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A NEW APPROACH FOR IN SITU POULTRY CARCASSES DISPOSAL: A CLOSED SEMI-CONTINUOUS COMPOSTER

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ABSTRACT Composting experiences have been developed to evaluate the availability of a composter to decompose animal carcasses. These experiences were conducted over a four year period with poultry, under different operational parameters (aeration cycles, composting recipes and temperatures). The amount of carcasses and co-composting materials added was recorded during each loading of the composter. Additionally, pH, conductivity and redox potential were recorded during composting processes, on a weekly basis, and for the final product. Samples for physico-chemical analyses were also taken. Gases released from the decomposing material (CO_2, CH_4, NO_2 and NH_3) were measured on a weekly basis by an automatic analyser. Temperatures of the material mass inside the composter and outside the composter were recorded continuously with Pt-100 sensors and a data logger device. Agricultural evaluation of the final product was determined by the procedure described by Zucconi *et al.* (1985). Composting has been shown to be effective in destruction of pathogenic agents. In order to minimize the environmental impacts, composting of animal mortalities should begin within 24-48 hours of death. For a carcass compost pile, a C:N ratio of 30-35:1, moisture content of 40-60% (wet basis by mass) and proper air movement (particle size of 3-12 mm and 35% air-filled porosity) provide thermophilic temperatures of 55-60°C for more than two weeks, accelerating aerobic degradation and pathogens inactivation. The experiences carried out with the closed semi-continuous composter developed at the University of Valladolid (Spain), have shown that this equipment is useful for small and medium carcasses disposal.

Keywords: animal mortalities, farm composting, recycling, soil conditioning, waste reuse

INTRODUCTION Animal wastes which are taken out from the farm are classified into three types: solid, slurry and waste water. Solid wastes are treated by drying or composting. Dried wastes are used not only as fertilizer but also as fuel for combustion to obtain energy. Slurry is treated by liquid composting or methane fermentation (Guimaraes 2002). Waste water is treated by the activated sludge process to obtain clean water or simplified aeration method to produce liquid fertilizer. The most appropriate techniques of animal waste management should involve proper treatment prior to the application to land.

The objectives in composting are to stabilize the biodegradable organic matter in raw wastes, to reduce offensive odours, to kill weed seeds and pathogenic organisms, and finally, to produce a uniform organic fertilizer suitable for land application (Haug 1993).

Disposal of animal mortalities has traditionally been done through incineration or burial of carcasses, but other methods (called alternatives in many cases) can be considered, (Stanford *et al*. 2000, 2007)

The elimination of carcasses in intensive livestock farms of the developed countries is an increasing problem (Sánchez *et al.* 2008). So, in the European Union the European Regulation CE 1774/2002 enforces removal of carcasses from farms to authorized treatment plants, which poses a high risk of epizootic dispersion among farms, calling for the implementation of elimination systems within each farm. These systems, without ground or water contamination in farms, should not attract insect or scavenging animals and should not entail animal storage (Kellegher *et al.* 2002; Körner *et al.* 2003). Improper animal mortality disposal may generate various environmental and health hazards such as odor nuisance (resulting from the anaerobic breakdown of proteins) that can reduce the quality of life and decrease property values. Pathogens, which may still be present in the decomposed material, are capable of spreading diseases in soil, plants, animals and humans. The potential leaching of harmful nitrogen and sulfur compounds from animal mortalities to ground water is another concern. To control these side effects, compost facility operators need to know and understand the science and guidelines of carcass composting (Kalbasi *et al.* 2005, 2006)

GENERAL PRINCIPLES

Carcass composting is a natural decomposition process by aerobic (oxygen-dependent) bacteria and fungi. Under optimum conditions, during the first phase of composting the temperature of the compost increases, the organic materials of mortalities break down into relatively small compounds, soft tissue decomposes, and bones soften partially. During this first phase of composting process, the volume and weight of compost mass may be reduced by 40-60%. After the first phase the entire compost pile should be mixed, displaced, and reconstituted for the secondary phase. In the second phase, the remaining materials (mainly bones) break down fully and the compost turns to consistent "humus" with a musty odour containing primarily non-pathogenic bacteria and plant nutrients. In these phase, if needed, moisture should be added to the materials to reheat the composting materials until an acceptable product is achieved. The end of the second phase is marked by an internal temperature of 25-30°C, and a reduction in bulk density of approximately 25%.

