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Dewaterability enhancement of digested sewage sludge by ultrasonic treamtment.

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1. Introduction

Large quantities of sludge are produced from biological wastewater treatment facilities. From operational and economical view points, one of the most important steps in wastewater treatment is the separation and removal of the excess water generated during the treatment process. Therefore, several sludge conditioning methods have been implemented to improve the dewatering characteristics, including the use of inert filter aids, thermal conditioning, freezing, thawing, elutriation and the addition of chemical conditioners[1),2)]. Ultrasound is also used as a process for dewaterability enhancement of sluge[3),4)]. The ultrasonic process leads to cavitation effects, which is extream condition as like high temperature (> 5000 K) and pressure (> 1000 atm) and highly oxidizing OH radicals due to implosive collapse of the cavitation bubble. This phenomenon of ultrasound can be changed to sludge dewatering propety, and to accelerate organic pollutants degradation.

Therefore, the objective in this study was observed dewaterability of sluge by ultrasonic treatment with capillary suction time (CST) and specific resistance to filtration (SRF), as indicator of sluge dewaterbility degree. And, increasing of volatile fatty acids (VFA) as biodegradable organic compounds was also investigated.

2. Experimental Method

The sludge samples were collected after the anaerobic digestion tank, from the Jungnang municipal wastewater treatment plant, Seoul, Korea. The total solids and water content of the sludge were approximately 1.5 and 98-99%, respectively. The pH of the sludge was 7.6. A bath type ultrasonic processor (Chosun, Model CS-1000, 30×30×30 cm, Korea) with 8 unit transducers of 28 kHz was used, as shown in **Fig. 1**. During the sonication treatment, the temperature of sludge was uncontrolled (from 15 ℃ to nearly 60℃)

The CST and SRF were measured to evaluate the dewaterability of sludge due to the ultrasonic

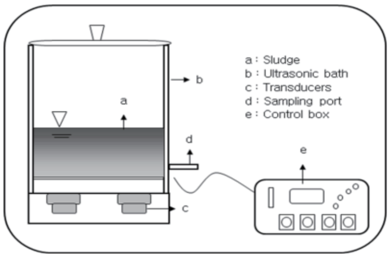

Fig.1 Schematic diagram for sludge treatment

process. The CST is a consumed time for the filtrate (CST paper; Whatman # 7, chromatography paper) to travel from the inner circle to the outer circle point measured in seconds[2)]. A CST of the raw sludge samples of about 100~110 seconds was chosen to correct other initial impacting factors. The SRF test, also known as the Büchner funnel test[2)], is one of the most commonly employed tests for the evaluation of the dewaterability/filterability of wastewater sludge. The filtering was performed using a 9-cm diameter Whatman #1 filter paper, at an applied vacuum pressure of 51 kPa. The CST and SRF tests were performed at a constant temperature (20℃) to minimize the influence of temperature.

Total solids (TS) of the ultrasonically treated sludge and water content of the sludge cake were measured using normalized methods[5)]. The VFA was also measured by the analytic procedure described by Buchauer (1998)[6)].

3. Results and Discussion

The results under each set of test conditions, both before and after ultrasonic treatment, are presented as the volumetric supplied energy term. The ultrasonic process is influenced by three factors: supplied input power, sample volume and ultrasonic treatment time, but at a fixed frequency (28 kHz). The volumetric supplied energy (kJ/L) parameter, denoted as *Ev*, has been used in order to compare results. *Ev* is defined by:

$$E_V = {}^{P \times t}\!/_{Vol.} \quad [1]$$

Where *P* is the consumed ultrasonic power (kW;

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0.1, 0.3, 0.6 kW), *Vol.* is the total volume of the sludge sample (ℓ; 0.2, 0.5 ℓ) and *t* is the ultrasonic irradiation time (sec; 1800, 3600 sec) [7].

Table Ⅰ shows the volume reduction between ultrasonically treated sample and controlled sample after centrifugation (50 ml).

