Win Win Win:
Biosolids + Pulpmill solids + Compost worms = Fertile soils
(The Western Bay Way)

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ABSTRACT

Western Bay of Plenty District Council (WBOPDC) has taken up the challenge of producing stabilised biosolids from its wastewater sludges so they can all be safely and beneficially applied to land. Te Puke WWTP biosolids reuse is contracted out for vermicomposting in Kawerau. EcoCast Ltd is mixing some 900 tonnes of biosolids, with several thousand cubic metres of primary solids from Tasman Pulp & Paper Mill.

EcoCast Ltd is now operating in its second year on a pasture block close to Tasman mill. Vermicomposting of the mix of biosolids and pulpmill solids produces an **'a'** contaminant grade after 6 months. Pulpmill solids provide required fibre and structure for dewatered biosolids while being extremely low in contaminant. This makes pulpmill solids an ideal co waste for vermicomposting biosolids from waste water treatment plants. Analysis on stabilisation grade proofs reduction of E. coli to < 16 MPN and no detectable Salmonella. Elimination of enteric viruses and helminth ova have not been investigated at this stage. Several hundred tonnes of vermicompost will be applied to crops in 2011 for the first time, based on resource consent.

Keyword: Biosolids, pulpmill solids, vermicomposting, land application.

INTRODUCTION

The Western Bay of Plenty District Council own and operate the wastewater treatment plant (WWTP) servicing the communities of Te Puke. The Te Puke WWTP consists of an activated sludge extended aeration process, with sludge wasted from clarifiers on a daily basis. The waste activate sludge (WAS) is dewatered through a centrifuge, with the resulting sludge cake requiring removal from site every five days. Traditionally Te Puke's sludge has been transported to landfill outside of the District.

Over the past two years the WBOPDC has set about investigating and implementing options to beneficially use the sludges as biosolids, defined by the Guidelines for the Safe Application of Biosolids to Land in New Zealand (NZWWA, 2003). By using vermicomposting as stabilisation technology the reliance on and cost of landfilling the sludge is avoided, and the intent of the New Zealand Waste Strategy (MfE, 2002) is achieved.

Vermicomposting is used worldwide for stabilisation of biosolids at various scales from single households to communities with 40,000 tonnes of biosolids per annum. During the process, stabilisation occurs in a decrease in pathogens and incorporation of solute nutrients in a more stable organic fraction if carbon rich fibre is used for co-processing. Pulpmill solids are characteristically known to have a wide carbon/nitrogen (C/N) ratio and extremely low contaminant content. Noke Ltd has been conducting trials to develop a safe and economic vermicomposting technology to vermicompost biosolids from WWTPs such as Te Puke and Rotorua in combination with pulpmill solids from Tasman Pulp & Paper Mill.

Volcanic ash soils in the Kawerau Whakatane region of the eastern Bay of Plenty are extremely low in organic matter. These soils are of a coarse texture with low water holding capacity, shallow root development of pasture and crops, and as a result very low nutrient holding / exchange capacity. Vermicompost in well known for its beneficial use in cropping and pasture systems.

MATERIALS AND METHODS

Te Puke Biosolids

Te Puke is a rural township in the Western Bay of Plenty District with approximately 7,000 residents and medium size industries such as food and timber processing. The Te Puke WWTP generates 900 tonnes per annum of centrifuge dewatered WAS. Since 2009 the sludge has been sent to an industrial vermicomposting operation near Kawerau, 70 km from Te Puke. The following sections characterise the Te Puke sludge with respect to NZWWA (2003) guidelines, describe the vermicomposting process, and summarise the local operation for the Te Puke product. Table 1 shows the characterisation of Te Puke sludge compared to NZWWA (2003) biosolids limits Grade ‘a’. Values in Table 1 that are underlined in bold indicate parameters that exceed the ‘a’ grade contaminant guideline value.

