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Article

The Effect of Some Amendments to Reduce Ammonia during Pig Manure Composting

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Occurrence of malodor could cause adverse impacts on human health and increase public interest. Therefore, scientific methods to decrease odor is required. Endeavor to decrease odor from compost however has not fully been successful. The purpose of this research is assessment of some amendments to reduce NH_3 from immature composts. Calcium hydroxide was applied to composts due to it's characteristics to increase pH. Activated carbon and zerovalent iron (ZVI) were selected because of their adsorption properties. The research results were as follows: Calcium hydroxide, activated carbon, zerovalent iron increased the composting temperature above 60℃. The addition of calcium hydroxide, activated carbon, and ZVI to compastry process increased pH 8.6 - 8.8 from 1st day to 14th day. During the 14 days of composting, addition of calcium hydroxide, activated carbon and ZVI changed EC from 2.15 - 0.66 dS m^{-1}, 1.48-1.11 dS m^{-1}, respectively and 1.77-0.68 dS m^{-1}. The difference in EC of the compost was due to irregularities of samples. Organic matter in the compost decreased through out theexcept control. The NH_4-N/NO_3-N ratio of all experimental compost increased through the process. The addition of activated carbon, calcium hydroxide and ZVI decreased NH_3 from 0.1ppm, 0.7ppm and 1.7ppm more than the control (pig manure and sawdust), 9.3ppm, in 30 days of composting. In conclusion, odor from pre-matured compost decreased by addition of chemicals like calcium hydroxide, activated carbon, zerovalent iron. Moreover, use of these NH_3 reducers alone or together combined at different periods of composting etc. could decrease NH_3.

Key words: Ammonia, Animal Waste, Calcium Hydroxide, Zerovalent Iron, Activated Carbon.

Introduction

Generally, animal wastes as by-product are used by undergoing composting process. Composting is the process which organic materials are transformed to inorganic materials resulting in resources for soils and crops. Composting is advantageous for resources due to adverse microorganism's death, decreased rate for weed germination, lignin degradation in manure, decreased pollutant concentration. However, composting causes malodors such as ammonia, H_2S, CH_3S from CN compounds (cystein, methionine, etc.) and volatile fatty acids (Seo et al., 1998.). The odors maybe interlaced with the pungent smell of ammonia. If the C:N of the animal waste was low and the pH of the composting mass is above 7.5, the concentration of ammonia may mask others.According to the report by the Ministry of Environment (2004), major malodor from animal compost is NH_3 rather than H_2S, mercaptane, etc. An averaged NH_3 content in animal (pig etc.) manure was 73.2 ppm, which far exceeds acceptable criteria for NH_3 emission (1-2 ppm) (Ministry of Environment, 2004.). Therefore, reduction of NH_3 through composting will be very helpful to decrease malodors. Odor control during pre-processing can be accomplished by enclosing the entire operation in a building, conditioning the feed, and treating exhaust gases through absorption, adsorption, or oxidation methods. In the absence of proper management, all composting materials not as yet fully matured can become sources of foul odors (Diaz et al., 1993). Conventional techniques are available for treating foul odors. Means of control involves trapping the odors through ventilation or containment of the compost process. Chemicals such as calcium hydroxide also can be used to treat the odors. The objective of this research was to assess the effect of potential candidates (calcium hydroxide, activated carbon and zero valent iron) to reduce NH_3.

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Materials and Methods

For rapid composting, air was injected at the interval of 1 hour. The amount of injected air was 20L per hour. The size of pot for this experiment is described in Figure 1. This research was conducted in plastic film house in Kangwon National University. Throughout the experiment, temperature in plastic film house was adjusted at 25℃. NH_3 analysis was conducted by modified indophenol method. NH_3 gas was collected by pump at the flow rate of 50L min^{-1}, and measured by using UV/Vis spectrophotometer at 640 nm (NIER, 2005).

