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Agricultural Need for Sustainable Willow Effluent Recycling (ANSWER)

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Key external stakeholders:

Local authorities
Water utilities
Environmental policy makers
Farmers
Rural Communities

Practical implications for stakeholders:

The outcome/technology or information/recommendation is……

- An inexpensive proportional sampler is now available which can be used to measure overland flow at a large number of sites
- Results from the study suggest that overland flow is not a significant nutrient loss pathway when willow plantations are used to filter nutrients from wastewater.

Main results:

A proportional sampler for measuring overland flow water was developed. This technology is less expensive than current equipment but allows far more sites to be monitored at one time. The sampler provides a proportional sample from which total flow can be calculated. It gives a wide range of measurement possibilities on research centres and on farms.

Results from an experiment conducted at AFBI Hillsborough showed that the application of wastewater to a site with significant slope resulted in relatively small amounts of N and P runoff through the overland flow pathway.

The general conclusion from this research is that the risk of nutrient loss through the overland flow pathway is likely to be low when wastewater is applied to willow on suitable sites.

Opportunity / Benefit:

The development of a proportional sampler allows overland flow to be monitored at a large number of sites in a relatively short time. This means that aspects of soils and agriculture can be investigated at relatively low cost.
Willow plantations can be used to absorb nutrients from wastewater and reduce eutrophication to surface water without significant nutrient loss through the overland flow pathway.

Collaborating Institution

Agri-Food and Bio-sciences Institute

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Teagasc project team: John Finnan, Paul Galbally, Declan Ryan

External collaborators: Prof. Alistair McCracken, Agri-Food and Bio-Science Institute

1. Project background:

Wastewater must be treated before it is returned to the environment in order to remove contaminants which would pose an environmental risk but a significant number of waste water treatment plants in rural areas can only offer rudimentary treatment before wastewater is returned to surface water. However, wastewater from such small rural plants can be applied to energy crops whose growth is enhanced by absorbing the nutrients from these wastes. In this way, the potential for eutrophication to nearby rivers and streams is decreased using a mechanism by which the yield of renewable energy resources is increased. The ANSWER project had the objective of exploring the practical, commercial, and sustainable environmental aspects of using short rotation coppiced willow plantations to treat tertiary wastewater that has already received treatment, but is still not of a quality good enough for release to water courses. However, the practise of waste application to energy crops has still to be proven to be safe and one concern is that the surrounding environment will be affected adversely from direct overspill of wastewater being applied to a willow plantation through runoff. One of the quickest loss pathways is for nutrients or organic matter to be carried away (or "lost") in surface flows of water during heavy rainfall events, termed "overland flow". Overland flow can occur when soil becomes saturated and unable to absorb any more liquid ("Saturation Excess"), or when the rate of application exceeds the ability of the ground to absorb (or infiltrate) the wastewater being applied ("Infiltration Excess"), and also when the ground the wastewater is being applied to is highly compacted thereby permitting water to flow freely across it with little infiltration. This latter problem is unlikely to occur in willow plantations.

2. Questions addressed by the project:

- Is it possible to make simple overland flow instruments that can take a proportional sample
- Can wastewater be applied to willow plantations without the risk of significant nutrient loss through overland flow

3. The experimental studies:

The experimental studies were conducted in two stages. The first stage involved the design and proofing of a proportional sampler for overland flow. In the second stage, overland flow samplers which were developed in the first stage were deployed to measure overland flow in a willow plantation irrigated with wastewater.

The principal of a proportional flow sampler is that flow through the weir and sampler is proportional to the main flow so sample volume is proportional to main flow volume. Therefore if sample volume and composition is known flow volume can be calculated as also can export of dissolved chemicals. A shallow tank was constructed as a laboratory rig in order to develop and test proportional sampler designs. The rig was 2 m wide with walls 0.15 m high and sloping forward towards the outlet weir. Port location, ground slope and sampler slope were all found to have significant effects on sample flow and proportional measurement. It was found that these parameters needed to be optimised in the design and installation of the proportional samplers in order to ensure accurate results.

Overland flow was measured from willow plots irrigated with wastewater which were located at AFBI's research station at Hillsborough, Co. Down. This site features a significant slope where there is a greater possibility of overland flow being measured compared to a flat site.

Overland flow sutro weirs included electronic sensors which recorded overland events in real time were

installed on four plots which received waste water irrigation and four control plots which received no irrigation. The devices were installed in late 2013 and were run from December 2013 until October 2014 providing overland flow and nutrient loss data for 11 months through a variety of seasonal conditions. Over the winter months of January and February 2013, overland flow was recorded as occurring on all plots selected, and samples were captured from each individual sampler. There was significant variance in how plots reacted to rainfall in terms of overland flow, some being more prone than others to the phenomenon. Captured samples were filtered and analysed in a commercial laboratory for their nitrate and phosphorous concentrations, and export loads were calculated from the total overland flow recorded.

