

Wastewater Quality Monitoring and Treatment

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Series Preface

Water is a fundamental constituent of life and is essential to a wide range of economic activities. It is also a limited resource, as we are frequently reminded by the tragic effects of drought in certain parts of the world. Even in areas with high precipitation, and in major river basins, over-use and mismanagement of water have created severe constraints on availability. Such problems are widespread and will be made more acute by the accelerating demand on freshwater arising from trends in economic development.

Despite the fact that water-resource management is essentially a local, river-basin-based activity, there are a number of areas of action that are relevant to all or significant parts of the European Union and for which it is advisable to pool efforts for the purpose of understanding relevant phenomena (e.g. pollution, geochemical studies), developing technical solutions and/or defining management procedures. One of the keys for successful cooperation aimed at studying hydrology, water monitoring, biological activities, etc., is to achieve and ensure good water quality measurements.

Quality measurements are essential to demonstrate the comparability of data obtained worldwide and they form the basis for correct decisions related to management of water resources, monitoring issues, biological quality, etc. Besides the necessary quality control tools developed for various types of physical, chemical and biological measurements, there is a strong need for education and training related to water quality measurements. This need has been recognized by the European Commission which has funded a series of training courses on this topic, covering aspects such as monitoring and measurements of lake recipients, measurements of heavy metals and organic compounds in drinking and surface water, use of biotic indexes, and methods to analyse algae, protozoa and helminths. In addition, series of research and development projects have been or are being developed.

This book series will ensure a wide coverage of issues related to water quality measurements, including the topics of the above-mentioned courses and the outcome of recent scientific advances. In addition, other aspects related to quality control tools (e.g. certified reference materials for the quality control of water analysis) and

monitoring of various types of waters (river, wastewater, groundwater) will also be considered.

This book *Wastewater Quality Monitoring and Treatment* is the sixth one of the series; it has been written by experts in wastewater policy, treatment and analytical science and offers the reader an overview of existing knowledge and trends in wastewater monitoring features.

The Series Editor – Philippe Quevauviller

Preface

The European Community decided in 1991 to obligate all the Member States to be equipped with wastewater treatment plants for all the cities whose wastewater organic loads are greater than 15 000 equivalent-inhabitants, before the 31st December 2000, and 2000 equivalent-inhabitants before the 31st December 2005. In this context, the quality of the treated wastewater must be better than reference values for some variables such as BOD (biological oxygen demand), COD (chemical oxygen demand), TSS (total suspended solids), global nitrogen and total phosphorus. These obligations generate a huge range of activities within the European Union, including research and technological developments, and similar trends can be observed, e.g. in the USA and Canada.

Unfortunately, wastewater monitoring procedures are prone to many drawbacks because of difficulties to accurately and frequently measure the necessary variables, which essentially rely on 'classical' monitoring approaches involving sampling, storage and laboratory analysis. The only way to make progress in wastewater treatment (and hence to comply with related regulations) is to ensure that the plants are able to work with unqualified reliability which implies that reliable monitoring of the wastewater quality and quantity and of the treatment efficiency should be performed for the characterisation of raw and treated wastewaters and for the control of the plant itself.

This book reflects this awareness by summarising different views on wastewater treatment-related monitoring and control. The book is composed of six different parts. The first part provides an overview of EU and US wastewater policies, standard methodologies, reference materials and discusses sampling assistance, biosensors and alternative methods. Sewer quality control is examined in the second part, including considerations on sewage characterisation and evolution, flow measurements and monitoring in rural areas. This is followed, in the third part, by chapters concerning urban wastewater treatment plant control and, in the fourth, by industrial wastewater treatment plant control. Part 5 discusses monitoring in the context of discharges and receiving medium, including water quality modelling. Finally,

socio-economic aspects are considered in the sixth part, with a focus on data collection and merging, as well as training.

This book has been written by experts in the field of wastewater treatment policy, control and monitoring. It provides an overview of the existing knowledge in wastewater monitoring and identifies emerging needs, which will be of direct interest to policy makers, water scientists and industries, and analytical control laboratories.

