Study on rapid bio-drying technology of cow dung with CaO2

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Abstract. Effect of CaO2 on cow dung rapid bio-drying technology was researched. A static aerobic composting system was applied to this experiment which combining natural ventilation with Turing in the process of composting. The physical characteristics of cow dung was observed and the compost temperature, moisture content, organic matter, total nitrogen, total phosphorus, potassium content was determined which in order to study the effect of CaO2 on rapid drying of cattle in the compost. In the initial stage of compost, adding CaO2 groups compared with the control group, the temperature rise faster, 4-6 days in advance to the thermophilic phase; at the end of composting, the CaO2 composition and moisture content decreased significantly to below 30%. The addition of CaO2 in fertilizer was shorten the composting time, extend the thermophilic phase, to provide sufficient oxygen meeting the growth needs of aerobic microorganisms. It convinced that the rapid bio-drying of dairy manure has a good effect and provided a new idea for the effective treatment of cow dung.

1. Introduction
The intensity and concentrated activity of the livestock industry generate vast amounts of biodegradable wastes [1]. Cow breed in accounts for a large proportion of livestock and poultry breeding, dairy manure can turn into an important pollution source without treated properly. In recent years, cow dung can convert into organic fertilizers by composting technology, which realized harmlessness, reduction and resource utilization of the cow dung [2]. Composting of organic wastes is a biooxidative process involving the mineralisation and partial humification of the organic matter, leading to a stabilised final product, destruction of pathogens and with certain humic properties [3]. The aerobic composting of cow dung was dicussed in this paper.

According to the determination, the water content of the bedding and non-flush faeces is generally 65% ~ 85%, while the water content of flush livestock has come up to 90%. The higher water content has more influences to the storage, processing and transportation of faeces, it’s an important step in faeces treatment to reduce the water content of livestock faeces. Nowadays, there are a lot kinds of rapid desiccation of livestock faeces, including physical methods, chemical methods and biological methods, among them, the application of biological drying technology is more extensive, mainly because of the low cost, the easy to operate and the high fertilizer efficiency of biological drying technology. In 1984, American Cornell University scientist Jewell W J[4] proposed the word of feces of livestock and poultry bio drying (Bio-drying) firstly, and put forward the principle of biological drying is high temperature aerobic microbial composting process and it can quickly decompose organic matter and produce a lot of heat. The temperature of the stacking material, in the case of
ventilation or turning, to promote the distribution of water in the pile, dry dung to reduce the purpose of water. Choi [5] et al. (2013) and Richard [6] et al. (1997) proposed continuous batch or semi-continuous composting techniques on the basis of previous batch composting work and designed and manufactured Oxygen bioreactor. Many trials have shown that composting products have a moisture content of more than 30% at the end of composting. Singh [7] (2009) the use of vegetable waste, sawdust and cow dung as raw material for aerobic composting, composting for 20 days, the water content of each treatment group decreased from 63.5% ~ 76.0% to 47.5% ~ 72.0%, The effect is not very obvious. Roca-Pérez [8] et al. (2009) in the sludge and straw mixed aerobic composting test, after 90 days of composting, composting material moisture content from the initial 60.3% to 39.9% ~ 42%, moisture content decreased obviously, but the composting cycle is longer.

There’s little research of utilize of composting technology in the disposal and drying of livestock and poultry manure in China, compare to it's utilize in the application of sludge. Similarly, the research of livestock and poultry manure is less in bio drying technology aspect, Jiangsu Academy of Agricultural Sciences soil and fertilizer Chang zhizhou [9] and so on (2000) using pig manure for biological drying test, the results shows that the use of batch aerobic composting, adding additives and other methods, after 20 d of pig manure moisture content decreased from 700 g/Kg down to 550 g/Kg below, reduced by 150 g/Kg. Chen Tianrong developed a chicken manure fermentation drying equipment, using the equipment of biological fermentation processing of chicken manure, 25 ~ 35d after, the water content from 650g/Kg down to 200g/Kg, the following effect is obvious. This experiment uses cow dung and tobacco smoke as raw materials to study the effects of temperature, water content, pH, nitrogen, phosphorus and potassium on the composting of cow dung under the action of CaO2 by adding CaO2, in order to explicit the influence of CaO2 to the dry cow dung compost rapid biological technology, and to provide guidance of theory and technology used in harmless treatment of cow dung compost and manure production.

