# The challenges and benefits of in-vessel composting our food and catering waste to divert material from landfill and provide Eden Project with a valuable fertiliser

**Tim Pettitt (presenter)[1], David Bullock[1], Nicolette Knight[1], Maureen Newton[1], Maxine Fuller[1], Demetra Orthodoxou[2], Stephen Smith[2], Patrick Massey[1], Alistair Griffiths[1]**
[1]Eden Project, Bodelva, St Austell, Cornwall, PL24 2SG
[2]Department of Civil and Environmental Engineering, Imperial College London, London, SW7 2AZ, UK

## Abstract

As part of our Waste Neutral Programme, the Eden Project installed an in-vessel food waste composter, the ‘Neter 30’. This was developed by Torsten Hultin based on a smaller machine, the ‘Big Hannah’, many of which are in operation, predominantly in Scandinavia. Hultin promoted these composters to local communities and small businesses to provide food and other biodegradable waste recycling systems, producing a beneficial end product whilst fostering social responsibility towards waste.

Compliance with UK/EU legislation entailed shredding food waste going into the composting vessel. The resulting ‘paste’, consisting of much cooked waste, gave an acidic low temperature compost when mixed with recommended sawdust pellets. Experimentation under commercial operating conditions increased starting pH and achieved rapid high temperatures using a mixture of finished compost and card fluff as co-feedstocks whilst keeping moisture levels between 40-45%.

‘Neter 30’ compost can be used unamended as a growing medium or as a mulch. Containing high levels of N and K and reasonable levels of P, its real value is as a high nutrition additive to our green waste compost for use as a spring mulch to reduce our need for high N fertilisers. Work on this is ongoing but early results are very promising.

## Key words

Aerobic in-vessel composting, efficacy, food waste, moisture content, pH

## Introduction

An aerobic in-vessel food waste composter, the Neter 30, was installed at Eden Project as part of our ‘Waste Neutral’ programme. We set up our Waste Neutral Programme at Eden Project to minimise the waste of materials in our own operations and to promote the minimisation and recycling of waste to the general public (http://www.edenproject.com/whats-it-all-about/what-we-do/projects-and-programmes/waste-neutral.php). The aims of this programme were encapsulated in a simple slogan: Reduce, Reuse, Recycle and Reinvest. The composting of food waste streamed from our kitchens and catering operations constitutes an important component of the recycling effort at Eden Project and aims to divert a significant amount of organic waste from landfill. The Neter 30 system was selected over a number of composting technologies, including anaerobic digestion, based on its capacity to deal with the expected volumes and seasonal variation in quantities of food waste possible at Eden as well as the compatability of the philosophy of the producer with Eden Project’s aims. Built by Susteco AB, the Neter 30 was developed by Torsten Hultin based on a smaller machine, the ‘Big Hannah’, of which there are over 600 in operation, predominantly in Scandinavia (Wiles, 2006). Hultin promoted the use of these composters to local communities and small businesses to provide systems that could recycle food and other biodegradable waste, to produce a beneficial end product whilst fostering social responsibility towards this waste stream. Making the Neter 30 composter work at Eden is definitely a team effort and this is reflected in the large number of authors on this report! It is one thing to set up and work out the technicalities of operating a composting system, but it is quite another to successfully run such a system at a complex site like Eden Project. For this to happen, the operation of the composter has had to become embedded within the site culture and keeping it there is an ongoing project about support, shared knowledge and shared ownership.

**Description of the Neter 30 composter**

The Neter 30 in-vessel composter was designed for composting organic wastes, primarily catering waste with added sources of carbon and the optional addition of horticultural waste. It was designed as a single-stage, fully contained, continuous flow-through system, with waste fed *via* an in-auger into one end and compost automatically removed *via* an out-auger at the other. The composter consists of a horizontal stainless steel cylinder approximately 8.5m long, by 2m diameter (volume = *circa* 30$m^3$), which rotates against fixed end walls. It is housed within a stainless steel outer casing 9.5m long, 2.7m wide and 2.6m high. This outer casing acts as a safety barrier for the moving parts and provides some buffering from external temperature fluctuations. The rotation of the cylinder tumbles the material being composted, mixing and aerating it, whilst moving it along the vessel. The periods of rotation ('run') and standing ('wait') can readily be altered to suit the process. Fixed to the end walls is a spindle that runs through the centre of the vessel. Attached at right-angles to the spindle and spaced at 1.4m intervals, are 5 circular steel plates on each of which 4 temperature sensors and 1 water inlet nozzle (for wetting compost if it becomes too dry) are mounted (Figures 1 & 2).