Philippe Quevauviller, Olivier Thomas and André van der Beken

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1.1

Wastewater Regulation

Violeta Vinceviciene

- 1.1.1 Urban Wastewater Treatment Regulation in the European Union
 - 1.1.1.1 Urban Wastewater Treatment Directive in the Context of European Union Water Legislation
 - 1.1.1.2 Main Aspects of Wastewater Treatment Directives
 - 1.1.1.3 Other Related Legislation on Other Types of Wastewater Except Urban
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References

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1.1.1 URBAN WASTEWATER TREATMENT REGULATION IN THE EUROPEAN UNION

1.1.1.1 Urban Wastewater Treatment Directive in the Context of European Union Water Legislation

European water policy began in the 1970s with the adoption of so-called Community Environmental Action Programmes (EAPs) and legally binding legislation. The first EAP covered the period 1973–1976, and the latest – the sixth EAP – covers the period 2001–2010 and has four priority areas: climate change; nature and biodiversity; environment and health; and management of natural resources and waste. One out of the eight actions set up in the EAP relates to sustainable use and quality of water, where the measure to improve application of water legislation is underlined (European Commission, 2002).

Parallel to the political programmes, three waves of the European Union (EU) water legislation can be distinguished. The first wave of legislation used water quality-oriented approach; the second covered review and update of regulations from the first wave and addressed new legislation related to the emission-control approach. The Urban Wastewater Treatment Directive (UWWTD) 91/271/EEC (European Commission, 1991) and the Integrated Pollution Prevention and Control Directive (IPPCD) 96/91/EC adopted during the second wave are mainly dealing with urban and industrial wastewater (European Commission, 1996).

The third wave started with using integrated approach of those two, mutually reinforcing each other. The integrated approach takes into account two aspects: limiting pollution at the source by setting emission limit values (or emission standards); and establishing water quality objectives (or quality standards) for water bodies. This approach is in accordance with the principles established in the EU Treaty: i.e. the precautionary principle, high level of environmental protection, principle of preventive action and rectification of pollution at the source, polluter pays principle and integration of environmental protection into other Community Policies. The new EU policy area started with the adoption of the Water Framework Directive (WFD) 2000/60/EC (European Commission, 2000) with which the UWWTD is closely linked. The implementation of the UWWTD forms the cornerstone part of the programme of measures of WFD to be included in river basin management plans with the objective to achieve good ecological status of surface waters by 2015. However, the UWWTD sets up only minimum requirements to achieve this objective. More stringent measures than those prescribed in the UWWTD for urban wastewater treatment may be required in some specific cases when having sensitive water bodies or water bodies being at risk of becoming sensitive. One of the main problems of surface water bodies is eutrophication, thus specific treatment requirements for nitrogen and phosphorus removal shall be set up for urban wastewater discharges to receiving waters.

1.1.1.2 Main Aspects of Wastewater Treatment Directives

Related Community legislation

The UWWTD 91/271/EEC is the main piece of EU environmental legislation dealing with urban wastewater. IPPCD 96/91/EC sets up the provisions for wastewater from certain large industrial sectors. Dangerous Substances Directive (DSD) 76/464/EEC and daughter directives control discharges of wastewater containing certain dangerous substances (European Commission, 1976).

Community measures on emissions including water discharges on sector-oriented approach included in the IPPCD 96/61/EC set up emission limit values for large industrial installations of specific industrial sectors. However, water contamination depends on the quantity of discharges which may also stem from smaller plants. The Directive requires fixing emission limit values in the individual permits for installations that come under this Directive. Referring to the Directive the pollutants covered are those 'likely to be emitted from installation in significant quantities, having regards to their nature and their potential to transfer pollution from one medium to the other (water, air and land)'. Very important to fix emission limit values for 12 'main polluting substances' listed in the Annex III of the Directive.

The Directive 76/464/EEC fixed the framework conditions for discharges of dangerous substances into waters. The Directive establishes two lists of substances and groups of substances to be addressed: list I contains substances considered toxic, persistent or bioaccumulative; list II other polluting substances, which have a deteriorious effect on the aquatic environment and which depend on the characteristics and location of the water into which they are discharged. The Directive requires all discharges containing list I or list II substances to be authorized. The authorizations had laid down emission limit values for these substances. Under the Directive emission limit values and quality objectives were fixed for 17 substances, 'taking into account the best technical means available'. For the list II substances Member States have to establish programmes in order to reduce water pollution, and set timetables for their implementation. The programmes had to include quality objectives for water, and individual authorizations had to be issued in such a way that these quality objectives shall be respected.

Principles and requirements of Urban Wastewater Treatment Directive

The UWWTD **concerns** collection, treatment and discharge of urban wastewater from agglomerations and **aims** to protect the environment from being adversely affected by the disposal of insufficiently treated urban wastewater and discharges of wastewater from food-processing industries.

