HOFSTEDE & ASSOCIATES

WASTE MANAGEMENT & POLLUTION CONTROL

LIQUID GREASE TRAP WASTE PROCESSING CAPACITY THROUGH EVAPORATION BY COMPOSTING GREEN WASTE IN OPEN WINDROWS

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1. Introduction

Biological liquid waste such as grease trap and septic tank waste can be treated by incorporating the liquid waste into windrows of green waste as a form of treatment, where the water fraction evaporates and the biodegradable solids left behind are decomposed during the composting process. Grease trap waste includes fats, oils, waxes as well as food waste and detergents/soap, which can create significant issues in wastewater disposal due to its poor solubility and separation from the liquid solution when cooled. Since there are insufficient available research results or information for quantifying the processing capacity by introducing the waste into open windrow, this report makes an initial attempt to move towards quantifying the capacity of green waste to absorb and evaporate the water fraction of the liquid waste added at the Bio Organics site in Oakford, WA.

2. General moisture balance in a standard composting process

As demonstrated in Figure 1, a standard organic waste mixture, optimised for composting, contains 40% dry organic matter and 60% moisture. Hence in 100 tonnes of pre compost mixture, 40 tonnes consists of organic matter and 60 tonnes of water.

During the complete composting process, it is expected that around 10 tonnes of the 40 tonnes dry matter will be decomposed and released as 5 tonnes CO_2 and 5 tonnes (new) water.

The end compost should have a moisture content of around 50%, which equates to 30 tonnes of decomposed organic matter and 30 tonnes of water, 5 tonnes of which is (new) water.

As a consequence, the initial mix has to lose 35 tonnes of water according to the model calculation:

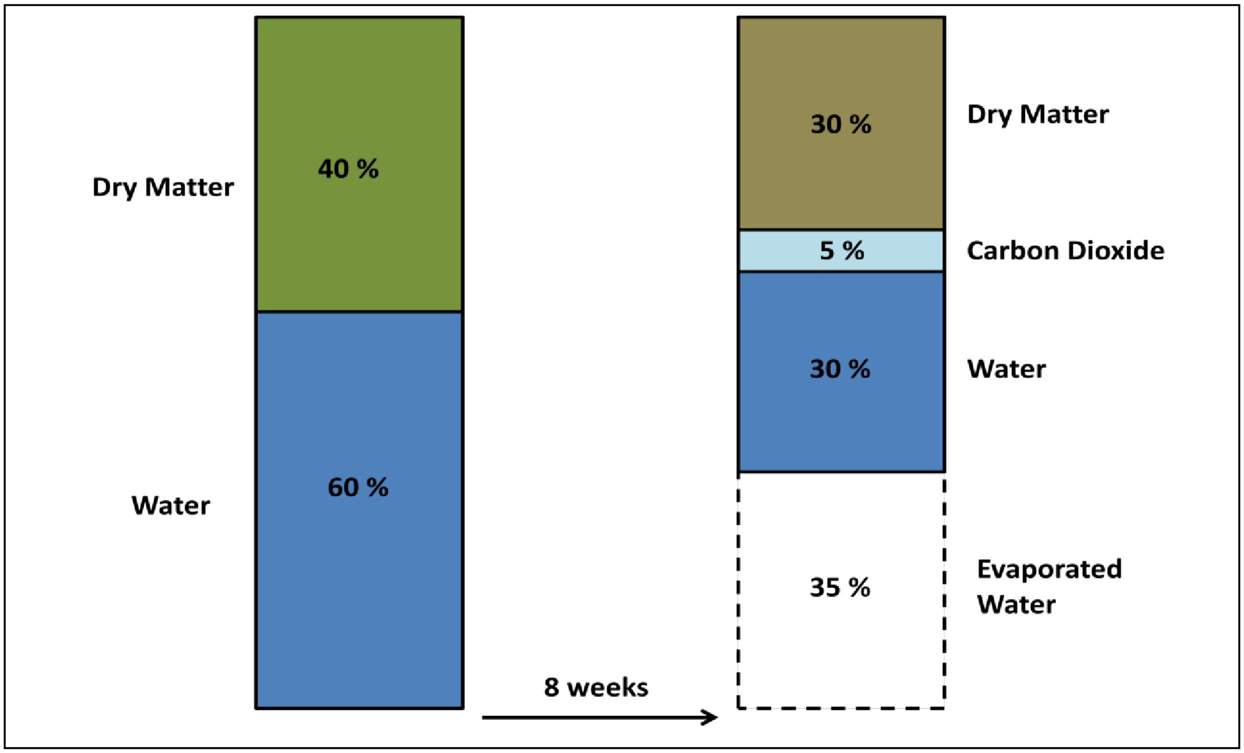

Figure 1 General Moisture Balance in a Standard Composting Process.

