EFFECTS OF LANDSPREADING OF LARGE AMOUNTS OF LIVESTOCK EXCRETA ON CROP YIELD AND CROP AND WATER QUALITY

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INTRODUCTION

In some areas of the Netherlands the supply of minerals in livestock excreta exceeds crop requirements, with enrichment of the soil as a result. Mobile constituents (NO_3,Cl) are easily transported to a considerable depth down the soil profile and may reach the groundwater and the surface waters. Ions of lower mobility (PO_4, Cu, Zn) accumulate in the top soil and may pollute surface waters under conditions conducive to runoff.

In the long term, enrichment of the soil with minerals may have adverse effects on crop production and crop quality, such as lodging of cereals, decreases in starch (potatoes) and sugar content (sugar beets); other effects may adversely affect animal health, for example, increases in nitrate and potassium and decreases in calcium and magnesium concentrations in pasture herbage, increased copper concentrations, toxic to sheep, in the upper part of the sod following application of large amounts of pig slurry.

The aim of the research, in which five institutions*were participating, was to study short and long term effects of very large dressings of manure on crop production and crop quality, accumulation of minerals in the soil and possible pollution of soil and surface waters. Some pertinent data and conclusions are reported here.

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FORESTRY

Long term effects of livestock manure disposal in conifer stands are considered harmful because of the more rapid mineralisation of the raw humus and litter layer (containing a large part of the roots) and the resulting stimulation of root fungi like *Fomus annosus*. Hardwoods, like poplar, tolerate up to 400 - 500 kg N ha^{-1} for some years (100 tonnes pig slurry ha^{-1}). Much less is known about the tolerance of other hardwoods, but spacing also plays a part.

GRASSLAND

Research included disposal of slurry of housed cattle after dilution with ten volumes of water by sprinkler irrigation. Generally, undiluted slurry cannot be applied to pasture in summer because it scorches the grass and reduces intake of herbage by cattle. So disposal occurs in winter and early spring resulting in considerable nutrient losses (mainly nitrogen). Irrigation with diluted slurry in summer presents few problems, and serves the dual purpose of supplying water and nutrients.

ARABLE CROPS

Sugar beet

The effect of large amounts of pig slurry, containing about 3 kg (effective) N, 2 kg P_2O_5 and 4 kg K_2O $tonne^{-1}$ fresh material, on sugar content and juice quality is shown in Table 1.

Sugar content decreases and concentrations of monovalent cations (Na + K) and α-amino N increase, following increasing applications of pig slurry. The overall effect of these constituents is shown by the alkalinity coefficient (AC), a value of 1.8 being optimal. With ACs higher than 1.8 monovalent cations interfere with sugar crystallisation, so that more sugar remains in the molasses. With ACs lower than 1.8 extractable sugar mainly depends on α-amino N content, which decreases juice pH and stimulates sugar decomposition. If present in excessive amounts, sodium carbonate has to be added, resulting in a lower extractability.

TABLE 1.

EFFECT OF PIG SLURRY ON SUGAR CONTENT AND JUICE QUALITY OF SUGAR BEET.

	Sugar	Sugar yield	m val 100 g^{-1} sugar		AC*
	%	kg ha^{-1}	Na + K	α-amino N	
0 tonne pig slurry/ha	17.4	9 740	24.4	13.4	1.8
40 tonnes " " "	17.4	9 670	25.5	12.6	2.0
60 tonnes " " "	17.4	9 960	25.8	11.8	2.2
80 tonnes " " "	16.7	10 620	31.2	19.1	1.6
100 tonnes " " "	16.5	10 580	31.9	22.9	1.4
120 tonnes " " "	16.1	10 690	33.8	22.6	1.5

$$\text{* AC = alkalinity coefficient} = \frac{\text{m val (Na + K) 100 g}^{-1}\text{ sugar}}{\text{m val } \alpha\text{-amino N 100 g}^{-1}\text{ sugar}}$$

Silage maize

A long term field experiment tested annual dressings of 50, 100, 150, 200, 250 or 300 tonnes ha^{-1} cattle slurry applied to a sandy soil (2.8% organic matter; pH-KCl 4.9) in the period December - April, annually since 1973 (Table 2).

Apart from mineral-N in 50 tonnes cattle slurry ha^{-1} nutrient supply always exceeded crop uptake. Results in Figure 1 demonstrate this clearly for the mineral-N (ammonium + nitrate N) concentrations in soil determined in 20 cm layers to a depth of 1 metre in spring (after the last slurry application) and in autumn (after harvesting). A considerable portion of

