SRU

German Advisory Council on the Environment

The implementation of the Water Framework Directive in Germany with regard to nitrogen inputs from agriculture

May 2015

Partial translation of the Special Report
„Nitrogen: Strategies for resolving an urgent environmental problem“

Contents

1. Introduction

The improved implementation of European environmental law is a key element of the 7th Environmental Action Programme. However, there are still grave shortcomings, particularly with regard to water protection. In its special report “Nitrogen: Strategies for resolving an urgent environmental problem” the German Advisory Council on the Environment (SRU) addressed the implementation problems in Germany. One of the key challenges is the persistently excessive levels of reactive nitrogen emissions from the agricultural sector.

The serious environmental problems caused by the excessive release of reactive nitrogen have troubled the water resource management sector for a long time. With the transposition of the Water Framework Directive and the Nitrates Directive, this challenge has become a matter of urgency. In July 2014, the European Commission called on Germany to take stronger measures to combat pollution caused by nitrates in groundwater and in surface waters with regard to the transposition of the Nitrates Directive (European Commission, 2014).

In order to achieve the objectives of the Water Framework Directive, further reductions in the levels of nitrogen pollution in surface waters and groundwater are essential. While advances have been made in this area, the rate of progress has been slowing down in recent years, and in part there has been an increase in pollution. The progress was due primarily to reductions in the inputs from point sources, in particular wastewater treatment plants. In

contrast, there have only been slight reductions in the inputs from diffuse sources, which are mainly in the agricultural sector.

The question, then, is how to reduce nitrogen inputs from agriculture in order to be able to comply with the quality targets for water resource management in the near future. The programmes drawn up by German federal states for the transposition of the Water Framework Directive make a contribution towards this goal, but do not appear to be sufficient. The requirements of the Nitrates Directive are particularly important. These are implemented in Germany mainly in the Fertiliser Ordinance (DüV), which specifies methods for the application of agricultural fertiliser. In addition, there are also environmental measures for agriculture, often combined with consultancy for farmers on water resource management. However, it is already foreseeable that these two pillars of the programmes of the German *Länder* will not be sufficient to achieve a good status for the bodies of surface water and groundwater.

2. The current situation

2.1 Groundwater

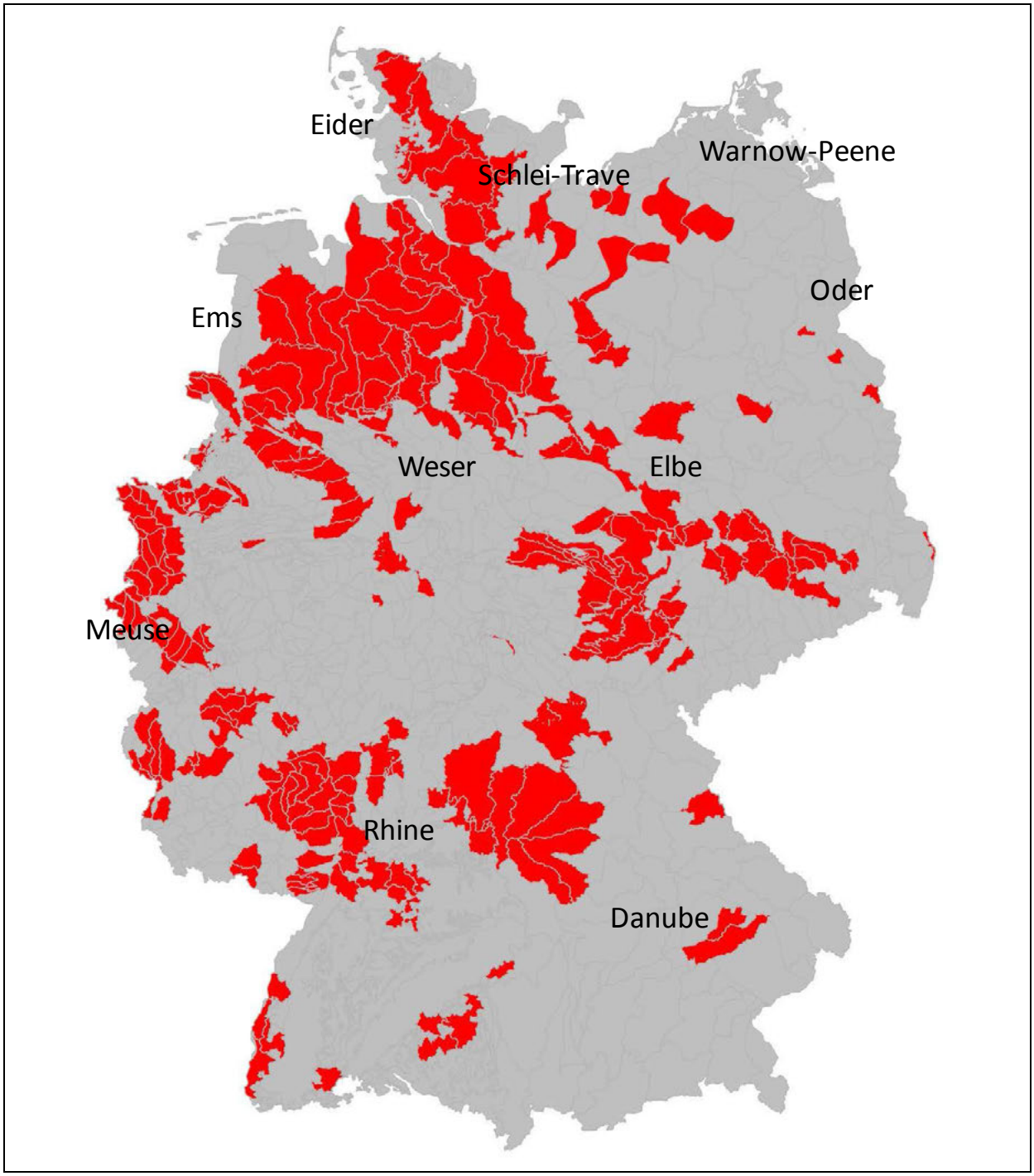
Groundwater not only receives inputs of nitrate pollution, but is also a pollution vector for surface waters. The inputs into groundwater are usually the result of leaching from the soil. Nitrates pass slowly through the unsaturated permeable rock strata. The passage can take a number of years or even decades (DURAND et al. 2011).

For bodies of groundwater near the surface, farming is the main cause of the nitrate inputs (BMU and BMELV 2012). This has also been confirmed by models based on agricultural nitrogen balances for 2007, which show that large amounts of nitrates percolate into the groundwater (KELLER and WENDLAND 2013).

The evaluation of the bodies of groundwater in Germany in accordance with the Water Framework Directive shows that 27 % fail to achieve good chemical status because their nitrate levels are too high (Figure 1). In general, the nitrate pollution is spread over all areas of the country, but it is possible to identify some regions with higher levels, for example in north-west Germany.

