THE AGRICULTURE - WATER INTERFACE – WHY IS IT CRITICAL TO THE ENVIRONMENT?

Globally, agriculture is reported to account for 34% of land area usage, contributes circa 24% of global greenhouse gas emissions and accounts 70 % of freshwater usage. Agriculture also plays a major role in water pollution and especially the degradation of inland and coastal waters and therefore is a major player when it comes to discussing current and future strategies for global environmental protection.

Water is the biggest limiting factor in our ability to feed a growing population. 40% of all food produced is irrigated and by 2030 it is predicted that the world will need a 69% increase in food calorie production and as a result the demand for water is predicted to exceed supply by 40%. It has also been claimed that climate change will account for about 20% of the worlds water scarcity by 2020 and the United Nations have reported that better water management is key to adapting to the effects of climate change.

These interesting facts were only some of those presented and discussed at a 1 day meeting in the Royal Society of Chemistry (RSC) on 1st November 2018 in London titled "The agriculture water interface – Current topics". The conference was jointly organised by the RSC Agriculture Sector and Water Science Forum interest groups and the day was split into 3 perspectives:- firstly from the Agricultural Industry, then from the Regulatory perspective and finally from those involved in monitoring and mitigating the fate of pollutants in water. This article summarises the key points from the presentations and highlights some major messages from the day. The full programme and pdf copies of the individual presentations can be found on the RSC Water Science Forum website at http://www.rsc.org/Membership/Networking/InterestGroups/WaterScience/Agriculture-2018.asp

The Industry Perspective

This session featured presentations form a range of activities in agricultre based industries and was opened by Steve Cann, from Future Food Solutions, who gave a farming perspective and described the "Sustainable Futures" programme which is looking at ways of locking sustainability actions into the supply chain. The programme focusses on four main elements: - actively encouraging supply chain collaboration, promoting the use of innovation and novel solutions, conserving key resources and ensuring long term supply chain resilience and profitability. To date the programme has engaged over 200 broad acre farmers in a whole supply chain approach linking farmers through to brands. It features peer learning with farmers both at home and abroad, the use of novel farm trials such as inter-row cropping, cover crops, transplanted sugar beet, soil analysis and precision farming technology and they have developed online systems to capture sustainability profiles and track improvements. Two of their high priority areas were in water management and increasing soil quality where raising the level of organic matter in the soil by 1% will retain an extra 20,000 gallons of water per acre (Fig 1).

The producers of crop protection solutions followed with a presentation titled "Stewardship approaches for water protection" by Dr Alison Hall from Adama Agricultural Solutions UK. Dr Hall began by introducing the use of voluntary stewardship of crop protection chemicals through a collaborative approach with end users. She showed Environment Agency data for the number of

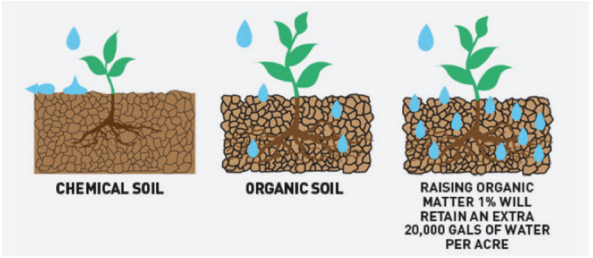

Fig 1 Soil quality is important in improving water holding capacity and increasing plant root depth and size. Source http://www.microlifefertilizer.com/academy/organic-landscapes-conserve-water

