ENVIRONMENTAL IMPACT ASSESSEMENT OF A SOLAR DRYING UNIT FOR THE PRODUCTION OF ANIMAL FEED FROM FOOD WASTE

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Abstract
Food waste from the hospitality sector is a key waste stream which causes policy implications in connection with the EU Landfill Directive (1999/31/EC). In order to tackle the aforementioned issue, an EU based partnership has been formed in order to implement the Life+ F4F (Food for Feed) project. The main aim of the project is to evaluate, through a pilot-scale demonstration, an innovative and simple technology, and a low-emission process that enables the safe transformation of food waste, mainly from hotels (and more generally from the hospitality industry and restaurants), into animal feed. The goal of the present study is the calculation of the environmental impacts caused by the pilot scale plant required to transformed food waste into animal feed. The analysis indicates that the construction of the floor that the pilot plant will be based on, is the dominant factor in the overall impact of the infrastructure.

Keywords: food waste; animal feed; hospitality sector; solar drying

Introduction

In the EU, it is estimated that 90 million tonnes of food waste is produced every year, equivalent to 180 kg per person [1]. In some EU countries, especially those in the south, the majority of food waste ends up in landfill. In Greece, for example, more than 95% of food waste ended up in landfill in 2013, either directly or indirectly.

The EU Landfill Directive (1999/31/EC) sets as a target the progressive reduction of biodegradable municipal waste going to landfill, to 35% of the 1995 disposal level by 2020, and the Circular Economy Package foresees a binding target to reduce landfill to a maximum of 10% of municipal waste by 2030. Furthermore, the latter foresees food waste as being one of the priority sectors that need to be addressed in a targeted way, to ensure that the interactions between the various phases of the cycle are fully taken into account along the whole value chain. It also foresees that measures will be taken so that foodstuff and by-products from the food chain are used in feed production without compromising safety.

In order to tackle the aforementioned issues, an EU based partnership has been formed in order to implement the Life+ F4F project [2]. The main aim of the LIFE-F4F (Food for Feed) project is to evaluate, through a pilot-scale demonstration, an innovative and simple technology, and a low-emission process that enables the safe transformation of food waste, mainly from hotels (and more generally from the hospitality industry and restaurants), into animal feed. Food will be processed using a solar energy to pasteurise and dry food waste, a process that has not been tested or applied previously, either in Europe or elsewhere worldwide. The F4F process will address the need to reduce waste food going to landfill, and will support the implementation of separation schemes at source for food waste to create valuable raw materials for the production of feed [2]. This reuse process, in line with the circular economy concept, will transform a waste management process into a feed producing one (and has been licensed as such). Since it utilises solar power (directly and indirectly), it is also a low energy and low carbon emission process. The project aims to influence EU legislation on waste, the Circular Economy Package and the Roadmap to a Resource Efficient Europe.

Process description

The main aim of the F4F project is to evaluate, through 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 unit. The capacity of the solar drying unit will be 40-50 tonnes of produced animal feed per year. The pilot plant will be built in the metropolitan area of Heraklio, in the island of Crete in Greece.

Figure 1. Outline of the pilot plant.

The first step of the process will be the collection from selected hotels of separated food waste. The collected food waste will be transferred to the pre-sorting unit, where it will be cleaned via means of manual hand selection. Then, the preselected food waste will be shredded and transferred via a pump to one of two drying channels of the solar drying greenhouse. The dried product will be the raw material for the production of animal feed. The main operating steps in the pilot plant are outlined in Figure 1.

Goal and scope of the research

The goal of the present manuscript is to present the environmental impact assessment of the infrastructure of a pilot plant required to transform the separated food wastes into animal feed utilizing an altered solar drying process. Similar studies, on the environmental impacts of food waste management options, are reported in the literature [3, 4]. The pilot plant consists of two units: the pre-sorting unit and the solar drying greenhouse. The pilot plant will occupy a total area of 880 m^2. Within this area, the pre-sorting unit and the drying greenhouse will be placed, covering an area of 468 m^2. The scope of the study includes the infrastructure of the pilot drying unit. More specifically, the scope of the study includes:

- Excavation works and construction of the presorting unit and the drying greenhouse; construction of an underground tank for wastewater collection in addition to the hydraulic and electrical infrastructure of the presorting and solar drying units.
- Infrastructure of the drying greenhouse: metallic structure, polycarbonate greenhouse covers, a transfer belt, a pump for the transfer of the mashed material, a submerged pump for wastewater. Moreover, the floor heating pipes needed for drying and two air-conditioning units.

Functional unit

The functional unit is defined as "processing of 1 tn of collected food waste annually". The lifespan of the pilot unit is estimated to be 20 years.

