

Reducing phosphate discharges: the role of the 1991 EC urban wastewater treatment directive

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Abstract This paper reviews the status of implementation of the 1991 EC urban wastewater treatment Directive in relation to its requirements for phosphate removal from wastewater discharges. Transposition of the Directive is satisfactory in most Member States as is implementation of requirements regarding collection and secondary treatment of sewage, with the notable exceptions of Belgium and Italy. A range of approaches has been adopted for the designation of sensitive areas under the Directive and designation is still not complete. It is likely that most Member States will have met the treatment requirements for sensitive areas by the end of 1998. Exceptions will include France and Spain (where implementation will be incomplete), the UK (which designated more sensitive areas in 1998 and will meet requirements for these at a later date) and Greece and Italy (for which sensitive area designation is lacking or uncertain). The Commission has indicated that it will examine compliance for both designation and treatment closely. This may place further pressure on Member States to designate further sensitive areas. It is estimated that currently in ten EU Member States, containing 90% of the EU population, about 375,000 tonnes of phosphorus are produced in domestic wastewater each year. In 1994 39–45% of this was removed in wastewater treatment works.

Keywords Wastewater treatment; phosphorus; European Union; eutrophication

Introduction

Phosphorus pollution in surface waters may lead to eutrophication problems (Farmer, 1997). A number of policy initiatives exist to overcome this problem. The most important of these within the European Union is the urban wastewater treatment Directive 91/271 (CEC, 1991). This paper outlines the way that the Directive tackles the problem of phosphorus discharges from wastewater, the degree to which it has, so far, been implemented in Member States and considers potential future developments.

The requirements of the 1991 urban wastewater treatment Directive

The purpose of the Directive is to improve Member States' investment in the collection and treatment of urban wastewater. Different requirements and deadlines apply to discharges in different receiving waters ("sensitive", "normal", and "less-sensitive" areas). The Directive leaves the Member States much freedom in its implementation, such as a choice between limit values for treatment plant effluents, percentage reduction goals and a choice between reducing phosphorus and nitrogen discharges.

The Directive has a strict timetable for meeting its obligations, ranging from June 1993 for transposition (met by few Member States) to 2005 for final technical compliance. According to the type of receiving water and size of agglomeration, the Directive sets minimum standards for the collection, treatment and discharge of urban wastewater.

The designation of areas

In Article 5 and 6 of the Directive the Member States are required to designate "sensitive" and "less sensitive" areas. If an area is to be classified as sensitive, significant reductions of nitrogen and/or phosphorus are required. This is necessary:

- either when the receiving water is “eutrophic or which in the near future may become eutrophic if protective action is not taken”;
- or if the water is used for drinking water abstraction;
- or if the water requires a more stringent than secondary treatment in order to meet other EU Directives.

A Member State may designate its entire territory as a sensitive area under Article 5(8). In sensitive areas adequate collection and “more stringent than secondary” (i.e. tertiary) treatment systems had to be installed by 31 December 1998 for all discharges from agglomerations of more than 10,000 pe. Member States are free to choose among five approaches of how to apply “more stringent treatment” in sensitive areas: four options from Article 5(3) and one option from Article 5(4).

The four options in Article 5(3) are listed in Annex I of the Directive. In option 1 or 2, discharges to sensitive areas must meet emission limit values for either phosphorus or nitrogen. The limit values for phosphorus are 2 mg/l in agglomerations of between 10,000 and 100,000 pe and 1 mg/l in larger agglomerations. The limit values for nitrogen are 15 mg/l for agglomerations of between 10,000 and 100,000 pe and 10 mg/l in larger agglomerations. Alternatively to the use of limit values, phosphorus may be reduced by 80% or nitrogen by 70–80% (options 3 and 4). The fifth option in Article 5(4) states that the above requirements need not apply in sensitive areas where the minimum percentage reduction of the overall load entering all urban wastewater treatment plants in that area is at least 75% for total phosphorus and total nitrogen.

Implementation of the urban wastewater treatment Directive

Degree of implementation

The following information is based on the national implementation programs submitted by Member States and with the data contained in the Commission’s own 1998 implementation report (CEC, 1998). Due to this decision the format of the presentation of the data is standardised. However, this does not mean that the data are directly comparable as data on sewage collection and treatment are collected differently in the Member States. More specific information on selected Member States was also gathered (Farmer, 1999; Farmer *et al.*, 2000) and is briefly summarised here.