2. Materials and methods

2.1. Compost raw materials
Fresh cow dung (Dali backyard cow dung), tobacco waste (factory smoke rod), CaO2 (industrial grade). The properties of composting raw materials are shown in Table 1.

| materials         | moisture content /% | pH   | organic matter % | N/% | P/% | K/% |
|-------------------|---------------------|------|------------------|-----|-----|-----|
| cow dung          | 84.60               | 7.42 | 93               | 1.8 | 1.7 | 1.5 |
| tobacco smoke     | 22.76               | 5.66 | 83               | 1.3 | 0.6 | 6.8 |

2.2. Composting design
According to the mass ratio of 5:2 (the fresh cow dung: tobacco waste) well mixed (the proportion of integrated organic fertilizer factory production and pre-experiment), which also added to bacteria, CaO2, microbial inoculum and CaO2, microbial inoculum and CaO2 (continuous addition), the treatment group was divided in Table 2, All the windrow fermentation piles were 1.5 meters tall, 3 meters long and 3 meters wide. Which turned and mixed once every three days until composting was over, the fermentation period is 35 days.
Table 2 Formula for different treatments

| Treatments | Formula |
|------------|---------|
| A:         | 3t a + 1.2t b |
| B:         | 3t a + 1.2t b + 15kg c |
| C:         | 3t a + 1.2t b + 100kg d |
| D:         | 3t a + 1.2t b + 100kg d + 15kg c |
| E:         | 3t a + 1.2t b + 100kg d + 15kg c (10kg CaO2 once per heap) |

a= cow dung; b= tobacco smoke; c=bacteria; d= CaO2

2.3. Determination index and methods

2.3.1. Temperature measurement. During the composting process, the temperature was measured at 8:30 am every day. The measured temperature was the temperature of 5 The positions of 20 cm, 35 cm and 50 cm below the surface of the each piles was measured by thermometer, the average of was regarded the compost temperature of each piles in one day.

2.3.2. Determination of pH, moisture content, organic matter, TN, TP, TK. Sampling was carried out at 9:00 am every day from five sample points of each piles by quartation, which was equilibrated at a distance of 30 cm at 50 cm far from the surface of the each piles, 50 cm and in different orientations, separate the two diagonals by four equal portions until the required sample size is 500 g each. Moisture content, pH, organic matter, TN, TP, TK are determinated by organic fertilizer agricultural standard NY525-2012 [10].

3. Results and Analysis

3.1. The changes and analysis of physical properties of compost materials
At the beginning of the composting, the contrast compost group A, B ware brown, and have a great smell of cow dung; With the addition of CaO2, the color of the treatment group C, D, E compost mixture shown dark brown, the smell of cow dung was reduced significantly due to the formation of alkali. After 6 days of composting, the surface color of the treatment group C, D, E were deepen, which appeared white hyphae, the contrast group B group also appeared white mycelium, but its surface color change was not obvious, due to the agent added, while at ninth days the contrast group A appeared white mycelium on the surface, it delayed 4 days compared to the treatment group. After about fifteenth days of composting the piles body of the treatment group C, D, E tended to be uniform and loose without caking phenomenon. At the end of composting, the color of the compost material of the contrast group A, B presented light brown, have caking phenomenon but not obviously, the surface color of the treatment group C, D, E shown black brown, and piles are loose, uniform and without caking. The effect of group E was obvious. The color of the decayed fertilizer products became dark brown, odorless, with obvious smell of humus (soil flavor), its structure is loose granular. The color of the under decayed fertilizer finished is brown, can smell the odor, with the phenomenon of caking, and the particles is larger. Thus, the contrast group A, B have not reached maturity and the treatment group C, D, E have reached maturity at the end of composting. Then fater lasted about 7 days of composting the time contrast group A, B reached maturity.

3.2. The changes and analysis of composting temperature.
The change of temperature is an important indicator of microbial activity during composting, which can reflect the degree of maturity of compost [11]. On the one hand, the temperature chang have an effect on the rate of biological drying directly. Temperatures are essential for composting, range of optimum temperature is 50°C~ 60°C during aerobic composting, which can result in the death of pathogens and weed seeds on this condition. The composting temperature below optimum temperature
have an effect on microbial activity, which can reduce the rate of organic matter decomposition. The composting temperature above optimum temperature can inhibit aerobic microbial activity in the aerobic thermophilic composting and lead to composting piles carbonization [12]. The composting experiment was carried out in winter and the environment temperature was low, the change of temperature as shown in Fig.1 (a) and Fig. (b), group A and group B need 12 days and 11 days up to the thermophilic phase respectively and the peak temperature above 55°C. On the one hand, group C, group D and group needs 6 days, 7 days and 7 days respectively. In the thermophilic phase, group a, group B, group C, group D, E lasted for 22 days, 22 days, 28 days, 28 days and 27 days respectively, and then entering cooling stage. The results indicated that the addition of CaO₂ can shorten the heating period in the compost, which enter the thermophilic phase 5~7 days in advance and prolong the time of thermophilic phase, make the pile composting more thoroughly. According to group B and group C, it is concluded that the pile before 6 days into the thermophilic phase due to the addition of CaO₂ instead of the effect of microbial inoculum. The mechanisms can explained that CaO₂ reacts with the water in the piles to produce oxygen with release of energy. The combined effect leads to the increase of the temperature of the composting piles and avoid the production of anaerobic environment. The temperature fluctuation is caused by the turning and ventilation.

