Project number: 6099
Funding source: Teagasc
Date: Dec 2015
Project dates: July 2011-Dec 2015

Time Lag in the soil: tracking "nutrient trajectories" to link measures and water quality.

Key external stakeholders:
Water Quality Regulators
Policy Makers
Farmers

Practical implications for stakeholders:
Time lag during nutrient transport from a source to a receptor (including both soil and groundwater components) may delay water quality response to agricultural programmes of measures for mitigation beyond remediation deadlines e.g. under the EU Water Framework Directive (WFD). Ascertaining the duration of time lags in the soil unsaturated zone is critical to inform policymakers about expected response times and facilitate evaluation of programs of measures efficacy. A methodological toolkit has been developed for determining unsaturated time lag ranges in agricultural catchments.

Main points

- **Farmers:** programmes of measures take a while to affect water quality and the duration or delay depends on many factors such as soil type and underlying geology.
- **Policymakers:** The unsaturated zone provides a basis for early indications of efficacy and should be monitored in vulnerable catchments.
- **Scientific:** A methodological toolkit has been developed for determining unsaturated time lag ranges in agricultural catchments.

Main results:

- A toolkit to estimate unsaturated zone time lag was created.
- Monitoring should focus on the unsaturated zone to give quick indicators of whether mitigation measures are working or not.

Opportunity / Benefit:

- Using such a tool could indicate in a much shorter timeframe when programmes of measures are affecting water quality.

Teagasc project team: Dr. Owen Fenton
Dr. Karl Richards
Dr Rachel Creamer
Dr Sara Vero

1. Project background:

The European Union Water Framework Directive (WFD) requires that all water bodies attain 'good' chemical qualitative status (amongst other stipulations) within set reporting periods (e.g. 2015). Attainment of this status is attempted through implementation of programmes of measures (POM), such as those described by the Nitrates Directive, which remediate pollution from agricultural sources via land and fertiliser management strategies. However, the inherent delay or 'time lag' that surplus nutrients (or other potential contaminants such as heavy metals or pesticides) encounter through subsurface pathways renders correlation between POM efficacy and water body status challenging. Time lag can take a long time and it is split into a unsaturated (soil) and saturated (rock) component. This project focuses on the soil component to see if early

Contact Dr Owen Fenton Email: owen.fenton@teagasc.ie.

indicators in much quicker time frames can be elucidated.

2. Questions addressed by the project:

- Does the unsaturated zone offer potential in a quicker time frame to assess the efficacy of programmes of measures?

3. The experimental studies:

This was a laboratory and field based study with associated open day and training events, which culminated in scientific publications.

4. Main results:

The results of this study indicate that predicting when "nutrient trajectories" can be picked up in unsaturated zones is possible within much shorter time periods than expected for time lag equivalents. A range of potential unsaturated time lag within studied catchments, depending on the stage of transport in question, soil series, and depth of the soil profile (or slope position). In the study catchments, trends were first observed at the base of the soil profile up to 27 months after implementation of measures, while the full effects (time lag) may exceed 6 years within the two catchments studied. It is important to recognise that the catchments studied were considered to be well drained, and so more prolonged durations may be likely at other locations, and furthermore, this represents a basic toolkit framework which should, in future, be built upon in order to account for nutrient attenuation.

5. Opportunity/Benefit:

From a policy perspective, employing this toolkit bridges a critical knowledge gap by identifying trends in water quality quickly based on existing soil data. Such an approach is implementable at other sites, requiring only appropriate input data, and access to freely available models of unsaturated zone flow. From a research perspective, this toolkit introduces a hitherto unachieved level of site-specificity to time lag assessment. A potential agricultural research application of this toolkit, outside of WFD deadline appraisal, is in characterisation of study locations. Unlike more generic approaches to time lag quantification, the toolkit allows tailoring of input data selection, with respect to the level of characterisation required, financial and time constraints pertaining to parameter assessment, the stage of unsaturated time lag in question, and uncertainties regarding water table/bedrock depth.

6. Dissemination:

Throughout the project there was a comprehensive series of open days and training days for a variety of stakeholders on time lag.

Main publications:

Vero, S.E., Ibrahim, T.G., Creamer, R.E., Grant, J., Healy, M.G., Henry, T., Kramers, G., Richards, K.G., Fenton, O. (2014) 'Consequences of varied soil hydraulic and meteorological complexity on unsaturated zone time lag estimates'. Journal Of Contaminant Hydrology, 170 :53-67

Vero, S.E., Healy, M.G., Tiernan, Creamer, Ibrahim, Richards, Mellander, McDonald, Fenton, O. 2017. A framework for determining unsaturated zone water quality time lags at catchment scale. Agriculture, Ecosystems and Environment 236: 234–242

Popular publications:

Vero, S.E., Creamer, R.E., Healy, M.G., Henry, T., Forristal, P., Richards, K.G., Fenton, O. (2015) Achieving equilibrium in the soil water characteristic curve: an 'effective' approach ASA, CSSA, and SSSA International Annual Meeting Minneapolis, MN, , 13-NOV-15 - 19-NOV-15

7. Compiled by: Dr. Owen Fenton

Contact Dr Owen Fenton Email: owen.fenton@teagasc.ie.