The Directive **applies**: (a) to all agglomerations having the organic load of more than 2000 population equivalent (p.e.);¹ (b) to agglomerations with less than 2000 p.e. having collecting systems in place; and (c) to food-processing industries having the load of more than 4000 p.e. and discharging treated wastewater directly to receiving waters.

The requirements for treatment level are defined depending on the **agglomeration size** and type of receiving water body where treated wastewater is discharged.

Types of wastewater covered by the Directive are urban, domestic, and industrial wastewater:

- Urban wastewater means domestic wastewater or the mixture of domestic wastewater with industrial wastewater and/or run-off rain water.
- Domestic wastewater means wastewater from residential settlements and services which originates predominantly from the human metabolism and from household activities.
- Industrial wastewater means any wastewater, which is discharged from premises used for carrying on any trade or industry, other than domestic wastewater and run-off rainwater.

Four main principal obligations are laid down in the directive: **planning; regulation; monitoring; and information and reporting.**

The planning aspect requires:

- To designate sensitive areas (sensitive water bodies) in accordance with three specific criteria, and to review their designation every 4 years; to identify relevant hydrologic catchment area of this sensitive area, and to ensure that all discharges from agglomerations with more than 10 000 p.e. located in sensitive area and their catchment shall have more stringent treatment (containing nutrients removal) in place.

Surface water body shall be designated as sensitive if it falls into one of the following groups:

- it is eutrophic or in the nearest future may become eutrophic if protective action is not taken;
 - it is intended for abstraction of drinking water;
 - where further treatment than secondary is necessary to fulfil other Council Directives.
- Less sensitive areas (as an option) can also be specified according to certain criteria.

¹ According to Article 2(6) of the UWWTD, '1 p.e. means the organic biodegradable load having five day biochemical oxygen demand (BOD5) of 60 g of oxygen per day'.

- To establish a technical and financial programme for the implementation of the Directive for construction of sewage networks and wastewater treatment plants addressing treatment objectives within the deadlines set up by the Directive.

Regulation requires ensuring that:

- All urban wastewater generated in agglomerations discharging into urban sewer systems and treatment plants have prior regulation or specific authorization.
- Industrial wastewater discharging into urban sewage networks is based on prior regulation and/or specific authorization; pretreatment requirements, ensuring that:
 - (a) treatment plant operation and sludge treatment will not be impeded;
 - (b) it will be no adverse effect to the environment (including receiving waters); and
 - (c) safe disposal of sewage sludge.
- Food-processing industries have prior regulation and/or specific authorization and permit system.
- All urban wastewater generated in agglomerations with more than 2000 p.e. are supplied with collecting systems, and the capacity of those is such that it ensures to collect all urban wastewater taking into account normal local climatic conditions and seasonal variations.
- National authorities are taking measures in relation to collecting systems to limit pollution of receiving waters from storm water overflows under unusual situations, such as heavy rain.
- Wastewater treatment is provided for all these agglomerations, at the level of treatment specified and within the required deadline:
 - The basic rule for the level of treatment is secondary (i.e. biological) and more stringent treatment in sensitive areas (i.e. with nutrient removal in particular and other pollutant affecting the quality of specific use of the receiving water).
 - For certain discharges in coastal waters treatment might be less stringent, i.e. primary, under specific conditions and subject to agreement of the Commission.
 - For agglomerations with population equivalent of less than 2000 but equipped with collecting system, ‘appropriate treatment’ has to be provided, i.e. treatment that ensures to meet the relevant quality objectives of the receiving waters.
- Technical requirements on design, construction, operation and maintenance for wastewater treatment plants treating urban wastewater are maintained ensuring adequate capacity of the plant and treatment of urban wastewater generated in agglomeration taking into account normal local climatic conditions and seasonal variations.
- Environment is protected from adverse effects of the discharge of wastewater.

- Environmentally and technically sound reuse or disposal of sewage sludge is subject to general rules, registration or authorization, and requirements of specific inter-linked directives for agricultural reuse (86/278/EEC), incineration (89/429/EEC and 89/369/EEC), and landfill (99/31/EC), are respected. The disposal of sludge to surface waters is banned.

Monitoring requires ensuring that:

- appropriate monitoring capacity of parameters to be monitored;
- proper analysis of samples by using standard methods;
- timely frequency of monitoring for:
 - monitoring of discharges from urban wastewater treatment plants; and
 - monitoring of waters receiving those discharges.

