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### IMPLEMENTATION OF THE 1991 EU URBAN WASTE WATER TREATMENT DIRECTIVE AND ITS ROLE IN REDUCING PHOSPHATE DISCHARGES *(Summary of Report)*

*The deadline fixed by EU  
legislation for phosphorus  
removal in sewage works  
was 31 December 1998.*

*This report assesses to  
what extent this objective  
is being achieved.*

*Waßmannsdorf sewage works,  
Berlin. Phosphorus removal  
achieving discharge levels of 0.6  
mgP/l (objective 2000 0.5 mg/l)  
using biological processes only  
(enhanced biological nutrient  
removal EBNR). 1 million pe.  
Commissioned 1997.  
Berlin Wasser Betriebe.*



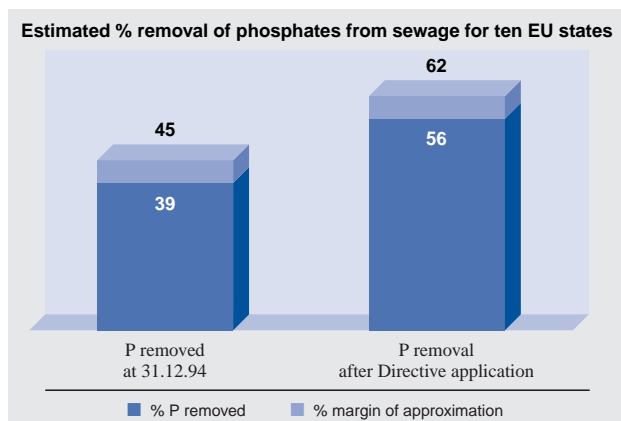
## EXECUTIVE SUMMARY

## INTRODUCTION

Phosphate pollution in surface waters may lead to eutrophication problems - excessive growth of algae and higher plants with adverse effects on ecosystems and amenity. A number of policy initiatives exist to overcome this problem, at international, national and local levels. The most important of these within the European Union is the urban waste water treatment Directive 91/271. This report outlines the way that the Directive tackles the problem of phosphate discharges from waste water, the degree to which it has, so far, been implemented in Member States and considers potential future developments.

## PHOSPHATE POLLUTION

There has been a decline recently in the quantities of phosphate discharges (both point and diffuse sources) to the surface waters of Europe. However, phosphate concentrations in surface waters are still, across much of Europe, very much higher than would be the case without human influence and in places severe eutrophication problems continue to occur.



Sources of phosphate pollution vary considerably in different European countries. They principally include agriculture, sewage and industry. In some cases one source may predominate and in others combinations of sources are significant. However, generally approximately one third of phosphate sources to surface waters are derived from sewage.

Phosphates from sewage can be controlled in a number of ways in waste water treatment works. Secondary treatment may remove about 30-40% of phosphate present. However, more stringent control is provided by tertiary treatment, either biological (70-85% removal depending on conditions), chemical (up to 95% removal), or some combination of the two.

## THE URBAN WASTE WATER TREATMENT DIRECTIVE AND ITS IMPLEMENTATION

The EU urban waste water treatment Directive 91/271/EEC is an important tool in dealing with some of the major sources of phosphate pollution. *Inter alia*, regarding nutrient discharges from sewage works, the Directive requires that phosphates and nitrates must be removed (to specified limits) wherever discharges are into 'sensitive areas', defined as being 'eutrophic or which in the near future may become eutrophic'. However, its specific action on phosphates is limited to waste water treatment works serving conurbations above 10,000 pe., or to overall reductions of 75%, although "appropriate" treatment is also required for smaller villages. Other pressures (eg international conventions or national priorities) may result in additional action.

Even though the urban waste water treatment Directive was adopted eight years ago, it is not yet clear the extent to which it has been implemented in Member States. The complexity of the Directive and the range and flexibility of measures contained within it make assessment difficult.

TABLE 1

	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	Percentage phosphate removal after implementation
Phosphorus discharge	375	208-227	39-45%	143-164	27-31%	56-62%

*Estimated phosphate discharge from waste water treatment plants at present level of waste water treatment for the ten EU Member States<sup>1</sup> and as expected after full implementation of urban waste water treatment Directive (EEA, unpublished).*

<sup>1</sup> France, Finland, Germany, Greece, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom.

The most recent implementation report (COM (98)775) is incomplete and does not address the issue of nutrient removal. The following conclusions can nonetheless be highlighted:

1. 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.
2. A range of approaches has been adopted for the designation of sensitive areas under the Directive and designation is still not complete.
3. This report could not address the likelihood of compliance with the end of 1998 deadline for nutrient removal in sensitive areas.
4. 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).
5. 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.
6. It is estimated that currently in ten EU Member States, containing 90% of the EU population, about 375,000 tonnes of phosphorus is produced in domestic waste water each year. In 1994 39–45% of this was removed in waste water treatment works.

### **FUTURE IMPLEMENTATION OF THE DIRECTIVE**

Following full implementation of the urban waste water treatment Directive, it is estimated that phosphate removal will have increased in ten Member States (discharging 375 kt of phosphate per year prior to treatment) to between 56 and 62%, with total discharges after treatment ranging from 143-164 kt phosphate per year, as illustrated in Table 1.

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 waste water 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.

It is, however, unlikely that implementation will meet the timetable in the Directive and that any future timetable will largely depend on domestic and Commission pressure on individual Member States. Indeed a European Court of

Auditor's report of 18 June 1998 stated that 'most of the Member States were finding [meeting the requirements for sensitive areas] difficult to achieve...within the specified time frame'. The Commission's response was hardline, 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.

It is expected that the urban waste water treatment Directive will result in the following treatment conditions across the EU:

- The population not connected to sewers will be halved.
- No untreated waste water should be discharged.
- Most waste water will be subject to, at least, secondary treatment.
- 45% of municipal sewage will be subject to tertiary treatment (nutrient removal).
- Secondary treatment will predominate in Belgium, Ireland, Italy, Portugal, Spain and the UK.
- Secondary treatment with nutrient removal will predominate in Austria, Denmark, Finland, France, Germany, Luxembourg, the Netherlands, and Sweden.

### **FUTURE TRENDS**

At this time it is impossible to be precise about the future of phosphate removal from urban waste water. The deadline for meeting discharge requirements for sensitive areas under the urban waste water treatment Directive was the end of 1998. However, it will be some time before it is known precisely whether some Member States have complied for those areas designated and whether the correct areas have been designated. It can already be concluded that many northern EU Member States will have complied with the Directive's requirements, while for many southern Member States, compliance will be only partial. 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 demonstrated by the proposed water framework Directive. As currently proposed, this leaves standing the existing Directive's requirements, but focuses on 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 waste water. It is certainly likely to highlight agricultural sources as the next pollution problem to address.

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## 1. INTRODUCTION TO PHOSPHATE POLLUTION AND ITS CONTROL

### 1.1 PHOSPHATE POLLUTION IN EUROPEAN SURFACE WATERS

The pollution of surface waters by phosphates from a wide variety of sources is a serious problem in many parts of Europe. Phosphorus is a plant nutrient and excess quantities of it, together with an excess of the other main plant nutrient, nitrogen, can lead to extensive growth of phytoplankton, macroalgae and higher plants. In some cases, and along with other factors such as reduced flow rates resulting from dams or weirs or changes in the balance of food webs, this can adversely affect invertebrate and fish populations and even result in the production of toxic substances from algal blooms (Farmer, 1997).

Etymologically, eutrophication simply means high concentrations of plant nutrients, but the word is often in fact used to refer to the adverse response of an ecosystem to excess nutrients (Harper, 1991) and the problems mentioned above.

Plants require both phosphorus and nitrogen to grow and one or other of these nutrients is usually the limiting factor preventing excess growth. In freshwaters this tends to be phosphorus, while in many marine waters nitrogen is often limiting. Thus prevention of eutrophication symptoms in freshwaters usually emphasises targeted action against phosphorus and, for marine waters, action against nitrogen. However, there are instances where this pattern is different and action may often need to be targeted at both pollutants.

In natural, unimpacted freshwaters total phosphorus concentrations are usually below 25 mgP/l, although some natural minerals may cause locally elevated levels. Unless otherwise demonstrated, it is generally assumed that concentrations above 50 mgP/l are the result of anthropogenic influences. A survey of rivers across Europe (EEA, 1998) found that a large proportion of 1000 monitoring stations had levels of total phosphate exceeding 50 mgP/l, many by a considerable margin. Indeed only about 10% of

TABLE 1.1

MEMBER STATE	EXTENT OF EUTROPHICATION
Austria	Some localised eutrophication.
Belgium	Widespread eutrophication in rivers, canals, lakes and coastal waters. Most of the surface waters in Flanders are classified as eutrophic.
Denmark	Extensive eutrophication of rivers and lakes.
Finland	Eutrophication limited to a few localised areas.
France	Eutrophication localised to particular river basins, lakes and reservoirs, especially the Loire and Meuse.
Germany	Serious eutrophication, especially lakes in southern Germany, the Baltic Sea and Schleswig-Holstein.
Greece	Highly localised eutrophication, but important.
Ireland	Highly localised eutrophication, but important.
Italy	Serious eutrophication problem affecting lakes, rivers and reservoirs. Discharges to the Adriatic Sea cause acute problems.
Luxembourg	Significant eutrophication.
Netherlands	Widespread eutrophication in most surface water bodies.
Portugal	Eutrophication rarely a problem.
Spain	Eutrophication is localised, but an increasing problem.
Sweden	Eutrophication localised in the south, but generally of decreasing significance.
United Kingdom	Eutrophication localised, but of high significance in a number of rivers, canals, lakes and reservoirs.

*Extent of eutrophication in EU Member States.*

the monitoring stations reported mean total phosphorus concentrations below 50 mgP/l. Table 1.1 provides a brief summary of the types of problems found in different EU Member States. It can be seen that in some cases eutrophication problems are widespread, in other cases localised. This is reflected in the choice of approach in different Member States to the designation of sensitive areas (areas where a reduction in nutrient discharges is required) under the 1991 urban waste water treatment Directive, the principle EU legislative initiative to, *inter alia*, reduce impacts of eutrophication (see chapter 2).

Phosphates in surface waters can sometimes be of natural origin (bedrock), but are often the result of soil erosion, agricultural run-off and discharges of municipal and industrial waste waters. Sewage contains phosphates from human sources (about 2g P/person/day), detergents, food waste, food additives and other products.

There are marked trends in phosphate concentrations in surface fresh waters across Europe (EEA, 1994, EEA, 1998). The lowest concentrations of phosphate are found in the streams and rivers of the Nordic countries. Here 91% of the monitoring stations report mean concentrations below 30 mgP/l and 50% below 4 mgP/l. This pattern results from a generally very low human population and the presence of a slow-weathering and nutrient-poor bedrock. Higher phosphorus concentrations are found in a band stretching across central Europe, from southern England to Romania. While some monitoring sites in southern Europe also report high phosphate levels, the general pattern is for lower concentrations than central and eastern Europe, often because much of the waste water produced is discharged directly to the sea.

A similar pattern of phosphate levels in lakes can also be found, with low concentrations in the Nordic and Alpine regions. However, in many parts of Europe lakes can be severely affected by phosphate eutrophication. This can be a particularly difficult problem to address as phosphates may accumulate in lake sediments. Even when the phosphate pollution source is controlled these accumulated phosphates may be released (eg by climatic events or the action of fish) into the water column and maintain a eutrophic condition. Overcoming this problem requires expensive manipulation of the sediments and lake biota.

Phosphate levels have shown a general decline across Europe between 1987 and 1996. This trend occurs for annual average concentrations for both total and dissolved phosphorus, but it appears that high peak concentrations still occur even where improvements are being made. Improvements have been found in most regions and much of this is due to increased treatment of urban and industrial waste water and some decline in agricultural fertiliser use.

There has also been an improvement in lake water phosphate concentrations, although many lakes are still seriously affected.

Phosphate concentrations in the marine environment are more variable. However, high levels are found in the North Sea, Mediterranean, Baltic and Black Seas. Phosphate discharges have continued to increase in, for example, the North Sea, and, in other areas have largely remained stable.

## 1.2 SOURCES OF PHOSPHATE

Phosphate pollution arises from a number of sources (Table 1.2). Point sources (eg from waste water treatment plants, industry and some agricultural) account for more than half of the phosphates discharged in Europe. The principle sources of phosphate in municipal waste water coming from human waste and, in some countries, from the use of detergents.

Emissions of phosphates from sewage into surface waters, across Europe, have typically fallen by about 30-60% since the mid-1980s (EEA, 1998). However, this decline has varied considerably across the continent. For example, declines in emissions from the Netherlands and Denmark have been of the order of 70-90%, largely as a result of highly improved waste water treatment.

