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International Journal of Current Research
Vol. 10, Issue, 08, pp.72184-72187, August, 2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

A STUDY ON IMPROVEMENT OF DEWATER ABILITY OF SEWAGE SLUDGE USING COAL ASH THROUGH CST

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ARTICLE INFO

Article History:
Received 20th May, 2018
Received in revised form
14th June, 2018
Accepted 25th July, 2018
Published online 30th August, 2018

Key Words:
Sewage sludge, Coal ash, CST (Capillary Suction Time), Dewatering, Flocculation.

ABSTRACT

Sewage sludge in South Korea was generated 9,810.5 tons/day and Sludge treatment costs account for 25~50% of total wastewater treatment costs, so sludge dewatering and reduction are needed. About 20.4% of the generated sewage sludge is recycled as fuel, but it takes a lot of energy and cost to dewater and dry sewage sludge with high moisture content. Therefore, this study investigated whether coal ash, which is easy to dewater, can be used as an agent to improve the dewaterability of sewage sludge which is difficult to dewater due to high cake specific resistance through CST (Capillary Suction Time).CST was measured by adding 1, 3, 5, 7 and 10% of coal ash incinerated for more than 12 hours at 700°C to the excess sludge generated from S sewage treatment plant. Andthe pH of each mixed sample was measured to determine the effect of coal ash on the pH of sewage sludge. As a result, it is expected that the use of coal ash as an agent to improve will not affect the pH of sewage sludge and it will not be a problem when used with other flocculants. Also, when 1% of coal ash was added to the sewage sludge, the CST was decreased by about 16% or more. This suggests that coal ash can be used as an agent to improve sludge dewaterability.

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Citation: ***Hyun-Goo Han, Seon-Ung Min, Young-Gyun Jin, Wan-Su Hyeon, Eun-Ji Jo and Woon-Ho Yeo,*** **2018.** "A study on improvement of dewater ability of sewage sludge using coal ash through cst", *International Journal of Current Research*, 10, (08), 72184-72187.

INTRODUCTION

Sewage sludge in South Korea wasgenerated 9,810.5 tons/day in 2016, (Ministry of Environment, 2016) and sludge treatment process accounts for 25 ~ 50% of the total treatment cost during wastewater treatment. Therefore, increase in sludge dewater ability is directly related to reduction of treatment cost (Cho, 2004). About 20.4% of the generated sludge is recycled as fuel and the most important factor in sewage sludge fueling is energy and cost in the process of dewatering and drying. Much energy and cost are consumed to lower the moisture content of sewage sludge with high moisture content. Sludge is difficult to dewater due to the high cake specific resistance, but fly ash generated from thermal power plant is classified as easy dewatering material. This suggests the possibility of improving the dewaterability of the sludge (Lee, 2010 and 2011). The coal ash generated from Koenergy(KOEN) was 2530.2 thousand tons in 2015, of which 81.9% was recycled. However, the remaining 858.7 thousand tons were landfilled (Koenergy, 2016).

Currently, South Korea needs to make efforts to increase the recycling of coal ash and reduce the amount of landfill as the existing landfill is saturated and new landfill sites are difficult to construct. Therefore, this study investigated the possibility of recycling coal ash as a sewage sludge improvement agent by measuring the dewatering ability of sludge through CST (Capillary Suction Time).

Experimental methods

Sample preparation: The sludge used in the experimentwasexcess sludge sampledfrom S sewage treatment plant. In order to prevent transmutation of the sample, it was refrigerated at 3 ℃and experimented within 3 days after sampling. The coal ash was pre-treated at 700℃ for more than 12 hours and then sieved to have a particle size of 100mesh or less.Because the incinerating condition did not affect the dewaterability, (Park, 2007) the incinerating was carried out under the single condition of 700℃. And the coal ash was added to the sewage sludge at a ratio of 1%, 3%, 5%, 7%, and 10% as shown Table 2.

pH for solid: The pH is related to alkalinity and has a large effect on flocculation reaction (Cho, 2004).

