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GaiaRecycle Process and Outcomes

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Gaia recycle™

Food Waste – how big a problem is it?

From published data and from our own interaction with clients in many business segments we can summarise some food waste statistics as follows:

- Each Australian household throws away approximately 585 kgs of food waste every year
- Australian businesses generate around 2.5 million tonnes of organic waste each year
- A supermarket typically discards between 200 and 400 kgs per day of food trimmings and expired food products
- Hospitals generate food waste in the order of 1 – 2 kgs per in-patient per day
- In an Aged Care Facility, food waste may be as much as 0.75 kg per resident per day
- Mining accommodation villages generate organic waste at the rate of at least 0.5 kg per resident per day. Some allow for up to 1.0 kg per resident per day.
- Food waste per inmate in correctional facilities is as much as 0.75 kg per day
- A business with a staff canteen generates up to 1.5 kgs of food waste per cover per week
- Even in a business with no canteen, food waste can be as much as 0.5 kg per employee per week
- Restaurants typically create up to 2.5 kgs of food waste per cover per week

Whichever way you look at it, it's a major problem

On one point, the level of agreement is virtually unanimous – these organics **MUST** be diverted from landfill. Organic waste in landfill rots anaerobically producing methane gas (1.9 tonnes CO_2 equivalent per tonne of waste) and leachate (500 litres per tonne of waste). Methane is 25 times more damaging than carbon dioxide as a greenhouse gas (GHG) while leachate – the liquid run-off from landfill bases – contaminates water tables and waterways.

Every 2 tonnes of waste diverted from landfill has the same GHG reduction effect as taking a car off the road for a year!

How, then, to deal with the problem of Food / Catering waste? In the following pages we discuss some of the options:

1. Dehydration at source

GaiaRecycle is a system that receives food waste of any kind at the place where it is generated. In a batch process, it breaks down and ferments the waste while the moisture content is driven off and condensed for draining without any pollution-risk or for recovery for use as grey water on site.

Over a period of some 7 hours, the waste volume is reduced by 85 to 90% and, because it is processed at high temperature, it is sterilised – pathogens and seeds are rendered inactive. After a cooling period the dried biomass is unloaded from the system and is usable directly as a soil amendment or as an enhancer for compost. The carbon and nitrogen content of the original waste is retained. Alternatively, the biomass can be further processed to become a fuel for use in, for example, biomass boilers or gasification systems.

Energy is an input into the process but the minimisation of greenhouse gas emissions directly and by avoiding transportation of the waste means that the process creates positive carbon offsets. Where gas is used as the energy source, the reduction in greenhouse gases may be as much as 90% compared with dumping the waste in landfill.

Because the **GaiaRecycle** system produces re-useable solids and water it can be described as the most sustainable of all the systems discussed here. It is also highly tolerant in that inorganic contamination and quantities of paper or cardboard can be included without any negative effect on the process. Supermarkets, for example, do not need to take expired foods out of their packaging - everything can be put into the system where mechanical action and heat will cause the packaging to break open. Residual packaging can be simply screened from the finished biomass. Similarly, inorganic contaminants do not have any detrimental effect on the **GaiaRecycle** process. (See more detailed process description later in this bulletin)

2. In-vessel composting

For many small to mid-size waste-generating organisations, in-vessel composting is a viable option. Because the process occurs in a sealed container, there are no issues with vermin being attracted. Because the system is installed where the waste is generated, there is no transportation involved and therefore no CO_2 generation. The composting mass is agitated daily and therefore the incidence of anaerobic rotting is minimised.

The need to balance the carbon and nitrogen components holds true as it does for larger scale composting operations and it is particularly important that the composting mass has an open consistency to allow aeration to occur. For this reason, if the waste product is predominantly food, it must be balanced by the addition of equal volumes of carbon material such as wood-chips. Clearly, the availability of carbon materials has to be considered before installing an in-vessel system. It also needs to be noted that the addition of the carbon material effectively reduces the capacity of the equipment in terms of food waste.

In-vessel composting is a continuous process to which new raw material can be added daily. It takes approximately two to five weeks for completion of each day's input and the resulting material must then be allowed to mature in a closed container for a further six to eight weeks before it is recommended for use as a fertiliser.

3. Commercial-scale composting

Composting on a large scale (windrow method) is a time-honoured process for producing rich fertiliser / soil amendments. The composting process relies on a correct mix of carbon and nitrogen components in controlled temperature, pH and humidity conditions. It is perfect for mixed organics such as garden waste.

