THE EUROPEAN ENVIRONMENT

STATE AND OUTLOOK 2010

FRESHWATER QUALITY

European Environment Agency

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1. a set of 13 Europe-wide **thematic assessments** of key environmental themes;
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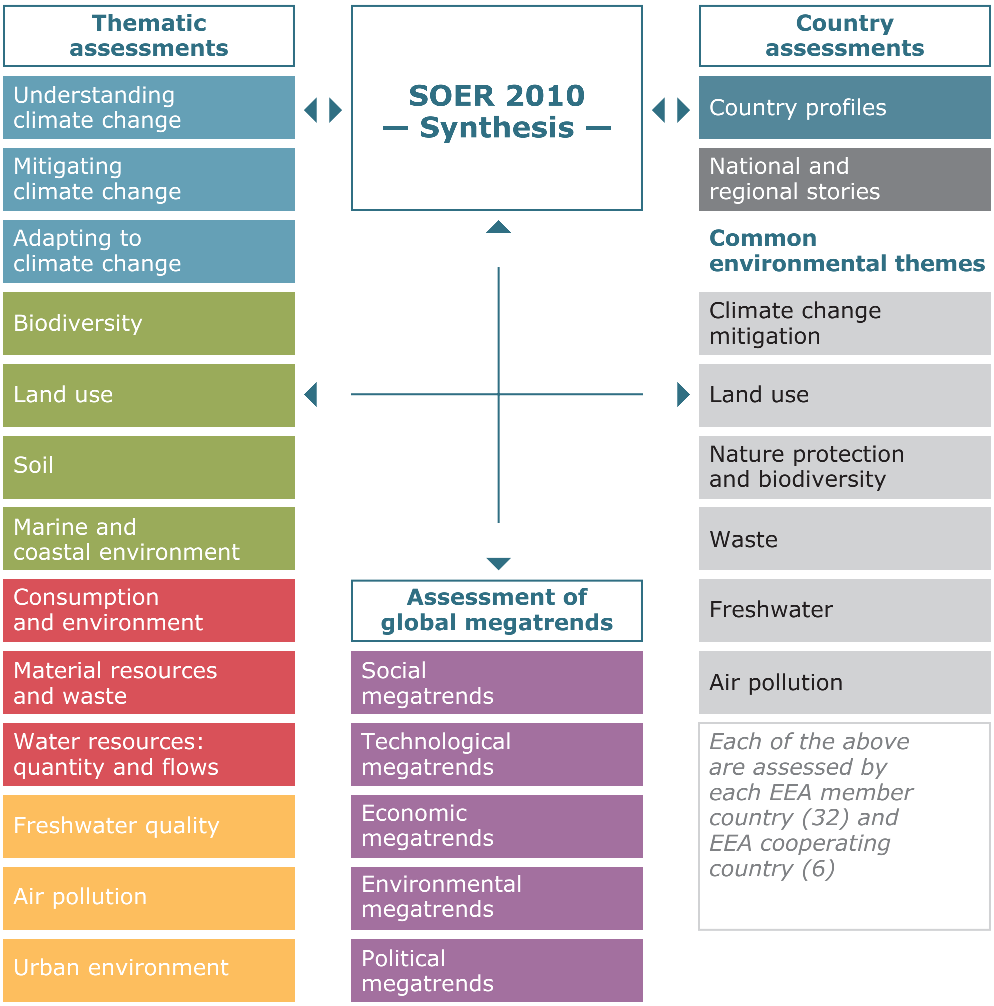
3. a set of 38 **country assessments** of the environment in individual European countries;
4. a **synthesis** — an integrated assessment based on the above assessments and other EEA activities.

SOER 2010 assessments



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EEA lead author
Robert Collins.

EEA contributors
Bo Jacobsen, Beate Werner, Eva Goossens, Peter Kristensen, Trine Christiansen.

EEA's European Topic Centre on Water (ETC-Water)
Anne Lyche Solheim, Jannicke Moe, Kari Austnes (NIVA); Anita Kuenitzer, Hana Prchalova, Petra Ronen, Renata Filippi, Vít Kodeš (CENIA); Lidija Globevnik, Tina Kirn (IWRS); Kim Gustavson, Morten Bjergstrøm (DHI).

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European Commission
DG ENV; Agnieszka Romanowicz
JRC; Faycal Bouraoui.

European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark
Tel.: +45 33 36 71 00
Fax: +45 33 36 71 99
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

Freshwater quality

Summary

The continuing presence of a range of pollutants in a number of Europe's freshwaters threatens aquatic ecosystems and raises concerns for public health. Current reporting under the EU Water Framework Directive (WFD) shows that a substantial proportion of Europe's freshwaters are at risk of not achieving the aim of 'good status' by 2015. Driven by the EU Urban Wastewater Treatment Directive (UWWTD), improvements in the collection and treatment of wastewater in some regions of Europe have led to a reduction in the discharge of some pollutants to fresh and coastal waters. Challenges remain, however, because UWWTD implementation remains incomplete and other significant sources of water pollution exist, especially agriculture and urban storm flows. The implementation of effective and timely measures, required under the WFD, needs to encompass a greater focus on controls 'at source' and the efficient use of resources including water, energy and chemicals.

Main pollutant sources: agriculture and the urban environment

Despite improvements in some regions, pollution from agriculture remains a major pressure on Europe's freshwater. Nutrients (nitrogen and phosphorus) from fertilisers, pesticides, organic material, sediment and pathogenic micro-organisms are washed to waterways, primarily via diffuse pathways. Cost-effective measures exist to tackle agricultural pollution and need to be implemented through the WFD, while full compliance with the Nitrates Directive is also required. The forthcoming reform of the Common Agricultural Policy provides an opportunity to further strengthen water protection.

The urban environment generates a range of pollutants including industrial and household chemicals, metals, pharmaceutical products, nutrients, pesticides and pathogenic micro-organisms. The UWWTD has led to more of the EU's population being connected to a municipal treatment works via a sewer network and to a reduction in the wastewater discharge of some pollutants to receiving waters. However, there is considerable scope for increased control of pollutants at source which reduces the burden on the treatment process including the consumption of energy. Full-cost pricing for wastewater services will help drive controls at source. Storm overflows in the urban environment also remain a significant concern.

Water quality

Excessive concentrations of phosphorus are the most common cause of freshwater 'eutrophication' — characterised by a proliferation in the growth of problematic algal blooms and an undesirable disturbance to aquatic life. Phosphorus levels in freshwater have declined in recent years due primarily to improved wastewater treatment and bans on phosphates in detergents. However, this trend has slowed suggesting that a greater targeting of diffuse sources of phosphorus is required for further improvements to occur.

While some declining trends in nitrate concentrations are apparent, current levels of nitrate in a number of Europe's rivers are often of a magnitude sufficient to promote eutrophication in receiving coastal waters. Many countries also report groundwater bodies with nitrate concentrations above threshold levels. Clear downward trends in organic pollution are evident in most of Europe's rivers, mainly due to measures implemented under the UWWTD, although these trends have levelled in recent years. The quality of EU inland bathing waters has improved significantly since 1990 — in 2009, 89 % of inland bathing areas complied with mandatory values. Information describing pesticide levels in freshwater remains incomplete across Europe.

Impacts

Pollutants in some of Europe's freshwaters have led to detrimental effects on aquatic ecosystems and the loss of freshwater flora and fauna. Aside from eutrophication, which remains widespread, chemicals with endocrine-disrupting properties have been shown to trigger feminising effects in male fish, raising implications for their fertility. Pesticides and metals can be toxic to aquatic life, while concern is growing about the effects of chemical mixtures found in Europe's more polluted waters. Much of the pollutant load in freshwaters is ultimately discharged to coastal waters with the potential to adversely impact the quality of the marine environment. Poor water quality is also a potential threat to public health through various exposure routes.

Outlook and response

The implementation of a comprehensive range of water-related legislation, led by the WFD, will continue across Europe in the coming years. Currently, reporting under the WFD indicates that a substantial proportion of Europe's freshwaters are at risk of not achieving good status. Strong, cost-effective and timely measures therefore need to be implemented, addressing all pollutant sources. They must also ensure that resources, including water, energy and chemicals, are used in an efficient manner. The extent and effectiveness of measures to be implemented also need to account for driving forces that could affect water quality over the coming decades, including climate change, increasing global food demand and an expansion of the cultivation of bioenergy crops.

1 Introduction

Water is critical for life and is integral to virtually all economic activities, including food and industrial production. Not only is clean water a prerequisite for human health and well-being, it provides for aquatic habitats that support healthy freshwater ecosystems.

A range of pollutants including nutrients, biocides, pathogenic micro-organisms, industrial and household chemicals, metals and pharmaceutical products can be found in a number of Europe's freshwater bodies. These pollutants can come from numerous sources including agriculture, industry, transport and domestic dwellings, and can reach freshwater by various pathways. Much of this freshwater pollutant load is ultimately discharged to coastal waters with the potential to also adversely impact the quality of the marine environment.

The level at which some pollutants are found in some of Europe's freshwater has led to detrimental effects on aquatic ecosystems, degrading habitats and resulting in the loss of freshwater flora and fauna. For example, excessive nutrient concentrations promote eutrophication, characterised by a proliferation of the growth of problematic algal blooms and an undesirable disturbance to the balance of organisms present in the water. The presence of chemicals with endocrine-disrupting properties has also been shown to trigger feminising effects in male fish, raising implications for their fertility and population survival. Pesticides and metals too can be toxic to aquatic life. Concern is also growing about the combined effects on aquatic biota of the mixture of chemicals that is often found in Europe's more polluted water.

Poor water quality is also a potential threat to public health through freshwater and marine recreation, the consumption of contaminated freshwater and seafood, where sanitation is inadequate and, where access to safe drinking water is lacking.

To protect freshwater from pollution, a comprehensive range of legislation has been established in Europe. Most notably, the Water Framework Directive (WFD), which represents the single most important piece of EU legislation relating to the quality of fresh and coastal waters, aims to attain good ecological and chemical status by 2015. The WFD includes a strong economic component and, in accordance with the polluter-pays principle, requires that Member States implement full recovery of the environmental and resource costs of water services. In addition, water-pricing policies are to be established that provide adequate incentives for the efficient use of water resources.

Other legislation, directly related to the WFD and providing its basic measures, targets particular groups of pollutants. Compliance with the Urban Waste Water Treatment Directive (UWWTD) and Nitrates Directive (ND), for example, will improve nutrient water quality and aid, although not necessarily guarantee, the achievement of good ecological status under the WFD. The chemical quality of Europe's surface waters is primarily addressed by the recently established Environmental Quality Standards Directive (EQSD). This daughter directive of the WFD defines concentration limits for pollutants of EU-wide relevance known as priority substances (PS). The limits are defined both in terms of annual average and maximum allowable concentrations, with the former protecting against long-term chronic pollution problems and the latter against short-term acute pollution. Some of these pollutants have been designated as priority hazardous substances (PHS) due to their toxicity, their persistence in the environment and their bioaccumulation in plant and animal tissues. The EQSD requires cessation or phase-out of discharges, emissions and losses of PHS. Regulation of other chemicals — those not classified as PS or PHS — is to be addressed at the national level. The Registration, Evaluation, Authorisation and Restriction of Chemical substances regulation (REACH) also has an important role to play through its aim to improve the protection of human health and the environment from the risks of chemicals. REACH gives greater responsibility to industry to manage these risks and to provide safety information on substances used.

The Bathing Water Directive (BWD) aims to protect public health by setting concentration limits for microbiological pollutants in Europe's inland and coastal bathing waters. The BWD also addresses risks from toxic cyanobacteria, requiring immediate action, including the provision of information to the public, to prevent exposure.

Concern for the current state of Europe's freshwater is also reflected by the EU's 6th Environmental Action Programme (6th EAP), in particular, the prioritisation of 'full implementation of the WFD'. This goal is strongly related to many other 6th EAP objectives, including implementation of a thematic strategy on the sustainable use of pesticides, protection of biodiversity from pollution, the sustainable management of water resources and the conservation of marine ecosystems. With WFD implementation ongoing, one key objective of the 6th EAP is being met. However, achieving WFD compliance and fulfilling the other water quality priorities of the 6th EAP present a major challenge for the coming years. Successfully meeting this challenge will require, amongst other things, the implementation of strong, effective and timely measures under the River Basin Management Plans (RBMP) of the WFD.

2 Sources, emissions and water quality

The sources of freshwater pollution are extremely diverse and can vary considerably with geographical location. However, while landfills, forestry, mining, aquaculture and dwellings un-connected to a municipal sewage treatment works, for example, can all be of great importance locally, two broad sources alone contribute most to the freshwater pollution observed across Europe: agriculture and the urban environment. For clarity and brevity, the following discussion focuses on these two sources, although it is recognised that this is a simplification, with the wider urban environment in particular encompassing a number of different sources of pollution.

2.1 Agriculture

Background

Despite improvements in some regions, diffuse pollution from agriculture remains a major cause of the poor water quality currently observed in parts of Europe. In particular, nutrients — nitrogen and phosphorus — from fertilisers, pesticides, sediment, pathogenic micro-organisms excreted by livestock and organic pollution from manure are regularly detected in freshwaters at levels sufficient to impact aquatic ecosystems or require treatment where water is abstracted for drinking.

The extent, speed and pathways by which pollutants are transported from agricultural land to freshwater bodies are varied and depend on a range of factors. In broad terms, high intensity rainfall on poorly drained soils leads to surface runoff that can relatively quickly wash pollutants into water bodies. In contrast, lower intensity rainfall on well-drained soils promotes the infiltration of water and pollutants into the soil. Some pollutants, for example microbes, are generally readily attenuated within soil, reducing the likelihood of their transport to a water body. For others, particularly nitrogen in the form of nitrates and certain pesticides, little attenuation occurs in soil and, unless the downward movement is interrupted for example by artificial subsurface drains, considerable leaching to groundwater can occur. Depending on hydro-geological characteristics, the leaching of these pollutants to groundwater and any subsequent onward transport to surface waters can take several decades. In such cases, there may be a significant time lag between the implementation of mitigation measures on agricultural land and any improvements in water quality.

In addition to soil, certain features of the rural landscape, particularly small ponds, marshes and carbon-rich wetlands, can play an extremely important role in the attenuation of pollutants through various processes including physical entrapment, settlement and gaseous loss. However, drainage of much of Europe's agricultural land has resulted in a considerable loss of such features (LIFE III, 2007), reducing the capacity of the rural landscape to store and attenuate agricultural pollutants.