Table 1.2 indicates the main phosphorus sources in each EU Member State. The data are based partly on phosphate input information (eg on detergents) and partly on *de-novo* calculations. The calculation for human phosphate production assumes that each person in the EU produces 0.7 kgP each year and that 50% of this is available. It is important to note, therefore, that it provides data on the generation of phosphate waste from each sector, not discharge, ie it does not take account of the degree of phosphate treatment of waste water once produced (except possibly for a generalised average removal rate of 50%). The relative importance of each sector to *in situ* eutrophication will depend on waste water treatment and other pollution control measures.

The amount of phosphate discharged from waste water treatment plants has been declining for two reasons:

1. There has been a steady decline in the quantity of phosphate produced by each person in many EU Member States, leading to a reduction in the concentration of phosphate in the receiving waters of treatment plants. This has largely been due to a reduction in the use of phosphates in detergents. For example, in Denmark the production of phosphate in the 1980s was about 1.2-1.6 kg/year pe, while in the 1990s this has declined to about 1.0 kg/year pe.

2. There has been an increase in the number of waste water treatment plants providing some form of phosphorus removal. Some of this is the result of increased secondary treatment, which removes some phosphate, while in many instances high rates of phosphate removal occur.

Overall in the 1980s typical average values for phosphorus discharges were about 0.7-0.8 kgP/year pe, while at present they are around 0.05-0.2 kgP/year pe in those Member States with high levels of phosphorus removal. Table 1.3 provides an example of this trend from Denmark. However, given problems in calculating the contribution of different sources of phosphate input, most recent figures from the European Environment Agency (unpublished, 1998) still estimate an overall discharge from waste water treatment (human, detergent and industry) of 208-227,000 tonnes per year from the EU (excluding Austria, Belgium, Denmark, Ireland and Sweden). Data from Morse *et al* (1993) above suggest that these sources would contribute around 200,000 tonnes per year. It is evident that clearer summary information is required, specifically indicating how such data are obtained and calculated.

### 1.3 POLICIES TO CONTROL PHOSPHATE POLLUTION

Policies (legislation, conventions, etc) to control phosphate pollution or eutrophication more generally can be found at many levels in Europe. Of most interest in this study are those at the EU and national level. Principally these include the urban waste water treatment Directive and national programmes to implement this. It is also worth stressing that there is also a significant role for local policy initiatives in some cases. This may include formal im-



Photo: Chevalier/F38300 Bourgoin

plementation in federal states such as Germany. However, general eutrophication strategies are often developed at a catchment or river basin level (eg in France or the UK) taking account of different pollutant sources (eg waste water and agriculture) and seek local solutions albeit within a national policy framework. Again examples of these will be considered in the Member State specific chapters.

Finally, there are also the impacts of international agreements or conventions. These are important in taking a broader view than is currently undertaken within EU legislation and some can be briefly summarised here.

### 1.4 INTERNATIONAL CONVENTIONS

It is important to note that some pressure for action on the discharge of pollutants to surface waters comes also from international conventions to protect marine environments. These include:

- The Helsinki Convention (HELCOM) to protect the Baltic Sea.
- The Paris and Oslo Conventions (OSPAR) to protect the North Sea and Atlantic.
- The Barcelona Convention to protect the Mediterranean Sea.

Much of the action required under these conventions has focused on the reduction in emissions of dangerous substances (from industrial and urban waste water). However, there has also been agreement for action in relation to the discharge of nutrients (both nitrogen and phosphorus). It is not possible here to examine all of the developments in detail, but some key points can be illustrated by examination of HELCOM and OSPAR.



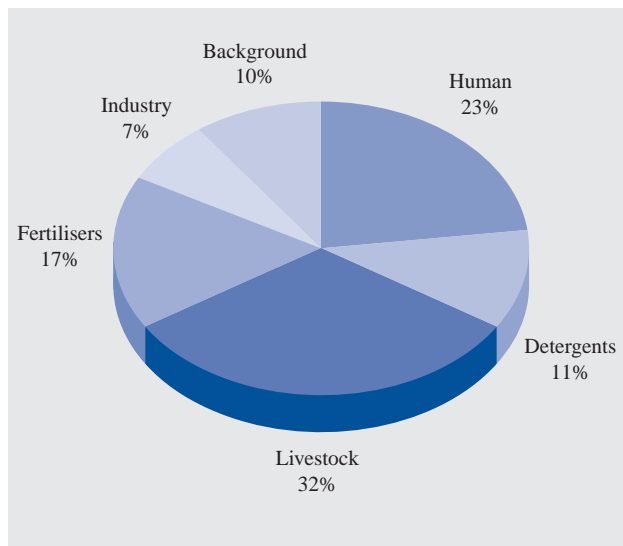
Photo: Thornton/CEEP

*Agriculture is the source of around 50% of phosphorus input to surface waters (see table 1.2), particularly inadequately stored and treated animal wastes from intensive livestock production and runoff resulting from soil erosion or inappropriate fertiliser use.*

TABLE 1.2

MEMBER STATE	HUMAN	DETERGENTS	LIVESTOCK	FERTILISERS	INDUSTRY	BACKGROUND	TOTAL (t/A)
Austria	20	10	36	16	6	12	13
Belgium	26	11	43	7	8	5	13
Denmark	12	11	55	11	5	6	15
Finland	18	9	17	15	3	38	9
France	18	15	31	19	6	11	106
Germany	28	3	44	12	6	7	97
Greece	21	7	18	34	5	15	17
Ireland	9	7	49	24	2	9	15
Italy	35	2	26	18	8	11	56
Netherlands	23	3	57	9	5	3	24
Portugal	24	14	27	16	7	12	15
Spain	19	16	18	26	7	14	72
Sweden	21	10	15	14	7	33	14
UK	24	19	29	14	8	6	82
<b>EU total</b> <i>(excluding Luxembourg)</i>	<b>23</b>	<b>11</b>	<b>32</b>	<b>17</b>	<b>7</b>	<b>10</b>	<b>548</b>

Phosphate sources in Europe in 1992 (percentage from each source and total) (source Morse et al, 1993).



#### 1.4.1 HELCOM

This Convention has probably focused more on the effects of nutrients than other Conventions. In particular it is clear that eutrophication in the Baltic Sea is driven by discharges of both nitrogen and phosphorus and action is needed to reduce both in order to reduce the problem. However, the recent huge improvement in phosphate removal from discharges in Sweden has begun to highlight nitrogen reduction as a leading priority. The Baltic Sea is also interesting in that the countries bordering its shores are characterised by two contrasting groups:

- EU Member States that have taken extensive action to reduce nutrient, including phosphorus emissions from urban waste water discharges, eg Sweden.
- Eastern European Countries which have very poor levels of waste water treatment, especially in relation to phosphate removal, eg Poland.

TABLE 1.3

	1984	1989	1990	1991	1992	1993	1994	1995
Concentration (kgP/year pe)	0.67	0.48	0.43	0.30	0.26	0.19	0.19	0.14

Concentration of phosphorus in outflow water from waste water treatment plants in Denmark 1984-1995. (Danish Environmental Protection Agency, 1995; EEA, unpublished)

It is also important to note that much improvement is taking place due to a decline in the use of fertilisers by agriculture. This is largely due to the collapse of intensive collective agriculture since the end of the Communist governments and its subsequent poor performance as an economic sector. In Estonia, for example, the use of phosphorus-based fertilisers fell from 60,000 tonnes to 10,000 tonnes per year between 1988 and 1994.

#### 1.4.2 OSPAR

OSPAR has also focused on the need to reduce discharges of pollutants to marine waters. This includes actions to reduce nutrient inputs, both nitrogen and phosphorus, eg for an overall input of all pollutants by 50% between 1990 and 1995, which was achieved in some cases, though not for phosphates. Eutrophication areas were identified on the coasts of Belgium, Denmark, Germany, France, the Netherlands, Norway and Sweden. Although the UK also identified three estuaries, these have undergone further studies and the problem, where accepted, is considered to result from nitrogen pollution.

Action to reduce nutrient inputs has focused on discharges to those eutrophication areas identified, ie from the states listed above and from Switzerland which discharges upstream on the Rhine. The UK argues that no action beyond that in the urban waste water treatment Directive is required because it does not consider that its discharges affect eutrophication on the eastern side of the North Sea. Action is identified in five areas for phosphate emissions:

- Municipal waste water treatment
- Detergents
- Agriculture
- Fish farming
- Industry

#### 1.4.3 Phosphate discharges

The particular action taken by different countries is outlined in other sections of this review. However, it can be seen from Table 1.4 and Table 1.5 that action of discharge of phosphates to marine areas under these two conventions has limited success and that mostly in the Baltic Sea. The apparent increase in discharges from Sweden is largely a problem of earlier reporting of riverine inputs in 1991. Significant increases from the Netherlands is probably largely agricultural. It is uncertain what the future impact of the urban waste water treatment Directive will be. This is because only proportions of some countries (eg Germany and France) discharge to the North Sea and nutrient removal is (and will remain) limited in a number of countries (eg Portugal, Spain and the UK). Given also the fact that the most important source is agricultural, the potential impact of the Directive may be limited.

TABLE 1.4

COUNTRY	1991	1995
Belgium*	2.0	4.0/5.0
Belgian Coast	2.0	1.8
Denmark	2.3	2.0
France	No data	No data
Germany	11.6	11.5
Ireland	6.3	7.3
Netherlands	17.0	34.1
Norway	3.3	3.9
Portugal	3.1	3.1
Sweden	0.2	1.3
United Kingdom*	39/40	36

*Annual discharges of total phosphorus (1000 tonnes/year) to the North Sea and north-east Atlantic Ocean. Source EEA (1998).*

\* (low/high estimate)

TABLE 1.5

COUNTRY	1990	1995
Denmark	5.3	2.3
Estonia	2.8	1.3
Finland	3.4	3.6
Germany	1.2	0.6
Latvia	3.2	2.2
Lithuania	1.7	1.4
Poland	15.0	14.2
Russia	9.5	7.1
Sweden	4.0	4.7

*Annual discharges of total phosphorus (1000 tonnes/year) to the Baltic Sea. Source EEA (1998).*

## 1.5 TREATMENT PROCESSES TO REMOVE PHOSPHATES FROM WASTE WATER

Two basic types of process are available to remove phosphates from waste water. These are chemical and biological treatment (Horan *et al.*, 1994; Brett *et al.*, 1997).

*Chemical* phosphate removal involves the stripping of phosphate by the addition of metal salts, of which the metal phosphate is insoluble. Common salts used include aluminium or iron chloride or sulphate, and in some cases calcium hydroxide (lime). The phosphate present precipitates as iron or aluminium phosphate. Not all phosphate present in waste water is present as soluble orthophosphate (and so able to react with the added salts). However, the organic phosphate that may be present may also be adsorbed onto the precipitate and thus enhance phosphate removal. The precipitate can be removed by mechanical methods.

*Biological* phosphate removal involves the removal of phosphates by the action of bacteria. The bacteria use the energy contained in the organic matter contained in waste water (or also sometimes, where necessary, with added organic substrate) to incorporate the phosphate into their own biomass.

It is beyond the scope of this review to examine the details of each type of process, with their particular advantages and disadvantages. However, it is important to summarise a number of key points about each process type as these may affect the possible adoption of particular systems by countries or individual companies required to reduce phosphate discharges and the costs of these options.

Key points relating to chemical phosphate removal include:

- The process may operate at any phosphate concentration and at any temperature. It is not, therefore, too dependent on the quality of the waste water received or the climate.
- The chemical reactions can remove phosphate down to very low concentrations, sufficient to meet the most stringent regulatory discharge limits.
- Chemical phosphate removal can result in the production of significant additional volumes of sewage sludge due to the quantities of precipitate produced. This may be a disadvantage if sludge disposal is a problem.
- Chemical treatment systems do increase the quantities of chloride or sulphate discharged into the receiving waters and these may change their quality. The implications of this depend on the character of the receiving waters and its undesirability is open to significant debate.
- The investment costs of chemical treatment plants are lower than biological treatment plants, but the annual

running costs are significantly higher. The implications for choice of installation depends, therefore, on the particular short or long-term financial strategy of the private or public operator involved.