UK surface and groundwater abstraction points considered to be at risk from contamination (Fig 3) and it was noticeable that metaldehyde from slug control was by far the biggest risk. Dr Hall introduced the Voluntary Initiative (VI) which is an industry-led partnership (https://voluntaryinitiative.org.uk/) with a mission to promote the responsible use of pesticides in order to protect water and the wider environment and ensure the availability of professional pesticides in agriculture and horticulture while avoiding unnecessary regulation on the sector. The initiative has a number of stewardship schemes and tools to help those using pesticides to do so while protecting water, the wider environment and human health. Details can be found on their website and Dr Hall went on to describe the application of several of these tools including Water Aware. Water Aware is a smartphone app which links data for the location, soil type, soil moisture deficit, forecast weather and an active substance decision tree to determine the likelihood of drains flowing in the next 7 days and then advise on whether it is considered safe to apply the selected product. The Voluntary Initiative is also working with water companies and the agricultural sector in its entirety to raise awareness of the issue and promote and encourage best practice in Oil Seed Rape (OSR) agronomy to help protect water. Five key herbicides used to grow oilseed rape and control blackgrass and other weeds in arable rotations are being detected with increasing frequency in surface water. The OSR herbicides being detected are metazachlor, propyzamide, carbetamide, quinmerac and clopyralid. Propyzamide is the most frequently detected, while quinmerac and clopyralid are more difficult for water companies to remove. The OSR Herbicides Think Water stewardship scheme is working with water companies and the farming and crop protection industry to raise awareness of the issue, improve practices and develop new tools that will support farmers in continuing their responsible use of these herbicides.

The final presentation in the industry session was "Working with Nature – Creating Business Value from Healthy Landscapes" by Andrew Griffiths, Head of Sustainability for Nestle UK. He began by discussing water as a critical global sustainability issue and that water was essential to Nestle to run their business from running factories and growing their ingredients, to the consumer aspects of their packaged water products and the water needed to prepare their products in use. They have along with their partners developed a clear and aligned approach to water stewardship at the global and local level with a focus on their factories, the agricultural supply chain, local communities and the preservation of shared water resources. Since 2007 as a result of their Reduce, Reuse, and Recycle management they have reduced water withdrawals per tonne of product by 60% in the UK and Ireland and 38% globally. They also work with Landscape Enterprise Networks (LENs) in creating business value from healthy landscapes and have active projects with milk suppliers in Cumbria and Scotland and with cereal suppliers across England. (https://iale.uk/landscape-enterprise-networks-lens-creating-business-value-healthy-landscapes)

The Regulatory Perspective was covered by Dr Robin Blake from Compliance Services International with a talk titled "Importance of chemical legislation to water quality in agriculture" who began by reiterating global food security challenges and the importance of water to agriculture. Agriculture globally accounts for 70% of freshwater use but it also plays a major role in water pollution and especially the degradation of inland and coastal waters and therefore it was critical that legislation is in place to protect this increasingly finite resource. He described the EU Water Framework Directive (WFD) which is intended to establish a framework for the protection of inland surface waters, coastal waters and groundwater. It is an innovative approach for water management based on river basins and the aim is for Member States to achieve "good status" of all water bodies by a set deadline. For surface water the "Good Status" refers to both "Good ecological status" and "Good chemical status"

"Good ecological status" covers the biological community quality, the hydrological characteristics and the chemical characteristics. "Good chemical status" refers to compliance with all quality standards established for chemical substances at EU level and Includes Priority substances & other EU-level dangerous substances and 38% of EU surface water bodies have been declared "good" (EEA 2018).

For Groundwater the focus has moved to protecting it for its environmental value. As groundwater moves slowly through the subsurface the impact of man-made activities may last for a long time which when combined with its inaccessibility means the focus is on preventing pollution in the first place. Ground water is assessed based on a combination of its chemical status, with a presumption that it should not be polluted at all, and its quantitative status, which relates to the effects of direct and indirect abstraction over time.

Robin then discussed in detail regulations of relevance to the agriculture sector including the drinking water directive, the nitrates directive and the plant protection products regulations including the use of metaldehyde.