**Operating the composter**

The food waste at Eden consists of catering waste from the kitchens and food preparation areas together with scraps from cleared tables and some spent compostable packaging and wooden eating utensils. Until relatively recently this waste contained little raw vegetable material (primarily salad trimmings and scraps) or peelings, as the vast majority of the vegetables cooked on site were delivered ready-prepared (i.e. peeled and washed). This situation is now changing with increasing vegetable preparation (e.g. onions and cabbages) on site (Figure 3).

Members of the catering team in the kitchens and in service areas of the cafeterias (Figure 4) carry out a key role in the running of the composter by source-separating the food waste from other recyclables such as glass, metal, plastics etc. and from general waste. This vital task can be very demanding, especially when the pressure is on during the peak season when Eden can host more than 10 thousand visitors in one day, but without the continuous attention to detail at this stage by the catering team, the quality of the compost produced can be compromised.

The separated food waste is collected by members of the Waste Neutral Operations Team and taken to the recycling compound in 90 litre 'wheelie' bins. When full, these can vary in weight from 25kg (predominantly bread) to 75kg (predominantly wet food waste), with the average full bin weighing approximately 40kg. Food bins are weighed and emptied by bin lift (Figure 5) onto conveyor belts, where the waste is manually inspected (Figure 6) and any contaminants (metal, plastics etc.) missed by the catering team are removed. After inspection, the conveyor delivers the waste to a shredder set to reduce the particle size to 20mm. Once shredded, the food waste is transferred to the composter vessel by the 'in-auger' (Figure 1) and mixed with other feedstocks in the vessel. As the vessel rotates the composting mixture progresses along its length until, after about 70-90 days, it reaches the 'out end' and is removed by the 'out-auger' (Figure 1) as finished compost. The composting process is regularly monitored by members of the Waste Neutral Operations and Science Teams, who collect records of temperatures in the vessel and of the weights of feedstocks put in and of finished compost taken out as well as taking samples from the vessel for measurements of pH, moisture contents and microbiological activity.

**Experiences developing the process**

Shredding the food waste to 20mm is carried out to comply with the U.K. Animal By-Products Regulations ('ABPR' – HMSO, 2005). The resulting homogenate (Figure 7), is mixed with other feedstocks to reduce its moisture content and adjust its pH and carbon to nitrogen ratio to the optimal ranges of 6-8 and 25:1 - 40:1 respectively (Gilbert *et al.*, 2001). The recommended co-feedstock for use in the Neter 30 was sawdust pellets (Figure 8), which have been successfully used in Scandinavian systems. However, mixing Eden food waste with sawdust pellets resulted in a rapid decline in the pH of the mixture to levels as low as 4.2, leading to very poor composting temperatures. It was suspected that this was in part due to the nature of our food waste, especially its very low raw vegetable material content, and the effect was reduced by the addition of shredded green waste from the Eden Project gardens and finished compost to the mix. The large particles of green waste improved the structure of the compost and both co-feedstocks probably added useful micro-organisms, whilst the alkalinity (pH 8.5 – 9.0) and low moisture content (25-35%) of the finished compost helped to dry the mix and stabilise/increase its initial pH.

Operationally this mix of feedstocks was difficult to put into the composter as a result of the way in which the front end of the vessel was configured and produced mixed results due to the variable nature of the green waste. The addition of co-feedstocks was greatly facilitated by the fitting of a hopper directly over the in-auger (Figure 9), whilst an in-depth investigation of the interaction of physical and chemical factors within the vessel (Orthodoxou, 2008) demonstrated that the moisture content of the compost mix was the main factor affecting the pH and hence the composting temperature (Figure 10). The optimum moisture content was found to be between 35 and 45%, considerably lower than the 50-60% normally considered optimal for composting. Gas analysis in the same study also established that when moisture levels rose, anaerobic conditions did not develop and consequentially were not the cause of the decline in pH associated with such moisture increases (Figure 11). The precise cause of acidic fermentation conditions developing in the composter is not certain, but it was clear that excessively wet (i.e. >50% moisture) and acidic feedstock mixes are to be avoided.