Large scale composting requires that the waste be transported to the processing facility and this means that carbon dioxide is generated as a downside to the environmental equation. Another factor in large scale composting is that anaeorobic decomposition can occur within the mass, with the consequence that methane is generated and released.

Food waste is not handled by many composters because it tends to be high in nitrogen and moisture content to the detriment of the composting process. In addition, food waste in windrows attracts vermin and causes odours. For these reasons, many composters are not licensed to handle food waste.

4. Untreated animal feed

Organic waste from businesses such as food manufacturing or processing plants is often donated or sold cheaply to stock breeders as food for the animals, especially pigs. In recent times, there has been a tendency for stock breeders to require greater quality control in terms of moisture content, sterilisation and concentration of nutrients. (In UK, untreated food

waste was suspected as the source of an outbreak of foot-and-mouth disease, so that the use of untreated food waste as stock feed in now banned if there is any meat protein content or if the waste may have been in contact with meat.)

Transporting food waste from factory to the piggery means that cost and carbon emissions are occasioned by transporting what is 80% water.

Food waste with a known composition (not including animal proteins) may be de-hydrated and sterilised at source making it more acceptable to the stock-feed industry. (See "Dehydration at source" above.)

5. Biogas conversion

Landfill sites can be configured so that the methane gas emitted is collected and used for the generation of so-called green energy (electricity). This clearly requires major infrastructure and can only be considered on a vast scale. Industrial plants can be installed to receive organic waste from subscriber sites and to digest it anaerobically to produce methane for the same purpose. On the opposite side of the ledger we have to recognise that transportation to the site creates carbon dioxide. This system is likely to be viable overall in future but, at present the availability of processing plants is very strictly limited.

In connection with the prior paragraph, a number of manufacturers and service companies are promoting in-house systems that grind up food waste with water, pumping the resulting slurry to a holding tank from which it is collected by a road tanker. The issues here include odours in the grinding systems and pipework, transportation of the waste, consumption of water.

Large-scale food manufacturers or producers of waste food may consider installing an on-site biogas plant, which, if they have well-qualified technical staff on site, may be a viable solution.

6. Vermiculture

Although it is often said that worms will digest anything, this is actually not true. On a certain scale and with strictly controlled feedstock, a worm farm can be effective but the following must be noted:

- Meat, seafood and dairy products cannot be included (risk of odours, pathogens and vermin).
- Fruit and vegetables need to be mixed with shredded cardboard in order to avoid rotting or waterlogging of the vermiculture mass.
- Worms tend not to like citrus waste or onions.
- Moisture content is critical and must be carefully controlled.
- E.Coli in the output product is a risk if the vermiculture bed is established (as it commonly is) with a pig manure base.

7. On-site accumulation in bins

Waste contractors may offer a modified rubbish skip equipped with an air-circulation and deodorising system to act as a receptacle on site for organic waste for up to six weeks pending the next collection cycle. The waste decomposes in the bin before it is taken away for processing at a central location. The odour control system may not be fool-proof and there have been cases where odour emissions have become a public nuisance, especially when putrefaction liquids seep from the bin. Further there are the downside influences of bin transportation and the risk of methane emissions.

8. Pulping and Straining

Most readers will be familiar with the concept of a grinding device installed in a sink which allows small quantities of waste to be slurried with added water (not good) so that it can be flushed down the drain.
Of all the systems reviewed in this document this is the most environmentally unacceptable. In fact, many Water Authorities in Australia simply will no longer allow them to be installed because they create a level of Total Suspended Solids that is up to 16 times greater than the allowed limit in trade waste water. This is unacceptable because of the level of remediation it requires at the sewage processing plant.

On a larger scale, a commercial kitchen can be fitted with a number of slurrying stations that pump the wet waste to a filtering system comprising a fixed screen to intercept the solids. Given that the screen has to be large enough to allow water to pass at a reasonable flow rate, it allows an unacceptably high proportion of solids through as well.
It has to be asked whether adding potable water which one later runs to drain is a truly sustainable practice.

Embedding pipework in a building leads to high initial cost and does not allow any flexibility for future changes to the host establishment (not future-proofed).

This type of system when it is not used daily, poses the risk that organics may putrefy in inaccessible pipework causing unhygienic and odorous conditions.

9. Bio-digestion – Wet

Systems are available that use enzymes to digest organic waste in an aqueous culture to produce what is called “clear water”. However, Water Authorities are reluctant to receive any waste that has been enzymically treated because of the risks of:

- The downstream re-precipitation of any apparently dissolved content
- The uncontrolled activity at the sewage plants of any “live” enzyme remaining in the effluent.

