Environmental Audit Committee Inquiry: Nitrates

January 2018

Wildlife and Countryside Link (Link) brings together 47 environment and animal protection organisations to advocate for the conservation and protection of wildlife, countryside and the marine environment. Link is the biggest coalition of environmental and animal protection organisations in England. Our members practice and advocate environmentally sensitive land management, and encourage respect for and enjoyment of natural landscapes and features, the historic and marine environment and biodiversity. Taken together we have the support of over eight million people in the UK and manage over 750,000 hectares of land.

This response is supported by the following organisations:

- Amphibian and Reptile Conservation Trust
- Angling Trust
- Buglife
- Butterfly Conservation
- Institute for Fisheries Management
- National Trust
- Plantlife
- The Rivers Trust
- RSPB
- Salmon & Trout Conservation
- Sustainable Food Trust
- The Wildlife Trusts
- Wildfowl & Wetlands Trust
- Woodland Trust
- WWF-UK
- Zoological Society London

The majority of nitrogen on Earth is present as un-reactive nitrogen gas (N2) in the atmosphere. Since the development of the Haber-Bosch process in the early 20th century, it has been possible to convert this atmospheric nitrogen into a form that can be used by plants and animals. Reactive forms of nitrogen (including nitrates) have been used as agricultural fertilisers throughout the 20th and 21st centuries, often in excess of what is needed for a specific crop. The excess nitrates from these crops are the source of much nitrate pollution in the UK.

1. ***What is the scale of nitrate pollution in the UK and what is the likelihood of the pollution getting worse?***

62% of the UK's sensitive ecosystems suffer from high levels of nitrogen deposition - a figure that rises to 96% for England only – and this is not expected to significantly decrease by 2025.[1] Baseline concentrations of nitrate in groundwater beneath natural grassland in temperate regions are typically below 2mg l1.[2] Groundwater monitoring in the UK indicates an average nitrate concentration of about 38 mg/l in 2001.[3] In 2004, almost 15% of monitoring sites in England (none in Wales) had an average nitrate concentration that exceeded 50 mg/l, the upper limit for nitrate in drinking water.[4]

Nitrate is a long-term issue with many factors affecting the speed with which it travels from release into groundwater. Even if significant reductions in runoff are achieved in the near future, it is likely that the nitrate in some aquifers may not peak for years into the future due to the specific geology and soil profiles of some areas.[5] Intensive agriculture has resulted in a large store of nitrate pollution building up over time, even after putting in place controls on fertiliser use.

The UK has some of the highest concentrations of nitrates in rivers in Europe. Model estimates indicate that agricultural emissions of nitrogen to freshwater exceed 10 kg per ha per year across some European regions, with values exceeding 20 kg per ha per year in western UK. Figures 1-5 highlight high concentrations seen in England compared with other parts of Europe.[6]

Changes in temperature, precipitation quantity and distribution, and atmospheric carbon dioxide concentrations will change soil processes and agricultural productivity consequently affecting agricultural nitrate inputs. Studies of soil processes suggest climate change is likely to lead to increased nitrate leaching from the soil under future climate scenarios.[7]

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[1] Hall, et al. 2016. Defra Contract AQ0826: Report: Modelling and mapping of exceedance of critical loads and critical levels for acidification and eutrophication in the UK 2013-2016

[2]Wakida, F.T. & Lerner, D.N. (2005) Non-agricultural sources of groundwater nitrate: a review and case study, Water Research 39: 3–16

[3] Stuart, et al. 2007. Screening for long-term trends in groundwater nitrate monitoring data. Quarterly Journal of Engineering Geology and Hydrogeology, 40. 361–376
British Geological Surgey (accessed 10/01/2017) Trends in nitrate concentrations in UK groundwater http://www.bgs.ac.uk/research/groundwater/quality/nitrate/trends.html

[4] EA report, under ground, under threat, The state of groundwater in England and Wales http://webarchive.nationalarchives.gov.uk/20140329205941/http://cdn.environment-agency.gov.uk/geho0906bldb-e-e.pdf

[5] Wang, et al. (2011) Prediction of the arrival of peak nitrate concentrations at the water table at the regional scale in Great Britain, Hydrological Processes, 25 http://www.bgs.ac.uk/research/groundwater/quality/nitrate/peaks.html

[6] EU factsheet: Agri-environmental indicator - nitrate pollution of water (data Sept 2012) http://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_nitrate_pollution_of_water