Tasman pulpmill solids

The relevance of the pulp mill solids data is that Bay of Plenty pulp mills generate between 80,000 and 100,000 tonnes of solids per year, which also requires disposal or preferably beneficial use. A small portion of the primary solids is currently composted for potting mix or used as fibre source for vermicomposting, more than 90% is currently land filled. The pulpmill solids are generated at a counter sheer from the effluent, dewatered at 29.9% solids. The structure can be described as fluffy, bulky structure. Characteristics of the fibre, which is carbon rich and small in nutrients, are presented in Table 1.

Vermicomposting

Vermicomposting of municipal biosolids is a natural, self sustaining and safe technology (Edwards 1988). Vermicomposting of biosolids is undertaken worldwide at various scales from septic tank level, to small communities in Mexico and India, and at industrial scales such as in Brisbane (40,000 tonnes/year) (Quintern *et al*., 2008).

Some biosolids are not a suitable feedstock for vermicomposting when fed as a single source. High concentrations of ammonia, high electrical conductivity, a demand for carbon, and a sloppy consistency can either become harmful to compost worms or require specific feeding technologies. As a result, municipal biosolids are often combined with bulking agents for vermicomposting. Suitable bulking agents are manure (Gupta & Garg, 2008), paper, wood and pulp mill solids wastes (Dominguez *et al*, 2000).

Table 1. Properties of Te Puke Biosolids, Tasman Pulpmill (primary) solids, and vermicompost compared to requirements and limits of Biosolids Guidelines (NZWWA, 2003).

Parameter	**Te Puke WAS**	**Pulpmill Solids**	**Vermicompost**	**Guidelines Grade 'a'** after 31/12/12
Nutrients [g/100g dry wt]				
Dry Matter	20.2	29.9	57.7	
Carbon	41.0	34.7	26.5	
Nitrogen	1.43	0.37	1.06	
C/N ratio	28.7	94	25.0	
Nutrients [mg/kg]				
Phosphorus	3,400	749	3,490	
Potassium	1,230	2,440	1,680	
Sulphur	1,190	1,056	2,000	
Magnesium	700	1,504	3,140	
Calcium	1,540	48,900	57,900	
Metals [mg/kg]				
Arsenic	3.67	<0.1	4.0	20
Cadmium	0.68	0.13	0.44	1
Chromium	9.8	23.75	44.9	600
Copper	**125**	11.24	37	100
Lead	18.8	4.23	12.48	300
Mercury	**1.5**	<0.1	0.17	1
Nickel	8.9	5.09	8.6	60
Zinc	289	41.23	99	300

Vermicomposting is an aerobic process and requires avoidance of anaerobic conditions at any time. As a result decomposition of the organic matter in the feedstock leads to carbon dioxide emissions and avoids emission of methane and nitrogen dioxide which are highly relevant green house gases (GHG). The GHG emissions of vermicomposting are lower than conventional composting where these processes are not able to avoid pockets of anaerobic conditions.

During vermicomposting, compost worms feed on bacteria, organic matter such as cellulose, fungi, and small mineral particles (Edwards, 1988). During the approximately 5 cm long pass through the gut of the worm the feedstock is screened and ground in the worm's gizzard, which increases the surface area of the feedstock so bacteria can decompose the waste much faster. Further on, the intestine of the worm acts as a bioreactor for bacteria to rapidly decompose the organic matter to provide energy and nutrients to the worm. The grinding and antibiotic substances in the mucus of the worm's gut destroy pathogens effectively. (Eastman, 1999). The feedstock is inoculated with 'good' bacteria generally found in fertile topsoils. At the end of the 5 cm pass through the worm's gut decomposed and stabilized waste is finally capsulated in mucus and released as casting.

Scientists worldwide have studied the effect of earthworm activity on trace elements in soils or in vermicomposting of organic wastes. While vermicomposting in general is a process of concentrating trace elements and nutrients where carbon is released as carbon dioxide, studies show that worms are reducing some trace element concentrations during vermicomposting (Carraquero Duran *et al*, 2006).

