INTELLIGENT, INTEGRATED WASTE TREATMENT BY CONSOLIDATING ORGANIC WASTE STREAMS

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ABSTRACT

Wastewater treatment is a continuous process, with very high energy needs and a large carbon footprint across the wastewater network. Most often, at a New Zealand council level, there is mixing of domestic and industrial wastewaters. Similarly, most plants in NZ process wastewater to secondary treatment level, without nutrient reduction or tertiary treatment processes. However, more stringent national effluent standards will require additional higher levels of liquid stream treatment – incurring greater costs, larger energy needs and higher embedded and operating carbon footprints.

Higher treatment of the liquid streams will result in more sludge being produced which will need to be dealt with more innovatively and intelligently than our current practices, which are dominated by dewatering and landfilling, adding to landfill gas emissions. Some large NZ WWTPs operate sludge digesters, and while these plants recover significant energy, they do not export "green energy" as is common for many "wastewater recovery facilities" (WRRFs) elsewhere.

Many of our large primary industries operate their own wastewater treatment facilities, often to recover usable by-products, but they also produce residual sludge, which must be dealt with. Often, landfills will not accept DAF sludge from meat works or from dairy plants, and these problems will be compounded by expected higher environmental controls on liquid and solid waste disposal.

On the other hand, most Councils operate separate facilities to manage green waste, food waste and other organic waste materials. This inevitably increases both capital and operational costs because of the lack of scale and the non-realisation of possible co-management benefits.

KEYWORDS

Integrated Waste, Carbon Footprint, Organic wastes, Emissions, Resource Recovery, Circular Economy

PRESENTER PROFILE

Garry Macdonald is widely recognised as an expert in wastewater engineering with over 46 years' experience in a wide variety of wastewater projects, both in New Zealand and abroad. He has a high-profile involvement in many industry organisations and has received a number of prestigious industry awards and presented over 60 technical papers in industry publications and at conferences in NZ, Australia, and USA.

Harmaan Madon is an Edmund Hillary Fellow and founder of Alimentary Systems whose intelligent Integrated Waste Treatment Plant concept targets clean energy, cleaner waterways and increased soil biodiversity. He is passionate about our natural world and works at the intersection of science, engineering, and public policy to drive improved outcomes, with a tau iwi commitment to kaitiakitanga.

INTRODUCTION – PROBLEM STATEMENT

We in Aotearoa/New Zealand have a national "waste problem" – both with our inorganic and our organic wastes. While some Councils and industries have tackled this head-on with respect to municipal wastes (household wastes and wastewater solids) and byproducts of industrial processing, landfilling of the majority of our waste solids had been and still is the default option. It is only with the proposed imposition of higher landfill charges – and perhaps as in other countries – a ban on organic wastes being disposed to landfills which will we cause a paradigm shift in how we manage our liquid and solid wastes.

However, our view is that we must shift our national focus from just looking at this problem through a "waste" lens, to one in which we take into account the environment as a whole – land, water and air or atmosphere. That is, we adopt what is commonly called the lens of the "circular economy" in which a more holistic view is taken of how our wastes are a valuable resource which can be reused or substituted for other non-renewable resources that are currently used in our day-to-day lives.

We postulate that we should be visionary in our approach – targeting both zero waste and carbon zero, not only creating value from waste but also restoring biodiversity and reducing our dependence on non-renewable resources, such as chemically-based fertilisers, and coal and gas energy. Our primary topic in this paper is that of wastewater treatment and the management of the solids from these processes, as well as the organic solids which are produced by many of our primary production industries and contained within our domestic wastestreams.

Our problems are multi-faceted and can be summarized at a macro-scale in Figure 1. With a more focused lens on organic and green waste solids, Figure 2 shows some of the problems we have in our conventional waste management practices.