The fresh pig manure was sampled at the livestock farm in Kangwon National University in Oct. 2006. Sawdust (0.05-0.2 mm diameter) was applied as bulking agent to adjust initial water content and C/N ratio of pig manure. As potential candidates to reduce NH_3, we applied activated carbon, calcium hydroxide, and zero valent iron (ZVI) at the rate of 5%(w/w) in each pig manure sample, respectively. Water content was adjusted at 60% for initial stage of composting. Throughout the experiment, we monitored pH, EC, organic matter, T-N, NH_4-NO_3 ratio based on standard method by NIAST (1999).

Results and Discussion

Temperature changes during composting Temperature is one of the major indicators in composting process. Lo et al. (1993) reported that optimal temperature for composting of manure ranges from 50℃ to 55℃. Falcon et al. (1987) suggested that more than 70℃ temperature for composting caused nutrient loss and decrease of composting due to thermal kill of microorganisms. Figure 3 shows temperature change of pig manure depending on the application of treatments during composting period. Manure treated with calcium

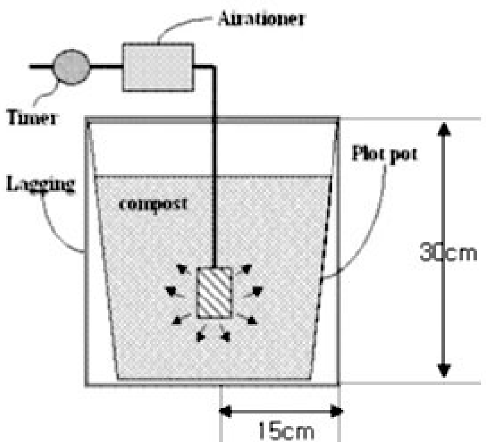

Fig. 1. Scheme of Portable composting equipment.

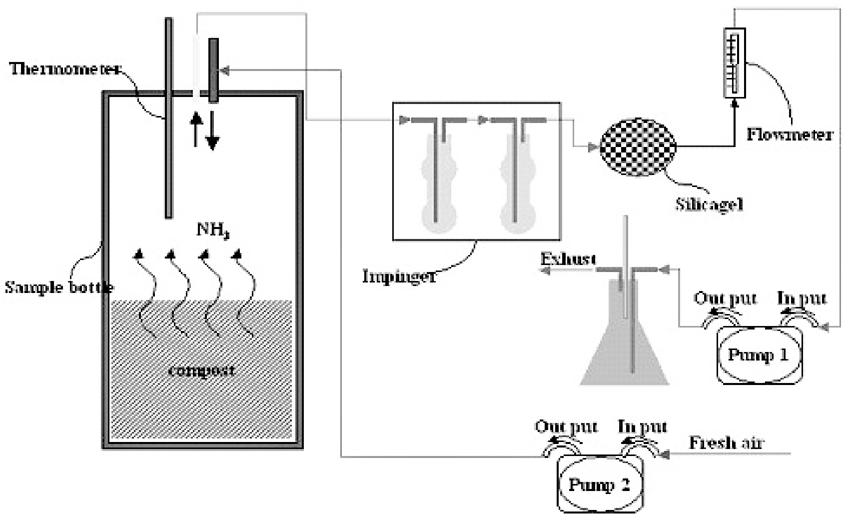

Fig. 2. Scheme of NH_3 analysis equipment by modified indophenol method.

hydroxide showed fastest temperature rise among treatments. This might be caused by stabilization effect of calcium hydroxide application. The highest temperature in manure treated with activated carbon was relatively lower than those of manures treated with calcium hydroxide and zero valent iron (ZVI). According to the report by Shimamoto (1991), composting of manure is fully accomplished If composting starts at 1 or 2 day after treatment and temperature for composting rises greater than 60℃ after 1 week's duration. Our result showed similar composting trend to Shimamoto (1991).

pH change during composting Chardenas et al. (1989) reported that pH decreased at the early stage of composting, gradually increased with the emission of ammonia, and was finally stabilized as pH 7-pH8. Mori et al. (1981) commented that pH became 8 10 at the early stage of composting process, gradually decreased due to occurrence of organic acids, and finalized as 6-7.

