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Effect of Cow Manure and Saw Dust as the Additive Materials for Efficient Vermistabilization

Chul Kim* · Hee-Jeong Son† · Tae-Kyung Yoon

Terra & Aqua Environmental Co., Ltd., 6-4 Namchun-2dong, Suyoung-gu, Busan, Korea
**Dept. of Environmental Engineering, Dong-eui University, 995, Eomgwangno, Busanjin-gu, Busan, Korea*
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Abstract: The influence of additive materials including saw dust and cow manure in the ripening of leather sludge for the efficient vermisabilization was studied. The ripening characteristics of the leather sludge, the growth of earthworms in the growth bed and the by-products like cast were observed according to the mixing ratio of additive materials. When the mixed leather sludge of which the additive materials contents were over 20% were ripened for 50 days, the values of ORP and alkalinity were changed to the favorable ranges for earthworms, the positive (+) and below 1,000 mg/*l* as $CaCO_3$, respectively. The velocity of ripening improving the characteristics of the leather sludge was faster in the sludge mixed with cow manure than saw dust. This results could also be verified from the monitoring of the states of earthworm growth using the survival rate, the increase rate of lifeweight and the hatching rate of earthworm cocoon in the their growth bed packed with the ripened sludge. The values of CEC in cast, the vermi-stabilized sludge, were increased with the mixing ratio of additive materials, but the content of heavy metals was drcreased by the dilution effect and accumulation in the earthworm body. Above results show that the leather sludge might be efficiently stabilized by earthworms through the ripening for 50 days using additive materials. Cow manure can be used as a good additive materials for leather sludge as much as saw dust, and the optimum content of additive materials in the well-ripened leather sludge was about 30%.

Keywords: vermistabilization, earthworms, additive materials, survival rate, increase of earthworms weight, hatching rate of cocoons

Introduction

The enormous amount of organic waste including industrial wastewater sludge, food waste and agricultural residuals is produced in Korea, and most of the waste has been landfilled together with other municipal solid waste.[1,2] Then, it causes the serious public concerns related to malodor, leachate and pathogens due to the putrescible nature of the waste.[3] Recently, the researches on the organic waste have been focused on the reasonable technologies ensuring the effective management of organic waste such as composting, anaerobic digestion and manufacture of livestock feed. Vermistabilization using earthworms is a good alternative due to the low energy and cost requirement in the treatment of organic waste compared with the existing processes.[4,5] However, the efficiency of the vermistabilization process of organic waste can be governed by the substrate characteristics such as pH, moisture content, temperature, alkalinity and ORP (oxidation and reduction potential) due to the weak digestion system of earthworms.[6] It resulted in the less application of vermistabilization in the management of organic waste. However, It has been reported that most of organic waste can be vermistabilized through the pretreatment like ripening to change the characteristics in the raw material.[7,8] In this study, the influence of the additive materials including cow manure and saw dust in the ripening of leather sludge was evaluated to ensure the efficient vermistabilization.

†Corresponding author : Terra & Aqua Environmental Co., Ltd., 6-4 Namchun-2dong, Suyoung-gu, Busan, Korea
Tel. 017-567-8358, Fax. 82-51-611-8784
E-mail : hjsons@hanmail.net

Materials and Methods

Earthworms, *Lumbricus rubellus*, were obtained from a culture maintained in the laboratory at 15~25°C and 70±5% moisture content. The leather sludge contained moisture content of 78% was obtained from C leather wastewater treatment plants. Saw dust and cow manure were used as the

Table 1. The characteristics of leather sludge and additive materials

Raw materials	pH	Water content (%)	ORP (mV)	Alkalinity (mg/*l*, as $CaCO_3$)	C/N ratio	Heavy metals (ppm)					
						As	Cu	Cd	Hg	Pb	Cr
Leather sludge	7.44	78	–480	5,500	6.2	-	75	-	-	147	425
Cow manure	7.97	77	–280	2,900	12	-	8.2	-	-	4.5	2.1
Saw dust	7.54	35	85	750	287	-	6.2	-	-	13.3	6.81

additive materials. The saw dust was obtained from a sawmill, and sieved with a 3 mm mesh to minimize the particle size effect. Cow manure was prepared through drying using an air blower to control the moisture. The physico-chemical characteristics of raw leather sludge and additive materials are detailed in Table 1. The prepared additive materials were mixed to the leather sludge, and then their contents in the mixed sludge were varied from 10% to 40%.

The mixed wastes were ripened for 50 days under 65±5% of the water content. During the ripening, these wastes were turned over 3 times a day for the first 10 days, 2 times a day for the second period to get them aerobically fermented. A part of the ripening wastes were sampled intermittently and then the physico-chemical characteristics such as ORP, alkalinity and pH etc., were analyzed. Earthworms were put in the sampled wastes and then the survival rate, increase rate of earthworm weight and hatching rate of cocoons of earthworm was observed for 50 days.