Windrows and bin composting are the most usual composting systems for carcasses disposal. To increase the rate of carcass decomposition, different methods have been practiced. Most of the efforts have been focused on making consistent and uniform raw materials (carcasses and carbon sources) by grinding and mixing (Kube 2002), improving aeration rates (Farrell 2002) and using closed containers such as rotating vessel (Rynk 2003), stationary drum (Cekmecelioglu et al. 2003) and aerated synthetic tube (Haywood 2003), for the first phase and then windrow for the maturation phase of composting. With these methods, composting time can be decreased between 30-60% and controlling and adjusting composting parameters (temperature, moisture content and pH) is easier.

NEW CLOSED SEMI-CONTINUOUS COMPOSTER FOR CARCASSES DISPOSAL

The new closed semi-continuous composter has been developed to small and medium carcasses disposal by the research group on composting of the University of Valladolid (Spain). This equipment is divided of two parts: The Box-Compost container and the Compostronic device. Figure. 1 show a view of the composter.

Figure 1. View of the composter.

Dimensions of the Box-Compost container are 2370 × 1080 × 1420 mm (Fig. 2), and it is constructed with panel of polyester in both faces and polyurethane foam (thickness of 60 mm), with an external stainless steel structure of 2 mm of thickness. It has six orifices in the top side to take solids and gases samples (with tubes of PVC with 50 mm of diameter). The composter is loaded by the folding top side. The bottom of the composter is open and it is unloaded by lifting it.

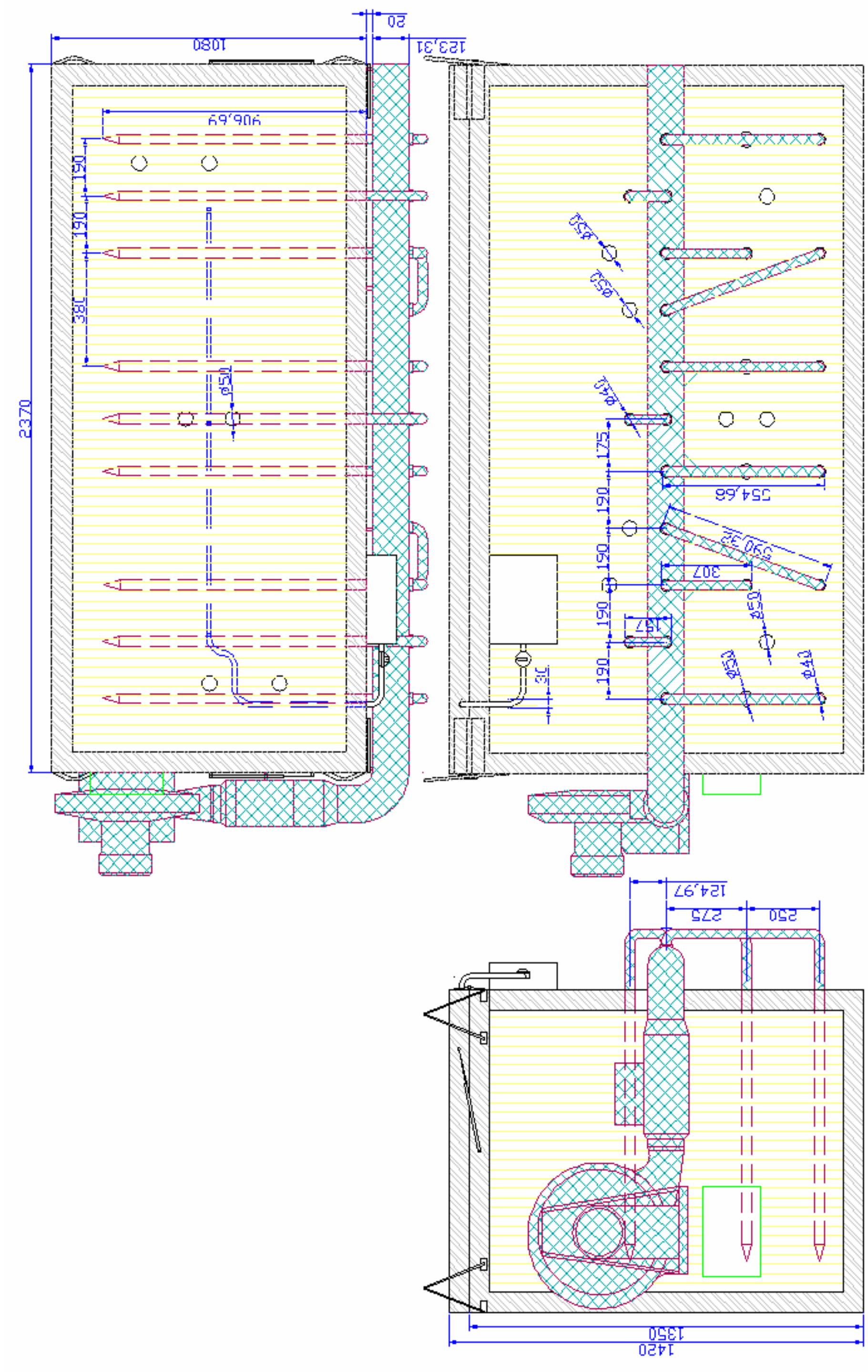

Figure 2. General design of the composter.

