Assessing the potential impacts of a revised set of on-farm nutrient and sediment 'basic' control measures for reducing agricultural diffuse pollution across England

A.L. Collins a,⁎, J.P. Newell Price b, Y. Zhang a, R. Gooday c, P.S. Naden d, D. Skirvin c

a Sustainable Agriculture Sciences Department, Rothamsted Research, North Wyke, Okehampton, Devon EX20 2SB, UK
b ADAS, Gleadthorpe, Meden Vale, Mansfield, Nottinghamshire NG20 9PD, UK
c ADAS, Titan 1 Offices, Conwell Avenue, Wolverhampton Science Park, Wolverhampton WV10 9RT, UK
d CEH Wallingford, Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB, UK

HIGHLIGHTS

• Stakeholders scored ninety measures for water pollution from agriculture.
• Model optimisation shortlisted twelve measures for livestock and arable farms.
• Shortlisted measures reduced national nitrate load to rivers by 2.5%, sediment 5.6%.
• Shortlisted measures reduced national phosphorus load to rivers by 11.9%.
• Annual cost to farms at national scale was £450 M equating to £52 per hectare.

GRAPHICAL ABSTRACT

ABSTRACT

The need for improved abatement of agricultural diffuse water pollution represents cause for concern throughout the world. A critical aspect in the design of on-farm intervention programmes concerns the potential technical cost-effectiveness of packages of control measures. The European Union (EU) Water Framework Directive (WFD) calls for Programmes of Measures (PoMs) to protect freshwater environments and these comprise 'basic' (mandatory) and 'supplementary' (incentivised) options. Recent work has used measure review, elicitation of stakeholder attitudes and a process-based modelling framework to identify a new alternative set of 'basic' agricultural sector control measures for nutrient and sediment abatement across England. Following an initial scientific review of 708 measures, 90 were identified for further consideration at an industry workshop and 63 had industry support. Optimisation modelling was undertaken to identify a shortlist of measures using the Demonstration Test Catchments as sentinel agricultural landscapes. Optimisation selected 12 measures relevant to livestock or arable systems. Model simulations of 95% implementation of these 12 candidate 'basic' measures, in addition to business-as-usual, suggested reductions in the national agricultural nitrate load of 2.5%, whilst corresponding reductions in phosphorus and sediment were 11.9% and 5.6%, respectively. The total cost of applying the candidate 'basic' measures across the whole of England was estimated to be £450 million per annum, which is equivalent to £52 per hectare of agricultural land. This work contributed to a public consultation in 2016.

© 2017 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Keywords:
Control measures
Costs
Efficacy
Nutrients
Sediment
Water Framework Directive

⁎ Corresponding author.
E-mail address: adrian.collins@rothamsted.ac.uk (A.L. Collins).
1. Introduction

Agricultural diffuse sources of pollution are recognised as the principal polluters of many rivers and lakes worldwide including those in the Baltic (Elofsson et al., 2003), Mediterranean (Panagopoulos et al., 2011), north America (Kramer et al., 2006), Europe (Lacroix et al., 2005; Crossman et al., 2013; Berger et al., 2017; Fischer et al., 2017; Mockler et al., 2017), Australia (Kroon, 2009; Thorburn, 2013; van Grieken et al., 2013; McDowell and Nash, 2013) and New Zealand (McDowell and Nash, 2013). The significant challenges posed by delivering effective control of diffuse pollution sources, including agriculture, mean that globally, the degradation of freshwater ecosystems has outpaced remedial action (e.g. Doole et al., 2013). In addition, climate change, land use change, and the need to provide food, water and other ecosystem services for a growing population have combined to create a ‘perfect storm’ (Beddington, 2009).

Since its introduction in 2000, the European Union (EU) Water Framework Directive (WFD) (Directive 222/60/EC; European Commission, 2000, 2012) has focussed much scientific research and policy team work across Member States on the problems of controlling diffuse agricultural pollution and especially those posed by elevated policy targets (Bouraoui and Grizzetti, 2014). Ongoing programmes are that evidence is increasingly required on the scope for combined or integrated diffuse agricultural pollution control measures to help achieve policy targets (Bouraoui and Grizzetti, 2014). Ongoing programmes are designed to deliver such evidence, including the Demonstration Test Catchments (DTC) initiative in England (McGonigle et al., 2012, 2014; Outram et al., 2014) and many other studies both in the EU and elsewhere (Gren et al., 1997; Elofsson, 2003; Berbel et al., 2011; Panagopoulos et al., 2011; Gren et al., 2013; Lescot et al., 2013; Panagopoulos et al., 2014; Roebeling et al., 2014; Rocha et al., 2015). The complexities of pollution mobilisation, transfer and delivery through river catchments mean, however, that monitored outcomes will take years to decades to confirm successful impacts arising from targeted on-farm remediation (Kronvang et al., 2005; Meals et al., 2010; Collins et al., 2014; McGonigle et al., 2014; Wang et al., 2016).