According to the 1998 implementation report, most Member States have undertaken the basic legal requirements which would lead to regulatory action to remove phosphate from urban wastewater discharges where necessary. However, legal transposition is lacking or was incomplete in some cases, particular Italy, and Greece and neither had yet designated sensitive areas (although some data for Greece do relate to areas that may be designated). Of the other Member States only Austria considered that no sensitive area designations are required. All Member States reported on the early stages of implementation of the Directive, except Italy. However, none had reported on the 1998 deadline for compliance with discharge requirements in sensitive areas.

Sensitive areas

The designation of sensitive areas remains incomplete across the EU. Some Member States (e.g. Greece and Italy) had not adopted domestic legislation to formalise the designation process. It will also be some time before Member States have reported on implementation of this requirement. Designation is important as it will drive the installation of nutrient removal, although this is less important in Member States where phosphate removal has been a domestic environmental objective for some time.

Member States can be categorised into three groups, according to the identification of sensitive areas. In the first group are Denmark, Sweden and the Netherlands which regard their

whole territory as a sensitive area. The second group includes Member States, where normal areas also exist, like France, Germany, Ireland and Austria. Austria is unusual in that it regards its whole territory as a normal area. This was done primarily to gain time, as Austria still aims to meet the requirements for sensitive areas in their whole territory without being bound to the strict deadlines. The third group consists of Portugal, the United Kingdom and Spain. Besides having sensitive areas, these Member States have also designated less sensitive areas. Most of the territory in these countries is regarded as a normal area.

Discharges and agglomerations

The organic load discharged to normal, sensitive and less sensitive areas and the number of agglomerations within each area are shown in Table 1. The population data are, of course, not the same as population equivalents, which is why the total population equivalent in the final column is different to the Member State population. It is also important to note that the data are based on agglomerations of 2,000 pe or above. Thus small populations (e.g. in rural areas) are not included. This also means that the number of agglomerations and the population equivalent in sensitive areas is not the same as that required to adopt tertiary treatment under the Directive. This requirement only applies to agglomerations of 10,000 pe or more. Thus although 37% of the organic load (population equivalent) in the EU is discharged within sensitive areas, this would not all require nutrient removal.

There are limited sources of more up to date comparative data on EU Member States. The status of treatment in ten EU Member States in 1994 (population of 334 million or 535 million population equivalents, i.e. 90% of the EU total), together with the expected requirements following implementation of the Directive are shown in Table 2. The total population equivalents used are different from that given in the Commission's implementation report of the Directive. Note also that the tables consider levels of treatment from wastewater treatment works (not total wastewater production) and, therefore, the population equivalents will change as connection rates to sewerage systems increase. It can be seen that it is estimated that after implementation 48% of wastewater from treatment plants will be subject to tertiary nutrient removal. If one adds in the estimate for the remaining part of the population which will be unconnected to sewerage systems (29.2 million pe), the proportion of the overall population with nutrient removal is 45%.

Table 1 The population equivalent and number of agglomerations of greater than 2,000 pe in normal, sensitive and less sensitive areas in each Member State (excluding Italy) according to the 1998 European Commission implementation report (updated for Germany)

Member State	Population (1000 inhabitants)	Normal areas		Sensitive areas		Less sensitive areas		Total	
		No.	1000 pe	No.	1000 pe	No.	1000 pe	No.	1000 pe
Austria	8,040	703	18,569	0	0	0	0	703	18,569
Belgium	10,131	119	1,775	245	7,389	0	0	364	9,164
Denmark	5,216	0	0	382	8,393	0	0	382	8,393
Finland	5,099	0	0	201	4,007	0	0	201	4,007
France	58,027	2,359	49,927	1,137	20,583	0	0	3,496	70,510
Germany	81,533	1,179	27,397	3,658	101,406	0	0	4,837	128,803
Greece	10,442	169	6,189	60	2,101	86	1,913	315	10,203
Ireland	3,577	137	3,748	9	170	0	0	146	3,918
Luxembourg	407	0	0	42	914	0	0	42	914
Netherlands	15,423	0	0	414	17,218	0	0	414	17,218
Portugal	9,912	598	12,651	114	1,814	34	1,806	746	16,271
Spain	39,170	2,611	47,263	253	4,659	356	22,517	3,220	74,439
Sweden	8,816	0	0	454	7,496	0	0	454	7,496
United Kingdom	58,276	1,764	61,816	127	4,187	155	10,523	2,046	76,526
Total	314,069	9,632	229,335	7,088	158,073	631	36,759	17,351	424,361