Despite the often large potential for attenuation within rural catchments, a significant proportion of the nutrients, pesticides, microbes, etc. generated on agricultural land do reach a receiving water body. The magnitude of such emissions, together with those from other sources, determines the resulting water quality of Europe's freshwater.

Nutrients

While nitrogen fixation, atmospheric deposition and the application of treated sewage sludge can all be important, typically the major nutrient inputs to agricultural land are from inorganic mineral fertilisers and organic manure from livestock. Today, the highest total fertiliser nutrient application rates — mineral and organic combined — generally, although not exclusively, occur in Western Europe. Ireland, England and Wales, the Netherlands, Belgium, Denmark, Luxembourg, north-western and southern Germany, the Brittany region of France and the Po valley in Italy all have high nutrient inputs (Grizzetti et al., 2007; Bouraoui et al., 2009).

Inputs of nutrients to agricultural land across Europe are generally in excess of what is required by crops and grassland, resulting in nutrient surpluses (Grizzetti et al., 2007). The magnitude of these surpluses reflects the potential for detrimental impacts on the environment since it is available for gaseous loss to the atmosphere as ammonia, build-up in soil pools over time, or transport to the nearest receiving water body where excess nutrient levels in water promote eutrophication. The pattern of national scale nitrogen surpluses across Europe reflects the magnitude of inputs via mineral and manure fertilisers. Whilst most countries exhibited a nitrogen surplus, calculated as an average between 2002 and 2004, of at least 30 kg per hectare of total agricultural land, values in excess of 100 kg/ha were apparent for Belgium, Denmark, Luxembourg and Germany and even exceeded 200 kg/ha in the case of the Netherlands

(OECD, 2008). Generally, however, those values reflected an already significant decline in nitrogen surplus between 1990 and 2004 (OECD, 2008). In addition, the SOER 2010 country assessments provide evidence that this decline has continued since 2002–2004, for example, in the Netherlands, Denmark and the Flanders region of Belgium, as reflected directly by a national surplus or a closely related indicator such as nutrient emissions.

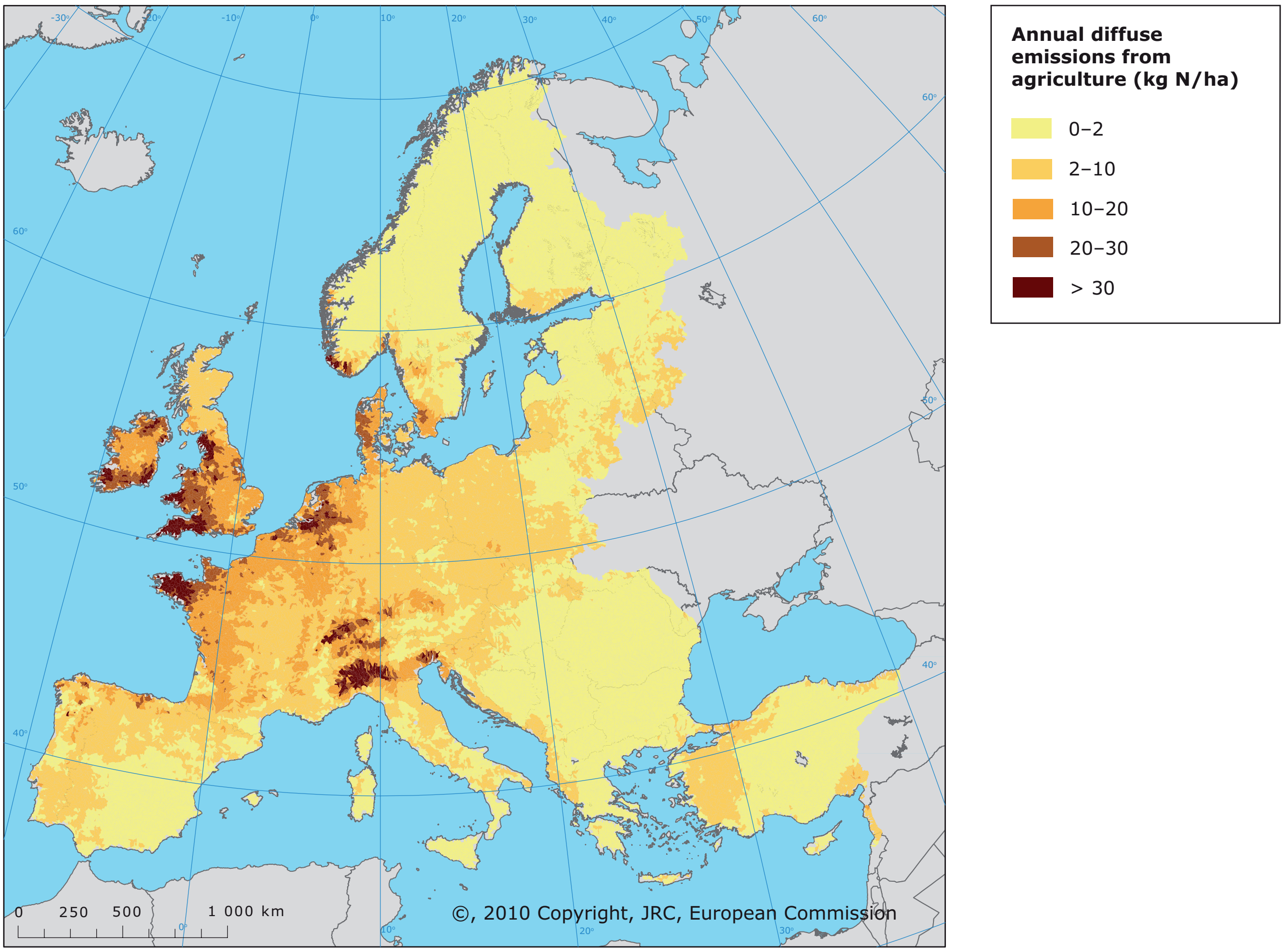
Wider agro-economic factors and improved training for farmers are likely to have played a role in the decline of surpluses. In addition, policy measures, such as national action plans, as in Denmark, (Nørring and Jørgensen, 2009) and the implementation of the ND have been of importance. Fundamental to the latter is the establishment of Nitrate Vulnerable Zones (NVZs) in areas where agricultural sources of nitrates have led to excessive concentrations in freshwater or threatened waters sensitive to eutrophication. Action programmes are required for NVZs that detail a range of measures that need to be implemented to reduce the levels of nitrate pollution.

Despite the general decreases over recent years, nutrient surpluses in some regions of Europe remain at an excessively high level. Although the catchment processes described above attenuate much of the nutrient surplus, a significant proportion can still be transported to freshwater, and hence termed an emission. Such diffuse emissions are strongly influenced by rainfall. According to model estimates, agricultural emissions of nitrogen to freshwater exceed 10 kg/ha/year across some European regions, with values exceeding 20 kg/ha/year in parts of Denmark, southern Sweden and Norway, western United Kingdom, Ireland, Belgium, Netherlands, Brittany, and the Po Valley (Bouraoui et al., 2009; Map 2.1). A broadly similar spatial pattern is evident for agricultural phosphorus emissions to freshwater, with values exceeding 0.1kg/ha/year across much of Europe but reaching more than 1.0 kg/ha/year in hotspots.

Pesticides

Pesticides used in agriculture are widely detected in freshwater, having been transported by diffuse pathways

Map 2.1 Annual diffuse agricultural emissions of nitrogen to freshwater (kg nitrogen per hectare of total land area)



Source: Bouraoui et al., 2009.

via surface runoff and leaching. Point discharges of pesticides are also important and occur from accidental spillage, sprayer loading and wash-down and inappropriate storage and disposal. Just how much pesticide pollution of freshwater occurs depends on a range of factors including the chemical nature of the pesticide, the physical properties of the landscape and weather conditions. Operator practice, however, plays a major role (Cooper and Taylor, 2007) and this recognition has led to the identification of best-management practices through, for example, the EU LIFE project Training Operators to prevent Pollution from Point Sources (TOPPS). However, information describing pesticide emissions to freshwaters across Europe is limited.

Other agricultural pollutants

Other pollutants from agriculture include organic material, sediment, pathogenic micro-organisms and some metals, although good pan-European information on their emissions to freshwater is not generally available.

Organic pollution that depletes oxygen levels in water comes from livestock manure and is washed to waterways from grazed pastures, slurry and effluent stores and, yard areas. Elevated levels of suspended sediment are often found in streams draining agricultural land, reflecting soil and riverbank erosion. As well as silting up reservoirs and navigable waterways, excessive sediment smothers spawning gravels for fish, and damage to fish gills can result from excessive levels of suspended sediment. Sediments from agricultural land also transport nutrients, pesticides and microbes to waterways. Pathogenic micro-organisms excreted by grazing livestock are readily washed into freshwaters or deposited directly by cattle with access to waterways. Their presence there poses a risk to public health via freshwater and marine recreation.

Metal emissions from agriculture include cadmium, found naturally in the phosphate rock used to make fertiliser, and zinc, an essential trace element that is added to animal feed. A significant proportion of zinc is not absorbed by livestock, however, and is excreted in manure that may then be flushed into rural streams. Copper, too, is found in feedstuffs and hence manure, but can also come from copper baths used in the treatment and disinfection of livestock hooves. While metals are generally well retained in soil, there is evidence that agricultural sources can make a significant contribution to freshwater loads (RIVM, 2008a; RIVM, 2008b).

2.2 The urban environment

Background

A range of pollutants is generated within the wider urban environment, including industrial and household chemicals, metals, pharmaceutical products, nutrients, pesticides and pathogenic micro-organisms. These pollutants come from various sources including domestic premises, transport networks, industrial plants and atmospheric deposition within urban areas. Domestic premises discharge sewage, personal care products, household chemicals and medicines to sewer networks while hydrocarbons and heavy metals such as zinc from the wear of vehicle tyres arise from the transport sector. Industrial wastewaters are treated either on-site or by their transfer to a municipal wastewater treatment works. The treatment process can, however, be incomplete resulting in industrial pollutants being discharged to surface waters. Pesticide release to the wider urban environment arises from their use in controlling unwanted plant growth on sports grounds, public parks and buildings, private gardens, roads and railways.

Wastewater treatment

The transport pathways and ultimate fate of urban pollutants can be highly variable and how much of a pollutant load is discharged to freshwater depends on a number of factors. Of critical importance, however, is whether pollutants are collected and directed to a treatment facility and, if so, the degree to which they are treated.

The UWWTD requires the collection and treatment of wastewater from all agglomerations of more than 2 000 people and its ongoing implementation has led to an increasing proportion of the EU's population being connected to a municipal treatment works via a sewer network (see Figure 2.1). Connection rates in northern Europe now exceed 80 % of the population while in central Europe the figure is above 95 %. Elsewhere in Europe, however, connection rates are lower, although in the case of the newer Member States this is explained by the later compliance dates agreed in the accession treaties.

The UWWTD requires secondary biological wastewater treatment and, therefore, the substantial removal of both biodegradable and nutrient pollution. In addition, in catchments with waters designated as sensitive to eutrophication, the legislation demands more stringent tertiary treatment to remove much of the nutrient load from wastewater. Consequently, in addition to higher collection rates, the UWWTD has also driven improvements in the level of wastewater treatment over recent years. The majority of wastewater plants in northern and central Europe now apply tertiary treatment although elsewhere in the EU, particularly in the south-east, the proportion of primary and secondary treatment is higher (see Figure 2.1). While considerable progress has been made in implementing the UWWTD, excluding the longer compliance timelines for the newer Member State, full compliance is yet to be achieved, including the lack of more stringent tertiary treatment in some sensitive areas and inadequate treatment levels in wastewater treatment plants in some larger cities (EC, 2009).

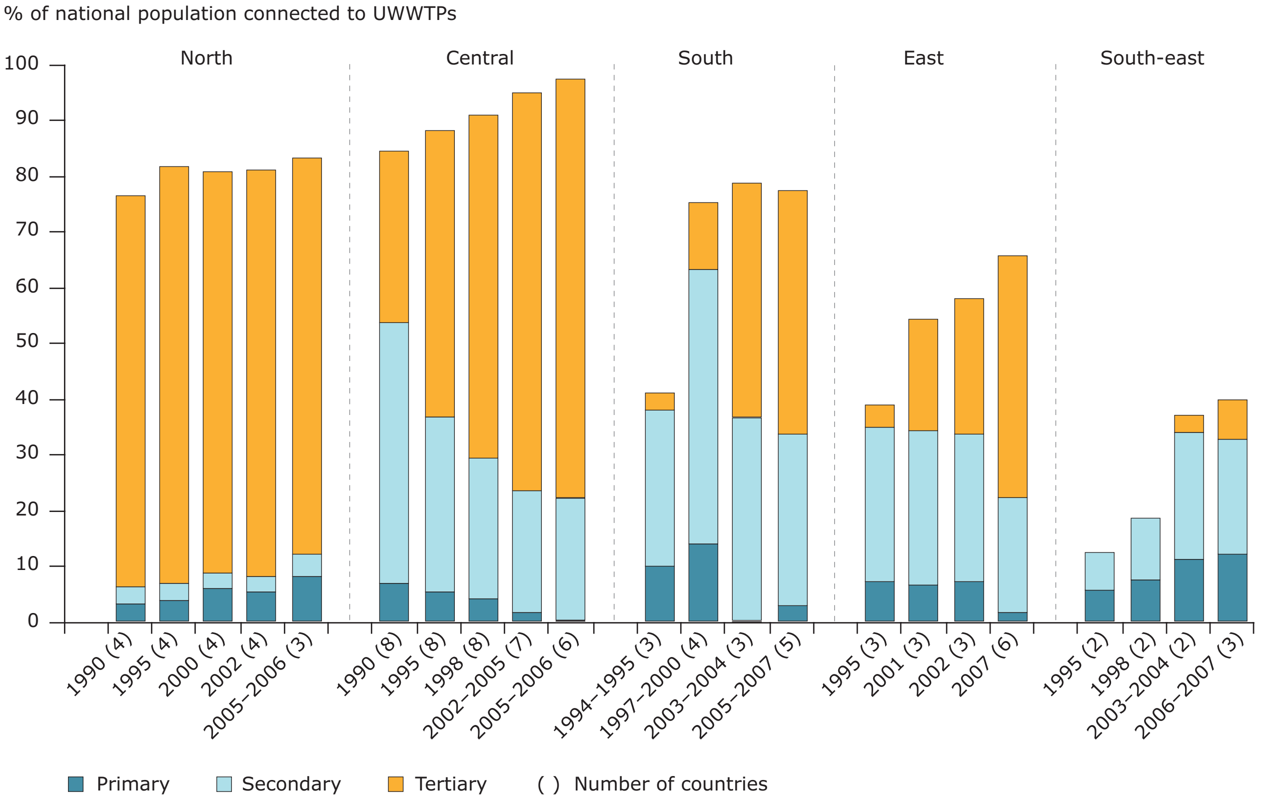
Implementation of the UWWTD has led to a reduction in the wastewater discharge of nutrients, biological oxygen demand — a measure of organic pollution — and of ammonia to receiving waters. The emission of some hazardous chemicals has also been reduced, as evidenced, for example, by a decline in the discharge of heavy metals in treated sewage to the River Seine (Meybeck et al., 2007). Enhanced wastewater treatment in Europe has, however, resulted in the generation of more sewage sludge, raising environmental issues about its subsequent disposal, particularly given the presence of hazardous substances. Increasingly, sewage sludge is used for biogas generation.

