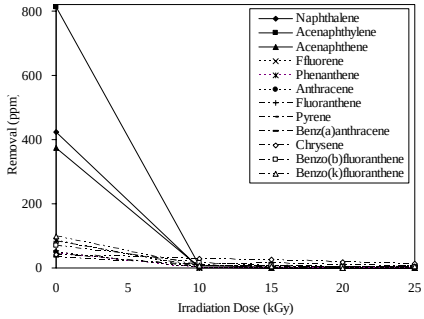

Figure 3. Decomposition of PAHs by radiation.

2.5 Composting of Sewage Sludge

Sludge was recycled in the form of compost to recycle the bio-waste. Irradiated and unirradiated sludge were composted for 60 days and their germination indices for the Chinese cabbage and the lettuce were measured to evaluate the worth of compost and the toxicity. Figure 4 and 5 showed that irradiation induced a good effect on sludge compost because high energy of radiation could eliminate not only the hazardous microorganisms but also other toxic organic materials.

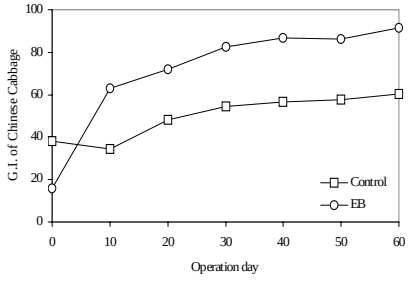

Figure 4. Irradiation effect on the germination index (G.I.) of sludge compost for the Chinese cabbage.

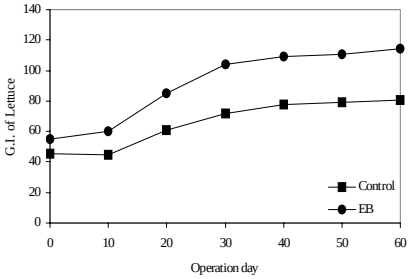

Figure 5. Irradiation effect on the germination index (G.I.) of sludge compost for the lettuce.

3. Conclusion

From this work, the following conclusions were made. Moisture content in sludge was reduced up to 10% (w/w) by using electron beam. It suggests that radiation treatment could be one of the promising processes for reducing the bio-waste. Radiation process could give the clue for securing the biological safety and the clean environment by sterilization of the bacteria and *E. Coli* and by decomposition of the toxic organic contaminants in sewage sludge. Radiation process might be an environmentally sound method for treatment and recycling the sewage sludge.

Acknowledgement

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