Key points relating to biological phosphate removal include:

- The efficiency of phosphate removal increases with increasing phosphate concentration and is better when waste water contains at least 5-10 mg/l. This is important where waste water may be regularly or occasionally diluted (eg with rain water in combined sewer systems) or where domestic waste water may have lower phosphate concentrations (eg where phosphates in detergents have been reduced or prohibited).
- The activity of the bacteria requires the presence of readily assimilable organic molecules for the biological phosphate removal process. This means that the COD/P ratio should be at least 35 or the BOD/P ratio is above 20. Where organic matter concentrations are low, or the proportion of appropriate molecules (short chain fatty acids) is insufficient, organic substrates may be added as part of the treatment process (eg acetone, methanol, biological fermentation liquors).
- It is usually very difficult to meet some of the strictest phosphate discharge consent levels found in the EU, eg 1 mg/l, as biological treatment often only removes between 40 and 70% of the phosphate present (or exceptionally 80-85%). Where severe restrictions exist biological treatment has to be combined with an additional chemical precipitation.
- The activity of the bacteria is temperature dependent. The optimum temperature is 30°C, but it can operate down to 5°C. If removal of phosphates can be seasonal (eg to prevent spring and summer algal blooms in rivers) then reduction or even cessation of activity in winter may not be a problem. However, if continuous removal is necessary (eg to prevent phosphate build-up in sediments) biological removal may prove ineffective in cold climates.
- Biological treatment systems are able to be installed more readily in smaller treatment works.

Table 1.6 summarises the relative phosphate removal efficiencies of different stages and options in waste water treatment. Both biological and chemical processes produce sludge. In pure biological removal the sludge is formed by accumulation of cellular polyphosphates, producing around 3.4 kg of suspended solids per kilogramme of phosphorus. Chemical processes produce a precipitate of phosphate with iron (or other added cation) producing around 5-7 kg of suspended solids per kilogramme of phosphorus. Combined processes varying in their relative contribution of different sludge types and quantities depending on the details of operation.

TABLE 1.6

TREATMENT OPTION	PHOSPHATE REMOVAL
Primary	5-10% (P removed is that combined to organic particulates)
Secondary	20-40% (Due to bacterial metabolic action)
Tertiary: biological	40-85% (Heavily dependent on a range of conditions)
Tertiary: chemical	95% (or more) (Degree of removal dependent on quantity of salts added to reach a desired endpoint)

*Phosphate removal rates for different waste water treatment options.*

A further method of waste water removal is the septic tank. The use of septic tanks varies across Europe, but is particular common in remote or rural areas where the costs of connection to sewerage collection systems are too high to be practical. Septic tanks are of various designs and may allow more or less significant ingress of phosphates into the soil. Provided this is not close to water courses, the phosphate released is usually trapped onto the soil particles.

It is also important to note that the construction of artificial reed beds is becoming more widespread in Europe as a means to treat waste water. The use of the common reed takes advantage of a number of characters of such beds. They actively aerate the sediment, which aids in nitrogen removal by the nitrification of ammonia. The sediments also act as a filter for ammonia. The usually high iron content also helps to remove phosphate. A recent survey (Haycock, 1996) of the efficiency of 285 European reed-beds for pollution control has shown that while they are good at controlling organic pollution, they are more variable at the removal of phosphate (average reduction of 65%). The survey found that the ability of reed-beds to remove phosphate was a function of the way that they are constructed. Reed-beds only begin to control nutrients after the biological oxygen demand has been reduced significantly, but this requires reed-beds of a large size. For good phosphate removal a reed-bed may need to be about six times the size of one required to control BOD alone. Many such reed-beds are recent constructions and it is uncertain how they will perform over many years, as their efficiency declines. It is evident, therefore, that reed-beds are not an option for treatment of large quantities of discharge (for phosphate removal the area of reed-bed required to treat waste water from one person is about 20-30 m<sup>2</sup>) and they do not meet the high rates of removal required by the urban waste water treatment Directive.



*Biological phosphorus removal is achieved by subjecting sewage sludge micro-organisms to a controlled series of anoxic/anaerobic and aerobic phases in specifically engineered tanks. The process is often combined with biological denitrification. 70 - 80% removal of phosphorus can generally be achieved, but some modern installations reliably achieve 90% removal or better. Biological phosphorus removal and denitrification at Hofkirchen sewage works, Austria (Phostrip process).*

Photo: Posch and Partners Consulting Engineers, Innsbruck, Austria.



*Chemical phosphorus removal is achieved by adding precipitation chemicals, usually iron or aluminium salts. Near 100% of phosphorus in sewage can be removed. Installations for storing and dosing chemicals for phosphorus precipitation, Darmstadt sewage works, Germany.*

Photo: Posch and Partners Consulting Engineers, Innsbruck, Austria.

However, for small sources they may be a valuable additional tool to reduce the overall phosphate load to surface waters, along with having the additional benefit of providing some useful wildlife habitat.

## 1.6 CURRENT USE OF CHEMICAL AND BIOLOGICAL PHOSPHATE REMOVAL SYSTEMS TO TREAT WASTE WATER IN SELECTED EU COUNTRIES

Chemical removal systems have been in existence in Europe for many years longer than biological systems and this certainly affects the current distribution of systems adopted in the EU, ie in those countries that took action to remove phosphates at an early stage. The current situation in a selection of Member States is as follows:

### Denmark

Denmark requires very strict phosphate discharge limits and has low concentrations of phosphate in receiving waters. Older plants are based on chemical treatment. However, in recent years there has been a greater concentration on biological systems, usually with combined chemical precipitation.

### France

France has adopted the use of both simple biological (very rarely enhanced biological) and chemical removal systems. However, they are limited in number (see chapter 5). It is important to note that many of the biological systems operate at low efficiency. In 1997 only 11% of the 210 treatment plants studied had an efficiency of 80% removal or more. Another important particularity in France is that many waste water treatment works are small, 85% serving agglomerations of 5,000 pe or less.

### Germany

Germany has about 900 treatment plants with phosphate removal. Only about 13% of these involve biological treatment. This is partly because of some very strict discharge limits and some areas with older plants. However, future systems may favour a higher proportion of biological removal.

### Italy

Phosphate removal is not widespread in Italy currently, but almost all existing plants are based on chemical treatment systems.

### The Netherlands

The Netherlands is similar to Denmark in its strict limits and early reliance on chemical treatment and recent developments in biological systems

### Sweden

Sweden has very strict phosphate discharge limits and it was an early country to require extensive phosphate

removal. Thus most systems are chemical treatment plants and those with biological systems have combined chemical treatment.

### United Kingdom

Until the advent of the urban waste water treatment Directive, the UK had installed very few phosphate removal processes. By 1997 23 removal systems were operating, only 3 based on biological treatment. By the end of 1999 this will have increased to 50, all new systems being chemical. While the receiving waste water has sufficiently high phosphate concentrations to operate biological removal, the BOD levels are often lower than required for efficient operation.

## 1.7 CONCLUSIONS

There has been a decline recently in the quantities of phosphate discharges (both point and diffuse sources) to the surface waters of Europe. However, phosphate concentrations in surface waters are still, across much of Europe, very much higher than would be the case without human influence and chronic and severe eutrophication problems continue to occur.

Sources of phosphate pollution vary considerably in different European countries. They principally include agriculture, human and food wastes, detergents and industry. In some cases one source may predominate and in others combinations of sources are significant. It is important to note that discharges from each of these sources is changing rapidly, both spatially and over time. Any analysis of policy responses does, therefore, have to take this into account in seeking to identify cost-effective solutions to eutrophication problems and that variable policy responses are needed to ensure that the most effective action is taken in the most appropriate location.

Policy responses exist in a number of frameworks, at local, national, EU and international level. Each has an important role to play, as will be explored later in this study.

There are a variety of methods available to reduce phosphate concentrations in waste water prior to discharge. The type of method chosen depends on a range of factors including:

- cost
- practicalities of location
- type of sewage collection systems
- size
- relationship to the eutrophication problem
- national experience
- climate
- policy requirements (national or EU).

Finally, general EU policy is itself still developing, both in relation to central and eastern Europe and towards a more holistic, catchment-based approach to pollution control.

## 2. THE EU URBAN WASTE WATER TREATMENT DIRECTIVE AND ITS IMPLEMENTATION IN MEMBER STATES

### 2.1 INTRODUCTION

Eight years ago Directive 91/271/EEC on the treatment of urban waste water was adopted. The Directive sets a number of emission standards for urban waste water discharge and requires the step-wise introduction of comprehensive treatment facilities.

This analysis is based on all reports of Member States which have so far been submitted to the Commission according to the provisions of Article 17 of the Directive<sup>2</sup> and the implementation report published by the European Commission in December 1998. These reports are mostly based on data from 31 December 1992. Therefore, an effort was made to contact all competent authorities of the Member States to up-date the information and discuss special questions of interest. Specific details relating to some individual Member States are contained in subsequent chapters.

### 2.2 SITUATION OF SEWAGE TREATMENT IN EUROPE PRIOR TO THE DIRECTIVE

In this section the situation of sewage treatment in the European Community during the 1980s is outlined. This information serves as a baseline against which the success of the urban waste water treatment Directive can be measured.

At the end of the 1980s the provisions for collection and treatment facilities within Europe were, and continue to be, very unequal (Table 2.1). While in the former West Germany 84 % of the total treatment capacity was tertiary, in Portugal most of the waste water (about 89 %) discharged was untreated. The situation in Belgium resembled the situation in Portugal - about 70 % of the sewage reached the receiving waters untreated. In the UK, while almost all sewage was subject to treatment (84 %), waste water discharged into the sea received no proper treatment at all and sewage sludge was dumped at sea.

The data presented in Table 2.1 should be interpreted with care. The data are drawn from different information sources (IKSR, WHO, EC) and data do not exist for all the Member States. Nevertheless, the table indicates vast differences in treatment standards among the Member States. A study undertaken for the Community also highlighted the need for regulating sewage treatment. In 1984, only 45 % of the total organic load was undergoing any treatment (COM(89) 518 final).

Hence, in 1989 the European Commission proposed a Directive on the treatment of urban waste water. The intention of this Directive was to establish a comparable standard and to guarantee a high level of treatment for the whole territory of the European Community.

TABLE 2.1

	TOTAL CONNECTION RATE: SEWERAGE AND TREATMENT IN SEWERAGE WORKS	MECHANICAL TREATMENT ONLY
Belgium	no data	no data
Denmark	98%	8%
Germany	90%	2%
Greece	no data	1% (1985)
Spain	29% (1985)	13% (1985)
France	50%	no data
Ireland	no data	no data
Italy	60%	no data
Luxembourg	91%	14% (1985)
The Netherlands	89%	7%
Portugal	11%	4%
Great Britain	84%	6%

*Urban Waste Water Treatment in EU Member States (in 1987). Source: Dörr (1998).*

<sup>2</sup> By Mid 1998 ten Member States had submitted reports: Denmark, Germany, France, United Kingdom, Ireland, the Netherlands, Austria, Sweden, Spain and Portugal.

### 2.3 THE EU DIRECTIVE ON URBAN WASTE WATER TREATMENT (91/271)

The principle measure taken to control, *inter alia*, phosphate pollution from urban waste water has been the 1991 urban waste water treatment Directive. This has set significant requirements for a range of issues relating to waste water treatment across the EU (NRA, 1995) and because of the costs of compliance is one of the more difficult elements of EU environmental legislation for central and eastern European countries to comply with in preparation for EU accession (see chapter 7). Some Member States do undertake measures additional to the requirements of the Directive and these will be considered in the following chapters.

The purpose of the Directive is to stimulate the Member States to invest in the collection and treatment of urban waste water. Different requirements and deadlines apply to the different areas of discharge ('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 and percentage reduction goals and a choice between reducing phosphorus and nitrogen discharges.

### 2.4 FORMAL AND TECHNICAL COMPLIANCE REQUIREMENTS

Particular for the Directive is the strict timetable for fulfilling the formal and technical obligations. The formal compliance date of 30 June 1993, until when Member States had to transpose the Directive into national laws, regulations and administrative provisions, was, in fact, hardly met by any Member State.

The last deadline for the technical compliance is to be met by the year 2005. According to the type of area and size of agglomeration, the Directive sets minimum standards for the collection, treatment and discharge of urban waste water.

Table 2.2 supplies an overview of these requirements and the respective deadlines. The data in the cells refer to the size of the agglomeration (stated as sewage load in population equivalents (p.e.)) and the type of area (less sensitive, normal and sensitive areas).

Urban waste water that is collected is to be subject to treatment, which generally becomes more stringent the larger the agglomeration. The treatment levels required also depend on whether the receiving waters are coastal, estuarine or freshwater and whether discharges are to sensitive, normal or less sensitive areas. In general, agglomerations with a population equivalent (p.e.) greater than 2,000 p.e. are to be subject to a minimum of secondary treatment (biological treatment with a secondary settlement). For agglomerations greater than 15,000 p.e. secondary treatment must be in operation by 31 December 2000, while the deadline for smaller towns is in general five years later. All agglomerations greater than 10,000 p.e. discharging into sensitive areas required more stringent (tertiary) treatment (ie nutrient removal) by the end of 1998.