[7] Stuart, *et al*. (2011) A review of the impact of climate change on future nitrate concentrations in groundwater of the UK. *Science of the Total Environment*, 409 (15), 2859–2873.
British Geological Survey (accessed 10/01/2018) A review of the impact of climate change on future nitrate concentrations in groundwater of the UK http://www.bgs.ac.uk/research/groundwater/quality/nitrate/climate_change.html

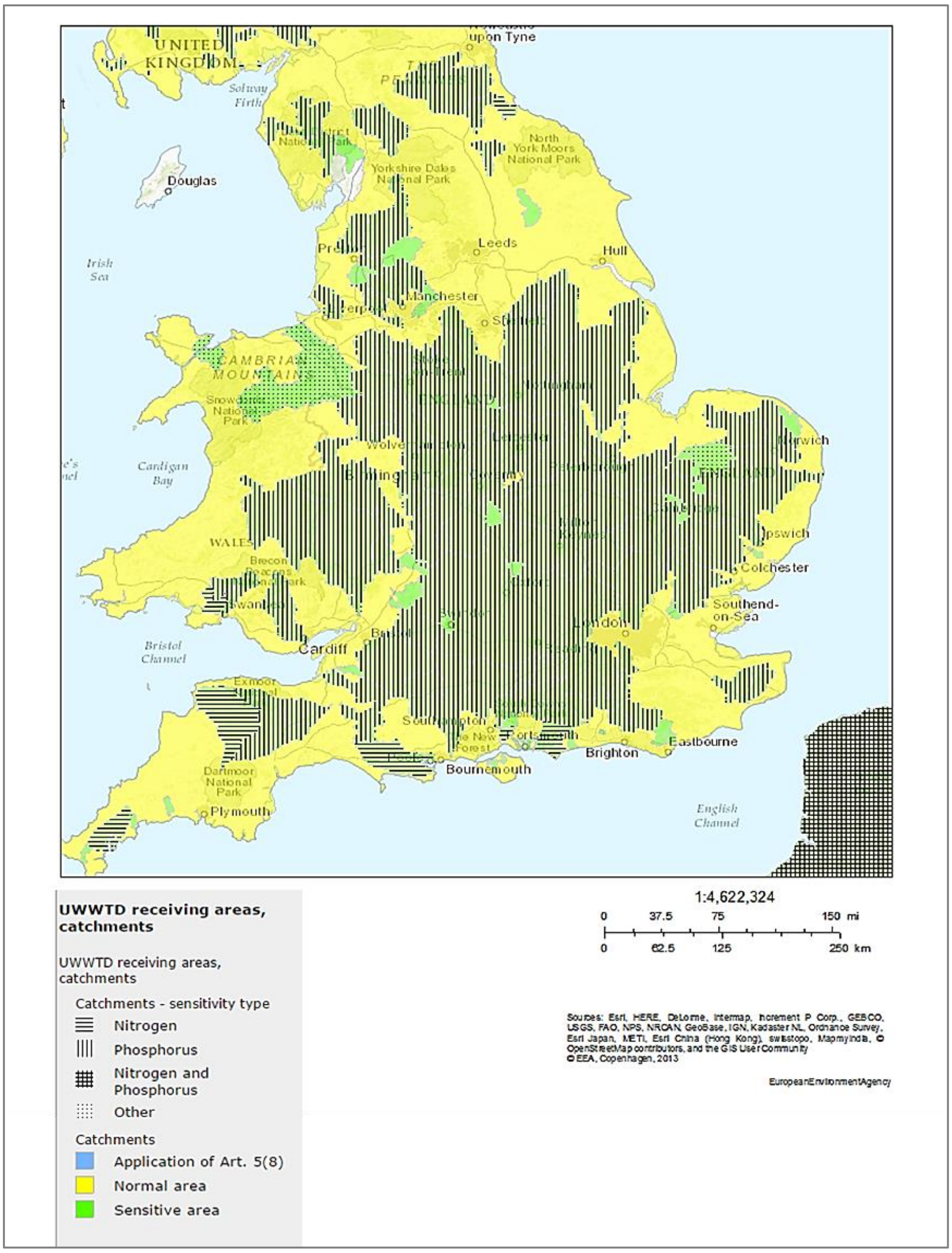

Figure 1: Current (as of 2012 dataset) Sensitive Area Boundaries and sensitivity type.[8]