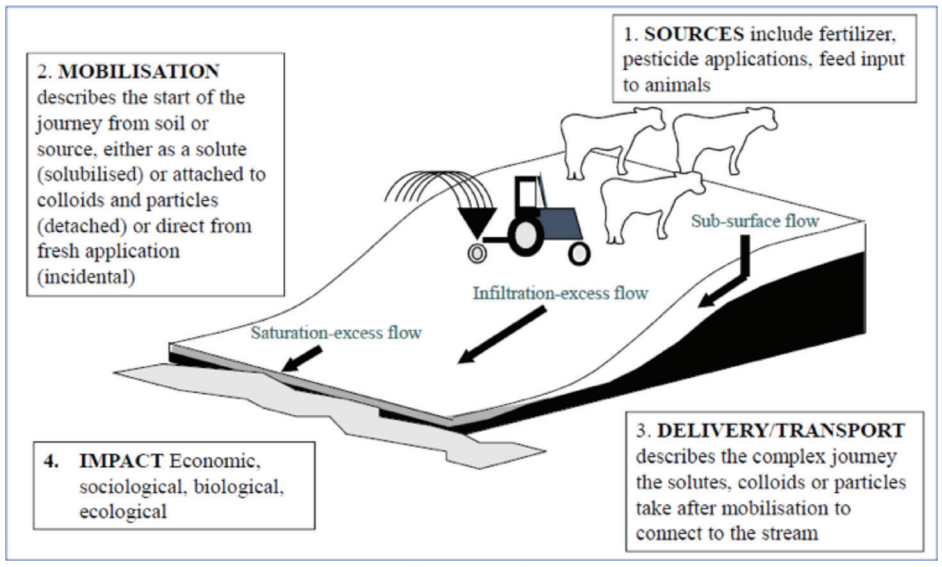

Fig 2 Illustration of the main processes in diffuse pollution of ground and surface waters as presented by Prof Collins

The implementation of Water Framework Directive has introduced an integrated approach to manage water quality which in turn has led to improvements in quality of surface water and groundwater across the European Union - but further work is needed to achieve targets set out in the WFD and related directives.

Monitoring and Fate of Pollutants

Prof Adie Collins from Rothamstead Research opened the session with a talk on "The agricutlture – water quality interface: mitigating the multiple unintended consequences" and began by highlighting the links between diffuse pollution from agriculture and water quality. He stated that in 2016 only 14% of surface water bodies in UK were classified as good / high status under the Water Framework Directive and that agriculture has been directly attributed to 31% of failures. The diffuse pollution model breaks the process into 4 main categories, Sources, Mobilisation, Delivery/Transport and finally Impact (Fig 2)

For surface water Drinking Water Protected Areas (DrWPAs) in England pesticides are the largest cause of these being 'at risk' with 122 surface waters declared 'at risk' in 2015. Figure 3 shows that metaldehyde is causing the majority (102) of those surface waters to be"at risk" and that pesticides in general account for 70% (348 of the 498) of the reasons for surface water DrWPAs being 'at risk'.

Under the UK Government 25 Year Environment Plan four pioneer project locations in Devon (Landscape), Greater Manchester (Urban) Cumbria (Catchment) and East Anglia (Marine) have been set up and learning from these projects will help shape and adapt the plan based on the latest evidence and knowledge of "what works". The main challenges for farmers are what are the technical remedies available and how to get them engaged to deliver sustained positive outcomes from targeted on-farm interventions. Prof Collins then shared efficacy data from a range of trials using mitigation options to tackle the source and delivery of pesticides in demonstration test catchments and discussed the challenges to be overcome. These challenges include falling farm income, changing weather patterns, hydromorphological modifications and the age and condition of the drain flow pathways. He concluded by describing the Soil to Nutrition (S2N) strategic programme which is aimed at advancing farming systems through an enhanced mechanistic understanding of nutrient use efficiency, productivity and resilience from soil to food product (https://www.rothamsted.ac.uk/projects/soil-nutrition-s2n).

