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RANGAHAU AHUMĀRA KAI

Quantifying the supply of plant-available nitrogen from dairy effluents to grow crops

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Introduction

Intensive dairy farming in New Zealand generates large volumes of effluent which may be used as a nitrogen (N) source for forage and arable crops. To optimise the use of effluent farmers must understand how effluent characteristics affect N supply patterns, including both the quantum and rate of release.

Objective

To investigate the N supplying power of dairy effluents and link this to effluent characteristics measured at the time of application.

Methodology

- Five slurry and six solid effluents were collected from commercial dairy farms in the Waikato region of New Zealand and analysed for a range of measures relating to N supply.
- An open incubation assay was established in a single, low N cropping soil (0.36 % total N). Effluent was applied at a target application rate of 100 kg N/ha and the amended soil incubated in 500 ml filtration units at 20°C and 90% of field capacity for 182 days.
- Units were leached 15 times during the assay and drainage water characterised for inorganic and organic N components. Estimates of N supply were calculated, corrected for background N supply from a non-effluent control, and relationships with a wide range of effluent characteristics assessed.

Results

- Effluent characteristics varied considerably, even within the same effluent type (i.e. slurries or solids) (Figure 1).
- The pattern and magnitude of N supply varied considerably, both within and across effluent types (Figure 2). However on average and after 182 days, more N was released from slurry (36% of total N applied, range of 4–74%) than from solid effluents (16% of total N applied, range of 2–34%).
- Net N supply values (calculated to quantify the proportion of N mineralised from the applied organic pool after 182 days) ranged from −25.5 to 36.7% and −8.6 to 28.3% for slurry and solid effluents respectively. Values were positive for seven of the 11 treatments (indicating a net N mineralisation effect) and negative for the remaining four (indicating a net N immobilisation effect).
- Strong positive correlations were found between water-soluble N and C components and the flush of N during the first 28 days of incubation and with final N supply after 182 days (Table 1).
- There were fewer correlations between effluent characteristics and the rate of N supply in the later stages of the assay (112–182 days) and no statistically significant correlations ($P < 0.05$) observed between effluent characteristics and the amount of N released from the applied organic N pool.

