Report Summary

Evaluation of mechanical separation of pig and cattle slurries by a decanting centrifuge and a brushed screen separator

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Executive Summary

This report summary is a précis of a detailed report by Gilkinson and Frost (2007)[1].

Mechanical separation of animal slurry produces a liquid fraction with a lower dry matter concentration than the input slurry and a solid fraction with a higher dry matter concentration than the input slurry. Plant nutrients in the slurry are partitioned between the liquid and solid fractions. Differential partitioning occurs if one or more component of the input slurry is partitioned in excess of the weight/volume split between the liquid and solid fractions.

In the current work, AFBI-Hillsborough evaluated the performances of a brushed screen separator and a decanting centrifuge with pig and cattle slurries. The effects of adding coagulant and polyelectrolyte to the slurries (chemical treatment) on separator efficiencies were also evaluated.

For the brushed screen control treatment (no chemicals added), separation efficiency for all components measured was positively correlated with input pig slurry dry matter concentration. There was some differential partitioning of dry solids into the separated solid fraction; otherwise the brushed screen separator partitioned nutrients more or less in proportion to the fresh mass of the liquid and solid fractions. The weight of fresh solids produced from the brushed screen per tonne of slurry was dependent on the input slurry dry matter concentration e.g. with pig slurry dry matter concentrations of 25g/kg and 60g/kg, 10kg and 91kg fresh solids per tonne of slurry were produced respectively. Chemical treatment of slurry inputted to the brushed screen resulted in improved partitioning of total nitrogen (TN), total phosphorus (TP) and dry solids, though the effect was small.

The decanting centrifuge partitioned a much greater proportion of TN, TP and dry solids in pig slurry into the separated solid fraction than the brushed screen separator. The weight of fresh solids produced from the decanting centrifuge per tonne of pig slurry was dependent on input slurry dry matter concentration

[1] Stephen Gilkinson and Peter Frost, 2007. Evaluation of mechanical separation of pig and cattle slurries by a decanting centrifuge and a brushed screen separator. AFBI-Hillsborough, September 2007.

e.g. at pig slurry dry matter concentrations of 25g/kg and 60g/kg, 58kg and 111kg fresh solids per tonne of slurry were produced respectively. Chemical treatment of pig slurry further increased the quantity of fresh solids produced from the decanting centrifuge e.g. at 60g/kg slurry dry matter concentration, 185kg of fresh solids were produced per tonne of slurry. Without chemical additions, 79% of the TP in pig slurry and 64% of the TP in cattle slurry was partitioned to the separated solid fraction by the decanting centrifuge. Adding chemicals to slurry inputted to the decanting centrifuge increased the TP in pig and cattle slurry partitioned into the separated solids to 93% and 82% respectively but had very little effect on the partitioning of potassium (K) and ammonia nitrogen (NH_3-N). The brushed screen separator without chemical addition transferred an average of 6% and 17% of the TN from pig and cattle slurry respectively into the solid fraction, increasing to 7% and 23% with chemical additions. The corresponding figures for the decanting centrifuge were 21% and 25% for pig and cattle slurry respectively, increasing to 34% and 41% with chemical additions.

For both separator types, adding chemicals to pig slurry to improve separation efficiency significantly increased the volume of supernatant by between 9% (medium rate of polyelectrolyte addition) and 28% (high rate of polyelectrolyte addition) as a result of dilution with water. The cost of the chemicals used in this experiment ranged from £1.50 (low rate coagulant/medium polyelectrolyte addition) to £3.74 (high rate coagulant/high polyelectrolyte addition) per tonne of slurry inputted to the separators. The increased volume of supernatant resulting from the high rate of polyelectrolyte addition would not be practical for many farms.

