Composting of Sewer Screenings

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Abstract

The purpose of this study was to evaluate composting of sewer screenings as an alternative to direct landfill disposal. The study incorporated a five month full scale trial at the Pukekohe wastewater treatment plant. The trials were conducted using a static, in-vessel system that tested the effectiveness of composting to reduce quantities for disposal and stabilise the material. Temperatures varied greatly throughout the compost piles, reaching thermophilic temperatures within the centre of the mass but remaining mesophilic within the outer regions. Limitations of the mixing methods also resulted in a non-homogeneous mix containing lumps of faecal matter.

Heavy metal testing of both sewer screenings and end product samples indicated that contamination levels were well below EPA regulatory thresholds however faecal coliform testing showed that only 60 percent of the end product samples met with EPA pathogen limits. Levels were lower in samples taken from the centre of the compost pile, rather than the edge and also lower in cured material. An improved in-vessel system with controlled aeration and/or turning capabilities would ensure a more homogeneous and better aerated mix. This would lessen variations in microbial activity throughout the compost mass, attaining thermophilic temperatures throughout and therefore achieve improved pathogen destruction throughout the screenings material. Germination testing also showed that the material required additional curing to overcome phytotoxic properties.

Three options for final disposal were considered, with the suitability of each option dependent on the success of the treatment process. The three options involved treatment of the screenings via the composting process followed by disposal to landfill as a special waste, disposal to landfill as a general waste and thirdly disposal to land within the bounds of the wastewater treatment plant. All three options would offer potential for considerable savings although the two options with potential for the greatest savings, on-site disposal and reclassification of the material as a general waste, would require an improved composting system to ensure pathogen destruction.

1.0 Introduction

Sewer screenings are the solid waste product arising from the initial screening of the wastewater flow. The screenings contain a mix of organic and inorganic material, including faecal matter and other potentially infectious materials. The volumes and composition of the sewer screenings are dependent on a number of factors including the type and size of the screen mechanism, flow rates into the wastewater treatment plant, the surrounding land use and the presence of any industrial flows into the plant. At the Pukekohe treatment plant solid material greater than 6 mm is captured by the step screen and tipped into the screenings feed hopper. A hydraulic ram then condenses the material pushing it though the washing chamber, main compaction zone and through the discharge pipe into a continuous bagging system, which is then tied off when required.

Although enclosed in a bag, the sewer screenings are odourous and required disposal to landfill twice per week. Due to the potentially infectious properties sewer screenings are categorised as a special waste and for acceptance at the landfill must be contained and buried separately from the general municipal waste, incurring high disposal costs. The material collected by the Pukekohe screen appeared to have a very high food waste content. This was thought to be a result of waste products coming through the sewer system from nearby organic based industry and was grounds for composting to be considered as a waste treatment option for the material. It was hoped that composting could result in alternative options for disposal or a reduction in the landfill disposal charges.

The objectives of this study were to provide a composition analysis of the sewer screenings collected at the Pukekohe wastewater treatment plant, determine if composting was an appropriate option and make recommendations as to a suitable method. The quality of the end product was assessed and options for final disposal of the material reviewed.

2.0 Methodology

The field studies involved a visual assessment of the screenings yield and sorting of screenings samples to provide a physical composition analysis. Once the composition of the screenings had been assessed, an onsite composting trial was conducted, incorporating the total volume of screenings obtained over a five-month period. The trial site was an area of the wastewater treatment plant previously used for the disposal of sludge dredged from the oxidation ponds. A 10 m square, 100 mm thick concrete pad was laid at the site. Any potentially contaminated runoff was collected and redirected back into the adjacent oxidation pond.

A simple static, in-vessel system was decided upon as the best option for the composting trials, in the form of 1.5m3 boxes constructed from wooden crates. This was to suit both the scale of the trial and site limitations, particularly the restricted power supply, which rendered mechanical options unsuitable. By completely enclosing the material the effects of climatic conditions were minimised and the material protected from vermin. The sides, bases and lids of the bins were constructed in separate pieces to enable simple dismantling around the compost mass and easy access for monitoring and sampling of the pile. The base planks were elevated off the concrete pad allowing air to be drawn up through the pile. The timber lids were covered in black polythene to prevent rain from getting into the boxes and to minimise the loss of hot air escaping from the pile.

Samples were taken from both the raw sewer screenings and the end product after various levels of composting treatment. Chemical testing of the screenings samples determined the appropriateness of composting as a treatment option by comparing the results with optimum composting parameters (moisture, C: N ratio, oxygen content, pH). A heavy metal analysis indicated the level of contamination of the raw material, compared against NSW EPA standards. Samples taken from the treated material were assessed for contamination levels (both inorganic and from heavy metals), pathogen levels (in the form of faecal coliform numbers) and phytotoxicity (based on seed germination).

