College of Agriculture, Food & Rural Enterprise

Agri-Food and Biosciences Institute

Technical Note

Mechanical Separation of Slurry on Northern Ireland Dairy Farms

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Mechanical separation of slurry, though not a common practice in Northern Ireland, is widely used across the EU. The products of mechanical separation are a stackable fibrous fraction and a liquid fraction. The liquid fraction is lower in volume and dry matter concentration than the original slurry. Typical on-farm separators divide the nutrients in the slurry (nitrogen, phosphorus and potassium) between the separated liquid and solid fractions approximately in proportion to the weight of liquids and fibre produced. Other types of separators, such as decanting centrifuges, partition more of the nutrients, particularly phosphorus, into the separated fibre fraction. Export of the separated fibre off-farm has the potential to lower the livestock manure nitrogen and phosphorus loading on a farm. On farms where a separator is used, the Nitrates Action Programme allows up to a 20% reduction in the storage capacity of undiluted slurry.

Slurry separation equipment

The most popular types of on-farm separators make use of mesh grills allowing liquid and smaller solid particles to pass through, leaving larger fibrous material behind. This fibrous material is then pressed or squeezed to remove more liquid. Decanting centrifuge separators (employed widely in the wastewater industry) use a spinning action (centrifugal force) to separate fibre and liquid. Due to the technology involved, centrifuges are more expensive both to purchase and operate than conventional 'farm-type' separators. However, decanting centrifuges have the ability to concentrate more nutrients into the separated fibre (differential partitioning) and hence, may have a role in particular farm situations.

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Research at AFBI Hillsborough

Research completed at AFBI, Hillsborough evaluated the performances of a ‘farm-type’ brushed screen separator and a decanting centrifuge. Some results from this work are presented in Tables 1. and 2. below (see www.afbini.gov.uk. for the full report).

Table 1. The influence of slurry dry matter on the efficiency of separation of cattle slurry using a brushed screen separator (without chemical additions).

Slurry DM (%)	4	5	6	7	8
Volume reduction of liquid fraction as a percentage of original slurry (%)	6	9	13	17	21
Percentage of input separated to fibre fraction					
Total nitrogen (%)	10	13	16	20	23
Total phosphorus (%)	16	20	24	28	32

The volume reduction (or fresh weight of fibre), together with the amounts of nitrogen and phosphorus separated to the fibre fraction by the brushed screen depended on slurry dry matter concentration (Table 1.). Compared to slurry at 4% dry matter, slurry at 8% dry matter produced over three times the amount of fresh weight of fibre and twice the amount of nitrogen and phosphorus in that fibre, per unit of slurry separated. Hence, slurry dilution with yard water and parlour washings has a significant impact on the volume reduction of the liquid fraction and the amount of nutrients separated to the fibre fraction.

Table 2. The influence of slurry dry matter on the efficiency of separation of cattle slurry using a decanting centrifuge (without chemical additions).

Slurry DM (%)	4	5	6	7	8
Volume reduction of liquid fraction as a percentage of original slurry	7	10	12	14	17
Percentage of input separated to fibre fraction					
Total nitrogen	21	21-30	21-30	21-30	30
Total phosphorus	59	59-70	59-70	59-70	70

Similar fresh weights of fibre were produced by both separators, but the fibre fraction from the decanting centrifuge contained more of the nutrients (Table 2.). Importantly there was greater partitioning of phosphorus, with on average, 64% of slurry phosphorus partitioned to the separated solid fraction. With the decanting centrifuge, slurry dry matter percentage had a smaller influence on the amount of nutrients separated to the fibre fraction, compared to the brushed screen separator.

The amount of nitrogen partitioned to the separated fibre fraction ranged between 10% and 30% of that in the initial slurry, depending on the separator type and dry matter concentration of the slurry. This has important implications for farmers seeking to reduce the organic nitrogen loading by separation of slurry and export of the fibre. The impact of separator type and slurry dry matter percentage had an even greater impact on phosphorus partitioning to the fibre fraction (range 16-70% of slurry phosphorus inputted). The addition of chemicals enhanced nutrient partitioning to the separated fibre fraction, particularly with the decanting centrifuge. However, as water is added along with the chemicals, there is an increased volume of separated liquid that must be stored and handled.

Benefits of mechanical slurry separation

Under current legislative conditions, the adoption of slurry separation technology has a range of potential benefits on commercial farms. These benefits include;

1. Reduction in the volume of liquid requiring storage as indicated by the research findings.

2. Potential to export separated fibre together with the nutrients (particularly nitrogen and phosphorus) contained in it, thus lowering the nutrient loading on the export farm.

3. Improved efficiency in the uptake of nitrogen from the liquid when applied to grassland or crops.

4. Greater window of opportunity for application of separated liquid slurry to silage aftermaths.

5. Less leaf contamination of pasture may allow quicker return of grazing stock after application.

6. Separated liquid should require little or no mixing prior to spreading.

1. Reduction in the volume of liquid requiring storage

Achieving a net 20% saving in liquid storage capacity may not always be possible in practice. As indicated above, the volume reduction resulting from separation depends on separator type and slurry dry matter concentration. In addition, slurry separation systems require a reception tank for whole slurry and a storage tank for separated liquid. On some farms it may be necessary to construct tanks for these purposes. Consequently, incorporation of a slurry separation system may result in an increased requirement for slurry storage volume. Storage for separated fibre must also be considered. If land application takes place within 6 months of production, the fibre can be stacked in the field where application is to take place. However, if the separated fibre is to be stored for a longer period of time, a suitable concrete storage area with adequate effluent collection facilities are required.

2. Potential to export the fibre fraction to lower the organic nitrogen loading on the farm

Exporting the separated fibre fraction could reduce nitrogen loading on the farm. For example, it is calculated from the data in Table 1. that separating slurry (8% dry matter) produced over the winter (6 months) through a brushed screen, would produce separated fibre containing approximately 12% of the yearly manure nitrogen excreted. The impact of slurry separation on the amount of land required for compliance with the 170kg organic N/ha/year is given in Table 3.

Table 3. Impact of different scenarios on land area requirement for 100 dairy cows plus replacement heifers (30% replacement rate), to comply with the 170kg organic N/ha/year limit.

		[1] All winter slurry production separated	
	No separation	Brushed screen separator	Decanting centrifuge
Land area required (ha)	59	52	50

1. Assuming 6 months housing with separated fibre removed off-farm, slurry 8% DM, with brushed screen removing 23% of total nitrogen in fibre and decanting centrifuge removing 30% of total nitrogen in fibre.

However, on many farms the slurry dry matter concentration may be less than 8%, due to dilution. This will reduce the quantity of fibre produced and amount of nutrients in this fraction.

3. Improved efficiency in the uptake of nitrogen in the liquid when applied to grassland or crops

Separated liquid should percolate into soil more readily than raw slurry, leading to less nitrogen loss and increased crop yields per unit of organic nitrogen applied. Research at AFBI, Hillsborough has shown that spreading separated liquid on grassland resulted in higher yields compared to those that followed spreading of raw slurry. The improvement in grass yield increased as the separator screen size decreased. For example, compared to raw slurry, slurry separated through a 3mm mesh resulted in 25% more grass dry matter yield (same amount of slurry nitrogen applied). Increases in yield were attributed to less nitrogen lost to the atmosphere and hence greater uptake of nitrogen by the grass. As a result, the lower volume of separated liquid produced by separation will have a total fertiliser value similar to that of the higher volume of un-separated slurry.

4. Greater window of opportunity for application to silage aftermaths

Separation reduces the proportion of fibrous particles in the separated liquid, which are responsible for grass leaf contamination when making silage. Consequently, spreading separated liquid on grassland should result in less sward contamination than raw slurry. As a result, the window of opportunity for spreading separated liquid after silage cutting is greater than with raw slurry.

5. Less contamination of pasture, allowing quicker return of grazing stock

As with silage aftermaths, the benefit of less contamination also applies in grazing situations, offering the potential for slurry to be utilized as a fertilizer on grazing areas. However, spreading separated liquid may not totally eliminate sward rejection by grazing animals.

6. Separated liquid may not require mixing prior to spreading

As much of the fibrous material and larger particles have been removed from the slurry, the liquid is easier to pump and there is little settlement during storage. As a result, separated slurry should require little to no mixing prior to removal from store for spreading. Consistency of nitrogen content throughout the liquid in the tank is a further advantage of separated liquid not settling during storage.