The mixed sludge was ripened in a static pile process for 50 days. During the ripening of the sludge, water content of the sludge was controlled to 65±5%, and turned manually over every day. The changes of characteristics in the ripening sludge were monitored according to the ripening time. Then, the ripened sludge was transferred to the earthworm growth-beds to evaluate the earthworm activity in the sludge ripened according to the content of the additive materials.[9,10] The survival rate, the increase rate of weight, and the hatching rate of earthworm cocoons were observed for 50 days.

Results and Discussion

Characteristics of the Leather Sludge Ripening

Table 1 shows the characteristics of the raw leather sludge and additive materials including the values of high pH and alkalinity, and the negative (–) value of ORP, it indicates that a pretreatment to change the physico-chemical characteristics of the sludge might be required to stabilize efficiently using earthworms. When the additive materials were mixed with the raw leather sludge to the ripening, the values of ORP and alkalinity in the mixed leather sludge were a little changed to –150~380 mV and 1,950~4,500 mg/*l* as $CaCO_3$ (Table 2), depended on the type and mixed amount of additive materials. It indicated that the characteristics of the leather sludge could be improved by the dilution effect resulted from the addition of additive materials, although not enough for earthworms growth. When the mixed leather sludge was ripened for 50 days, the values of pH in the all ripened sludge were easily changed to 6.4~7.3 considered as the favorable range for earthworms. The velocity of improvement of ORP and alkalinity in the ripened leather sludge mixed with cow manure was faster than those in the sludge with saw dust (Table 3), although the saw dust offered higher bulky state to the ripening sludge. It is considered that low C/N ratio and higher content of easily degradable organic in the cow manure had influence on the activity of microorganisms related with the ripening process. However, the values of ORP and alkalinity in the ripened sludge of which content of both additive materials were over 20% were only improved to the favorable values for earthworms. These results indicates that the ripening efficiency of leather sludge might be affected by both the characteristics and mixing amount of additive materials as well as the ripening time.

Growth of Earthworms in the Ripened Leather Sludge

The earthworms growth in the ripened sludge mixed with the additive materials was investigated to confirm the efficient vermistabilization of the

Table 2. The characteristics of the leather sludge mixed with additive materials

Mixed amount of additive material		pH	VS (%)	Eh (mV)	Alkalinity (ppm, as $CaCO_3$)	C/N ratio	Heavy metals (ppm)					
							As	Cu	Cd	Hg	Pb	Cr
Control	0%	7.44	87	−380	4,500	6.2	-	75	-	-	147	245
Cow manure	40%	7.9	79	−250	2,550	14	-	55	-	-	68	150
	30%	7.7	80	−275	3,300	12	-	57	-	-	51	75
	20%	7.55	84	−320	3,700	12	-	56	-	-	32	175
	10%	7.5	86	−350	4,100	11	-	65	-	-	27	200
Saw dust	40%	7.3	81	−105	1,950	87	-	42	-	-	64	105
	30%	7.8	85	−145	2,700	60.9	-	44	-	-	38	125
	20%	7.65	86	−250	3,500	52.8	-	51	-	-	34	140
	10%	7.45	83	−305	4,500	40.4	-	68	-	-	24	175

Table 3. The changed characteristics in the leather sludge ripened for 50 days

Mixed amount of additive material		pH	VS (%)	Eh (mV)	Alkalinity (ppm, as $CaCO_3$)	C/N ratio	Heavy metals (ppm)					
							As	Cu	Cd	Hg	Pb	Cr
Control	0%	7.15	69	−145	1,350	5.9	-	75	-	-	147	245
Cow manure	40%	6.4	58	134	250	14	-	55	-	-	68	150
	30%	6.9	58	67	370	12	-	57	-	-	51	75
	20%	7.25	61	4	810	12	-	56	-	-	32	175
	10%	7.3	63	−27	1,150	11	-	65	-	-	27	200
Saw dust	40%	6.95	62	−168	400	87	-	42	-	-	64	105
	30%	7.1	62	105	450	60.9	-	44	-	-	38	125
	20%	7.3	65	20	870	52.8	-	51	-	-	34	140
	10%	7.2	68	−37	1,100	40.4	-	68	-	-	24	175

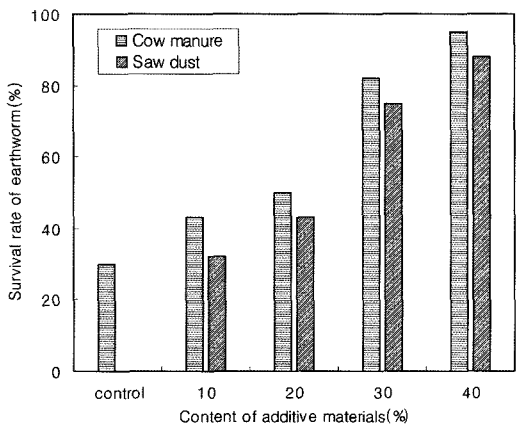

Fig. 1. Survival rate of earthworm in the ripened leather sludge for 50 days.