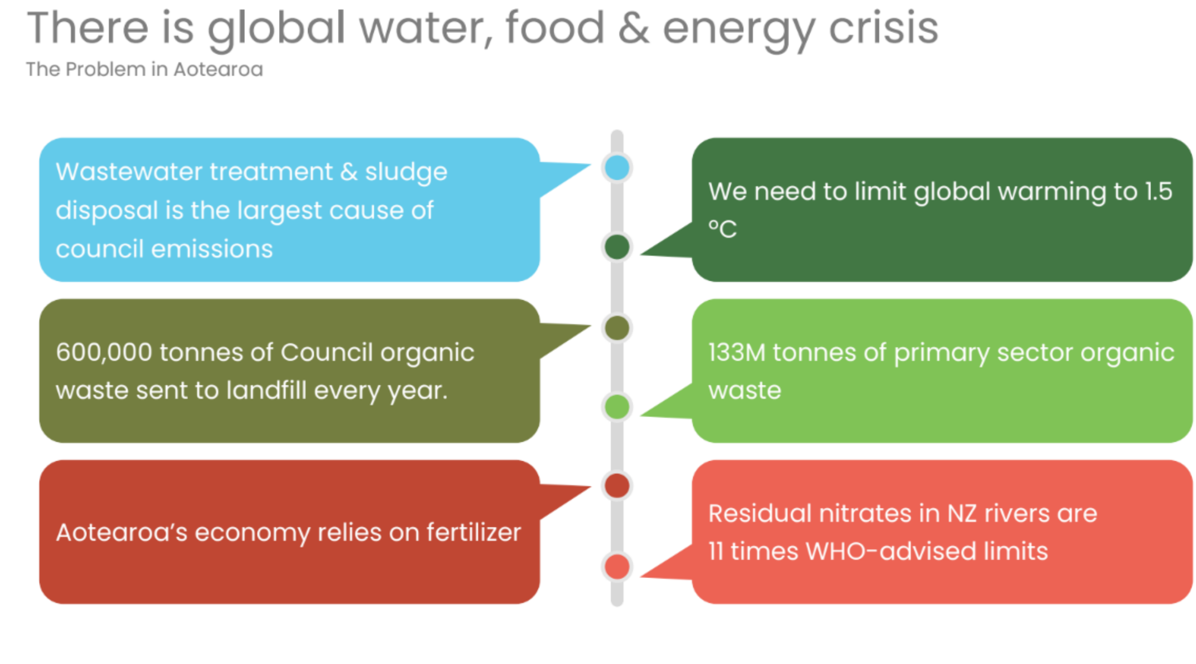

Figure 1: The Food/Waste/Water Nexus for Aotearoa/New Zealand

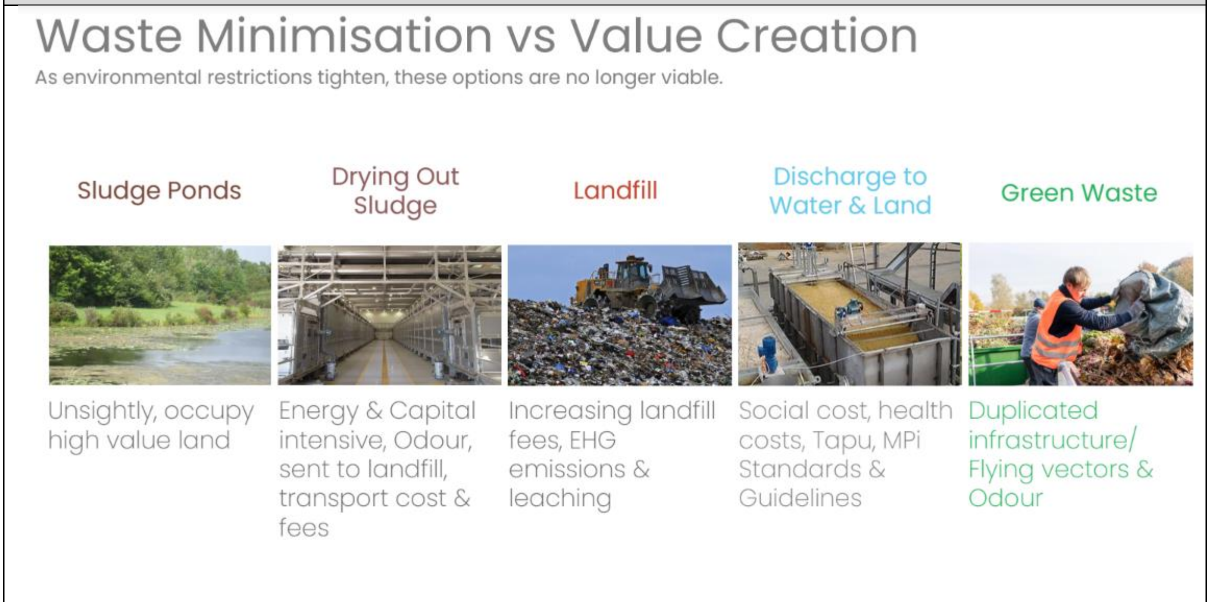

Figure 2: Conventional Solid and Organic Waste Management Practices

OUR PROPOSAL

By consolidating all organic wastes management at a city/regional level, utilising an intelligent, integrated wastes treatment plant (iIWTP), would bring several advantages and benefits to the wastes contributors (see Figure 3). Such plants would process all organics, including WWTP sludge, primary industry sludge, green waste, food waste etc, with these mixed waste streams allowing for optimising C:N ratio of the input feedstock, a key process parameter for optimising the breakdown of the input streams