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THE CONUNDRUM OF REALISING FERTILISER BENEFITS OF WASTEWATER FOR GREATER SUSTAINABILITY – OPPORTUNITY VS REALITY

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ABSTRACT

Land application of nutrients in municipal effluent (ME) and farm dairy effluent (FDE) have the potential to support the New Zealand agricultural industry by reducing reliance on fertiliser, contributing to removing nutrients from waterways and sustainably recycling nutrients. However, these positives have to be weighed against perceived negatives, including: “not in my back yard”, “it smells”, “it contaminates groundwater”, “it carries terrible chemicals” and “the products can’t be consumed”. It’s not easy being green!

The discharge of FDE has changed from approximately 100 % to water to almost 100 % to land in 20 years. This change has come from better irrigation practices and greater awareness of water quality impacts. ME has traditionally been discharged to waterways, but like FDE, has the potential to benefit productive land and contribute to improved waterway quality. However, the uptake of ME to land has not been as successful, with less than 24 % currently applied to land.

Nationally New Zealand municipal wastewater treatment plants generate approximately 12,000 tonnes of N and 2,000 tonnes of P annually. This compares to 41,000 tonnes N and 6,500 tonnes P from dairy farms. The ME volume is 470 M m^3 annually compared to 93 M m^3 of FDE. At a N loading rate of 150 kg N/ha, this equates to 80,000 ha of land needed for ME and 270,000 ha for FDE. Applying an annual application of 400 mm irrigation would require 120,000 ha and 23,000 ha for ME and FDE respectively.

Environmental lobby groups and some government departments support land application of ME. But limitations have emerged with industry bodies (potential negative impact on market access) and other government departments (generation of contaminated sites).

Resource vs water quality vs adverse perception. What a conundrum! This paper identifies the opportunity of two key wastewater resources and the disparity, with reasons, between their use.

KEY WORDS

Land Treatment, Municipal Effluent, Farm Dairy Effluent, Nutrient Resource, Irrigation.

INTRODUCTION

Land application of nutrients in municipal effluent (ME) and farm dairy effluent (FDE) have the potential to support the New Zealand agricultural industry by reducing reliance on fertiliser, contributing to removing nutrients from waterways and sustainably recycling nutrients. The discharge of FDE has changed from approximately 100 % to water to almost 100 % to land in 20 years. Municipal effluent to land has not followed this same level of application with less than 24 % currently applied to land.

A preliminary survey of wastewater treatment plants (WWTP) in New Zealand was carried out to provide an introduction to the current types of discharge being utilised and the volumes of wastewater from each plant. This data was compared to FDE regarding the nutrient application to land and the potential for large scale irrigation.

The positives for wastewater application to land have to be weighed against perceived negatives and the practicality of implementing irrigation systems for wastewater. Environmental lobby groups and some government departments support land application of ME. But limitations have emerged with industry bodies (potential negative impact on market access) and other government departments (generation of contaminated sites). This paper identifies the opportunity of two key wastewater resources and the disparity, with reasons, between their uses.

METHODS

New Zealand Wastewater Production Data Collection

Part of this discussion includes outputs from an introductory survey that identified the following data about New Zealand's ME:

- Number of WWTPs;
- Populations serviced by WWTPs;
- Volume of discharges; and
- Type of discharges.

The data was collected by direct contact with councils and from the most up to date data from council websites. Access to the Water NZ spreadsheet (WNZ 2012) of similar data was also referenced. Note that the total population of NZ is different from that contributing to ME. 7% of the NZ population was identified not contributing, and therefore was considered to be using independent on-site wastewater systems.

This data was categorised as follows:

- Nationally;
- Regionally; and
- Per discharge type.

General categories for the type of discharge used were created to compare the data. Some detail of a WWTP plant operation may be lost but does not detract from the purpose of comparison. The following categories were used to distinguish the different approaches used for discharges.