[8] http://www.eea.europa.eu/

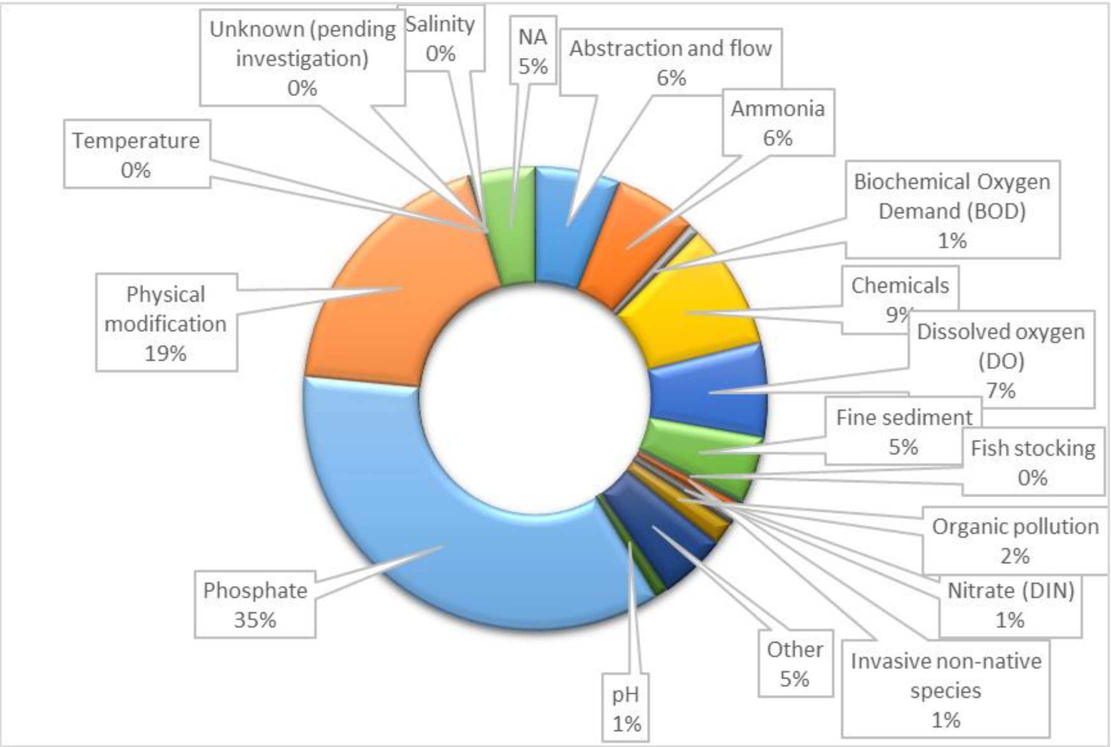

Figure 2: Overall activities responsible for RNAG.[9]