Costs of installing and operating slurry separators

The purchase and installation of a farm-type separator may cost between £20,000 and £30,000 (September 2008). Table 4 gives the purchase and installation costs per tonne of slurry separated for different capital outlays and yearly throughputs, assuming depreciation over 10 years and interest at 7% per annum. Using these assumptions, across the range of throughputs and capital outlays presented in Table 4, the capital cost per tonne of slurry separated may range between £0.71 and £4.27. Hence capital outlay and throughput have a major impact on cost per tonne of slurry separated.

Table 4. The capital cost per tonne of slurry separated, as affected by throughput and capital outlay.

	Tonnes per year separated						
Capital Cost	**1000**	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**
£20,000	£2.85	£1.90	£1.42	£1.14	£0.95	£0.81	£0.71
£25,000	£3.56	£2.37	£1.78	£1.42	£1.19	£1.02	£0.89
£30,000	£4.26	£2.85	£2.14	£1.71	£1.42	£1.22	£1.07

Running costs, consisting of electricity consumption and maintenance, are relatively small, compared to the capital costs outlined in Table 4. above.

For a 100 cow dairy unit, rearing 30 heifers per year, the volume of slurry produced over 22 weeks will be approximately 1000m^3, excluding dilution with parlour washings and rainwater. For cattle slurry, the Nitrates Action Programme allows the volume of liquid storage to be reduced by a maximum of 20% of the undiluted slurry volume if mechanical separation is employed (200m^3 maximum reduction in this example). This equates to potential savings of between £7,000 and £12,000 (assuming £35- £60/m^3 for new above ground slurry stores, DARD Farm Business Data 2008), if additional slurry storage is required. However, a 20% reduction in total storage may not be achievable in practice as this will be offset by the need for extra storage for the liquid fraction. In addition, dilution of slurry with parlour washings and yard water will increase the volume of slurry to be stored and separated, but also reduce the total amount of fibre produced. Table 1. illustrates the influence of slurry dry matter percentage on the amount of fibre produced or the volume reduction of the liquid fraction.

Organic N loading

A stocking rate of 2.1 cow equivalents per hectare (average Northern Ireland benchmarked dairy farms) equates to 191kg organic N/ha, i.e. 21kg organic N over the 170kg limit. By separating all the winter slurry production (6 months) with a brushed screen separator, the separated fibre may contain 23% of the winter slurry nitrogen produced (Table 1, assuming 8% slurry dry matter). This equates to 22kg organic N/ha. Exporting the fibre fraction off-farm would bring the farm just under the 170kg limit. If the winter slurry production was separated by a decanting centrifuge, with the fibre exported, this would remove approximately 29kg organic N/ha, (Table 2, 30% of the nitrogen in the fibre fraction with slurry @ 8% dry matter), so that the farm would have an organic N loading of 162kg/ha and thus, be well within the 170kg limit, as stipulated in the Nitrates Action Programme.

Separation of slurry and export of the fibre to reduce farm organic nitrogen loading is one method to aid compliance with the 170kg organic nitrogen limit. However, obtaining a sustainable end use for the fibre fraction is essential. Analysis of the nitrogen and/or phosphorus content of the fibre fraction may be required to verify the reduction in farm nutrient loading. The costs/benefits of separation must be compared with other potential solutions for farms currently producing excess organic nitrogen. Excess phosphorus may be an issue for farmers who obtain a derogation. Options to reduce nutrient loading include reducing stock numbers and/or controlling more land. Each option needs careful consideration to determine the best solution for any given farm situation.

Summary

1. Mechanical separation of slurry allows easier handling of the liquid. The separated liquid should require little or no mixing before land application and has less potential to contaminate grass, compared to raw slurry. These benefits should make storage and application of slurry more easily managed.

2. Grass yields per unit of organic nitrogen applied have shown a 25% increase with separated liquid (3mm screen), compared to raw slurry.

3. Mechanical separation of slurry offers the potential through export of fibre, to lower nutrient loading and aid compliance with the Nitrates Action Programme.

4. While theoretical requirements for slurry storage capacity may be reduced by mechanical separation, this may not be realised in practice, due to the requirement for separate storage for the liquid fraction and the need for a reception tank for the slurry prior to separation.

5. The separation system needs to integrate well with the current farm set up. Requirements for substantial restructuring or construction work will increase installation costs. These costs could outweigh potential savings in the reduced requirement for liquid storage.

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