Effects of anaerobic digestion of organic manures on N turnover and N utilization

Sørensen, P.[a], Khan, A.R.[a], Møller, H.B.[b], Thomsen.I.K.[a]
[a] Aarhus University, Department of Agroecology, 8830 Tjele, Denmark
[b] Aarhus University, Department of Biosystems Engineering, 8830 Tjele, Denmark

1. Background & Objectives

Animal manures and plant-based manures are used for biogas production by anaerobic digestion (AD). After AD the concentration of ammonium-N in manure is increased and the concentration of decomposable C is decreased. Thus, the potential first year fertilizer value of the manure can be increased by the treatment. However, pH is also increased by AD thereby increasing the risk of ammonia losses. The objective of this paper was to compare N turnover in soil after application of digested and corresponding undigested manures, and to compare N fertilizer values of digested manures after direct injection or surface-banding in cereals.

2. Materials & Methods

Cattle and pig slurries, a dairy cattle feed mixture (mainly maize silage), cattle faeces (cow fed on the same diet) and plant-based green manures were digested in continuously fed pilot digesters at thermophilic conditions (47-53°C) as described by Møller et al. (2007). The average hydraulic retention time was about 20 days. Two experiments were carried out each involving selected digested and non-digested products. In the first experiment the net release of mineral N from digested and non-digested manures applied to soil was measured in a laboratory incubation study with a sandy loam soil incubated at 20°C. Soil mineral N was extracted with 1M KCl 4, 7, 14, 28, 84 and 119 days after manure application. In the second experiment, the mineral fertilizer replacement values of total N (MFRV) were measured in framed field plots on a loamy sandy soil where grain yields and N uptake were compared to plots receiving increasing amounts of mineral N fertilizer (Sørensen and Eriksen, 2009). The manures were surface-banded in spring in winter wheat simulating a trailing hose application (150 kg total N ha^{-1}) or applied in a band at 10 cm depth simulating a direct injection before sowing spring barley (80 kg total N ha^{-1}).

3. Results & Discussion

In the incubation experiment the proportion of total N on ammonium form increased after AD and more mineral N was released during decomposition in soil (Figure1). For slurry the increase in mineral N release was equivalent to about 10-25% of total slurry N. After AD of the cattle feed mixture the mineral N release in soil increased from about 20% of total N to about 80%, and AD of cattle faeces (from cattle fed the same diet) increased the mineral N release in soil from about 20% of total N to about 60% (Figure 1). In the field experiment the MFRV of the two injected cattle slurries applied to barley increased from 58% and 75% of total N to 69% and 82% with AD (Table 1). The MFRV of cattle slurry after surface-banding in winter wheat was significantly lower. The low availability after surface-banding was ascribed to high ammonia volatilization losses. The MFRV of injected pig slurry was high (89-91%) and similar with and without AD. After surface banding of pig slurry MFRV was 75% for untreated and 87% for digested pig slurry. Thus, the reduced fertilizer value after surface banding was most significant for the manures with the highest dry matter content as was expected due to lower infiltration in soil. The MFRV of digested plant-based manures was in the same range as digested cattle slurries, 73-77% after injection and only 43-57% after surface-banding of the manure.

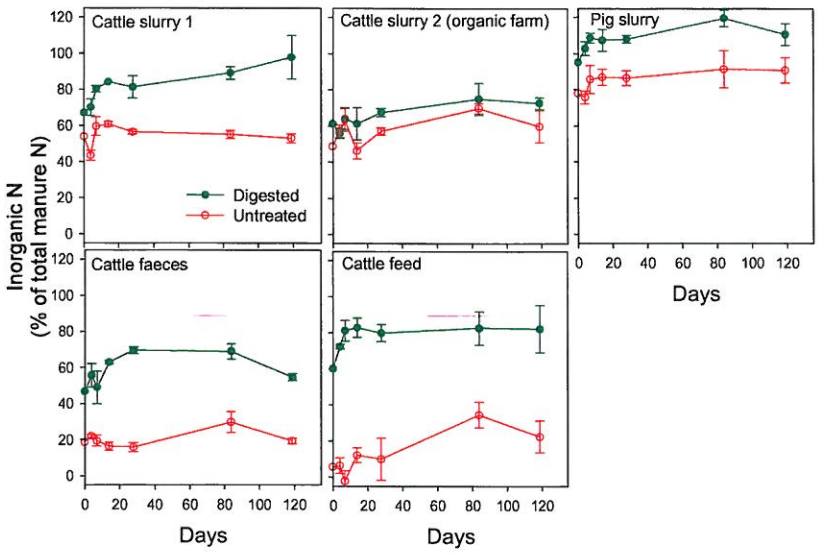

Figure 1. Incubation experiment: Net release of inorganic N in soil after application of digested and corresponding undigested manures. Bars indicate standard errors (n=3).

Table 1. Field experiment: Chemical composition of digestates and corresponding untreated manures. Mineral fertilizer replacement values (MFRV) were measured after injection in spring barley and surface-banding in winter wheat (n=4).

Manure	Total N	NH_4-N/total N	DM	pH	MFRV Spring barley	MFRV Winter wheat
	kg N/t	%	%		% of total N	% of total N
Cattle slurry 1	3.00	54	6.43	6.72	75	37
Cattle slurry 1 digestate	3.05	67	4.82	7.52	82	38
Cattle slurry 2 (organic farm)	2.92	49	6.95	8.17	58	30
Cattle slurry 2 digestate	2.94	61	4.65	8.09	69	49
Pig slurry	2.81	78	3.45	7.71	91	75
Pig slurry digestate	2.57	95	1.46	8.4	89	87
Clover-grass digestate	4.53	61	5.18	7.81	73	57
Lupine digestate	2.78	68	3.5	7.71	73	48
Triticale-vetch digestate	2.69	59	5.25	7.48	77	43
LSD (P<0.05)	-	-	-	-	14	19

4. Conclusion

After AD of pig and cattle slurry the increase in potential plant availability was equivalent to 10-25% of total manure N. AD of cattle faeces and a mixed cattle diet increased the net mineral N release in soil even more to about 60 and 80% of total N, respectively. The present results indicate that the plant availability of N of digested plant materials is similar to that of digested cattle slurry. After surface-banding of digested manures rich in fibers, such as cattle and plant-based manures, significant ammonia loss can be expected resulting in relatively poor utilization of manure N.

References

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