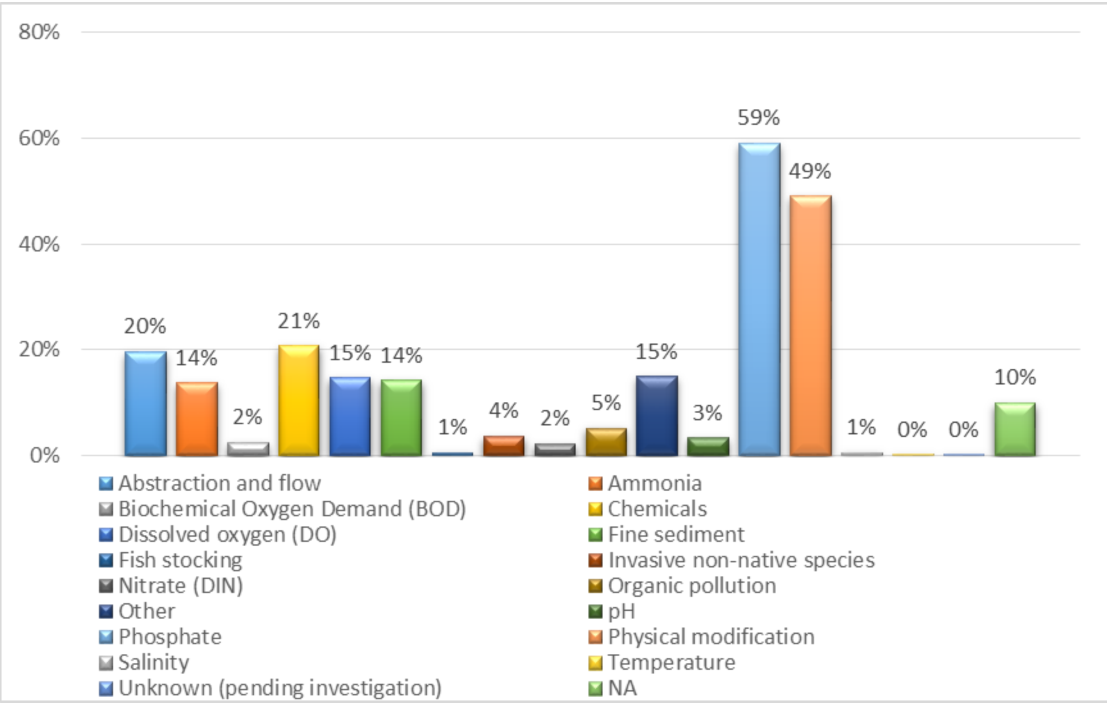

Figure 3: Percentages of failing water bodies affected by each Overall Pressure.[9]

[9] Artesia Consulting. 2017. Rivers on the Edge - an assessment of the impact of sewage pollution.

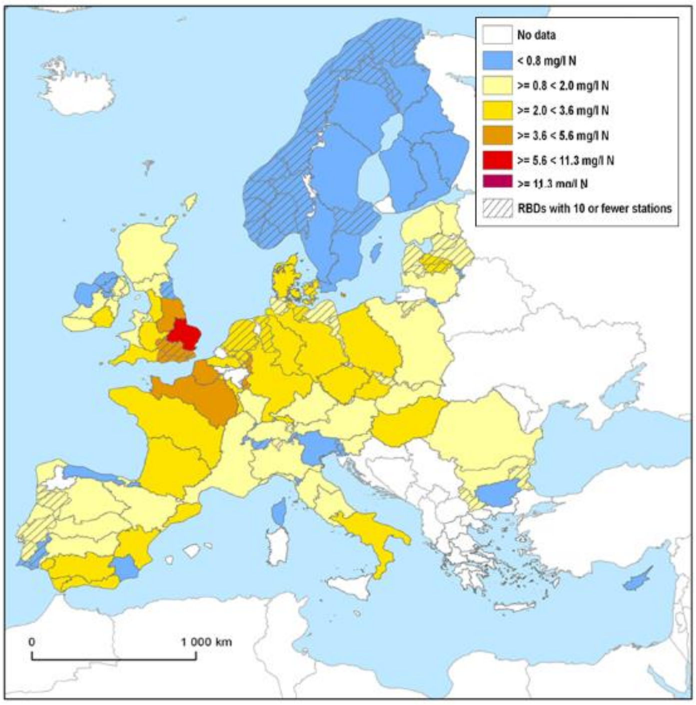

Figure 4: Annual river nitrate concentration averaged by National River Basin Districts (mg N per l), (2009)

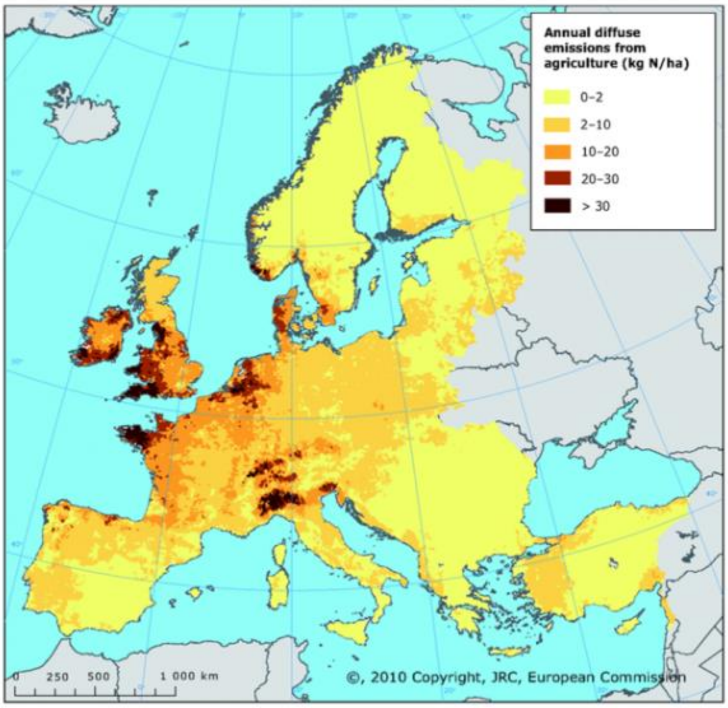

Figure 5: Annual diffuse agricultural emissions of nitrogen to freshwater (kg N per ha of total land area), (2009)