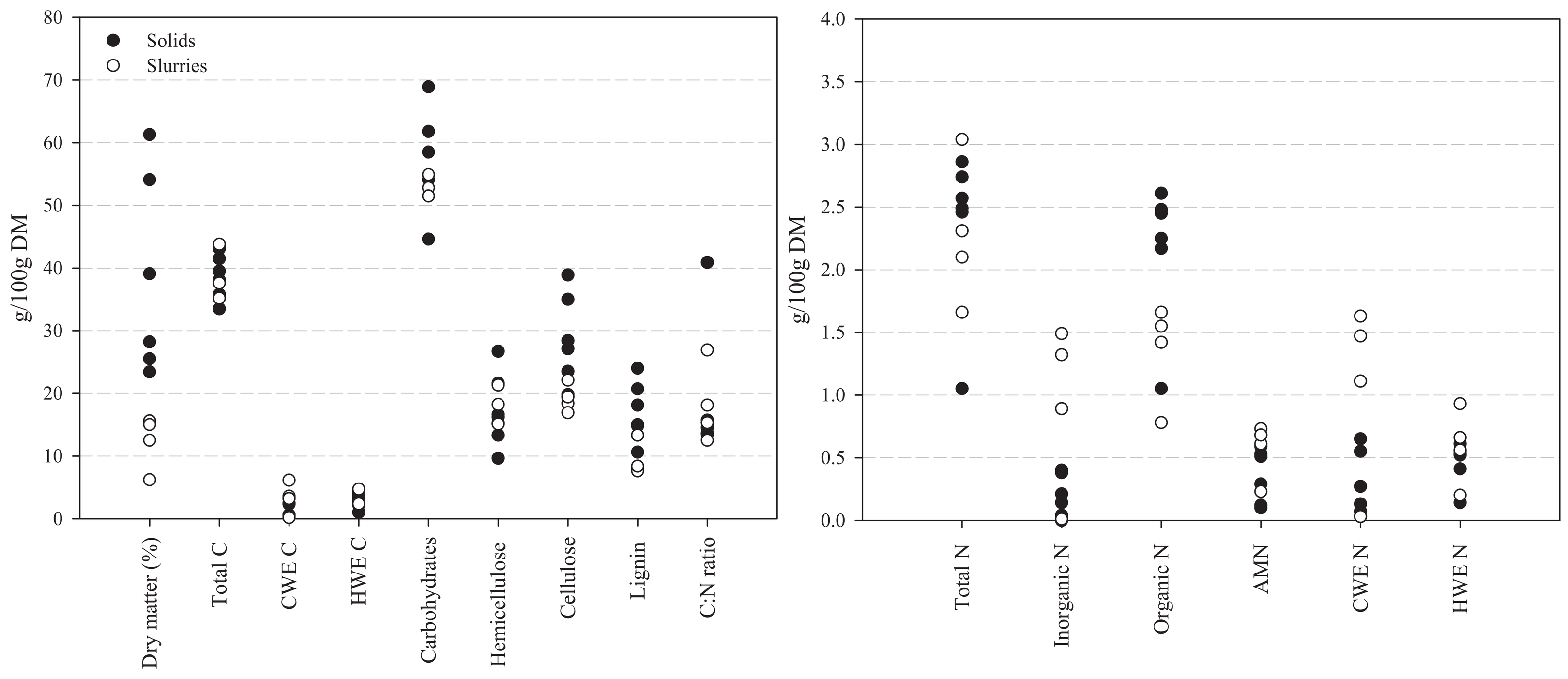

Figure 1: Summary of key carbon (C) and nitrogen (N) characteristics for the 11 dairy effluents (5 slurries and 6 solids) used in the assay. AMN = anaerobically mineralisable N, CWE = cold water extractable, HWE = hot water extractable.