Information and reporting requires ensuring that:

- Adequate cooperation and exchange of information with other member states in cases where discharges of wastewater have a transboundary effect on water quality of shared waters.
- Adequate reporting procedure and databases for the requests from the Commission for information on:
 - transposition of the directive into national legislation, implementation programmes, situation reports on the disposal and reuse of urban wastewater and sewage sludge;
 - status of collecting systems, efficiency of treatment plants (i.e. treatment level and monitoring results) and water quality of receiving waters;
 - status of discharges from food-processing industry to surface waters.
- That the public has access to relevant information and that relevant authorities of member states every 2 years will publish status reports to the public on the status of wastewater collection and treatment and disposal or reuse of sludge.

The Directive is based on a number of **principles** that have been laid down in the Treaty of the European Union, such as precautionary, nondeterioration, sustainable use of water resources, and principle of subsidiary. The implementation of the Directive should not result in deterioration of the current level of environmental protection offered by the member states. Furthermore, the level of protection may be even stricter than the Directive requires in case there is a need to fight deterioration of quality of receiving water bodies and to try to restore waters affected by wastewater discharges.

Parameters and parametric values in the Urban Wastewater Treatment Directive

The Directive **regulates the main conventional pollutants** in treated wastewater discharges from treatment plants. These are: total suspended solids, chemical oxygen demand, biochemical oxygen demand, total nitrogen and total phosphorus. However, other parameters shall also be considered especially when making the assessment of receiving waters to designate sensitive areas and to achieve water quality objectives of water bodies.

The Directive sets up emission limit values for the above-mentioned parameters or by showing treatment efficiency (calculating it through incoming and outgoing pollution load of each regulated parameter). Either the concentration of a pollutant at the discharge point or the reduction rate of pollution load shall apply.

The Directive sets up a general requirement for:

- Treated urban wastewater reuse to ensure that there will be no adverse effect to the environment. However, there are no detailed regulations on treated wastewater quality for the purposes of its reuse for various economic activities.
- The usage of sewage sludge indicating that it shall be re-used whenever appropriate having no adverse affect on the environment.

However, there are no precise provisions in this Directive on setting emission limit values or quality standards to be achieved when having activities of the reuse of these end-products from wastewater treatment process. These two aspects are partly or indirectly regulated by the other EU pieces of legislation.

Sampling and monitoring

The Directive requires establishing a monitoring and inspection programme for compliance assessment of discharges from urban wastewater treatment plants and for assessing the amounts and composition of sludge.

The Directive defines minimum monitoring requirements for treated wastewater by setting sampling frequency, which is dependent on the size of urban wastewater treatment plant. The maximum number of noncomplying samples is also defined in the Directive.

The Directive also defines the standard laboratory methods to be used for the analysis of the samples.

Quality control and assurance

Member States have to ensure laboratory capacities, and laboratories must use the methods specified in the Directive Annex I and to be subject to regular quality

control. Accreditation schemes for laboratories are the means of constantly ensuring quality control. Quality control is restricted to the analytical laboratory methods to be used for the analysis of samples. Member States need to have some quality control system in place in the approved laboratories for wastewater analyses.

Taking into account the principle of subsidiary, Member States have a duty to organize and self-control the Directive implementation by setting adequate urban wastewater collection systems and treatment facilities as well as controlling wastewater pollution level through monitoring of urban wastewater against Directive requirements.

The control of annual monitoring results of treated urban wastewater is a duty of Member States to check against the Directive requirements. The data shall be stored in the Member State to analyse trends and impact of discharged wastewater to the environment and to ensure the reporting of the results to the Commission to check the implementation status. Member States have to provide requested data within the deadline of 6 months.

1.1.1.3 Other Related Legislation on Other Types of Wastewater Except Urban

Implementation of the main UWWT Directive is closely linked with other EU legislation, in particular:

- Water Framework Directive 2000/60/EC;
- Nitrates Directive 91/676/EEC;
- Integrated Pollution Prevention and Control Directive 96/91/EC;
- Dangerous Substances Directive 76/464/EEC and its seven daughter directives;
- Sewage Sludge Directive 86/278/EEC;
- Landfill Directive 99/31/EC;
- Incineration Directives 89/429/EEC and 89/369/EEC;
- Environmental Impact Assessment Directive 85/337/EEC;
- Directive on Access to Environmental Information 90/313/EEC;
- Reporting Directive 91/692/EEC and Decision 94/741/EEC;

Particularly relevant issues in these directives concern:

- The provisions under UWWTD are the integral part of basic measures in the programme of measures to be included into river basin management plans under

WFD, without any change of deadlines set under UWWTD for the EU-15 and in line with the transitional periods set up in the Accession Treaty for the EU-10.

