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Studies on the management and utilisation of soiled water and dilute slurry on Irish farms

Key external stakeholders:

Dairy farmers, dairy industry, policymakers

Practical implications for stakeholders:

- Dairy soiled water (DSW) is water from concreted areas, hard stand areas and holding areas for livestock that has become contaminated by livestock faeces or urine, chemical fertilisers and parlour washings.
- This project examined dairy soiled water produced on Irish dairy farms, to assess soiled water quantity and composition, and the best management options available to farmers.
- On average, 9784 l of DSW are produced per cow per year, containing 6.9, 0.9 and 6.3 kg of N, P and K, respectively and has potential as an organic fertiliser on-farm.
- Dairy soiled water has a high fertiliser replacement value for grass growth. Greater effectiveness as a fertiliser than slurry due to better infiltration and decreased ammonia losses.
- Current management of slurries and soiled water in Ireland is regulated primarily by the Nitrate Regulations (SI No. 101 of 2009) giving effect to Council Directive 91/676/EEC.
- The Nitrate Regulations define soiled water as having a Biological Oxygen Demand (BOD) of less than 2,500 mg/l or a dry matter (DM) content of less than 1 %. Anything more concentrated is considered a slurry.
- The highest economic savings can be attained using low cost storage and application methods combined with strategic application during the growing season for optimum NFRV and DM response.

Main results:

- Dairy Soiled water contains significant quantities of nutrients (N, P, K) and has potential as an organic fertiliser on-farm. high fertiliser replacement value for grass growth
- On average, 9784 l of DSW are produced per cow per year, containing 6.9, 0.9 and 6.3 kg of N, P and K, respectively.
- For a typical Irish dairy farm stocked at 2.5 cows ha^{-1}, this DSW could supply approximately 17.2, 2.3 and 15.8 kg ha^{-1} of N, P and K, respectively, across the farm, annually.
- Woodchip can be used as a filter medium as an effective method of reducing the concentration of organic matter, suspended sediment, and nutrients, which proved to be an effective alternative treatment process for DSW.
- The results illustrate that, integration of dairy soiled water (DSW) into nutrient management planning, while applying during conventional agronomic practices, reduced total N emissions and leaching losses compared to inorganic fertiliser.

Opportunity / Benefit:

These results have implications for dairy farmers, the dairy industry, policy makers and the research community. The findings provide valuable data on dairy soiled water focusing in its nutrient and biological content, agronomic response, environment losses, treatment options and the economic implications of different management practices. These findings allow DSW to be integrated into farm nutrient management planning, enabling farmers to use DSW as a replacement for inorganic fertiliser N in temperate grassland systems.

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1. Project background:

Irish agriculture must conform to EU requirements under the EU Nitrates Directive and the Water Framework Directive to reduce the nitrate loss from farming systems to improve the quality of water. Currently producers are under increased economic pressure due to volatile product prices and increasing costs of production while minimising any negative effects on the environment. Producers are increasingly looking towards adopting efficient low cost production systems, while utilising all available resources of the enterprise.
This project characterised soiled water produced on Irish dairy farms and examined the effects its management and utilisation.
Dairy soiled water (DSW) is a farm effluent produced through the washing-down of milking parlours and holding areas to maintain hygiene levels in the production of high quality milk. Dairy soiled water consists of a relatively dilute mixture of cow faeces, urine, spilt milk and detergents. This effluent typically contains nutrients that are potentially plant-available but may also pose a risk of environmental pollution if not managed correctly. The best management option for organic residues, both in Ireland and internationally, is land application and appropriate applications are widely recognised as an opportunity to enhance plant nutrient supply and soil structure. However, while they can be beneficial, a number of studies have also confirmed the environmental problems associated with organic residue application. Current management of these effluents in Ireland is regulated primarily by the Nitrate Regulations giving effect to the EU Nitrates Directive. The regulations are focused on decreasing N loss to ground and surface waters through improved on-farm nutrient management. The Nitrates Directive states that there should be a balance between nitrogen supply from animal manures and chemical fertilisers and the nitrogen demand of the crop, thus avoiding nitrogen surpluses and associated losses to water. However, little is known about its nutrient content, and the effect of management practices on DSW production. Knowledge of nutrient sources on farm is a prerequisite to effective nutrient management planning to increase farm efficiency and profitability while protecting water quality.