While municipal wastewater treatment has increasingly been implemented across Europe, the process does not remove all pollutants, with household and industrial chemicals and pharmaceuticals, for example, being detected in treated effluent that is subsequently discharged to surface waters (Reemtsma et al., 2006, Gros et al., 2010, Ashton et al., 2004). Sewage treatment plants can remove 80 % or more of endocrine-disrupting chemicals (EDC) (Andersen et al., 2003; Baronti et al., 2000), resulting in low concentrations — around tens of nanograms per litre — subsequently being discharged to receiving waters. However, even such low concentrations can result in endocrine disruption in aquatic biota (Jobling et al., 2006).

Urban storm overflows

In some cities across Europe the sewage collection system has also been designed to collect runoff from streets, roofs and other impervious surfaces. The collection pipes and treatment plants of such combined systems are designed

Figure 2.1 Regional variation in wastewater treatment between 1990 and 2007



Note: Regional percentages have been weighted by country population.
North: Norway, Sweden, Finland and Iceland;
Central: Austria, Denmark, England and Wales, Scotland, the Netherlands, Germany, Switzerland, Luxembourg and Ireland. For Denmark no data has been reported to the joint questionnaire since 1998. However, according to the European Commission, Denmark has achieved 100 % compliance with secondary treatment and 88 % compliance with more stringent treatment requirements (with respect to load generated) under the UWWTD (EC, 2009). This is not accounted for in the figure.
South: Cyprus, Greece, France, Malta, Spain and Portugal (Greece only up to 1997 and then since 2007);
East: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovenia, and Slovakia;
South-east: Bulgaria, Romania and Turkey.

Source: EEA-ETC/WTR (CSI 024) based on data reported to OECD/EUROSTAT Joint Questionnaire 2008. www.eea.europa.eu/data-and-maps/indicators/urban-waste-water-treatment/urban-waste-water-treatment-assessment-1.

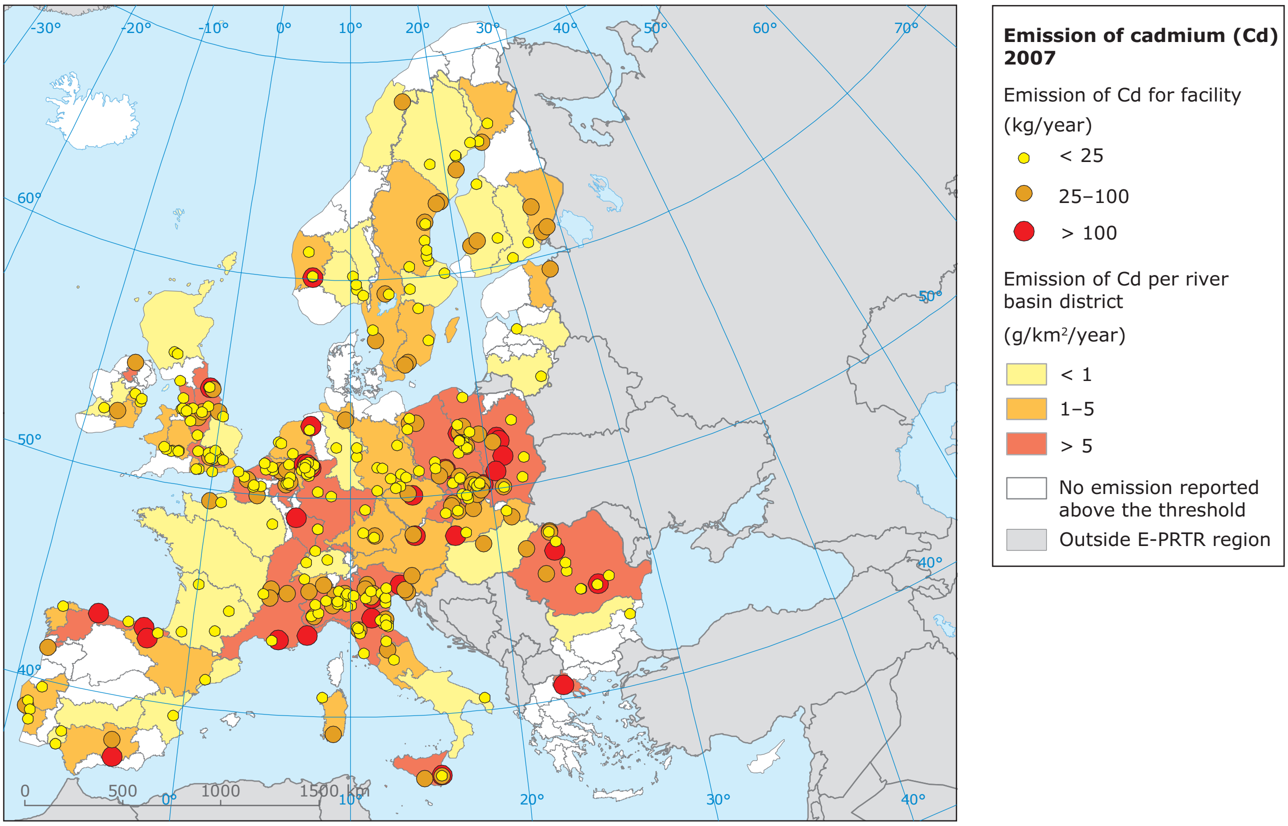
to be able to handle both sewage and urban runoff generated during rain storms but only up to defined levels. During larger storm events, the combined flow generated can exceed the capacity of the system. When this happens, to prevent sewage back-up into streets and homes, relief structures are built into the collection system, enabling the flows to bypass the treatment plants and discharge the combined waste more or less untreated to a receiving watercourse. Such combined sewer overflows (CSOs), together with discharges from separate storm-water systems, typically discharge a range of pollutants and can cause rapid depletion of oxygen levels in receiving waters (Even et al,. 2007), sometimes to a level fatal to aquatic life. In addition, the quality of bathing waters near such discharges can deteriorate very quickly.

However, other than in respect of their design criteria, neither CSOs nor discharges from separate storm-water systems are subject to direct environmental regulation and little information is publicly available describing their pollutant loads. Innovative solutions are required, particularly as the retro-separation of combined sewers is expensive and technically challenging. Good practice is already apparent in Europe in this respect, such as the retention of overflows in storage ponds during heavy rainfall, with a subsequent back pumping to the system for treatment. In the greater Paris region, for example, such storm-water retention ponds have contributed to a clear decline in sewer overflow volumes (Meybeck et al., 2007).

Point emissions from the urban environment to freshwaters

Pollutant emissions to freshwater from industrial facilities and wastewater treatment plants are reported under the European Pollutant Release and Transfer Register (E-PRTR). The register requires that emissions (known as 'releases' under E-PRTR) of numerous pollutants to water are reported, provided that their annual emissions or the plant or facility in question exceed specified thresholds. As a result, where countries have complied with the reporting requirement, the E-PRTR is able to provide a quantitative overview of most point emissions of pollution to freshwater in the wider urban environment. Maps 2.2 and 2.3, for example, illustrate combined industrial and

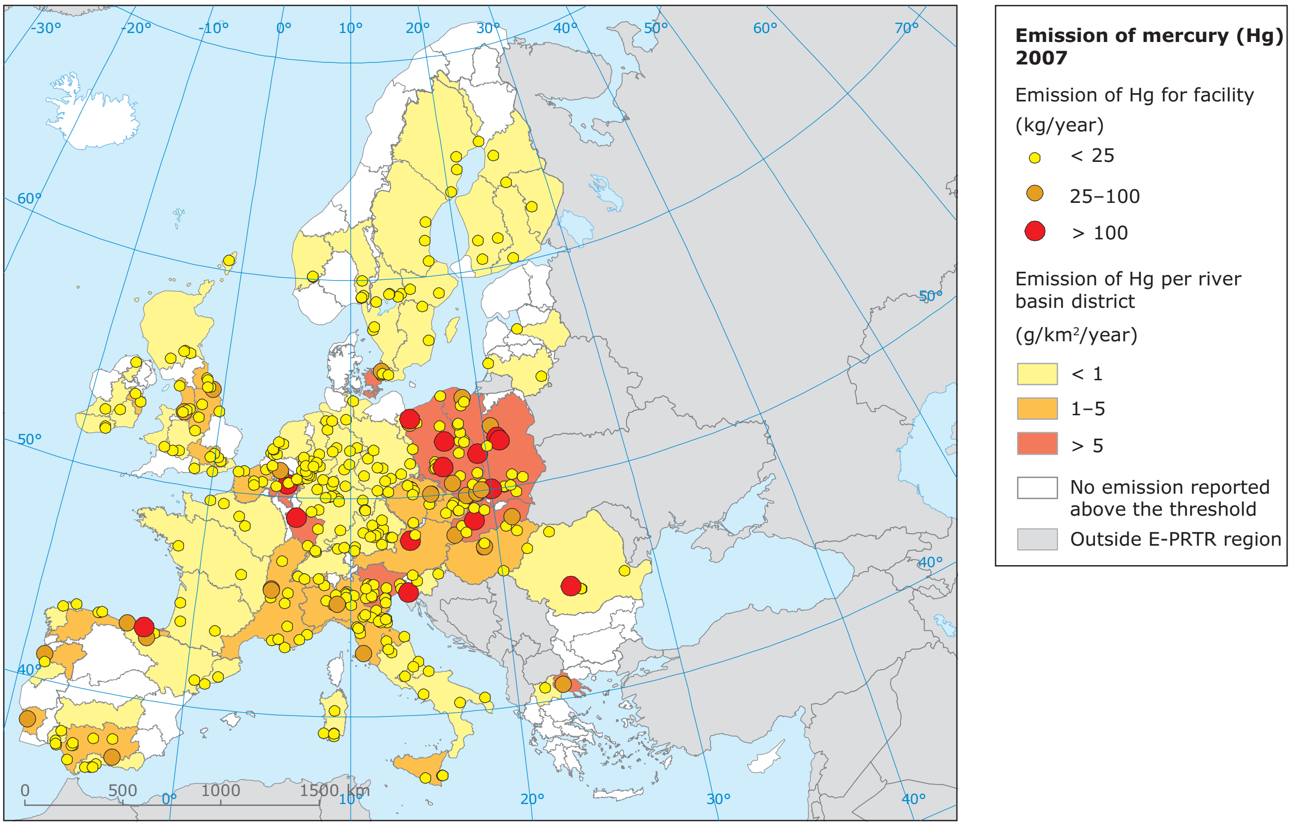
Map 2.2 Emissions of cadmium to water based on E-PRTR reporting of 2007 data



Note: Reported emissions (releases) are from the following E-PRTR sectors; energy; production and processing of metals; mineral industry; chemical industry; waste and water management; paper and wood production and processing; animal and vegetable products from the food and beverage sector, other activities.

Source: Version 2 published on 8 June 2010; www.eea.europa.eu/data-and-maps/data/ds_resolveuid/474c9e597ecce6a79bfc63ba5be76ba7.

Map 2.3 Emissions of mercury to water based on E-PRTR reporting of 2007 data



Note: Reported emissions (releases) are from the following E-PRTR sectors; energy; production and processing of metals; mineral industry; chemical industry; waste and water management; paper and wood production and processing; animal and vegetable products from the food and beverage sector, other activities.

Source: Version 2 published on 8 June 2010; www.eea.europa.eu/data-and-maps/data/ds_resolveuid/474c9e597ecce6a79bfc63ba5be76ba7.

wastewater emissions to freshwater in 2007 for cadmium and mercury from plants or facilities that have reported under E-PRTR. Both these metals are now classified as PHS under the EQSD.

2.3 Water quality — current status and recent trends

The current quality of Europe's water bodies is assessed mainly through national monitoring programmes which typically record the concentrations of a range of pollutants. Through a voluntary process, a representative sub-sample of these data are reported by member countries to the EEA and held in the Eionet-water database. The following sections illustrate the current state of Europe's freshwater using data from Eionet. This is supported with information reported under the BWD and ND.

A more extensive overview of the state of freshwater quality across Europe is to be provided in the river basin management plans (RBMP) of the WFD. These will describe freshwater ecological status and associated biological elements. Unfortunately, the timing of the availability of the RBMP and the assessment of information in them precludes a presentation of pan-European ecological status in this thematic assessment. However, overview information is available in the SOER 2010 country assessments.