It should also be noted that such systems are intolerant of non-organic contamination, do not work well with bones or raw meat and may be a source of odours if cultures are not balanced. By definition, they also require the addition of quite large amounts of water to create the culture medium.

10. Bio-digestion – Dry

On a small scale and in carefully controlled conditions, it is feasible to use micro-organisms to break down organic waste. A number of different micro-organisms need to be added to cover different types of organics while fibrous material, such as sawdust is needed initially to create the correct porosity.

Successfully scaling this technology up to industrial capacities, however, has been singularly unsuccessful to date and, in Japan and Korea, has led to the demise of many manufacturers.

Essentially it is difficult to control the nuances of the digestive mix when dealing with large quantities and varying types of waste. This can lead to incomplete processes or to the complete failure of the digestive process, causing the organic waste and dead micro-organisms to rot and emit foul odours.

This type of system is also intolerant of non-organic contamination while even organics such as paper and cardboard can disrupt the process. Care must be taken in relation to the use of the mass after processing. In many countries, compost is required to have been held at minimum 70’C for not less than one hour. If this condition is not met, the mass is regarded as still being a waste product that must be disposed of. Dry bio-digestion systems tend to be extremely large in relation to capacity and some consume quite large amounts of electricity.

GaiaRecycle Process Description

Introduction

GaiaRecycle is a process of dehydrating and sterilizing organic waste at source and it requires that, as much as possible, the organic waste should be segregated from other types of waste. Inorganic contamination will be unaffected by the process but may limit the options for the use of the organic biomass that results from the dehydration cycle.

Untreated organic waste dumped in landfill will rot, producing methane (a greenhouse gas that is less prevalent than carbon dioxide but which traps 25 times more atmospheric heat than does CO_2) and leachate which pollutes soils and waterways. Many countries are taking steps to stop organic waste entering landfill by reducing the number of sites and / or increasing the charges levied for their use.

It is increasingly common for companies to segregate their waste into organic and inorganic streams, seeking solutions for the former that grant a more environmentally suitable outcome than landfill dumping.

Process Description

GaiaRecycle, a concept that has already been highly successful in Europe, Japan, USA and Canada and which is now firmly established in Australia, involves automatically heating, shredding, dehydrating and deodourising organic waste in a closed chamber, usually on the premises where the waste is generated. The equipment should be located under cover, as close as possible to the main area of waste generation. The batch-process requires only the input of electrical power for motors and heat energy (electricity or gas), while the outputs comprise condensed water and a dry bio-mass, both of which are free of pathogens.

Unlike many other processes, the GaiaRecycle system requires no additives:

- NO water
- NO sawdust
- NO woodchips
- NO enzymes
- NO microbes

Untreated organic waste is added to the GaiaRecycle chamber (either gradually or in batches from storage bins or buckets) until the chamber is two-thirds full. Once the loading is complete, the lid is closed and latched securely before the “Start” button is pressed. The process thereafter is automatic and takes approximately 8 to 10 hours to complete.

The waste is kept in constant motion by the rotating agitator while thermostatically controlled hot air is circulated through it. In this way, the physical structure of the waste is broken down while the temperature is elevated – akin to the cooking process in a stirring kettle – creating an “organic stew” inside the machine. Bacteria that cause rotting are killed as the temperature rises above 40°C while thermophyllic bacteria (or archaea) are activated at 70°C and above. These latter cause rapid fermentation of the waste, breaking down the cellular structure while also promoting the production of yeast which is a highly desirable component of soil amendments.

The water content of the waste evaporates during this process and is passed over an ambient-temperature condenser where it returns to liquid form and passes out of the machine at a temperature of approximately 40°C. This condensate is virtually pure but may have a slightly elevated mineral content. It may be drained to sewer without any environmental concerns or liquid trade-waste issues or, if appropriate, it may be captured for use in grey-water applications such as cleaning, toilet flushing or irrigation.

Once the dehydrating phase is completed, the heat source is switched off while the agitator, condensor and circulating fan continue to run, allowing the contents of the chamber to cool. At the end of this phase, the unit shuts down pending the intervention of an operator to initiate the unloading process.

The Biomass

Remaining in the chamber at this point is a dried, nutrient-rich biomass that is between 10% and 15% of the original volume of the untreated waste, it is inert in that all bacteria, pathogens and seeds have been neutralized in the processing

and it is so dry that it may be stored on site, if necessary, for many days. It is unloaded automatically from the GaiaRecycle unit through a hatch on the front face of the machine. The biomass is virtually odourless and its composition is discussed in a separate Bulletin herewith.