3.0 Results

3.1 Composition of the sewer screenings

Figure 1 illustrates the results of the physical composition analysis while Table I shows the chemical composition of the screenings material. The physical composition analysis of the wet weight screenings showed that the material was 88 percent organic while chemical analyses indicated the organic content of the wet weight to be around 87 percent. Moisture contents were considerably higher than the recommended range for composting (50 to 60%). The test results indicated an average C: N ratio of 24, slightly below the optimum range of 25 to 40 (Haug, 1993). This indicated that a bulking agent was required to reduce the moisture content, increase carbon levels and allow greater airflow through the material by improving the matrix of the mix.

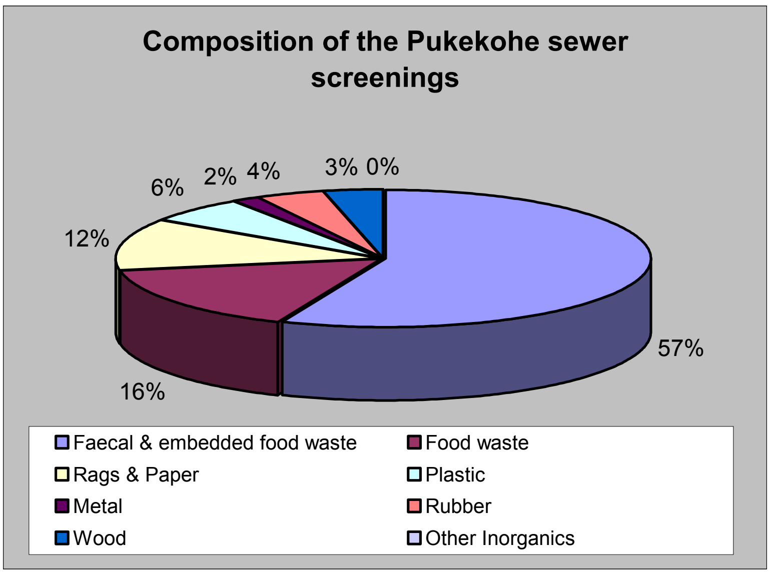

Figure 1: Physical composition of the Pukekohe screenings

Table I: Chemical Parameters of the Pukekohe Sewer Screenings (wet weight basis)

Parameter	Unit	Sample A, taken 15/5/00	Sample B, taken 15/5/00	Sample C, taken 17/5/00	NSW EPA A	B	C	D
Moisture	%	82.5	85.4	70.1				
pH		5.29	5.39	5.61				
Soluble salts	%	0.55	0.50	0.52				
Total organic C	%	6.7	5.5	11.1				
Total N	mg/kg	2750	1160	5650				
Organic N	mg/kg	2380	820	4880				
Nitrate-N	mg/kg	<1	<1	<1				
Nitrite-N	mg/kg	<1	<1	<1				
Ammonia-N	mg/kg	370	340	770				
Aluminium	mg/kg	297	177	894				
Antimony	mg/kg	<0.2	<0.2	<0.2				
Arsenic	mg/kg	<0.2	<0.2	<0.2	20	20	20	30
Barium	mg/kg	4	4	4				
Bismuth	mg/kg	<0.2	<0.2	<0.2				
Boron	mg/kg	3	2	3				
Cadmium	mg/kg	<0.2	<0.2	<0.2	3	5	20	32
Chromium	mg/kg	4	2	62	100	250	500	600
Cobalt	mg/kg	<0.2	<0.2	<0.2				
Copper	mg/kg	14	7	585	100	375	2000	2000
Iron	mg/kg	310	233	1608				
Lead	mg/kg	1	1	5	10	150	420	500
Magnesium	mg/kg	316	284	618				
Manganese	mg/kg	10	13	33				
Mercury	mg/kg				1	4	15	19
Molybdenum	mg/kg	1	<0.2	2				
Nickel	mg/kg	11	1	6	60	125	270	300
Selenium	mg/kg				5	8	50	90
Tin	mg/kg	1	<0.2	8				
Thallium	mg/kg	<0.2	<0.2	<0.2				
Zinc	mg/kg	56	50	238	200	700	2500	3500

Generally the heavy metal contents of the screenings samples were low and well below regulatory thresholds, however aluminium, chromium, copper, iron, lead, magnesium and zinc all showed large variations within the results. The maximum copper content of the screenings samples was higher than that allowed for by the NSW EPA for Grades A and B but did meet the limits for lower grade products.