**Fig.1** Temperature changes of different treatments.

### 3.3. The changes and analysis of pH value during composting process

During composting, pH is an important parameter for aerobic microbial activity. Under normal circumstances, the most suitable microbial pH value is between 6 ~ 9, when bellows 4.5, it will seriously affect the activities of microorganisms, when bigger than 10.5, the most of bacterial activity decreased. PH value is too high or too low, it will lead to protein denaturation, and is harmful to the survival of microbes [13]. The change in pH during composting was result of the organic acids from microbial decomposition and nitrogen-containing organic compounds, ammonia and protein from piles worked together [14].

Fig.2 reflected that the trend of pH about each pile during whole composting process. The initial pH value of each treatment was 6.57, 6.52, 6.7, 6.46 and 6.61 respectively, which all satisfied the growth conditions of aerobic microorganisms. With the change of composting time, the pH began to rise, the treatment with addition of carbon dioxide rised obviously, it may due to the reaction of CaO₂ with water to produce Ca (OH)₂ and alkaline substances. This alkaline environment provided by CaO₂ contributes to the biodegradation of refractory organic matter. With the composting reaction continues, the pH value of group C, D, E both decreased, CaO₂ addition went into the thermophilic phase in
advance, which is a result of a large number of microbial metabolic accumulation. Since group E with the continuous addition of CaO$_2$, the pH value presented fluctuant change.

3.4. Changes and analysis of moisture content during composting process

Compost moisture content is an important parameter which affect composting, moisture content directly influences the activity of the cow dung aerobic microorganisms and the degree of maturity at the end of the composting process, too high or too low of moisture content have a negative impact on aerobic microbial decomposition and metabolic activities, which is not conducive to aerobic composting process [15, 16]. Generally, initial moisture content is controlled at 50% ~ 60% on initial composting [17].

![Fig.2 pH value changes of different treatments.](image)

![Fig.3 Moisture content changes of different treatments.](image)

The change of moisture content with different treatments during composting process as shown in Fig.3, the initial moisture content of group A, C, D, E. is 60.2%, 60.1%, 61.05% and 60.2% respectively by processing. The moisture content of each treatments components is declining with the composting process. Moisture content of group E dramatically decrease, which declined to 28.76% at the end of the composting and group A, C, D fell to 36.87%, 36.87% and 30.35% respectively, although the control group did not reach the standard organic agriculture (≤30%) [10]. Moisture content of the groups have fallen by 23.33%, 29.75%, 30.49% and 23.33% respectively. It may due to CaO$_2$ with water by reaction, which released the oxygen and energy, furtherly promoted the moisture evaporation. Consequently, moisture content of three groups (C, D, E) are lower than the control group after the end of composting cycle. Fluctuation of descent curve is affected by the rainfall.

3.5. Changes and analysis of organic matter during composting

Figure 4 shows the variation curves of organic matter in the compost. Organic matter changes mainly due to aerobic microbial decomposition, it is transformed into the necessary nutrients for its own growth. On the one hand, organic matter was decomposed into water, organic acids, carbon dioxide, minerals, etc. then microorganisms transformed anti-product into humic substances[18]. At the end of composting, the moisture content of organic matter decreased to 60.92%, 61.16%, 61.11%, 60.28% and 56.87% respectively. From the present national standards in agricultural organic fertilizer, the organic matter content of each treatment accorded with the organic matter content standard (≥45%). The results show that there is an increase in the content of organic matter in each treatment group during composting. The reason may be that thermophilic aerobic microorganisms have a high degree of activity, which consumes water and organic matter in the middle stage of composting. Although the
composting piles moisture and organic matter decreased gradually, but compare to the loss of piles volume and weight, the content of organic matter increased. When the volume and weight of composting piles keep relatively stable, the content of organic matter is decreasing and maintain to the end of composting. The organic matter value declined 74.99% to 56.87% in group E, reduce the amount of 18.12%. The amount of reduction more than other treatments, it may due to the continuous addition of carbon dioxide replenishes continuous oxygen for composting piles, improved the rate of decomposition and metabolism of aerobic microorganisms, which can decompose more organic matter.