Figure 4 shows pH changesdepending on the treatment of calcium hydroxide, activated carbon and zero valent iron. pH increased as composting proceeded, and became 8.6-8.8 at the later stage of composting. With the treatment of calcium hydroxide, pH reached up to 9 to 10 at the early stage, however, pH stabilized at pH 8 after 14 days of treatment.

EC changes with treatment of several chemicals during composting According to Kim et al. (2005), there are no criteria for pH and EC to assess by-product ofanimal manure in Korea. Therefore, plant damage by application of immature by-products are frequently reported. By-products with relatively higher EC values cause poor germination or poor transplanting. Figure 5 shows EC changes with treatment of some chemicals during composting. Initial EC value in fresh manure without any treatment was 2.32 dS m^{-1}. After 14 days, EC value increased as 3.03 dS m^{-1} probably due to decrease of water content in manure. However, EC values in animal manure with the treatment of calcium hydroxide, activated carbon and zero valent iron (ZVI) after 14 days of treatment were 0.66, 1.11, and 0.68, respectively.

Organic matterand nitrogen content changes with treatment of somechemicals during composting Figure 6 shows effect of some chemicalson organic

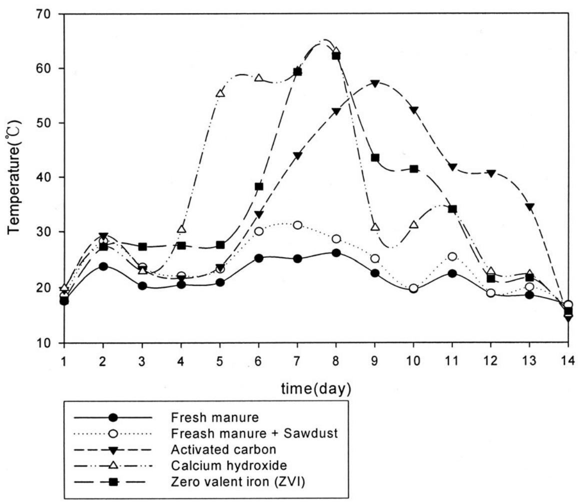

Fig. 3. Change of temperature by treatments of some chemicals during composting.

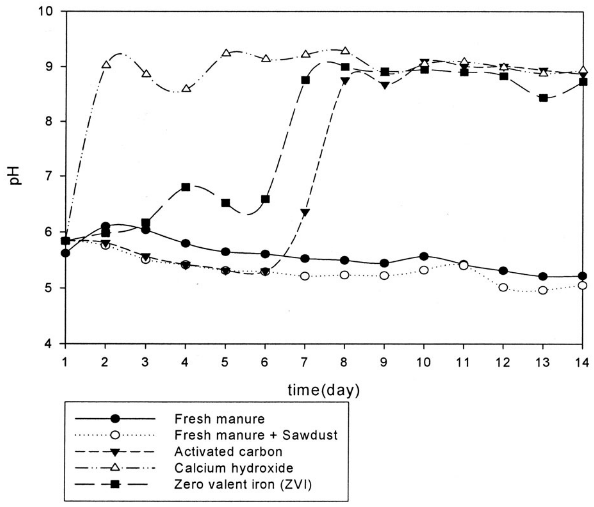

Fig. 4. Change of pH by treatments of some chemicals during composting.

Table 1. The properties of fresh manure and fresh manure with sawdust.

Treatment	pH	EC	Water content (F.W)	Organic matter (D.W)†	T-N (D.W)	NH_4-N/NO_3-N ratio
		dS m^{-1}	-------	%	-------	
Fresh manure	5.62	2.88	75.00	53.68	4.13	2.37
Fresh manure+ Sawdust	5.84	1.93	61.40	86.84	2.02	6.73

† D.W: Dry Weight

matter content during composting. Except the control pot without any chemicals, organic matter content decreased as composting proceeded. This might be caused by decomposition of microorganisms. Figure 7 shows NH_4-N/NO_3-N ratio changes with treatment of somechemicals during composting. All the pots with the treatments of chemicals underwent decrease of NH_4-N/NO_3-N ratio.