3.2 End Product Analysis

3.2.1 Heavy metal analysis

Table II outlines the results of the heavy metal testing and again compares them against the NSW EPA regulatory thresholds for heavy metals. As with the raw screenings the maximum values were generally much lower than regulatory thresholds. The variation between samples indicated a low level of accuracy however the maximum values are generally much lower than regulatory thresholds for heavy metals. Zinc and nickel were at higher levels than those allowed for a NSW EPA Grade A product but well below the thresholds for the lower grades.

Table II Heavy metal analysis of end-product material from the Pukekohe sewer screenings compost trials
(with the exception of the organic content, values given on a wet weight basis)

	Moisture content (%)	Organic content (%)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Zn (mg/kg)
Box 4, Trial 4	62.4	57.9	<0.1	11	76	19	<0.2	6.3	327
Box 6, Trial 7	47.3	54.3	<0.1	11	33	16	<0.2	6.7	125
RT[1]-NSW, A			3	100	100	150	1	60	200
B			5	250	375	150	4	125	700
C			20	500	2000	420	15	270	2500
D			32	600	2000	500	19	300	3500

3.2.2 Pathogen testing results

Pathogen testing for the Pukekohe trials was limited to faecal coliform levels, as it was known that the organism would be contained in large numbers within the sewer screenings. Therefore any reduction in numbers during the composting process showed the extent of stabilisation of the material achieved by composting. Although an insufficient number of samples were analysed to make valid conclusions from the pathogen testing, the results do indicate that the composting process will reduce faecal coliform levels, however some of this reduction would be due to the dilution of the screenings by the addition of green waste.

Table III Results of faecal coliform testing of raw sewer screenings and end product material

Sample Source	Date sampled	Faecal coliform count (MPN/g,)	Pass / Fail (where fail = >1000 MPN/g, dw[2])
Screenings	24/11/2000	>5 500	Fail
	8/01/2001	2 300 000	Fail
Box 4, Trial 4 (windrow)	24/11/2000	>2 200	Fail
	8/01/2001	8	Pass
	22/01/2001	620	Pass
Box 6, Trial 7	8/01/2001	186	Pass
	22/01/2001	700	Pass
	22/01/2001	4 400	Fail

[1] Regulatory Threshold, NSW EPA , 1997
[2] US EPA, 1995; NSW EPA, 1997

Material taken from the centre of the compost mass appears to have lower faecal coliform counts that material taken from the edges. This observation is verified by temperature readings, which showed that inner material met temperature requirements for pathogen destruction whereas edge material did not. Material that has undergone extended composting time through curing, appeared to give a lower faecal coliform count than younger material.

3.2.3 Germination testing results

Germination testing was a form of phytotoxicity testing that analysed the effects of the end product material on germination rates and provided an indication of the maturity of the end product (NZPMMF, 1998). The results of the germination testing of sewer screenings end product showed that the radish seeds germinated slightly better in cured material (15 weeks old) than in the control yet considerably worse in the composted but uncured material (4 weeks). It is likely that the reason for this was due to the maturity of the product. These results indicated that a composting period greater than four weeks was required in order to apply the end product material to land without any adverse effects on vegetation. Although further testing is required for more conclusive results, material that has been composting for approximately three months appears to be sufficiently mature to not be phytotoxic.

3.2.4 Inorganic content of the end product

The samples tested for inorganic content were taken from material was approximately 15 weeks old and had passed through both a thermophilic and curing phase. The average percentage of inorganic contamination of the end product from was 16 ± 5 percent. The inorganic material consisted predominantly of plastic and rag material. As plastic material tends to be lightweight and the end product contained green waste particles of similar sizes, screening of the end product material could be difficult. If final disposal of the end product were application to land then the issue of inorganic contamination would need to be addressed. The acceptable level of contamination is relative to the selected method of final disposal.

3.3 Potential disposal options

Three options were considered as alternatives to disposal of the Pukekohe sewer screenings to Greenmount Landfill. Each of these options was based on varying degrees of success of composting as a treatment process.

The first option was disposal of the composted material to land within the wastewater treatment plant. Although this option could result in a considerable reduction in disposal costs there are a number of criteria that would need to be met in order for disposal to land within the wastewater treatment plant to be acceptable. Resource consent would be required to dispose of the material on-site. Limitations of the composting method utilised for the trial resulted in only the inner temperatures reaching the EPA requirement for pathogen destruction of 55 °C or more for at least three consecutive days. The results of pathogen testing of the end product material showed that 20 percent of the samples had very high faecal coliform levels (in excess of 1 000 MPN per gram). An improved in-vessel system with controlled aeration and/or turning capabilities would ensure a more homogeneous and better aerated mix. This would lessen variations in microbial activity throughout the compost mass, attaining thermophilic temperatures throughout and therefore achieve improved pathogen destruction throughout the screenings material. Testing of the inorganic content of the end product showed a visual contamination level of 16 ± 5 percent. Germination testing indicated that the 15 week old composted material was not phytotoxic whereas the 4 week old material noticeably hampered plant growth. These are issues that would require further investigation to ensure that on-site disposal of the end product material would not hamper grass or other plant growth.