All agglomerations with a population equivalent (p.e.) greater than 2,000 are obliged to have collection systems by the end of either the year 1998, 2000 or 2005, depending on their size and the type of area they are discharging to (Article 3).

### 2.5 THE DESIGNATION OF AREAS

In Article 5 and 6 of the Directive the Member States are asked to designate 'sensitive' (Article 5) and 'less sensitive' (Article 6) areas according to Annex II A and B. An area is to be classified sensitive, in which case 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' (as defined by the list of criteria in the Annex);

TABLE 2.2

	12/1998	12/2000	12/2005
sewerage collection	> 10,000 p.e. in sensitive areas	> 10,000 p.e. in normal and less sensitive areas	> 2,000 p.e. in all areas
primary or secondary treatment		> 15,000 p.e. in less sensitive areas <sup>1</sup>	>10,000p.e. in less sensitive areas <sup>1</sup>
secondary treatment		> 15,000 p.e. in normal areas	> 2,000 p.e. in normal and sensitive areas <sup>2</sup>
more advanced treatment	> 10,000 p.e. in sensitive areas		

if the sewerage is collected in agglomerations < 2,000 p.e., appropriate treatment should be applied

*Technical Compliance Deadlines for Collection and Treatment Requirements from Directive 91/271*

- or if the water is used for drinking water abstraction;
- or if the water requires a more stringent than a secondary treatment in order to meet other EU Directives.

A Member State has the possibility to designate its entire territory as a sensitive area under Article 5 para.8. In areas, where sewage is discharged into the sea, without any adverse effects on the environment, coastal and estuarial waters may be designated to be less sensitive. Here, standards for treatment are lower. A minimum of primary treatment (a physical and/or chemical process involving the settlement of suspended organic solids which produces a specified reduction in biological oxygen demand (BOD) is required. For such ‘less sensitive areas’ secondary treatment is not required for agglomerations smaller than 150,000 p.e. discharging into coastal waters and for agglomerations between 2,000 and 10,000 p.e. that discharge into estuaries.

## 2.6 REQUIREMENTS FOR MORE ADVANCED TREATMENT

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 population equivalents.

Article 5 para.2 states that:

“[...] urban waste water entering collection systems shall before discharge into sensitive areas be subject to more stringent treatment than that described in Article 4 [...]”

Member States are basically free to choose among five approaches of how to apply “more stringent treatment” in sensitive areas (i.e. how to remove nutrients): four options according to Article 5 para.3 and one option according to

Article 5 para.4. These options comprise of phosphorus reductions, nitrogen removal or a combination of both.

The four options according to Article 5 para.3 are listed in Annex I, table 2 of the Directive. If one chooses option 1 or 2, the effluent of the treatment plants in sensitive areas must meet emission limit values for either phosphorus (P) or nitrogen (N). The limit values for P are 2 mg/l in agglomerations of between 10,000 and 100,000 population equivalents and 1 mg/l in larger agglomerations (measured as P). The limit values for N are 15 mg/l for agglomerations of between 10,000 and 100,000 population equivalents and 10 mg/l in larger agglomerations (measured as N). Alternatively to the use of limit values, phosphorus may be reduced by 80 % or nitrogen by 70 - 80% (options 3 and 4). The following Table 2.3 summarises this information.

The 5th option is based on Article 5 para.4 of the Directive that states that the above requirements need not apply in sensitive areas for which it can be shown that the minimum percentage of reduction of the overall load entering all urban waste water treatment plants in that area is at least 75 % for total phosphorus and total nitrogen. With the wording ‘overall load entering all urban waste water treatments plants in that area’, this Article clearly opens the possibility for emissions trading within an ‘emissions bubble’<sup>3</sup>. However, it also could establish restrictions. Notably, the ‘bubble area’ must be a ‘sensitive area’ within the definitions of the Directive, the reduction must be achieved over all urban waste water treatment plants and not only in the larger installations, and the reduction probably must be attained for both phosphorus and nitrogen simultaneously. The weight of these restrictions is not clear but unlikely to present serious obstacles to a pragmatic implementation of an emissions trading regime.

<sup>3</sup> ‘Bubble’ usually refers to the total amount of emission that is allowed within a specific area. The competent authorities are free to choose how the reduction goal is met - it is only of importance that the reduction goal is met in total. In the context of the Urban Waste Water Treatment Directive this means for example, to reach a reduction goal of 50 % one treatment facility may eliminate all emissions whereas another facility does not reduce its emissions at all. “Emission trading” therefore may occur in the sense, that treatment facilities negotiate their respective reduction targets among each other. Facilities with low standards are thereby enabled to buy emission rights from facilities which overcomply with the Directive.

PARAMETERS	CONCENTRATION	MINIMUM PERCENTAGE OF REDUCTION <sup>1</sup>
Total Phosphorus	<p><b>Option 1</b> 2 mg/l P (10,000 - 100,000 p.e) 1 mg/l P (more than 100,000 p.e)</p>	<p><b>Option 3</b> 80%</p>
Total Nitrogen	<p><b>Option 2</b> 15 mg/l N (10,000 - 100,000 p.e) 10 mg/l N (more than 100,000 p.e)</p>	<p><b>Option 4</b> 70-80%</p>

Requirements for Discharge from Urban Waste Water Treatment Plants to Sensitive Areas. Source: Council Directive 91/271/EEC concerning Urban Waste Water Treatment. Annex I, table 2.

<sup>1</sup> Reduction in relation to the load of influent.

None of the EC Member States so far appear to have used the possibility of establishing emissions trading in sensitive area bubbles, and it does not appear to have been discussed among the national experts in the Technical Committee established by the Directive. The general lack of interest may be regrettable as a potentially important source of economies in pollution abatement costs remains untapped, in spite of the wide-spread concerns about the financial implications of the Directive.

Some Member States like the Netherlands and Luxembourg make use of the provision of Article 5 para 4. These Member States regard their whole territory as a sensitive area. However, to our knowledge, no trading of emission rights has occurred among the different treatment facilities. This might be due to the ownership structure of the waste water treatment plants in these countries.

## 2.7 ADDITIONAL PROVISIONS

According to Article 14, sewage sludge should be reused if possible and resulting effects on the environment should be limited to a minimum. The disposal of sludge is to be subject to general rules, registration or authorisation by 31 December 1998. The same deadline applies for the ending of dumping of sewage sludge from municipal sewage treatment at sea or other surface waters.

The Member States are obliged to publish situation reports every two years on the disposal of urban waste water and sludge and send them to the Commission (Article 16). According to the European Commission no Member States has yet submitted such a situation report. Likewise, programmes for the implementation of the Directive according to a 'format', set out in the Council Decision 93/481 (OJ L 226, 7.9.1993), had to be submitted to the Commission by 30 January 1994 (Article 17). The implementation programmes consist of a set of tables including information on the state of sewage collection and treatment at the end of 1992 and scheduled plans for the implementation of the requirements set by the Directive. By mid 1998 only ten Member States had submitted their implementation programmes to the Commission.

Emission limit values and minimum percentage reductions that systems of secondary and tertiary treatment must meet, as well as the reference methods for monitoring and evaluating the results, are set out in Annex I of the Directive. It also sets emission limits for nitrogen and phosphorus discharges from treatment plants to designated sensitive areas.

Those smaller towns or villages which are not obliged by the Directive to install secondary treatment systems are nevertheless required to provide 'appropriate' treatment, sufficient to ensure compliance with quality objectives or the requirements of other relevant Community legislation.

Derogations and exceptions to these general rules are possible when the installation of sewerage systems involves 'excessive costs' and alternative systems giving the same degree of environmental protection can be used. Under Article 8, Member States may apply to the Commission for derogations from the requirement to install secondary treatment for larger towns over 150,000 p.e., if it can be justified on the basis of technical reasons and be for a geographically-defined population. The compliance deadline can then be postponed to the end of 2005.

Article 11 regulates industrial waste water that is discharged into municipal collection systems and treatment plants. Such discharges are to be subject to prior regulation and/or authorisation and subject to pre-treatment until 31 December 1993. Conditions to be met by the waste water are specified in Annex I(c). These include health security for the personnel working in the sewerage services, the protection of sewerage installations from corrosive substances and the provision that the resulting sludge can be disposed safely in an environmentally acceptable manner. Bio-degradable industrial waste water from specified sectors of the food and beverage industry listed in Annex III, which is not discharged into municipal treatment plants is also to be subject to prior regulation/authorisation by 31 December 2000 (Article 13).

A Committee of representatives of Member States and the Commission is established to consider future changes in the standards set in the Directive.

## 2.8 IMPLEMENTATION OF THE URBAN WASTE WATER TREATMENT DIRECTIVE

### 2.8.1 Level of Implementation

The following information is based on the national implementation programs which had to be submitted by the Member States according to the Commission Decision 93/481/EEC and with the data contained in the Commission's own 1998 implementation report. 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. Data on sewage collection and treatment are collected differently in the Member States. The discussion about the comparability of data on urban waste water remains quite controversial (for a thorough discussion compare EWPCA 1995).

The Directive uses a number of colloquial expressions like "agglomeration", "heavy rain" or "unusual situation". These terms are not adequately defined, which makes it difficult to apply the provisions of the Directive consistently in all Member States.

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TABLE 2.4

(g/DAY)	A	DK	F	D	GR	IRL	I	L	P	E	NL	UK
BOD <sub>5</sub>	60	60	57	60	50-60	60	54-60	60	54- 60	60	54	60
N	12	-	15	11	10-14	-	12	11	-	-	-	-
P	2	-	4	2,5	2-2,5	-	2-3	2,5	-			

Definitions of Populations Equivalents (p.e.) in Member States. Source: Jacobsen et al. (1997).

TABLE 2.5

MEMBER STATE	TRANSPOSITION	DESIGNATION OF SENSITIVE AREAS	IMPLEMENTATION PROGRAMME REPORT
Austria	Not in conformity	Yes (none)	Yes
Belgium	Yes	Yes	Not in conformity
Denmark	Yes	Yes (Article 5.8)	Yes
Finland	Yes	Yes (Article 5.8)	Yes
France	Yes	Yes	Yes
Germany	Yes	Yes	Yes
Greece	Not in conformity	No	Yes
Ireland	Yes	Yes	Yes
Italy	No	No	No
Luxembourg	Yes	Yes (Article 5.8)	Yes
Netherlands	Yes	Yes (Article 5.8)	Yes
Portugal	Yes	Yes	Yes
Spain	Yes	Yes	Yes
Sweden	Yes	Yes (Article 5.8)	Yes
United Kingdom	Yes	Yes	Yes

Implementation of the urban waste water treatment Directive in Member States according to requirements relevant to nutrient control and its reporting according to the European Commission (COM(98)775).

TABLE 2.6

	CATEGORY I	CATEGORY II	CATEGORY III
Areas of Discharge	only sensitive areas	sensitive/normal areas	sensitive, normal and less sensitive areas
Member States	Denmark The Netherlands Sweden Ireland	Austria <sup>1</sup> France Germany	Portugal United Kingdom Spain

Overview of the different Areas of Discharge in the Member States

1 The whole territory of Austria is treated as normal area

Additionally, in cases where the Directive requires the use of certain parameters, Member States still apply different criteria as in the case of the BOD parameter. According to the Directive, one population equivalent (1 pe) should be measured as biological oxygen demand of 60 g per day. In most cases it cannot be determined which definitions are applied in the national implementation reports. Nevertheless, Table 2.4 presents the variety of definitions of population equivalent used in the Member States. However, these are very similar, except for the somewhat higher phosphate definition in France.

According to the 1998 implementation report of the Directive, most Member States have undertaken the basic legal requirements which would lead to regulatory action to remove phosphate from urban waste water discharges where necessary (Table 2.5). However, legal transposition is lacking or is incomplete in some cases, particular Italy, and Greece and neither has yet designated sensitive areas (although some data for Greece do relate to areas that may be designated). Of the other Member States only Austria considers that no sensitive area designations are required. All Member States have reported on the early stages of implementation of the Directive, except Italy. However, no Member States will have reported yet in relation to the 31 December 1998 deadline for compliance with discharge requirements in sensitive areas.

### 2.8.2 Sensitive areas

The designation of sensitive areas remains incomplete across the EU (Table 2.4). The deadline for compliance with discharge limits for sensitive areas was 31 December 1998, but as stated above some Member States (eg Greece and Italy) have still 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 in that, in most cases, 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.

As can be seen from Table 2.6 Member States can be categorised into three groups, according to the identification of sensitive areas. Denmark, Sweden and the Netherlands fall into category 1. These Member States regard their whole territory as sensitive area. The second category comprises Member States, in which normal areas also exist, like France, Germany, Ireland and Austria. However, Austria is an exception in the sense that it regards its whole territory as 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 for sensitive areas. The third Category 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. The following table gives an overview of these results.