Figure 1

Bodies of groundwater in Germany which do not have good chemical status due to excessive nitrate concentrations (> 50 mg/l)



SRU/SG 2015/Fig. 3-9;
Data from: VÖLKER 2014, based on WasserBLIcK (n.d.), as of 22 March 2010

The data from the measuring stations of the pollution measurement network show a clear influence of agricultural operations. Overall, the assessment of the measurement data shows that the levels of pollution have declined in recent decades. The proportion of most-polluted sites (values > 50 mg/l), which was 64.2 % for the reporting period 1992 to 1994, was down

to 49.4 % for the period 2008 to 2010. However, 42.6 % of the sites still had values between 25 mg/l and 50 mg/l for the period 2008 – 2010, which indicates a significant anthropogenous impact. In more recent reporting periods there has also been a less positive trend. For example, the proportion of measuring stations showing a rise in nitrate concentration increased between the reporting period 2004 – 2006 and the last available period 2008 – 2010, when 40 % showed an increase (BMU and BMELV 2012; ARLE et al. 2013).

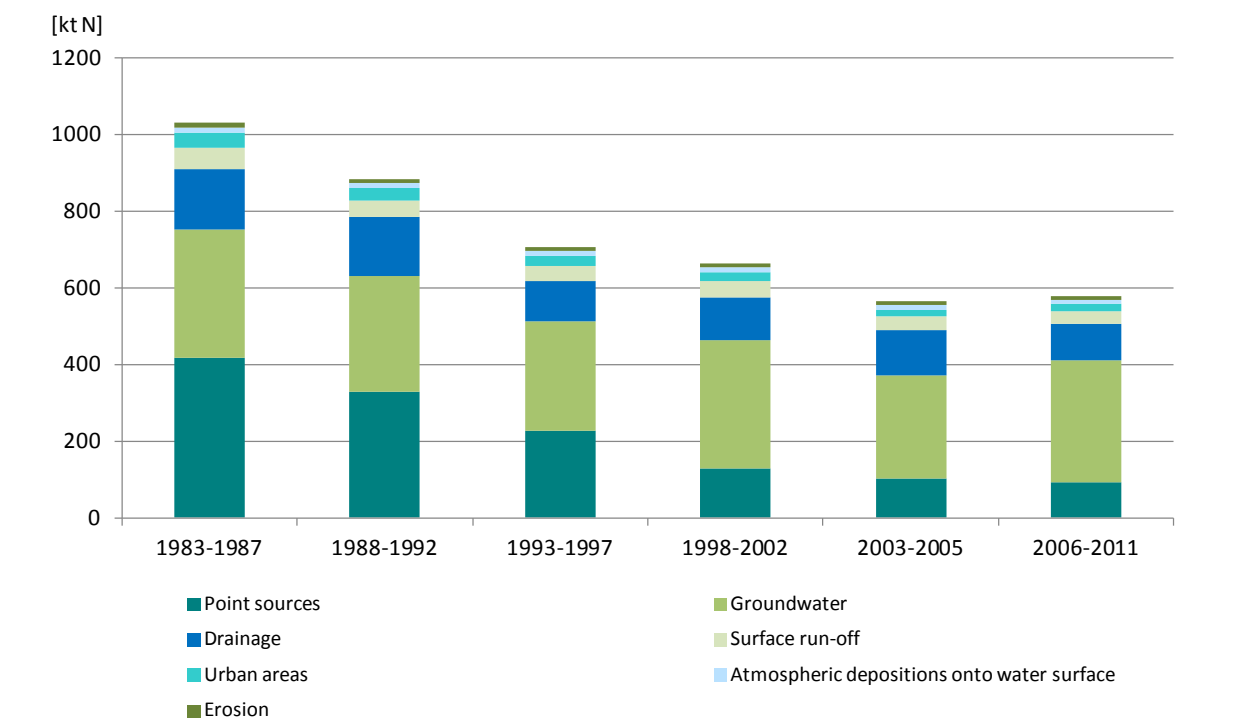
Pollution with reactive nitrogen has an influence on the use of groundwater as a drinking water resource, but also impacts on the biocoenosis of the groundwater bodies.

2.2 Inland surface waters

The nitrogen inputs into German surface waters declined from an annual input of 1,030 kt/a over the reporting period 1983 – 1987 to 578 kt/a for the period 2006 – 2011, a reduction by some 44 % (Figure 2). However, there has been a slight increase between the period 2003 – 2005 and the period 2006 – 2011. Today, some 80 % of the pollution finds its way into the surface waters via pathways that are mainly fed by agriculture (groundwater, drainage water, run-off, and erosion).

Figure 2

Nitrogen inputs* (annual means) from point and diffuse sources into the surface waters in Germany, 1983 to 2011



* Nitrogen inputs modelled with MoRE (Modelling Regionalized Emissions).
The length of the reporting periods varied from 3 to 6 years.

Source: written communication from UBA, 9 October 2014, amended

Much of the reduction in inputs in the past has been attributable to measures adopted at point sources such as municipal water treatment plants and direct industrial emitters. However, there has been little change in the inputs from diffuse sources, which reach the surface waters via drainage, through groundwater, erosion, surface run-off, and from urban areas or atmospheric depositions (ARLE et al. 2013).

There are considerable regional variations in input intensities. The highest inputs into the surface waters are found in north-western and south-western Germany. This is attributable firstly to the high levels of livestock farming, and secondly to the types of soil and the high levels of runoff (ARLE et al. 2013).

The positive trend in the reduction in reactive nitrogen emissions is also reflected in the development of pollution levels in surface waters. Evaluations of the results from the measurement network of the Federal Government and Federal States Working Group on Water Issues (LAWA) show a decline in nitrate concentrations in running waters between the reporting periods 1991 – 1994 and 2007 – 2010 for 89 % of the measuring stations, while only 6 % of the measuring stations showed an increase.

The environmental quality limit from the Nitrates Directive (91/676/EEC) of 50 mg nitrates per litre was met in 2011 at almost all stations of the LAWA measuring network. In addition, LAWA and UBA have established a target value of 2.5 mg nitrate-nitrogen per litre water for the good chemical status in accordance with the Water Framework Directive (LAWA 1998; ARLE et al. 2013). Only 15 % of the measuring stations for running waters were below this limit value.

Of the rivers in Germany, only about 8 % had a good or very good ecological status in accordance with the classification of the Water Framework Directive. This is due in the first place to the changed morphology of the surface waters, and secondly to eutrophication (BMU and UBA 2010).

For the growth of algae in rivers and lakes, phosphorus is more frequently the limiting nutrient than nitrogen. However, this does not apply for the lakes of the north German lowlands, which are nitrogen-limited either temporarily or throughout the year (ARLE et al. 2013; UBA 2009b).

The consequences of high nutrient content are shown in particular by the status of macrophytes and phytobenthos. On the basis of these two quality elements, 71 % of natural running waters in Germany were classed as eutrophic (BMU and UBA 2010). As a result of excessive nutrient inputs, 61 % of the natural lakes in Germany failed to achieve a good ecological status in accordance with the Water Framework Directive.