Following on from this study a range of potential co-feedstocks were screened for their ability to adjust the pH to >6 and the moisture content to <45% when mixed with freshly shredded food waste. At this stage 'card fluff', a new material for us, was considered. This waste material consists of fibres and dust collected by cyclone separator from the air in a corrugated board box manufacturing plant (Figure 12) and would normally be disposed of to landfill. It has a pH of 8.5-8.8, probably resulting from sodium hydroxide present in the starch glue used in corrugated board, a moisture content of 7-10%, and a high carbon content, making it a potentially ideal co-feedstock for food waste. Comparisons of different ratios of feedstocks (Figure 13) indicated that the best mix is about 50% food waste to 25% finished compost and 25% 'card fluff'. This gives a pH of 6.5-7.5 and a moisture content of 40-48%. In practice this ratio of feedstocks has produced excellent results, with temperatures rapidly becoming thermophilic (>45$^{o}$C) within the first metre of the vessel. However it can be difficult to adhere to, especially when large amounts of food waste need to be processed. When this happens, there is the danger of too high a proportion of food waste in the mix giving a reduced pH and increased moisture content, leading to a steady decline in pH and an undesirable drop in composting temperature to 30-40$^{o}$C. Nevertheless, the temperature of the compost at the first monitoring point gives a good indication of composting efficacy and over the last year this has been >45$^{o}$C for 80% of the time, and >50$^{o}$C for more than 60%, leading to temperatures above 60$^{o}$C in the central portion of the vessel and production of a great compost product that is safe to use.

## The finished compost

The Neter 30 enables us to divert approximately 20 tonnes of food waste from landfill and produces about 10 tonnes of compost per year. The compost produced (Figure 14) has passed the PAS 100 quality standard (BSI, 2005) and can be used as a growing medium (Figure 15). However, the majority of the food waste compost produced at Eden is used as an activator co-feedstock in our green waste composting (Figure 16) or as a high nutrition mulch/soil improver (a 25 mm thick mulch will give approximately 40kg N ha$^{-1}$). Our food waste compost also contains high levels of K and moderate amounts of P, but applying it directly to soil can be unpleasant as it can be dusty and we are now looking at the feasibility of using it as a fertiliser in mulch mixes with our finished green waste compost.

## References


BSI (2005). Publicly Available Specification PAS 100:2005, Specification for composted materials. British Standards Institution, London, UK, ISBN 0-580-45195-X, 47pp.

Gilbert, EJ, Riggle, DS, Holland, FD (2001). Large-scale composting: A practical manual for the UK. The Composting Association, Northamptonshire, UK, 144pp.

HMSO (2005). The Animal By-products Regulations 2005. *Statutory Instrument* 2005 No. 2347, ISBN 0 11 073280 4, HMSO, London, U.K.

Orthodoxou, D. (2008). *Investigation of the physical, chemical and microbiological parameters influencing a small-scale in-vessel composting system for food waste.* MSc Thesis, Department of Civil Engineering, Imperial College, London, 105pp.

Wiles, D. (Ed.). (2006). Composting made easy. *Sweden Today* 2006 (2), 33.

**Figure 1:** A) Diagram of the Neter 30 composter showing positions of temperature sensors and access hatches. B) Cross-section showing the central spindle and positions of temperature sensors and water inlet pipes located on plates A – E within the vessel.