2. ***What are the consequences of nitrate pollution for the environment and for human life?***

The main consequences of nitrate pollution in aquatic ecosystems are:

- Acidification of freshwater ecosystems; reduces species diversity of phyto- and zoo-plankton, with some species of macro benthic invertebrates being acid sensitive. Acidification has led to significant loss of fish, affects the development of embryonic and larval stages of amphibians, including the common frog, toad and natterjack toad and the distribution of fish-eating birds may be influenced by the effects of acidification on the performance of their prey[10];
- Eutrophication is the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of primary producers, some of which may be toxic and/or not grazed effectively by aquatic grazers to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned. This can lead to changes in community structure and composition and cause significant fish and shellfish kills;
- Nitrate can reach toxic levels that impair the ability of aquatic animals to survive, grow and reproduce. Nitrate pollution also affects the chemistry of freshwaters such as causing a decline in dissolved oxygen concentrations which can promote the formation of reduced compounds, such as hydrogen sulphide, resulting in higher toxic effects on aquatic animals.

Inorganic nitrogen pollution of ground and surface waters can also induce adverse effects on human health and economy.[11]

Species and communities such as those adapted to low nutrient levels or poorly buffered against acidification are most sensitive to chronically elevated nitrogen deposition. For example in Europe, grassland, heathland, peatland and forest ecosystems are considered vulnerable. Exceedance of critical loads for nutrient nitrogen is linked to reduced plant species richness in a broad range of European ecosystems. Wetlands dominantly fed by rain water are highly sensitive to atmospheric deposition. An associated loss of biodiversity occurs where the rate of Nitrogen deposition increases over time.

Nitrogen also plays a role in determining the food web structure and relative productivity of any water body through microbial, algal and plant uptake of Nitrogen in the form of both inorganic Nitrogen species and Dissolved Organic Nitrogen. Any change in the rate of supply of nitrogen to a water body, or the relative abundance of Carbon, Nitrogen, Silicon and Phosphorus, will lead to changes in the productivity of the water body and its microbial metabolism. This can lead to secondary effects in terms of microbial, plant and animal community species composition and relative abundance, and the structure and balance of the aquatic food web.

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[10] Muniz, I.P. (1990) Freshwater acidification: its effects on species and communities of freshwater microbes, plants and animals, Proceedings of the Royal Society of Edinburgh, Section B: Biological Sciences, 97:227-254

[11] Camargo, J.A. & Alonso, A. (2006) Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment, Environmental International, 32(6):831-849

Often these impacts will 'cascade' through the system. For example, in alpine moss heaths in the UK, N deposition is efficiently retained by mosses, altering carbon:nitrogen ratios in the moss tissue, which in turn impacts on decomposition rates and results in depletion of the moss mat.[12] Underlying soils become increasingly N saturated and nitrogen is then leached into surface waters.[13] Similar responses are seen in a range of ecosystems. Ultimately, reduction in surface water quality as a result of increased nitrogen leaching impacts on human populations and water treatment costs.[14]

Recovery from nitrate pollution is likely to be slow, especially in highly impacted ecosystems. In some aquifers, the increase of Nitrogen concentrations will continue for decades even if efficient mitigation measures are implemented now. While total Nitrogen deposition is now declining in many parts of Europe, nitrate leaching continues to slow the chemical recovery of freshwaters from acidification, due to Nitrogen saturation of terrestrial ecosystems.[15]

As an example, Poole Harbour is failing to achieve 'Good' status under the Water Framework Directive and conservation objectives associated with its status as a Special Protection Area. This is due to eutrophication and the presence of dense algal mats across large areas of inter-tidal mudflats, which can lead to a decrease in the diversity and richness of the macrobenthic infaunal community, with consequences for animals and birds further along the food chain.[16] These failures are mainly driven by nitrogen enrichment and investigations reveal that a high proportion of the nitrate-nitrogen loading entering the harbour is from diffuse agricultural sources.[17]

A case study produced by WWF in 2015[18] summarises the impact that pollution is having on Poole Harbour:

"Poole Harbour, is a Special Protection Area (SPA) and supports internationally important populations of breeding, passage and over wintering birds, including being home to 40% of the UK's wintering avocet population. It is also a vital economic asset to the local economy, attracting visitors, business and recreational users.