Table 2 Levels of wastewater treatment (in 1,000 population equivalents) in selected EU Member States in 1994. (Source: EEA 1999)

Member State	Untreated	Primary	Secondary	Tertiary	Total
Finland	0	700	0	4,800	5,500
France	2,000	4,500	41,000	1,000	48,500
Germany	2,500	8,300	7,300	104,600	122,700
Greece	2,700	2,700	700	1,800	7,900
Italy	28,800	7,000	53,000	6,000	94,800
Luxembourg	60	30	480	50	620
Netherlands	100	200	5,700	18,000	24,000
Portugal	7,400	1,000	2,300	200	10,900
Spain	43,600	3,500	30,400	700	78,200
United Kingdom	13,000	13,000	43,000	9,000	78,000

The data show significant differences to Table 1. Some levels of treatment are significantly higher. However, this may be in part that the analysis is not limited to agglomerations greater than 2,000 pe. It is also important to note that different forms of tertiary treatment (nutrient removal and disinfection) are not distinguished.

Member State examples: France, Germany, Spain and the United Kingdom

France. France has designated a significant proportion of its territory (just over a quarter in terms of population equivalent) as sensitive areas. However, the Water Agencies have elsewhere indicated other sites which may be at risk from eutrophication which are not currently designated. In 1996 only 38% of the treatment works serving >10,000 pe in sensitive areas, representing only 13% of the population equivalent, removed phosphorus to 80% efficiency or greater. It is not known what upgrading was completed by the Directive's implementation deadline for sensitive areas of 31 December 1998, but it is certain that significant further investment is still needed to meet its requirements.

It is also apparent that the pattern of nutrient removal in France has not obviously been connected to the requirements of the Directive. There are many more agglomerations with nitrogen removal systems than there are for phosphorus removal. While nitrogen is an important nutrient contributing to marine eutrophication, the distribution of nitrogen removal from wastewater in France is not targeted at protection of the coastal zone. Phosphorus removal itself also has not been targeted at the requirements of designated sensitive areas. Of treatment works with >80% phosphorus removal, only around a third discharged into sensitive areas, amounting to about half of the population equivalent served with phosphorus treatment. Most sensitive areas still contained large wastewater point sources with poor phosphorus removal. In contrast there are some undesignated areas with phosphorus removal systems. This probably reflects the consequences of some early investment in nutrient removal systems prior to designation. With full implementation of the Directive, tertiary treatment should be applied to discharges from at least a population equivalent of 15.5 million (from a country total of 70 million pe).

Germany. The *new Länder* in Germany, in particular, have considerable problems in their inheritance of an old infrastructure and in huge costs of upgrading their wastewater treatment systems, although this general upgrading would have resulted even without the existence of the urban wastewater treatment Directive due to the existing strict German environmental legislation. Most of the territory of Germany is designated as sensitive. Only three of the *Länder* have not designated the whole of their territory as sensitive, although this has been challenged by the European Commission (see below). Germany has installed extensive phosphorus reduction in wastewater treatment plans across the *old Länder*. Many

of these installations are on smaller treatment works. It is estimated that by the end of 1998 the total reduction in phosphorus discharge from receiving waters was about 72% across all sensitive areas, i.e. very close to the minimum requirements of the Directive. Those parts of the *new Länder* that do not meet the required standards by 1998 will have established investment programmes to ensure compliance within a few years. Further improvements will take place.

Spain. The situation of wastewater treatment in Spain required a major effort in order to achieve compliance with the obligations and periods established by the urban wastewater treatment Directive. As a result, priority has been assigned to the construction of wastewater treatment plants in large urban population centres. Spain has tended to declare the smallest number possible of sensitive areas as required by the Directive. In contrast, special attention has been paid to wastewater treatment in less sensitive areas (much of the coast except for closed bays and estuaries and some areas with major urban population centres). This is because many coastal areas are bathing areas, so secondary and tertiary wastewater treatment has been considered necessary for the purpose of satisfying the quality sections of the bathing waters Directive and conserving the competitiveness of Spanish coasts in the tourism market.