### 2.8.3 Discharges and agglomerations

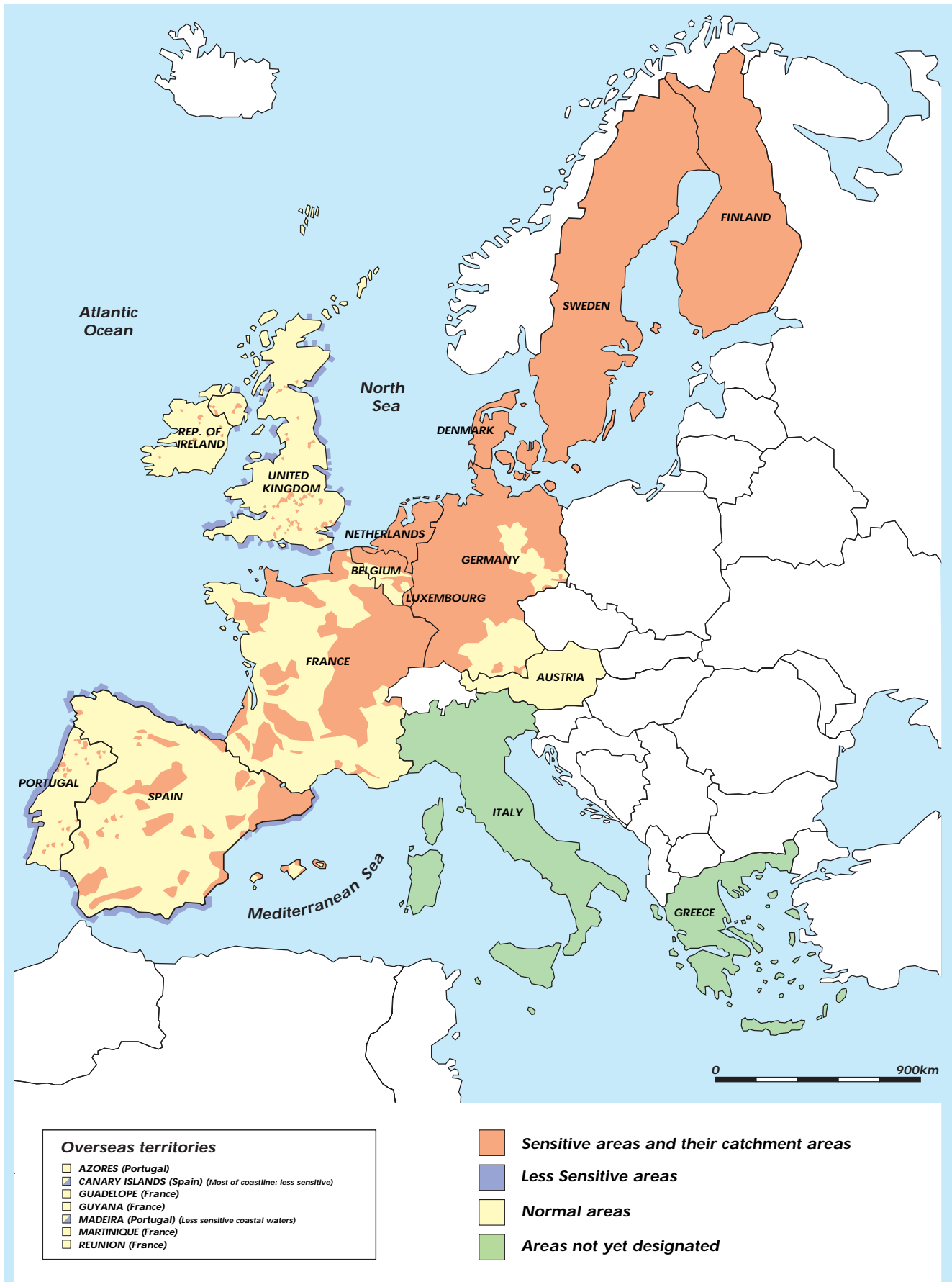
The organic load discharged to normal, sensitive and less sensitive areas and the number of agglomerations within each area are shown in Table 2.7. Table 2.7 requires interpretation. The population data are, of course, not the same as population equivalents (see above), which is why the total population 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 (eg 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.

### 2.8.4 Capacity of collection systems and treatment facilities

Table 2.8 indicates the capacity of the collection systems as a percentage of the respective load in the area of discharge and how the capacity is predicted to change by 2005. Table 2.9 provides a similar analysis of the capacity of treatment facilities. For example 89.2% for Austria (first cell in Table 2.8, column 2) means that the capacity of collection systems 'deemed to be in compliance', is able to carry 89.2% of the load in normal areas.

While considering the percentage of the capacity of treatment and collection systems, as given in Table 2.8 (collection systems) and 2.9 (treatment plants), it has to be noted that "100% capacity" does not indicate an ideal capacity adequately to treat 100% of the generated sewage. This would only be possible if at all places and at all times the respective treatment or collecting capacity matched the amount of waste water discharged. It is however more likely that some agglomerations have an overcapacity of treatment or collection systems whereas other agglomerations face a lack of capacity. Therefore, a total capacity of 120% is regarded as sufficient to collect and treat all waste water discharges to facilities that are deemed to be in compliance with the Directive.

The *collection systems* 'deemed to be in compliance' of the Member States in category I (Table 2.6) show a remarkable overcapacity. Sweden has the highest overcapacity with 174%, followed by Denmark (144.6%) and the Netherlands (126.5%). At a first glance, the data do not seem to reflect the situation in Sweden adequately.



Extent of "sensitive areas" and "less sensitive areas" across Europe.

TABLE 2.7

MEMBER STATE	POPULATION (1000 INHABITANTS)	NORMAL AREAS		SENSITIVE AREAS		LESS SENSITIVE AREAS		TOTAL	
		Agglomerations	1000 pe	Agglomerations	1000 pe	Agglomerations	1000 pe	Agglomerations	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
UK	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

*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)*

However, according to the Swedish Environmental Agency this overcapacity is due to an inaccurate prognosis of the population and economic development. Within category II Austria and Germany have a collecting capacity of approximately 90%, France of 79% and Ireland about 24%. The collection capacity for the United Kingdom seems to be calculated on the basis of the sewage generated, as it reaches exactly 100%. In Portugal and Spain the relative share of the collection systems 'deemed to be in compliance' lies around 50%.

A different picture of the status of implementation is drawn, if one regards the capacity of *treatment plants* 'deemed to be in compliance'. Within category I Denmark is an exception: the percentage of 70.9% of treatment plants 'deemed to be in compliance' indicates that work remains to be done here. The Netherlands with 124.3%, show slight overcapacities, Sweden again has remarkable overcapacities at its disposal (173.9%). Similar to the performance of collection systems, there are large differences in the capacity of treatment plants within category II. Germany nearly hits the 100% mark with a capacity of 98.5% of treatment plants in compliance in

sensitive areas. More investments need to be made in normal areas, as treatment plants in compliance can only handle 56.7% of the load in these areas. In total Germany has a capacity of 90% for treatment plants 'deemed to be in compliance' - this capacity is comparable to the German capacity of collection systems. In Austria, the treatment capacity 'deemed to be in compliance' of 77% shows that improvements can be made. France faces a relatively high necessity for further investment in the treatment sector.

Currently only 57.2% of the waste water load can be treated in facilities that are deemed to be in compliance with the Directive. In Ireland the number of treatment facilities that are deemed to be in compliance with the Directive seems to be quite low. According to the Irish implementation report only 12.3% of the waste water is treated in compliant facilities. However, these data might have to be qualified, taking into account the low population density in Ireland. In Portugal, Spain and the United Kingdom (category III) the capacity of the treatment systems 'deemed to be in compliance' only allows for the treatment of a third of the waste water discharge.

TABLE 2.8

MEMBER STATE	1992 (1000 PE)	% CAPACITY IN COMPLIANCE	2005	INCREASE (1000 PE)	INCREASE (PERCENTAGE)
Austria	16,571	89.2	19,467	2,896	17
Belgium	1,721	18.8	2,201	480	28
Denmark	12,133	144.6	12,133	0	0
Finland	3,395	84.7	3,576	181	5
France	55,780	79.1	70,508	14,728	26
Germany	114,107	88.6	127,055	12,948	11
Greece	7,278	71.3	8,708	1,430	20
Ireland	878	22.4	3,918	3,040	346
Luxembourg	914	100.0	969	55	6
Netherlands	21,780	126.5	21,780	0	0
Portugal	9,367	57.6	16,462	7,095	76
Spain	35,001	47.0	74,439	39,438	113
Sweden	13,044	174.0	13,044	0	0
United Kingdom	76,526	100.0	75,604	-922	-1
Total	368,472	86.8	449,864	81,392	22

*The capacity of waste water collection systems (in population equivalents) in Member States as reported for 1992 and as predicted for 2005 from the Commission implementation report (updated for Germany). The percentage capacity in compliance is calculated by comparing the collection capacity with the total discharge in each Member State for agglomerations greater than 2,000 pe in Table 2.7, page 20.*

The latest OECD Environmental Performance Review of Belgium points at particular serious delays in implementing the Directive. Water management presents a key challenge according to the report. The country's high population density, strong industrialisation and very intensive agriculture result in a strong pressure on water resources. According to the report the introduction of modern waste water treatment in Belgium is "among the lowest in the OECD". The implementation of the Urban Waste Water Treatment Directive therefore remains a political and financial challenge in Belgium.

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, ie 90% of the EU total), together with the expected requirements following implementation of the Directive are shown in Table 2.10. The data are from unpublished work of the European Environment Agency and 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 waste water treatment works (not total waste water 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 waste water 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%.

The data show significant differences to Table 2.9. Some of 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).

TABLE 2.9

MEMBER STATE	1992 (1000 PE)	% CAPACITY IN COMPLIANCE	2005 (1000 PE)	INCREASE (1000 PE)	INCREASE (PERCENTAGE)
Austria	14,413	77.6	19,467	5,054	35
Belgium	5,499	60.0	9,919	4,420	80
Denmark	5,950	70.9	9,246	3,296	55
Finland	3,598	89.8	3,935	337	9
France	40,333	57.2	69,378	29,045	72
Germany	115,436	89.6	143,831	28,395	25
Greece	2,058	20.2	8,637	6,579	320
Ireland	483	12.3	3,810	3,327	689
Luxembourg	777	85.0	969	192	25
Netherlands	21,396	124.3	22,053	657	3
Portugal	5,731	35.2	16,387	10,656	186
Spain	23,872	32.1	73,754	49,882	209
Sweden	13,038	173.9	13,038	0	0
United Kingdom	29,335	38.3	75,323	45,988	157
Total	277,939	65.5	469,747	191,808	69

*The capacity of waste water treatment facilities (in population equivalents) in Member States as reported for 1992 and as predicted for 2005 from the Commission implementation report (updated for Germany). The percentage capacity in compliance is calculated by comparing the collection capacity with the total discharge in each Member State for agglomerations greater than 2,000 pe in Table 2.7, page 20.*