The Frome, one of England's unique chalk streams, is the main river feeding the harbour. It is failing to achieve good health and carries the majority of diffuse pollutants such as sediment, nitrate and phosphate.

The Frome is failing because of pollution. The harbour itself is also failing to achieve good health because of seasonally high nitrate concentrations which cause algae to build up. Over 75% of the land within the catchment is used for agriculture. The 2009 River Basin

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12 Britton, in press
13 Armitage, et al. (2012) Nitrogen deposition enhances moss growth, but leads to an overall decline in habitat condition of mountain moss-sedge heath. Global Change Biology 18(1): 290-300.
14 Phoenix, et al. (2012) Impacts of atmospheric nitrogen deposition: responses of multiple plant and soil parameters across contrasting ecosystems in long-term field experiments. Global Change Biology 18(4): 1197-1215.
15 Durand, P., Breuer, L. & Johnes, P.J. (2011) Nitrogen processes in aquatic ecosystems, Chapter 7 In: *The European Nitrogen Assessment*, ed. Mark A. Sutton, Clare M. Howard, Jan Willem Erisman, Gilles Billen, Albert Bleeker, Peringe Grennfelt, Hans van Grinsven and Bruna Grizzetti. Published by Cambridge University Press.
16 ADAS (2017). Poole Harbour Nitrogen Management Investigation.
17 ADAS (2017). Poole Harbour Nitrogen Management Investigation.
18 WWF (2015). Poole Harbour Case Study.

Management Plan identified that agricultural pollution was a key pressure on Poole Harbour, causing sediment, nitrogen and phosphorous to enter the rivers which feed into the harbour. This poses a real risk to people and wildlife:

- *The nutrients cause excessive growth of algae, which smother 15% of the harbour during the summer months, covering the mud flats and affecting food supply for many protected birds such as the shelduck, redshank, curlew and lapwing.*
- *Wintering numbers of breeding birds are not faring well. High alerts have been placed on over half of the bird species the site is protected for. These are: shelduck, pochard, goldeneye, red-breasted merganser, lapwing, dunlin and curlew.*
- *Globally, the curlew is in danger and have declined by 80%.*
- *Nearly half of public water supply sources have exceeded drinking water standards for nitrogen.*
- *Recreation and leisure activities are vital to the local economy, but 95% of visitors participating in water sports would reduce their visits or just stop coming altogether if water quality further deteriorated."*

Nitrate pollution also has significant effects on human health, with high levels of nitrate-nitrogen in drinking water (above 10ppm) linked to methemoglobinemia, in which red blood cells are prevented from taking up oxygen efficiently. High nitrate levels have also been linked to stomach cancer and increased seasonal allergies.[19]

3. How important are the different sources of nitrate pollution? Where should action be undertaken?

Agricultural land is the major source of nitrates in UK groundwater. More than two thirds of the nitrate in groundwater comes from past and present agriculture. If too much is applied, or is applied in the wrong place or at the wrong time, it can get leach out of the soil and into groundwater.

Other major sources of nitrate are leaking sewers, septic tanks, water mains and atmospheric deposition. Atmospheric deposition of nitrogen makes a significant contribution to nitrate inputs to groundwater. A study in the Midlands concluded that around 15% of the nitrogen leached from soils came from the atmosphere. For example, major sources of nitrogen in the Nottingham area are mains leakage and contaminated land, with approximately 38% each of a total load of 21 kg Nitrogen per hectare per year.[4]

Contaminated land, such as abandoned landfills, gasworks sites or abandoned industrial sites, contribute a significant quantity of nitrogen to groundwater. In the UK, it is estimated that there are at least 5,000 closed landfills and approximately 10,000 coal gasification related sites in the UK (1996). Pollution and leaching of Nitrogen from such sites are likely to persist for years given the historical numbers of unlined landfills and un-remediated sites.