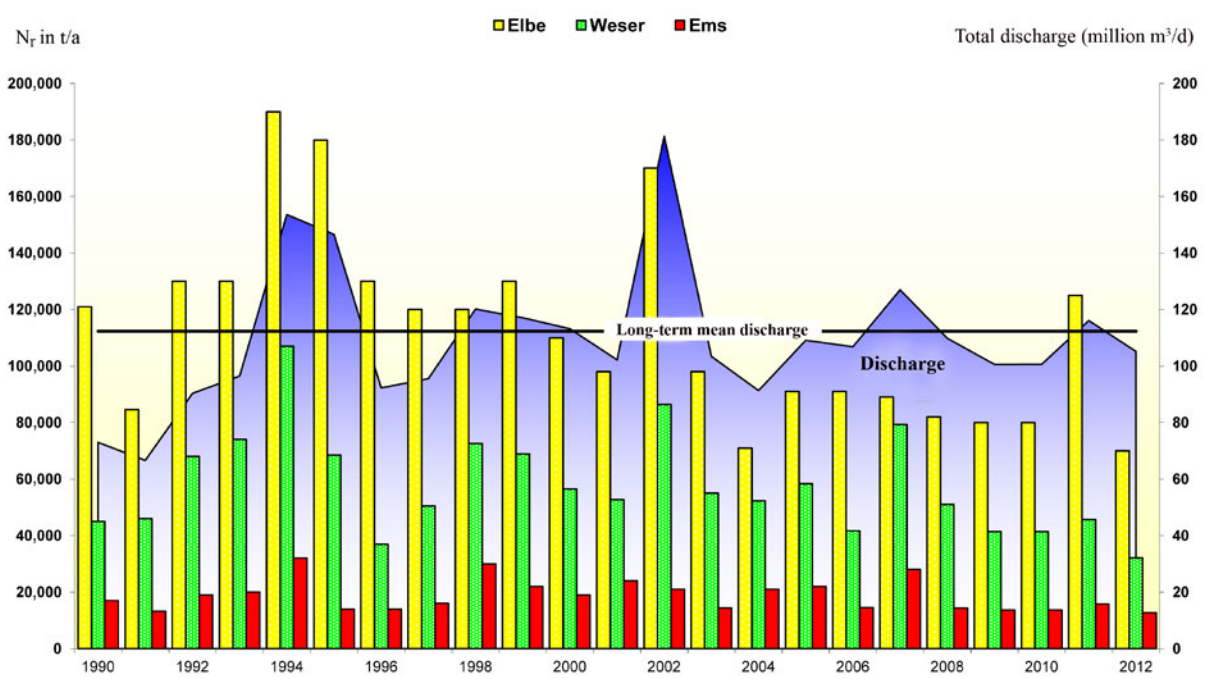
2.3 Marine waters

Reactive nitrogen reaches the transitional and coastal waters as a result of the degradation of organic matter, in rivers, via atmospheric deposition, by direct inputs, and marine currents, as well as to a small proportion as a result of nitrogen fixation by blue-green algae (VOSS et al. 2012).

The largest amounts of reactive nitrogen flowing directly into the North Sea from German sources are carried by the Rivers Elbe and Weser, which corresponds to the size of the river basins and the discharge volumes (Figure 3). In total, the annual nitrogen input into the surface waters of the German North Sea catchment area decreased by 44 % between the periods 1983 – 1987 and 2006 – 2008 (ARLE et al. 2013). The main source of the nitrogen inputs into the North Sea is the agricultural sector, which accounted for 77 % of the nitrogen inputs over the period 2006 – 2008 into the rivers flowing into the North Sea (ARLE et al. 2013). As already mentioned, the decline in the total inputs is due primarily to the reduction in inputs from point sources.

Figure 3

Reactive nitrogen inputs* from German rivers flowing into the North Sea compared with total discharge



*Data from German Länder for the OSPAR reporting

Source: Written communication from UBA, 16 July 2014

In 2010, a total of 758,337 t of reactive nitrogen was carried into the Baltic Sea by rivers and from direct inputs (SVENDSEN et al. 2013). Because no major German rivers flow into the Baltic Sea, the German share of the overall inputs is only 3.2 %. Looking at the inputs from German rivers into the Baltic Sea over the past 15 years and adjusting for levels of

discharge, then no downward trend can be identified. Agriculture accounts for 82 % of the inputs (ARLE et al. 2013).

Atmospheric depositions of reactive nitrogen into marine waters are markedly smaller than the amounts carried in from rivers. An estimated 33 % of total nitrogen inputs into the North Sea are from the atmosphere. In the period 1996 – 2006, total nitrogen depositions into the North Sea only decreased by about 10 % (UBA 2013d). Agriculture is the main source of nitrogen depositions into the North Sea, followed by transport and the energy sector. Germany accounts for 12 % of the total reactive nitrogen depositions into die North Sea (OSPAR Commission 2009b).

For the Baltic Sea, atmospheric nitrogen depositions accounted for 22 % of total nitrogen inputs in 2010. The German share of total nitrogen depositions was 18 %, not including shipping (SVENDSEN et al. 2013). Reactive nitrogen reaches this marginal sea via the atmospheric pathway primarily in the form of nitrogen oxides or ammonium. The most important sources for nitrogen oxides are shipping, road transport and power generation, while some 90 % of ammonium comes from agriculture (BARTNICKI and LOON 2010).

The nitrate pollution levels in the German coastal water bodies are today lower than in the first reporting period (1991 to 1994). However, many measuring stations near the North Sea coast have shown increased nitrate concentrations for the last available reporting period (2007 to 2010), in particular those which are impacted by the discharge from river estuaries (BMU and BMELV 2012). This increase in concentration levels is related to the increased discharges due to higher levels of precipitation. For the measuring stations near the Baltic Sea coasts, both decreases and increases in nitrate values have been documented between the period 2003 – 2006 and the period 2007 – 2010.

High nitrogen concentrations lead to an increased primary production of phytoplankton and the growth of short-lived macroalgae and also to a disturbance in the balance between organisms. Eutrophication is associated with an increase in algal bloom (DAVIDSON et al. 2012), for example the foaming *Phaeocystis* blooms in the Wadden Sea (WOLFF et al. 2010). This phenomenon has not become less frequent in the Wadden Sea in recent years, despite the reduction in nutrient concentrations, but it appears that the blooms do not last as long. A high density of phytoplankton reduces the water transparency and the reduced penetration of sunlight limits the depth to which macrophytes and sea grasses can grow. The decline in sea grass beds in the North Sea and Baltic Sea is largely attributable to the effects of eutrophication (WOLFF et al. 2010; NARBERHAUS et al. 2012).

As a result of eutrophication effects, nearly all the transitional waters and coastal waters of the German North Sea and Baltic Sea assessed in the course of the implementation of the Water Framework Directive in 2008 failed to achieve a good ecological status (BMU and BMELV 2012; ARLE et al. 2013).

Eutrophication is a problem for almost the entire Baltic Sea. One of the most striking effects of excessive levels of nutrients is the formation of hypoxic or anoxic zones in deep water layers. In particular in the central Baltic Sea and in the Gotland Basin these permanently cover large areas. According to a recent study, the extent of these areas in the Baltic Sea has increased more than ten-fold over the past 115 years (CARSTENSEN et al. 2014). In anoxic areas, higher organisms are unable to survive near the sea bed due to the lack of oxygen and the presence of hydrogen sulphide, which is formed there. The spread of anoxic zones is dependent not only on the nutrient concentrations but also on other factors such as the temperature, the inflow conditions and the annual fluctuations in currents. Overall, there is little indication of any fundamental improvement in the eutrophication situation in the Baltic Sea (HELCOM 2013; UBA 2013e; ARLE et al. 2013).