$$(60\ tonnes\ of\ water\ present\ at\ the\ start + 5\ tonnes\ of\ newly\ formed\ water)$$
$$-\ 30\ tonnes\ of\ water\ in\ the\ end\ compost$$
$$= 35\ tonnes\ of\ water, or\ 35{,}000\ litres.$$

Hence 100 tonnes of pre compost mix at 60% moisture requires losing 35 tonnes of water (and 5 tonnes as CO2) to generate 60 tonnes of compost at 50% moisture. Due to this aspect, composting can be referred to as a biological drying process.

3. Process Description

Following a site visit, it was understood that the Bio Organics site receives approximately 100,000 litres of grease trap waste per day from 6 – 10 tankers. It is understood from the operators that each day liquid waste is introduced to a different windrow over a 6 day cycle, hence 100,000 litres per windrow per 6 days.

3.1 Site visit

A site visit was conducted on the 27th November in the presence of [redacted] from the Department of Environment Regulation (DER) and two technical officers at the Bio Organics Site in Oakford.

The purpose of the site visit was to gain an understanding of their composting and liquid waste blending process and verify data that was provided by the site owners and operators.

This included quantifying the amount of green waste on site, measuring windrow dimensions, gain a visual understanding of the liquid waste blending process and collect samples of fresh windrowed green waste and mature (spent) green waste to be analysed.

3.2 Windrow processing capacity

The dimensions of the 6 windrows vary but generally are 120m long X 7m wide X 4.1m height (5.4m on the slope); which amounts to a total volume of 10,332m^3 for the composting site and 1,722m^3 per windrow. This report will focus on the capacity of a single windrow, which can then be used to reflect for the whole dynamic composting process on site.

The total exposed surface area for each windrow is 1,324.7 m^2, say 1,350 m^2.

Figure 2 Inspection and Measurement of the moat by DER Staff and the Consultant

3.3 Liquid waste blending procedure

Approximately 100,000 litres of grease trap waste is being added to the Oakford site each day, from 6 – 10 tankers. Figure 3 below is a simple diagram showing the liquid waste blending procedure observed during the site visit for one windrow.

Part (a) shows that first one side of the windrow was scraped down in order to create a moat as shown in part (b). The volume of the moat came to approx. 400 m3 assuming that there was 300mm of green waste between the surface of the moat and the ground, but in actuality, there were some sections where there was no green waste and the ground was visible. Part (c) shows the a tanker introducing the liquid into the moat and part (d) where the green waste was pushed back up onto the windrow with the liquid waste.