![Fig.4](image1.png) The organic matter changes during composting  
![Fig.5](image2.png) The total nitrogen changes during composting

3.6. Changes and Analysis of TN, TP, TK during composting

3.6.1. Changes of total nitrogen content. As shown in Fig. 5, the total nitrogen content of each treatment showed a relatively stable trend with the composting time, and the total nitrogen content did not decrease significantly due to nitrogen volatilization. Although the addition of CaO\(_2\), the pH value increased accordingly, the oxygen content of the composting piles is supplemented, which promote the degradation of protein in the piles to produce ammonia and ammonia oxidation into nitrate furtherly; On the other hand, the reduction of the volume and weight of the piles lead to the increase of total nitrogen content during composting. The combination of these two aspects and nitrogen volatilization showed that the trend of total nitrogen content is relatively stable, there is no significant downtrends. The change of total nitrogen between the different treatments was consistent, and there was no obvious discrepancies. Therefore, CaO\(_2\) have a weak nitrogen retention effect during composting, but the effect is not obvious, which needs further study.

3.6.2. Changes of total phosphorus content. The volume and weight of the composting piles decreased due to the organic matter decomposition by microorganisms during composting, however, generally the total phosphorus and total potassium concentration increases during composting due to the concentration effect [19]. As show in Fig.6, the content of total phosphorus presented slowly raise in the compost. At the end of composting, the final value of the total phosphorus in every treatment is higher than the initial value. Furthermore, it is also observed that the total phosphorus content of the group with addition of CaO\(_2\) was higher than control group, it may due to the addition of CaO\(_2\) prolonged the thermophilic period, increased the consumption of organic matter and promoted the "concentration effect", which resulting in a higher final value than the control group.

3.6.3. Changes of total potassium content. The change in total potassium for different treatments are shown in Fig.7. It can observed that the total potassium of each treatment are higher than initial value,
which increased by 0.73, 0.54%, 0.89%, 1.25% and 1.23 % respectively. The increase of total potassium in treatment group B was smaller than that in control group. The increase of total potassium in treatment group D was much higher than that in control group, it may due to the addition of CaO₂, which supplemented the content of oxygen, prolonged thermophilic phase, be conducive to the evaporation of water and the consumption of organic matter, and promoted the "concentration effect". It is observed that microbial inoculum have no effect on the increase the total potassium compared the treatment only with CaO₂, the fore, it can be concluded that the addition of CaO₂ was related to the increase of total potassium content instead of microbial inoculum.

![Fig.6 The total phosphorus changes during composting](image)

![Fig.7 The total potassium changes during composting](image)

3.6.4. Changes of total nutrient content. The total nutrient content affected of total potassium content, which reached the peak value on the 12th day of composting, and then the decline eventually stabilized. At the end of composting, the final values of total nutrient contents were higher than the initial values, increasing by 0.87%, 0.97%, 1.42%, 1.42% and 1.42% respectively. It can be observed that the total nutrient content higer than control group and CaO₂ contributes to the increase in total nutrient content. The total nutrient content of E was 7.24%, which was much higher than the total nutrient content (≥5%) stipulated by the national organic fertilizer standard.

4. Conclusion
The addition of CaO₂ could promote the rapid bio-drying of cow manure and play an emphasis on the Whole composting process. This study determined common indices of compost maturity from cow manure. The results showed that the final pH value of compost dropped around 8, which within the optimum PH range. The moisture content decreased to below 30%, which decreased by 6% ~ 8% compared with the control group, which was conducive to aerobic microbial decomposition and metabolism. Total nitrogen, total phosphorus, total potassium and total nutrient content were increased compared to the initial stage of composting, which can enhance the fertilizer efficiency. However, The organic matter decreased but met organic fertilizer requirements. Through the research, it can be explained that the function of CaO₂ include there aspects: CaO₂ released oxygen slowly by chemical reaction, which continuously replenished the oxygen content in the piles, so that promoted the microbial activity and avoid the formation of anaerobic environment, it can make the composting process become more thoroughly, furthermore, continuous adding CaO₂ is best; CaO₂ released energy by chemical reaction, it accelerate into the thermophilic phase and shorten the composting cycle; the generation calcium hydroxide by chemical reaction with CaO₂ and water, which can cause the micro-alkaline environment and be beneficial to the biodegradation.
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