An innovative solar drying method for transforming hotels' food wastes into animal feed

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Abstract Through a pilot scale realization, an innovative, simple technology and low emissions process is attempted the safe transformation of source separated food wastes, mainly from hotels (and generally from the hospitality industry and restaurants), into animal feed, utilizing an altered solar drying process. A greenhouse-type solar dryer will be developed in order to convert a food waste to animal feed, which uses solar drying processes in the shortest possible period, towards the production of feed. The resulting by-products, once dried out and pasteurized, have a final application as animal food. The greenhouse, with a roof height of 4.7m and total area of 384m^2, will be consist of two parallel concrete corridors 5 m wide and 20 m long, completely covered by a strong polycarbonate cover (Plexiglas), resistant to unfavorable climatic conditions. Using free solar energy for drying and pasteurized source separated food wastes can be beneficial from the point of view of energy consumption and, consequently, the drying system cost. The main innovation of the process is using the most abundantly available energy source in Greece – and the Mediterranean basin generally - the sun.

Keywords: Food waste; animal feed; solar drying; pet food

1. Introduction

The EU Directive requires Member States to reduce the amount of biodegradable municipal waste going to landfills to 75% of 1995 levels by 16 July 2006, to 50% by 16 July 2009 and to 35% by 16 July 2016. Indeed, the implementation of European legislation reduced the share of landfilling in the EU-27 from 68% in 1995 to 38% in 2008, with the landfill rate in Greece being 81% in 2008 (Eurostat, 2011). Municipal solid wastes in Greece consist mainly of fermentable organic material (50%) and paper residuals (20%) (Bosdogianni, 2007).

The sun is the largest available carbon-free energy resource and the world's most abundant permanent source of energy, with the potential to meet a significant proportion of the world's energy needs. The solar drying system is one of the most attractive and promising applications of solar energy. Applying free solar energy may well be an alternative solution for reduction of drying process costs. However, contrary to drying under constant conditions, the obtained drying kinetics during solar drying present some variations, as the operating conditions continuously change over time.

The effective benefits of using renewable energy, and primarily solar energy, have been studied by many researchers (Ekechukwu and Norton, 1999; Sharma *et al.*, 2009). Many advantages have been reported in the different applications of solar drying in agriculture as well as industry.

This study presents, a pilot scale realisation, an innovative, simple technology and low emissions process that allows the safe transformation of source separated food wastes, mainly from hotels (and generally from the hospitality industry and restaurants), into animal feed, utilizing an altered solar drying process.

2. Methodology – Materials and methods

2.1 Materials

The food wastes will be provided mainly from hotels (and generally from the hospitality industry and restaurants). These materials are provided by a separated collection scheme, in a touristic area of Crete (Greece), taking advantage of the source separating system applied, due to ISO and HACCP regulations.

2.2 Experimental unit

The experimental study will be carried out at a pilot solar drying unit, a greenhouse with a roof height of 4.7m and total area of 384m^2, located in Heraklion, Greece. The schematic view of the unit is shown in Fig. 2 and a similar greenhouse solar drying unit in Fig. 3. Fig. 2 shows all the coupled transfers in the greenhouse, air and boundary walls due to radiation and convection, as well as the quantity of water evaporation from the materials (Roux *et al*., 2010). Aeration of the surface of the materials is effectuated by side windows. The greenhouse solar system (greenhouse system) is a large solar collector in which the curing and drying process takes place for effective year-round solar energy utilization in agricultural production. The greenhouse provides effective use of solar energy. Natural solar radiation is used for water evaporation solar-dried plants: The materials warm up and the water inside evaporates. The unit consists of a prefabricated building composed by four connected, 7 m long and 3 m wide containers which will be used for the hand sorting. The buildings will create a 14 m long and 6 m wide room where a series of air-conditions and air extraction and recirculation units (for health and safety issues) will be installed. The first few meters of the building will be dedicated in storing the relevant bins from the truck before emptying them in the hand sorting conveyer belt.

The belt of 6 m long will allow four people to work in removing foreign particles / objects from the wastes (non-food wastes as plastic, metal etc). The sorted food waste will then be collected at the end of the belt and will be thoroughly shredded. The pulp will be collected into a small tank at the bottom of which a powerful sucking pump will be placed. The pump will forward the shredded wastes into one of the two drying halls, based on which is available at the time. The halls will be basically two greenhouses 30 m long and 6.40 m wide, with strong polycarbonate cover (Plexiglas), insects net in the windows (stopping insects getting inside) and concrete floor for pest control. Each drying hall will have a drying corridor (20 m long and 5 m wide) with 0.80 m high reinforced concrete side walls, on the top of which the turning system will be moving. The corridor floor will be covered with an extensive network of pipelines connected to the water solar heaters. On top of the pipelines a high quality stainless still cover will be placed covering all surfaces, where the food waste will come in contact with. A schematic representation of the pilot unit is presented in fig 4 and 5. Materials are mixed inside the greenhouse using two different mixing engine (a rotation drum for horizontal operation and a drum for vertical operation) to prevent the formation of crusts and ensure an evenly granulate dry material and sufficient aeration of the dry material. The height- adjustable rotating drum is mounted on a frame and aerates the material during the drying process with fixed paddles. This crane-like frame runs longitudinally through the hall. The immersion depth of the drum in the material can be adjusted continuously. The operation of the technology is very simple and essentially automatic. Personnel costs can be kept very low and no technical skills are required. Aeration of the surface of the materials is effectuated by two side windows and four fans.