into bioenergy and valuable digestate. The digestate produced from the process is stable, nutrient dense and pathogen free, with potential applications in agriculture, displacing chemically based fertilisers.

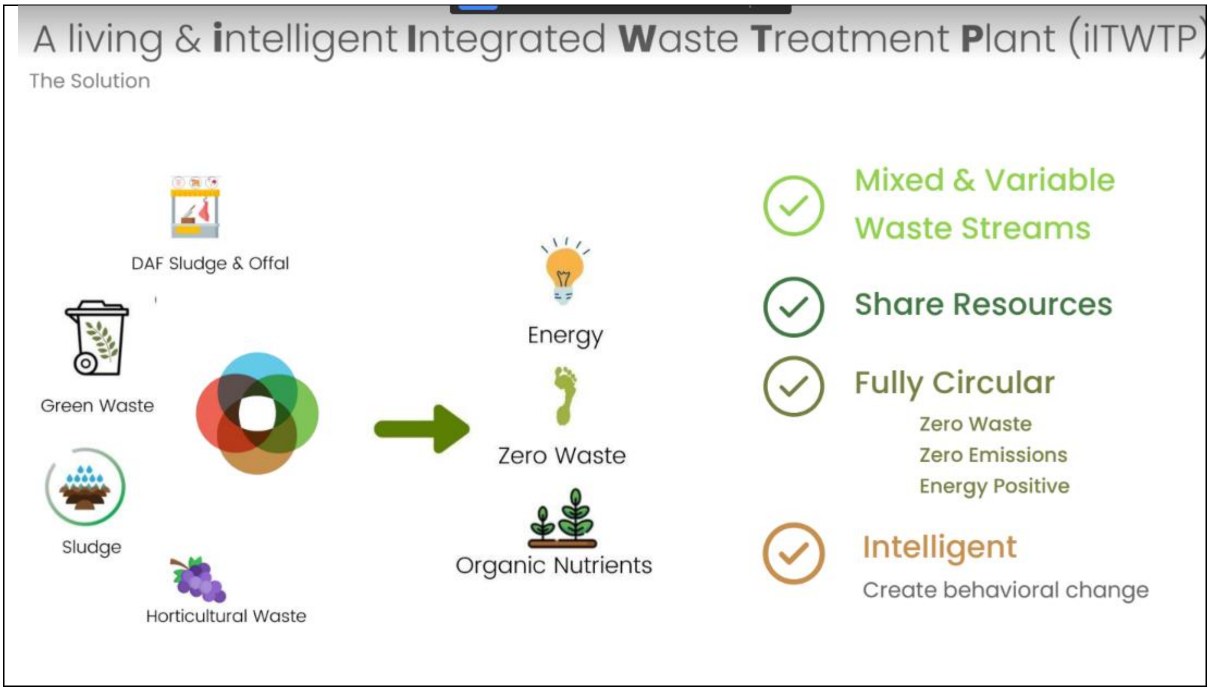

Figure 3: Organic Wastes Consolidation for Combined Treatment

None of the processes in the liquid and solids streams are novel, in fact many of them such as wastes sorting, solids homogenization, thermal-hydrolysis (THP), anaerobic digestion, thickening, dewatering are commonplace in wastewater treatment plants around the world and in Aotearoa/New Zealand. It is the holistic approach, the multiple organic wastes inputs, and the scaling-up of the solids management system that is novel.