- The provision of adequate facilities for either incineration or landfill of sewage sludge.
- The quality requirements for sewage sludge used in agriculture.
- Certain size large installations of food-processing industries covered by UWWTD also fall under requirements of the IPPCD (i.e. for some installations the requirements of both directives overlap). It should be borne in mind that IPPC Directive sets requirements for application of a combined approach (as the WFD does) of emission controls and water quality standards. In each particular case the more stringent approach (setting more stringent treatment standards for wastewater) to reach certain water quality objectives applies.

Integration of EU water legislation does not only imply compliance to the requirements of various related directives but will also involve harmonization and streamlining of monitoring and reporting requirements. Reporting requirements will have to address compliance and the state of, and trends in, the quality of aquatic environment through implementing prevention measures – decrease generation of wastewater at the source, sustainable management of water resources as well as when wastewater is generated – ensuring the adequate required wastewater treatment. The process on harmonization of reporting has been started with the concept and the ambitious goal to have an integrated reporting system in Europe, the so-called Water Information System for Europe (WISE).

1.1.1.4 Conclusions

It should be underlined that the implementation of the UWWTD ranks amongst the most challenging and expensive tasks throughout the range of EU legislation. This is why early and careful consideration of the environmental and technical aspects of the Directive is of significant importance.

Much of the environmental legislation in the EU is interrelated, both within a specific sector (e.g. water sector) and between sectors. Consequently, individual Community legal acts cannot be implemented in isolation. For example, implementation of UWWTD 91/271/EEC in advance of another directive can lead to environmental problems, e.g. increased volumes of sewage sludge which then need to be disposed of in accordance with Waste Framework Directive 75/442/EEC. Furthermore, the main measures to implement the UWWTD are one of the main components of the Programme of measures of River basin management plans required by the Water Framework Directive. However, complete implementation of UWWTD is only a minimum requirement to achieve good ecological status of surface waters required by the WFD 2000/60/EC.

The EU regulation on urban wastewater treatment has contributed significantly to the improvement and regulation of wastewater treatment and improvement of quality of discharges of wastewater into receiving waters and has contributed to fighting the pollution at the source and the improvement of quality of surface waters. It is expected that the underlying principles of the UWWTD will be further strengthened and improved when implementing the WFD and by using an integrated approach. Extending the control of wastewater discharges from end-of-pipe to using an integrated approach and meeting water quality standards and objectives to achieve good ecological status of surface waters, boosts the confidence of European citizens concerning the safety and wholesomeness of the use of surface waters for various needs. Close cooperation between the European Commission and Member States is a prerequisite to achieve this target.

1.1.2 URBAN WASTEWATER TREATMENT REGULATION IN THE UNITED STATES

1.1.2.1 Introduction

The main regulatory basis to deal with water pollution control in the United States is the Federal Water Pollution Control Act (FWPCA), known as the Clean Water Act (CWA). It is a comprehensive statute aimed to restore and maintain chemical, physical and biological integrity of the US waters. Enacted originally in 1948, the Act was amended numerous times until it was reorganized and expanded in 1972. The CWA is part of the US main legislation included in the Code of Federal Regulation (CFR) on 18 October 1972 and forms Title 33 of this Code; it continues to be amended almost every year (Deketelaer and Gekiere, 2002).

As authorized by the CWA, the National Pollutant Discharge Elimination System (NPDES) permit programme controls water pollution by regulating point sources that discharge pollutants into waters of the US. Since its introduction in 1972, the NPDES permit programme has been responsible for significant improvements in quality in the water bodies in the US (<http://cfpub.epa.gov/npdes/>).

1.1.2.2 Development of Urban Wastewater Treatment Regulations

History of the Clean Water Act

The CWA is a law that establishes **environmental programmes**, including the NPDES programme (introduced in 1972) to protect US waters and directs the Environmental Protection Agency (EPA) to issue rules on how to implement this law. The Act does not deal directly with ground water nor with water quantity issues. The statute employs a variety of regulatory and nonregulatory tools to reduce direct

pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff.