Effects of some amendments on reduction of ammonia gas A major problem in composting is the odor caused by the release of ammonia. Ammonia is a by-product of aerobic composting of low C/N ratio (Hong et al, 2005). Research and development for animal waste compost should involve low ammonia emission, high quality, low cost composting and proper distribution and application (Haga, 1998). Figure 8 shows the effect of three amendments (calcium hydroxide, activated carbon and zerovalent iron) during composting for 30 days. All three amendments effectively reduced NH_3, ranging from 0.1 to 1.7 ppm 30 days after treatments. The effect of Calcium hydroxide application in animal manure is pH increase in compost resulting in reduction of NH_3, while the effects of activated carbon and ZVI application for composting are adsorption of NH_3. The activated carbon and ZVI are frequently used as adsorbent for malodor or heavy metals. The pot with the calcium hydroxide treatment showed highest NH_3 gas emission 1 week after treatment, which indicate nitrogen was transformed to NH_3 form.

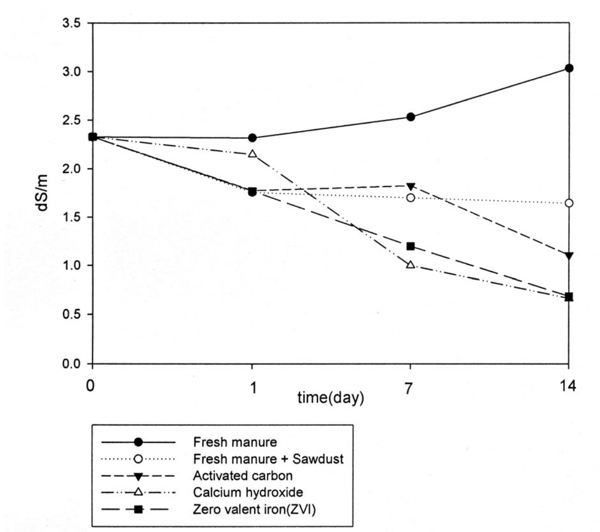

Fig. 5. Change of EC by treatments during composting.

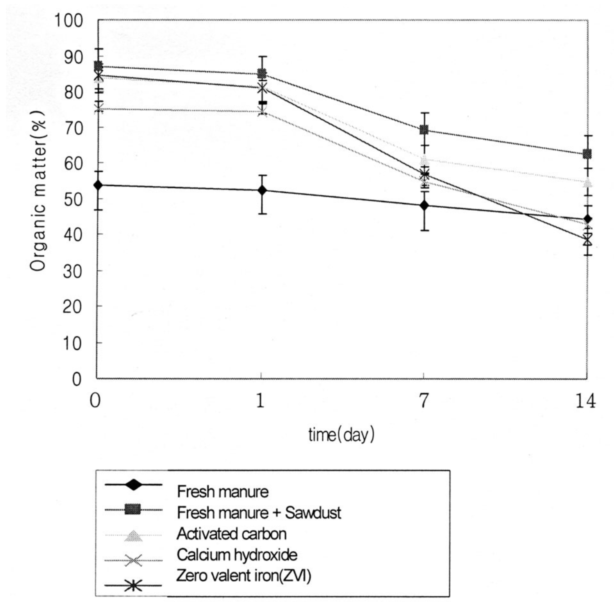

Fig. 6. Change of Organic matter contents by treatments of some chemicals during composting.

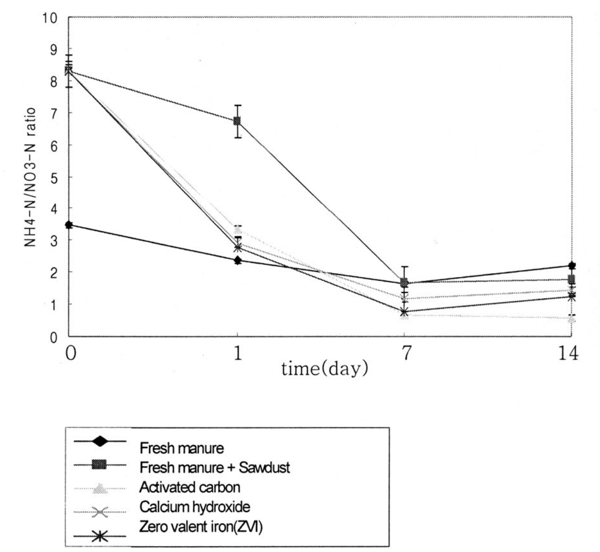

Fig. 7. Change of NH_4-N / NO_3-N ratio by treatmentsof some chemicals during composting.