4. Main results:

Both V-notch and Sutro weirs were tested for proportionality but only the Sutro weir was found to offer a proportional relationship between sample flow and main flow.
The sampler was mounted at various places around the weir but a location directly below the weir was found to be best. The sampler was further tested at various slopes, with a hump in the middle, ventilation and with various nozzles and pipe sizes. A 1 mm nozzle at intake and at two points at the vent provided sampling down to 1/1,000. Flow through the final sampler proved to be proportional to pressure so the weir and sampler combined gave proportional flow.

Sutro weir (left). Sutro weir installed at Hillsborough (right)

Overland flow data was used to measure export of both N and P from each of the Hillsborough plots, there were significant differences between treatment and control plots, with higher nutrient export from treatment plots.

The total exports of both nitrate and phosphate recorded during the winter season were relatively small as can be seen in the figure, and there was no significant difference between controls and treated plots. The highest exports occurred in the summer months when wastewater irrigation was ongoing. However, averaged losses were of the order of approximately 100 g ha-1 y-1 whereas losses from arable land spread with commercial fertilizer can often run into tens of kg of dissolved material.

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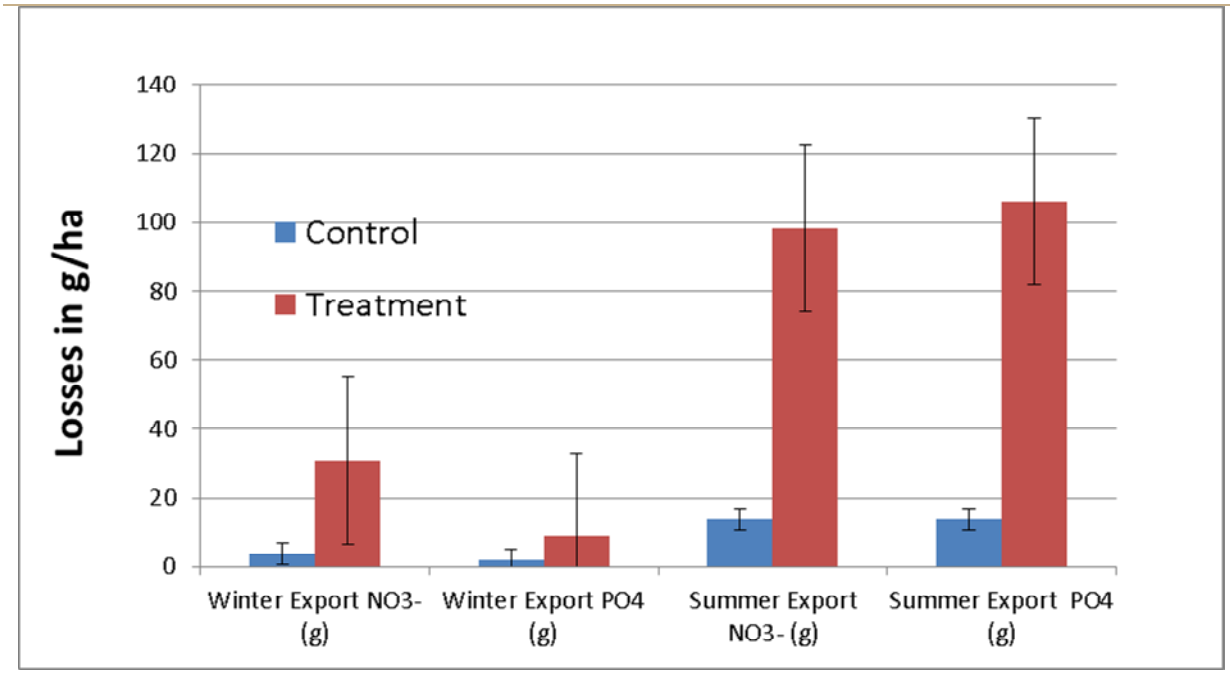

Export of P and N from control and treatment plots, winter and summer 2013-2014

Overall, the results suggest that application of wastewaters to sites such as those at Hillsborough are manageable and only result in relatively small amounts of N and P runoff. This result is significant as overland flow events are more likely to be measured at sites with significant slope such as that at Hillsborough. On more suitable sites without significant slope, the risk of nutrient loss from overland flow can be expected to be lower than that in Hillsborough. Thus, the general conclusion from this research is that the risk of nutrient loss through the overland flow pathway is likely to be low when wastewater is applied to willow on suitable sites. However, measurements on several sites is recommended in order to verify this result.

5. Opportunity/Benefit:

The development of a proportional sampler allows overland flow to be monitored at a large number of sites in a relatively short time. This means that aspects of soils and agriculture can be investigated at relatively low cost.

Willow plantations can be used to absorb nutrients from wastewater and reduce eutrophication to surface water without significant nutrient loss through the overland flow pathway.

6. Dissemination:

Main publications:

Ryan, T.D. and Forristal, D.2014. Laboratory Development of a Passive Proportional Sampler for Overland Flow Studies in Agricultural Fields. Canadian Biosystems Engineering Journal, Vol. 56, 7 pages

Popular publications:

Ryan, D. and Galbally, P .2014. Water Quality in tillage and grassland T-Reseach, 9(2), Pages 42, 43.

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