Nitrate leaching from fertilizers applied to lawns and for growing vegetables is likely to be a significant source of nitrogen to groundwater. A study carried out in a rural community in

[19] Townsend, et al. (2003) Human health effects of a changing global nitrogen cycle. Front Ecol Environ, 1: 240–246. doi: 10.1890/1540-9295(2003)001[0240:HHEOAC]2.0.CO;2

Germany concluded that home gardens with a cover of only 3.5% of the total study area were responsible for 27% of the total amount of nitrogen leached.[20]

4. *How effectively does Government regulate nitrate usage so that nitrate pollution is reduced as quickly as possible?*

In England nitrates are currently regulated through transposition of the Nitrates Directive via the Nitrate Pollution Prevention Regulations, 2008 (last amended in 2016). Baseline management of nitrates is via current cross compliance under the EU Common Agricultural Policy. As Britain exits the EU it is important that a strong regulatory baseline is put in place to ensure good land management. Currently around 58% of the UK is designated as a Nitrate Vulnerable Zone (NVZ). These are reviewed every four years.

Nitrates are also reduced through action to meet Water Framework Directive and Marine Strategy Framework Directive objectives.

Most legislation considers inorganic nitrogen only and consideration will need to be given to a much wider range of sources, practices, and pathways for nitrogen delivery to waters if the problem is to be fully addressed. Investigating all effects and managing the cascade of aquatic nitrogen on ecosystem services has not been conducted yet in a comprehensive way and there is a clear need for further research in this respect.

5. *Are other nations taking more effective action on nitrates that the UK can learn from?*

Denmark has recently made some innovative changes to their management of nitrate. Although too early to realise results, these are nevertheless very interesting options for England. Denmark has removed their controls on reducing the amount of nitrogen applied on farms. To avoid any increase in nitrate leaching the following measures have been put in place:

- Establishment of mandatory catch crops – a mandatory requirement of 10-14% of farm holding under catch crops.
- Establishment of mini-wetlands - constructed wetlands are well-established in Denmark. They propose to establish 1,000 mini wetlands by 2021 with an assumed average effect of about 900kg N per year per installation. The efficiency of measures depends on correct location.
- Afforestation – aiming to establish 1,000 hectares of new forest with a reduction average of about 30kg N per year per hectare.
- Targeted catch crop scheme – voluntary catch crops must be in addition to the national mandatory requirement.
- An emission based regulation of livestock holdings based on an environmental assessment of the production area.

[20] Wakida, F.T. & Lerner, D.N. (2005) Non-agricultural sources of groundwater nitrate: a review and case study, Water Research 39: 3–16

From 2019, every farm will have a leaching permit to the aquatic environment which will be assessed each year. Each farm within a catchment area will be appointed the same leaching permit per hectare. Each farmer has flexibility in how they comply with the leaching permit (e.g. catch crops, buffer strips, reduced nitrogen application).

The yearly amount of nitrogen permitted at a farm basis is calculated taking into account the characteristics of the area and the balance between the nitrogen requirement of the crops and the nitrogen supply (including that already in the soil); farmers then submit their annual fertilisation account.

It is estimated that the measures and baseline effects will reduce load by between 49,500 and 57,000 tons Nitrogen.[21]

The Netherlands has seen significant reductions in nitrate pollution following their implementation of the Nitrates Directive.[22] The Netherlands also has a comprehensive system to monitor and control nitrogen pollution, the Integrated Approach to Nitrogen (PAS) and a tool for tracking nitrogen deposition, AERIUS. This scheme has only been running since 2015, but shows early promise.[23]

6. What more could Government do to reduce nitrate pollution as quickly as possible?

Relying on voluntary measures to deal with this issue is not working. Better regulation and enforcement is needed, as well as upholding the court order on protected areas.[24] The Government should use all the mechanisms available to implement the measures needed to protect the environment, such as Water Protection Zones. This should include taking an integrated approach to tackling pollution through all aspects of the nitrogen cycle – atmospheric, water and land-based.

- We recommend that Government trial schemes similar to that being undertaken in Denmark, including developing nitrogen budgets.
- The Government could also introduce tighter and more effectively enforced rules around the spreading and storage of slurry, particularly that resulting from intensive dairy farming.
- Effective and enforced baseline land management regulations replacing current cross compliance and GAECS (Good Agricultural and Environmental Condition Standards) could be used, including:
    - reducing the use of artificial fertilisers,
    - reducing the extent of ploughing in the autumn,

