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Solid-liquid separation of pig manure and manure management

A fixed decanter centrifuge

Key external stakeholders:

Pig farmers, tillage farmers, agricultural consultants, food manufacturers, policy makers

Practical implications for stakeholders:

- The outcomes of this study allow pig producers to make well-informed decisions regarding the implementation of solid-liquid separation systems on their farm.
- Knowledge regarding the use of separated solid and liquid manure fractions as crop fertilisers to increase crop performance was generated from this project
- In addition, the outcomes provide pig farmers with knowledge and models to enable appropriate animal feeding and water management to minimize nutrient excretion and manure volume. This not only allows pig farmers to reduce their costs of production but also enables them to reduce their environmental load and to adhere to the regulations under the Nitrates Directive.

Main results:

- For solid-liquid separation a fixed decanter centrifuge proved to be the most effective method of removing dry matter from the liquid into the solid fraction. However direct land spreading of raw pig manure is still the most economic method of utilising pig manure. Therefore solid-liquid separation is not currently considered to be cost-effective
- Separated liquid manure fractions proved to be a useful N source for winter wheat production, helping to reduce fertilizer costs. However, land application of the solid fraction is limited by its high phosphorus content.
- Reducing dietary crude protein and increasing dietary fibre for pigs reduced manure volume, ammonia emissions and increased manure dry matter. However, including dietary fibre reduced separation efficiency and consequently did not increase the dry matter content of the separated solid fraction from pig manure.

Opportunity / Benefit:

Pig farmers are well informed of the benefits and costs of solid-liquid manure separation and are provided with options (such as dietary changes and reduction of water use) to improve manure composition and reduce manure volume on their farms. Crop farmers are informed of the financial opportunities of using the liquid and solid fractions of separated pig manure in addition to chemical fertilizers on winter wheat.

Collaborating Institutions:

UCD

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1. Project background:

The Nitrates Directive Action plan imposes restrictions on the use of pig manure on intensive grassland. Separation of manure into solid and liquid fractions gives the possibility of utilising the two fractions in different situations (e.g. the solid fraction which is rich in phosphorus (P) might be used on tillage land and the liquid which is relatively rich in nitrogen (N) might be used for grassland or even on growing cereal crops). In addition, it would allow the liquid fraction to be applied at a higher rate to land in the vicinity of the pig unit and the solid fraction could be transported more economically to land further away where nutrient requirements are higher. However, not much is known about the practical and economical benefits of solid-liquid separation for both pig and tillage farmers.

In addition, the variable composition of pig manure and the generally low nutrient content, limits the attractiveness of pig manure as a crop fertilizer. Reducing the manure volume by reducing water wastage and/or by optimising the water to meal ratio on pig units, would increase the dry matter content of pig manure. Manure of high dry matter has many advantages. It will occupy less storage space, cost less to transport and spread and has more nutrients per unit weight/volume.

The amount of nutrients excreted in manure (total per pig produced) can be minimised by feeding diets which are formulated to more closely match the nutrient requirements of the pig at each stage of growth. Reduced surpluses of nutrients in the diet will result in an overall reduction in manure nutrients and also a redistribution of nutrients between the faeces and urine. Other dietary influences include high fibre levels in diets which result in increased N excretion in faeces and reduced N excretion in the urine. The aim here was to determine how such dietary adaptations could be combined to minimize nutrient excretion and manure volume, and to determine their influence on solid-liquid separation.

2. Questions addressed by the project:

- What is the current composition of pig manure on Irish farms?
- Is solid-liquid separation an efficient option for treating manure?
- What is the fertiliser value of the separated solid and liquid fractions of pig manure?
- Can the composition of pig manure and the separated fractions be improved by changing diet composition?
- Is solid-liquid separation currently cost-effective compared to traditional land spreading?

3. The experimental studies:

A manure survey was carried out on a sample of 11 farms to give an indication of current pig manure composition. Samples were taken from under-slat storage tanks and analyzed for pH, dry matter, N, P and K.

The performance of a fixed decanter centrifuge for solid-liquid separation was monitored and compared to other mechanical separators. In addition, tests were carried out to determine the effect of chemical pre-treatments on separation efficiency. A field study was carried out to test the fertiliser value of the separated solid and liquid fractions for winter wheat. The latter was carried out over a two year period.

Several tests were run to determine the effect of pig diet composition on manure output. Pigs were fed diets with different levels of crude protein, dietary fibre (sugar beet pulp inclusion) and phosphorus in a set-up that allowed complete monitoring of input (feed) and output (urine and faeces). Manure output was analysed for nutrient composition and ammonia emissions. In a further test, the manure output was submitted to solid-

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liquid separation to determine the effect of diet on the partitioning of manure into the solid and liquid fractions.

