STATIC AND DYNAMIC COMPOSTING SYSTEMS FOR SHEEP MANURE TREATMENT

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1 INTRODUCTION

In recent years the tendency in Europe has led to intensified livestock, resulting in an increased number of cattle that has not been accompanied by a proportional increase of the agricultural area for farming. Intensification of livestock production has resulted in generation of animal manure, which may be a significant source of harmful nutrient emissions into the environment if handled improperly. Therefore, the need for environmentally friendly methods to treat and use animal manure has become an imperative.

Composting takes place to achieve stable, mineralized and hygienic organic products, to save energy and reduce emissions. This way it is intended to recover the compounds to reintroduce them in the productive cycles. Composting is a controlled aerobic digestion, during which the waste is disinfected and stabilized. The stabilization of organic matter is achieved by the oxidation of complex molecules to form simple compounds. The process generates heat, and this produces substrate sterilization removing pathogens and seeds.

For the composting process, the carbon and the nitrogen are usually the limiting factor of composting. High C/N ratios make the process very slow as there is an excess of degradable substrate for microorganisms. However, with a low C/N ratio there is an excess of N per degradable C and N can be lost by ammonia volatilisation or by leaching from composting mass and can also cause odors and other environmental problems (Bernal et al., 2009). Therefore, the optimal C/N relation is 25-35. Around 40-75% of humidity is also needed for composting process, since the decomposition process occurs mostly in thin liquid layers on the surface of the particles. Furthermore, the porosity of the pile is also a limiting factor, because if the manure is very compact, the air would not enter inside it and the aerobic digestion would not take place.

Generally, most of heavy metals tend to remain in the end-product; this constitutes a very important problem from an agricultural and environmental standpoint (Ko et al., 2008). Hence, Royal Decree 824/2005 (Table 1) establish ceilings and classify the compost into three categories (A, B and C), depending on the content of heavy metals it has. The fertilizers of column C can not be applied on agricultural soils in doses greater than 5 tn DM/ha/year.

TABLE 1 **Heavy metal ceiling set by RD 824/2005.**

Heavy metal ceiling (RD 824/2005)			
Heavy metal (mg/kg D.M.)	**A category**	**B category**	**C category**
Cadmium	0,7	2	3
Copper	70	300	400
Nickel	25	90	100
Lead	45	150	200
Zinc	200	500	1000
Mercury	0,4	1,5	2,5
Total Chrome	70	250	300

The aim of this study was to compare two composting systems (static and dynamic piles) in order to improve the management of manure obtaining a quality compost.

2 MATERIALS AND METHODS.

Sheep manure was used for composting in both systems (Table 2). The carbon and nitrogen, the humidity and the heavy metals were analyzed at the beginning and at the end of the process.

TABLE 2 **Characteristics of input manure.**

	Input manure
Dry matter (%)	30,46
Cu (mg/kg) D.M.	32
Zn (mg/kg) D.M.	1476,45
Cd (mg/kg) D.M.	0,56
Pb (mg/kg) D.M.	3,2
Cr (mg/kg) D.M.	24,8
Ni (mg/kg) D.M.	12,95
N total (%) F.M.	1,15
C (%) F.M.	37,25
C/N ratio	32,4

2.1 Dynamic piles composting system

Windrow composting is based on natural convection and diffusion, aided by regular volts for oxygen supply. Its effectiveness varies with microbial activity and pile porosity. The row had triangular section and its dimensions were around 1.8 m high by 3-4 m wide and 40 meters long. Therefore, the initial total volume was approximately 126m^3. The pile is covered with a geotextile cloth that waterproofs it and, at the same time, allows the pile breath.

To prevent drying, crusting and preferential air paths, the composting material was turned over regularly. Through this periodic turning the piles released heat and humidity and the porosity was increased temporarily. It also contributed to shred the material, so that increased the oxygen transfer. To determine the turning frequency a long tip thermometer, to obtain the temperature at the centre of the pile, was provided to the farmer in charge of the pile. When the temperature decreased to approximately 55 ºC, the pile was turned over.