Pig slurry treated with chemicals prior to decanting centrifuge separation produced a supernatant that contained approximately 9g/kg dry matter content, 2g/kg total nitrogen and 0.04g/kg total phosphorus

For an annual throughput of 4,000 tonnes of pig slurry it was estimated that the cost of separation, without chemicals, with the decanting centrifuge could be approximately £4.50 per tonne of input slurry and about £0.85 per tonne for the brushed screen. At this annual throughput of pig slurry and without chemical addition, the estimated costs for partitioning phosphorus and nitrogen into the separated solids could be in the order of £6,000/t of TP and £5,000/t TN for the decanting centrifuge and £13,000/t TP and £3,000/t TN for the brushed screen. All these costs are dependant, *inter alia*, on the quantity of slurry separated per year, depreciation and interest charges. For example, at a throughput of 8,000 tonnes per year, costs could be approximately halved.

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General Introduction

The following report summary is a précis of a detailed report by Gilkinson and Frost (2007)[2].

Mechanical separation of animal slurry produces a liquid fraction with a lower dry matter concentration than the input slurry and a solid fraction with a higher dry matter concentration than the input slurry. Plant nutrients in the slurry are partitioned between the liquid and solid fractions. Differential partitioning occurs if one or more component of the input slurry is partitioned in excess of the volume split between the liquid and solid fractions. During centrifugal separation chemicals are sometimes added to improve the efficiency of separation. The two basic types of chemical used are coagulants[3] and polyelectrolytes[4]. Because polyelectrolyte is expensive it is desirable to minimise the quantity required through addition of a coagulant, which is cheaper.

The separated liquid fraction (supernatant) is normally lower in volume and dry matter concentration than the original slurry and should not require mixing before being applied to the land. Additionally, because separation removes larger particles from the slurry that might otherwise block pipes, the supernatant is more suitable for pumping through delivery pipes on slurry distribution machinery.

Separators evaluated

AFBI-Hillsborough evaluated two types of separator between April and October 2006 - a brushed screen (NC Engineering, Northern Ireland) (Figure 1) and a decanting centrifuge (Westfalia, Germany) (Figure 2). The decanting centrifuge had a maximum throughput of 5t/h while the brushed screen had a nominal throughput of 10-15 t/h. The brushed screen separator was fitted with a 0.75kW electric motor, while the centrifuge was fitted with a 7.5kW electric motor.

[2] Stephen Gilkinson and Peter Frost, 2007. Evaluation of mechanical separation of pig and cattle slurries by a decanting centrifuge and a brushed screen separator. AFBI-Hillsborough, September 2007.
[3] metal bases that cause small particles and dissolved material in the slurry to coagulate
[4] normally synthetic water soluble polymers, such as polyacrylamide, that adhere particles into larger separable particles called flocs

Figure 1: Brushed screen separator.

Figure 2. Decanting centrifuge.

Chemicals used

In the current work coagulant and polyelectrolyte were used for both types of slurry in both types of separator. The slurry was pumped to both separators at approximately 2.6m^3/h for pig slurry and 1.8m^3/h for cattle slurry. The coagulant used was an aluminium salt in liquid form (PC31, Celtic Water Care, Cork) and the polyelectrolyte used was a water soluble polyacrylamide (C1900P, Celtic Water Care, Cork) that was diluted with water to 0.4% by volume. For pig slurry the coagulant was added into the slurry supply line at 0.16%, 0.24% and 0.38% of slurry volume for the low, medium and high coagulant treatments respectively and the diluted polyelectrolyte was added at approximately 17% by volume. For the cattle slurry the coagulant was added into the slurry supply line at 0.18%, 0.49% and 0.79% of slurry volume for the low, medium and high coagulant treatments respectively and the diluted polyelectrolyte was added at approximately 28% by volume.

Treatments applied

The experimental treatments applied were:

2 x separator type – brushed screen and centrifuge

3 x chemical treatment - low, medium and high rate of coagulant combined with a constant rate of polyelectrolyte addition

Within each slurry type there were a minimum of 5 replicates of each treatment across a range of slurry dry matter concentrations.