The costs of solid-liquid separation by a decanter centrifuge and of manure haulage and spreading on land were modelled based on previous outcomes and compared. The economic implications of water management were also modelled.

4. Main results:

Based on the manure survey, current manure composition values are estimated at: dry matter: 48.0kg/m^3 (SD ± 3.8), N: 2.4kg/m^3 (SD ± 1.3), P: 1.3kg/m^3 (SD ± 1.4), K: 2.3kg/m^3 (SD ± 1.5), and pH: 7.55 (SD ± 0.58). Thereby the main finding is that nitrogen concentrations have decreased since the last manure survey (1996). A large variation between farms was found, illustrating the importance of management factors.

The fixed decanter centrifuge was found to produce solid fractions of up to 35% dry matter, thereby outperforming the other mechanical separators tested. The centrifuge proved to have a good performance regarding P removal, but its effect on N removal was poorer. Increasing doses of a coagulant (a liquid mixture of Polydadmac and Poly Aluminium Chloride) and a flocculant (a high molecular weight/highly cross linked Cationic Polyacrylamide), that were added during the separation process, were found to increase the separation efficiency of P and DM.

In the study with winter wheat, the average N uptake efficiency of separated liquid pig manure N was 67.3% with chemical N being 82.1%. Liquid pig manure use at the stem elongation phase of crop growth made a significant contribution to crop performance increasing grain yield and grain protein levels, compared to inorganic N use alone. Separated solid pig manure application increased grain yield and crop nitrogen uptake of spring barley compared to untreated treatments, but also increased crop lodging. Solid pig manure application may be a useful N source for spring barley on lower N index soils. However, its high phosphorus content will limit its rate of application.

Inclusion of dietary fibre (sugar beet pulp) reduced manure output possibly reflecting the reduced water and dry matter intake of pigs offered diets containing sugar beet pulp. Moreover it reduced the urine: faeces output ratio and therefore increased the dry matter content of the manure. However, dietary fibre did not increase the dry matter of the separated solid fraction, due to a decrease in separation efficiency. Reducing crude protein levels and including sugar beet pulp in diets resulted in lower ammonia emissions from manure. The effects were additive, with a low crude protein diet formulated to include sugar beet pulp delivering the lowest emission value. Thus, lowering crude protein and including sugar beet pulp in pig diets will increase manure quality, but does not improve the separated solid and liquid fractions.

The annual costs of separation with a fixed decanter centrifuge were estimated at €123,067 (€11.7 per m^3 of manure) for a 500 sow integrated pig farm, producing 10,500m^3 manure per year at 4.8% dry matter. After separation, however the two separated fractions still need to be transported and spread on land. In comparison, transport of the raw liquid pig manure with a tractor and tanker for a distance of 1km and spreading would cost €13,877 (€1.32 per m^3 of manure) per year. Haulage with a truck for 100km and spreading would cost €123,830 (€11.79 per m^3 of manure) per year. Thus, direct land spreading remains the most cost-effective manure management option. With regard to water management as a means of reducing manure volume and haulage costs, reducing the water: meal ratio (without affecting animal welfare) was calculated to yield the greatest immediate benefit.

5. Opportunity/Benefit:

The findings of this project have been communicated to pig farmers, who can use this information to make well considered decisions with regard to manure handing, animal feeding and water management. Crop farmers were informed of the benefits and limitations of using separated pig manure fractions as crop fertilisers. The results have been published in scientific and popular articles and were communicated to pig farmers in workshops.

6. Dissemination:

Main publications:

O'Shea, C.J., Lynch, B., Callan, J.J., Lynch, M.B. and O'Doherty, J.V. (2010) 'Effect of cereal type and crude

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protein concentration of high and low phosphorus pig diets on nutrient digestibility, nitrogen and phosphorus excretion and composition of separated liquid and solid pig manure fractions' *Journal of Animal Science* 88:1411-1420.

Meade, G., Lalor, S.T.J., McCabe, T. (2011) 'An evaluation of the combined usage of separated liquid pig manure and inorganic fertiliser in nutrient programmes for winter wheat production' *European Journal of Agronomy* 34(2): 62-70

Popular publications:

Lynch, B. (2006). Manure processing. Teagasc pig newsletter Vol. 9 (2): 7-1

Treanor, S. (2008) Pearls from pigs. Today's Farm Vol. 19 (1): 36-37.

Lynch, B. (2008). Costing pig manure handling. Teagasc pig newsletter Vol. 11 (2): 6-7

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