Actions planned for wastewater treatment are not being carried out at an optimal rate for achieving compliance with the Directive and its deadlines, although a major effort is under way to ensure the highest level of compliance possible. Within this general framework, compliance with the deadlines established by the Directive for treatment in sensitive areas has not been considered a priority.

United Kingdom. The urban wastewater treatment Directive has proved to be one of the most expensive EU environmental Directives to have been implemented in the UK. The UK has taken the approach of designating individual sensitive areas under the Directive. The government has extended considerably the number of designated sensitive areas in 1998. This will result in additional requirements for phosphate removal. It is uncertain whether there will be any further pressure to extend the number of designations still further, although any such development would not occur in the near future.

A new investment/price review has recently concluded. This will result in significant additional action on environmental improvements, including phosphate control. These requirements not only include investment for phosphate removal for relevant treatment works in sensitive areas, but also reductions in phosphorus discharges from small wastewater sources into rivers designated under both EU and national legislation for their nature conservation importance, where eutrophication is thought to be a problem.

Future developments

Action by the European Commission

It is difficult to predict future implementation of the urban wastewater treatment Directive. Any future timetable will largely depend on domestic and Commission pressure on individual Member States. Indeed, some Member States are still designating sensitive areas. It is important to stress that implementation of the Directive allows significant flexibility to Member States and, therefore, the particular action taken will reflect practical, political and economic considerations. The Commission may, in the future, put pressure on individual Member States to designate further areas as it begins to examine the basis for the existing designations. Indeed, this process has begun. The European Commission is currently involved in a number of actions to ensure that the current provisions of the Directive are enforced. Current Commission action includes:

- Follow-up to the 1998 European Court of Auditors and Commission reports on financing and implementation of the Directive. This will include closer examination of schemes and also of general implementing measures such as the designation of sensitive areas and levels of wastewater treatment therein. The Commission's response was hard-line, stating that it "considers the deadlines for achieving the objectives ... sufficient, and does not at present consider proposing any changes in the deadlines". The Commission also noted that no Member State had requested changes to the deadlines.
- Application (December 1998) to the European Court of Justice against Italy for failure to transpose legislation to give effect to the Directive. Italy is currently responding by drafting such legislation.
- A Reasoned Opinion (December 1998) against Greece for adopting legislation in 1997 that does not fully comply with the provisions of the Directive, e.g. in identifying sensitive areas.
- A Reasoned Opinion (December 1998) against Belgium concerning its implementation programme. This relates to the city of Brussels, which will not have the required collection and treatment systems in place until 2004.
- A Reasoned Opinion (October 1999) against Germany for failure to designate Sachsen and Sachsen-Anhalt as sensitive areas, as these areas form part of the Baltic catchment.
- A Reasoned Opinion (July 2000) against Belgium for failure to designate sensitive areas correctly in the Flanders Region.
- A Reasoned Opinion (July 2000) against Italy for failure to remove nutrients from waters discharged from Milan into two sensitive areas.

It can be seen that the Commission is having to examine basic issues relating to transposition and implementation. These types of problems can be analysed relatively easily. Similarly, failure to install phosphate removal in sensitive areas could also be readily determined. However, far more difficult is an assessment of whether the right surface waters in a Member State have been correctly designated as sensitive areas. The only way to assess compliance is to review all data on surface water quality to determine which waters should be designated as sensitive, also bearing in mind that the Directive specifies that this includes waters which "may become" eutrophic in the future. The Commission issued proposals in May 1999 for a new study on the state of compliance of Member States with the designation of sensitive areas and discharge requirements. This study will be important in determining whether any further extension to phosphate removal will be required to implement the Directive.

Analysis of future trends

The European Environment Agency has commissioned some work to consider future implementation in the Directive in ten Member States. Results are summarised in Table 3. In a number of Member States the current pattern of treatment is much as currently exists, e.g. high levels of tertiary treatment in the Netherlands, relatively low levels in Spain and the UK (albeit it with improvements). The largest predicted change is for France, which, in order to meet this, would also require significant investment in phosphate removal outside current sensitive areas.

From Table 3 it is possible to estimate the amount of phosphate that will be removed from wastewater. Table 4 provides an estimate of the quantity of phosphate produced in the receiving waters of the wastewater treatment plants in the ten Member States described in Table 3, an estimate of removal rates in 1994 and of the removal rate following implementation of the urban wastewater treatment Directive.