In addition, for the pig slurry separated through the centrifuge, a further treatment was applied that comprised the high rate of coagulant addition (0.38% of slurry volume) plus high rate of diluted polyelectrolyte addition (47% of slurry volume).

Brushed screen with pig slurry results

The mean dry matter concentration of pig slurry was 45.5 g/kg (range 22.2 to 71.0 g/kg).

Dry solids were differentially partitioned to the solid fraction (Table 1). There was little differential partitioning of the other components measured (Table 1). Chemical addition had no significant (P>0.05) effect on separator efficiency.

Table 1. Separator efficiency of a brushed screen separator with pig slurry

Separator Efficiency[1]	Mean chemical	Mean control	Significance[2]
Dry Solids	19.3	19.0	NS
Total nitrogen	7.4	6.0	NS
Ammonia nitrogen	3.3	3.1	NS
Total phosphorus	10.2	6.9	NS
Potassium	4.4	4.7	NS
Separated liquid volume change (% slurry input volume)	+12.1	-5.2	***

Footnote 1. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 2. NS = not significant; *** P< 0.001

Addition of chemicals resulted in 12% more separated liquid than the volume of slurry input to the separator as a result of the dilution water used with the polyelectrolyte. For the control treatment the volume of separated liquid was 5% less than the input slurry volume (Table 1).

For the control treatment with the brushed screen, separation efficiency for all components measured was positively correlated with input slurry dry matter concentration (Table A1, Appendix). The weight of fresh solids produced from each tonne of pig slurry depended on input slurry dry matter concentration e.g. at slurry dry matter concentrations of 25g/kg and 60g/kg, 10kg and 91kg fresh solids were produced respectively (Table A1, Appendix).

Decanting centrifuge with pig slurry results

The mean dry matter concentration of pig slurry was 38.4 g/kg (range 23.8 to 68.4 g/kg).

In the control treatment, ammonia nitrogen (NH_3-N) and potassium (K) were not differentially partitioned. Whilst chemical addition significantly (P<0.05) improved separation efficiency for NH_3-N and K, the absolute increases were small (Table 2). All other components measured were differentially partitioned into the solid fraction with chemical treatment further improving efficiency. Of particular note were the high separation efficiencies in the control treatments for dry solids and TP (53% and 79% respectively). These efficiencies were significantly improved by chemical treatment to an average of 71% and 93% respectively. TN was also differentially partitioned into the solid fraction for the control treatment and this partitioning was increased by chemical addition (Table 2).

Table 2. Characteristics of the supernatant and separated solids from pig slurry separated through a decanting centrifuge.

Separator Efficiency[1]	Mean chemical[2]	Mean control	Significance[3]
Dry solids	70.6	52.9	***
Total nitrogen	34.4	21.3	***
Ammonia nitrogen	10.2	7.8	*
Total phosphorus	93.4	78.9	***
Potassium	10.8	8.0	**
Separated liquid volume change (% slurry input volume)	12.2	-7.9	***

Footnote 1. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 2. High rate of polyelectrolyte addition included in the mean
Footnote 3. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Across all chemical treatments and pig slurry dry matter concentrations, there was an average of 12% increase in volume of the liquid fraction, relative to the input slurry volume (Table 2). When the high rate of polyelectrolyte addition is excluded from the calculation, the increase in supernatant volume was approximately 9%. These volume increases were due to the volume of water required to dilute the polyelectrolyte.

For pig slurry separated without chemicals through the decanting centrifuge, the weight of fresh solids partitioned to the separated solid fraction was positively correlated with the dry matter concentration of the slurry (Table A2, Appendix). For example, at slurry dry matter concentrations of 25g/kg and 60g/kg, 58kg and 111kg fresh solids per tonne of slurry were produced respectively (Table A2, Appendix). Chemical treatment of pig slurry further increased the weight of fresh solids produced so that slurry at a dry matter concentration of 60g/kg, 185kg of fresh solids were produced (Table A3, Appendix).