For many years after reorganization of the CWA in 1972, the EPA, states, and Indian tribes focused mainly on chemical aspects of water quality. During the last few decades, however, more attention has been given to physical and biological parameters. In the early decades of the Act's implementation, efforts focused on regulating discharges from traditional point sources, such as municipal sewage plants and industrial facilities, with little attention paid to runoff from streets, construction sites, farms, and other 'wet-weather' sources.

Starting from late 1980s, efforts have been concentrated to address and regulate nonpoint sources of pollution and 'wet weather point sources' (like urban storm sewer systems and construction sites).

Evolution of CWA programmes over the last decade has also included a shift from a programme-by-programme, source-by-source, pollutant-by-pollutant approach to watershed-based strategies by using an integrated approach on protecting water bodies.

The Act established **the basic structure for regulating discharges of pollutants into the water bodies** of the US. It gave the EPA the authority to implement pollution control programmes such as setting wastewater standards for industry. The CWA also set up **water quality standards for all contaminants in surface waters**. The Act prohibits discharging any pollutant from a point source into navigable waters without a permit. It also regulates funding of the construction of sewage treatment plants under the construction grants programme.

The current version of the CWA consists of six main titles (International, EC and US Environmental Law; Sands, 2002; Kramer 2003):

- Title I – Research and Related Programmes (Sections 1251–1271 of 33 US CFR, 18 October 1972).
- Title II – Grants for Construction of Treatment Works (Sections 1281–1299).
- Title III – Standards and Enforcement (Sections 1311–1330).
- Title IV – Permits and Licenses (Sections 1341–1345).
- Title V – General Provisions (Sections 1361–1377).
- Title VI – State Water Pollution Control Revolving Funds (Sections 1381–1387).

National Pollutant Discharge Elimination System (NPDES)

The NPDES permit programme **aims** to control water pollution by regulating point source discharges and is **based on** statutory requirements contained in the CWA and regulatory requirements contained in the NPDES regulations.

The NPDES permit system consists of a number of programmes and initiatives and is based on water quality and technology-based permitting regulations.

Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit. In most cases, the NPDES permit programme is administered by authorized states.

The US EPA Water Permits Division (WPD) of the Office of Wastewater Management (OWM) leads and manages the NPDES permit programme in partnership with 10 EPA regional offices, states, tribes, and other stakeholders.

Total Maximum Daily Loads

Following the integrated approach to the management of water resources, the watershed-based NPDES permitting system is also used in the US. One of the basic elements of this system is a total maximum daily load (TMDL) calculation methodology – a tool for implementing water quality standards, which is based on the relationship between pollution sources and in-stream water quality conditions. The TMDL establishes the allowable loading of pollutants to a water body and provides the basis to establish water quality-based controls. These controls should provide the pollution reduction necessary for a water body to meet water quality standards.

Implementation and control bodies

The primary authority for the implementation and enforcement of the CWA and controlling water pollution in the US is the EPA of OWM together with 10 regional EPAs. Their main responsibility is to promote effective and responsible water use, treatment, disposal and management and to encourage the protection and restoration of the catchments of surface water bodies (<http://www.epa.gov/owm/>; <http://ipl.unm.edu/cwl/fedbook/fwpc.html>).

The US EPA OWM WPD in partnership with EPA regional offices, states, tribes, and other stakeholders leads and manages the NPDES permit programme and ensures its effective implementation. It also regulate discharges from point sources (including pipes, ditches, and sanitary or storm sewers) into surface waters such as wetlands, lakes, rivers, estuaries, bays and oceans. The US EPA OWM is also responsible for management of the Clean Water State Revolving Fund, the largest water quality funding source, focused on funding wastewater treatment systems, nonpoint source projects and estuary protection (<http://www.epa.gov/owm/>).

If changes to the NPDES regulations are needed, then EPA issues (proposed and final) rules related to the NPDES permit programme. When making changes to the NPDES regulations, EPA first develops a proposed rule and provides it in the Federal Register for public review and comment. After receiving public comments, EPA develops a final regulation and publishes it in the Federal Register. Once each

year, all final federal rules are compiled into a document called the Code of Federal Regulations (<http://www.epa.gov/waterscience/guide/>).

1.1.2.3 Highlights of Federal Water Pollution Control Act (Clean Water Act)

The objectives of the CWA are to restore and maintain the chemical, physical and biological integrity of the US waters.