Phosphorus

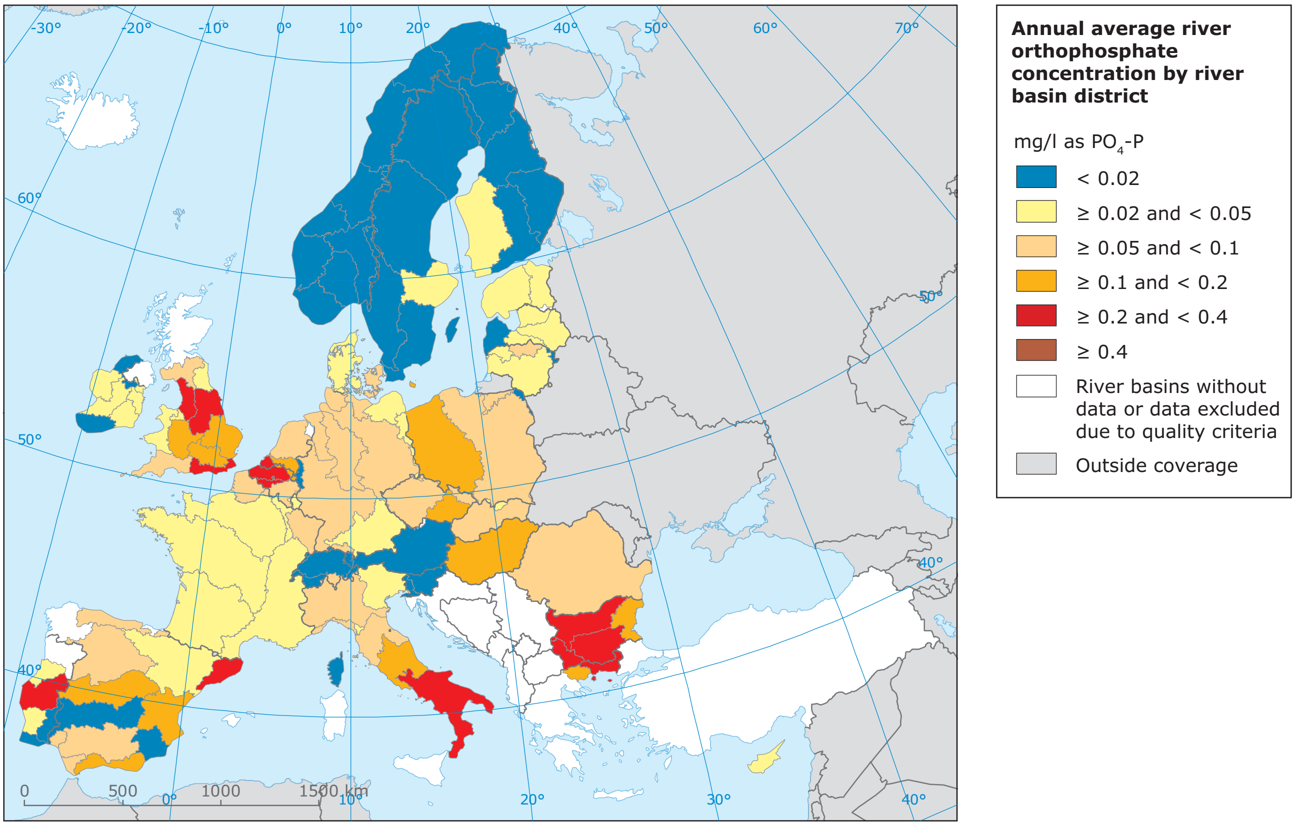
Excessive concentrations of phosphorus are the most common cause of freshwater eutrophication (Correll, 1998) and source apportionment studies indicate that, in general terms, agriculture and point discharges are the key sources of phosphorus found in Europe's freshwater bodies (EEA, 2005). Eionet holds data on riverine concentrations of orthophosphate, a dissolved inorganic form available for biological uptake, although it should be noted that other forms are also of importance, including organic and particulate phosphorus. Mean annual orthophosphate concentrations (PO_4-P) exceed 0.2 mg/l in some river basins across Europe (see Map 2.4) and, whilst values vary with waterbody type, far lower concentrations are suggested as a threshold to prevent eutrophication (Dodds, 2006).

Current concentrations in certain rivers therefore suggest that substantial improvements will be required for good ecological status to be achieved under the WFD.

While current orthophosphate concentrations are excessive in some European rivers, 42 % of monitoring stations with long-term data show a statistically significant declining trend over the period 1992–2008 (see Figure 2.2). These improvements can be attributed to the progressive implementation of the UWWTD and comparable non-EU legislation since the early 1990s, including the requirement for enhanced levels of nutrient removal at many wastewater treatment plants (e.g. Kinniburgh and Barnett, 2010). In addition, bans on the use of phosphate in detergents have also played a role in some countries, leading to a reduction in the amount of phosphate in wastewater received at treatment plants; in Switzerland, for example, such a ban was implemented as long ago as 1985. In more recent years, however, the rate of improvement in orthophosphate levels appears to have slowed in some European rivers. This indicates that where wastewater treatment has already been substantially improved — to tertiary levels — further significant reductions will have to be achieved through the targeting of diffuse sources.

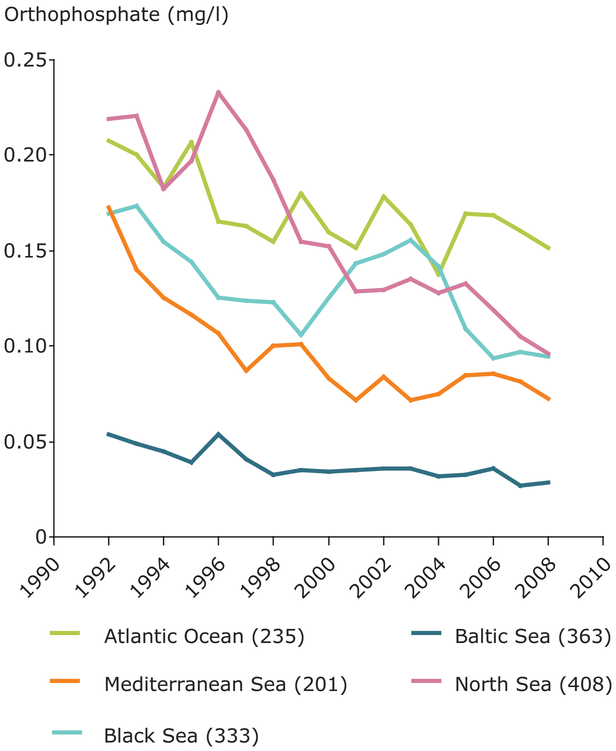
Phosphorus levels in lakes in Western Europe have declined since the early 1990s, reflecting improvements in wastewater treatment. As with some of Europe's rivers, however, the rate of improvement has slowed in recent years. Levels in eastern lakes have remained broadly constant over the same period. Currently, overall mean levels of total phosphorus in western and eastern lake regions are approximately 0.05–0.06 mg/l (see Figure 2.3) and, in many cases, such concentrations are likely to challenge the achievement of WFD targets. Total phosphorus concentrations in northern lakes are much lower — around 0.02 mg/l — and have remained broadly constant for a number of years. However, although such concentrations are low relative to the other regions, they may also challenge the achievement of WFD targets, since most Northern lake types have total phosphorus 'reference' concentrations of less than 0.01 mg/l (Cardoso et al., 2007). For Southern and South-eastern Europe, the Eionet dataset is too limited to be presented. The general decline in Western European lake phosphorus levels illustrated by Eionet is supported by research studies. Jeppesen et al., (2005), for example, examined long-term datasets for European lakes, concluding that many have experienced a reduction in total phosphorus loading, resulting in lower chlorophyll concentrations and improvements in

Map 2.4 Annual average river orthophosphate concentration (mg/l as PO_4-P) in 2008, by river basin district



Source: EEA/ETC-Water based on data reported to Eionet. www.eea.europa.eu/themes/water/interactive/soe-ri-or.

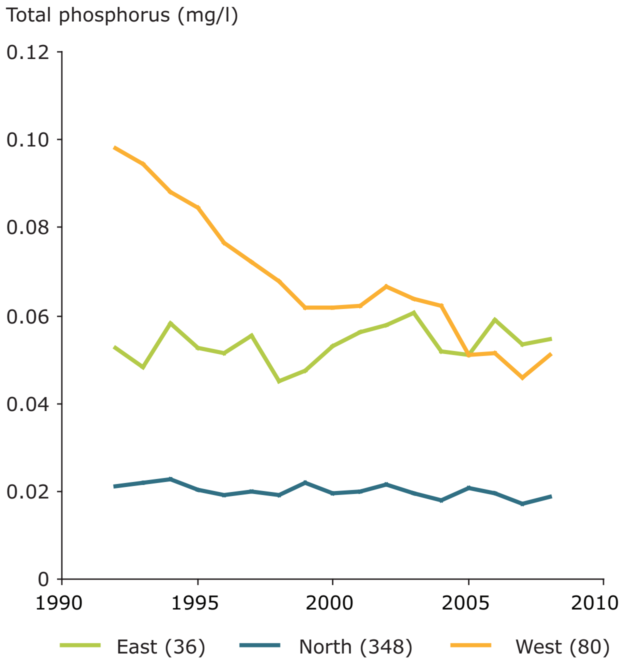
Figure 2.2 Trends in annually averaged river orthophosphate concentration (mg/l) aggregated to the sea region to which each river drains



Note: The number of monitoring stations included in the analysis of each region is given in parentheses.

Source: EEA-ETC/Water (CSI 020) based on data reported to Eionet. www.eea.europa.eu/data-and-maps/indicators/nutrients-in-freshwater/nutrients-in-freshwater-assessment-published-1.

Figure 2.3 Trends in total phosphorus concentrations (mg/l) in lakes of three European regions



Note: The number of lakes analysed in each region is given in parentheses.

Source: EEA-ETC/Water (CSI 020) based on data reported to Eionet. www.eea.europa.eu/data-and-maps/indicators/nutrients-in-freshwater/nutrients-in-freshwater-assessment-published-1.

water clarity. Delay in recovery can occur, however, being attributed to internal phosphorus loads built up in lake sediments (Sondergaard et al., 2007).

Nitrogen

Source apportionment studies indicate that, generally, agriculture contributes 50–80 % of the total nitrogen load observed in Europe's freshwater, with point discharges, including from wastewater treatment plants, providing much of the remainder (EEA, 2005). Eionet holds data on river and groundwater concentrations of nitrate, an oxidised and stable form of nitrogen used by plants, although organic forms of nitrogen are also of importance. Currently, the highest river nitrate concentrations, in excess of 3.6 mg/l NO_3-N (to convert from NO_3-N to NO_3, multiply by 4.4) are found across much of England and France and, more locally, in other locations (see Map 2.5). The concentrations and spatial pattern illustrated by Eionet broadly reflect those provided under the ND (EC, 2010), which provides a comparable but non-identical dataset (due to differences in both temporal and spatial aspects of the data). Current levels of nitrate in a number of Europe's rivers are of a magnitude sufficient to promote eutrophication in many receiving coastal waters.

Data from Eionet indicate that declining trends in nitrate concentrations were apparent in around 30 % of Europe's rivers between 1992 and 2008, including many in Denmark, Germany, the Netherlands and central Europe. Improvements in nitrate water quality over this period can be attributed to one or more of a number of factors: measures implemented under national programmes and the ND to tackle nutrient pollution from agriculture; improved farmer training; more efficient use of farm inputs in order to achieve cost reductions; a reduction in the atmospheric deposition of nitrogen (EMEP, 2009); and implementation of the UWWTD which, in addition to its impact on phosphorus, has also led to a reduction in nitrogen discharges from municipal wastewater plants.

The nitrogen surplus on agricultural land can be transported to groundwater as well as to surface waters. A number of countries report, under Eionet, a proportion of groundwater sites with concentrations that exceed 50 mg/l of nitrate (as NO_3), the threshold level above which a groundwater body should be designated as an NVZ under the ND (see Map 2.6). This data are supported by reporting under the ND (EC, 2010) that shows, in the period 2004–2007, that 15 % of groundwater monitoring stations across the EU-27 had average nitrate concentrations that exceeded 50 mg/l (as NO_3). An additional 19 % of monitoring stations had concentrations in the range 25 to 50 mg/l (as NO_3). Depth-specific information reported under both Eionet and the ND indicates that the highest proportion of contaminated water lies in the upper soil layers.

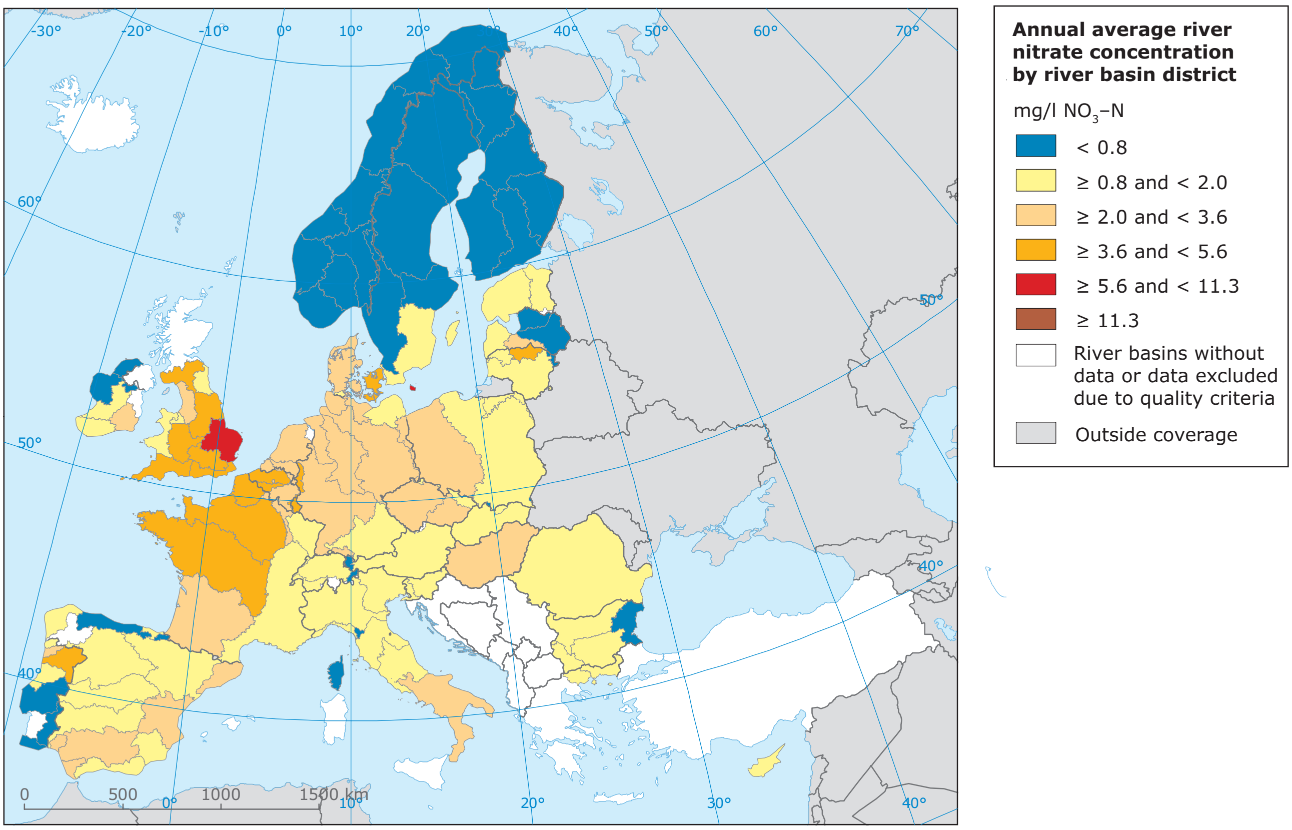
Biological oxygen demand

Wastewater discharges, industrial effluents and agricultural run-off all contribute to the organic pollution of Europe's freshwater and, in severe situations, may lead to rapid de-oxygenation to a level fatal to fish and aquatic invertebrates. Biological oxygen demand (BOD) describes the uptake rate of dissolved oxygen by the organisms in a body of water and thereby provides an indication of organic pollution: the higher the organic pollution, the higher the BOD. Due mainly to the implementation of secondary biological wastewater treatment under the UWWTD, clear downward trends in BOD concentration are evident in most of Europe's rivers (see Figure 2.4). These improvements in wastewater treatment have contributed to improvements in water and biological quality. In the Czech Republic, for example, significant improvements in river water quality have occurred since the early 1990s based on a classification scheme incorporating indicators for BOD, nutrients and macro-invertebrate communities (see the SOER 2010 country assessment on Czech Republic (EEA, 2010b)). Similarly, in the River Rhine, the number of invertebrate species has increased markedly since the early 1980s, in line with substantial improvements in oxygen levels (ICPR, 2010). In recent years, however, the downward trends in BOD across Europe have generally levelled. This suggests that either further improvement in wastewater treatment is required or that other sources of organic pollution, for example from agriculture, require greater attention, or both.