Rate of chemical additions to pig slurry with the decanting centrifuge
Increasing the rate of coagulant addition, resulted in a significant ($P<0.05$) increase in the amount of TP transferred to the solid fraction (Table 3).

With the exception of TP, the high rate of coagulant/high rate polyelectrolyte addition treatment did not significantly improve separator efficiency over the other chemical treatments. However, due to the volume of diluted polyelectrolyte added with this treatment, the volume of supernatant was increased significantly ($P<0.05$) to 28% more than the volume of input slurry (Table 3).

Table 3. Characteristics of the supernatant and separated solids from pig slurry with added polyelectrolyte and coagulant, separated through a decanting centrifuge.

Coagulant (% slurry volume) Polyelectrolyte (% slurry volume)	0.16% 17%	0.25% 17%	0.38% 17%	0.38% 47%	Signif- icance[2]
Separator efficiency[1]					
Dry solids	68.0	68.9	71.4	77.4	NS
Total nitrogen	33.0	32.8	34.5	39.8	NS
Ammonia nitrogen	11.9	11.9	13.3	12.5	NS
Total phosphorus	91.3	92.1	95.3	96.1	*
Potassium	10.0	10.6	11.2	11.6	NS
Separated liquid volume change (% slurry input volume)	10.7	8.7	9.0	27.9	*

Footnote 1. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 2. NS = not significant; * P< 0.05

Removal of Suspended Solids from pig slurry by the decanting centrifuge
The mean effect of chemical treatment on total suspended solids (TSS) concentrations in the supernatants from the decanting centrifuge for 3 different pig slurries (mean slurry dry matter 43.1 g/kg, mean slurry suspended solids 18.3 g/kg) is presented in Table 4.

Table 4. Mean effect of medium and high levels of polyelectrolyte addition along with low, medium and high levels of coagulant addition to pig slurry on total suspended solids (TSS) concentration in decanting centrifuge supernatant.

Coagulant (% slurry volume) Polyelectrolyte (% slurry volume)	Control 0% 0%	0.16% 17%	0.25% 17%	0.38% 17%	0.38% 47%	Signif- iance[1]
Supernatant						
DM concentration (g/kg)	20.6	9.4	9.4	9.2	6.9	NS
TSS (g/kg)	7.69	1.04	0.86	0.67	0.34	**
Proportion TSS in slurry removed by centrifuge	0.60	0.94	0.95	0.96	0.98	***

Footnote 1. NS = not significant; ** P< 0.01, *** P< 0.001

TSS in the supernatant from the control treatment was reduced by 60% compared to the raw slurry. Compared to the control treatment, the proportion of TSS removed by the chemical treatments were significantly (P<0.001) higher. The high coagulant/ high polyelectrolyte treatment removed 98% of the suspended solids and 77% of total solids from the slurry.

Brushed screen separator with cattle slurry results

Cattle slurry with a mean dry matter concentration of 60.4 g/kg (range 40.5 to 79.3 g/kg) was separated through the brushed screen separator (1.6 mm diameter mesh).

Separation efficiencies within the control treatment indicated that there was some differential partitioning of dry solids and total phosphorus (Table 5). Chemical addition resulted in small improvements in separator efficiencies, though the effect was only significant ($P<0.05$) for total nitrogen (Table 5).

Table 5. Characteristics of the separated liquid and solids from cattle slurry separated through a brushed screen separator.

Separation efficiency[1]	Mean chemical	Mean control	Significance[2]
Dry solids	40.4	35.8	NS
Total nitrogen	22.6	17.5	*
Ammonia nitrogen	15.4	13.1	NS
Total phosphorus	32.0	25.5	NS
Potassium	13.9	14.6	NS
Separated liquid volume change (% slurry input volume)	+6.6	-14.2	***

Footnote 1. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 2. NS = not significant; * P< 0.05, *** P< 0.001

Fresh solids from the control treatment had a dry matter concentration of 163.5g/kg and were stackable with very little effluent seepage. Use of chemicals significantly (P<0.001) lowered the dry matter concentration of the separated solids to 129.9g/kg. These separated solids had the consistency of thick slurry, were not stackable and produced effluent seepage.