The turner used was a MENARD SP 4300 equipped with a rotor with shovels and a geotextile cloth roller.

2.2 Static piles composting system

The static piles are not turned mechanically, once built it remained in place until the decomposition slowed down. The absence of agitation requires maintaining an adequate porosity for an extended period of time, so in most cases the substrate requires an input of structuring (straw or sawdust) to avoid compaction. In our case, the manure was already mixed with straw, so it was not needed an input of structuring.

The static piles system used was BC-A20 biocomposter from Agrotech Applied Biotechnology S.A., consisted of a closed system of six reinforced concrete elements that form a tight silo. Each element measured 2.4 meters long, 5 meters wide and 1.1 high. The maximum filling height was 2.5 meters; therefore, the approximate capacity of the installation was 120 m^3.

The bottom of these silos was equipped with three PVC pipes for the aeration system and leachate collection. The leachate was collected to a tank of 0.5 m^3 of capacity, from which it was recirculated through two pipes placed above the pile. The plant is isolated by a fixed cover, made from a steel frame and a waterproof plastic film covering that protects from environment while creating a greenhouse effect inside it. The pile was covered with a geotextile cloth.

The process was controlled via a pressure ventilation system, using temperature as control variable. The electronic system managed its operation based on parameters entered into the operator. The continuous temperature measurement, carried out by four temperature sensors, made the ventilation management possible.

Once the composting time was completed, a stage of maturation outside the system was needed, in which the compost is stabilized and humidified. This phase ended when the compost temperature was around 45 ºC.

3 RESULTS AND DISCUSSION

During the active phase of the composting process the organic carbon decreases in the material due to decomposition of the organic matter by the microorganisms. This loss of organic matter decreases the C/N ratio (Bernal et al., 2009), as it is shown in Table 3. The final compost volume decreased in both systems due to moisture loss and volatile organic matter destruction. The moisture in the static piles final compost was higher than in the other system because of the leaching recirculation system it had. But this recirculation was not uniform, so there were many dry areas in the final compost.

TABLE 3 **Characteristics of input manure and static and dynamic piles final compost.**

	Biocomposter compost	**Dynamic pile compost**
Dry matter (%)	38,87	46,8
Cu (mg/kg) D.M.	18,9	21,9
Zn (mg/kg) D.M.	707,5	451,4
Cd (mg/kg) D.M.	0,42	0,5
Pb (mg/kg) D.M.	3,29	3,4
Cr (mg/kg) D.M.	125	44,3
Ni (mg/kg) D.M.	77	26,3
N total (%) F.M.	1,05	1,4
C (%) F.M.	14,45	17,1
C/N ratio	13,76	12,3

During composting, and in respect of moisture, two antagonistic phenomena take place, on the one hand, the moisture content decreases because of the heat that is generated in the process and because of the leaching, and secondly, the aerobic microbial metabolism of organic matter produces carbon dioxide and water. In practice, it is usually most severe the first phenomenon and the composting material loses moisture (provided by Agrotech), as happened in both systems (Table 3).

As is shown in the Table 3, the concentration of Zn is the highest, followed by Cr, Ni, Cu, Pb and Cd in composts sampled at the end of the composting process. The high concentration of Zn in compost was largely derived from animal feeds used as additives that contained high levels of Zn. In addition, most of the dietary Zn is not absorbed in animal bodies but excreted in animal manures (Ko et al., 2008).Composting can concentrate or dilute heavy metals present in manure. The increase of metal level (Cr and Ni) was due to weight loss during composting because of organic matter decomposition, release of carbon dioxide and water and mineralization processes (Amir et al., 2005). Lowering the amounts of heavy metal present depends on metal loss by leaching. Grimes et al. (1999) used batch leaching tests to show the binding of metals to compost and it is found to be in the order Pb>Cd≃Cu>Zn. This explains why the concentrations of Pb, Cd, Cu and Zn did not increase in the final compost. We obtained a B category compost from the dynamic piles system and C category compost from the static piles system.