Bathing water quality — inland waters

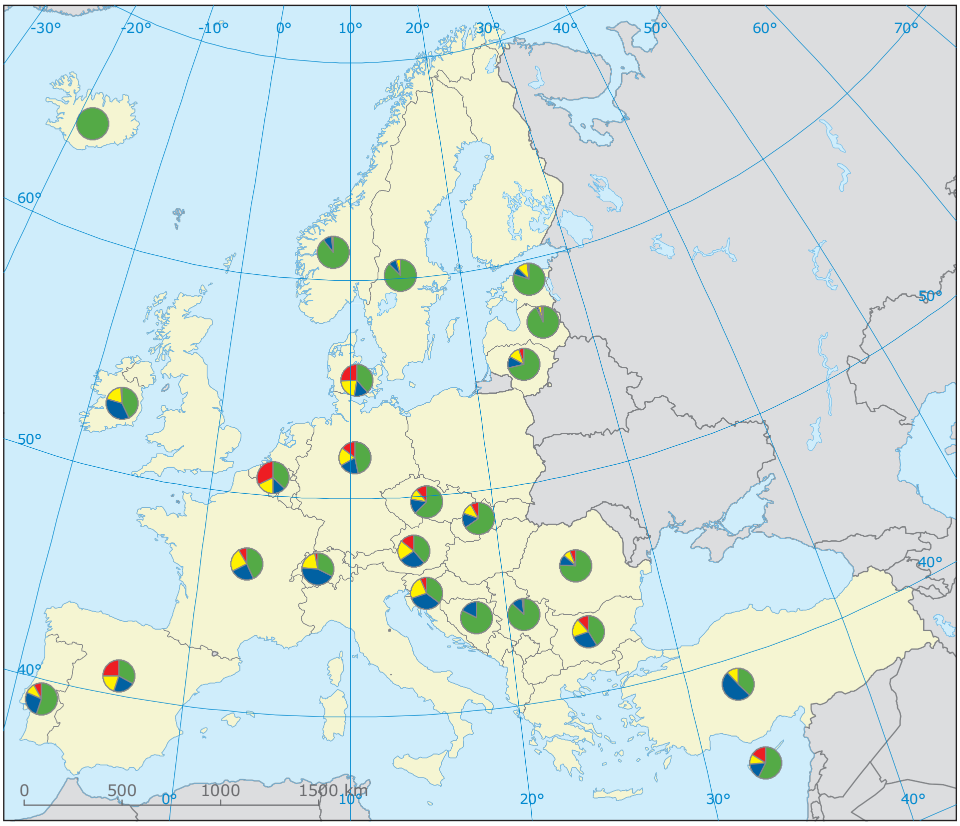
Pathogenic micro-organisms from human sewage and livestock can be emitted to water, raising a threat to public health through ingestion during freshwater and

Map 2.5 **Annual average river nitrate concentration (mg/l NO_3-N) in 2008, averaged by river basin district**



Source: EEA/ETC-Water based on data reported to Eionet. www.eea.europa.eu/themes/water/interactive/soe-ri-ni.

Map 2.6 **Annual average national groundwater nitrate (mg/l NO_3) by concentration class, 2008**



Annual average national groundwater nitrate by concentration class

mg/l NO_3

- < 10
- >= 10 and < 25
- >= 25 and < 50
- >= 50
- EU and EEA member and collaborating countries
- Outside coverage

Source: EEA/ETC-Water based on data reported to Eionet. For clarity, data for Liechtenstein are not shown but all reported average concentrations are < 10 mg/l NO_3. www.eea.europa.eu/themes/water/interactive/nitrates-gw.

marine recreation. Driven by the implementation of the BWD and associated improvements in wastewater treatment, the quality of inland bathing waters — rivers and lakes — in the EU has improved significantly since 1990 (see Figure 2.5). In 2009, 89 % of inland bathing areas complied with mandatory values, whilst 71 % complied with the more stringent guide values. Nevertheless, inadequate treatment of sewage and urban stormwater, together with emissions of pathogenic micro-organisms from livestock, continue to prevent full compliance across Europe.

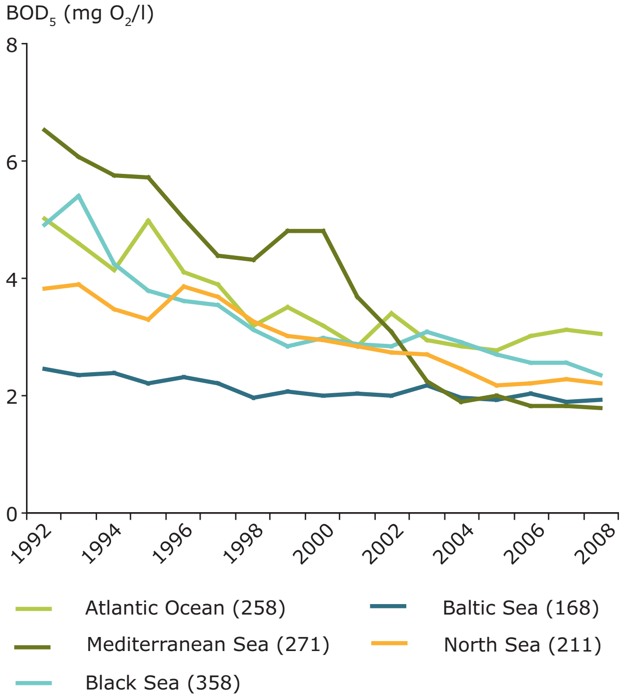
Pesticides

Both spatial and temporal information on pesticide concentrations in water bodies across Europe is generally limited. Sufficient data are available through Eionet, however, to provide some indication of pesticide levels in groundwater. Map 2.7, for example, illustrates — for those countries that have reported data to the EEA — which of the triazine group of pesticides have been found in groundwater in recent years, on at least one occasion, at concentrations greater than 0.1 μg/l. This is the standard established under both the Groundwater and Drinking Water Directives.

Triazine pesticides are of particular concern to freshwater contamination due to a number of their properties, including a relatively high water solubility, persistence (long half-life) and low soil adsorption. Of the triazine pesticides, both atrazine and simazine have been used as herbicides on cropland, on transport highways and domestically, acting through inhibiting photosynthesis in unwanted plants. Both, however, have now been banned and are classified as PS under the EQSD. Despite the ban, both pesticides remain evident in groundwaters across Europe and have occurred, at least on occasions, in excess of the 0.1 μg/l standard. In addition, both the transformation products of atrazine — desethylatrazine, desisopropylatrazine, desisopropyldesethylatrazine and hydroxyatrazine — and terbuthylazine, an active substance replacing atrazine, are found at concentrations exceeding the standard (see Map 2.7).

To date a number of pesticides have been classified as PS under the EQSD, each with a designated environmental

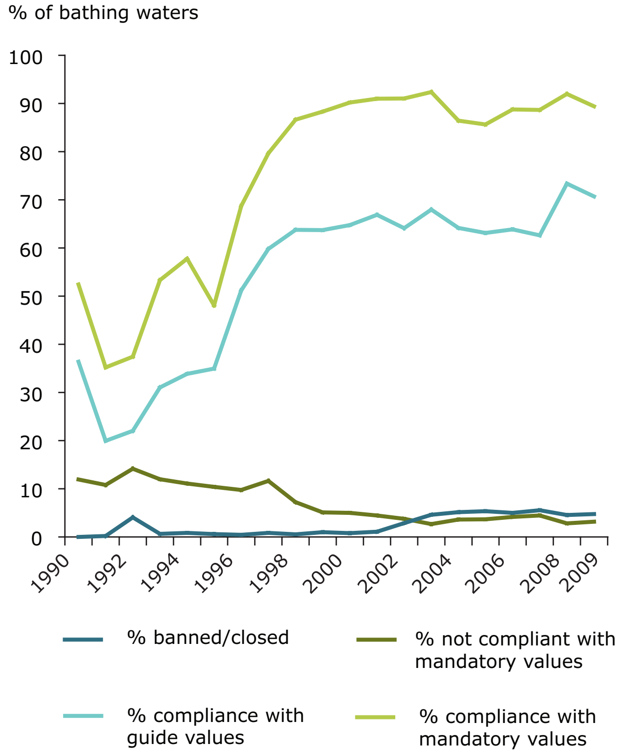
Figure 2.4 **Trends in annual average BOD_5 concentrations in rivers, aggregated to the sea region to which each river drains**



Note: The number of monitoring stations included in the analysis of each region is given in parentheses. Source: EEA/ETC-Water (CSI 019) based on data reported to Eionet. BOD_5 is defined as the amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter.

Source: www.eea.europa.eu/data-and-maps/indicators/oxygen-consuming-substances-in-rivers/oxygen-consuming-substances-in-rivers-2.

Figure 2.5 **Inland bathing water quality in the European Union**



Source: EEA/ETC-Water (CSI 022) based on data reported to the European Commission under the Bathing Water Directive. www.eea.europa.eu/data-and-maps/indicators/bathing-water-quality/bathing-water-quality-assessment-published-1.

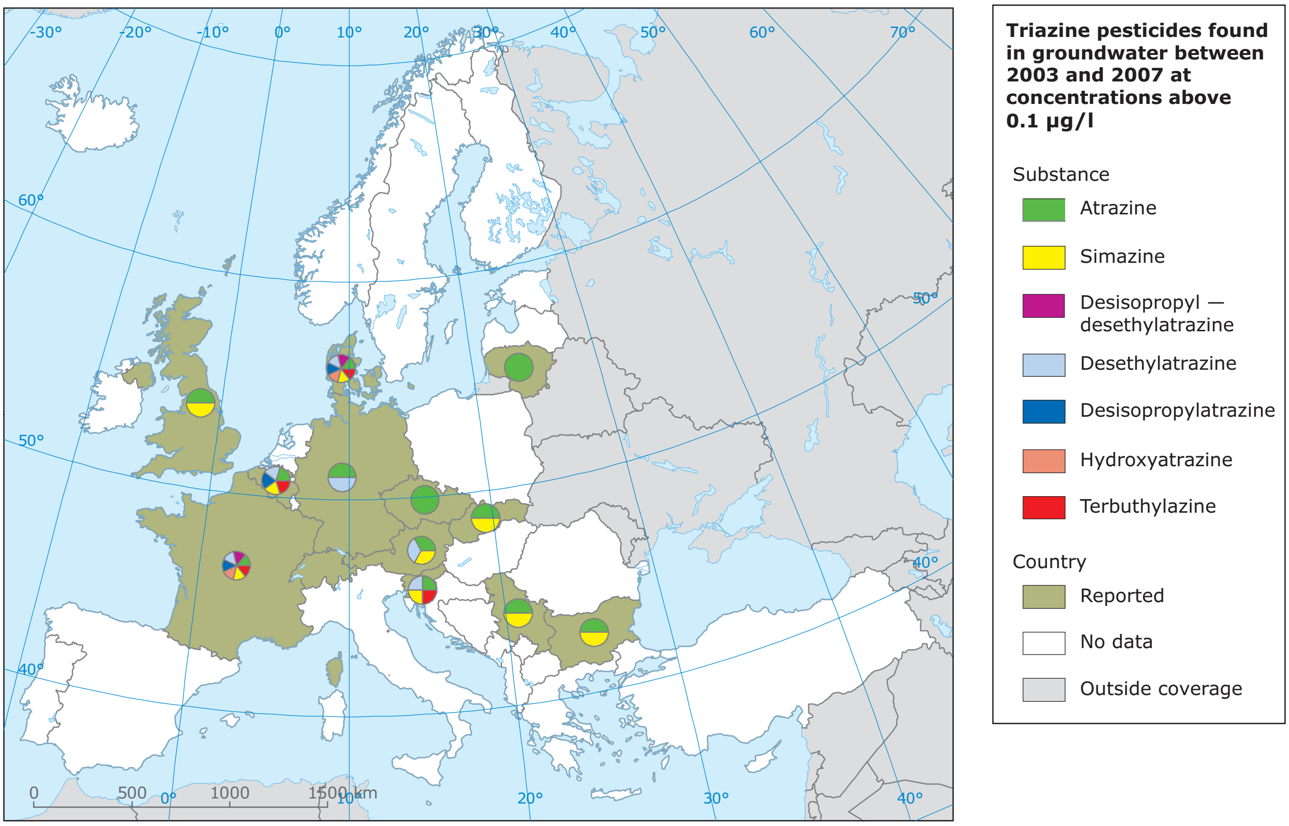
quality standard with respect to surface waters across Europe. While information on pesticides in surface waters in Eionet is relatively limited, the available data show that some apparent exceedance of the environmental quality standard in Europe's rivers has occurred in recent years, for each of the PS pesticides, albeit at relatively low frequency. A true picture of the extent and degree of exceedance, however, will only emerge through WFD reporting.

Focused monitoring studies have shown that much of the transport of agricultural pesticides to freshwaters occurs during wet weather in the period immediately following application to cropland. This can result in short-lived but fatal exposure of non-target aquatic organisms, particularly in small rural streams. As a result, standard monitoring programmes involving relatively infrequent sampling may miss such pollution peaks and their impacts.