Even prior to the enactment of the 1972 version of the CWA, the Act authorized a number of actions, for example, the action to prepare comprehensive programmes for eliminating and reducing the pollution of interstate waters and tributaries and improving sanitary condition of surface and groundwater (CWA, Sections 1251–1252).

The Act authorizes water quality programmes, requires federal effluent limitations and state water quality standards and permits for the discharge of pollutants into navigable waters, provides enforcement mechanisms, and authorizes funding for wastewater treatment works construction grants and state revolving loan programmes, as well as funding of states' and tribes' water quality programmes. Provisions also address water quality problems in specific regions and specific waterways.

Title II 'Grants for Construction of Treatment Works' of the CWA deals with the **regulation of wastewater treatment management plans and grants**. The Act requires development and implementation of the wastewater treatment management plans and practices using best practicable technology before they discharge pollutants into receiving waters. The confined disposal/discharges of pollution should be so that they will not migrate to cause water and other environmental pollution. It also requires identification of areas with substantial water quality control problems. Furthermore, no NPDES permit may be issued which is in conflict with an approved plan. The Act outlines a programme of grants to state, municipalities or intermunicipal or interstate agencies for the construction of publicly owned treatment works (POTWs).

Title III 'Standards and Enforcement' of the Act deals with **regulation of emission limit values and water quality standards**. The Act prohibits discharge of pollutants except in compliance with emission limit values and other provisions of the Act. Effluent limitations from point sources other than POTWs must be treated using best practicable control technology. Toxic pollutants, defined and otherwise described in the Act, require treatment using the best available technology, which is economically achievable. If it is discharged into POWTs, it must comply with applicable pretreatment requirements. The Act makes it unlawful to discharge any radiological, chemical, or biological warfare agent, any high-level radioactive waste, or any medical waste into navigable waters.

Effluent limitations must be determined for point sources, which are consistent with state water quality standards, including toxic and pretreatment standards. The Act requires establishing procedures to assure water quality standards, developing

guidelines to identify and evaluate the extent of nonpoint source pollution, and setting water quality inventory requirements. The Act also requires the EPA to develop national standards of performance for the control of discharge of pollutants from new sources.

When discharges of pollutants from a point source or group of point sources under established emission limit values would have an adverse effect on the receiving water body or on maintenance of water quality necessary to assure protection of public health, public water supplies, agricultural and industrial uses, and the protection and propagation of a balanced population of shellfish, fish and wildlife, and allow recreational activities in and on the water, the EPA must establish emission limit values for the point source or sources which can reasonably be expected to contribute to the attainment or maintenance of water quality (CWA, Sections 1311, 1312, 1314, 1316, 1317).

Continuing public information and education **programmes on recycling and reuse of wastewater (including sludge)** are also required under CWA (Section 1294).

The state must establish a TMDL for those pollutants suitable for maximum daily measurements (CWA, Sections 1311, 1313, 1315). States must identify waters for which controls on thermal discharges are not stringent enough to assure protection and propagation of a balanced indigenous population of shellfish, fish and wildlife. The Act imposes **requirements for storage of monitoring results and reporting requirements, and allows for inspections**. The states must report on their water quality biennially. It also contains extensive provisions on enforcement, with administrative, civil and criminal penalties available for violations (CWA, Sections 1318–1319). The institutional entities which are planning to have discharges of wastewater into water bodies are subject to certification and must obtain federal permits or licenses in order to assure that it will not violate applicable effluent limitations and water quality standards (CWA, Section 1341).

Title IV ‘Permits and Licenses’ of the Act deals with regulation of permitting systems of wastewater discharges based on the NPDES. According to the NPDES, all industrial sources and publicly owned treatment works must have a permit to discharge pollutants into navigable waters. Discharge must meet the requirements outlined extensively in the CWA and meet federal emission limit values and state water quality standards. The state has to administer its own permit programme in line with the federal programme. The Act also sets up **special provisions on municipal and industrial storm water discharges** (CWA, Section 1342). Discharge permits also comply with the guidelines for determining the degradation level of the waters of the territorial seas, the contiguous zone and the oceans. The guidelines include, for example, the effect of disposal of pollutants on human health or welfare; on marine life, changes in marine ecosystem diversity, productivity and stability, or species and community population changes; the effect of pollutants on aesthetic, recreational and economic values, etc.

The EPA is authorized to prohibit the use of a site for disposal of dredged or fill material in navigable waters if discharges would have an adverse effect on municipal