For cattle slurry separated through the brushed screen without the use of chemicals, there were significant (P<0.001) positive linear relationships between slurry dry matter concentration and separator efficiency for dry solids, TN, TP and K (Table A4, Appendix). The weight of fresh solids produced from each tonne of cattle slurry depended on input slurry dry matter concentration e.g. at slurry dry matter concentrations of 40g/kg and 80g/kg, 55kg and 208kg fresh solids were produced respectively (Table A4, Appendix).

Decanting Centrifuge with Cattle Slurry results

The mean dry matter concentration of cattle slurry prior to separation through the decanting centrifuge was 59.7 g/kg (range 41.4 to 82.9 g/kg).

The volume of the supernatant in the control treatment, compared to the input slurry volume, was reduced by a mean of 12.5% (Table 6). In contrast, for the chemical treatments there was a mean increase in supernatant volume of 9.1% as a result of water added along with the polyelectrolyte (Table 6). In the control treatment, dry solids, TP and TN in cattle slurry were differentially partitioned into the solid fraction and this partitioning was significantly (P<0.001) increased by chemical addition. There was very little differential partitioning of the soluble components, NH_3-N and K (Table 6).

Table 6. Separation efficiency of a decanting centrifuge for cattle slurry, with and without chemical treatment

	Mean chemical	Mean control	Signif-icance[2]
Separation efficiency[1]			
Dry Solids	65.4	50.9	***
Total nitrogen	40.6	24.6	***
Ammonia nitrogen	16.6	13.7	NS
Total phosphorus	82.3	63.9	***
Potassium	14.9	13.0	NS
Separated liquid volume change (% slurry input volume)	+9.1	-12.5	***

Footnote 1. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 2. NS = not significant; *** P< 0.001

For cattle slurry separated through the decanting centrifuge with and without addition of chemicals, there were significant (P<0.001) positive linear relationships between slurry dry matter concentration and separator efficiency for dry solids (Tables A5 & A 6, Appendix). The weight of fresh solids produced from each tonne of cattle slurry was also dependent on input slurry dry matter concentration e.g. at slurry dry matter concentrations of 40g/kg and 80g/kg, 71kg and 166kg fresh solids were produced respectively without chemical addition (Table A5, Appendix). Chemical treatment of cattle slurry further increased the weight of fresh solids so that slurry at a dry matter concentration of 80g/kg, 271kg of fresh solids were produced (Table A6, Appendix).

Increasing the rate of coagulant significantly (P<0.01) increased differential partitioning of TP (Table 7), but did not significantly increase the partitioning of other components measured.

Table 7. Decanting centrifuge supernatant concentrations following addition of low, medium and high levels of coagulant to cattle slurry (with constant rate of polyelectrolyte).

Coagulant (% slurry volume) Polyelectrolyte (% slurry volume)	0.18% 28%	0.49% 28%	0.79% 28%	Signif-icance[2]
Separator efficiency[1]				
Dry solids	61.7	65.7	68.7	NS
Total nitrogen	35.8	40.8	45.1	NS
Ammonia nitrogen	14.6	17.0	18.3	NS
Total phosphorus	75.6	81.4	89.5	**
Potassium	13.9	14.8	15.9	NS

Footnote 1. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 2. NS = not significant; ** P< 0.01

Removal of Suspended Solids from cattle slurry by the decanting centrifuge

Coagulant plus polyelectrolyte addition to cattle slurry prior to separation through the decanting centrifuge significantly increased the removal of suspended solids from the supernatant (Table 8).