Other chemicals

Concentrations of metals in Europe's freshwater and freshwater sediments have been mapped during the development of a geochemical atlas for Europe, a collaborative study involving the Association of the Geological Surveys of The European Union (EuroGeoSurveys) and published by the Geological Survey of Finland (Salminen, 2005). Historically, information about other chemicals of potential concern has been relatively scarce, both temporally and spatially. Recently, however, EU-wide surveys have been established by the Joint Research Centre (JRC) with levels of persistent organic pollutants in more than 100 European rivers documented (Loos et al., 2009), and ongoing Europe-wide monitoring for chemicals now focused on groundwater, effluents and sewage sludge. In addition, the Network of Reference Laboratories for Monitoring of Emerging Environmental Pollutants network (NORMAN) has been established to enhance

Map 2.7 **Triazine pesticides found in groundwater on at least one sampling occasion between 2003 and 2007, at concentrations above 0.1 µg/l**



Note: The data shown do not reflect the frequency with which the threshold has been exceeded. All reported concentrations for Switzerland are ≤ 0.1 µg/l.

Source: Data are sourced from Eionet and, in the case of Denmark, supplemented by information from the Danish national groundwater monitoring program (1989–2007) and the Geological Survey of Denmark and Greenland. Data from Switzerland has been provided but for no substance has a concentration greater than 0.1 µg/l been recorded.

the exchange of information and collection of data on emerging environmental pollutants. Furthermore, the Source Control Options for Reducing Emissions of Priority Pollutants (SCOREPP) and Source Control of Priority Substances in Europe (SOCOPSE) research projects have improved knowledge of the sources and emissions of certain chemicals of concern. All these sources will be complemented by information reported in WFD RBMP, however, given the number of chemicals potentially emitted to Europe's freshwater comprehensive assessment of chemical status presents significant challenges.

3 Impacts

3.1 Impacts on freshwater ecosystems

Various detrimental impacts of poor water quality on freshwater ecosystems have been identified across Europe. Impacts of eutrophication, pesticides and chemicals with endocrine-disrupting properties have been relatively well documented and are described below, although metals (Poleksic et al., 2010) and sediment (Soulsby et al., 2001) are also known to adversely affect aquatic life. Furthermore, a small but growing body of evidence links pharmaceuticals to adverse effects in freshwater ecosystems, including on fish, benthic invertebrates and crustaceans (Triebskorn et al., 2007; De Lange et al., 2006; Cleuvers, 2004). For many other hazardous chemicals of potential concern, however, information on biological effects is scarce or non-existent. Furthermore, while awareness of the potential for additive or synergistic effects on biota due to exposure to a mixture of pollutants has grown, studies of this problem remain limited. Recent research has, however, led to the development of tools to support the diagnosis and prediction of impacts of pollution upon aquatic biodiversity, for example, those arising from the 'Models for Assessing and Forecasting the Impact of Environmental Key Pollutants on Marine and Freshwater Ecosystems and Biodiversity' (MODELKEY) study.

Eutrophication

Eutrophication, driven by excessive nutrient levels, is characterised by the proliferation of algal blooms that are aesthetically unappealing and reduce the clarity of water, giving it the appearance of 'green soup', often accompanied by unpleasant smells. This proliferation is also associated with the loss of 'desirable' plant and animal species. Furthermore, as the algal bloom dies away huge amounts of organic matter are generated and oxygen levels are diminished.

Impacts of eutrophication on freshwater ecosystems are documented throughout Europe. In Greece, for example, algal blooms have led to a disruption of the dynamics of lake plankton communities (Michaloudi et al., 2008) while in Spain, the release of nutrient-rich reservoir water has affected downstream periphyton and macro-invertebrate communities (Camargo et al., 2005). In the Danube River, nutrient pollution is linked to impacts upon phytobenthos (ICPDR, 2008). Reporting under the ND shows that, for 33 % of the surface water stations across Europe which monitor trophic status, the water is defined as eutrophic or hypertrophic (EC, 2010). In addition to measures to reduce nutrient emissions and discharges, there are increasing numbers of restoration initiatives for eutrophic water bodies in Europe. In Denmark and the Netherlands, for example, clear improvements in water quality have occurred in shallow lakes following bio-manipulation although challenges in maintaining such improvements remain (Sondergaard et al., 2007). It is worth noting that secchi depth is an inexpensive and straightforward method of measuring lake water clarity and hence to account for the results and benefits of restoration efforts. These in turn can be related to the economic value of improvements.

Pesticides

Because of their intrinsic properties, pesticides can be harmful to non-target organisms in the wider environment, including freshwater biota. Detrimental effects of pesticide contamination of fish, for example, have been directly observed in Lake Balaton, Hungary: Deltamethrin, a synthetic pesticide used for the extermination of mosquitoes on the shores of the lake, induced severe impairment of the nervous system of several fish species, including carp, goldfish, eel and wels (Csillik et al., 2000). Similarly, insecticide runoff has been shown to adversely affect freshwater macro-invertebrates. For example, in a small agricultural stream in northern Germany, Schulz and Liess (1999) found that short-term contamination during rainfall events led to the loss of eight of the 11 common macro-invertebrate species normally present in the stream, with a significant reduction in the population density of the remaining three species. In aquatic micro-organisms — bacteria, algae, fungi and protozoa — pesticides have been shown to interfere with respiration, photosynthesis and cell growth and division (deLorenzo et al., 2001).

Endocrine-disrupting chemicals

A number of chemicals released to the freshwater environment have potentially endocrine-disrupting properties. These include naturally occurring hormones such as oestrogen from both humans and animals, and synthetic chemicals including pesticides, fungicides, insecticides, and industrial chemicals such as polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs) and dioxins. In addition, synthetic oestrogens are introduced to the body in pharmaceutical products such as oral contraceptives and hormone replacement therapy drugs. Numerous cases of endocrine disruption in wild fish populations have been documented, particularly feminising effects in male fish such as the presence of female ovarian tissue in the testes and feminised reproductive ducts (Nolan et al., 2001). In severely feminised fish, fertility is reduced raising implications for population survival (Jobling et al., 2002). Endocrine disrupting chemicals are mainly discharged to freshwater via wastewater treatment plants and there is growing evidence, across Europe, of sexual disruption in fish found in river reaches receiving treated sewage effluent. These include studies in the United Kingdom (Jobling et al., 2006), Spain (Petrovic et al., 2002) and the Netherlands (Vethaak et al., 2005). Livestock are also a source of endocrine disrupting chemicals, with monitoring of surface waters draining intensive livestock farms suggesting that levels may be high enough to cause endocrine disruption in some aquatic organisms (Matthiessen et al., 2006; Orlando et al., 2004).

3.2 Impacts on human health

Poor water quality can affect human health via freshwater and marine recreation, the consumption of contaminated freshwater and seafood, inadequate sanitation and a lack of access to safe drinking water. Understanding of the relative risk of each of these exposure routes and how they vary geographically, however, remains limited.

Toxic cyanobacteria associated with algal blooms pose a threat to public health. Direct skin contact with water containing these cyanotoxins, for example through freshwater and marine recreation, can cause allergic reactions similar to hay fever and asthma. Skin, eye and ear irritations can also occur, and ingestion of the toxins may result in gastrointestinal illness and liver damage. Cyanotoxins can also affect the nervous system. A recent assessment of European waters indicates that mass populations of bloom-, scum-, mat- and biofilm-forming cyanobacteria with cyanotoxin potential are relatively widespread and occur in water resources used for drinking water supply, aquaculture, recreation and tourism (UNESCO/IHP, 2005). Moreover, health incidents involving cyanotoxins have been reported in some European countries (UNESCO/IHP, 2005). While excessive nutrient levels are strongly linked to cyanobacteria blooms, understanding of the impact of human activities on their occurrence remains incomplete.

Public health threats are also posed by the presence of pathogenic micro-organisms in water used for recreational purposes, which, if ingested in sufficient number, give rise to intestinal diseases. While the quality of Europe's bathing waters — both inland and coastal — has improved significantly over recent years, full compliance with the BWD has not yet been achieved across Europe and health risks remain.

The consumption of contaminated freshwater and marine food can also pose threats to public health, particularly as some pollutants bio-accumulate. The bio-accumulation of mercury and some persistent organic pollutants, for example, can be enough to raise health concerns in vulnerable population groups such as pregnant women (EC, 2004; EFSA, 2005).

The drinking water directive (and comparable non-EU legislation) sets quality standards for water at the tap based on microbiological and chemical parameters, with the general obligation that drinking water must be 'wholesome and clean'. Much of Europe is now connected to municipal systems supplying treated water under quality-controlled conditions. As a result, health problems are infrequent and mainly limited to the rare coincidence of water source contamination and a failure in the treatment process. However, in some rural areas of Europe drinking water is taken from wells and consumed without any purification — such small-scale supplies are not covered by the directive. Any pollution of groundwater in the vicinity of such wells clearly poses threats to public health and, in 2008, ten of 12 waterborne disease outbreaks reported in the EU were linked to the contamination of private wells (EFSA, 2010).

Improvements in the collection and treatment of wastewater in some regions of Europe have led to a reduction in the release of pathogenic micro-organisms, nutrients and hazardous chemicals to fresh and coastal waters, diminishing public health risks. Challenges remain, however, because implementation of the UWWTD remains incomplete and because other significant sources of water pollution exist including agriculture and urban storm-flows. Furthermore, potential public health risks remain from sanitation in rural areas of Europe that lack municipal sewage collection and treatment systems (WECF, 2010).

3.3 Economic costs

Significant capital and operating costs are associated with water and wastewater treatment. The presence of agricultural pollutants in sources used for drinking water, for example, can require the removal of pesticides, nutrients and disease-causing micro-organisms such as cryptosporidium that are resistant to chlorination. In some cases, polluted drinking water supplies are blended with cleaner water sources or, where the level of treatment required is so great as to be uneconomic, the supply is decommissioned, requiring a new source to be found. In both cases, significant costs are incurred (Environmental Outlook for Wallonia, 2008). A key measure for reducing the level of purification treatment required for Europe's drinking water is the establishment of safeguard or protection zones around drinking water extraction sources. Such zones, recognised in the WFD legislation (Article 7), need to be associated with regulatory powers to control activities, such as agriculture, that pollute drinking water supplies. A growing number of countries have established protection zones.

4 Outlook and response

The implementation of a comprehensive range of water-related legislation, led by the WFD, will continue across Europe over the coming years. As a consequence, the outlook with respect to water pollution is very closely linked to the objectives set and the degree of compliance with this legislation — the response. Much of the quantitative outlook information with respect to the quality of Europe's freshwater is to be described in the WFD RBMP, providing an overview, for example, of the proportion of water bodies currently at risk of not reaching good status, measures to be implemented and the anticipated situation in 2015. At the time of finalising this assessment, however, the reporting of RBMP by Member States was incomplete, precluding a comprehensive outlook analysis. Nevertheless, it is clear from earlier WFD reporting that a substantial proportion of Europe's freshwaters are at risk of not achieving good status by 2015 (40 % of surface waters and 30 % of groundwaters, in 2004), with agricultural emissions and wastewater discharges being prominent pressures with respect to ecological and chemical status (EC, 2007).

The following sections explore the means by which water-related legislation, assuming full compliance, will lead to an improved quality of Europe's freshwaters, drawing attention to cost-effective and innovative measures, the benefits of tackling pollutants at source, and synergies between different pieces of legislation. For clarity, a distinction is again made between pollution generated by agriculture and that from the urban environment.

4.1 Agricultural pollution

While clear improvements in the nutrient content of water over recent years are evident in some agricultural catchments across Europe, for others the situation is worsening or has stabilised but with concentrations at a high level. These findings reflect the fact that while some action has been taken in certain locations, compliance with the environmental objectives of the WFD is not required until 2015. Furthermore, appropriate measures under the ND have only recently been implemented in many countries and, in others, full compliance is yet to be achieved.

Provided that full compliance is achieved, the ND is eventually likely to result in clear improvements in nitrate water quality, particularly since ten countries have now designated their entire national territory as a Nitrate Vulnerable Zone (NVZ), although this does not necessarily mean the whole country is currently vulnerable to excessive nitrate levels. In the remainder, NVZs often encompass a substantial area of agricultural land. Overall, almost 40 % of the EU area has been designated an NVZ (EC, 2010). The ND requires, within NVZs, that fertiliser applications are balanced to crop requirements, including compliance with a threshold limit for the application of manure nitrogen to land of 170 kg/ha/yr. Other ND measures include the provision of sufficient manure storage capacity that will not only lead to a reduction in nitrate pollution but also reduce the emission of greenhouse gases from agriculture. The ND also requires restrictions on fertiliser application when soil conditions are unsuitable, for example, during prolonged wet weather or when the ground is frozen. In addition, applications near water bodies or steeply sloping land are to be avoided.

All EU Member States have now established one or more action programmes on their territory, with almost all such programmes incorporating the manure nitrogen application threshold of 170 kg/ha/year (EC, 2010). However, implementation of the ND is still incomplete and, even where full compliance has occurred, sufficient improvement in nitrate water quality will take some time because of transport processes in soils and groundwater. As a result, reported timescales for substantial restoration of water quality reflect this time lag, with recovery times ranging from 4–8 years in Germany and Hungary to several decades for deep groundwater in the Netherlands (EC, 2010). Moreover, measures to address nitrate pollution may still be required in agricultural areas not classified as NVZs.

The achievement of good status in agricultural catchments will depend not only on the implementation of measures to address emissions of nitrogen, but also those of other pollutants, particularly phosphorus and pesticides. In this respect, the RBMPs of the WFD have a critical role to play in identifying cost-effective measures to tackle all sources of agricultural pollution. It is worth noting, however, that some national initiatives have already had clear positive impacts. For example, building on an earlier voluntary scheme, Switzerland, in 1998, introduced a range of agri-environmental measures made conditional in a cross-compliance mechanism. Declines in nutrient surplus have been realised with improvements in the nutrient quality of both surface and groundwaters (Herzog et al., 2008).

The thematic strategy on the sustainable use of pesticides will be of importance, providing a framework for minimising the hazards and risks to health and the environment from the use of pesticides. The related Pesticides Directive will require the establishment of national action plans to set objectives to reduce hazards, risks and dependence on the chemical control for plant protection. Measures identified include the encouragement of low-input or pesticide-free cultivation, prohibition of aerial spraying under certain circumstances, and defining areas of significantly reduced or zero pesticide use in line with measures taken under other legislation, for example the Habitats Directive. In addition, the potential to reduce the amount of harmful active substances by their substitution with safer alternatives is also recognised. Furthermore, specific measures to protect the aquatic environment from pollution from pesticides are identified, such as buffer strips along water courses. Modelling studies (for example those from the FOOTPRINT study) indicate that buffer strips can lead to substantial reductions in pesticide concentrations in surface waters. National legislation also has a role to play in limiting pesticide levels. Denmark for example, has set a limit to the frequency with which pesticides can be applied to agricultural land (See the SOER 2010 country assessment on Denmark (EEA, 2010c)).