- Water Discharges
    - Ocean
    - River in-stream
    - River bank

- Land Discharges
    - Irrigated to trees
    - Irrigated to dairy
    - Irrigated for cut and carry
    - Irrigated to grazed pasture
    - High Rate
    - Unknown land discharges
- Unknown Discharges

Two main attributes are supplied from the use of wastewater: nitrogen and irrigation. Each of these attributes is discussed regarding their potential contribution to NZ farming.

The data used for FDE was based on NZ Dairy (2014) statistics that identified the number of cows per region.

Assumptions

The data must be interpreted in general terms because of the following assumptions:

- The 'urban population' (Statistics NZ estimated 2015) are the contributing number of people to a WWTP;
- 300 L of water used/person/day; and
- 70L/cow/day.

The urban populations were added on the assumption they represented the population contributing to each WWTP.

There were over 100 WWTPs where the population was not easily identified. It was assumed that these plants service populations below 100. This assumption was based on the remaining population in New Zealand not accounted for from statistics used minus the 7% population using separate individual on-site wastewater systems. It is known that some WWTPs have very low populations served, such as the Waiotira plant in Northland that is contributed to by 7 households. A nominal figure of 50 persons contributing to these WWTPs was given to complete the data set.

A flow of 300 L/person/day has been allocated to calculate the wastewater discharge from each WWTP. The amount is based on approximately 200 L/person per day from household use. The additional 100 L allocates a nominal value to account for infiltration and inflow through the reticulation network and possible industrial or commercial inputs that may enter a municipal plant. This data is summarised in Table 1.

A flow of 70 L/cow/day is the average statistic often allocated per dairy cow, such as for the Pond Storage Calculator. Actual data varies widely as defined by Heubeck et al. (2014), where effluent ranged from 40 L/cow/day to 87 L/cow/day. For comparative purposes and the generalised presentation of this paper, the accepted average is used. This data is summarised in Table 1.

RESULTS

Nitrogen and phosphorus from wastewater

Nationally New Zealand municipal wastewater treatment plants generate approximately 12,000 tonnes of N and 2,000 tonnes of P annually. This compares to 41,000 tonnes N and

6,500 tonnes P from dairy farms. At a N loading rate of 150 kg N/ha, this equates to 80,000 ha of land needed for ME, and 270,000 ha for FDE.

This data is presented in Table 2 and equates this generation of nutrients into fertiliser equivalents and monetary values. There is not a great financial gain from the phosphorus additions but ME could offer $14 M of nitrogen fertiliser. It is assumed from the statistics that close to $51 M is gained from dairy effluent that is now irrigated to pasture.

Irrigation from Wastewater

ME produces approximately 470 M m^3/year compared to 93 M m^3/year from FDE. Applying an annual application of 400 mm irrigation would require 120,000 ha and 23,000 ha for ME and FDE respectively. Although this volume of irrigation water can only accommodate 11% of the existing 1.7M ha.s of dairy land (Dairy NZ 2014) it could increase the current FDE irrigated area five-fold.

Table 1: NZ population and estimated effluent production

	Effluent/ head L/P/Day	Effluent/ head L/P/year	NZ Population	%DM		NZ Production m^3/year
				N (gN/L)	P (gP/L)	
Municipal Effluent[1]	*300*	*109500*	*4,651,965*			*509390168*
Municipal Effluent [2]	300	109500	4,300,180	0.025	0.005	470869710
Dairy Cow effluent	70	18900	4,922,806	0.44	0.07	93041033
Dairy Cow solids		0	4,922,806	4.5	0.72	0

1 based on NZ known population
2 calculated from WWTP surveyed contributing population

Table 2: Calculated nutrient and returns from effluent

	Nitrogen tonnes/ year	Urea tonnes/ year	Urea Cost at $575/tonne	Phosphorus tonnes/ year	Super phosphate tonnes/ year	Super Cost at $330/tonne
Municipal Effluent[1]	*12,735*	*27,684*	*$ 15,918,443*	*2,547*	*28299*	*$ 9,339*
Municipal Effluent [2]	11,788	25,626	$ 14,735,039	2,358	26196	$ 8,645
Dairy Cow effluent	40,938	88,996	$ 51,172,568	6,513	72365	$ 23,881
Dairy Cow solids	0	0	$ -	0	0	$ -