### 2.8.5 Discharge limits for phosphate in EU Member States

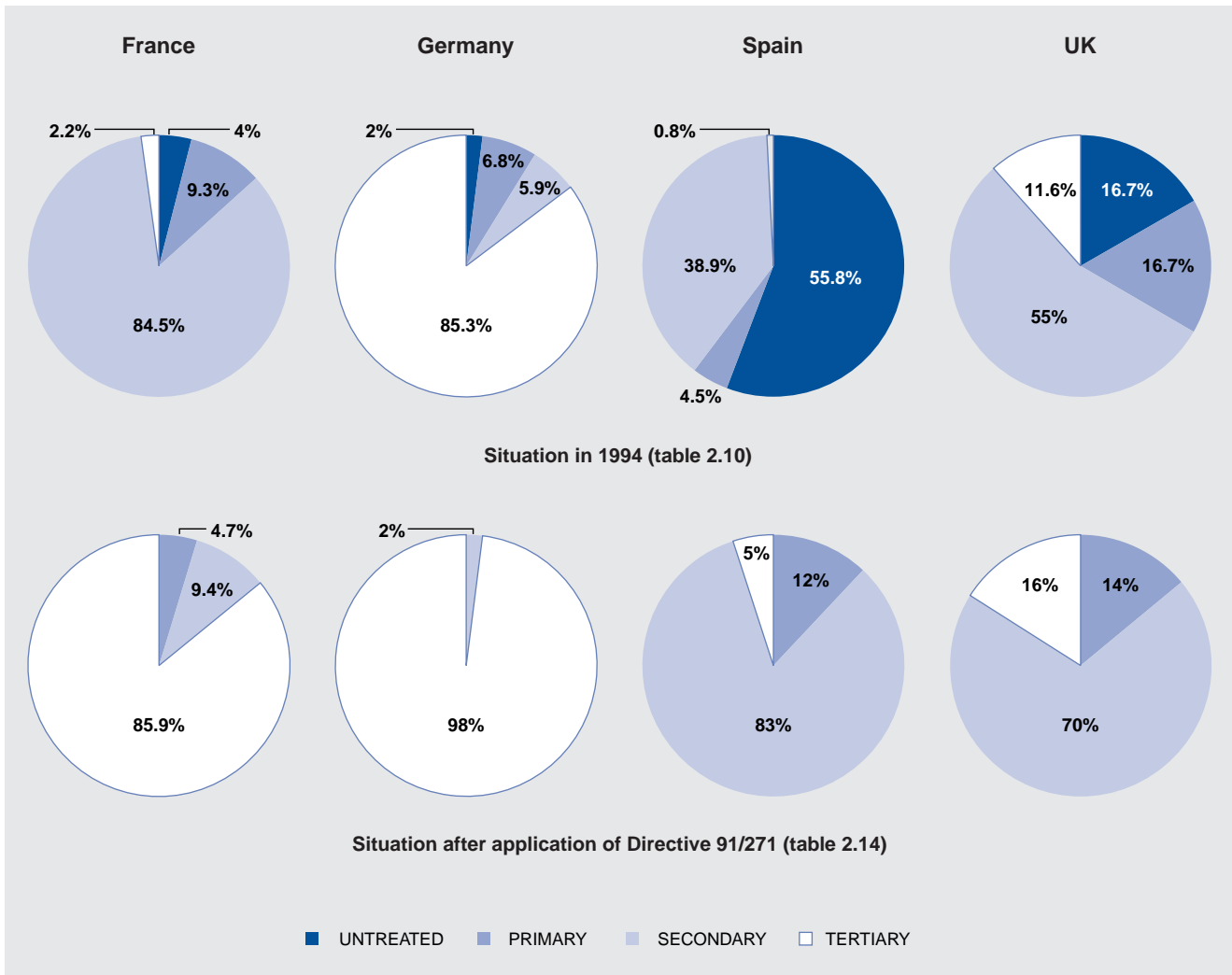
The Table 2.11 compares the discharge standards for phosphorus within the 1991 urban waste water treatment Directive with those of a selection of Member States. It can be seen that the requirements in some Member States (eg France and the UK) are exactly those indicated in the Directive. However, other Member States (most notably Sweden) have significantly stricter discharge standards. The effect of varying standards is to affect the type (and thus cost) of the phosphate removal processes adopted in the Member States and, possibly, the extent to which eutrophication is overcome in particular circumstances. It is important to note that where some Member States have discharge limits following, or similar to, the Directive, they may also adopt stricter limits for especially sensitive environments.

### 2.8.6 Tertiary treatment

Information contained in the Member States implementation reports provides only limited information on tertiary treatment provision in some Member States for the end of

1992. The data available are given in Table 2.12. A more up to date picture is given in Table 2.10 above.

A direct comparison of the data on nutrient elimination is not possible, although Table 2.13 does give an overview of the capacity of treatment works for different Member States according to the level of treatment. As explained above the Member States can chose from a variety of options to reduce nutrients. According to the different approaches the Member States supplied different information in their national implementation programmes. Again, Sweden reports an overcapacity of treatment plants equipped with tertiary treatment. The Netherlands have, for nearly their whole territory, tertiary treatment at their disposal. In Denmark, nearly half of the waste water load can be treated with tertiary treatment. In Germany, the majority of treatment plants allow for tertiary treatment, which in Germany mainly means phosphorus elimination. This is also true for Ireland, where eutrophication can be addressed most efficiently by phosphorus elimination. Large scale phosphorus reduction facilities already existed in Ireland. Ireland tries to go well beyond the requirements



*Levels of waste water treatment in four EU Member States*

TABLE 2.10					
MEMBER STATE	UNTREATED	PRIMARY	SECONDARY	TERTIARY	TOTAL
Finland	0.0	700	0.0	4,800	5,500
France	2,000	4,500	41,000	1,000	48,500
Germany	2,500	8,300	7,300	104.6	122.7
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	2,00	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

*Levels of waste water treatment (in 1000 population equivalents) in selected EU Member States in 1994. (Source: EEA unpublished).*

TABLE 2.11

SOURCE OF STANDARDS	COMMENTS	DISCHARGE LIMITS
Austria		2 mg/l (< 5,000 pe) 1 mg/l (> 5,000 pe) 0.5 mg/l (>10,000 pe in the catchments of lakes)
Denmark	To North Sea (annual average) Small rivers.	1.5 mg/l 0.3 mg/l
France	As total P, annual average. Required for discharges to designated sensitive areas. Alternatively a treatment plant may operate to reduce total P by 80%.	2 mg/l (10,000-100,000 pe) 1 mg/l (>100,000)
Germany	Standards apply to short-term sampling (variable) and 80% of samples each day must comply.	2 mg/l (>10,000-100,000 pe) 1 mg/l (>100,000 pe)
The Netherlands		2 mg/l (< 100,000 pe) 1 mg/l (>100,000)
Sweden		0.5 mg/l (< 50,000 pe) 0.3 mg/l (> 50,000 pe or for discharges to sensitive waters)
United Kingdom	As total P, annual average. Required for discharges to designated sensitive areas. Alternatively a treatment plant may operate to reduce total P by 80%.	2 mg/l (10,000-100,000 pe) 1 mg/l (>100,000)

*Phosphate discharge limits (mg/l) from selected Member States.*

TABLE 2.12

MEMBER STATE	CAPACITY OF TREATMENT WORKS			NUMBER OF TREATMENT WORKS		
	Tertiary treatment	Phosphorus removal	Nitrogen removal	Tertiary treatment	Phosphorus removal	Nitrogen removal
Austria		5,379			206	
Denmark	4,627			67		
France	6,152			164		
Germany	23,602	21,812	8,519	312	374	172
Portugal	30			1		
Spain	471			9		
Sweden		11,561			191	
United Kingdom	248			10		

*Capacity and number of treatment works with tertiary waste water treatment (1992) according to Member State implementation reports.*

of the Directive by installing phosphorus reduction also in agglomerations under 2,000 p.e. In Luxembourg, 90% percent of the treatment facilities are biological. Some of the biggest treatment plants do not remove nitrogen. In 1991 a nitrogen removal programme was set-up. However, it will be difficult for Luxembourg to meet the 1998 deadline for sensitive areas. The phosphorus removal seems to be considerably advanced and therefore there are no problems with regard to phosphorus. The United Kingdom and Spain hardly have any treatment plants equipped with tertiary treatment in the implementation reports.

Further examination of the status in individual Member States (see chapters 3-6) indicates that France is unlikely to comply with the requirements for sensitive areas for some years. Germany will meet outstanding requirements in the east by 2005. Spain, however, has only recently undertaken designations and appears to place nutrient removal as a lower priority to other waste water treatment requirements. In contrast, the requirements for existing designations in the UK should have been met by the end of 1998. Implementation and future trends are, therefore, highly variable.

## 2.9 FUTURE IMPLEMENTATION OF THE DIRECTIVE

It is difficult to predict future implementation of the urban waste water treatment Directive. It is certainly unlikely that timetables contained within the Directive will be met, as they have not been followed up to this point. Any future timetable will largely depend on domestic and Commission pressure on individual Member States. Indeed, some Member States are still designating sensitive areas. These remain to be confirmed in Greece, identified in Italy and the UK has just announced a major expansion in the number of designations. Such changes make predictions uncertain. It is also important to stress the point made at the outset that implementation of the Directive allows significant flexibility to Member States and, therefore, the particular action taken will reflect practical, political and economic considerations as decisions are made. 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. The Commission may take a more objective view of which sites suffer from adverse eutrophication, based on the definition in the Annex to the Directive.

However, the European Environment Agency has commissioned some work to consider future implementation in ten Member States. Table 2.14 summarises the likely levels of treatment in each Member State following full implementation of the Directive. In a number of Member States the current pattern of treatment is much as currently exists, eg 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 sensitive areas. This is further elaborated in Table 2.15.

From Table 2.14 it is possible to estimate the amount of phosphate that will be removed from waste water. Table 2.16 provides an estimate of the quantity of phosphate produced in the receiving waters of the waste water treatment plants in the ten Member States described in Table 2.16, an estimate of removal rates in 1994 and of the removal rate following implementation of the urban waste water treatment Directive.

For four of the Member States these data may be broken down as shown in Table 2.19. It should be noted that the estimate given for the likely levels of treatment that will be applied in France in Table 2.14 is considerable more stringent than might be assessed from 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 waste water treatment at the end of 1994 (Table 2.10). This represents at least a further 9,900 tonnes of phosphate removed from a total of 15,300 tonnes produced.

## 2.10 SEWAGE SLUDGE PRODUCTION

Many of the issues relating to sludge production and disposal are outwith the scope of this study. However, of relevance to waste water treatment (as sludge production varies with choice of treatment) is the cost of sludge disposal. This varies significantly and some comments are made in subsequent chapters. However, Table 2.19 provides an overview of current and predicted levels of sludge production and its likely use in agricultural spreading.

Within the United Kingdom, Spain and Ireland part of the sewage sludge was discharged into the sea. This is now prohibited under the urban waste water treatment Directive. However, Spain has indicated that it will continue to dispose of around 57,000 tonnes of sludge in this way. In general, the discharge of sewage sludge is handled quite heterogeneously in the Member States. Germany produces the largest amount of sewage sludge. In Denmark, the largest amount of sewage is reused in agriculture, a practise that is politically controversial.

TABLE 2.13

	SENSITIVE AREAS	COLLECTION SYSTEMS <sup>1</sup>	TREATMENT PLANTS <sup>1</sup>	TERTIARY TREATMENT
	%	%	%	%
Denmark	100	144.6	70.9	~ 50
The Netherlands	100	126.5	124.3	~ 100
Sweden	100	174	169.8	~ 160
France	29.2	79.1	57.2	~ 10
Germany	78.7	88.6	89.6	~ 90
Ireland	6.3	22.4	12.3	no data available
Austria	0	89.2	77.6	~ 25
Portugal	12.2	56.9	34.8	~ low
United Kingdom	5.2	100	38.7	~ low
Spain	4.3	47	32.1	~ low

Comparative overview of the treatment capacity in Member States according to levels of waste water treatment (1992). The column "sensitive areas" states the percentage of the sensitive areas in relation to the total territory (given in p.e.). The column "collection systems" indicates how much of the total waste water load for the country ideally can be handled by collection systems 'deemed to be in compliance'. The third column "treatment plants" deemed to be in compliance gives the same information with regard to the treatment facilities. 'Tertiary Treatments' refers to phosphorus elimination, denitrification or both. The capacities of treatment plants equipped with tertiary treatment are set into relation to the total capacity of treatment plants.

<sup>1</sup> Facilities that are deemed to be in compliance with the Directive

TABLE 2.14

MEMBER STATE	UNTREATED	PRIMARY	SECONDARY	TERTIARY	TOTAL
Finland	0.0	0.0	0.0	5.5	5.5
France	0.0	3.0	6.0	54.5	63.5
Germany	0.0	0.0	2.5	121.0	123.5
Greece	0.0	0.1	1.3	8.6	10.0
Italy	0.0	4.2	87.0	10.6	101.8
Luxembourg	0.0	0.03	0.1	0.48	0.61
Netherlands	0.0	0.0	0.2	24.0	24.2
Portugal	0.0	2.1	10.9	1.2	14.2
Spain	0.0	10.2	70.3	4.2	84.7
United Kingdom	0.0	11.0	55.0	13.0	79.0
Total	0.0	30.6	233.3	243.1	507.0
Percentage EU10	0.0	6.0	46.0	48.0	100.0

Waste water treatment after implementation of the urban waste water treatment Directive (in million population equivalents) (EEA, unpublished).

## 2.11 COSTS

Assessing the costs of implementation of the Directive across the EU is difficult. A detailed analysis is outwith the scope of this study. However, some brief comments can be made which are important in considering future developments. The 1998 implementation report estimates that the overall investments required for upgraded waste water collection systems between 1993 and 2005 will be 68.53 billion ECU. The upgrading required for treatment systems over this period is given in Table 2.19.

Unfortunately no detailed figures are available on the expected costs of upgrading nutrient removal across the EU as the result of implementation of the Directive. Many of the investments indicated in Table 2.17 will, in practice, largely be costs of installation of secondary treatment. According to these data, Germany will spend by far the largest amount of money on the implementation of the Directive. However, these data are hard to interpret, as it is impossible to see which data refer to general investments in the waste water sector and which data refer to costs induced by the urban waste water Directive.