Recent reforms of the Common Agricultural Policy (CAP) have resulted in a general decoupling of agricultural subsidies from production and the implementation of a cross compliance mechanism whereby farmers must comply with a set of statutory management requirements, including those that address the environment. Cross-compliance rules also identify the need to maintain existing permanent pastures and avoid their conversion to arable land. Adherence to this, however, may be a challenge given the goals of the Renewable Energy Directive and the increased demand for energy crops it is likely to drive (BFN, 2009). Challenges have also been raised with respect to implementation of the specific requirements for cross-compliance, which need to be SMART (specific, measurable, achievable, relevant and timed) (ECA, 2008).

In addition to decoupling and cross-compliance, the CAP's rural development regulation includes the implementation of agri-environmental and farm modernisation measures. These involve payments to farmers who carry out specific agri-environmental commitments that go beyond usual good farming practice. The regulations identify a range of potential measures for the improvement of water quality, including improving manure storage, the use of cover crops, riparian buffer strips and wetland restoration. They also recognise the importance of educational and advisory programmes for farmers. Implementation of these CAP measures could play a key role in addressing diffuse pollution from agriculture. In this respect, the forthcoming CAP reform offers an opportunity to strengthen water protection and the implementation of European water legislation — in particular through a strong integration of funding mechanisms with respect to both the polluter pays and provider gets principles. Strong synergies exist between the rural development measures of the CAP, the agri-specific measures identified within WFD RBMPs, the action programmes currently being implemented under the ND, and measures to be required under the Pesticides Directive. Maximising these potential synergies and achieving optimal outcomes will require strong integration between all the relevant national and regional authorities including river basin districts.

It is of note that a number of on-farm measures have been shown to reduce emissions of agricultural pollutants at little or no cost. In some cases these measures control 'at source', for example, the reduction of phosphorus inputs in fertiliser onto land, where phosphorus levels in soils have progressively built up over time to the extent that they are sufficient for plant growth. According to the United Kingdom's Department for Environment, Food and Rural Affairs such an approach could reduce phosphorus losses substantially and at no cost (DEFRA, 2003). In addition, reducing phosphorus in animal feeds has been shown to be of minimal cost (Jacobsen et al., 2004; Malmaeus and Karlsson, 2010). Other low-cost measures include the restriction of fertiliser applications in high-risk (critical-source) locations and at high-risk times, for example when soils are saturated, since under these conditions a significant proportion of fertiliser applied is simply washed away.

4.2 Urban pollution

Continuing improvement in the level of pollutant removal from urban wastewater discharges is anticipated, driven by requirements under the UWWTD and non-EU legislation. While compliance with the UWWTD is already relatively high in the older Member States, country-specific deadlines for each of the newer Member States, established in the Accession Treaties, range between 2010 and 2018. As a consequence, improvements in both connection rates and treatment levels are likely to be realised for these countries over the coming years, provided that the directive is complied with. Small-scale rural sanitation is not, however, directly addressed by any European legislation and its inadequate nature in some locations poses a potential threat to public health. Action is needed to address this issue, with some cost-effective approaches having potential in this regard (EC, 2001; WECF, 2010).

Wastewater treatment needs to continue to play a critical role in the protection of Europe's freshwater although significant investment will be required simply to maintain infrastructure in many European countries (OECD, 2009). Cohesion Policy funds can continue to make an important contribution through co-financing improvements to wastewater treatment (EC, 2009). The overall burden on the treatment process can, however, be reduced through a greater control of pollutants at source, an approach that is not only beneficial environmentally, particularly with respect to pollutants for which the treatment process was not specifically designed, but also in terms of cost-effectiveness (EEA, 2005a). Full-cost pricing for wastewater services will help drive controls at source.

The possibilities for source control are varied and often specific to particular pollutants. The availability of alternative cleaning agents has enabled the use of phosphate-free industrial and domestic detergents, for example, significantly reducing phosphate levels received by wastewater treatment plants. A number of countries have either implemented legislation or established voluntary agreements with detergent manufacturers at the national level. Significant potential remains, however, for a greater use of phosphate-free detergents across many parts of Europe and the establishment of Europe-wide legislation in this respect would ensure that this potential is realised.

Other potential source-control measures include the implementation of legislative limits to the amount of zinc in tyres and construction materials, while alternatives are available to the use of copper in brake linings, roofs and water pipes (RIVM, 2008b). Source controls for pharmaceutical products include the provision of advice on, and mechanisms for, the appropriate disposal of unused medicines and containers. Such advice could also include information on the environmental effects of inappropriate disposal. Opportunities also exist to implement green-pharmacy methods, including a reduction in the environmental impact of pharmaceutical manufacture and the creation of active ingredients which decline after use (EEA, 2010a; Kümmerer, 2007).

REACH will promote the control of chemicals at source particularly through its requirement for the progressive substitution of the most dangerous chemicals, once suitable alternatives have been identified. The Biocides Directive and EQSD will also play important roles, the latter with respect to PS and PHS.

Reduced levels of the generation of industrial wastewater can be achieved through enhanced levels of on-site treatment, recycling and reuse of water and materials. Innovative approaches in the textile industry, for example, have led to marked reductions in the discharge of pollutants and a decrease in water use (LIFE III, 2008).

While every effort to control pollutants at source should be made, it is very likely that measures to attenuate pollutants once they are emitted to the urban environment will continue to be needed. A range of best management practices exist with respect to the management of urban stormwater (Scholes et al., 2008) which act to prevent runoff from impervious surfaces from entering conventional drainage systems, directing it instead to features such as reed beds, constructed wetlands, detention ponds, filter strips and swales. Attenuation of pollutants in such features then occurs through a range of physical, physico-chemical and biological processes, allowing relatively clean water to be returned to rivers or groundwater. Such measures are also a means of reducing urban flooding. Greater implementation of these stormwater management measures is especially important in the light of predicted future increases in the generation of urban stormwater.

4.3 Future challenges

A comprehensive range of legislation has been established in Europe to protect freshwater from pollution. Full compliance with this legislation will result in substantial improvements in water quality, providing healthier aquatic ecosystems and reducing potential threats to public health. Certain measures to reduce pollution can result in significant water quality improvements at a relatively low cost.

The extent to which water quality improvements can be achieved across Europe is, however, likely to be challenged by certain factors. These include the economic costs that will need to be borne by societies in order that good status is achieved under the WFD. Comprehensive analysis is required to demonstrate a sound balance between costs and improvements. However, the concept of disproportionate costs encompassed by the WFD should not be used to significantly weaken implementation at the expense of the health of and services provided by aquatic ecosystems.

Other driving forces exist that could, in the absence of appropriately strong measures, have a negative impact on water quality over the coming decades. These include climate change where a range of potentially detrimental impacts on water quality has been identified (Kundzewicz et al., 2007). In regions where intense rainfall is expected to increase, for example, flushing of diffuse agricultural pollutants to freshwater will be exacerbated (Bouraoui et al., 2004, Boorman,

2003) and the frequency and severity of polluted urban stormflows increased (Waters et al., 2003; Nie et al., 2009). Hotter drier summers will enhance soil mineralisation processes, potentially increasing nitrate levels in freshwater (Whitehead et al., 2006) whilst rising water temperatures will increase the likelihood of cyanobacterial blooms (Paerl and Huisman, 2008; Battarbee et al., 2008). In addition, depleted river flows will reduce contaminant dilution capacity, resulting in higher pollutant concentrations (Whitehead et al., 2009; Ducharne 2008). Climate-induced changes in water quality are expected to detrimentally impact freshwater ecosystems, see the Euro-limpacs Project and Battarbee et al., 2008.

Future changes in land use are likely to also influence water quality. A review of land use outlook studies for the EEA (RIKS, 2010) indicates that most studies predict a continued decline in grassland cover across the EU-27, with the area of permanent crops remaining stable or decreasing slightly. Further details are provided in the SOER 2010 land use assessment. Of particular note, however, is the implementation of the Renewable Energy Directive which is likely to drive an increase in the cultivation of energy (biofuel) crops in Europe. If energy crops are cultivated on agricultural land previously used in the production of food crops, either the food crop will be grown elsewhere or less food will be produced. Given a growing global demand for food, the latter outcome is less likely to be realised. The former case, however, could lead to a shift of food production onto formerly natural land, with the conversion being associated with a release of carbon and the use of agrochemicals (Netherlands Environmental Assessment Agency, 2010). Alternatively, food crop yields can be maintained through intensification of the management of remaining agricultural land. Associated with this intensification, however, is a strong likelihood of an increase in the use of agrochemicals (Netherlands Environmental Assessment Agency, 2010) and, hence, emissions of fertilisers and pesticides to freshwater. A range of measures, such as improved fertiliser use efficiency will, therefore, be required to ensure that detrimental impacts from energy cropping upon water quality are minimised (EEA, 2007).

References

Andersen, H.; Siegrist, H.; Halling-Sørensen, B. and Ternes, T. A., 2003. Fate of estrogens in a municipal sewage treatment plant. *Environ. Sci. Technol*., 37, 4 021–4 026.

Ashton, D.; Hilton, M., and Thomas, K.V., 2004. Investigating the environmental transport of human pharmaceuticals to streams in the United Kingdom. *Science of the Total Environment*, 333 (2004), 167–184.

Baronti, C.; Curini, R.; D'Ascenzo, G.; Di Corcia, A.; Gentili, A. and Samperi, R., 2000. Monitoring natural and synthetic estrogens at activated sludge sewage treatment plants and in receiving river water. *Environ. Sci. Technol.*, 34, 5 059–5 066.

Battarbee, R.W.; Kernan, M.; Livingstone, D.M.; Nickus, U.; Verdonschot, P.; Hering, D.; Moss, B.; Wright, R.; Evans, C.; Grimalt, J.; Johnson, R.; Maltby, E.; Linstead, C. and Skeffington, R., 2008. Freshwater ecosystem responses to climate change: the Euro-limpacs project. In: Quevauviller, P.; Borchers, U.; Thompson, C. and Simonart, T. (eds.). *The Water Framework Directive — Ecological and Chemical Status Monitoring*. John Wiley and Sons: 313–354.

BFN, 2009. *Where have all the flowers gone? Grünland im Umbruch*. Bundesamt für Naturschutz (BfN); Bonn Bad-Godesberg. www.bfn.de/fileadmin/MDB/documents/themen/landwirtschaft/Gruenlandumbruch_end.pdf.

Boorman, D.B., 2003. LOIS in-stream water quality modelling. Part 2. Results and scenarios. *Sci. Total Environ.*, 314–316, 397–409.

Bouraoui, F.; Grizzetti, B.; Granlund, K.; Rekolainen, S. and Bidoglio G., 2004. Impact of climate change on the water cycle and nutrient losses in a Finnish catchment. *Climatic Change*, 66, 109–126.

Bouraoui, F., Grizzetti, B. and Aloe, A., 2009. *Nutrient discharge from rivers to seas.* JRC EUR 24002 EN, 72 pp.

Camargo, J.A., Alonson, A. and de la Puente, M., 2005. Eutrophication downstream from small reservoirs in mountain rivers of Central Spain. *Water Research*, 39, 3 376–3 384.

Cardoso, A.C.; Solimini, A.; Premazzi, G.; Carvalho, L.; Lyche Solheim, A. and Rekolainen, S., 2007. Phosphorus reference concentrations in European lakes. *Hydrobiologia*, 584, 3–12.

Correll, D., 1998. The Role of Phosphorus in the Eutrophication of Receiving Waters: A Review. *J. Environ. Qual*., 27: 261–266.

Csillik, B.; Fazakas, J.; Nemcsók J. and Knyihár-Csillik, E., 2000. Effect of the pesticide Deltamethrin on the Mauthner cells of Lake Balaton fish. *Neurotoxicology*, 21(3), 343–352.

Cleuvers, M., 2004. Mixture toxicity of the anti-inflammatory drugs diclofenac, ibuprofen, naproxen, and acetylsalicyclic acid. *Ecotoxicology and Environmental Safety*, 59, 309–315.

Cooper, S. and Taylor, B., 2007. Training the operators of spray machines to prevent point source pollution of water with pesticides. *Outlooks on pest management*, 18, 4, 172–174.

DeLange, H.J.; Noordoven, W.; Murk, A.J.; Lurling, M. and Peeters, E.T.H.M., 2006. Behavioural responses of *Gammarus pulex* (*Crustacea, Amphipoda*) to low concentrations of pharmaceuticals. *Aquatic Toxicology*, 78, 209–216.

DeLorenzo, M.E.; Scott, G.I. and Ross, P.E., 2001. Toxicity of pesticides to aquatic microorganisms: A review. *Environmental Toxicology Chem*., 20(1), 84–98.

DEFRA, 2003. Cost curve assessment of phosphorus mitigation options relevant to UK agriculture — PE0203. http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=10324 (accessed September 2010).

Dodds, W.K., 2006. Eutrophication and trophic state in rivers and streams. *Limnol. Oceanogr*, 51, 671–680.

Ducharne, A., 2008. Importance of stream temperature to climate change impact on water quality. *Hydrology and Earth System Sciences*, 12: 797–810.

EC, 2001. *Extensive wastewater treatment processes adapted to small and medium sized communities (500 to 5 000 population equivalents)*. ISBN 92-894-1690-4.

EC, 2004. *Methyl mercury in fish and fishery products*. Information note.

EC, 2007. Towards sustainable water management in the European Union. Accompanying document to the Communication from the Commission to the European Parliament and the Council. First stage in the implementation of the Water Framework Directive 2000/60/EC, SEC(2007) 363.

EC, 2009. 5th Commission Summary on the Implementation of the Urban Waste Water Treatment Directive. Commission Staff Working Document SEC(2009) 1114 final, 3.8.2009.

EC, 2010. Report from the Commission to the Council and the European Parliament on implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources for the period 2004–2007 SEC(2010)118.

ECA, 2008. *Is cross-compliance an effective policy?* Special report no. 8. Luxembourg: European Court of Auditors.

EEA, 2005. *Source apportionment of nitrogen and phosphorus inputs into the aquatic environment.* EEA Report No 7/2005. European Environment Agency, Copenhagen.