By co-locating the iIWTP next to a WWTP, the amount of land required for waste management is minimised and the bioenergy recovered can offset the energy needs of the WWTP, which is running continuously. Because the iIWTP is importing high-strength organic wastes, as well as wastewater sludges, it is most likely to produce bioenergy in excess of that needed by the WTTP.

This is evidenced by plants in the USA such as the EBMUD Wastewater Resource Recovery Facility (WRRF) in Oakland California (Figure 4) and Gresham WRRF in Oregon (Figure 5), both of which exemplify the iIWTP concept. These are just two examples of facilities in the USA which have embarked on their own "resource recovery" or circular economy journeys, from which we in Aotearoa/New Zealand can learn much.

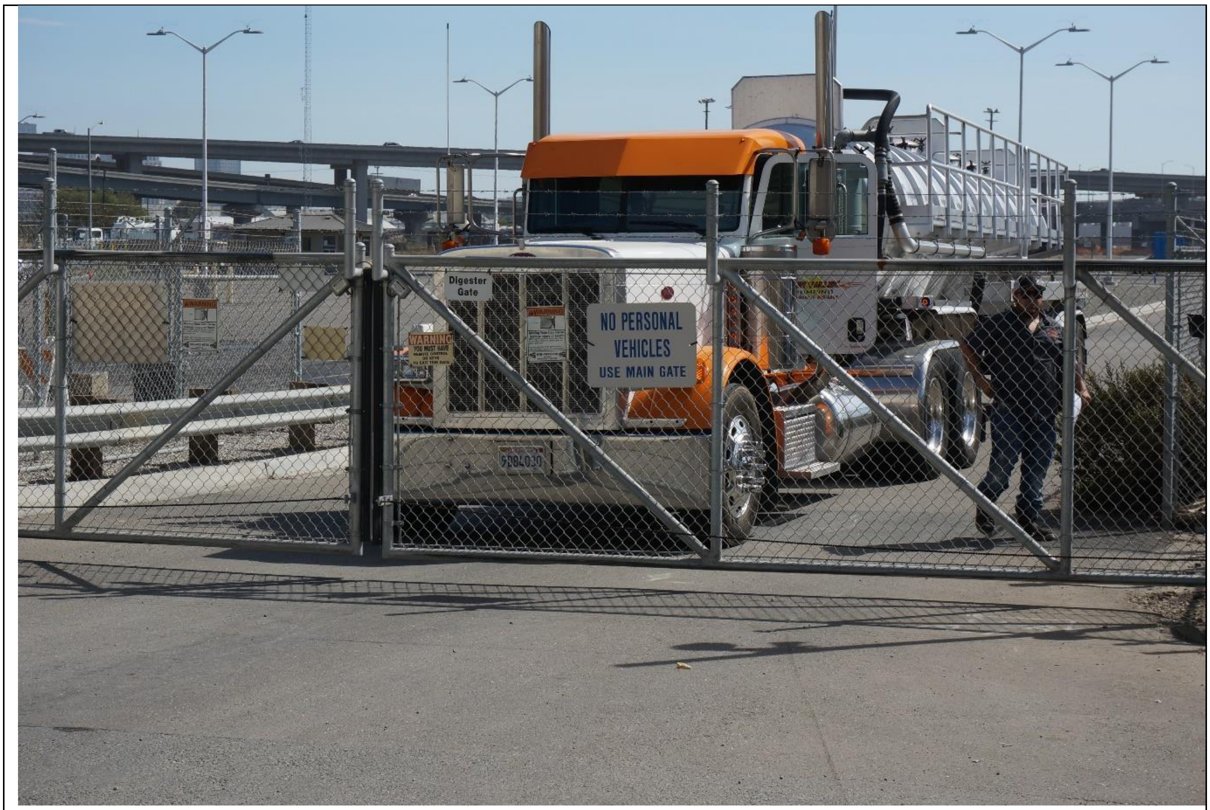

Figure 4: EBMUD WRRF, Oakland, California – Trucking in Winery Wastes for Enhanced Co-Digestion with Municipal Sludges and Net Energy Export to local businesses