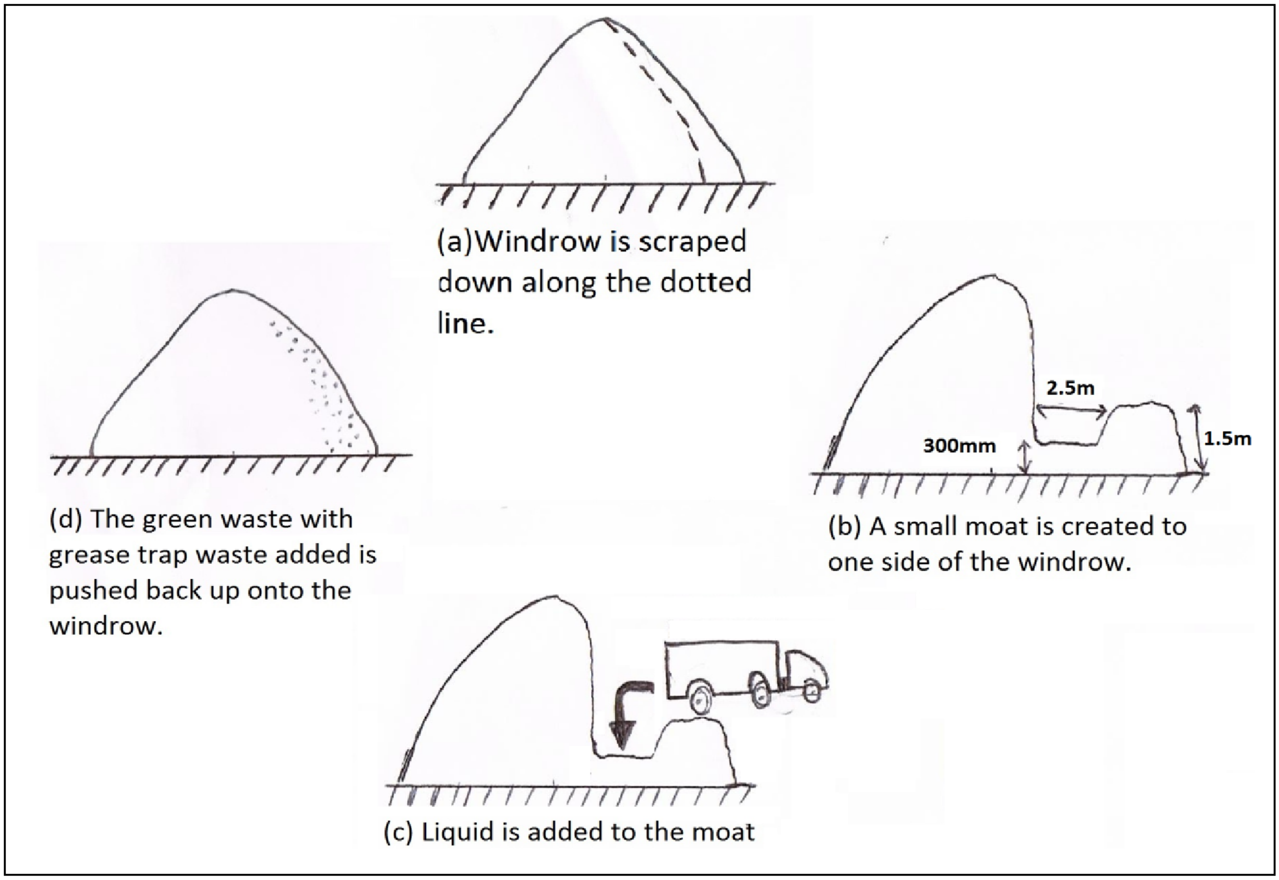

Figure 3 Liquid Waste Introduction Process

The liquid waste mixing method shown in Figure 3 have limitations in the build-up of the moat, addition of liquid then pushing back up of the moat in the closing of the windrow. The moat should not be pushed back up until there is no free liquid that can be absorbed by the moat material and windrow to avoid spillage. The length of time required will need to be confirmed through the monitoring of the windrow's capacity to absorb the liquid as well as the permeability of the hardstand and whether it is impermeable to liquid waste. It is strongly recommended that an independent monitoring is conducted to determine moisture losses from each windrow.

3.4 Green Waste Analysis

A regular analysis of the moisture absorption capacity green waste, particularly in terms of moisture content would be useful in assessing the amount of liquid that is absorbed by the material compared with the amount that is added to deduce the liquid that is being seeped directly into the ground.

4. Green waste compost properties

Two samples were taken; one from the newest windrow which was around 14 days old and another sample from the matured green waste, which was over 12 months old. A copy of the lab report is attached in the Appendix A.

Table 1 shows a summary of the analytes that were measured, including a brief description of how these amounts were quantified. When comparing the fresh green waste material and mature green waste material, approximately 12 months difference, the pH, porosity and amount of potassium showed negligible differences.

The fresh material had an Electric Conductivity, a parameter reflecting soluble salt content, almost double the Mature material, reflecting the build up of soluble ions in the fresh materials due to recent addition of grease trap waste. As the water fraction of the grease trap waste evaporates organic matter and non volatile salts are left behind.