3. The implementation of the Water Framework Directive with regard to the reduction of agricultural nitrogen inputs

In the following, an overview is provided of the measures planned in Germany to reduce nutrient and reactive nitrogen pollution from agriculture. For 60 % of all riverine water bodies in Germany, agricultural measures are planned for the reduction of nutrient inputs (see Table 1). These include both basic and supplementary measures. Measures are also planned for 69 % of groundwater bodies and for 46 % of lakes. Only a small number of the coastal and transitional waters are affected by such measures.

Table 1

Number of bodies of water in Germany for which agricultural measures* are planned

Category	No. of affected bodies of water/ (total no. of bodies of water)	Aggregation
Rivers	5,978 (9,900)	Surface waters
Lakes	324 (710)	
Transitional waters	1 (5)	
Coastal waters	2 (74)	
Groundwater	690 (1,000)	Groundwater

* Not including consultancy measures

SRU/SG 2014-2/Tab. 6-3

3.1 Surface waters

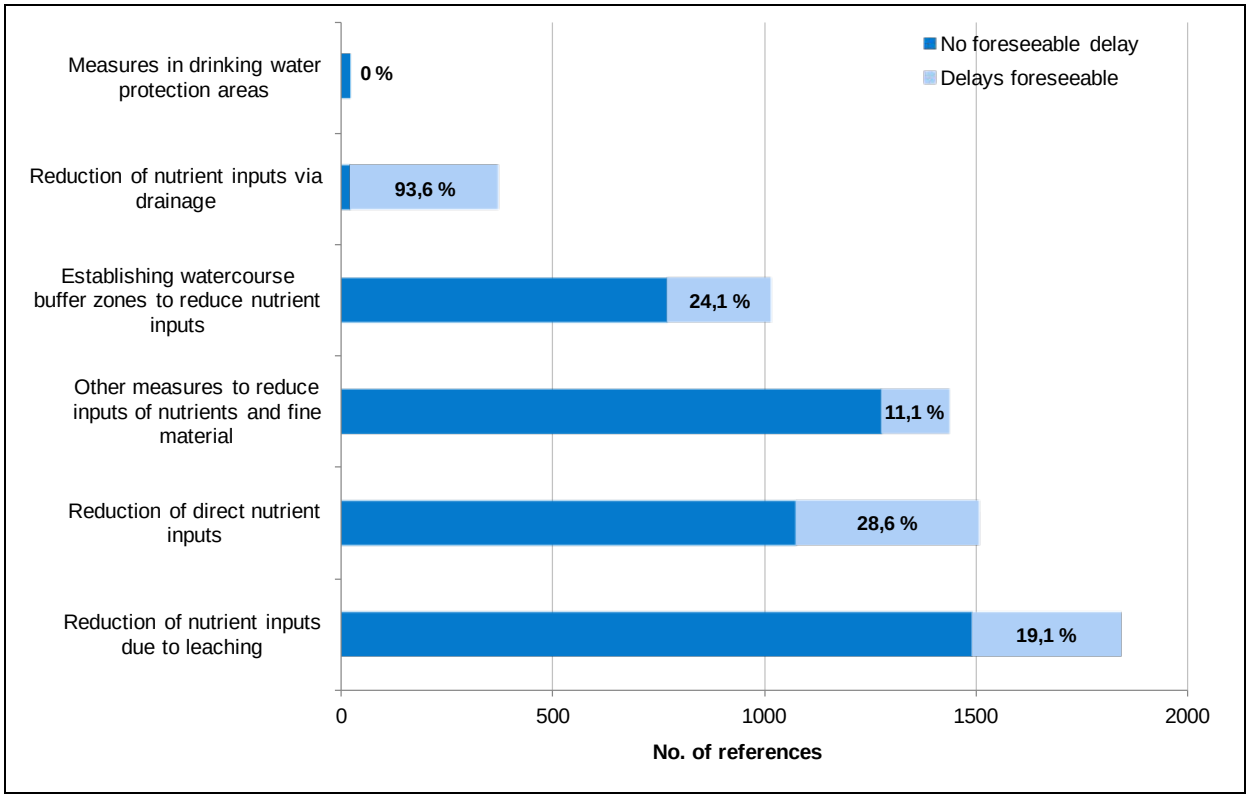
For surface waters, the majority of agricultural measures relating to nutrient problems aim to reduce the nutrient inputs due to leaching. These include the planting of catch crops and converting to organic farming methods (Figure 4). In second place are measures to reduce direct nutrient inputs. These are exclusively measures to implement good agricultural

practice and are thus basic measures or obligations that farmers are obliged to comply with anyway.

Somewhat less frequently (1,436 times) measures were included in the German national river basin management plans to prevent inputs of fine materials into the surface waters. These primarily relate to changes in soil working methods. It is envisaged that watercourse buffer zones will be created for some 1,000 bodies of surface water. There is a direct link here to the implementation of hydromorphological measures. References to drainage improvements are comparatively infrequent in plans for the reduction of nutrient inputs, although this is a very relevant route for nutrient inputs into surface waters, especially in northern Germany. Only two German *Länder* said that they were adopting such measures.

Figure 4

Types of measures and the proportions with foreseeable implementation delays



SRU/SG 2014-2/Fig. 6-5;
Data from: VÖLKER 2014, based on WasserBLIcK (n.d.), as of 31.10.2012