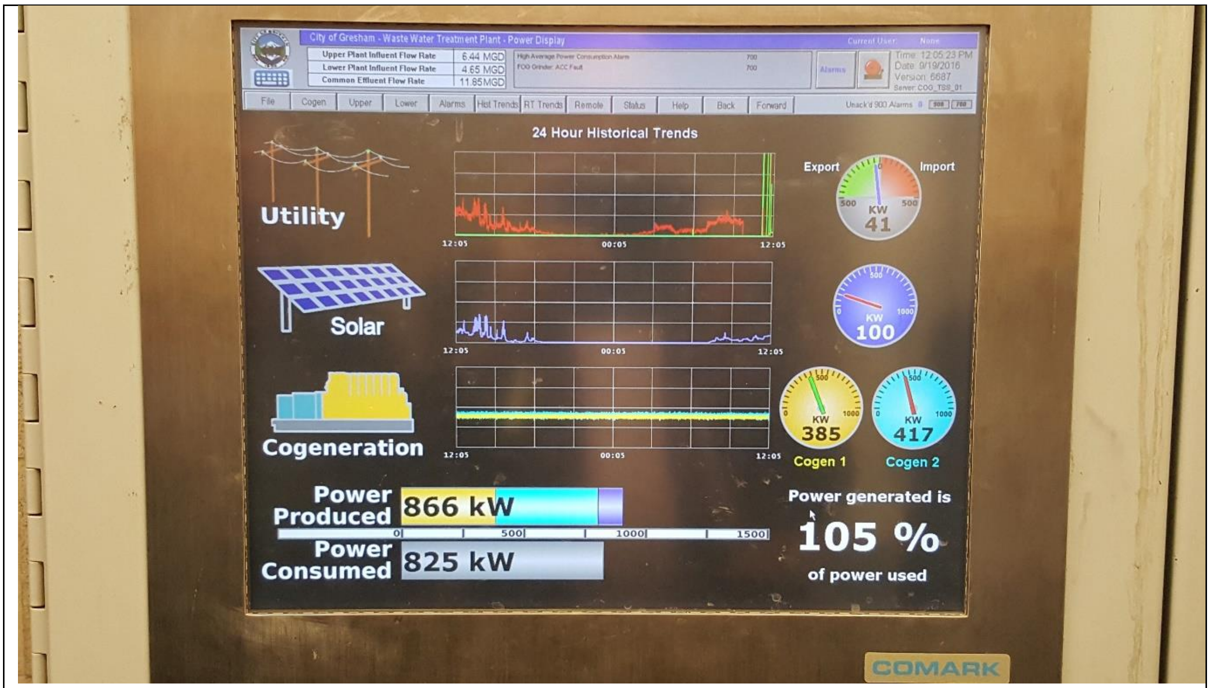

Figure 5: Gresham WRRF, Oregon – High-Strength industrial wastes imported for Increased Biogas production and achieving an Energy Neutral Plan (more power produced than consumed)

BENEFITS OF THE IIWTP APPROACH

BIOENERGY

Surplus "green energy" (biogas or biomethane) can be exported to local industries, offsetting their use of fossil fuels, hence reducing their emissions liability. The energy recovered can qualify for an Energy Allocation Factor, or EAF under our ETS mechanism. This system would reduce the costs and liabilities for Council and primary industry significantly, and the Default Emission Factor (or DEF) of the given waste stream is avoided.

A recent joint study (Ref 1.) estimated the energy value which would be extracted from a wide range of organic wastes in both the public and private (industrial) sectors (See Table 1). More work should be prioritized in this area to see how quickly and with what investment this extraction of bioenergy could be realized.

Energy Potential of NZ Waste

Category	Feedstock Type	Biogas Potential (PJ/year)
Municipal Waste	Municipal Wastewater solids	0.6 to 0.9
	Source-Segregated Food Waste	1.5
Industrial Wastewater*	Dairy	1.1 to 1.9
	Meat	0.7
	Pulp and Paper	0.6
	Dairy Manure	6.8
Agricultural Waste	Pig Manure	0.4
	Poultry Manure	1.3
	Crop Residue	1.4 to 2.9
	Total	12.6 to 16.9 PJ
Landfill Gas	Existing Landfill Gas Capture	3
	Total	15.6 to 19.9 PJ

These figures are based on a set of assumptions around achievable collection of different feedstocks in a New Zealand context, typical conversion rates and technical limitations on processing different waste streams.