The bulk densities for the two materials also varied, with the fresh material being lower than the mature material. As a result of decomposition, finer particles are expected, meaning a loss of dry matter and subsequently an increase in the concentration of non volatiles. As the material gets finer, as a result of decomposition, the bulk density (kg/L) increases, and subsequently the water holding capacity increases. An increase in water holding capacity may reduce the water evaporation rate. By saturating the the material with grease trap waste all pore space is occupied with water which removes air (oxygen) from the pore space. However, the high oxygen demand that the grease exercises may as a result cause anaerobicity in the material which would explain the odour emission and volatile organic compounds which may get airborne and explain off side airborne impacts related to odour or public health.

In conclusion as the green waste ages its water holding capacity increases and it may subsequently reduce evaporation rates and increase the possibility of anaerobic conditions prevailing with in windrow mass due to lack of air filled pore space. The pH is high at 8.4. At this pH ammonia is volatile and escapes of ammonia gas (NH3), a major cause of odour from composting or waste treatment facilities.

Analyte	Method	Unit	Fresh Material	Mature Material
EC	(AS 4454)	dS/m	4.4	2.6
H_2O	(AS 4454)	%ar	45.4	35.0
pH	(AS 4454)	%	8.4	8.1
Porosity	Density		76.0	74.0
Bulk	Density	g/cm^3 db	0.34	0.49
K	(ICP)	%ar	0.24	0.23
P	(ICP)	%ar	0.46	0.10

Analyte	Method	Description
H_2O	(AS 4454)	Moisture content calculated from % mass lost on drying at 105 deg C by AS4454-2012
pH	(AS 4454)	pH of extract by AS4454-2012 Appendix B
EC	(AS 4454)	Electrical Conductivity of extract by AS4454-2012 Appendix B
K	(ICP)	Potassium, K nitric/perchloric acid digestion by method P2

P	(ICP)	Phosphorus, P nitric/perchloric acid digestion by method P2
Porosity	Density	Porosity of soil. Calculated from mineral density and bulk density.
Bulk	Density	Bulk density (dry basis)

Table 1 Analysis of the Fresh Material and Mature Material

Recommendation 1: It is recommended to maintain a pH in the windrow between 6 and 7.2 to avoid volatilization of ammonia.

Recommendation 2: It is recommended that the windrows maintain aerobic conditions to promote water evaporation and prevent anaerobic conditions from occurring, which avoids formation of volatile organic compounds, which are an added source of odour and may act as soft tissue irritants to mammals.

Water Holding Capacity

Moisture is essential to support microbial activity in the decomposition of organic matter but too much liquid in the pore space prevents proper air movement through the composting material by reducing the void space. The excess liquid will drain from the windrow seep onto the site surface.

A porosity test was conducted on the two samples of compost to identify the maximum water holding capacity of the material at the beginning and the end of its processing life. This was determined by drying out the samples and then introducing water to the base of a cell containing one litre of sample. The quantity of water that was consumed to reach the surface of the sample was measured and then the cell was allowed to free drain with that volume also measured. This resulted in a calculation of the maximum water retention ability of the fresh and mature compost material as shown in Table 2 below.

	Pore Space	Retained Water
	mL/L	mL/L

Fresh Material	760	310
Mature Material	740	480

Table 2 Porosity Test Results on the Fresh Material and Mature Material

The data show that due to the relative coarser nature of the fresh material it has a lower water holding capacity compared to a standard compost mix, but a likely greater water evaporation capacity due to larger pore spaces which allow air to pass and remove water.

The water holding capacity increases from fresh material to mature material due to an increase in the finer particles fraction in the mature material as result of decomposition. The fine particles form a finer pore space and increase the capillary effect.

Based on these results and focusing on a single windrow with a volume of approx. 1,722 m^3 per windrow, the fresh material can hold a maximum 533,820 L of water in the free pore space and the mature material up to 826,560 L of water at any one time. These figures are hypothetical and are related to the volume of water that may be added to a new fresh windrow and are not to be confused with the volume of grease trap waste that can be added to the windrow at any one time. The values are based on total moisture, including baseline moisture content held within the green waste structure (cellulose) and moisture held within the pore space; and no excess free draining water is to leaking from the material. Since the mature material is approximately 12 months older than the fresh material, then each month, the increase in water holding capacity increases by 24,395 litres. However it must be observed that only water that has evaporated can be replaced to avoid excess water leakage from the windrows.