1 based on NZ known population
2 calculated from WWTP surveyed contributing population

Fig. 1 graphically presents the availability of wastewater per region. The distribution of ME throughout the country is largely weighted in Auckland and Waikato producing 46% of the national volume. Most other regions produce 5% or less. Whereas FDE is obviously rurally based not urban based and more evenly distributed throughout the country. Waikato and Taranaki produce 33% of FDE and Canterbury and Southland produce 29%.

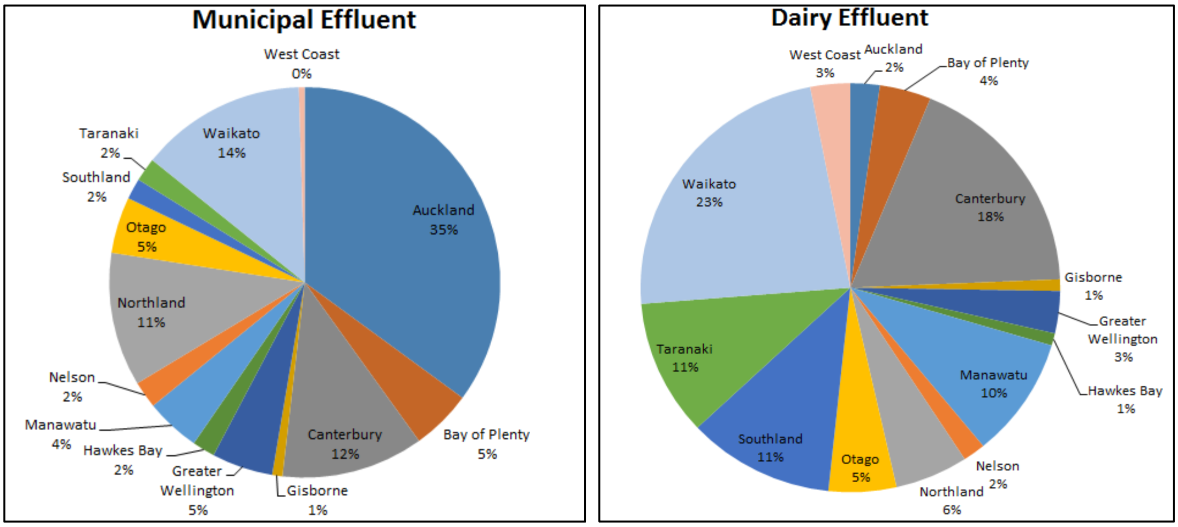

Fig.1: Distribution of effluent per region, NZ

Campaign For Clean Waterways

FDE to land campaign

Farm dairy effluent could provide a template to promote the use of other organic waste products including ME. The use of FDE has changed from being discharged to waterways to the largest dairy region in New Zealand having around 90% being applied to land (Waikato Regional Council, 2015). Regional Councils began promoting this change in the mid-1990s after campaign groups and legislation pushed to clean up waterways.

The number of contributing factors that promoted the change in FDE management came from many quarters. The clean waterways campaign focussed on dairying, encouraged by such phrases as ‘dirty dairying’. Fonterra and Councils are following up with conditions and education around farming practices to realise the change. The extent of interest was evident with the responses from the Parliamentary Commissioner for the Environment Report on Water Quality (2013). Government parties, Federated Farmers, Fish & Game, Fonterra and research groups such as AgResearch have all provided perspectives.

The practical implementation of applying FDE to land has several advantages:

- The dairy farm gains from the nutrients and water applied to pasture.
- The environmental benefits could be promoted for marketing purposes.
- The FDE production is in close proximity to where it is irrigated and the inputs into the waste quality is well understood because it is controlled by the farm production system it comes from.

ME to land campaign

The use of ME on land has a similar profile to the FDE campaign. It has a tradition of being discharged to and contaminating waterways, but has the potential to support sustainable recycling of nutrients and contributing to the New Zealand agricultural industry. However, the campaign behind the use of ME on land has not been quite the same.

ME application to land has no lobby groups or campaigns to drive change. The regional council role is to improve environmental conditions thus encouraging improvements and upgrades to ME is part of that programme. If something goes wrong, or if an upgrade process occurs so some groups become involved, they are typically reactive processes not proactive as was seen in the FDE to land campaign.

The practical implementation of ME has a few more complications compared to FDE. The inputs to ME are varied and not well understood by the general public. The location of WWTPs can often be locked into an urban environment, a long way from potential land for irrigation. The majority of wastewater comes from a small number of WWTPs with most WWTPs (by number) servicing small populations below 35,000 which generate small volumes.

ME Production

Eighteen out of the 330 WWTPs identified in New Zealand produce 83% of the national total of ME. These 18 plants service the populations above 35,000 people. Fig. 2 represents the number of plants that service the populations compared to the volume. 400 M m^3 per year come from the 18 WWTPs by comparison to 79 M m^3/year from the 312 plants servicing small populations below 35,000. Mangere being the largest plant, services 1.2 M people with a volume of 1.3×10^8 m^3/year.

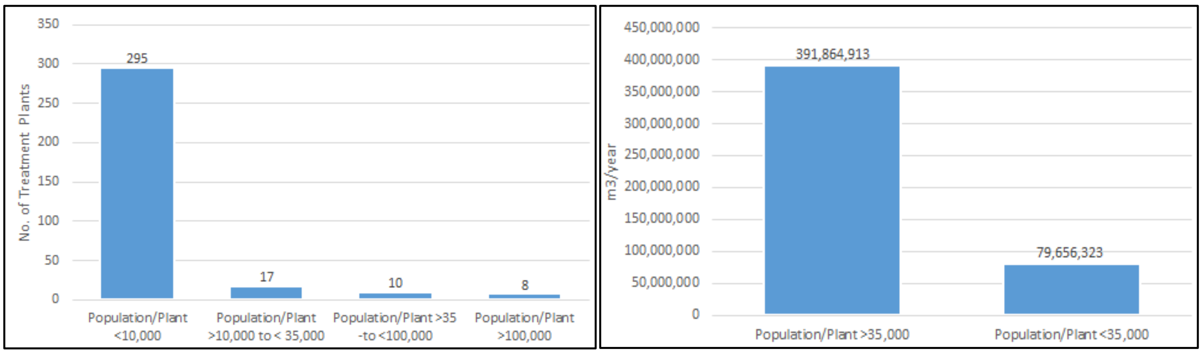

Fig. 2: Number of WWTPs servicing populations compared to Volume of wastewater from populations above and below 35,000

ME is discharged to either land or water, or may have a combined system where the discharge is to land and only discharged to water when high flows occur in the waterway. This combined approach significantly reduces the effects on the environment and avoids discharge into waterways at the most vulnerable time of the year when low flows occur.

Seventy eight percent of the discharge from the 18 large WWTPs goes to water. There are 3 of these WWTPs discharging 22% of the volume to land as follows:

- Whangarei (pop. 47,500) discharging to land and water;
- Taupo (pop. 23,700) discharged to land; and
- Rotorua (pop. 68,000) discharging to land.

The volume of wastewater discharged to water (58%) is still high from smaller WWTPs servicing populations less than 35,000. However, this volume comes from 129 WWTPs that discharge to land or use a combined system. Fig. 3 shows the total 330 WWTPs and the type of discharges used. Fig. 4 shows the volume of wastewater from the 330 WWTPs, 11% (54 M m^3) of the volume is discharged to land; 13% (59 M m^3) is used in a combined land and water system. 75% (352 M m^3) of the volume is discharged direct to surface water with an ocean or river outfall.

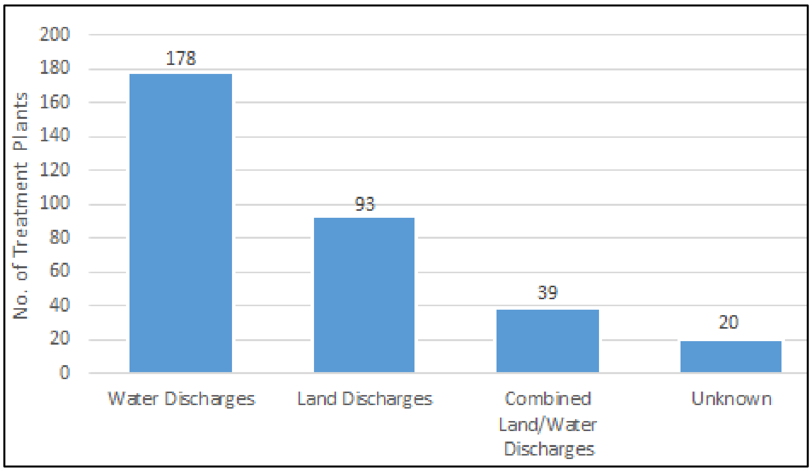

Fig 3: Number of WWTPs discharging to land, water or a combination

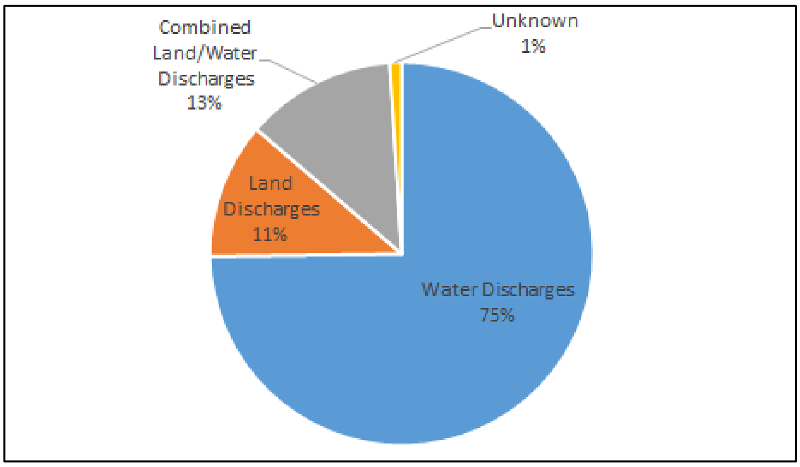

Fig.4: NZ Wide Treatment Plant Discharges

Each WWTP has a unique design to manage the discharge. The land or the combined discharge systems were categorised to represent the designs installed as identified above.

The criteria that have to be considered within the design process can be complex when discharge and distribution of supply throughout the year is considered. The quality of the discharge, the location of suitable land and the quality of the soil and its ability to receive wastewater must be included.

Fig. 5 indicates the types of systems used for land based discharges. The discharges to land are mostly allocated as high rate. High rate discharges include a variety of approaches but mostly wetland systems or soakage trenches. Eleven constructed wetland discharge systems were identified in the Northland region. The 'unknown' category in Fig. 5 includes applications to land but the method of land use was not identified, although it does include discharges to one park from Denehirst WWTP and one golf course from Omaha WWTP. This highlights the need for an additional category for recreational use. The remaining categories are self-explanatory. There are no discharges applied to pasture used for dairy production. This is likely to be caused by a rule set by Fonterra that requests wastewater must be treated to California Health Law Title 22 standards before it can be used.