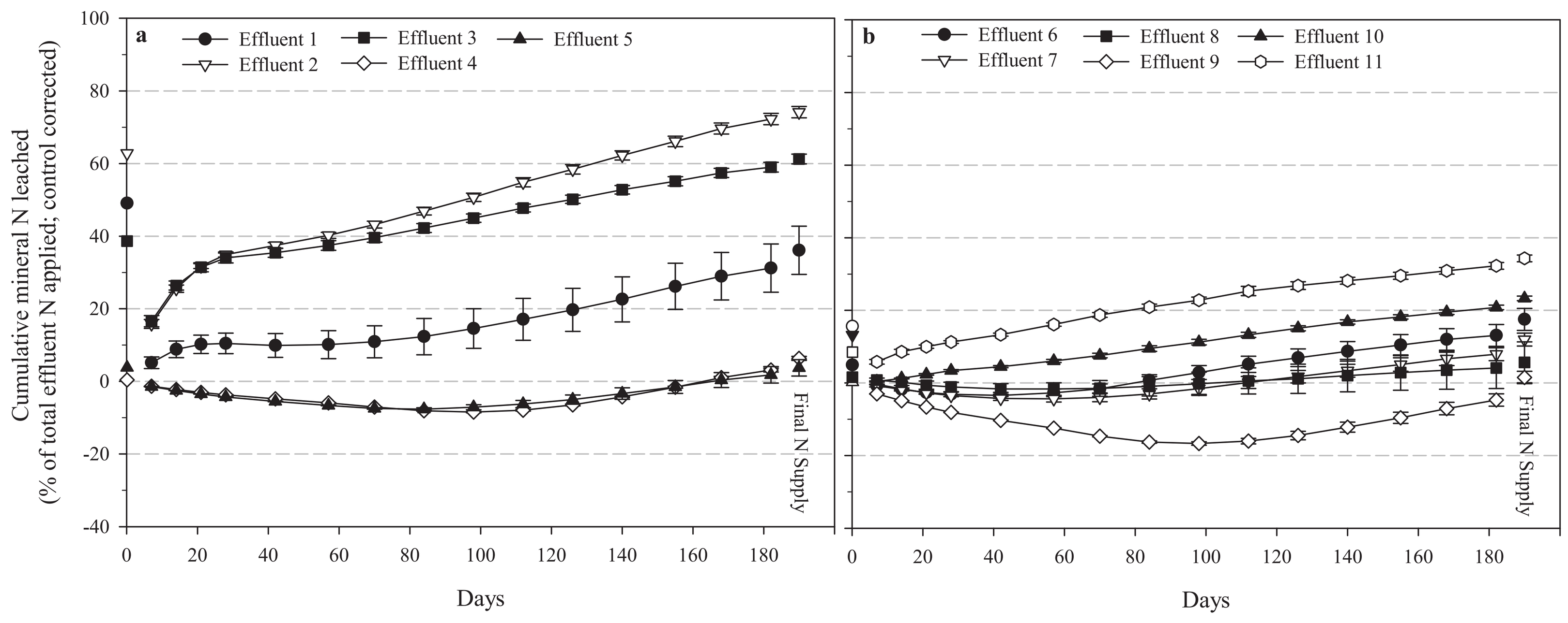

Figure 2: Cumulative inorganic N leached over a period of 182 days for a Horotiu silt loam amended with (a) 5 effluents classified as slurries and (b) 6 effluents classified as solids. Points at day 0 represent the amount of effluent N applied in an inorganic form. Final N supply represents the sum of cumulative inorganic N leached at 182 days and residual inorganic N in the soil (control corrected). Bars around each point represent the standard error of the mean.

Table 1: Correlation matrix showing the strength of linear relationships (r value) between effluent characteristics and patterns of supply (slope parameters) and magnitude of supply. Only statistically significant ($P < 0.05$, $n = 11$) r values are presented. Correlations of greater than 0.80 were considered to be strong (bold text) and those between 0.58 and 0.80 weak.

Effluent component applied (µg/g oven dry soil)	Slope 0-28 days[1]	Slope 112-182 days[2]	*Final N supply*	*Net N supply (% of organic N)*
Ammonium N	**0.87**	0.79	**0.88**	-
Inorganic N[3]	**0.91**	0.78	**0.91**	-
WS[4] inorganic N	**0.93**	0.79	**0.93**	-
WS organic N	0.70	-	0.66	-
WS organic C	**0.84**	0.74	**0.86**	-
HWE[5] N	0.76	-	0.75	-
HWE inorganic N	**0.85**	0.61	**0.82**	-
Inorganic N:total N[6]	**0.83**	**0.80**	**0.85**	-
WS inorganic N:total N[7]	0.69	-	0.71	-
HWE C:N[8]	-0.64	-	-0.65	-
HWE inorganic N:total N[9]	0.76	-	0.74	-

[1]Slope of mineralisation curves (Figure 1) between 0 and 28 days. [2]Slope of mineralisation curves (Figure 1) between 112 and 182 days. [3]Sum of nitrate-N and ammonium-N. [4]Water soluble. [5]Hot water extractable. [6]Ratio of inorganic N to total N. [7]Ratio of WS inorganic N to WS total N. [8]Ratio of HWE C to HWE N. [9]Ratio of HWE inorganic N to HWE extractable total N.

Example of a filtration unit used to incubate the effluent amended soil

Conclusions

- Effluent characteristics varied widely and had a strong effect on the quantum and rate of N supply following application to soil.
- Nitrogen supply in the first 28 days correlated strongly with expected effluent characteristics that largely described the inorganic N pool.
- Correlations between effluent characteristics and later supply patterns were less clear and work is ongoing to understand key relationships.

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