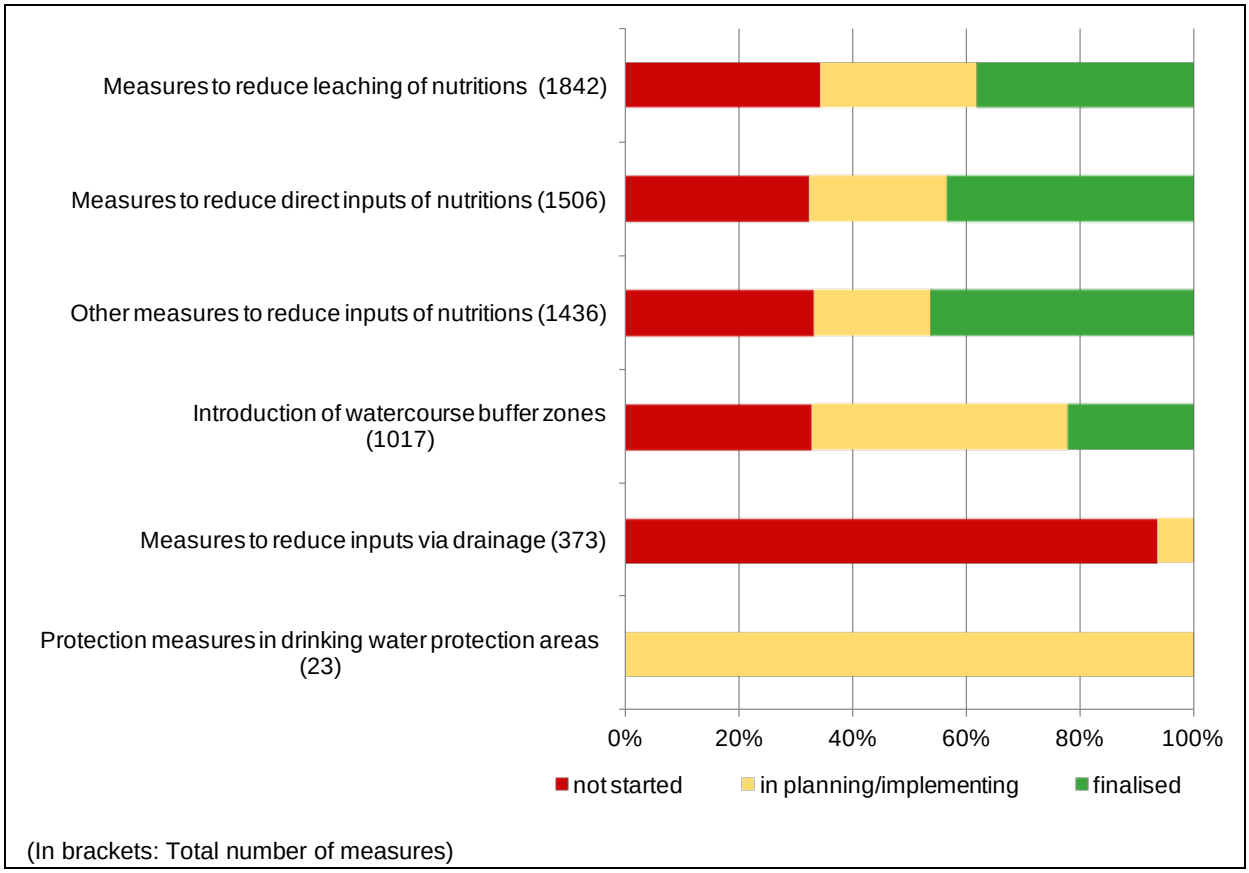
Technically, measures such as creating drainage ponds and artificial wetland areas are not particularly challenging (GOCKE et al. 2012). However they do require resources, for example in the form of farmland.

As of 31 October 2012, a total of 36 % of the measures to reduce nutrient inputs from agriculture had been completed, 27 % were still in planning or implementation, and 37 % had not yet been started (Figure 5). A particularly low proportion of completed measures were in

the categories drainage and watercourse buffer zones. Delays in the completion of watercourse buffer zones were attributed mostly to a lack of resources.

Figure 5

State of implementation of measures to reduce agricultural nutrient inputs



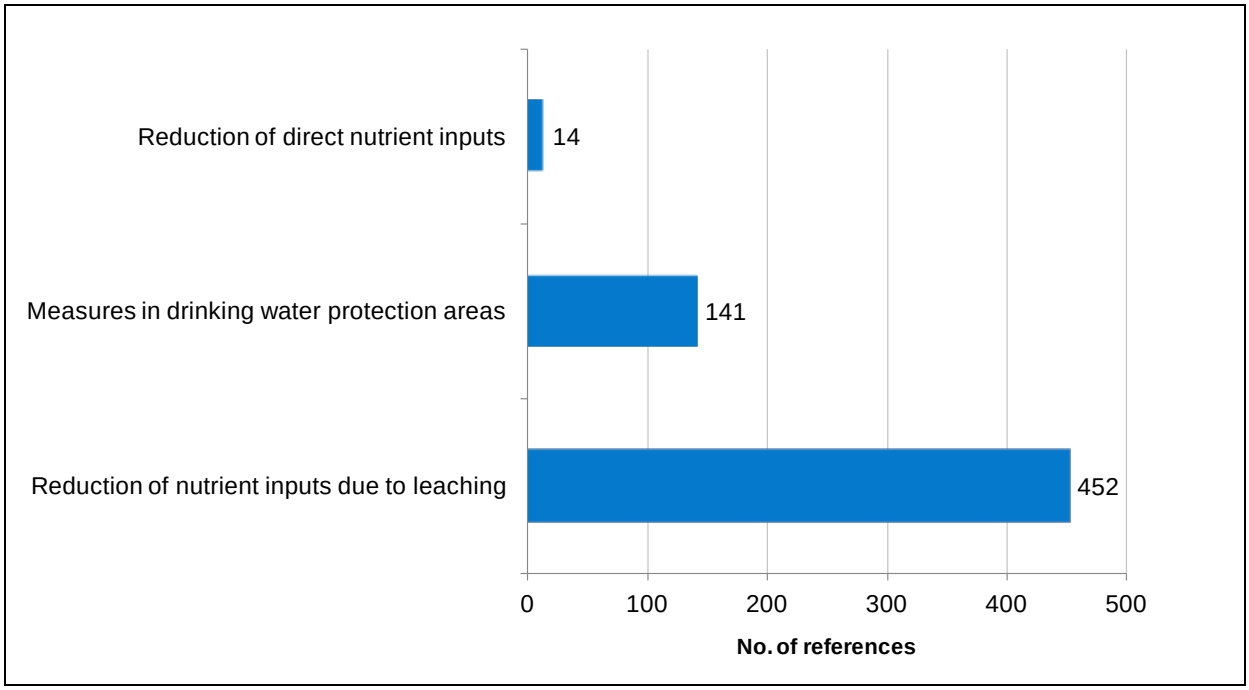
SRU/SG 2014-2/Fig. 6-7;
Data from: VÖLKER 2014, based on WasserBLIcK (n.d.), as of 31.10.2012

3.2 Groundwater bodies

Three types of measures were distinguished for the reduction of nutrient inputs into groundwater bodies. Most frequently, measures are planned for the reduction of nutrient inputs due to leaching (Figure 6). As with the surface waters, these include catch cropping, under-sowing, or switching to organic farming. These are followed by measures in drinking water protection areas, which are envisaged for 141 groundwater bodies. The measures go beyond good farming practice and are either contractually or legally binding. There are relatively few measures to reduce direct nutrient inputs, in particular because these are not so relevant for groundwater bodies. The figures show that 1.6 % of the measures have not yet been started, 93 % are still in planning or implementation, while only 5.4 % of the measures have already been completed.