2. Questions addressed by the project:

The project was established, to identify soiled water/dilute slurry management practices which, maximise nutrient uptake by grass, minimise risk of nutrient loss to the environment.
To devise and disseminate best-practice guidelines for the management of soiled water/dilute slurry.
Promote sustainability, reducing risk to the environment by providing better management solutions for soiled water/dilute slurry. Increasing nitrogen efficiency; decreasing the impact of reduced organic nitrogen limits. Increasing nutrient recovery from soiled water/dilute slurry while reducing fertiliser requirements and costs.

3. The experimental studies:

This study quantified DSW production on Irish dairy farms and assessed the agronomic benefit and environmental risks associated with application to grassland. Sixty dairy farms across 18 counties were surveyed to characterise the volumes and chemical composition (nutrients and other biochemical parameters) of DSW produced on Irish dairy farms and to relate them to management practices. The number of farms selected in each county was reflective of it's share of the national dairy herd so that each farm represents between 10,000 and 20,000 dairy cows. Dairy soiled water was evaluated to assess the risks of loss of nitrogen to the environment through leaching and gaseous emissions using Lysimeters with two contrasting soil types. Laboratory scale and farm scale wood chip filters were constructed to test the potential of woodchips as a filter for treating and polishing soiled water. A plot experiment was undertaken to

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evaluate herbage yield response from DSW applied to grassland on two sites with contrasting soil and drainage conditions. The effect of application timing (season) and dilution on yield was also investigated. Inorganic NFRV of DSW for herbage production was calculated to assess the potential of DSW as a replacement for inorganic fertiliser N in temperate grassland systems. An economic evaluation was undertaken to assess of a range of solutions for the management of soiled water/dilute slurry on Irish farms. The different management solutions investigated the economic effect of contrasting storage and application methods, combined with a range of storage periods.

4. Main results:

- On average, 9784 l of DSW are produced per cow per year, containing 6.9, 0.9 and 6.3 kg of N, P and K, respectively.
- A typical Irish dairy farm stocked at 2.5 cows ha^{-1} this DSW could supply approximately 17.2, 2.3 and 15.8 kg ha^{-1} of N, P and K, respectively, across the farm, annually.
- Mean nitrogen fertiliser replacement values of 72 to 90 % indicate that DSW has the potential to substitute for inorganic fertiliser N.
- Dairy soiled water has the potential to used as a fertiliser to increase grass herbage production during the growing season. Yield response to soiled water application were similar to that of inorganic fertiliser.
- The optimal application timing, agronomically and environmentally, is during the growth period, from March to September. The integration of dairy soiled water (DSW) into nutrient management planning, while applying during conventional agronomic practices, reduced total N losses from nitrate leaching and nitrous oxide emissions.
- The total N losses observed for integrated DSW treatments were significantly lower than that of FN.
- Total N losses (leaching) for the DSW integration treatments were reduced by 45-38 %, when compared to chemical fertiliser.
- The integration of DSW into nutrient management planning, while applying during the grazing season, significantly reduced the production of N_2O (3.97 kg N $ha^{-1}yr^{-1}$) when compared to inorganic fertiliser (6.36 kg N ha^{-1} yr^{-1}).
- Application of DSW during the winter period significantly increased nitrate leaching and nitrous oxide losses.
- For the laboratory-scale filters, average COD, SS and TN decreases of 95, 99 and 88 %.
- The dominant treatment mechanism was physical filtration, but sorption and biological uptake also played a role. As the filters were aerobic, mineralisation and nitrification occurred.
- The farm-scale filters had average COD, SS, NH_4^-N, PO_4^-P and TN reductions of 66, 86, 72, 31 and 57 %, respectively, giving effluent concentrations of 1,961 mg L^{-1}, 84 mg L^{-1}, 37 mg L^{-1}, 24.7 mg L^{-1} and 153 mg L^{-1}. Effluent nutrient concentrations remained relatively stable over the study period, indicating the robustness of the filter.
- The effluents exiting the woodchip filters were put through a further filtration process using a Sand filter to further polish the effluent. The COD SS, TN exiting the sand filter was reduced by a mean of 55%, 62%, 57% respectively, Sand filters appear to offer an effective method of achieving good decreases in the concentration of organic matter, suspended sediment, nutrients and coliforms, highlighting sand filters are an effective component in the treatment process of DSW.
- The economic analysis highlighted, storage and application were the main costs associated with DSW.
- Storing DSW together with slurry proved to be up to 45% more cost effective per m^3 stored than storing DSW separately.
- Higher savings can be attained using low cost storage and application methods combined with strategic application during the growing season for optimum NFRV and DM response.