Table Ⅰ Digested sludge by ultrasonic treatment

Sludge	Control	5,400 kJ/L
Water content in sludge cake (%)	88	67
Sludge cake production rate (L/m^3 of total sludge, kg TS/ton of total sludge)	100/ 7.1	26/ 5.0
Volume ratio (V_2/V_1) Mass ratio (M_2/M_1) (of sludge cake)	0.26/0.69	

Final sludge cake volume is reduced about 75 % from 5ml to 1.2ml at ultrasonic energy of 5,400 kJ /L. And, TS of sludge cake also was decreased about 30 % as compared to that of sludge cakes without ultrasonic treatment. From these results, we know that produced sludge cake mass was reduced by ultrasonic treatment. In order to verify this phenomenon, a VFA as soluble or biodegradable organics and water content change were measured with operation time (E_v), as shown in **Fig. 2**

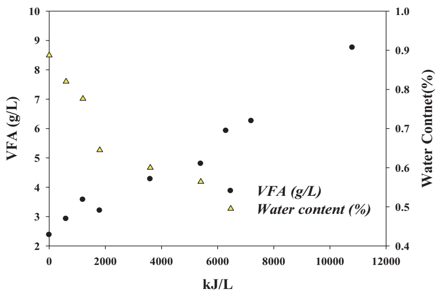

Fig.2 VFA (g/L) and water content (%) change of ultrasonically treated sludge.

The VFA was increased about 4 fold with ultrasonic treatment according to input energy increasing. And the water content was also decreased about 50%. This means that water and dissolved organic which are locked inside the sludge can be easily extracted due to the sludge flocs decomposition and suspended solid fragment in presence of ultrasound. Therefore, after dewatering process, the water content and total solid in sludge cake can be decreased. In addition, increased soluble organic matter (VFA) can be positively used as a carbon source at advanced wastewater treatment system including the biological nitrification/denitrification process.

Fig. 3 shows the CST and SRF change, as an indicator of dewatering degree of sludge during a set operation time, according to increase of E_v.

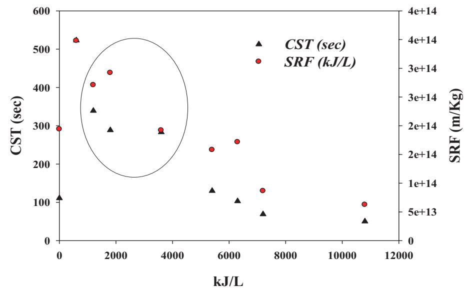

Fig. 3 CST (sec) and SRF (mg/kg) of sludge change with ultrasonic treatment energy.

A decrease of the CST and SRF was observed in the Fig. 3, except within the 4,500 kJ/L. This result with the CST of ultrasonically treated sludge was increased than that of control sample was also observed from other references [8),9)]. This is because that the supplied ultrasonic energy in their research was too lowed about 100-1,200 kJ/L. At the low ultrasonic energy, the cell shearing in solution and viscosity increase can be occurred by incomplete sludge flocs disruption. However, if high energy level of ultrasound (above 5,400 kJ/L in this study) applied into solution, the dewaterability of sludge is increased according to decreasing of the CST and SRF. Therefore, we can know that total produced sludge cake volume and mass of ultrasonically treated sludge were decreased, and the dewatering property was also enhanced at high energy ultrasonic condition, from these results.

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References

1. P. J.Parker, A.G. Collins, J.P. Dempsey: ES&T. **32** (1998) 383.
2. C.C.Wu, C. Huang and D.J. Lee: Colloids & Suf. **122** (1997) 89.
3. Y.U.Kim and B.I. Kim : JJAP. **42** (2003) 5898.
4. J. H. Park, Y. U. Kim, J. S. Lee and M. C. Wang: JJAP **48** (2009) 07GM15-1.
5. APHA AWWA WEF: (Ame. Pub. Hea. Ass., Washington, D. C., USA, 1998)
6. K. Buchauer : Wat. SA. **24** (1998) 49.
7. E. Gonze, S. Pillot, E. Valette, Y. Gonthier and A. Bernis: Chem. Eng. Pro. **42** (2003) 965.
8. C.P.Chu, B.V. Chang, G.S. Liao, D.S. Jean and D.J. Lee : Wat. Res. **35** (2001) 1038.
9. A. Erdincler and P. A. Vesilind : Wat. Sci. Tech. **42** (2000) 119.