Inside the Box-Compost container, temperature, moisture and oxygen contents of the compost mass are conditioned and automatically controlled by the Compostronic device. Air is distributed inside the composter by means of 11 tubes of PVC (in three rows of, respectively, 6, 2 and 3 tubes), 1100 mm in length and 25.4 mm of diameter, with perforations of 6 mm of diameter each 30 mm. Tubes are finalized in a curved coupler to the collector air pipe. They enter by one of the greater length side of the Box-Compost container. The collector air pipe is directly fed from the air conditioner equipment and is made of PVC of 90 mm of diameter, perforated for the incorporation of the air distribution tubes. The water pipe, of polyethylene of 12.7 mm of diameter, supplies water for the compost mass from the top side of the Box-Compost container by means of sprinklers of 100 L·h-1. The air conditioner equipment is constituted by a high pressure centrifugal ventilator of 3 CV of power and an air heater of 7.5 KW. It is equipped with temperature sensors, for the measurement of temperature inside the composter and into the collector air pipe. Composter operation is automatically controlled by a programmable logic controller

Experimental procedure

Composting experiences have been developed to evaluate the availability of the composter to decompose animal mortalities. These experiences have been made during four years with poultry, with different operation parameters (aeration cycles, composting recipes and temperatures).

In all the experiences the co-composting materials were straw and poultry litter. Composter loading begins with a layer of straw of 30 cm of thickness, and continues with evenly spaced layer of mortalities and poultry litter. Carcasses were placed within about 20 cm of the sides. All operations with the composter (loading, unloading, lifting, moving) were mechanized by farm agricultural machinery to avoid any direct contact with raw materials. Sometimes carcasses were frozen between experiences to maintain them.

The amount of carcasses and co-composting materials added was recorded during each loading of the composter. Additionally, pH, conductivity and redox potential were recorded during composting processes, on a weekly basis, and for the final product. Samples for physico-chemical analyses were also taken.

Physico-chemical analysis of the composting product was conducted following the Spanish Official Methods of Analysis (MAPA 1994). Preparation of the samples was done by homogenization and drying at 65°C in a forced air oven and further grinding in a mill. To measure the pH, conductivity and redox potential, it was used a residue/water ratio of 1:25, for which 4 g of residue were diluted in 100 mL of water and shaken during 30 min. Moisture was measured inside the compost mass during the experiences by an automatic moisture meter. Moisture was also calculated by drying samples in an oven at 105°C until constant weight. Organic matter was analyzed by ashing/calcination in a muffle furnace at 550°C for 8 h. Total nitrogen was determined with an automatic analyzer. COD (Chemical Oxygen Demand) was determined by the Spanish regulation UNE 77-004-89 and BOD (Biological Oxygen Demand) was analyzed by a constant-volume respirometer. C:N relation was determined by a automatic infrared detector. For in-situ weekly measures of pH, conductivity and redox potential it was used a portable measurer.

Gases released from the decomposing material (CO_2, CH_4, NO_2 and NH_3) were also measured on a weekly basis by an automatic analyser. Measurement of gases was undertaken by connecting the analyzer inside the composter, Figure 3, through one of the holes of the top side Measurement of gases was also undertaken one half metre away from the composter, Figure 4 .