Dr Nick Paling from the Westcountry Rivers Trust gave a presentation on the Upstream Thinking partnership which is working to improve water quality in the South West of England by changing land management to protect rivers. (www.upstreamthinking.org) The programme looks to provide advice and grants for farmers and the restoration of peatland in partnership with landowners. The target for the programme is 750 farms and 1,300ha of moorland and other semi-natural land under revised management. Grants are targeted at farms with land connected to rivers above water abstraction points. The aim is to reduce the amount of unwanted substances in river water, which in turn helps to control the cost of chemicals and energy needed to turn raw water into high quality tap water. The project uses environmental risk assessment-based modelling to help find sources of pollution with a view to identifying areas of high risk and therefore a high opportunity for improvement. They use SCIMAP which is an approach to the generation of risk maps for diffuse pollution within catchments. SCIMAP aims to determine where within a catchment is the most probable source of diffuse pollution and is based on a probabilistic / relative approach. SCIMAP works by combining a map of the relative risk of generating diffuse pollution for 5m by 5m locations in the landscape. It works out the relative risk of each location in the landscape being connected to a river, lake or groundwater. This data combined with monitoring of spot samples throughout the catchment allows the team to develop a range of measures, advice and investment to engage with farmers to reduce the risk of pollution events. The project has also developed a pesticide simulator which provides a spatial assessment of pesticide pollution sources in a landscape using a wide range of input factors.

The pesticide simulator assesses risk at fine spatial (sub-field) and temporal (day) scale incorporating local data and can help target/design advice and measures to reduce risk. It simulates stochastic pesticide pollution events and works for grassland dominated catchments and demonstrates advice and measures.

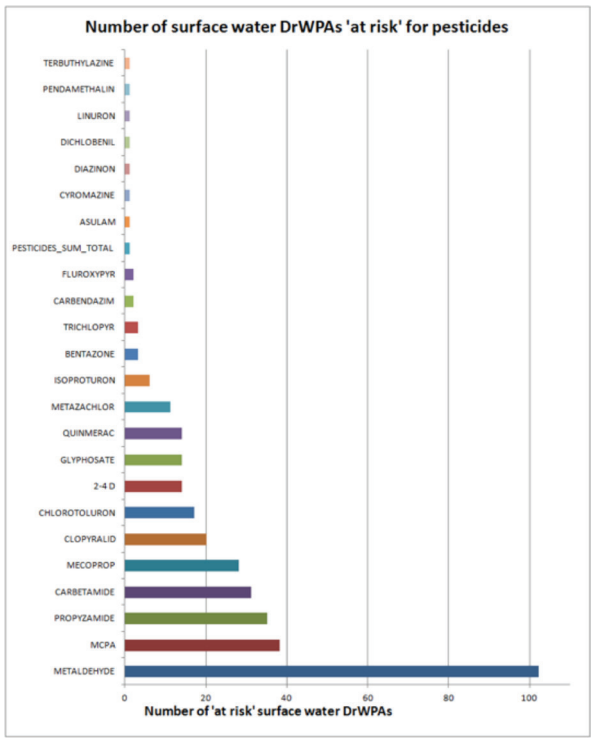

Fig 3 Number of "at risk" Drinking Water Protected Areas from individual pesticides Source UK Environment Agency

Prof Fred Worrall from Durham University presented "Learning from experience –pesticide monitoring in English groundwater" which described an approach to predict the occurrence of pesticides in groundwater. He described the generalised linear modelling of factors relating to the site and its vulnerability, the compound hazard, the interaction of the site and compound and a distribution error. He described the development and application of the model to data from English groundwater and finished by discussing model validation and future directions and development.

Dr Joanna Clint, Catchment Projects Manager for Thames Water gave a water companies view with her presentation "Monitoring and mitigating pesticides in water: a collaborative approach - Why, what and how". Thames Water provide 2.6 billion litres of drinking water per day to 9 million customers and sewerage services to 15 million customers producing 4,4 billion litres per day. They monitor drinking water for pesticides to meet regulatory limits and to understand the risks to water quality in their shared catchment areas over a large area of SE England together with their Thames catchment neighbours, Affinity Water and South East Water, using risk based approaches. Monitoring is undertaken upstream of the catchment, at abstraction points and during water treatment stages using both grab and passive sampling. Pesticides are the compounds at most risk of causing failures and are frequently found at raw water abstraction points. They can also be the most difficult contaminants to