Options for disposing of the bio-mass include:

- use directly as a soil amendment,
- use as brown waste in a composting process,
- add to finished compost to achieve a desired nutrient balance
- use as a supplement for animal feed (subject to local regulations),
- conversion to heat briquettes for use in biomass boilers or in gasification systems
- dumping to landfill, in the knowledge that the volume, cost and "rotting factor" have been greatly reduced.

G**AIA's** modular treatment units range from 30 kg to 3000 kg capacity per day. The larger capacity units incorporate conveyors and other materials-handling solutions according to site needs. "Capacity per day" is defined on the basis that in a single, 8 – 10 hour shift one process will be completed and a second one will be started which will run unattended for unloading at the commencement of the following day's shift.

Larger plants capable of processing up to 100 tonnes per day are also available – these and the 3000 kg unit perform a cycle in roughly 18 hours.

The Benefits

The sustainable benefits of the **GaiaRecycle** process are:

- the dramatic (if not total) reduction of organic waste in landfill saving landfill space for other purposes and eliminating the anaerobic rotting of the waste which generates methane and leachate.
- the elimination of carbon emissions that would otherwise result from transporting the waste to disposal sites.
- the utilisation of the condensed water effluent as grey water within the client's business.
- It requires no additives such as water for the processing of the waste
- It is not a pulping system and therefore does **not** discharge water with high Total Suspended Solids and / or generating a high Biological Oxygen Demand.
- It is not an enzymic system and does not discharge water from which solids may precipitate downstream.

The economic payback from the process arises from the long term reduction or elimination of fees for hiring skips or bins and paying landfill tip fees.

GaiaRecycle BIOMASS COMPARED WITH COMPOST

Natural composting generally takes 3 months to decompose organic waste by microbial action in aerobic process out in the open. The compost generally needs a further period of 8 to 12 weeks to "cure" before it can be used. During this time, nutrients, such as nitrogen and potassium, may get washed away by rain and therefore the fertilization effect will decrease.

Composting done in-vessel, indoors (or open space cover with a roof) will have higher nutrient value as fertilizer. Composting in the open will normally result in, on average:

- 60 – 80% moisture
- 0.2% to 10.5% nitrogen
- 0.2% to 0.5% phosphorus
- 0.4% to 1.5% potassium

granting a significant fertilization effect. There are high levels of nitrogen particles and organic phosphorus, and as these slowly decompose in the soil they provide a good fertilizing effect. The organic matter in the compost also decomposes due to microorganisms in the soil.

Compost as a result of decomposition increases soil's moisture content and provides many other effects, including improvement of the physical characteristics of the soil such as tillage. In addition, it increases the soil's ability to absorb fertilizers, blocks acidification of the soil, and improves soil's chemical properties.

Food waste (catering waste) has relatively high nitrogen content which, in conventional composting, has to be balanced by the addition of carbon materials such as sawdust or wood chips. Food waste is not normally allowed to be composted in open windrows due to odours and their attraction to vermin. On the other hand, food waste is simply and safely treated in the GaiaRecycle process because it takes place in a closed chamber. The process does not require the addition of carbon materials, microbes or water.

The soil-amendment produced by the GaiaRecycle system has less than 9% moisture content, and has been completely sterilized by the 95°C to 100°C temperature processing of the organic waste for 7 to 9 hours. Thermophyllic bacteria – more correctly called archaea - thrive during the heating up process while yeast (full of nutrition) is generated in large quantities (on average 10k ~1mil CFU (colony form unit/gram). Because of this accelerated fermentation, the soil amendment becomes excellent fertilizing material, much better than compost as a result of decomposition as described above.

Carbon over nitrogen ratio (C/N ratio) related to organic waste (generally a combination of carbon, nitrogen, and oxygen) - for example: Carbohydrates: $C_6H_{12}O_6$, Protein: $NC_2H_4O_2$, fat: $C_{57}H_{116}O_3$ – is determined by the composition of the raw organic matter itself and not by the composting process. A C/N ratio of less than 15 is considered good composted material; Korean food waste averages between 11 to 12 C/N ratio. Food products in the western world generally have higher protein and fat contents and therefore the C/N ratio may be lower than in Korea.