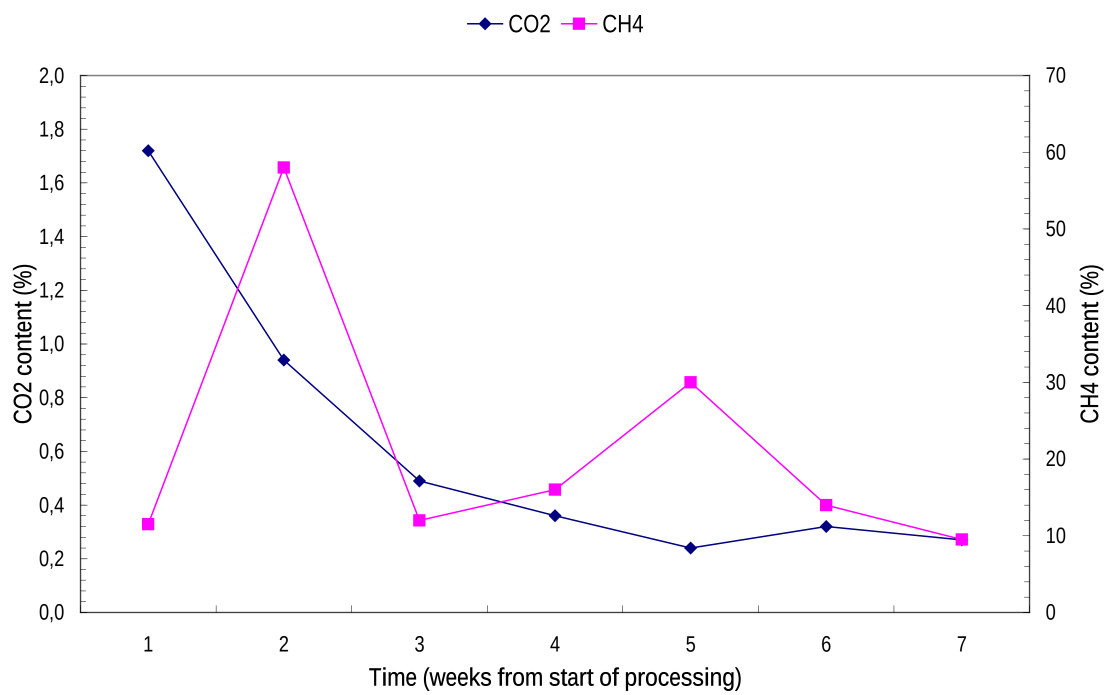

Figure 3. a exemple of poultry composting experience. Gases released from the decomposition process, measured inside the composter.

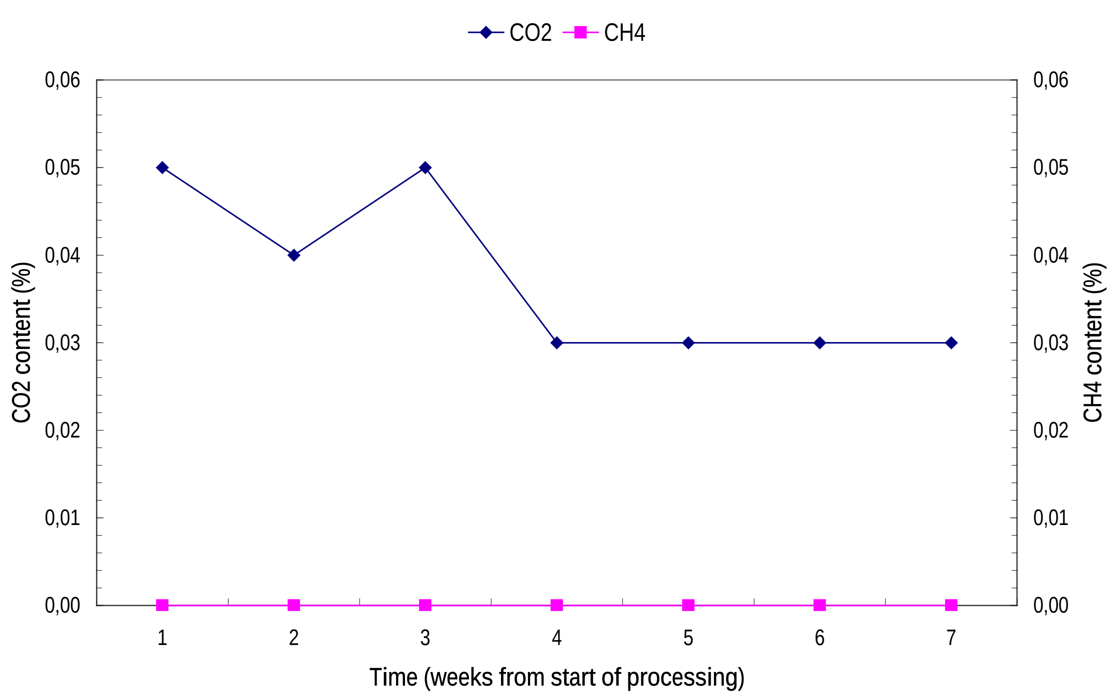

Figure 4. A exemple of poultry composting experience. Gases released from the decomposition process, measured outside the composter.