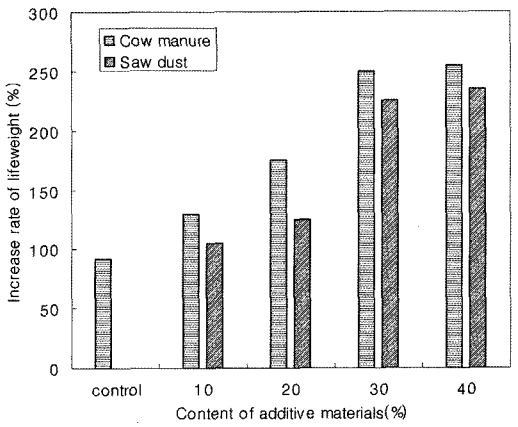

Fig. 2. Increase rate of earthworms lifeweight in the ripened leather sludge.

leather sludge. The survival rate of earthworms for 50 days in the sludge mixed with cow manure was 6~7% higher than that mixed with saw dust as shown in Fig. 1.

However, when the contents of both cow manure and saw dust were below 30%, the survival rate in the sludge was low as below 50%. The increase rate of weight, defined as the increased weight in

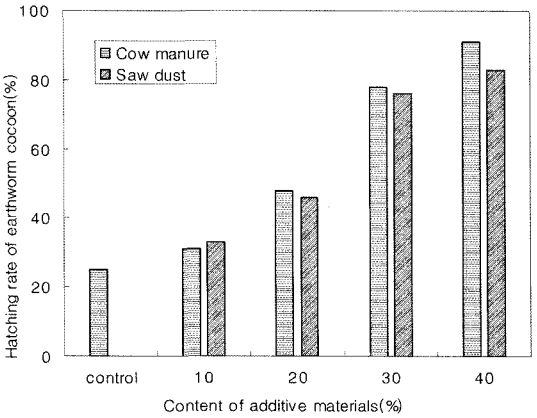

Fig. 3. Hatching rate of the cocoons of earthworms in the ripened leather sludge.

an individual earthworms during the test period, increased according to the increase of additive material content in the sludge, but the values in the sludge mixed with cow manure were also about 20% higher than that of the sludge mixed withsaw dust (Fig. 2).

The hatching rate of cocoon also showed the similar trend with the increase rate of weight in an individual earthworm (Fig. 3). These results also indicate that the efficiency of vemistabilization of leather sludge can be significantly affected by the type and mixed amount of the additive materials, and the proper amount of saw dust or cow manure to be mixed with leather sludge was over 30%.

The Characteristics of Cast

The values of pH in the cast from the sludge ripened with cow manure were somewhat higher than that with saw dust manure as shown in Table 4. It resulted from the higher ammonia content in the ripened sludge mixed with cow. The lower VS/TS and higher CEC in the cast from the ripened sludge with cow manure indicated that the sludge was more stabilized than that with saw dust. The contents of heavy metals in cast were about 11~57% lower than those of ripened sludge according to the mixed amount of additive materials, but the effect of the type of additive materials could not be observed clearly. It is considered that the reduction of heavy metal content in the cast might be resulted from both the accumulation in the earthworm body and the formation of complex with humic substance.[11]

Conclusions

Cow manure could be used as a good additive material for vermistabilization of leather sludge as much as saw dust. The leather sludge mixed with additive materials was stabilized efficiently by earthworms through the ripening for 50 days, and the percentage of additive materials in the well-ripened leather sludge was about 30%. When the mixture ratios of the cow manure and saw dust as additive materials is 30%, the growth of earthworms were 80.3%, 73% for the survival rate, 255%, 231% for the increase rate of earthworm weight, 78%, 76% for the hatching rate of the cocoons of earthworms, respectively. The content of heavy metals in the leather sludge might be reduced by the vermistabilization.

Table 4. Physic-chemical properties of cast in the vermistabilization leather sludge

Mixed amount of additive material		pH	VS (%)	CEC (me/100 g)	C/N ratio	Heavy metals (ppm)					
						As	Cu	Cd	Hg	Pb	Cr
Control	0%	6.65	49	25.6	5.2	-	68	-	-	156	211
Cow manure	40%	6.9	40	86	11	-	36	-	-	85	64
	30%	6.8	41	75.5	8.2	-	33	-	-	94	97
	20%	6.8	41	65.5	7.8	-	43	-	-	113	144
	10%	6.7	42	58.5	7.5	-	50	-	-	139	178
Saw dust	40%	6.6	46	76	22	-	22	-	-	88	78
	30%	6.3	47	67	27	-	23	-	-	103	94
	20%	6.3	48	63	27	-	31	-	-	132	109
	10%	6.4	41	45	31	-	45	-	-	136	137

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