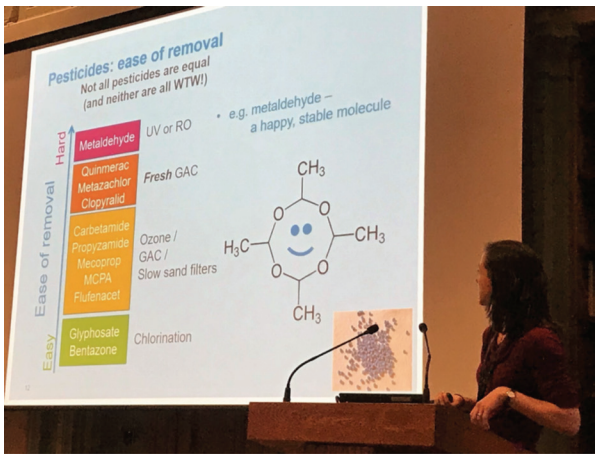

Fig 4 Dr Joanna Clint from Thames Water discusses the problems of removing pesticides, particularly metaldehyde, by water treatment.

treat and therefore mitigation at source is a major activity. Metaldehyde, was again highlighted as a major issue as it is a very stable molecule which is very hard to remove by treatment (Fig 4).

Mitigation was historically by treatment, but expectations have changed, and prevention rather than cure is now the way forward. It is achieved primarily through catchment management including informing and working with farmers to reduce pesticides reaching watercourses, encouraging integrated pest management, alternative option education and incentivisation for product substitution and ecosystem service payments. Dr Clint concluded that the combination of risk-based monitoring, collaboration and mitigation was the preferred way forward.

The Problem with Metaldehyde

As already mentioned, the issue of metaldehyde pollution from slug control was highlighted as probably the major issue currently for the Agriculture -Water interface by many of the speakers and this was reinforced by Dr Robin Price, Head of Water quality at Anglian Water, who presented "Achieving 100% compliance for metaldehyde – is treatment the answer". Dr Price described a scenario where in order to supply the city of Lincoln in England they had to abstract water from the river Trent which historically had exceeded the permitted regulatory standard for metaldehyde. As a result, they designed and built one of the most innovative water treatment works ever constructed. The cutting-edge technology employed meant that previously untreatable water from the Trent could be purified to the very highest drinking water standards. The process has been demonstrated to be very effective, but this came at a cost and to implement this process across their network would result in a significant increase in customers bills and so it was unlikely based on this cost model that metaldehyde treatment was a cost effective way forward on a larger scale. He then proposed that it was time for the industry to move on to discussing the risks from total pesticide levels and that reducing pesticides through catchment interventions and collaboration with agricultural colleagues to reduce pollution risk at source was the way forward.

Stop Press Around 7 weeks after this conference the UK government Environment Secretary announced "A ban on the outdoor use of metaldehyde, a pesticide used to control slugs in a range of crops and in gardens, is to be introduced across Great Britain from Spring 2020" Environment Secretary Michael Gove said: "I recognise that significant effort has been put into encouraging growers and gardeners to use this pesticide responsibly by the Metaldehyde Stewardship Group. However, the advice is clear that the risks to wildlife are simply too great – and we must all play our part in helping to protect the environment. I encourage companies and growers to look at the alternatives, such as ferric phosphate, which is authorised and does not carry similar risks."

Summary

This was a fascinating conference which clearly highlighted that the agriculture and water industries were inextricably linked. It was clear that pesticides were a major problem for water companies and that raw water treatment was not the way forward to deal with the increasing risks of agricultural related pollution. Working together to reduce and mitigate the risks through implementing best practice at source was clearly the preferred way forward the and that this approach could also deliver benefits for the farmers through reduced chemical costs, improved efficiency and infrastructure investment.

Author Contact Details
Tom Lynch CSci, CChem FRSC, Independent Analytical Consultant, Cricket House, High St, Compton, Newbury, RG20 6NY
• Email: tomlynch.lynch@btinternet.com