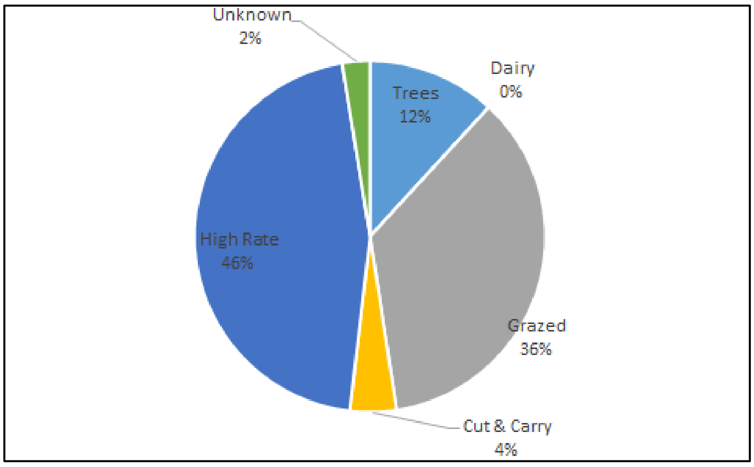

Fig. 5: NZ Wide Land Discharge Methods

PERCEPTIONS VERSUS REALITY OF WASTEWATER

Some of the difficulties that have emerged with the reality of applying wastewater to land are described below:

1. The process requires skills from engineers to design specialised irrigation systems because high rate irrigation system have the potential to adversely impact on groundwater systems.
2. Soil scientists need to assess the capability of the land to assimilate the water and ensure appropriate hydraulic loading rates are used.
3. Archaeological and ecological assessments ensure the area of application is not intruding upon any history that should be protected.
4. Cultural Impacts Assessments are typically required and may place additional restriction on land application/design options.
5. Community demands may include that the wastewater will not cause odours or drain into their properties or groundwater; plus there is often the additional demand that 100% of wastewater is taken out of the waterways.
6. The current regulatory environment provides for an evaluations of all the potentially affected parties and environmental effects, and recommends monitoring and in some cases management restrictions.
7. Due to the varying source and contributors of ME within a community, there is both an actual and perceived risk of hazards with in the wastewater, and as a result industry typically take precautions when accepting produce. Fonterra does not accept milk from sites without the wastewater treated to the California Health Law Title 22 standards.

The potential issues described above differ from FDE land applications, thus application of ME to land is not an easy process despite the nutrient and economic benefits to the agricultural industry and the environmental benefits to the waterways.

CONCLUSIONS

Over the last twenty years discharges of FDE has largely been removed from waterways and close to 100% is now applied to land. This has resulted in positive impacts on water quality and improvements in nutrient management systems on farms. On the other hand, only 24% of ME is either applied to land or discharged via a combined land and water system - Why are we not seeing the same change for municipal systems?

The reality is that the drivers are different for FDE and ME. Land application of FDE has been a result of a pro-active campaign typically focused on improving surface water quality and involving many parties.

Conversely, removal of ME from waterways has been much more reactive. Technically FDE is straight forward to apply to land because of the known on-farm inputs and the ability for it to be managed within the farm it is generated. For ME, unique discharge designs are required to suit each individual WWTP's criteria. The land must be suitable to receive the wastewater and close enough to make reticulation economically viable. A critical aspect is managing peak winter flows, which occur at a time when irrigation and nutrient demand is minimal.

Wastewater could supply 80,000 ha of land with nitrogen each year and 120,000 ha could be irrigated at typical irrigation rates.

Currently 132 WWTPs out of the 330 identified in New Zealand apply ME to land in some way. Despite the high number, only a few (<4%) use the water for productive purposes. The majority of wastewater comes from a few large plants that are the main contributors to the 75% of New Zealand's ME discharged to water.

Social, political and technical challenges require addressing to make land application of ME viable. Socially the demand exists for clean waterways but actual application is not received willingly with in communities. Markets suppliers demand certain quality standards of products grown to provide assurances to consumers. The high winter flow rate requires innovative solutions to allow winter flows to be captures or the use of alternative solutions.

Removal of ME from waterways is likely to benefit New Zealand socially, environmentally and economically. The reality is ME land application has far more technical and social hurdles than the FDE campaign, but this is a campaign that generators of ME need to consider.

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