Infrastructure inventory

The key components of the pilot plant infrastructure are presented in Table 1. The key components were extracted from the master plan of the pilot plant. These are:

- materials (e.g. reinforced concrete and asphalt) and operations (e.g. excavation) for landscaping and floor construction;
- metallic structures (presorting unit and solar drying greenhouse);
- water supply and drainage infrastructure (e.g. excavation and pipes);
- and electrical infrastructure (e.g. cables).

At this point, since the unit is still under construction, the electricity required for the operation of the pilot plant is not taken into account.

Table 1. Inventory table for the pilot plant.

Infrastructure component	**Unit**	**Measure**
Landscaping		
Excavation	m^3	129.3
Floor construction		
Reinforced concrete	m^3	39.2
Lightly reinforced concrete	m^3	65.2
Cover concrete	m^3	15
Lightly reinforced concrete floor	m^3	8.4
Industrial floor (epoxy resin)	m^3	8.4
Gravel	m^3	0.4
Excavation	m^3	0.8
Reinforce concrete for tank	m^3	1.8
Asphalt, bitumen	m^3	20.6
Metallic structures		
Stainless steel	kg	1500

Water supply and drainage infrastructure		
Cast iron covers	kg	20
HDPE pipe (25 mm diameter)	m	70
HDPE pipe (32 mm diameter)	m	50
Excavation	m^3	7
Drainage pipes (PVC-U) (125 mm diameter)	m	45
Drainage pipes (PVC-U) (100 mm diameter)	m	10
Electrical infrastructure		
Excavation	m^3	11
Pipes (PVC)	m	500
Cables	m	500
Electricity consumption during operation		
Food waste shredder	kW	8.2
Feeding pump	kW	1.1
Submerged wastewater pump	kW	1.1
Greenhouse openings motor	kW	1.5
Air conditioning units	kW	14.2

Results

Based on the data of Table 1, impact assessment was performed using the CML2 baseline 2000 ready-made method. The pilot plant process was modeled using the Simapro 5.1 database. The actual values of the impact assessment results per impact category are presented in Table 2.

Table 2. Characterisation results per impact assessment category.

Impact category	Unit	Total	Landscaping	Floor construction	Metallic structure	Water supply	Drainage	Electrical infrastructure
abiotic depletion	kg Sb eq	4610	444	3200	507	1.33	446	3.24
global warming	kg CO2 eq	246000	47700	109000	40800	96.8	47900	345
ozone layer depletion	kg CFC-11 eq	0.216	0.0135	0.0889	0.101	2.32E-05	0.0135	1.04E-08
human toxicity	kg 1,4-DB eq	105000	30100	41100	3960	30.9	30200	2.64
fresh water aquatic ecotox.	kg 1,4-DB eq	14200	4120	5550	428	4.62	4130	0.0594
marine aquatic ecotoxicity	kg 1,4-DB eq	1.05E+08	32100000	39400000	1610000	25900	32200000	198
terrestrial ecotoxicity	kg 1,4-DB eq	537	149	232	6.63	0.352	149	0.0106
photochemical oxidation	kg C2H2	149	21.6	44	60.6	0.0325	21.7	1.01
acidification	kg SO2 eq	1180	197	436	322	0.606	198	25
eutrophication	kg PO4--- eq	83	11.7	22.7	36.9	0.0112	11.6	0.00151

The relative impact assessment characterisation results per impact are presented in Figure 2. The construction of the pilot unit floor is the process that dominates the environmental impacts, followed by the landscaping. The metallic structure of the plant is also present in key impact categories (abiotic depletion, global warming, photochemical oxidation, acidification and eutrophication). In addition, the materials needed for the drainage systems are contributing to each one of the impact categories.