Over a period of three to six months the vermicompost matures. The introduced and increased number of bacteria in the casting decomposes the remaining organic matter slowly. The joint action of compost worms, bacteria, and fungi produces several products which stimulate and regulate plant growth. Some of these value adding substances which make the vermicompost a preferred product compared with general compost are humic acids, indole-acetic acids (auxins), gibberellins, and cytokinins (Arancon *et al*, 2008). Trials have demonstrated consistently that vermicomposted organic wastes have beneficial effects on plant growth independent of nutrient transformations and availability (Atiyeh *et al*, 2002).

Vermicomposting operation

WAS from Te Puke and pulp mill solids have been processed for almost a year at an industrial vermicomposting plant near the Tasman Pulp mill at Kawerau in the Bay of Plenty. The site is operated by Ecocast Limited who hold a resource consent for processing up to 20,000 tonnes of pulp mill solids and municipal biosolids from the Bay of Plenty Region including Rotorua and Tauranga. The site is located in a rural, industrial area. The current 900 tonnes per annum of Te Puke WAS, plus 1,000 to 4,000 tonnes of pulp mill solids requires an area of less than two hectares.

WAS is collected at the Te Puke WWTP directly onto a truck to avoid handling of the sludge on site and potential spills. The dewatered WAS is transported to the vermicomposting site every fifth day so no significant odour is built up at the WWTP. Vermicomposting is conducted by windrow technology where the physical and chemical qualities of the pulpmill solids are used to avoid nutrient leaching into the ground and to minimise odour emission. The feedstock preparation has been optimised in such a way that potential environmental and health effects of the WAS are reduced and worms are able to start processing almost immediately after feeding.

All activities and inputs are monitored, and in the future products will be tested according to NZWWA (2003). 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 municipal biosolids.

LAND UTILISATION OF VERMICOMPOST FROM BIOSOLIDS

Te Puke WAS can be considered to have a low level of contamination with metals. Only copper and mercury concentrations in the WAS are slightly above grade 'a' limits (Table 1), whereas pulpmill solids are well below all limits for 'a' grade biosolids. This makes the pulpmill solids from Bay of Plenty pulp and paper industry a potential blending agent for municipal biosolids such as Te Puke WAS, but potentially for the whole Bay of Plenty

Region including Rotorua and Tauranga City. Potentially mixing both organic wastes at a ratio of 1 to 1 would provide a product meeting all 'a' grade trace element contaminant limits.

The vermicompost was sampled first time, six months after introducing worms. Results are shown in Table 1 and all metals are well below Grade 'a' limits. The vermicomposting operation is focused on producing a stable and safe soil conditioner, which can be applied in nutrient sensitive areas such as lake catchments. Therefore the vermicompost should be a slow nitrogen and phosphorus-releasing product with high water and nutrient holding capacity. The vermicompost has a nitrogen content of above 1.06, which will lead to a small plant growth effect. The mineralisation rate is estimated to be below 20% of nitrogen and phosphorus in the first year. Table 2 shows the calculated application volumes based on 200 kg N/ha per year or 600 kg N/ha every 3 years. For 900 tonnes WAS from Te Puke per year and an application of 200 kg of N per ha and year a total of 12.9 ha are required for continuous and sustainable application. This would allow an application of 4.2 mm of vermicompost per year to be incorporated into top soil or (potentially applied onto surface as pasture dressing - Aa grade only). With co-vermicomposting of carbon rich pulpmill solids a total of 5 tonnes of carbon will be applied to soil to increase soil organic matter and soil carbon content.

Table 2. Application rates, volumes of vermicompost, and carbon application of vermicompost from annual biosolids production of Te Puke WAS.