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DOI: https://doi.org/10.24941/ijcr.31770.08.2018

Table 1. Sewage sludge generation and treatment amount

(Unit: ton/day)

Year	Generation amount	Recycling			Incineration	Drying	Landfill	Etc.
		Fueling	Composting	Etc.				
2011	8,480.7	611.7	-	2,198.1	1,884.6	-	715.8	302.5
2012	8,748.4	883.3	-	3,379.6	2,360.4	-	1,455.1	669.9
2013	9,671.1	958.0	-	4,025.6	2,318.5	-	1,113.9	1,255.1
2014	9,663.4	2,432.0	641.4	2,447.4	1,944.0	155.7	1,873.3	169.5
2015	10,526.7	2,171.9	1,164.5	2,660.8	1,971.4	902.7	1,444.2	211.3
2016	9,810.5	2,000.5	3,015.6	1,689.1	1,447.1	682,5	829.3	146.3

Table 2 Mixing ratio of sample

No.	Sample	Mixing ratio
1	Sewage sludge	Sewage Sludge100%
2	Sample1 (S1)	Sewage sludge99% + Coal ash1%
3	Sample2 (S2)	Sewage sludge97% + Coal ash3%
4	Sample3 (S3)	Sewage sludge95% + Coal ash5%
5	Sample4 (S4)	Sewage sludge93% + Coal ash7%
6	Sample5 (S5)	Sewage sludge90% + Coal ash10%

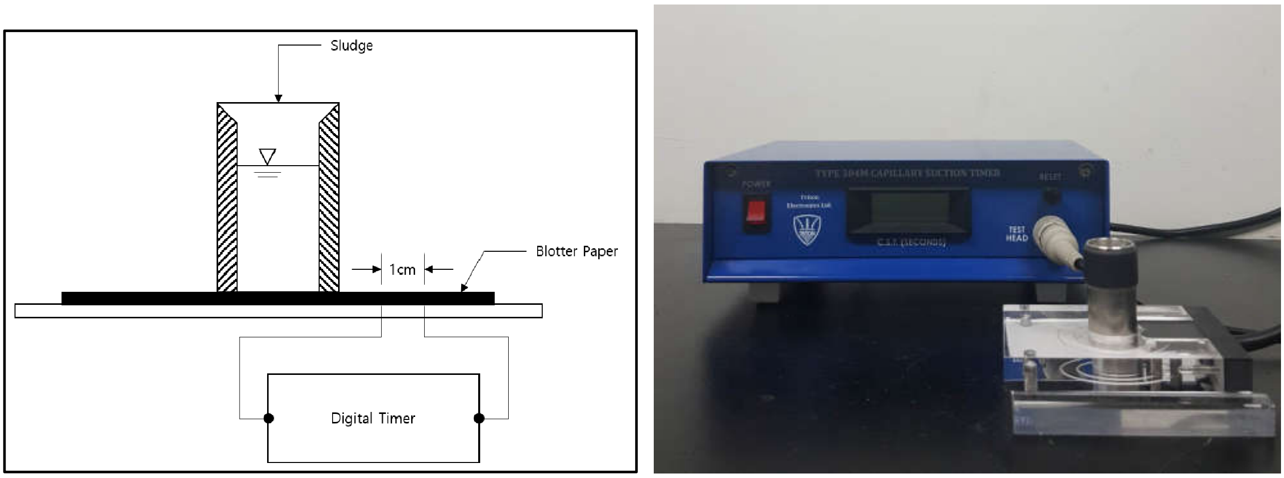

Fig. 1. Apparatus for the evaluation of CST

pH of the coal ash was measured by standard methods for the examination of environmental pollution (soil pollution) (Ministry of Environmen, 2008). 5g of the sample was mixed with 25ml of distilled water, left for 1 hour, and then measured using XL600 pH meter from Fisher Scientific.

CST (Capillary Suction Time)

CST(Capillary Suction Time) is a simple experimental method to approximate the specific resistance. CST measures the time it takes for the moisture in the sludge to travel 1cm from the blotter paper, thereby establishing a relationship with the specific resistance. Shown as Fig. 1, CST measuring device consists of a hollow stainless steel sludge sample funnel, blotter paper under it, two electrodes, and a timer. When the sample sludge is poured into the sample funnel, the filtrate coming out of the sludge moves to the outside of the funnel while saturating the blotter paper. When the filtrate reaches the first electrode, the timer starts to operate and when the second electrode is reached, the timer stops working. The time taken to move the distance of 1 cm between the two electrodes is called CST (Jin, 2018). In this experiment, the CST measuring apparatus and test papers were used Type 304M CST and CST papers (7 × 9 cm) from Triton Electronics. The samples were stirred rapidly to mix for 30 seconds and slowly to flocculate for 90 seconds. And the mixed samples were poured into a funnel with an inner diameter of 10 mm to measure the CST.

RESULTS AND DISCUSSION

Physical properties analysis

The results of physical properties of Sewage sludge and mixed samples are shown in Table 3 and 4, and the moisture content of sewage sludge was 97.63% and the total solid content was 2.37%. As shown in Table 5 and Fig. 2, the pH of sewage sludge was 5.90, coal ash was 5.06 and mixed samples were 5.84~6.00. The pH was changed with the addition of coal ash, but the change was not significant.