TABLE 2.15

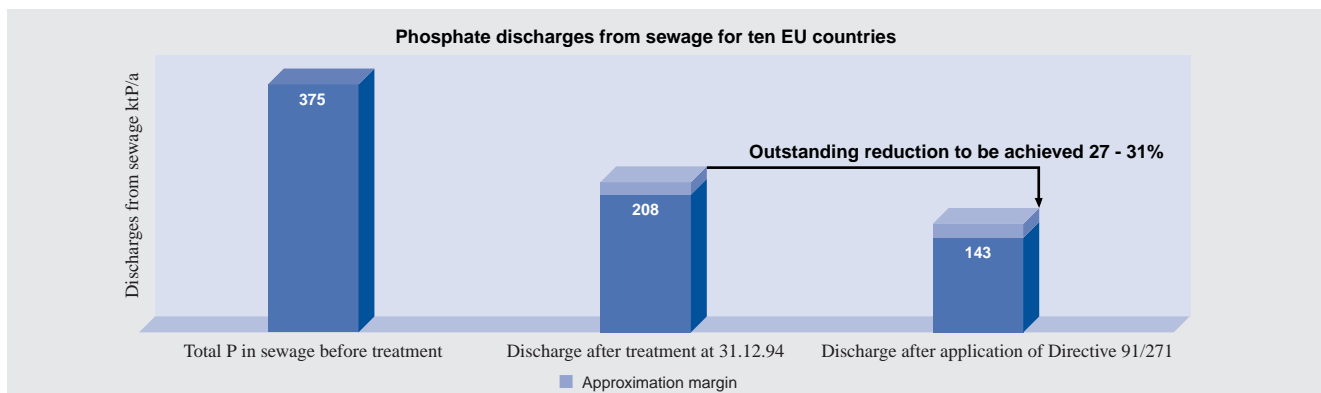
MEMBER STATE	UNTREATED	PRIMARY	SECONDARY	TERTIARY
Finland	0	-13	0	13
France	-4	-4	-76	84
Germany	-2	-7	-4	13
Greece	-34	-33	4	63
Italy	-30	-3	28	4
Luxembourg	-10	0	-61	71
Netherlands	0	-1	-23	24
Portugal	-68	6	56	4
Spain	-17	-3	15	4
United Kingdom	-17	-3	15	4

*Changes in levels of waste water treatment in different Member States following implementation of the urban waste water treatment Directive and the situation in 1994 (Tables 2.10 and 2.14). The table presents predicted percentage increases or decreases in the proportion of each level of treatment.*

TABLE 2.16

	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%

*Estimated phosphate discharge from waste water treatment plants at present level of waste water treatment for the EU10 given in Table 1.7 and as expected after full implementation of urban waste water treatment Directive (EEA, unpublished).*



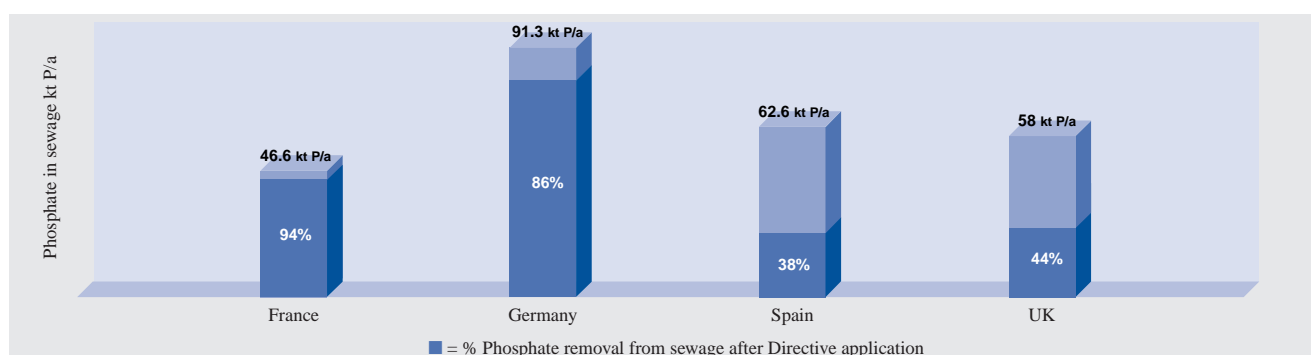


TABLE 2.17

	FRANCE	GERMANY	SPAIN	UNITED KINGDOM
Phosphate production prior to treatment	46.6 kt P/a	91.3 kt P/a	62.6 kt P/a	58.0 kt P/a
Estimated phosphate removal after full implementation of the Directive	40.1 kt P/a	85.7 kt P/a	23.7 kt P/a	25.3 kt P/a
Percentage of phosphate removed after full implementation of the Directive	94 %	86 %	38 %	44 %

*Estimates of phosphate removal in four Member States based on the unpublished EEA data (Table 2.15), assuming 95% removal from tertiary treatment and 40% removal from secondary treatment.*

It is also important to note that investment in waste water collection and treatment may be supported in some cases by EU funding through a range of financing initiatives. For example, the Cohesion Fund supports investments in infrastructure in the four poorer countries of the EU (Greece, Ireland, Portugal and Spain). Between 1993 and 1996 over 1.5 billion ECU were spent on waste water collection and treatment projects in the four countries from various EU sources. In 1998 the European Court of Auditors published a report (opinion 2/98) critical of the management of many of these projects. The Court examined 67 projects representing a total investment of 467 million ECU (292 million ECU supported by the EU under a variety of programmes). The Court found:

- A number of projects were designed so far in advance that at construction they were outdated (eg were an insufficient size or technical capacity)
- Projects did not adequately take account of issues such as storm water.
- Many projects provided inaccurate estimates of costs prior to construction.
- Some projects were delayed leading to increased costs.
- Treatment plants were constructed which did not meet the basic requirements of the urban waste water treatment Directive, so necessitating further investment to ensure compliance.
- Some plants built to the correct standards were not functioning due to lack of finance for running costs.

It is, therefore, clear that in some cases additional investments will be required and that estimates of costs for implementation of the Directive may contain inaccuracies.

TABLE 2.19

MEMBER STATE	INVESTMENT
Austria	2.12
Belgium	2.14
Denmark	1.7
Finland	0.55
France	4.02
Germany	28.87
Greece	0.73
Ireland	1.14
Luxembourg	0.27
Netherlands	1.83
Portugal	0.94
Spain	6.15
Sweden	1.50
United Kingdom	9.74
Total	61.70

*Forecasts of investments in treatment systems between 1993-2005 to implement the urban waste water treatment Directive. Data are in billions of ECU at 1994-5 prices (1996-7 for UK). Data for Greece are limited to 1993-2000.*

## 2.12 DEVELOPMENTS IN INDIVIDUAL COUNTRIES

### 2.12.1 Introduction

As stated earlier, policies developed at a national level to tackle the problem of phosphate discharges from waste water treatment plants will take account of developments at an EU level and also of national priorities. This section provides a brief overview of the status of such policies in four contrasting EU Member States (France, Germany, Spain and the United Kingdom), which have had historically different levels of tertiary treatment and have taken different approaches to the designation of sensitive areas. Given the current focus on the enlargement of the EU in central and eastern Europe, this section also concludes with some comments on the likely future responses of this region to the phosphate removal provisions in the Directive.

### 2.12.2 France

France has designated a significant proportion of its territory (just over a quarter in terms of population equivalent) as sensitive areas under the urban waste water treatment Directive. However, the Water Agencies have elsewhere indicated other sites which may be at risk from eutrophication which are not currently designated. For example, the Rhône-Méditerranée-Corse Water Agency indicates that 'not a majority of eutrophic rivers...but selectively identified rivers marked by a very important and chronic eutrophication problem' are designated as sensitive areas. Over 50 stretches of river identified by this Agency as showing symptoms of eutrophication (regular and important vegetal growth) are outside designated sensitive areas, including most of the Ain and Durance river basins. For the Artois-Picardie basin, where currently <10% of the basin is designated a "sensitive area", The SDAGE (official water management plan, June 1997) states that "*Given the variety and intensity of problems present, the whole of the Artois-Picardie water agency area has a vocation to figure as a sensitive area*".

However, in conformity with the spirit of Europe in 1996 only 38% of the treatment works serving >10,000 pe in sensitive areas, representing only 13% of the population equivalent, removed phosphate to 80% efficiency or greater. It is not known what upgrading will have been 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 is not obviously connected to the requirements of the Directive. There are many more agglomerations with nitrogen removal systems than there are for phosphate removal. While nitrogen is an important nutrient contributing to marine eutrophication, the distribution of nitrogen removal from waste water in France is not targeted at protection of the coastal zone.

Phosphate removal itself also does not seem to be targeted at the requirements of designated sensitive areas. Of treatment works with >80% phosphate removal, only around a third discharge in sensitive areas, amounting to about half of the population equivalent served with phosphate treatment. Most sensitive areas still contain large waste water point sources with poor phosphate removal. In contrast there are some undesignated areas with provision of phosphate 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).

There is little prospect of France complying with the requirements for sensitive areas in the near future. Ultimately action from the European Commission could free-up financial sources for investment that are not being made available today. It must be remembered that France still has to make significant investments in sewage collection and basic treatment. For Lyon and Marseille (France's second and third largest conurbations), currently 85% and 83% only of the sewage is, respectively, collected, with 56% and 31% only removal of organic matter. If the Directive requirements were fully implemented, then France would remove more phosphate from waste water than is necessary under the Directive, given the current presence of phosphate removal outside sensitive areas. Phosphate removal rates of greater than 80% currently apply to discharges of about 2.5 million population equivalent outside of sensitive areas. Overall this would result in high level phosphate treatment for at least 25% of waste water discharges in France. Together with extensive installation of secondary treatment, this would mean that approximately 55% of the phosphates in waste water would be removed. This is significantly lower than suggested in the EEA (unpublished) estimate for France (see above).

### 2.12.3 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 waste water treatment systems, although this general upgrading would have resulted even without the existence of the urban waste water 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 the main reason for this widespread designation has been to reduce nutrient inputs into the Baltic and North Seas as much as protection of inland surface waters. Germany has installed extensive phosphate reduction in waste water treatment plans across the *old Länder*. Many of these installations are on smaller treatment works. Germany is, therefore, expected to remove

very high levels of phosphate produced in human waste. Sludge re-use will be just under 50% of that produced, so that much of this phosphate recovered may be utilised. Given the size of the Germany population in relation to the EU, and that by 2005 the country is still expected to produce a third of the sludge within the Union and that the four other largest EU Member States (France, Italy, Spain and the UK) will not approach phosphate removal rates of Germany, it seems that Germany will retain its position as the major source of phosphate removal (or recovery for re-use) in the EU.

#### *2.12.4 Spain*

The situation of waste water treatment in Spain required a major effort in order to achieve compliance with the obligations and periods established by the urban waste water treatment Directive. As a result, priority has been assigned to the construction of waste water treatment plants in large urban population centres.

Spain has tended to declare the smallest number possible of sensitive areas and population centres required by the Directive. In contrast, special attention has been paid to waste water treatment in less sensitive areas (much of the coast except for closed bays and estuaries and some areas with major urban population centres). In these less sensitive zones the protection established in the Directive has been increased, with secondary treatment proposed for most municipalities of 150,000 pe or less. This is because many coastal areas are bathing areas, so secondary waste water 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 waste water treatment are not being carried out at an optimal rate for achieving compliance with the Directive and its deadlines, although a major effort is underway to ensure the highest level of compliance possible. Within this general framework, compliance with the time lines established by the urban waste water treatment Directive for waste water treatment in sensitive areas has not been considered a priority.

#### *2.12.5 United Kingdom*

The structure of the water services in England and Wales is unlike that in other Member States in being based on a private system. The near monopoly status of water service provision also means that an unusual regulatory system has been adopted with an investment/price regulator and an environmental regulator.

The urban waste water treatment Directive has proved to be one of the most expensive EU environmental Directives to have been implemented in the UK. This is not just because of any requirement for tertiary treatment in sensitive areas, but also because of the extensive requirement for

primary, secondary and, now, tertiary (disinfection) treatment in coastal areas, together with the effects of ceasing the dumping of sewage sludge at sea.

Phosphate pollution occurs throughout the UK, though it is not ubiquitous. As a result the UK has taken the approach of designating individual sensitive areas under the Directive. The government has recently extended considerably the number of designated sensitive areas. 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 is currently being undertaken in England and Wales and will not be complete until the end of 1999. There are a number of contrasting opinions. However, it is clear that the government is expecting significant additional action on environmental improvements, including phosphate control. However, this is also to be balanced against pressure for cuts in prices, but also the need for a range of other important environmental objectives, such as compliance with bathing water standards, controlling lead in drinking water, etc. Whatever the balanced reached, the capital investment costs for 2000-2005 will be significant (around £8.5 billion).