Source: EECA, FirstGas, Beca & Fonterra

Table 1 – Potential Bioenergy from NZ Wastestreams (PJ/Year)

NATURAL FERTILISER

We rely heavily on locally manufactured and imported fertilisers to support our primary industries and pastorally based economy and have done so ever since Aotearoa/New Zealand was colonized in the mid-1880s. Fertiliser use must be carefully balanced and there are well-developed management practices regarding time of use, application rates, and fertilizer balance. Approximate annual tonnages of Nitrogen, Phosphorus, Potassium and Lime applied to agricultural lands are summarised in Table 2 (for 2018-19 Ref 2.).

These fertilisers are essential for food production, but our current practice is – in general – not to recycle the very high nutrient and organic value of food wastes and food processing wastes back onto the land. By processing more of the organic wastes from food, dairy and meat processing plants through an iIWTP, and generating dried or dewatered biosolids as reusable fertilisers as well as recycling the digestate, we could reduce the use of conventional fertilisers and have a more "natural" primary processing sector with a lower carbon footprint.

Fertiliser	Tonnage p.a.	Main Purpose
Nitrogen	450,000	Stimulates grass growth for dairying and cropping
Phosphorus	150,000	NZ soils naturally low in Phosphorus and Sulphur
Potassium	130,000	For nutrient balance and maintaining soil productivity
Lime	1,100,000	Soil pH balance

Table 2: Fertiliser Use in Agriculture on New Zealand (2018/19)

There are a large number of wastewater plants and utilities around the world, and one in Aotearoa, which are producing highly-processed biosolids products which are commercially viable and are sold on the open market. Other plants in Aotearoa could emulate through developing their own iIWTPs and developing their own “branded” products. Examples from USA (Milwaukee Milorganite and DC Water BLOOM) and New Plymouth City (BioBoost) are shown in Figures 6, 7 and 8.

Milorganite is a fertilizer made in **Milwaukee, Wisc., from dried microbes that were used to treat and digest sewage sludge**.Milorganite NPK composition is 5 percent nitrogen, 2 percent phosphorus and.32 percent potassium.Milorganite is made up of 85 percent organic material and can be used as a mostly organic lawn fertilizer.Instead of a quick, chemical boost, microbes in the soil digest the nutrients in Milorganite and deliver them to plants over a period of about 10 weeks.Milorganite relies on soil microbes to breakdown the fertilizer for the plants.High temperatures, drought and rainfall do not prevent Milorganite application..

Figure 6: “Milorganite” from Milwaukee Metropolitan Sewage District, USA

Figure 7: BLOOM – DC Water, Washington - THP/Digested dewatered soil substitute

Figure 8: "BioBoost" – New Plymouth City - dried biosolids pellets

REDUCED LANDFILL UTILISATION, LEACHATES AND LFG EMISSIONS

By removing the majority of our wastewater biosolids (municipal and industrial) and other organic wastes from our landfills and processing them through a resource recovery facility such as an iIWTP we could significantly reduce the burden on our landfills across Aotearoa/New Zealand. The primary purpose of landfills would then be for the disposal of inorganic, non-recyclable and problematic wastes, which are much less likely to break down and produce landfill gases and difficult to treat leachates.

CONCLUSIONS

For our country to turn a corner and become both carbon zero and more innovative and responsible in the manner in which we manage our many organic waste streams, we must make a paradigm shift in current practices for waste and wastewater management. The processes within an iIWTP are not novel, and are well-proven, but the proposed approach of introducing scale; multiple, carefully chosen organic feedstocks; and a collaborative approach amongst agricultural producers, food processors, and Councils is innovative and requires a willingness to change old practices and embrace a new circular economic paradigm.

ACKNOWLEDGEMENTS

The ideas in and content of this paper are primarily those of the authors and do not necessarily reflect the policies of their respective organisations, although both Beca and Alimentary Systems are actively pursuing opportunities for resource recovery, bioenergy/biofuels and circular economy demonstration projects in Aotearoa/New Zealand and Australia.

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