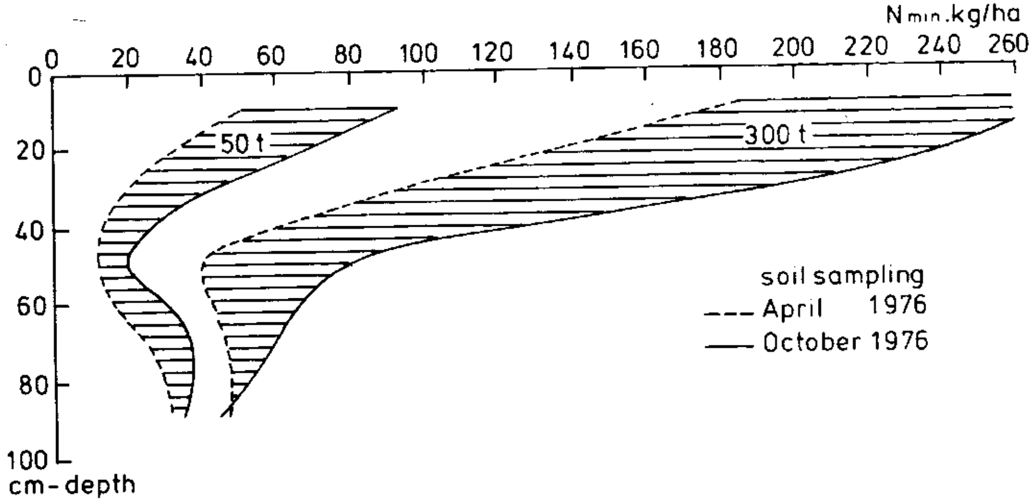

Fig. 1. Soil enrichment (0 - 100 cm) with mineral N following 3 years' application with 50 or 300 tonnes ha^{-1} cattle slurry, in kg ha^{-1} per layer of 20 cm.

nitrate-N left in the soil after harvesting is likely to be lost by leaching during the winter. Moreover, losses of mineral-N contained in the cattle slurry applied in winter will occur as a result of volatilisation as ammonia. Losses by denitrification to gaseous nitrogen products are thought to be small because of low winter temperatures. The average amounts of nitrogen not accounted for in the balance sheet for soil mineral-N during the winter periods (1975 - 1978) vary from 120 to 630 kg ha^{-1} with slurry applications of 50 and 300 tonnes ha^{-1} respectively. Part of it may not be lost but temporarily immobilised in a plant-unavailable form. However, considering the substantial rise in nitrate concentration of the ground water at 1.5 metre depth, shown in Figure 2, with the increasing supply of mineral-N, originating from the soil reserve in autumn plus the slurry application in winter, a substantial part is probably lost by leaching. The nitrate concentrations in ground water following the various applications of cattle slurry far exceed the EEC limit for potable water (11 mg NO_3-N $litre^{-1}$).

Following three annual applications of large quantities of cattle slurry, water-soluble P had penetrated to a depth of 40 cm and exchangeable K to 80 cm down the soil profile.

TABLE 2.

AVERAGE ANNUAL SUPPLY OF NUTRIENTS IN CATTLE SLURRY AND UPTAKE OF NUTRIENTS BY SILAGE MAIZE (1974 - 1977).

	Mineral N* kg ha^{-1}	P_2O_5 kg ha^{-1}	K_2O kg ha^{-1}	CaO kg ha^{-1}	MgO kg ha^{-1}	Yield t ha^{-1}
Nutrient supply						
50 t ha^{-1} slurry	120	100	270	120	60	12
300 t ha^{-1} slurry	730	685	1 500	615	365	14
Crop uptake						
50 t ha^{-1} slurry	175	50	215	25	25	
300 t ha^{-1} slurry	210	65	325	50	35	

* 50 % of total N

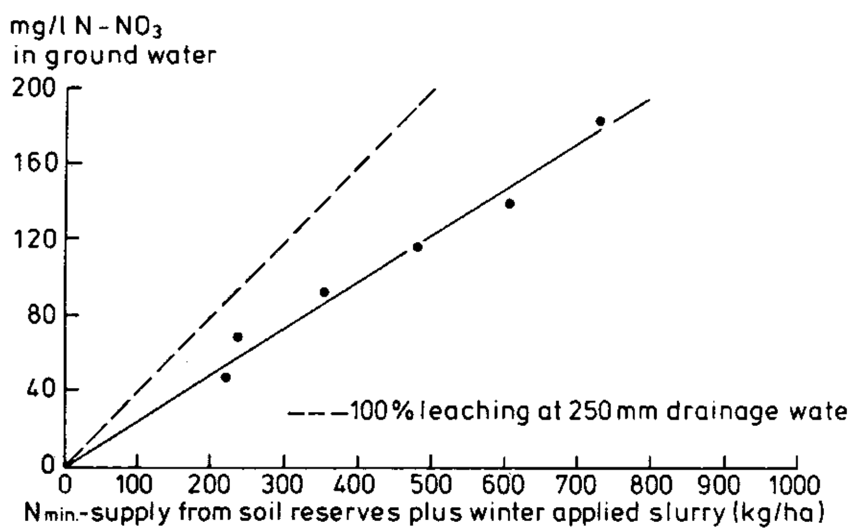

Fig. 2. Mineral N supply from the soil (0 - 100 cm; autumn) plus (winter) applied cattle slurry as influencing NO_3-concentration of groundwater (1.5 - 2 m depth).

CONCLUSIONS

Stands of hardwoods, like poplar, may be used for disposal of livestock excreta, but this practice is not recommended for conifers.

An effective way of applying livestock slurries to grassland is by sprinkler irrigation of the diluted material during the growing season.

Care should be taken not to overdose arable crops such as sugar beet with livestock excreta because of deterioration in crop quality and sugar extractability. Crops such as silage maize tolerate large doses of livestock excreta, the excess of nutrients, however, pollute the ground water (if soluble such as nitrate) or accumulate in the soil profile, if immobile such as phosphate.