In other words, the GaiaRecycle system accomplishes in 7 to 9 hours what takes 3 months in aerobic composting out in the open; at the same time the GaiaRecycle system sterilizes pathogens and significantly increases yeast. In addition, as the moisture content is very low, the soil amendment generated by the GaiaRecycle system is much more concentrated than regular compost.

Scientifically speaking, normal composted material has approximately 60% to 80% moisture content (approximate average is 70%); however, the soil-amendment processed by GaiaRecycle can provide the same nutrient effect with one-third to one-quarter the amount of moisture, meaning the soil-amendment has 3 to 4 times the nutrient effect than normal compost. For example, if you need 40kg of normal compost for 10,000 square meters than you would only need 10 – 13kg of soil-amendment processed by GaiaRecycle.

Compost's three major nutrients are nitrogen, phosphorus, and potassium - these nutrients will not be decreased or eliminated at high temperatures. Unlike vitamin C, nutrients in organic material are not destroyed by heat, but they become essential amino acids (e.g. Aragon, Asparagine, etc) as a result of the chemical change (decomposition) of nitrogen. This is different from nutrients in humans.

During the high-temperature GaiaRecycle process, weeds (which may have up to 90%+ moisture) will be eliminated leaving behind only fiber ($C_6H_{12}O_6$). Pathogens generally die in 30 minutes at 40°C and are therefore destroyed during the GaiaRecycle processing cycle.

Laboratory analysis of the biomass produced in the GaiaRecycle process confirms the sterility of the product and illustrates its properties as a **"High nitrogen content, slow release soil amendment.**

GaiaRecycle FAQs

What is GaiaRecycle

It is a system for dehydrating organic waste – in particular food waste – at source, preventing the waste going to landfill where it would rot, producing methane (25 times more potent than CO2 as a greenhouse gas) and leachate which poisons water tables. Using GaiaRecycle allows greenhouse gas emissions to be reduced by up to 90%

How does it work?

The waste is placed inside a drum through which hot air is circulated while a rotating paddle helps breakdown the physical structure of the waste. Over a period of up to nine hours the moisture content is driven off and condensed for (optional) recovery for use as grey water. The solid mass in the machine is reduced in weight and volume by 85 – 90% and is rendered fully sterile by the process.

Is it the same as composting?

No, absolutely not. Composting is a microbial process that takes many weeks to complete. GaiaRecyle takes only a few hours yet still produces a biomass that can be used as a soil amendment.

Does it run continuously?

GaiaRecycle is a batch process so, once the unit is started, it runs continuously through its pre-set cycle. We recommend that the process should not be stopped to add more waste as this may give an inconsistent result. After one process is finished, another can be started immediately.

Do you have to add anything to the waste to make the cycle work?

Absolutely not. Unlike other methods, GaiaRecycle requires NO sawdust, NO microbes or enzymes, NO water. You simply load, press “Start” and walk away.

Does it have to be full to start up?

No it doesn’t as the machine automatically senses when the added product has dried enough. We recommend using it full however to reduce your energy consumption. An added benefit is that you can store waste in the machine until ready to run and it won’t smell or attract vermin.

What happens if the waste is contaminated?

The process is not affected in any way if paper, plastic packaging or inorganics such as knives, forks and even glass are present. It is desirable to reduce the amount of contamination as much as possible depending on what is the intended use of the biomass.

Can any kind of organic waste go into the process?

Yes, but this process is particularly suited to food waste, which is a category that is not easily treated by other methods.

How much waste can be processed?

Capacities range from 30 kg per day up to 3000 kgs per day in modular units and then up to 100 tonnes per day in purpose-built plant!

How do you know the greenhouse gases are reduced by up to 90%?

The calculations are based on the Australian Government National Greenhouse Accounts (NGA) Factors Report dated July 2011

What uses are there for the dried biomass?

There are several. It can go to landfill but there are better environmental possibilities, including:

- use as a soil amendment. It is classified as a "High Nitrogen, slow release soil conditioner"

- it can be compressed into pellets or briquettes and used a fuel for boilers and stoves. Because the biomass is high in nitrogen and low in carbon, its emissions are much less than those of coal and coke. Further, the carbon in the biomass is considered as being already in the Carbon Cycle whereas the emissions from coal that has been sequestered for centuries are net additions to the carbon load in the cycle.

Can I see one in action?

You can see a video on our YouTube channel at http://www.youtube.com/user/EcoGuardiansAU. Depending on your location, we would also be happy for you to visit one of our established sites.

Who can I contact if I have more questions?

Please contact Eco Guardians on 1300 55 66 28 or info@ecoguardians.com.au