Therefore in order to calculate the amount of liquid that can be introduced to each windrow, first a baseline moisture content must be determined of the material to identify the amount of water already in the windrow to deduce the amount of liquid that can be added and subsequently determine evaporation rates in the windrow.

Liquid Waste Mixing Method

The liquid is currently being introduced to an estimated 40% of the total windrow volume, with the area beneath the moat measured to be 0.75 m^2 and the trapezoid-shaped bunding approximately 5 m^2, with a bottom width of 4 m. This totals to a volume of approximately 690 $m^3$of material or 234.6 tonnes using the bulk density measured by the ChemCentre. Based on an introduction rate of 100,000 litres or 100 tonnes per day the moisture content will increase by approx. 30% on a weight to weight basis. Hence the pre introduction moisture content should be a minimum of 30% lower than the maximum water holding capacity.

The plant evaporation capacity essentially equates to the liquid waste processing capacity. The liquid waste treatment capacity can be increased by introducing a technique that takes advantage of the entire windrow water holding capacity.

Liquid Waste Absorption Capacity

The current liquid waste introduction process for each single windrow sees the liquid waste being introduced to 690 m^3 of green waste. The 100,000 L of water can be held within the pore space since the 100,000 L represents approx. 50% of the maximum holding capacity, provided the material is surface dry.

In order to determine the actual processing capacity of a windrow, we would need to establish how long it takes to lose sufficient amount of water to allow for this to be replaced with new liquid waste.

Climate Variability

There will be seasonal variability in evaporation and precipitation conditions, which potentially leads to a higher amount of liquid that can be added to the windrows in months of higher evaporation and lower precipitation rates. Table 3 below shows the evaporation and rainfall rates as recorded from the Bureau of Meteorology for the Oakford location during Autumn, Winter, Spring and Summer.

The key parameters that determine evaporation in a compost windrow are:

- Specific surface area
- Moisture differential
- Moisture holding capacity
- Salinity
- Temperature differential
- Wind speed factor

The higher temperatures will mean that the liquid can be applied more frequently because it will evaporate quicker but the maximum water holding capacity will still have to be respected.

	Evaporation	Rainfall
Autumn	300 mm	200 mm
Winter	200 mm	450 mm
Spring	400 mm	150 mm
Summer	700 mm	50 mm
Total	**1600 mm**	**850 mm**

Table 3 Seasonal Evaporation and Rainfall Data

During the winter period a net excess rainfall is 250 mm, which when equated to 15 6 day cycles, means a net precipitation of 14, 000 litres per window. Hence we recommend a 10% reduction of introduced liquid waste during the winter period, compared to the other seasons.

A key aspect of the processing capacity of green waste windrows is to assess the water evaporation rate which is determined by the combined effect of the above mentioned factors. We recommend conducting research into the establishment of reference data by monitoring green waste windrows following introduction of liquid waste.

Recommendation 3: It is recommended that during winter, the volume of liquid waste introduced should be reduced by 10% to compensate for precipitation.

5. Conclusion

The method of introducing the liquid waste to the moat of 690 m^3 of green wastefor each single windrow is acceptable provided that the windrow material is surface dry.

We would like to conduct some research on the evaporation rate of the material to calculate the time taken for 100,000 L of liquid waste to be evaporated in order to determine the acceptable frequency of liquid waste introduction to each windrow.

6. Recommendations

- To maintain a pH in the windrow between 6 and 7.2 to avoid volatilization of ammonia.
- Maintain aerobic conditions in the windrow to promote water evaporation and prevent anaerobic conditions from occurring, which avoids formation of volatile organic compounds, which are an added source of odour and may act as soft tissue irritants to mammals.
- During winter, the volume of liquid waste introduced should be reduced by 10% to compensate for precipitation.
- To improve plant capacity, evaporation rates should be optimized.
- We require to determine the rate of evaporation from the windrows because essentially that determines the processing capacity of the plant since it is only that water that can be replaced.
- It is required to determine the base moisture content of the fresh green waste to allow determination of the additional liquids that can be added to the windrows for processing.