Table 8. Suspended solids in supernatant from cattle slurry separated in the decanting centrifuge with and without chemical treatment (high rate of coagulant plus polyelectrolyte).

	Control		
Coagulant (% slurry volume)	0%	0.79%	Signif-icance[2]
Polyelectrolyte (% slurry volume)	0%	28%	
Supernatant			
DM concentration (g/kg)	29.7	15.3	***
Suspended solids (g/kg)	6.43	0.72	**
Proportion of suspended solids removed by centrifuge	0.72	0.97	***

Footnote 1. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 2. NS = not significant; ** P< 0.01, *** P< 0.001

Points to Consider

Table 9 presents data comparing the composition of untreated pig slurry with the supernatant produced by the decanting centrifuge. Because these data are not from a common data set it has not been possible to carry out a statistical analysis.

Table 9. Characteristics of slurry and supernatant from pig slurry with added coagulant and polyelectrolyte, separated through decanting centrifuge.

		Supernatant	
	Input slurry	Control	High coagulant Medium polyelectrolyte[1]
Dry matter (g/kg)	38.4	19.8	9.3
Total nitrogen (g/kg)	3.53	3.20	1.97
Ammonia nitrogen (g/kg)	2.52	2.55	1.81
Total phosphorus (g/kg)	0.896	0.200	0.037
Potassium (g/kg)	2.45	2.57	1.835
Total suspended solids (g/kg)	18.3	7.69	0.67

Footnote 1 High coagulant, 0.38% slurry volume; Medium polyelectrolyte, 17% slurry volume

Dirty water is defined[5] as containing a dry matter content of less than 10g/kg, less than 0.3g/kg total N and no greater than 2,000mg/l BOD. Data in Table 9 indicate that pig slurry treated with coagulant and polyelectrolyte and processed through a decanting centrifuge produced supernatant with a dry matter concentration of 9.3g/kg, approximately 2g/kg total N concentration and a very low total P concentration of about 0.04g/kg. Without further treatment of the supernatant, the concentration of nitrogen in the supernatant was above the maximum value permitted for dirty water. In the current work it was not possible to determine BOD values for the slurries and supernatants.

[5] Environment and Heritage Service, 2007. Guidance Booklet for Northern Ireland farmers on the requirements of the nitrates action programme (Northern Ireland) regulations and the phosphorus (use in agriculture) (Northern Ireland) regulations 2006

Export of the separated solids off farm has potential to reduce the nutrient loading on any given land area from any given animal population (Table 10). Slurry produced during the housing period is normally collected and stored. Since dairy cows are normally housed for approximately six months each year, only about half of their annual slurry production is available for separation. In contrast, all of the slurry produced by housed pigs is available for separation.

Table 10. Land areas required for pig and dairy units to comply with 170kg/ha/yr organic N limit before and after slurry separation by brushed screen or decanting centrifuge with and without the use of chemicals (coagulant and polyelectrolyte) assuming export of separated solids off farm.

	No	Brushed Screen		Decanting Centrifuge	
	separation	Control	Chemical	Control	Chemical
200 sows birth to bacon[1]					
Land area required (ha)	100	94	93	79	66
155 dairy cows + followers[2]					
Land area required (ha)	100	91	89	88	80

Footnote 1. All slurry separated. Footnote 2. Winter production separated (6 months)