Figure 6

Measures to reduce nutrient inputs from agriculture into groundwater bodies



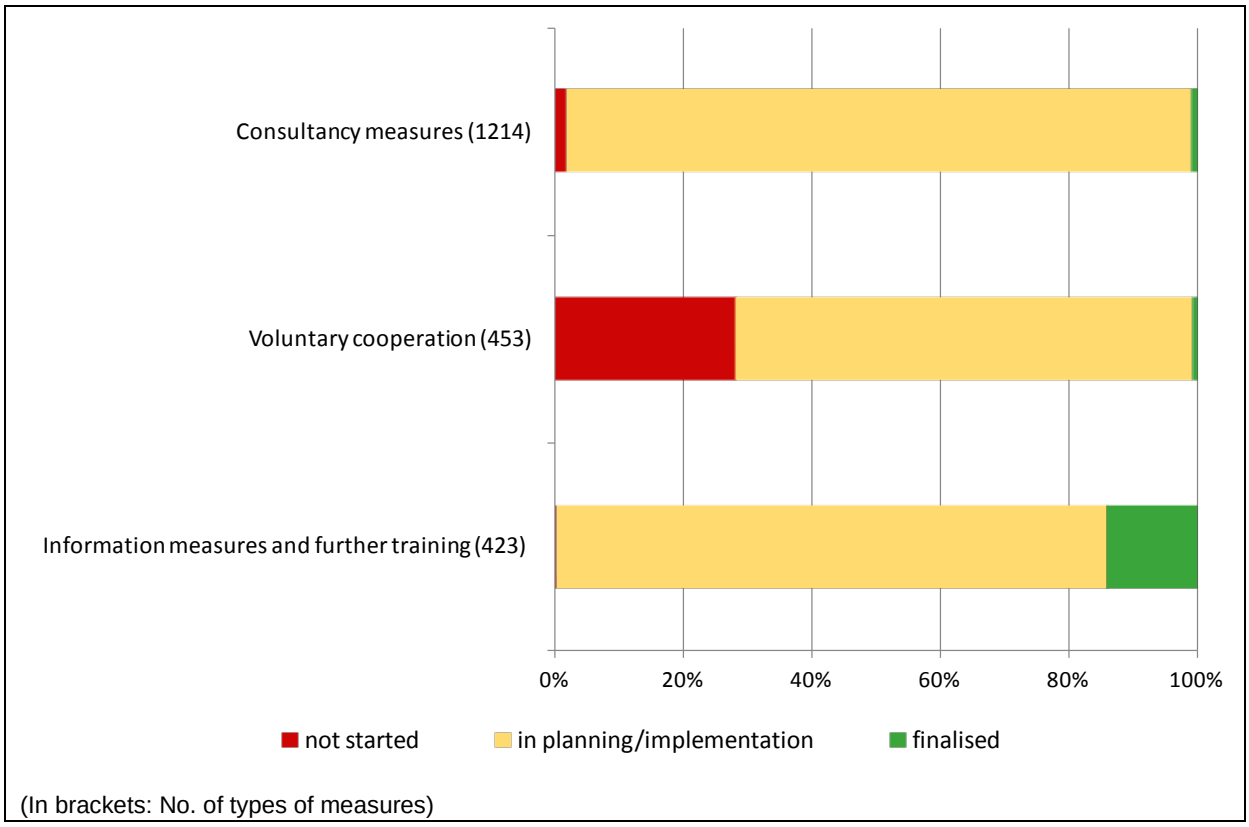
SRU/SG 2014-2/Fig. 6-8;
Data from: VÖLKER 2014, based on WasserBLIcK (n.d.), as of 31.10.2012

3.3 Conceptual measures and agricultural consultancy

So-called conceptual measures play an important role in the programmes of measures for the reduction of nutrient inputs from agriculture. The conceptual measures mostly involve consultancy, and less frequently voluntary cooperation agreements, information measures and further training. No distinction is made here between surface water and groundwater bodies, because the measures are to have a positive effect for both. As shown in Figure 7, most of the measures are still in the planning and implementation phase.

Figure 7

Implementation of measures for agricultural consultancy



SRU/SG 2014-2/Fig. 6-9;
Data from: VÖLKER 2014, based on WasserBLIcK (n.d.), as of 31.10.2012

3.4 Interim conclusions on the implementation of measures in agriculture

The presentation of the implementation of measures in agriculture is based on the data from the reports of the German government and the *Länder* to the European Commission (VÖLKER 2014). The interpretation of the aggregated data is difficult because they only refer to types of measures and therefore do not allow conclusions to be drawn about individual measures. In some cases, very different measures are subsumed under a single type. For example, “Reduction of nutrient inputs from leaching” not only includes measures relating to farm management (e.g. catch cropping) but also the conversion to organic farming. Equally, individual measures such as catch cropping may appear in different categories, so that an allocation of individual measures to one specific type of measure is not possible. It remains an open question whether a satisfactory assessment of the implementation is possible on the basis of such generalised reporting.

Overall it can be concluded that numerous measures for the reduction of nitrogen and nutrient inputs from agriculture are planned in the implementation of the WFD in Germany. The supplementary measures are as a rule voluntary, with hardly any references to legally or contractually binding measures. A large number of measures had not been concluded by the end of 2012. The delays in the case of surface waters were particularly striking. The main

reasons given for this were a lack of financial and human resources, and a lack of acceptance. Without adequate resources, however, it is hardly possible to overcome the lack of acceptance of farmers and other parties involved. This applies in particular for cost-intensive measures such as the reduction of nitrogen inputs through drainage or cases where there are conflicts of interests – for example when it comes to establishing watercourse buffer zones.

4. The three key instruments to reduce agricultural nitrogen inputs

4.1 Agri-environmental measures

A large proportion of the agricultural measures adopted in Germany to implement the Water Framework Directive are supplementary or voluntary measures for which financial compensation is provided. They are supported through rural development programmes of Germany's federal states. Measures to reduce nitrate inputs from agriculture are funded in particular under the EAFRD Regulation (EU) No. 1305/2013 or through the Federal Government/Länder Joint Scheme for the Improvement of Agricultural Structure and Coastal Protection (GAK). The EAFRD Regulation also allows for compensation for additional costs and foregone income related to the implementation of the Water Framework Directive (see Art. 30 Abs. 1 EAFRD Regulation).

The second pillar of the EU Common Agricultural Policy (CAP) provides an important source of funding for these voluntary reduction measures. However, the financial allocations have in the past been felt to be inadequate with regard to biodiversity and surface water management (OPPERMANN et al. 2013; SRU 2009). As part of the CAP reform, EU funds for the second pillar were further reduced. The Member States may decide to shift up to 15 % of their direct payments allocation and the funds generated from the capping or reduction of direct payments to the second pillar in accordance with Annex II. However, the German government plans only to make use of this to a very limited extent. Rather than exploiting this option to the full, as the SRU had recommended (SRU 2013b; SRU et al. 2013), it was decided to reallocate only 4.5 % (Article 5 DirektZahlDurchfG). This national measure will make up for part of the reduction of the second pillar at the EU level, but there remains a net reduction in these funds in Germany.

Of the funds available in Germany for rural development – in the period 2007 to 2013 these totalled EUR 16.4 billion – between a fifth and a third has in the past been spent in the various *Länder* on water protection measures (BMU 2010). In view of the considerable challenges associated with the implementation of the Water Framework Directive and the excessive levels of nutrient and nitrogen inputs from agriculture into the aquatic environment, the question arises whether this is sufficient. It is important to examine how water management concerns could be integrated to a greater extent in agri-environmental measures.