Both systems achieved temperatures around 70ºC during the composting, indicating an aerobic digestion. In the dynamic piles system, when the temperature decreased below 55ºC, the pile was turned out (the first one was a month after starting and the second one was a month and a half after it). In the case of the static piles system, the temperature was recorded during the process (figure 1).

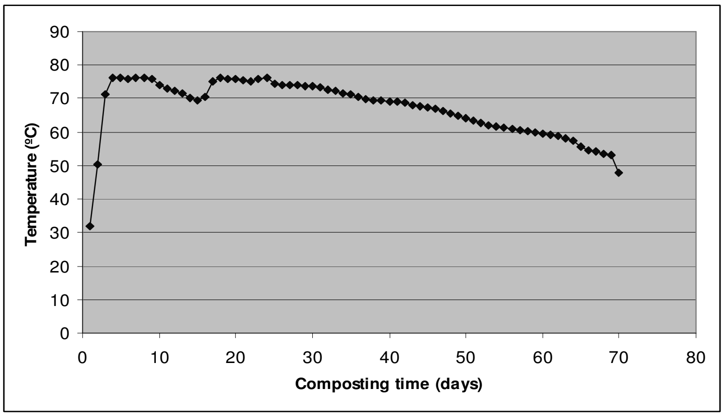

FIGURE 1 **Pile temperature during composting process.**

The dynamic pile system lasted about five months to complete the composting process. In the case of static pile, manure was 70 days in the biocomposter and then around a month out of it for the maturity stage. So the forced aeration pile need less composting time than the dynamic one.

The compost obtained by dynamic piles was more shredded and homogenous. The other compost was a very heterogeneous compost. It had many white areas due to the dryness caused by the unequal leaching recirculation.

4 CONCLUSIONS

On one hand, in the forced aeration system, the main advantages we observed were the process time required (3 months versus 5 months), the leachate capture and recirculation and the self-control of the degradation parameters. On the other hand, although the biocomposter is an automated system, it had problems to control the temperature and the humidity; the leaching recirculation was not uniform. The manure reached very high temperatures and high humidity was consumed, thus affecting the quality of the final compost.

With the dynamic system, we could control the increase in temperature by turning it over. Furthermore, this system allows to treat a variable amount of manure, while in the case of the static piles, the volume to treat depends on the volume of the biocomposter. Besides, the economical viability was better than in the other system because the compost turner could be used in many piles in many livestock farms, so the amount of manure treated could be higher. Furthermore, the compost turner shredded the manure, improving the degradation and achieving homogeneous final compost.

After evaluating the time maturing, parameters of quality and the technical-economic management of both systems, we conclude that the dynamic pile system fitted better with the livestock residue we treated.

REFERENCES

Agrotech Applied Biotechnology S.A., 08500 Vic (Barcelona), 0034-938850175 www.agrotech.es

Amir S, Hafidi M, Merlina G, Revel JC 2005. Sequential extraction of heavy metals during composting of sewage sludge. Chemosphere 59: 801-810.

Bernal MP, Alburquerque JA, Moral R 2009. Composting of animal manures and chemical criteria for compost maturity assessment. A review. Bioresource technology 100: 5444-5453.

Grimes SM, Taylor GH, Cooper J 1999. The availability and binding of heavy metals in compost derived from household waste. Journal of Chemical Technology and Biotechnology 74: 1125-1130.

Ko HJ, Kim K.Y, Kim HT, Kim CN, Umeda M 2008. Evaluation of maturity parameters and heavy metal contents in composts made from animal manure. Waste management 28: 813-820.

Royal Decree 824/2005, of 8 of July, about fertilizer products.