The second option was stabilisation of the screenings through the composting process and disposal to landfill as a general waste rather than as a special waste. Assuming that composting would stabilise the material so that it could be reclassified as general waste, the associated landfill gate fees would reduce. However the addition of green waste to act as a bulking agent in the compost mix would cause an initial increase in the mass of material present. Any savings in disposal charges would need to be offset by the increase in mass. As with option 1, an improved composting system would be required in order to meet pathogen destruction requirements and therefore ensure that the screenings material is stabilised sufficiently to be considered a general waste.

The third option viewed the composting as a treatment process to provide temporary storage on site and reduce the haulage costs associated with disposal to landfill. Although the savings for option 3 are not as high as for options 1 and 2, it may be acceptable for the method utilised during the compost trials to continue therefore savins potentially high set up costs of an improved method. However this depends on requirements set for resource consent of continued on-site composting. It should also be considered that special waste / category C material must be contained in some way in order to be accepted at the landfill, therefore an additional process to contain the end product material would be required.

4.0 Conclusions

The physical composition analysis of the Pukekohe sewer screenings showed that the material was 88 percent organic, including faecal matter, food waste, rags and paper. Chemical analyses indicated the organic content to be around 67 percent. This lower value is thought to result from using a dry weight method as opposed to the physical composition, which was conducted on wet material taken directly from the trailer. The Pukekohe sewer screenings are compostable but do require the addition of a bulking agent to reduce the moisture content, increase the carbon to nitrogen level and improve airflow through the mix by opening up the mix matrix. Therefore any potential mass / volume reductions would be offset by the need to add bulking agent to the screenings material.

Temperatures within the centre of the compost piles rapidly reached thermophilic temperatures and remained thermophilic for a number of weeks, meeting pathogen kill requirements of 55 °C or more for a minimum of three consecutive days. Temperatures varied greatly throughout the pile, with edge material generally not achieving EPA temperature requirements for pathogen destruction. The temperatures around the edge of the compost piles generally remained within the mesophilic range. Limitations of the mixing methods resulted in a non-homogeneous mix, which contained lumps of faecal matter well into the composting process.

Heavy metal testing of both sewer screenings and composted end product samples indicated that contamination levels were well below NSW EPA limits for compost and biosolids products. The variation between results indicated that further testing was required for these metals. Faecal coliform testing indicated that composting substantially reduces the extremely high values measured within the raw screenings material. There was considerable variation between the faecal coliform counts of samples taken from the same source therefore further pathogen testing is required. They also indicated that faecal coliform levels were lower in cured material than less mature samples, and lower in samples taken from the centre of the compost pile than in edge material. Cured material (15 weeks old) had no phytotoxic effects, however 4 week old material did appear to have phytotoxic effects and was deemed to be immature. Further analysis of the end product is required to determine the most appropriate method of final disposal. Pathogen levels are of particular importance as they determine whether the material can be reclassified as a general waste and / or disposed to land within the boundaries of the Pukekohe wastewater treatment plant.

Three options for final disposal were considered, with the suitability of each option dependent on the success of the treatment process. The three options involved treatment of the screenings via the composting process followed by disposal to landfill as a special waste, disposal to landfill as a general waste and thirdly disposal to land within the bounds of the wastewater treatment plant. All three options would offer potential for considerable savings although the two options with potential for the greatest savings, on-site disposal and reclassification of the material as a general waste, would require an improved composting system to ensure pathogen destruction.

The objectives of this study were met in that composting was deemed to be a viable option for stabilisation of the sewer screenings. This was based on both the high organic content shown by the screenings composition analysis and the ability of the composting process to destroy pathogens, thus converting the potentially infectious material to a more stable form with a greater range of disposal options. Although the composting method undertaken for the trials was inadequate the project objective of making recommendations as to a suitable method were still achieved. Consequently an improved in-vessel composting system with controlled aeration and / or turning capabilities is required to ensure a more homogeneous and better aerated mix. This would lessen variations in microbial activity within the compost mass, attain thermophilic temperatures throughout and therefore meet pathogen destruction criteria for the entire compost mass. The number of samples taken from the end product material was inadequate however the various forms of analyses undertaken on the material showed that heavy metal contamination was not significant. It was concluded that so long as the system was improved to achieve complete pathogen destruction alternative options for disposal would be viable. The most beneficial option would require additional curing to overcome phytotoxic effects and therefore produce a material suitable for spreading on land within the wastewater treatment plant.

5.0 References

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