Although the impacts of agri-environmental measures on the environment are not always clear, in view of limited funding greater attention should be paid to the effectiveness of the measures and their long-term impacts, with checks on whether goals are achieved (MÖCKEL 2014). For example, funding should only be provided for measures that go beyond good agricultural practice. An evaluation of agri-environmental measures envisaged for the implementation of the Water Framework Directive, like the one carried out by the Thünen Institute for North Rhine-Westphalia, is urgently recommended (REITER et al. 2008). On important evaluation criterion could be the spatial accuracy, i.e. the extent to which farms in areas in particular need of protection measures are motivated to take part. As a rule, agri-environmental measures only have an effect in the period in which the farmer participates, but no longer. For this reason, among others, the SRU has considerable doubts whether voluntary measures alone are sufficient and sees a need to include additional restrictions on use. This is in view of the fact that a whole range of factors influence the decisions by farmers on whether to participate and agri-environmental measures are often not attractive enough, particularly in problematic or sensitive areas and for highly-productive farms (REITER et al. 2008; TRAUTMANN 2009; HOMM-BELZER 2009).

4.2 Agricultural consultancy on water management issues

Agricultural consultancy and conceptual measures are a further important element of the supplementary measures in accordance with the Water Framework Directive for the reduction of agricultural nutrient inputs. In Germany, agricultural consultancy is the responsibility of the *Länder,* which have differing regulations and procedures. There are also differences in the forms of consultancy provided and the integration in the approach adopted. For the implementation of the Water Framework Directive a combination of various instruments is generally selected, of which consultancy is an important component. Additional incentives are made available, e.g. funding measures, and cooperation agreements are also offered in order to increase the willingness to accept consultancy. In some cases, the consultancy services are adapted to special local conditions. Cooperative approaches, e.g. to achieve common solutions for the nitrogen problem, are regarded as particularly promising and have been adopted in various *Länder* (Chamber of Agriculture North Rhine-Westphalia 2011; NLWKN 2014; THOMAS 2003). Other effective elements are the inclusion of best-practice examples or the presentation of model farms that have already implemented to relevant measures.

For North Rhine-Westphalia, the water protection consultancy for farms in connection with the implementation of the Water Framework Directive was evaluated (FOHRMANN and LIESENFELD 2012). The Chamber of Agriculture takes charge of most water management consultancy tasks. It developed and implements an appropriate concept on behalf of the Federal State Ministry for Climate Protection, Environment, Agriculture, Conservation and Consumer Protection (Chamber of Agriculture North Rhine-Westphalia 2004; 2011).

Consultancy is offered within the framework of the Cooperation Group on Drinking Water Protection, in which farmers and the water management sector have already cooperated for more than twenty years. On the basis of this experience, a consultancy strategy has also been developed for areas outside the water protection zones which do not comply with the requirements under the Water Framework Directive for groundwater or surface waters. The aim of the consultancy concept in North Rhine-Westphalia is primarily to ensure that more consideration is given to the concerns of water protection in farming methods and procedures, to increase the acceptance of agri-environmental measures, and in the long term to establish forms of production and farming which have a lower impact on water bodies. The consultancy is backed up by special funding programmes in heavily affected areas. The Chamber of Agriculture North Rhine-Westphalia draws attention to the measurable success of the consultancy services, but also notes that more work is needed in regions with intensive livestock farming and vegetable cultivation. The Chamber also argues that greater attention should be paid to the areas involved and measures should concentrate more on particularly sensitive regions (Chamber of Agriculture North Rhine-Westphalia 2011).

FOHRMANN and LIESENFELD (2012) comment that farmers involved in drinking water management joint-action groups in North Rhine-Westphalia are more willing to participate than farmers outside the drinking water management areas. Furthermore, the density of consultants is much higher in areas covered by existing drinking water cooperation arrangements. Important motivating factors are the public pressure generated as a result of the keen interest taken in drinking water issues, the group dynamics between farmers or other members of the joint-action groups, and in part also legal or financial advantages compared with farmers who are not in the cooperation group (ibid; THOMAS 2003). However, further measures are needed to stimulate active participation, possibly including legal obligations.

It should be noted that the production structure of agriculture in North Rhine-Westphalia has changed considerably in recent years. For example, there has been a decline in grassland farming and cattle farming, while in contrast there has been an increase in the cultivation of maize, winter oilseed rape and potatoes, as well as in pig and poultry farming. In addition, there are manure imports from the Netherlands. The Chamber of Agriculture NRW estimates that 1.4 million tonnes of liquid manure were delivered to North Rhine-Westphalia in 2012 (DUNAJTSCHIK 2014).

4.3 Fertiliser legislation

The Fertiliser Ordinance (DüV) regulates good agricultural practice for the fertilisation of farmland and aims to reduce material risks associated with the application of fertiliser (Article 1 DüV). For the implementation of the Nitrates Directive, Germany has formulated a nationwide action programme for the reduction of nitrate applications.

Important elements of the Fertiliser Ordinance are application ceilings, balance requirements, limitations on balance excesses, permitted application periods and prohibitions, and minimum distances to be maintained from bodies of surface water.

The current version of the Fertiliser Ordinance only specifies an upper application limit for animal manure. A farm shall on average apply less than 170 kg nitrogen per hectare per annum in this way. Artificial fertiliser and organic fertiliser from plants, such as digestates, are not covered by this application limit.

Not only must farmers properly determine the amount of fertiliser required by the crop before every application, they are also required to draw up an annual nutrient comparison on the basis of an area balance or aggregate field balance. The nitrogen extracted in the crops is set against the nitrogen added in the form of manure and artificial fertiliser, together with nitrogen fixed by legumes. The average balance loss over three years shall not exceed 60 kg per hectare. The way the farmers are required to draw up the balance has long been the subject of criticism from various parties, because the area balance and the aggregated field balance involve considerable inaccuracies and offer scope for manipulation (BAUMGÄRTEL et al. 2007; SRU 2008). One reason for this is that the yield of fodder crops can only be estimated. The farm-gate balance, which draws primarily on book-keeping data, is regarded as being much more reliable and the results are more accountable (SRU 2015).

The application of fertiliser is prohibited in periods when the plants take up only small amounts of nutrients, if any, so that application would only lead to nitrate leaching out. On arable land, after the last harvest of the main crop no fertiliser shall be applied which has an appreciable content of available nitrogen, except for solid manure without poultry manure. An exception is the cultivation of succeeding crops or equalisation fertilisation on stubble fields. There is also a ban on applying such fertiliser in the winter months (on arable land from 1 November to 31 January and on grassland from 15 November to 31 January) as well as on water-saturated, flooded, snow-covered or frozen ground.

The method chosen for application has a particular influence on the ammonia emissions. The current Fertiliser Ordinance includes a ban on some application techniques. However, this is no longer felt to reflect developments in the state of the art (BLAG 2012). In addition, it is argued that the periods when application is restricted are not specified with sufficient precision.

In order to prevent nutrients being washed away into surface waters, a watercourse buffer zones of at least 3 metres has to be left, unless appropriate technology makes it possible to apply the fertiliser with greater precision, in which case a buffer zone of 1 m must be set aside. On waterside slopes with a gradient of more than 10 % the buffer zones must have a width of at least 3 m and for a further 20 m strip measures must be taken to prevent run off.