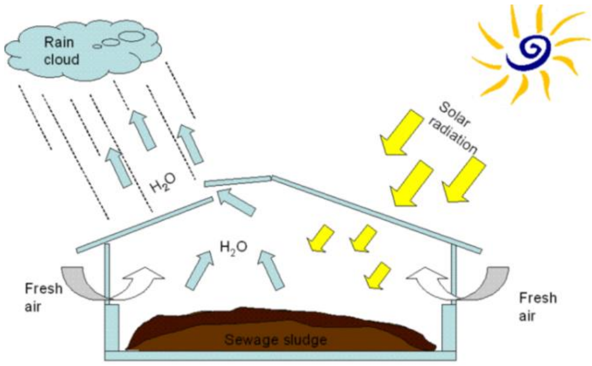

Fig. 2 Schematic view of the covered solar drying unit and transfer phenomena in the solar drying unit (Roux *et al*., 2010).

Fig. 3 A similar Greenhouse Solar Drying Unit.

Table 1 presents the Unit equipment.

Table 1. Unit equipment.

Equipment	Power (kw)
Vertical rotation drum	7
Horizontal drum	9
Sorting belt	1.5
Grinder	2.5
Pump	1.5
Fans (1.0 x2)	2

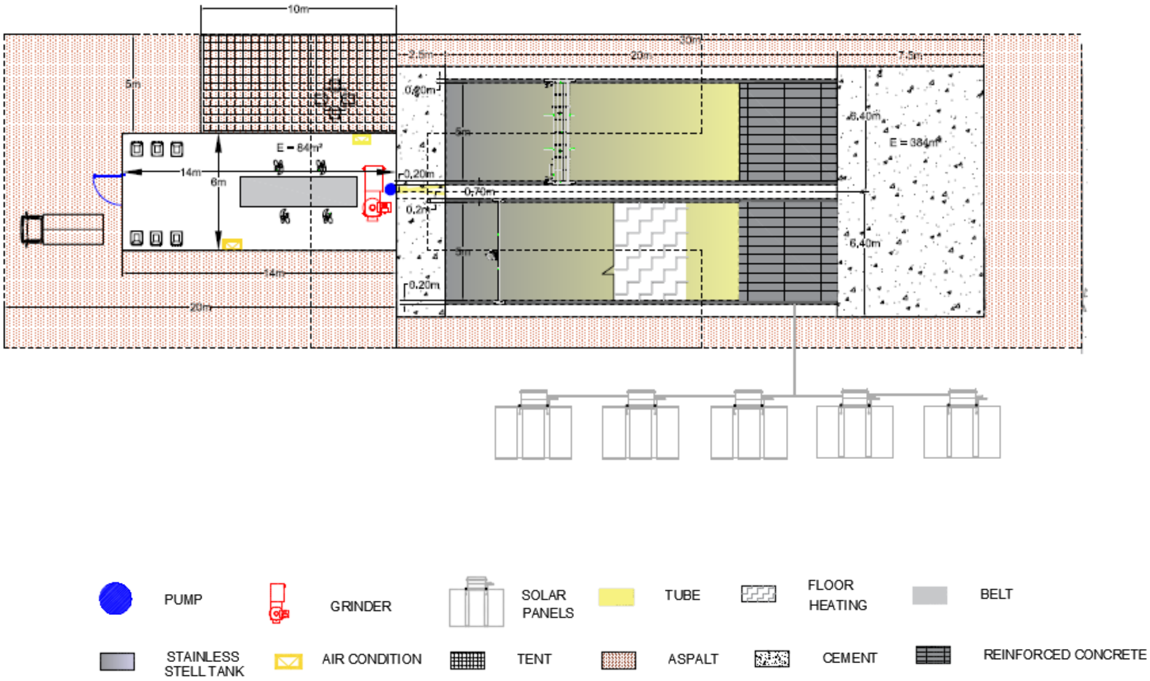

Figure 4. Plan view of the Unit.

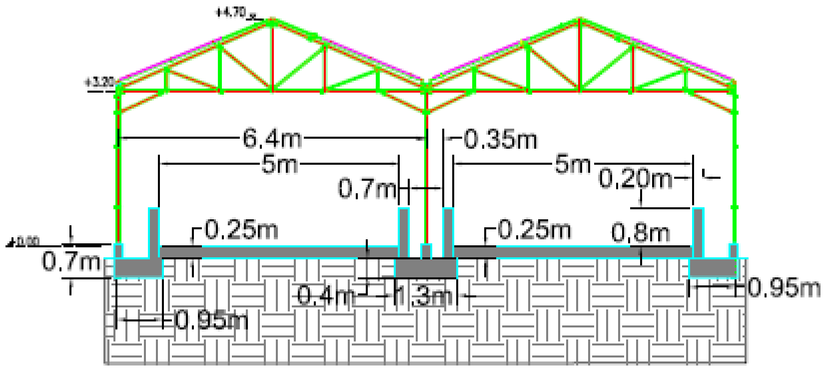

Figure 5. Cross Section of the Unit.

4. Conclusions

Solar drying processes can be a very attractive technology for drying and pasteurized source separated food waste in order to decrease the high energy consumption of the drying operations. In the present study, a solar drying process was used to remove moisture and pasteurize hotels' food waste and transform them into animal feed. The main innovation of the process is using the most abundantly available energy source in Greece – and the Mediterranean basin generally - the sun.

Acknowledgments

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