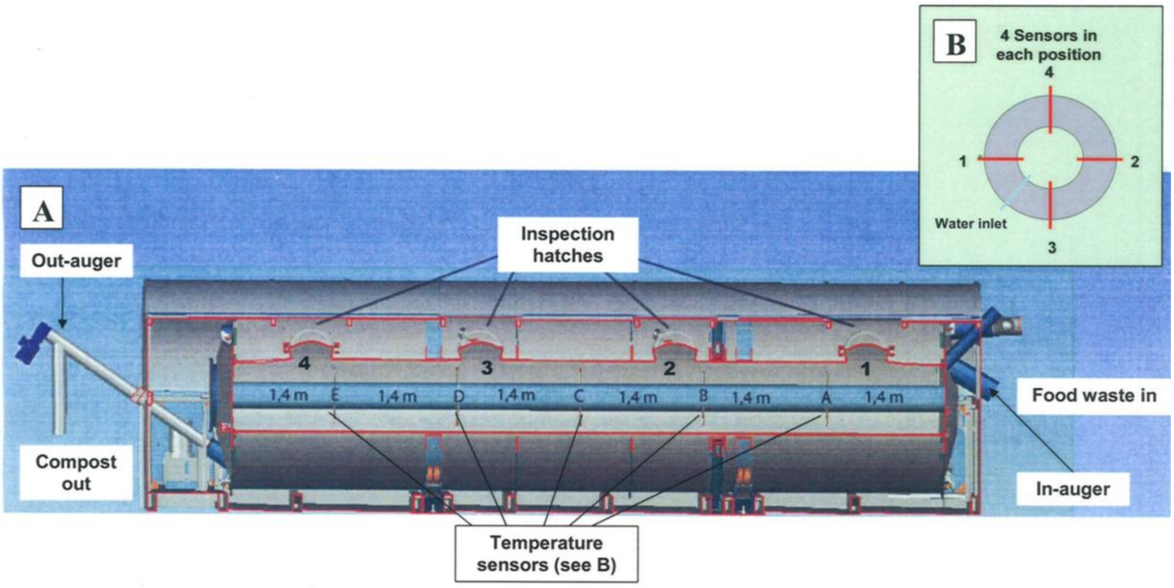



**Figure 2:** General view of the Neter 30 composter in position in the Recycling Compound at Eden Project.

**Figure 3:** Photographs of the contents of typical food waste bins at Eden Project.

**Figure 4:** Louise & Tara from the Eden Catering Team pose for a quick photograph whilst working on the source-separation facility in 'ZZub-ZZub' café.

**Figure 5:** Bin lift used to weigh and transfer food waste from 'wheelie' bins to the conveyor system for inspection and delivery to the shredder in preparation for composting.

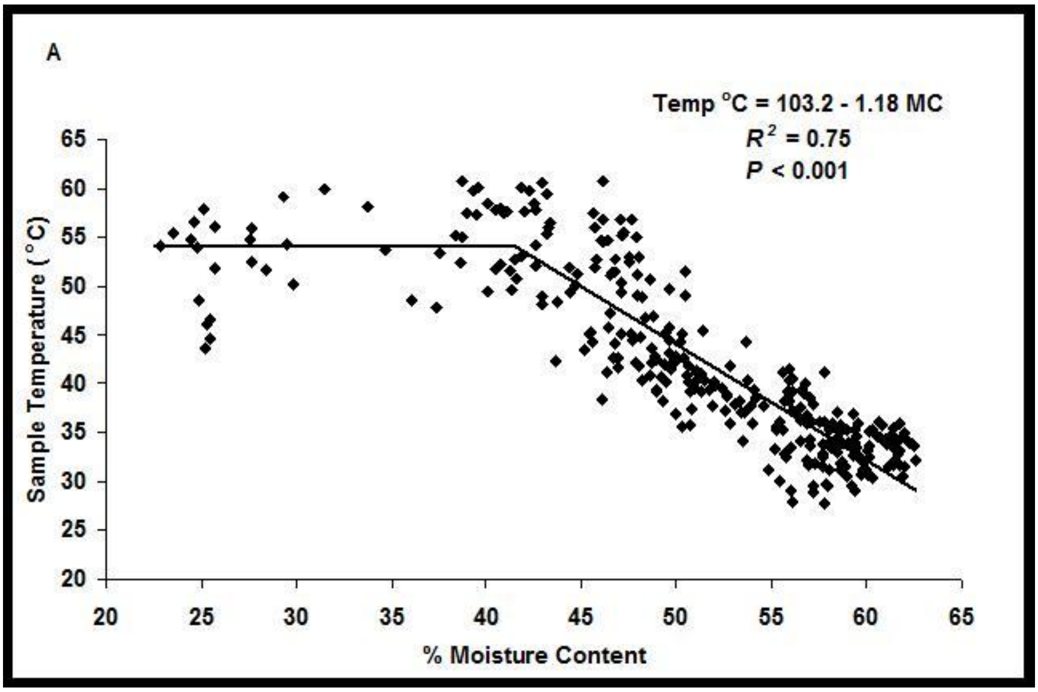

**Figure 6:** Clare and John from the Waste Neutral Operations Team carrying out final inspection of food waste before shredding and composting.

**Figure 7:** Macerated food waste entering the composter vessel after passing through the shredder.

**Figure 8:** Sawdust pellets alone (A) and added to the macerated food waste in the composter vessel (B).

**Figure 9:** Hopper installed over the 'in-auger' to help adding co-feedstocks to macerated food waste.

**Figure 10:** Effects of % moisture and the pH of the compost mix on the composting temperature in the Neter 30 composter (Data from Orthodoxou, 2008)



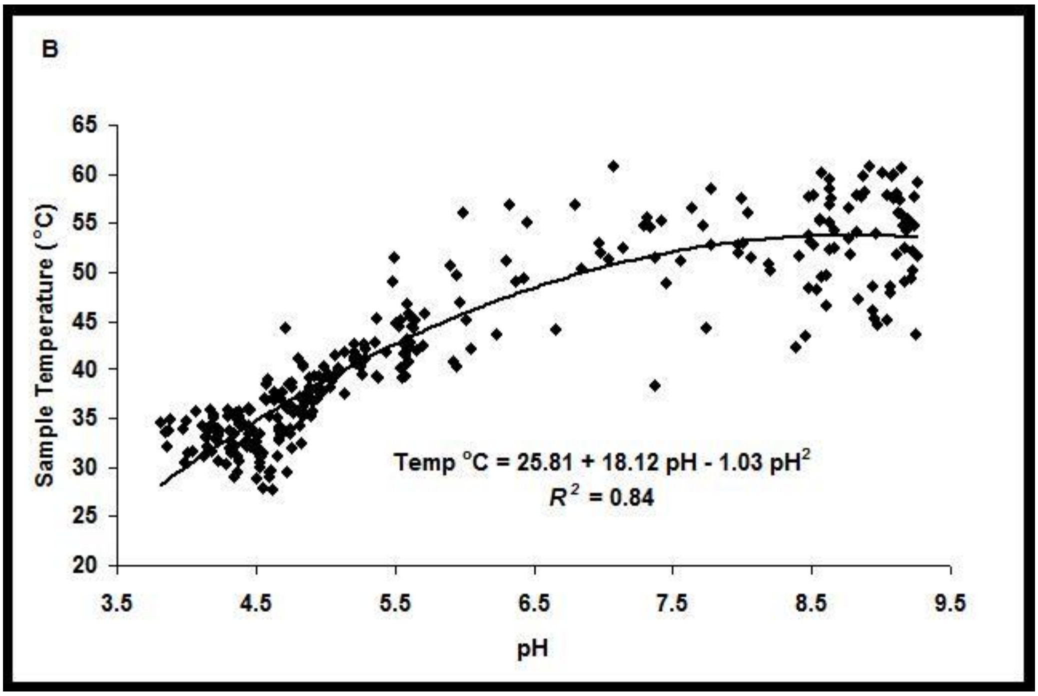



**Figure 11:** Demetra from Imperial College carrying out gas analysis on the compost mix at the first inspection hatch on the composter vessel.

**Figure 12:** Photographs of 'card fluff' and the corrugated board plant where it is extracted from the air.

**Figure 13:** Comparison of the effects of different ratios of co-feedstocks mixed with macerated food waste on the initial pH and moisture content of the compost mix.

**Figure 14:** The finished Neter 30 food waste compost as it emerges from the composting vessel.

**Figure 15:** Photograph and bar chart illustrating the effect of the proportion of Neter 30 food waste compost incorporated in a peat-free growing medium (0-100%) on the growth (root and shoot weight) of lettuce plants (*Lactuca sativa* cv. Little Gem).

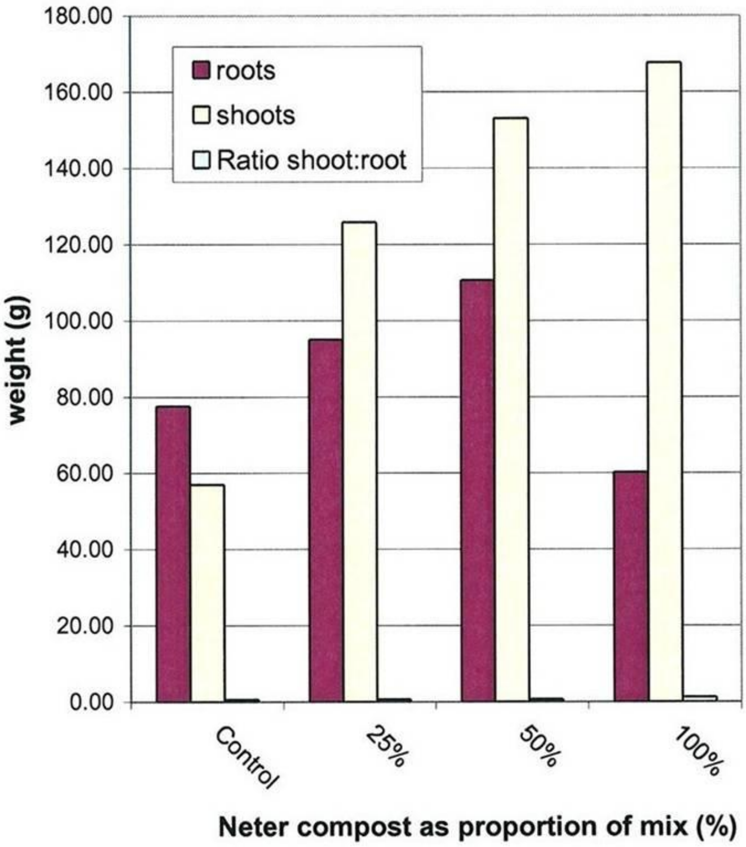


**Figure 16:** Eden food waste compost is used as an activator feedstock in our green waste composting operation. Here a recently mixed heap is being turned and aerated.