The Fertiliser Ordinance is currently being revised. This is mainly in response to the infringement proceedings begun by the European Commission. At the end December 2014, a draft revised version was published which contains a range of improvements: e.g. the introduction of the farm-gate balance, the extension of restricted application periods, the introduction of low-emission application techniques, the inclusion of digestate from biogas plants in the upper application limit of 170 kg/ha, the reduction of the permissible annual nitrogen surplus to 50 kg/ha and the extension of the watercourse buffer zones. However, it still has a number of weak points. For example, biogas plant operators are able to apply for a derogation from the application upper limit. The farm-gate balance will only be introduced in 2018 and only for large livestock operations. Low-emission application techniques are only to become obligatory in 2020 on arable land and in 2025 on grassland. The watercourse buffer zones alongside surface waters of 4 and 5 metres, depending on the slope, are only moderately ambitious.

A very important consideration is ensuring compliance with the provisions of the Fertiliser Ordinance and imposing sanctions on transgressions (BLAG 2012, SRU et al. 2013). The draft version also proposes changes for the latter case. Overall, however, the worry is that without effective implementation a revised Fertiliser Ordinance can have little impact. The draft revision proposed in December 2014 requires an amendment of the Fertiliser Act, so that it will probably not come into force before the end of 2015.

5. Synergies with the implementation of the Marine Strategy Framework Directive

The Marine Strategy Framework Directive is at the centre of efforts to protect European marine waters from the impacts of human activities, which still include excessive nitrogen inputs. It establishes goals and a time frame for the implementation of regional and national marine strategies.

The Marine Strategy Framework Directive draws on the Water Framework Directive. The two directives both adopt a comprehensive conservation approach, but there are also some differences. For example, the objectives of the Marine Strategy Framework Directive are formulated less stringently than those of the Water Framework Directive (cf. SRU 2012, p. 494 f.). The Marine Strategy Framework Directive came into force in 2008, later than the Water Framework Directive. The aim of the directive is to establish a framework within which Member States will take the necessary measures to achieve or maintain good environmental status in European marine waters by 2020. The Member States are obliged to develop a strategy which culminates in the execution of a programme of measures to protect their marine waters (cf. SRU 2012).

In the directive, eleven qualitative descriptors are listed as a basis for determining good environmental status (Annex I MSFD; SRU 2012, No. 467). Descriptor 5 is particularly

relevant for nutrient inputs into marine waters. It describes good environmental status in the form that human-induced eutrophication is minimised, in particular with regard to negative effects such as loss of biological diversity, ecosystem degradation, harmful algae blooms, and oxygen deficiency in bottom waters (Annex I MSFD). Other relevant descriptors are for biological diversity (Descriptor 1), food webs (Descriptor 4), and sea floor integrity (Descriptor 6).

For the implementation of the Marine Strategy Framework Directive, the following operative environmental goals have been formulated for the German areas of the North Sea and Baltic Sea concerning eutrophication (Descriptor 5):

- The nutrient inputs via rivers are to be reduced further. Reference is made to the reduction goals of the programmes of measures of the management plans under the Water Framework Directive. Indicators for monitoring these goals are the nutrient concentrations at the limnic/marine transition of the rivers flowing into the North Sea and Baltic Sea.
- It is also necessary to reduce the nutrient inputs from other marine areas. Efforts are to be made to achieve this through cooperation of OSPAR and HELCOM. Indicators in this case are the transport and distribution of phosphorus and nitrogen.
- Finally, the nutrient depositions from the atmosphere are also to be reduced further. Indicators are the emission values and the deposition of nitrogen compounds on the surface of marine waters (Bund/Länder-Messprogramm Meeresumwelt 2012b; 2012a).

It is to be expected that the problem of nitrogen inputs into marine waters via rivers will already be addressed as part of the implementation of the Water Framework Directive. Targets have already been formulated for the protection of coastal waters. Nevertheless, it remains to be seen whether the measures adopted will also be sufficient to meet the objectives of the Marine Strategy Framework Directive. Harmonising the work on the implementation of the Water Framework Directive and the Marine Strategy Framework Directive remains a significant challenge. It is improbable that additional measures for the reduction of agricultural nitrogen inputs from farmland will also be formulated as part of the implementation of the Marine Strategy Framework Directive. On the one hand, considerable work has already gone into tackling this problem in the course of implementing the Water Framework Directive, and on the other hand there are barriers to be overcome in the implementation of the existing measures. Anyway, targets for the protection of coastal waters are already being taken into consideration in the implementation. In view of the signs of failure to meet targets in the implementation of the Water Framework Directive, it is hardly likely that the goals will be made even more demanding.

The SRU feels that it is necessary for the German government to show considerably more awareness of its responsibility to reduce nitrogen inputs, including for the protection of marine waters.

6. Conclusions

Agriculture is the main source of the reactive nitrogen pollution in the seas, inland surface waters, and in groundwater. The Water Framework Directive is a key element of the environmental legislation for the reduction of this pollution. It also has a special importance for achieving marine strategy targets. The implementation of the Water Framework Directive involved the introduction of comprehensive measures to reduce nutrient inputs. It is already apparent that these measures alone will not be sufficient to reach the targets of the Water Framework Directive in the foreseeable future.

The Fertiliser Ordinance is a key element of Germany's programme of measures. It is therefore vital that this is thoroughly revised and implemented effectively.

The second element are the so-called supplementary measures, which are primarily agri-environmental measures and agricultural consultancy services. The second pillar of the Common Agricultural Policy (CAP) is an important source of funds for these voluntary reduction measures. In the course of the CAP reform and its implementation in Germany, little was done to improve this basic funding. Given that costs in agriculture have also been increasing at the same time, this is exacerbating the problem of meeting the costs of agri-environmental protection measures.

It is essential to make sure that agri-environmental measures are effective in the long-term, as well as evaluating progress regularly. The effectiveness and efficiency of water management consultancy programmes should also be evaluated regularly. Important criteria for such an evaluation are the acceptance of consultancy services by the farmers, in particular in problem areas, the extent to which water management proposals are implemented, and the changes in nitrogen inputs in the target areas.

Cooperation and voluntary participation are important elements in order to encourage farmers to become actively involved. However, in view of conflicting incentives, such as the indirect provision of aid to grow biomass for power generation, this approach will not be sufficient to reach the targets. In addition it does not give adequate consideration to the polluter-pays principle specified in the Water Framework Directive. Therefore, the SRU recommends that Germany's federal states should implement further regulations and adopt more extensive economic measures to reduce the nitrogen inputs into surface waters and groundwater. In particular in order to take into account the regional sensitivities of ecosystems, more water protection areas should designated, and not only as source protection zones for drinking water or spa waters. Watercourse buffer zones should also be

wide enough to make an effective contribution to reducing the nutrient inputs into the surface waters.

It is also advisable to adopt a more integrated approach to the reduction of nitrogen inputs, in order in future to be able to make more use of synergies, for example in the implementation of the Water Framework Directive and Marine Strategy Framework Directive, and at the same time to address conflicting interests – such as those between water protection and the promotion of bioenergy – in a timely fashion.

7. Literature

SRU (Sachverständigenrat für Umweltfragen) (2015): Stickstoff: Lösungsstrategien für ein drängendes Umweltproblem. Sondergutachten. Berlin: Erich Schmidt.

A detailed list of references is provided in the special report, which can be downloaded at http://www.umweltrat.de.

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