N rate kg N/ha	**Application interval**	**Required area per year ha**	**Application t/ha**	**Application m^3/ha**	**Carbon application t/ha**
200	every year	12.9	31.4	41.9 (4.2 mm)	5.0
600	every 3 years	4.3	94.3	125.8 (12.8 mm)	15.0

Testing of six month old vermicompost on faecal bacteria proved sterilisation of biosolids through vermicomposting to E.coli with <16 MPN/100g and no detectable Salmonella. Tests on complete reduction of pathogen according to biosolids guidelines (NZWWA, 2003) will be conducted on mature vermicompost. The aim is to achieve certification of BQM for vermicompost of Te Puke WAS.

FUTURE VISION

Council's vision for managing biosolids, septic tank sludges, and other organic wastes currently not recycled is a quadruple bottom line approach on economic development while maximising the social, cultural, and environmental benefits. Most critical to the WBOPD is independent organic waste management with a strong regional focus. Biosolids and septic tank sludge from the region have to be processed and recycled within the region whenever possible. Disposal to landfills and exporting biosolids from the Bay of Plenty region should be avoided.

WBOPDC is seeking to combine the benefits of a highly productive horticultural area (kiwifruit and avocado production) surrounded by large forest plantation, and the proximity to Tauranga City. Figure 1 presents a diagram of inputs and outputs as well as service opportunities for a proposed centralised vermicomposting operation in the WBOPD. The inputs from all sectors would be recycled, with the rural and urban communities becoming involved as the operation would provide services and opportunities for employment, research, education, and social projects. The diversity of land use in the District allows for wide ranging marketing and utilization of the end products.