CST (Capillary Suction Time)

The CST results of the sewage sludge and mixed samples are shown in Table 6 and Fig. 3.The CST of the sample1 mixed 1% of coal ash was about 16% lower than that of the single sample of sewage sludge. The highest efficiency was showed when 5 to 7% of coal ash was added. As the addition ratio of coal ash increased, the CST decreased. It was confirmed that the addition of coal ash improves sludge dewaterability.

Table 3. Result of physical properties for sewage sludge

Sample	Moisture(%)	Ash(%)	Volatile Matter(%)	Fixed Carbon(%)
Sewage sludge	97.63	1.14	1.02	0.21

Table 4. Result of solid analysis for sewage sludge

Sample	TS(%)	VS/TS(%)	VS(%)	SS(mg/l)
Sewage sludge	2.37	52.05	1.23	14,918

Table 5. Result of pH for sample

Item	Sewage sludge	Coal ash	S1 (1%)	S2 (3%)	S3 (5%)	S4 (7%)	S5 (10%)
pH	5.90	5.06	5.97	5.97	6.00	5.84	5.86

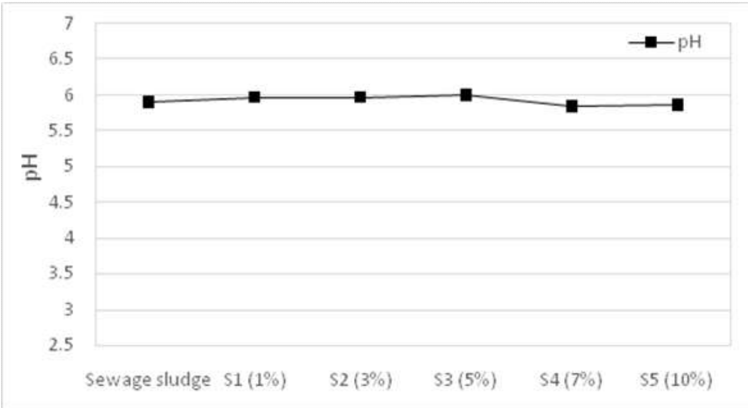

Fig. 2. Change in pH for addition of coal ash

Table 6. Result of CST for sample

Item	Sewage sludge	S1 (1%)	S2 (3%)	S3 (5%)	S4 (7%)	S5 (10%)
CST(sec)	23.0	19.3	19.1	17.6	14.5	14.1

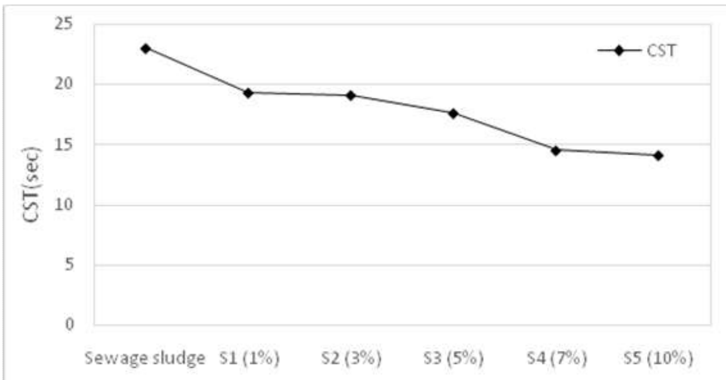

Fig. 3. CST for addition of coal ash

Conclusion

The pH has a great effect on the flocculation reaction, and each flocculant has optimum pH for each of them (Koenergy, 2016). The pH of the mixed sample was 5.86~6.00. The addition of coal ash did not affect the pH of the sludge significantly. Therefore, it could be used as a sewage sludge improvement agent with other flocculants. As the addition ratio of coal ash increases, the CST decreases, indicating that coal ash improves sludge dewaterability.

Fly ash from thermal power plant contains SiO_2, Al_2O_3, Fe_2O, CaO, MgO, and so on (Jin, 2018) and high concentrations of Ca^{2+}, Mg^{2+}, Fe^{3+}, and Al^{3+} reported to have an important effect on the improvement of dewatering performance of sludge (Ministry of Environment in S. Korea, 2008). Various forms of Al^{3+}, Fe^{3+}, etc. contained in coal ash seem to have affected this result. This result suggests that coal ash can be used as an agent for improving the dewaterability of sewage sludge. When coal ash is recycled as building material, it contains about 8% or more of unburned carbon, which remains as incomplete combustion, so this unburned carbon must be removed (Jin, 2018). But this unburned carbon is expected to help not only dewater but also increase heating value when sewage sludge is fueled.

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