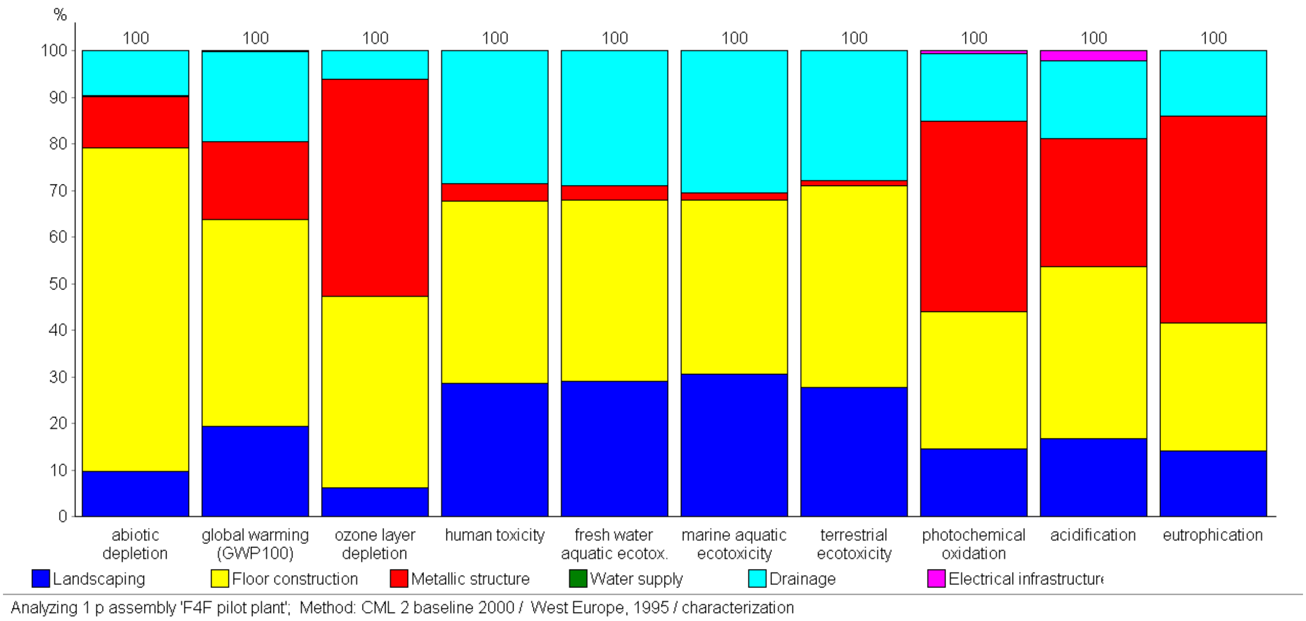

Figure 2. Contribution of pilot plant components to the impact assessment categories.

The normalised results are presented in Figure 3. As expected, since the focus of this analysis is on the infrastructure, the abiotic depletion impact category is among those mostly affected, mainly due to the contribution of the floor construction.

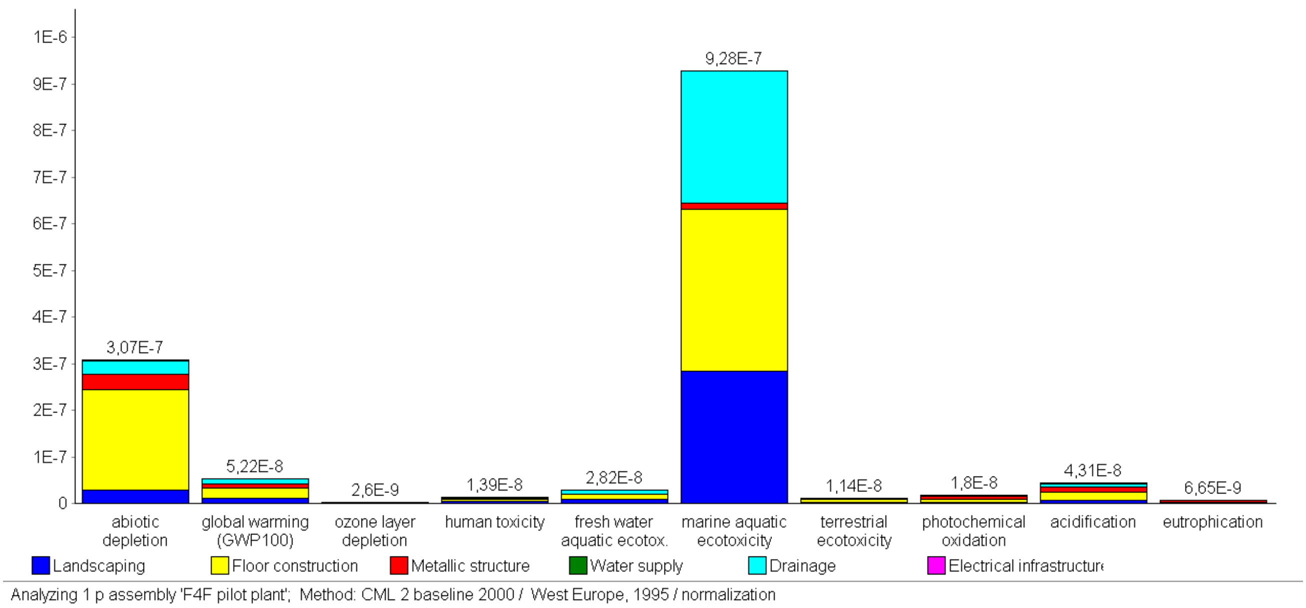

Figure 3. Normalisation of the impact assessment results.

Conclusions

A solar-driven pilot plant for the transformation to animal feed of food waste collected from hotels, is under construction. An analysis has been performed for the environmental impact assessment of the required infrastructure. The analysis indicates that the construction of the floor that the pilot plant will be based on, is the dominant factor in the overall impact of the infrastructure.

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