EEA, 2005a. *Effectiveness of urban wastewater treatment policies in selected countries: an EEA pilot study.* EEA Report No 2/2005. European Environment Agency, Copenhagen.

EEA, 2007. *Estimating the environmentally compatible bioenergy potential from agriculture*. EEA Report No 12/2007. European Environment Agency, Denmark, Copenhagen. www.eea.europa.eu/publications/technical_report_2007_12.

EEA, 2010a. *Pharmaceuticals in the environment. Results of an EEA workshop*. EEA Technical report No 1/2010. European Environment Agency, Copenhagen.

EEA, 2010b. *The European environment — state and outlook 2010: country assessment — Czech republic.* European Environment Agency, Copenhagen.

EEA, 2010c. *The European environment — state and outlook 2010: country assessment — Denmark.* European Environment Agency, Copenhagen.

EFSA, 2005. Opinion of the Scientific Panel on Contaminants in the Food Chain on a Request from the European Parliament Related to the Safety Assessment of Wild and Farmed Fish. *The EFSA Journal*, 236, 1–118.

EFSA, 2010. The community summary report on trends and sources of zoonoses and zoonotic agents and food-borne outbreaks in the European Union in 2008. *The EFSA Journal*, 1496.

EMEP, 2009. *Transboundary Acidification, Eutrophication and Ground Level Ozone in Europe in 2007.* EMEP Status Report.

Environmental Outlook for Wallonia, 2008. SPW-DGARNE(DGO3)-DEMNA-DEE. Ed. Delbeuck, C.

Even, S.; Mouchel, J.; Servais, P.; Flipo, N.; Poulin, M.; Blanc, S.; Chabanel, M. and Paffoni, C., 2007. Modelling the impacts of Combined Sewer Overflows on the river Seine water quality. *Science of the Total Environment,* 375; 140–151.

Grizzetti, B.; Bouraoui, F. and Aloe, A., 2007. *Spatialised European Nutrient Balance. Institute for Environment and Sustainability*. Joint Research Centre. EUR 22692 EN.

Gros, M.; Petrovic, M.; Ginebreda, A. and Barceló, D., 2010. Removal of pharmaceuticals during wastewater treatment and environmental risk assessment using hazard indices. *Environment International*, 36: 15–26.

Herzog, F.; Prasuhn, V.; Spiess, E. and Richner, W., 2008. Environmental cross-compliance mitigates nitrogen and phosphorus pollution from Swiss agriculture. *Environmental Science and Policy*, 11, 655–668.

ICPR, 2010. *Development of the species number of macrozoobenthos and of the oxygen contents*. International Commission for the Protection of the Rhine www.iksr.org/index.php?id=173&L=3 (accessed September 2010).

ICPDR, 2008. Joint Danube Survey 2. Final Scientific Report. International Commission for the Protection of the Danube River. www.icpdr.org/jds/files/ICPDR_Technical_Report_for_web_low_corrected.pdf (accessed September 2010).

Jacobsen, B.H.; Abildtrup, J.; Andersen, M.; Christensen, T.; Hasler, B.; Hussain, Z.B.; Huusom, H.; Jensen, J.D.; Schou, J.S. and Orum, J., 2004. *Costs of reducing nutrient losses from Agriculture — Analyses prior to the Danish Aquatic Programme III*. Report no. 167, Fodevareokonomisk Institut, Copenhagen.

Jeppesen, E.; Søndergaard, M.; Jensen, J.P.; Havens, K.E.; Anneville, O.; Carvalho, L.; Coveney, M.F.; Deneke, R.; Dokulil, M.T.; Foy, B.; Gerdeaux, D.; Hampton, S.E.; Hilt, S.; Kangur, K.; Köhler, J.; Lammens, E.H.H.R.; Lauridsen, T.L.; Manca, M.; Miracle, M.R.; Moss, B.; Nõges, P.; Persson, G.; Phillips, G.; Portielje, R.; Romo, S.; Schelske, C.L.; Straile, D.; Tatrai, I.; Willén, E. and Winder, M., 2005. Lake responses to reduced nutrient loading — an analysis of contemporary long-term data from 35 case studies. *Freshwater Biol*ogy, 50: 1 747–1 771.

Jobling, S.; Coey, S.; Whitmore, J.G.; Kime, D.E.; Van Look, K.J.W. and McAllister, B.G., 2002. Wild intersex roach (*Rutilus rutilus*) have reduced fertility. *Biological Reproduction*, 67: 515–524.

Jobling, S.; Williams, R.; Johnson, A.; Taylor, A.; Gross-Sorokin, M.; Nolan, M.; Tyler, C.R.; van Aerle, R.; Santos, E. and Brighty, G., 2006. Predicted exposures to steroid estrogens in U.K. rivers correlate with widespread sexual disruption in wild fish populations. *Environmental Health Perspectives*, 114, 32–39.

Kinniburgh, J.H. and Barnett, M., 2010. Orthophosphate concentrations in the River Thames: reductions in the past decade. *Water and Environment Journal*, 24, 107–115.

Kümmerer, K., 2007. Sustainable from the very beginning: rational design of molecules by life cycle engineering as an important approach for green pharmacy and green chemistry. *Green Chem.*, 9, 899–907.

Kundzewicz, Z.W.; Mata, L.J.; Arnell, N.W.; Döll, P.; Kabat, P.; Jiménez, B.; Miller, K.A.; Oki, T.; Sen, Z. and Shiklomanov, I.A., 2007. Freshwater resources and their management. In Parry, M.L.; Canziani, O.F.; Palutikof, J.P.; van der Linden, P.J. and Hanson, C.E. (eds.). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, the United Kingdom, 173–210.

LIFE III, 2007. *LIFE and Europe's wetlands — restoring a vital ecosystem*. European Commission, ISBN 978-92-79-07617-6.

LIFE III, 2008. *Breathing LIFE into greener businesses*. European Commission, ISBN 978-92-79-10656-9.

Loos, R.; Gawlik, B.M.; Locoro, G.; Rimaviciute, E.; Contini, S. and Bidoglio, G., 2009. EU-wide survey of polar organic persistent pollutants in European river waters. *Environmental Pollution*, 157, 561–568.

Malmaeus, J.M. and Karlsson, O.M. 2010. Estimating costs and potentials of different methods to reduce the Swedish phosphorus load from agriculture to surface water. *Science of the Total Environment*, 408: 473–479.

Matthiessen, P.; Arnold, D.; Johnson, A.C.; Peppe, T.J.; Pottinger, T.G. and Pulman, K.G.T., 2006. Contamination of headwater streams in the United Kingdom by oestrogenic hormones from livestock farms. *Science of the Total Environment*, 367, 616–630.

Meybeck, M.; Lestel, L.; Bonte, P.; Moilleron, R.; Colin, J.L.; Rousselot, O.; Herve, D.; de Ponteves, C. ; Grosbois, C. and Thevenot, D. R., 2007. Historical perspective of heavy metals contamination (Cd, Cr, Cu, Hg, Pb, Zn) in the Seine River basin (France) following a DPSIR approach (1950–2005). *Science of the Total Environment*, 375: 204–231.

Michaloudi, E.; Moustaka-Gouni, M.; Gkelis, S. and Pantelidakis, K., 2008. Plankton community structure during an ecosystem disruptive algal bloom of *Prymnesium parvum*. *Journal of Plankton Research*, 31, 3, 301–309.

Netherlands Environmental Assessment Agency, 2010. *Indirect effects of biofuels: intensification of agricultural production*. Publication number 500143005.

Nie, L.; Lindholn, O.; Lindholm, G. and Syversen, E., 2009. Impacts of climate change on urban drainage systems — a case study in Fredrikstad, Norway. *Urban Water Journal*, 6, 323–332.

Nolan, M.; Jobling, S.; Brighty, G.C.; Sumpter, J.P. and Tyler, C.R., 2001. A histological description of intersexuality in the roach. *Journal of Fish Biology*, 58(1), 160–176.

Nørring, N.P. and Jørgensen, E., 2009. Eutrophication and agriculture in Denmark: 20 years of experience and prospects for the future. *Hydrobiologica*, 629:65–70.

OECD, 2008. *Environmental Performance of Agriculture in OECD countries since 1990*. Paris, France, www.oecd.org/tad/env/indicators. (accessed September 2010).

OECD, 2009. *Alternative Ways of Providing Water. Emerging Options and their Policy Implications.*

Orlando, E.F.; Kolok, A.S.; Binzcik, G.A.; Gtes J.L.; Horton M.K. and Lambright C.S., 2004. Endocrine-disrupting effects of cattle feedlot effluent on an aquatic sentinel species, the Fathead Minnow. *Environ Health Perspect.*, 2004; 112: 353–358.

Paerl, H.W. and Huisman, J., 2008. Blooms like it hot. *Science*, 320, 5 872, 57–58.

Petrovic, M.; Sole, M.; Lopez de Alda, M. and Barcelo, D., 2002. Endocrine disruptors in sewage treatment plants, receiving river waters, and sediments: Integration of chemical analysis and biological effects of feral carp. *Environmental Toxicology and Chemistry*, 21, 10, 2 146–2 156.

Poleksic, V.; Lenhardt, M.; Jaric, I.; Djordjevic, D.; Gacic, Z.; Cvijanovic, G. and Raskovic, B., 2010. Liver, gills and skin histopathology and heavy metal content of the Danube sterlet (*Acipenser Ruthenus Linnaeus*). *Environmental Toxicology and Chemistry*, 29, 3, 515–521.

Reemtsma, T.; Weiss, S.; Mueller, J.; Petrovic, M.; Gonzalez, S.; Barcelo, D.; Ventura, F. and Knepper, T.P., 2006. Polar pollutants entry into the water cycle by municipal wastewater: A European perspective. *Environ. Sci. Technology*, 40 (17), 5 451–5 458.

RIKS, 2010. *Exploration of land use trends under SOER 2010*. Report to the European Environment Agency. Research Institute for Knowledge Systems, Maastricht, the Netherlands.

RIVM, 2008a. *EU-wide control measures to reduce pollution from WFD relevant substances. Cadmium in the Netherlands*. National Institute for Public Health and the Environment. Report 607633001.

RIVM, 2008b. *EU-wide control measures to reduce pollution from WFD relevant substances. Copper and Zinc in the Netherlands*. National Institute for Public Health and the Environment. Report 607633002.

Salminen, R. (ed.), 2005. *Geochemical Atlas of Europe. Part 1: Background Information, Methodology and Maps*. Geological Survey of Finland. www.gtk.fi/publ/foregsatlas/ (accessed September 2010).

Scholes, L.; Revitt, D.M. and Ellis, J.B., 2008. A systematic approach for the comparative assessment of stormwater pollutant removal potentials. *Journal of Environmental Management*, 88, 467–478.

Schulz, R. and Liess, M., 1999. A field study of the effects of agriculturally derived insecticide input on stream macroinvertebrate dynamics. *Aquatic Toxicology*, 46, 155–176.

Sondergaard, M.; Jeppesen, E.; Lauridsen, T.; Skov, C.; Van Nes, E.; Roijackers, R.; Lammens, E. and Portielje, R., 2007. Lake restoration: successes, failures and long-term effects. *Journal of Applied Ecology*, 44, 1 095–1 105.

Soulsby, C.; Youngson, A.F.; Moir, H.J. and Malcolm, L.A., 2001. Fine sediment influence on salmonid spawning habitat in a lowland agricultural stream. *Science of the Total Environment*, 265, 295–307.

Triebskorn, R.; Casper, H.; Scheil, V. and Schwaiger, J., 2007. Ultrastructural effects of pharmaceuticals (carbamazepine, clofibric acid, metoprolo, diclofenac) in rainbow trout (*Oncorhynchus mykiss*) and common carp (*Cyprinus carpio*). *Anal Bioanal Chem*., 387: 1 405–1 416.

UNESCO/IHP, 2005. *International Hydrological Programme-VI. CYANONET A Global Network for Cyanobacterial Bloom and Toxin Risk Management*. Initial Situation Assessment and Recommendations. Technical document in hydrology, Number 76. UNESCO, Paris, 2005.

Vethaak, A.; Lahr, J.; Schrap S.M.; Belfroid, A.C.; Rijs, G.B.J.; Gerritsen, A.; de Boer, J.; Bulder, A.S.; Grinwis, C.M.; Kuiper, R.V.; Legler, J.; Murk, T.A.J.; Peijnenburg, W.; Verhaar, H.J.M. and de Voogt, P., 2005. An integrated assessment of estrogenic contamination and biological effects in the aquatic environment of the Netherlands. *Chemosphere*, 59, 511–524.

Waters, D.; Watt, W.; Marsalek, J. and Anderson, B.C., 2003. Adaptation of a storm drainage system to accommodate increased rainfall resulting from climate change. *J. Environ. Plan. Manage.*, 46: 755–770.

WECF, 2010. Sustainable and cost-effective wastewater systems for rural and peri-urban communities *up to 10 000 PE*. Women in Europe for a Common Future. www.wecf.eu/download/2010/03/guidancepaperengl.pdf (accessed September 2010).

Whitehead, P.G.; Wilby, R.L.; Butterfield, D. and Wade, A.J., 2006. Impacts of Climate Change on Nitrogen in Lowland Chalk Streams: Adaptation Strategies to Minimise Impacts. *Science of the Total Environment*, 365: 260–273.

Whitehead, P.G.; Wade, A.J. and Butterfield, D. 2009. Potential impacts of climate change on water quality and ecology in six UK rivers *Hydrology Research*, 40(2–3): 113–122.

EU projects

This assessment refers to some key EU projects with respect to water quality. These are;

- Functional Tools for Pesticide Risk assessment and management (FOOTPRINT) www.eu-footprint.org/;
- Global change impacts on European freshwater eco-systems (Euro-limpacs) www.refresh.ucl.ac.uk/eurolimpacs;
- Models for Assessing and Forecasting the Impact of Environmental Key Pollutants on Marine and Freshwater Ecosystems and Biodiversity' (MODELKEY). www.modelkey.org;
- Source Control Options for Reducing Emissions of Priority Pollutants (SCOREPP) www.scorepp.eu/;
- Source Control of Priority Substances in Europe (SOCOPSE) www.socopse.se/;
- Training Operators to prevent Pollution from Point Sources (TOPPS) www.topps-life.org.

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European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: +45 33 36 71 00
Fax: +45 33 36 71 99

Web: www.eea.europa.eu
Enquiries: www.eea.europa.eu/enquiries

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