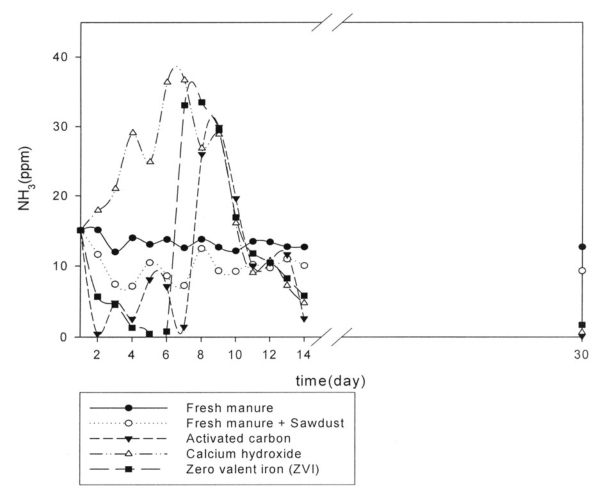

Fig. 8. Change of NH_3 concentration by treatments of some chemicals during composting.

Acknowledgement

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몇 가지 처리제의 첨가에 의한 돈분의 퇴비화 과정 중 암모니아 발생 저감 효과

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최근 악취발생으로 의한 사회적 관심 증가, 피해사례 증가에 대해 과학적 저감 기술이 요구되나 확실한 악취 저감 기술의 미흡과 악취저감용 처리제의 기초평가자료가 부족한 실정이다. 본 연구는 부산물 퇴비에서 발생되는 악취물질인 NH_3를 저감하기 위한 처리제 선발 및 평가에 목적을 두어 수행되었으며 본 연구 결과를 요약하면 다음과 같다. 부숙화 과정에서 calcium hydroxide, activated carbon, zerovalent iron (ZVI)처리에서 60 이상으로 온도 상승을 보여 부숙진행이 원할히 이루어졌음을 알 수 있었다. calcium hydroxide, activated carbon, ZVI에서 pH 변화는 퇴비화가 진행됨에 따라 상승하여 후부숙 단계에서는 pH 8.6 - pH 8.8을 보였다. 또한 부숙화 과정 14일 동안 calcium hydroxide 처리구의 EC는 2.15 dS m^{-1}에서 0.66 dS m^{-1}으로, carbon 1.48 dS m^{-1}에서 1.11 dS m^{-1}, ZVI 1.77 dS m^{-1}에서 0.68 dS m^{-1}으로 EC값이 큰 폭으로 줄어드는 것을 확인할 수 있었다. EC값이 1일차에서의 각각의 처리제별로 약간의 차이를 보이는 것은 퇴비 자체가 불규칙적인 상태의 고체이기 때문이라고 사료되며 측정치가 약 0.5 dS m^{-1} - 0.7 dS m^{-1} 의 차이를 보였다. 인도페놀법을 이용한 NH_3 측정 결과에 따르면 activated carbon의 경우 초기 8.8ppm에서 30일 후 0.1ppm으로 생분 + 톱밥의 9.3ppm보다 약 93배가량 저감하는 것으로 나타났다. Calcium hydroxide의 경우는 30일 후 0.7ppm으로 약 13배 정도 저감하였으며 ZVI의 경우는 30일 후 1.7ppm으로 약 5배 정도 저감하였다. 위 결과들을 종합해본 결과, 부산물퇴비에서 발생되는 NH_3를 저감하기 위한 처리제로서 calcium hydroxide, activated carbon, zero valent Iron (ZVI)를 활용할 수 있을 것이라고 사료 되나 향후 처리제의 독립적 사용가능성, 복합적 사용가능성 등에 대한 연구가 추가적으로 수행되어야 할 것이라고 판단된다.