The fixed and variable costs of separation include capital, depreciation, interest, electricity, chemicals, labour as well as spares and repairs. In addition, there may be other costs such as those associated with storing and handling the separated solid and liquid fractions. Whilst there was no measurement of electricity consumed by the separators in the current experiment, data from the literature[6] indicate electrical consumption at approximately 0.11kWh/t of animal slurry separated through a brushed screen and 4.0kWh/t and 2.9kWh/t for cattle and pig slurry respectively separated through a decanting centrifuge. It is estimated that the approximate cost (excluding chemicals and labour) for separating 4,000m^3/y of pig slurry through the brushed screen or decanting centrifuge, could be in the order of £0.85/t or £4.50/t of slurry separated respectively[7]. 4,000m^3 of slurry equates to the annual production from approximately 200 sows plus finishers, or 300 dairy cows over 6 months (allowing for some slurry dilution). At an annual throughput of 4,000m^3 of slurry without chemical addition, the estimated costs for partitioning nutrients into the separated solids from pig slurry could be in the order of £6,000/t of TP and £5,000/t TN for the decanting centrifuge and £13,000/t TP and £3,000/t TN for the brushed screen. The cost per unit of slurry separated decreases with increasing throughput e.g. at a slurry throughput of 8,000 tonnes per year, the cost per tonne could be approximately half of that at 4,000 tonnes. Throughput could be increased by servicing a number of farms with a mobile separator or by a centrally located separator. Bio-security and end use of separated fractions are major issues that must be addressed.

[6] Moller H.B., Lund, I., Sommer S.G., (2000) Solid-liquid separation of livestock slurry: efficiency and cost. Bioresource Technology 74 223-232.

[7] Assumptions: 10 year depreciation; interest 7% pa; brushed screen capital cost £20,000; decanting centrifuge capital cost £100,000; and 4,000 t/y slurry separated; 11p/kWh electricity; 2.9kWh/t slurry for centrifuge; 0.11kWh/t slurry for brushed screen; annual maintenance 2.5% of capital cost

The cost of chemicals must also be considered. In the current study, the cost of polyelectrolyte was approximately £1.80 per litre undiluted and the coagulant cost approximately £0.18 per litre. The cost of chemicals used in the separation of pig slurry in this experiment ranged between £1.50 and £1.89 per tonne of slurry input to the separators (£3.74/t for the high rate polyelectrolyte addition). The respective figures for cattle slurry ranged from £2.40 to £3.40 per tonne of slurry input to the separators.

Conclusions

1. The decanting centrifuge partitioned significantly more dry solids, total nitrogen and total phosphorus into the separated solid fraction than the brushed screen separator.
2. Use of coagulant and polyelectrolyte with the decanting centrifuge significantly increased partitioning of dry solids, total nitrogen and total phosphorus into the separated solid fraction when compared with no addition of chemicals.
3. The brushed screen separator and decanting centrifuge were not effective in differentially partitioning potassium or ammonia nitrogen in slurry into the separated solid fraction, irrespective of addition of coagulant and polyelectrolyte.
4. The decanting centrifuge produced a supernatant from pig slurry treated with coagulant and polyelectrolyte that contained less than 10g/kg dry matter content, 2g/kg total nitrogen and 0.04g/kg total phosphorus
5. Use of polyelectrolyte significantly increased the volume of the supernatant produced compared to the volume of input slurry.
6. The cost per tonne of pig slurry separated through a decanting centrifuge was estimated at more than 5 times of that for the brushed screen separator, excluding chemical costs. The ratios of decanting centrifuge to brushed screen for cost per tonne of total phosphorus and total nitrogen separated to the solid fraction were 0.47 and 1.5 respectively.
7. The cost of chemicals, at the rates used in the current experiment, ranged between £1.50 and £3.74 per tonne of slurry separated.

Appendix – Supplementary tables

Table A1 Separator efficiency of the brushed screen with a range of pig slurry dry matters without chemical additions

Slurry DM (g/kg)	25	30	40	50	60
Weight of fresh solids (kg/t slurry)[1]	10	21	44	67	91
Solids DM concentration (g/kg)[1]	145	149	163	178	192
Supernatant DM (g/kg)[1]	24.2	27.2	33.8	40.3	46.7
Separator efficiency[2]					
Dry solids[1]	9.3	12	17.4	22.8	28.2
Total nitrogen[1]	2.5	3.5	5.5	7.4	9.4
Total phosphorus[1]	3.2	4.2	6.3	8.4	10.5
Potassium[1]	1.3	2.3	4.2	6.1	8.0