5. Opportunity/Benefit:

- Dairy soiled water has the potential to be used as a fertiliser to increase grass herbage production during the growing season. Yield response to soiled water application were similar to that of inorganic fertiliser and can substitute inorganic fertiliser N, offering cost savings to farmers and decreasing farm N surpluses and their associated environmental impacts.
- Strategic application of DSW during the growing season reduces emissions and leaching loss from N and increases herbage DM production.
- The N_2O emissions and NO_3 leaching losses from DSW were dependant on timing (season) of application. Winter application of DSW resulted in the highest N_2O emissions NO_3 leaching. The integration of DSW into nutrient management planning, with applications during the grazing season, significantly reduced the production of N_2O emissions NO_3 leaching, when compared to inorganic fertiliser. Soil type was not found

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to affect N_2O emission significantly, despite a strong contrast in soil type and drainage conditions.

- The use of woodchip as filter medium for treating DSW highlighted that, woodchip is a low cost, minimal maintenance treatment system using a renewable resource that can be easily integrated into existing farm infrastructure, as a treatment and management option for the DSW.
- The best economic and agronomic savings were generated from reduced purchase of fertiliser N and additional DM grown during the spring and summer months from strategic applications of DSW.
- The different DSW management strategies investigated highlight the highest economic savings can be attained using low cost storage and application methods combined with strategic application during the growing season for optimum NFRV and DM response.

6. Dissemination:

The primary stakeholders for this research are Irish dairy farmers, research scientists and policy makers. Findings have been presented at national and international conferences. Publication in peer-reviewed journals is on-going- one paper accepted, 5 more submitted and 3 in preparation. Dissemination using the popular press (The Farmer's Journal, Today's Farm, TResearch, Irish Examiner) and the internet (articles on Moorepark website) has been undertaken.

Main publications:

Ruane, E., Murphy, P., Clifford. E., O'Reilly, E., French. P., Rodgers. M. 2012. Performance of a woodchip filter to treat soiled water. Journal of Environmental Management 98 49-55.
Ruane, E., Murphy, P., Clifford. E., Healy G., French. P., Rodgers. M. 2011. On-farm treatment of dairy soiled water using aerobic woodchip filters. Water research 45 6668-6676.
Minogue D, French P, Bolger T & Murphy P 2011. The fertiliser potential of dairy soiled water in temperate grasslands. Agricultural Research Forum 2011, Tullamore, Ireland.

Popular publications:

Murphy PNC, Minogue D, Ruane E, French P, Bolger T & Rodgers M, 2011. Soiled water – a valuable resource. TResearch 6 (3), 26-27.
Murphy PNC., Minogue D., Boland A., and French P. 2011. Fertiliser Value of dairy soiled water. Irish National Dairy Conference 2011, The Irish dairy industry to 2015 and beyond, 84-88.

7. Compiled by:

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