#### *2.12.6 Central and eastern Europe*

Ten central and eastern European states are currently in the process of transposing and implementing EU legislation in preparation for future membership of the EU. It is clear that the urban waste water treatment Directive will be one of the most expensive items of EU legislation requiring approximation.

Many central and eastern European states have inherited poor waste water collection and treatment systems. However, there is significant variation between individual states. Almost no provision had previously been made for nutrient removal. Improvements are already being made. However, the domestic priority is to collection systems and primary and secondary treatment requirements in the Directive. Indeed, as no sensitive areas are designated it is unknown what levels of tertiary treatment will be required.

Some investment in phosphate removal has taken place. This has mostly been due to bilateral aid from Scandinavian countries in the Baltic States and Poland as part of a general programme to protect the Baltic Sea. The European Commissions' best estimates for capital investments for waste water treatment are 27,794 MECU without nutrient removal and an additional 5,407 MECU with nutrient removal. These levels of investment are beyond the short-term financial ability of central and eastern European states. Implementation of the provisions of the Directive will either require extensive foreign assistance or a long implementation period.

### 3. LOOKING TO THE FUTURE AND CONCLUSIONS

#### 3.1 INTRODUCTION

It can be seen from the preceding chapters that while significant action is being taken to tackle the problems of phosphate pollution from waste water discharges, a lot more remains to be done before the problems of eutrophication can be controlled. This chapter will examine briefly some potential future developments at the level of the EU and what other action might be taken to reduce phosphate pollution.

#### 3.2 EUROPEAN UNION ACTION

##### *3.2.1 Future action on the urban waste water treatment Directive*

The European Commission is currently involved in a number of actions to ensure that the current provisions of the urban waste water treatment Directive are enforced. Indeed it is clear that even basic measures to ensure its implementation have been lacking in some instances. 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 waste water treatment therein.
- 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. It is also likely that action will also be taken against Italy for its failure to ensure that discharges of urban waste water from Milan have been adequately treated to prevent severe pollution of the River Po and the Adriatic Sea.
- A Reasoned Opinion (December 1998) against Greece for adopting legislation in 1997 that does not fully comply with the provisions of the Directive, eg 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 (six years after the Directive deadline of 31 December 1998).

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 pressure within a Member State may lead to it failing to designate particular waters due to the economic costs of investment in treatment facilities. 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. This is complicated further by the urban waste water treatment Directive providing no clear criteria for defining a eutrophic water body and that more detailed criteria have been developed within each Member State. Currently the Commission has also begun this task. It has funded a study to examine sensitive area designation in France and the United Kingdom. While this study will be complete at the beginning of 1999, results will not be announced until studies of all remaining Member States (which have not chosen the option of designating the whole of their territory) are completed. The Commission also 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. These studies will be particularly important in determining whether any further extension to phosphate removal will be required to implement the provisions of this Directive.

It is also important to note that the European Commission is taking increasingly tough action on other measures to reduce eutrophication from other sources. For example, in July 1999 it has made an application to the European Court of Justice against Germany and Luxembourg and notified a Reasoned Opinion against France, Belgium and the Netherlands concerning the implementation of the nitrates Directive. Problems have arisen due to adequate designations and the way that farm action programmes have been implemented.

##### *3.2.3 The proposed water framework Directive*

The proposed water framework Directive (COM(97)64, COM(97)614 and COM(1998)76) is currently under intense debate within the legislative processes of the EU. It provides the basis for an overall management framework for surface (including estuarine and coastal) waters and groundwaters. This is a major new development for EU water legislation, which has, until now, largely been issue-specific. It also provides a second important development in that environmental objectives are not only determined by chemical criteria, but also by ecological criteria. This latter development has not before appeared in EU water legislation (except in so far that ecological assessments are necessary in maintaining the conservation status of sites designated under the birds and habitats Directives).

The purpose of the Directive (Article 1):

‘to establish, for the protection of surface fresh water, estuaries, coastal waters and groundwater in the Community, a framework which:

- a) prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems..’

The key elements of the proposal are:

- Establishment of River Basin Districts: integrated management
- Characterisation of River Basin Districts by ecology, geology, hydromorphology, demography, land use, economic activities, etc.
- Identification of historical trends in water quality and use.
- Assessment of water quality, quantity, status and monitoring.
- Identification of point and diffuse sources of pollution and other anthropogenic influences.
- Meeting the requirements of Protected Areas.
- Undertaking economic analyses of water use.
- Full cost recovery of water use by sector: industry, households, agriculture.
- Developing a programme of measures to achieve objectives in each River Basin District.

The environmental objectives and the way that they are to be met are outlined in Article 4:

‘Member States shall draw up and make operational within a comprehensive River Basin Management Plan the programmes of measures envisaged as necessary, in order to:

- a) prevent deterioration of ecological quality and pollution of surface waters and restore polluted surface waters, in order to achieve good surface water status in all surface waters by 31 December 2010...’

The key criterion for judging performance is thus the achievement of ‘good ecological status’.

Waters will be classified into five classes, being ‘high’, ‘good’, ‘fair’, ‘poor’ and ‘bad’. ‘Ecological status’ is itself assessed by the worst performance of three separate assessments of biological, chemical and hydromorphological status. The proposal contains a number of definitions of different aspects of ecological status and also provides a detailed set of parameters (Annex V) to assess high, good and fair biological, chemical and hydromorphological status for lakes, rivers, estuaries and coastal waters. It is difficult to summarise these here, especially as there have been extensive proposals for changes to these, especially from the Environment

Council, so that the final wording of the detailed definitions in any final adopted text is uncertain. However, it is worth highlighting some from the original proposal:

**PROPOSED WATER FRAMEWORK DIRECTIVE ANNEX V. NORMATIVE DEFINITIONS FOR GOOD ECOLOGICAL STATUS:**

*Rivers and lakes (similar for estuaries and coastal waters):*

*‘General: detectable but low-level impacts on biological communities, and the physicochemical and physical environment. The biota shows signs of disturbance but deviates in terms of survival, reproduction and development only slightly from that normally associated with the ecotype under undisturbed conditions.*

*Phytoplankton: no accelerated growth of algae and higher forms of plant life such as to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned.*

*Macrophytes and phytobenthos: Only slight changes in species composition and abundance compared to type-specific conditions. No significant changes (increase or decrease) in macrophyte and phytobenthic biomass due to anthropogenic activities (eg nutrients).*

*Chemical: concentrations/levels not exceeding standards established so as to ensure the functioning of the ecosystem and the occurrence of the biological community specified above.’*

Note the definition of good status follows that used for defining eutrophication in the urban waste water treatment Directive (Article 2.11):

“eutrophication” means the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned.”

The urban waste water treatment Directive (Article 5) requires that Member States identify sensitive areas according to the criteria laid down in Annex II. However, this only provides general guidance to determine the threat from eutrophication. A number of parameters may be used to judge this, which might most easily be chemical (nitrogen or phosphorus concentrations). The proposed water framework Directive, however, stresses the importance of biological characters in assessing ecological quality and it will be necessary to determine the biological response (eg phytoplankton and macrophytes) to eutrophication in evaluating water status.

However, the links between the definitions in the urban waste water treatment Directive and the proposed water framework Directive are deliberate and suggests, therefore, that there is no stricter classification of eutrophic waters intended by the proposal.

The basic management unit to meet the requirements of the proposed Directive is that of the River Basin District (Article 3). Each River Basin District is to produce a River Basin Management Plan. These plans are required to provide a range of information for the District (Articles 5-11). The following are relevant to this discussion:

- Geographical and geological characteristics
- Hydrological characteristics
- Demographic information
- Land-use and economic activity
- Point sources of pollution
- Diffuse sources of pollution
- Other anthropogenic influences
- Economic information (values, prices, costs, including historical trends, investments and forecasts divided by households, industry and agriculture) for collection and discharge of waste water.
- Register of protected areas (EC, national and local designations), covering sensitive waters (e.g. nitrates, bathing waters, etc.) or nature conservation.
- Details of monitoring regimes for ecological and chemical characteristics and for protected areas.

Some of these characteristics are already covered by existing Directives (eg identification of protected areas). However, it is the linking together of a wide range of environmental issues with economic activity to provide an integrated management plan which is the radical departure for this Directive.

The proposed water framework Directive incorporates (and repeals) a number of existing items of EU water legislation. However, the urban waste water treatment Directive is not one of these. Indeed the implementation of the proposed water framework Directive must take special account of the provisions of the urban waste water treatment Directive, especially sensitive areas. This is understandable as any potential change in the provisions of the urban waste water 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 waste water treatment works serving an agglomeration > 10,000 pe, then the Member State may have no option but to install tertiary treatment, even if other controls may be less costly (eg reducing agricultural inputs). However, the proposal

may result in the need to take action to reduce phosphate pollution from small waste water treatment works in order to achieve good ecological status.

### 3.3 FUTURE CHOICE OF PHOSPHATE REMOVAL SYSTEMS IN EU MEMBER STATES

It is unlikely that there will be any radical change in the types of systems preferred within Member States. The strict standards required by the urban waste water treatment Directive tend to lead to the use of chemical phosphate removal (or combined biological/chemical removal). However, there is also a significant historical factor, whereby Member States tend to prefer systems with which they are already familiar.

Phosphate removal is also undertaken on smaller treatment plants than the 10,000 pe threshold of the Directive. Again such systems follow the same national patterns (eg chemical removal in Sweden). The use of reed-beds is also becoming more common for some small sources.

The adoption of more holistic policies towards phosphate pollution (both the 75% general reduction allowed under article 5.4 in the urban waste water treatment Directive and river basin management in the proposed water framework Directive) should enable a greater mix of treatment systems to come into operation.

### 3.4 OTHER DEVELOPMENTS IN REDUCING PHOSPHATE POLLUTION OF SURFACE WATERS

It is beyond the scope of this study to provide a detailed examination of the efforts to reduce eutrophication problems by controls of phosphate pollution sources other than from human waste. Such sources may include:

- agriculture;
- industry;
- detergents;
- fish farming.

The relative importance of each of these is highly variable, particularly at a local level. The earlier chapters detailing policy responses in different Member States illustrate that catchment-based or similar approaches to pollution control (including those of phosphates in sewage) may result in a range of local policy conclusions regarding different pollution sources.

It is important to note that sources of phosphate pollution exist other than sewage and that policies are under development to control them. This is part of the context for any future development of policies relating to urban waste water and is consistent with the approach advocated by the proposed water framework Directive.

### 3.5 CONCLUSIONS

At this time it is impossible to be precise about the future of phosphate removal from urban waste water. The deadline for meeting discharge requirements for sensitive areas under the urban waste water treatment Directive was the end of 1998. However, it is already certain that some Member States will not have complied for those areas already designated, it is not clear when compliance will be achieved and it will probably 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 waste water. 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 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. Moreover, implementation of the urban waste water treatment Directive is so costly in these Accession States, that it is likely that some derogations will be applied. This may mean that it is some years before widespread investment (except for particular foreign-supported construction) is available for tertiary treatment.



*Biological phosphorus removal at Laon sewage works (North East France), Lyonnaise des Eaux. Capacity 40,000 pe.*

Photo: Lyonnaise des Eaux

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[http://europa.eu.int/eur-lex/en/lif/dat/1991/en\\_391L0271.html](http://europa.eu.int/eur-lex/en/lif/dat/1991/en_391L0271.html)

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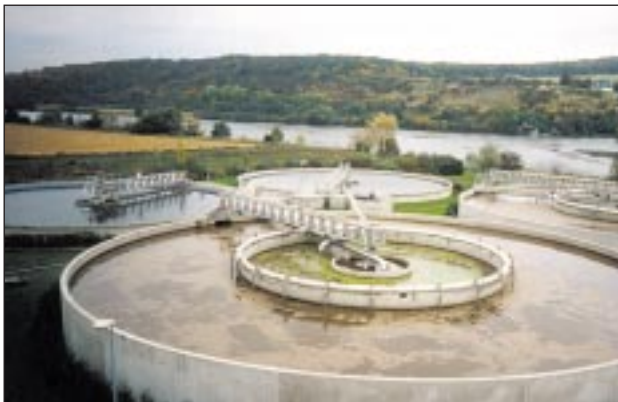
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*Biological phosphorus removal at Vernon sewage works (Western Paris area), Lyonnaise des Eaux. Capacity 60,000 pe.*

Photo: Lyonnaise des Eaux