Footnote 1. Data calculated from linear regression equations
Footnote 2. Percentage of component in total slurry input that was partitioned to solid fraction

Table A2 Separator efficiency of the decanting centrifuge with a range of pig slurry dry matters without chemical additions

Slurry DM (g/kg)	25	30	40	50	60
Weight of fresh solids (kg/t slurry)[1]	58	66	81	96	111
Solids DM concentration (g/kg) [1]	232	241	260	279	298
Supernatant DM (g/kg) [1]	12.7	15.2	20.3	25.3	30.4
Separator efficiency[2]					
Dry solids[3]	40 -- 60				
Total nitrogen[3]	13 -- 30				
Total phosphorus[3]	74 -- 86				
Potassium[3]	4 --11				

Footnote 1. Data calculated from linear regression equations
Footnote 2. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 3. Range of data – no relationship established

Table A3 Separator efficiency of the decanting centrifuge with a range of pig slurry dry matters with chemical additions

Slurry DM (g/kg)	25	30	40	50	60
Weight of fresh solids (kg/t slurry)[1]	80	95	125	155	185
Solids DM concentration (g/kg)[3]	201--258				
Supernatant DM (g/kg)[3]	5--13				
Separator efficiency[2]					
Dry solids[3]	49 -- 81				
Total nitrogen[3]	22 -- 46				
Total phosphorus[3]	86 -- 99				
Potassium[3]	5 --16				

Footnote 1. Data calculated from linear regression equations
Footnote 2. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 3. Range of data – no relationship established

Table A4 Separator efficiency of the brushed screen with a range of cattle slurry dry matters without chemical additions

Slurry DM (g/kg)	40	50	60	70	80
Weight of fresh solids (kg/t slurry)[1]	55	93	131	170	208
Solids DM concentration (g/kg)[3]	152 -- 173				
Supernatant DM (g/kg)[1]	32.7	38.7	44.8	50.8	56.9
Separator efficiency[2]					
Dry solids[1]	24.4	29.3	34.3	39.3	44.3
Total nitrogen[1]	9.6	13.0	16.3	19.7	23.0
Total phosphorus[1]	15.7	19.8	23.9	28.0	32.1
Potassium[1]	9.1	11.4	13.7	16.0	18.3

Footnote 1. Data calculated from linear regression equations
Footnote 2. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 3. Range of data – no relationship established

Table A5 Separator efficiency of the decanting centrifuge with a range of cattle slurry dry matters without chemical additions

Slurry DM (g/kg)	40	50	60	70	80
Weight of fresh solids (kg/t slurry)[1]	71	95	119	142	166
Solids DM concentration (g/kg)[1]	235	245	256	266	276
Supernatant DM (g/kg)[1]	25.8	29.6	33.5	37.4	41.3
Separator efficiency[2]					
Dry solids[1]	46	49	52	54	57
Total nitrogen[3]	21 -- 30				
Total phosphorus[3]	59 -- 70				
Potassium[1]	9	11	12	14	15

Footnote 1. Data calculated from linear regression equations
Footnote 2. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 3. Range of data – no relationship established

Table A6 Separator efficiency of the decanting centrifuge with a range of cattle slurry dry matters with chemical additions

Slurry DM (g/kg)	40	50	60	70	80
Weight of fresh solids (kg/t slurry)[1]	102	144	187	229	271
Solids DM concentration (g/kg)[3]	182 --229				
Supernatant DM (g/kg)[3]	13 -- 22				
Separator efficiency[2]					
Dry solids[1]	57	62	66	71	75
Total nitrogen[3]	28 -- 57				
Total phosphorus[3]	63 -- 98				
Potassium[1]	10	13	15	18	21

Footnote 1. Data calculated from linear regression equations
Footnote 2. Percentage of component in total slurry input that was partitioned to solid fraction
Footnote 3. Range of data – no relationship established