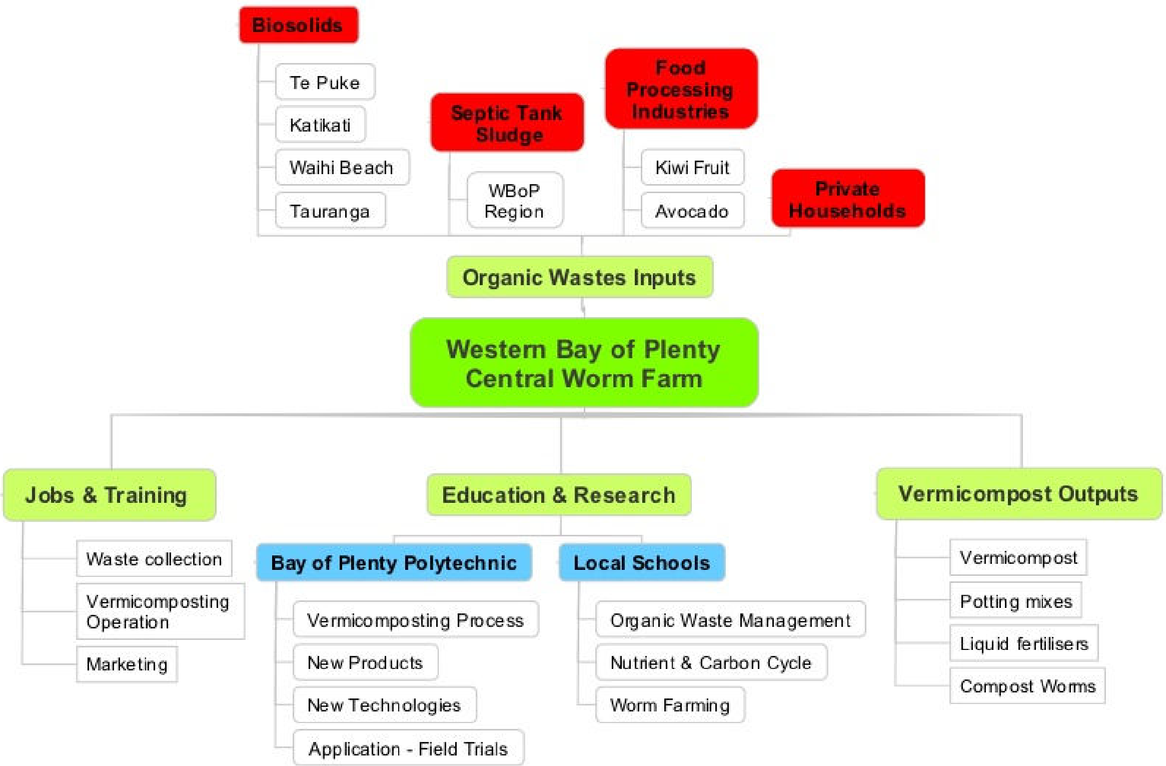

Fig. 1: Western Bay of Plenty Centralised Worm Farm

Currently WBOPDC are exploring a centralised vermicomposting operation that would recycle regional biosolids and septic tank sludge with the option of adding organic wastes from food processing industries and private households. Stabilising and fragmenting biosolids by using compost worms would address the quadruple bottom line in the following ways.

Economical

Operating a central biosolids processing plant provides scope for cost reduction compared to wide spread facilities. Transport costs for biosolids to and from a central site can be reduced by a coordinated approach to ensure average transportation distances are less. Monitoring costs would be reduced as the end products will become more consistent with less analysis required. One centralised plant also offers the opportunity to monitor land application of biosolids derived products in a regional GIS based monitoring system, with a single data communication path. Vermicomposting at large scale can be more cost effective than disposal to land fill, combustion, or thermal drying.

Environmental

Vermicomposting of municipal biosolids is a natural and environmentally safe technology as described in more detail in Section 2.2. Core benefits are emission reductions in odour, spores and GHG. Offset of GHGs in supplementing mineral fertilizer, and increasing soil organic carbon content when applying vermicompost to soil are added benefits.

Social

Worm farming is a popular way of recycling organic wastes at schools as well as at home as it creates minimal odour. Worm farms can play a central role for education on organic waste management and recycling, as well as in the environmental and biological fields. Vermicomposting offers tasks for different competence levels such as in bagging, process control, marketing and education. A wide range of skills can be gained on worm farms, creating opportunities socially and for future employment.

Although significant research has been conducted on vermicomposting of biosolids and other organic wastes, operating a large scale worm farm in the neighbourhood of an accredited environmental research facility such as the BOP Polytechnic offers an opportunity to develop new technology and products in the area of vermicomposting.

Cultural

Handling, processing, and most importantly disposal of human biosolids or derived products can have adverse effects on the relationship with local Iwi, as it may have impact on ancestral lands, waters, and waahi tapu. Fragmentation and stabilisation of human biosolids by vermicomposting is one of the most natural processes which turns the ‘feedstock’ into a safe and usable product. Therefore the land application of vermicompost is expected to be more acceptable to maori land owners. Working together with local maori groups will be essential for success of a central vermicomposting operation.

CONCLUSIONS

Vermicomposting is an efficient way to process wastewater sludges derived from human origin and reduce the associated potential health and environmental risks, which is supported by extensive research on the topic. A final beneficial use for the end biosolid product is however still required. The total volume of biosolids produced in New Zealand is likely to increase as treatment plants are improved in the future (MfE, 2006). As well as this, older pond systems, which are still providing sufficient treatment for their effluent receiving environment, will require more frequent desludging in order to continue doing so. If at the same time the land options available for beneficial use of biosolids are decreasing due to decisions such as Fonterra’s, the New Zealand wastewater industry will face an even greater challenge in the future to make economic and environmentally acceptable use of biosolids.

Breaking down barriers to make use of an excellent fertiliser and soil conditioner, which would otherwise becomes a waste product sent to landfill must be an objective for the wastewater industry as a whole. Overcoming negative public perception on the use of biosolids from human origin through education is imperative. Case studies presented on successful biosolids land application schemes would be a good start in this regard. MfE (2006) reports that from available data 79,440 tonnes, or 67.5% biosolids produced in New Zealand (excluding Mangere biosolids used for land reclamation) are landfilled each year. So there is some way to go before New Zealand’s use of biosolids can be considered environmentally sustainable. The WBOPDC is aiming to achieve that objective for its

District. Council's vision of a centralised vermicomposting facility, servicing the whole district, represents a difficult task, but one that should be strived for.

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