Temperatures of the material mass inside the composter and outside the composter were recorded continuously with Pt-100 sensors and a data logger device. Figure 5 show the result of one test. Continuous logging of internal operating temperatures in three zones of the mass permitted to assess general composting performance and the ability to meet pathogen reduction criteria used in the biosolids composting industry. Agricultural evaluation of the final product was determined by the procedure described by Zucconi et al. (1985).

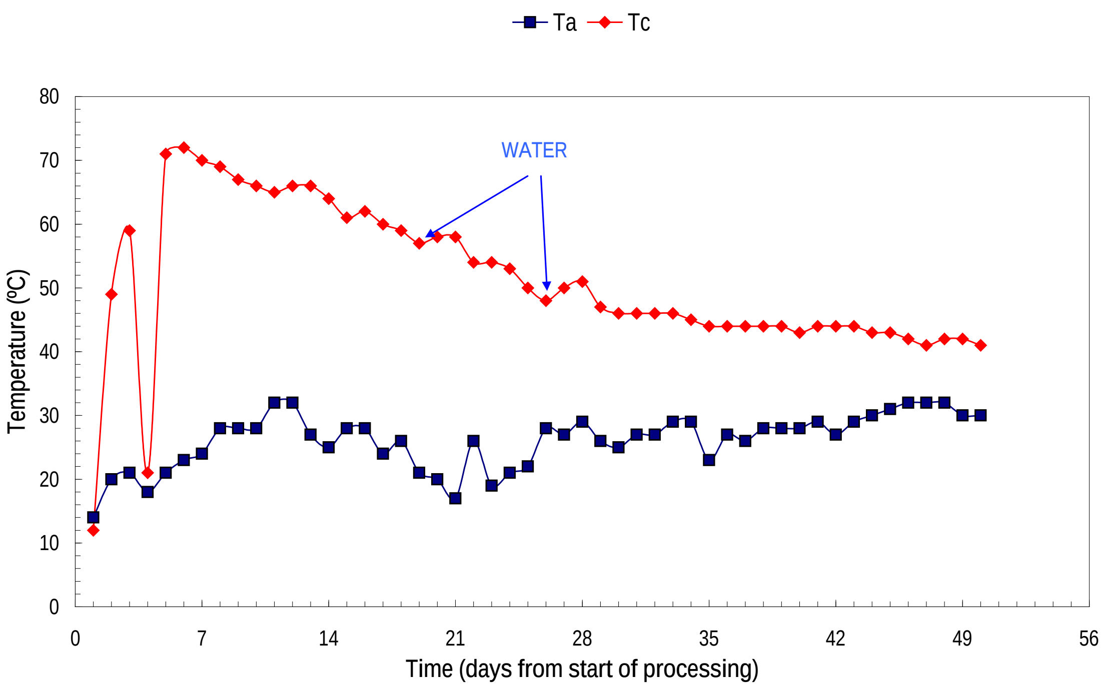

Figure 5. Poultry composting experience. Temperature evolution outside and inside the composter (Ta, air temperature; Tc, compost temperature).

CONCLUSION Agricultural use of animal wastes as compost is recommended. Total amounts of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) contained in animal wastes nearly equal to those of chemical fertilizers applied to arable land. Insufficient treatment and/or illegal dumping of excess animal wastes cause serious pollution problems. Then, recycling of animal wastes without any environmental pollution will be closely related to the development of sustainable agriculture with organic fertilizer.

Composting can potentially serve as an acceptable disposal method for management of animal mortalities, obtaining a beneficial end product that can be utilized as fertilizer or co-composting material. Successful conversion of whole materials into good-quality compost requires daily and weekly control of odour, temperature and moisture during the first and second phases of composting. Operations need to be prepared with site locations, cover materials and equipment to effectively compost carcasses. This management and control will prevent the need for major corrective actions. Composting has been shown to be effective in destruction of pathogenic agents. In order to minimize the environmental impacts, composting of animal mortalities should begin within 24-48 hours of death. For a carcass compost pile, a C:N ratio of 30-35:1, moisture content of 40-60% (wet basis by mass) and proper air movement (particle size of 3-12 mm and 35% air-filled porosity) provide thermophilic temperatures of 55-60°C for more than two weeks, accelerating aerobic degradation and pathogens inactivation.

Experiences carried out with the closed semi-continuous composter developed at the University of Valladolid (Spain), have shown than this equipment is useful to small and medium carcasses disposal.

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