It should be noted that the estimate given for the likely levels of treatment that will be applied in France in Table 3 is considerably more stringent than might be assessed from

Table 3 Wastewater treatment after implementation of the urban wastewater treatment Directive (in million population equivalents) (EEA, unpublished)

Member State	Total treated	Total subject to tertiary treatment	Percentage change in tertiary treatment from 1994
Finland	5.5	5.5	13
France	63.5	54.5	84
Germany	123.5	121.0	13
Greece	10.0	8.6	63
Italy	101.8	10.6	4
Luxembourg	0.61	0.48	71
Netherlands	24.2	24.0	24
Portugal	14.2	1.2	4
Spain	84.7	4.2	4
United Kingdom	79.0	13.0	4

Table 4 Estimated phosphate discharge from wastewater treatment plants at present level of wastewater treatment for the EU10 given in Table 6 and as expected after full implementation of urban wastewater treatment Directive (EEA, unpublished)

	Phosphate production prior to treatment (ktP/a)	Nutrient discharge 31-12-94 (ktP/a)	Percentage P removal due to treatment at 31-12-94	Nutrient discharge after implementation of the Directive (ktP/a)	Reduction in phosphate discharge required
Phosphorus discharge	375	208-227	39-45%	143-164	27-31%

examination of current requirements for sensitive areas. This would suggest that resulting tertiary and secondary treatment would remove about 55% of the phosphate produced. Only a completion of studies on the appropriateness of current designations in France will resolve this discrepancy.

Overall the effect of the treatment facilities required would be to remove between 56 and 62% of the domestic phosphate produced in the ten Member States. The remaining Member States also generally exhibit high levels of phosphate removal. Three of these Member States (Austria, Denmark and Sweden) had 14.2 pe of their total 21.8 pe with nutrient removal on wastewater treatment at the end of 1994. This represents at least a further 9,900 tonnes of phosphate removed from a total of 15,300 tonnes produced.

The proposed water framework Directive

The text of this proposal was agreed following the Conciliation Committee meeting in May 2000. It provides the basis for an overall management framework for surface waters and groundwaters. This is a major new development for EU water legislation, which has, until now, largely been issue-specific.

The proposed water framework Directive incorporates (and repeals) a number of existing items of EU water legislation. However, the urban wastewater treatment Directive is not one of these. Indeed the implementation of the water framework Directive must take special account of the provisions of the urban wastewater treatment Directive. This is understandable as any potential change in the provisions of the urban wastewater treatment Directive would create further delays to the implementation of its objectives. It is, however, also not entirely efficient. Under the proposed water framework Directive surface waters which are eutrophic would be classified as below “good status” and it would be up to Member States to identify the most efficient (least cost) route to improving water quality. If

part of the discharge of nutrients is from wastewater treatment works serving an agglomeration > 10,000 pe, then the Member State would have no option but to install tertiary treatment, even if other controls may be less costly (e.g. reducing agricultural inputs). However, the new Directive may result in the need to take action to reduce phosphate pollution from small wastewater treatment works in order to achieve good ecological status.

Conclusions

It is already certain that some Member States will not have complied for those areas already designated, but it is not clear when compliance will be achieved and it will probably be even longer before the results of the review of the designations themselves is published. Any additional action has been entirely a matter for national policies, which have diverged significantly, although even the UK, which has had, until recently, little phosphate removal, has identified national priorities for which action beyond that in the Directive may be necessary.

Future developments must also take account of the general thrust of policy development on water in the EU and this is towards a more holistic management of river basins, which should result in Member States identifying which of all phosphate sources is the most cost-effective to tackle. This may, or may not, include further action on urban wastewater. It is certainly likely to highlight agricultural sources as the next pollution problem to address.

Finally, EU policy is also expanding in the sense of its potential implementation in, *inter alia*, ten central and eastern European countries. It is clear that significant phosphate removal will be necessary in these states. However, the extent of the requirement is unknown as no sensitive areas are identified to date, although the Baltic catchment areas are likely to require designation and will result in significant costs to those countries concerned. For example, a low estimate of the costs for compliance with the general collection and treatment requirements in Poland is thought to be \$9.2 billion, with upgrade requirements for meeting sensitive area requirements being a further \$2.1 billion (Hughes and Bucknall, 2000). Implementation of the Directive is so costly in these Candidate Countries, that it is likely that some derogations will be applied.

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