[21] Environmental Protection Agency, Ministry of Environment and Food of Denmark (2017) Overview of the Danish regulation of nutrients in agriculture and the Danish Nitrates Action Plan
[22] Van Grinsven et al. (2016) Evaluation of the Dutch implementation of the nitrates directive: the water framework directive and the national emission ceilings directive. NJAS-Wageningen J. Life Sci., 78, pp. 69-84
[23] de Heer, et al. (2016) The Integrated Approach to Nitrogen in the Netherlands: A preliminary review from a societal, scientific, juridical and practical perspective. Journal for Nature Conservation
[24] High Court ruling in November 2015 found that the government had not used key regulation that was designed to tackle water pollution – Water Protection Zones. The resultant court order states that the government must look at all measures and mechanisms available (including Water Protection Zones) that are needed to achieve the Protected Area objectives in each Natura 2000 site. http://www.anglingtrust.net/news.asp?section=29&itemid=2830

- sowing autumn crops early,
- avoiding bare ground in the winter by sowing cover crops,
- delaying the ploughing-in of crop residues,
- carefully managing the disposal of farm wastes,
- managing soil exposure during winter months through early establishment of winter crops/leave rough surface/plant cover crops,
- introduction of riparian buffer strips,
- taking steps to address and repair soil compaction, and
- increasing soil organic matter.

Additional measures could be put in place and subsidised through targeted land management schemes.

- Enforcement of current regulations in England is not sufficiently robust or well-coordinated. For enforcement to be effective (and therefore regulation to be effective), it is essential that non-compliant farmers are systematically identified. Research for WWF[25] has shown that 20-30% of farmers are failing to comply with cross-compliance standards. A targeted and collaborative approach to working with the 20-30% of farmers to increase compliance levels needs to be undertaken as a matter of urgency. Future enforcement models in England could adopt a similar approach to Scotland's 'General Binding rules' (GBR). Non-compliant farmers are systematically identified through catchment walkovers. Where GBR breaches or pollution risks are identified, farmers are given time to address these issues before a second visit is arranged. If remedial action has not been taken, a third and final visit is then scheduled, and if no action is apparent a Fixed Penalty System is levied.

- Constructed wetlands are currently available under the higher tier countryside stewardship scheme and should be continued. Uptake has been low but could be a general consequence of low uptake of higher tier countryside stewardship more generally. Horizontal-flow wetlands can remove between 50 and 99% of nitrogen, depending on its form and effluent loading.[26] WWT have produced guidance with the Catchment Sensitive Farming initiative on the use of constructed wetlands in the agricultural landscape. This guidance document is aimed at farm advisors and provides information and examples of the use of wetland treatment systems and SuDS on farms. Different types of wetland treatment systems and SuDS are described with guidance on their suitability for different farm situations and pollution issues, design, costs, permits required and case studies. For such schemes to work expert advice is necessary and we support continued funding for farm advisors and recommend training in optimising delivery of schemes such as constructed wetlands. Constructed wetlands should be part of the toolkit the Government propose for reducing nitrate pollution. Constructed wetlands could also be used to reduce nitrate leaching from contaminated land such as landfill. Installing constructed wetlands can be cheaper than treating nitrates via waste water treatment plants.[27]

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[25] Alex Inman Consulting (2014), Investigating Agricultural Compliance Rates. Report for WWF-UK
[26] Dunne, E. J., Culleton, N., O'Donovan, G., Harrington, R., & Olsen, A. E. (2005). An integrated constructed wetland to treat contaminants and nutrients from dairy farmyard dirty water. *Ecological Engineering*, *24*(3), 219-232.
[27] Collins, A.R. & Gillies, N. (2014) Constructed wetland treatment of nitrates: Removal effectiveness and cost efficiency, Journal of the American Water Resources Association, 50(4):898-908

- The adoption of targeted farm-scale approaches or wider landscape-scale schemes using tree or woodland planting would provide an excellent and proven opportunity to help reduce nitrate leaching into watercourses[28]. Shelterbelts, riparian planting and carefully sited woodland buffer strips have been shown to reduce nitrate loads by root uptake in several different agricultural systems (including dairy and arable)[29]. Tree planting can provide numerous other ecosystem services in landscapes including biodiversity conservation and soil erosion mitigation.

[28] https://www.woodlandtrust.org.uk/publications/2015/04/role-of-trees-in-arable-farming/

[29] Sweeney BW, Newbold JD. (2014). Streamside forest buffer width needed to protect stream water quality, habitat, and organisms: A literature review. *J. Am. Water Resour. Assoc.* 50(3):560–84