Given the need to inform policy in the short-term, a range of approaches has been used to perform analyses of the technically feasible costs and effectiveness of packages of pollution control measures including nonlinear (Brady, 2003) or linear mathematical programming (Azzaino et al., 2002; Froschl et al., 2008; Cardenas et al., 2011), process-based (including spatially-distributed) modelling of nutrient exports (Lam et al., 2010; Rocha et al., 2015) or critical source areas (Roebeling et al., 2009; Shang et al., 2012; Lescot et al., 2013; Chen et al., 2014; Roebeling et al., 2014; Perez-Martin et al., 2016; Teshager et al., 2017), hydro-economic (Yang et al., 2007) or bio-economic modelling (Schou et al., 2000; Semaan et al., 2007; Eory et al., 2013; Ferrant et al., 2013), agricultural sector programming (Ribaud et al., 2001), abatement-cost curves using computable general equilibrium or partial-equilibrium models (Moran et al., 2010; Doole, 2012) and fuzzy logic (Ruitenbeek et al., 1999) or Bayesian belief networks (Barton et al., 2008).

A critical issue in the science-policy arena for diffuse agricultural water pollution and its cost-effective control is that there is growing evidence that the existing delivery of mitigation measures is not sufficiently targeted to deliver environmental outcomes commensurate with the value of environmental assets to society (Poole et al., 2013; Roebeling et al., 2016). In England, for example, a study of diffuse pollution and environmental status compliance concluded that the substantial expenditure on controlling the problem had not delivered value for money (NAO, 2010). Independent scientific evidence has also underscored the limited impact resulting from the current farmer uptake of water pollution interventions at national scale (Collins and Zhang, 2016). Consequently, packages of control measures need to be reviewed and revised to help secure positive environmental outcomes. Such experience is common across EU Member States and in its review of River Basin Management Plans (RBMPs) in 2012, the European Commission recommended that there is a need to ‘step up ambition in taking measures to achieve good status’.

Article 11.3 of the EU WFD sets out the requirements for PoMs to implement options and methods for preventing further deterioration of the status of freshwater environments. Control measures are divided into ‘basic’ (mandatory) and ‘supplementary’ (incentivised) categories. ‘Basic’ measures are described as minimum requirements including relevant existing EU legislation (e.g. the Nitrate Directive), designed to control practices resulting in point (e.g. farm yards) and diffuse (e.g. fields) source pollutant emissions. Mandatory expectations of farmers in England are outlined in so-called Cross Compliance which must be followed to secure support payments such as those administrated by the Basic Payment Scheme (BPS) or agri-environment agreements. Cross Compliance (Defra, 2016) comprises Statutory Management Requirements (SMRs) and standards of Good Agricultural and Environmental Condition (GAEC). In terms of SMRs relevant to agricultural pollution control, SMR1 is most relevant and pertains to reducing water pollution in Nitrate Vulnerable Zones (NVZs designated under the Nitrate Directive). GAEC rule 1 (establishment of buffer strips along watercourses), GAEC 4 (minimum soil cover), GAEC 5 (minimum land management reflecting site specific conditions to limit soil erosion) and GAEC 6 (maintenance of soil organic matter level through appropriate practices, including a ban on burning arable stubble, except for plant health reasons) are all relevant to nutrient and sediment management by the agricultural sector in England.

To comply with Article 11.3 and in the context of the need to review and revise PoMs, the Department for Environment, Food and Rural Affairs (Defra) and Environment Agency in the UK have recently funded research to inform policy on the options to develop a new candidate set of ‘basic’ measures that address the most common causes of agricultural water pollution. These measures need to be broadly applicable to all farmers for helping to tackle harmful emissions, including those represented by nutrients and sediment. The uptake of these ‘basic’ measures could be encouraged through a range of approaches including, government sponsored advice, promotion by the industry, as well as inclusion in farm assurance schemes and Cross Compliance, with strategic implementation underpinned by a ‘polluter pays’ approach driven by regulation. The work aimed to identify a candidate revised set of ‘basic’ measures that would be effective in addressing the most common water quality pressures and, critically, to gauge its acceptability to the farming industry. In doing so, five steps were used in this study: i) examination of the main pollution pressures arising from agriculture; ii) assessment of the current regulatory expectations of farmers; iii) identification of an alternative set of ‘basic’ measures; iv) assessment of the technical costs and effectiveness of implementing the alternative set of ‘basic’ measures and; v) consideration of the estimates of effectiveness in the context of cross sector pollutant emissions to rivers. The work involved integrating industry engagement and computer modelling of the technically feasible impacts of increased uptake of the shortlisted measures and therefore differed from much previous work wherein scientists independently select mitigation scenarios and run the corresponding simulations.
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات