Hamilton's Municipal Biosolids Up-Cycled at New Zealand's Largest Worm Farm

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ABSTRACT

Hamilton City Council has been evaluating beneficial utilisation of its 12,000 tonnes of municipal biosolids over the past 3 years. The process included reviewing existing and potential technologies for cost-effective management of HCC biosolids. During two workshops nine technologies were evaluated with input from associated industry experts. A ranking of the different options was conducted weighing four main criteria including cultural & social, environmental, risk, and costs. Regional aspects have been considered throughout the process. Scores from each of these criteria was weighted and summarised to gain an overall ranking. Vermicomposting was ranked as one of the top four technologies. The following criteria lead to a preference for vermicomposting over other technologies. 1. The vermicomposting operation is 'close' to Kinleith and the associated paper pulp, it allowed the vermicomposting operation to be. 2. Financially viable/cost effective. 3. Highly cultural and socially accepted technology. 4. Proven technology as biosolids from Te Puke and Rotorua have been vermicomposted in Kawerau successfully for several years. 5. High quality soil conditioner as final product, based on results of a feasibility trial at Kinleith vermicomposting operation.

KEYWORDS: Biosolids, Pulpmill Solids, Vermicomposting, Land utilisation

INTRODUCTION

Hamilton City Council (HCC) has reviewed its biosolids disposal option from Pukete Waste Water Treatment Plant (WWTP) with the aim to provide the best beneficial method to its community. Potential options have to be evaluated economically, environmentally, culturally, and socially.

MATERIALS AND METHODS

Up-cycling municipal biosolids using vermicomposting technology requires additional fibrous material with a wide C/N ratio which is highly digestible to compost worms. The two mayor ingredients for vermicomposting in this operation are Hamilton's municipal biosolids and rejecter pulpmill solids from Kinleith Pulp & Paper Mill.

Hamilton Pukete WWTP Biosolids

HCC produces between 12,000 to 13,000 tonnes of biosolids at its Pukete WWTP per year. The sewage sludge is a combination of sludge from the WWTP as well as some sludge from filtering the Waikato river water for drinking water supply. The combined sludge is then anaerobically digested and thereafter dewatered to approximately 25% solids. The characteristics of the biosolids are shown in Table 1.

Kinleith's Pulpmill Solids

Various fibrous wastes are produced at the Kinleith Pulp & Paper plant such as so called primary pulpmill solids (Table 1), secondary solids as a sediment from oxidation ponds, recycling paper solids and fibre rich sediments from stormwater sedimentation ponds (Quintern, 2011).
The primary pulpmill solids, recycling paper solids and fibre from stormwater sedimentation ponds show high carbon contents and low nitrogen contents expressed as C/N ratio of up to 247. At the same time these fibres have extremely low metal content well below the Grade 'a' contamination limits of the Biosolids Guidelines (NZWWA, 2003).

Table 1. Properties of HCC biosolids, Kinleith primary pulpmill solids and biosolids contamination limits for Grade a (NZWWA, 2003).

Parameter	Hamilton Biosolids	Kinleith Pulpmill Solids*	Grade a max. concentration NZWWA (2003)
Nutrients [g/100g dry wt]			
Dry Matter	22.7	5.5 – 23.5	
Carbon	32.2	35.3 – 47.1	
Nitrogen	4.25	0.19 – 0.56	
C/N ratio	7.6	80 - 247	
Nutrients [mg/kg]			
Phosphorus	23,800	420 - 550	
Potassium	1,212	150 – 320	
Sulphur	5,390	2,230 – 4,210	
Magnesium	1,997	931 – 1,160	
Calcium	16,890	33,700 – 57,400	
Metals [mg/kg]			
Arsenic	104	ND	20
Cadmium	0.89	ND – 0.5	1
Chromium	117.6	48 - 77	600
Copper	238	22 - 30	100
Lead	22.2	5 - 10	300
Mercury	1.12	ND	1
Nickel	39.5	24 - 72	60
Zinc	444	64 - 147	300

* Data provided by Kinleith Pulp & Paper plant

Sewage Sludge Options Study

HCC conducted a Sewage Sludge Option Study (SSOS) in 2011 to review its current biosolids disposal method of landfilling with a view to move to a more environmentally friendly and cost saving re-use solution. Consultants Sinclair Knight Merz Ltd facilitated the SSOS at two workshops in March and April 2011.

The first workshop:

- Identified a short-list of viable options with stakeholders.
- Introduced potential assessment criteria to assess the long list of options.
- Determined a shortlist of options for more detailed evaluation.

The second workshop:

- Discussed the assessment criteria with stakeholders.
- Determined a ranking of the shortlisted options.

The following options for beneficial reuse options were considered at the SSOS (Table 2)

Table 2. Technical Options Summary. Sewage Sludge Option Study (SKM, 2011a).

Technology	Input	Summary	Output	Existing Plants
Cement Kiln - NOx Reduction	Dewatered sewage sludge	Sludge added to cement kiln to reduce NOx emissions.	None (incorporated in cement)	International (3 identified)
Incineration	Dewatered sewage sludge	Burning of sewage sludge, usually with pre-drying. With or without energy recovery.	Ash + energy	NZ (Dunedin) International (multiple)
Lime Stabilisation	Dewatered sewage sludge	Addition of lime with heating to stabilise sludge for land application or disposal.	Stabilised, alkaline sludge	NZ (multiple e.g. Auckland) International (multiple)
Composting (incl vermi-composting)	Dewatered sewage sludge	Composting of dewatered sludge with appropriate bulking agent.	Biosolids compost, Grade Aa	NZ (Te Puke, Rotorua) International (multiple)
SlurryCarb	Dewatered sewage sludge	Carbonises organic matter in sewage sludge and lyses cell walls, resulting in fuel product.	Slurried e-fuel as product or to drying	International (1)
Thermal Dryer	Dewatered sewage sludge	Thermal drying of dewatered sludge using a range of fuels including gas and waste wood.	Dried sludge - fuel or soil conditioner/ fertiliser	NZ (New Plymouth, Hutt Valley, Christchurch), International (multiple)
Solar Dryer	Dewatered sewage sludge	Evaporation of moisture over a period of several weeks in glass houses.	Dried sludge - fuel or soil conditioner/ fertiliser	International (multiple)
Pyrolysis	Dried sewage sludge	Production of a light fuel oil.	Fuel oil + char	NZ – Lakeland Steel pilot International - pilot
Gasification	Dried sewage sludge	Converts sewage sludge into a combustible ‘syngas’.	Fuel gas + char	International - pilot
Vitrification	Dried sewage sludge	Converts sewage sludge into a stabilised glass.	Glass aggregate	NZ – Kapiti failed pilot International (1)
Lystek	Primary & secondary sewage sludge	Converts Grade B biosolids to Grade A.	Slurried biosolids	International - pilot
Sterm	Dewatered sewage sludge (digested and/or raw)	Process dries sludge which is used as the main source of fuel for the drying process.	Surplus bio-fuel and ash	Hamilton (pilot)
Cambi	Dewatered sewage sludge	A pre-mesophillic digestion process that increases biogas production and volatile solids reduction and produces Grade A sewage sludge.	Grade A sewage sludge	International (20?)

Results

Sewage Sludge Options Study

Table 3 present the results of the SSOS based on weighed criteria in four categories:

- Risks
- Environmental benefits (including climate changes)
- Costs

- Social/cultural impacts

Social and cultural assessment criteria were lowest for land application of untreated biosolids. Land application of vermicomposted biosolids scored at a high level of community acceptance, as vermicast is not defined as a biosolid after processing. STERM and landfill options were highly accepted by Hamilton's community.

Environmental benefits assessment criteria were weighed against beneficial use potential and against assessment of carbon emission. Here all options scored high, except landfill.

The assessment criteria considered risks associated with the Resource Management Act resource consent risks, technology risks, market risks, and supplier. Landfill scored the highest as a result of the ongoing operation and most common practice in New Zealand for handling biosolids. STERM and vermicomposting are relatively new technologies in New Zealand and therefore scored lower than landfill with regards to technology risks.

Costs assessment criteria did not show high variation between the options with a favour for STERM as this would be operated on site and no transportation of biosolids would be required. Landfill costs were comparable to vermicomposting and land application based on landfill costs as at 2011.

Table 3. Summary of detailed assessments results of shortlisted options for beneficial use and landfill disposal option for HCC biosolids during the Sewage Sludge Option Study (SKM, 2011b).

Assessment Criteria (scored out of 5)	Weighting	Land application	STERM	Vermi-composting	Landfill
Social/Cultural	**12.5%**	3.0	5.0	5.0	5.0
Environmental	**25%**	**4.5**	**4.0**	4.0	2.5
Risk	**50%**	3.8	3.3	3.5	4.5
Costs	**12.5%**	**4.0**	**5.0**	**4.0**	**4.0**
Overall Score (out of possible 5)		**3.9**	**3.9**	**3.9**	**4.0**

In 2012 HCC decided to proceed with the vermicomposting technology for beneficial reuse of the biosolids. Local consultants, BCD Group Ltd were commissioned for developing and conducting the project though the planning, site evaluation, logistics, and reporting to stakeholder stages. Vermicomposting of HCC biosolids in combination with pulpmill solids from Kinleith pulpmill started in February 2013 in an isolated forest site near Tokoroa.

Vermicomposting Operation

Vermicomposting of biosolids in combination with pulpmill solids was established in New Zealand on a commercial scale in 2009 for the processing of approximately 900 tonnes of biosolids per year from Te Puke WWTP at the Tasman pulp and paper mill in Kawerau (Glasner and Quintern, 2011). In 2011 Rotorua District Council decided to divert its 10,000 tonnes of biosolids per year from the landfill and to use the same vermicomposting facility in Kawerau. In 2012 Western Bay of Plenty District Council launched its onsite vermicomposting operation at the recently built WWTP at Maketu (Glasner and Quintern, 2011).

Vermicomposting of mixed biosolids and pulpmill solids is a natural, self-sustaining and economic technology and has been studied successfully internationally (Elvira et al. 1995; Dominguez *et al*, 2000). Latest publications are demonstrating a global increase in using vermicomposting for beneficial reuse of biosoldis (Rodríguez-Canché *et al*, 2010; Suthar, 2010; Edwards and Subler, 2010; Yadav *et al*, 2010; Suthar and Singh, 2009; Khwairakpam and Bhargava ,2009; Suthar, 2009; Sinha *et al*, 2010; Yadav *et al*, 2008).

MYNOKE Worm Farm is operating in Tokoroa on approximately 37 ha within a 6km radius of the source of pulpmill solids. Pulpmill solids are vermicomposted solely for are organic certified vermicast on a 20ha site, while the new site for vermicomposting HCC's biosolids is located on a 17 ha block in the Kinleith forest located approximately 3 km from the pulpmill. Mechanical processing is minimised to reduce carbon emissions from vermicomposting. The biosolids and various pulpmill solids are mixed with a standard agricultural feedstock mixer and applied to advanced windrows for vermicomposting.

All activities and inputs are monitored. It is intended that all land application of vermicompost will be documented in a GIS based monitoring system allowing traceability of all applications and to review the long term effects of land application of vermicompost derived from pulpmill solids.

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