MUNICIPAL EFFLUENT DISPOSAL STANDARDS

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Keywords: Municipal effluent, Disposal standards, Water quality criteria, Technology-based effluent regulations

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Summary

Municipal wastewater is one of the principal causes of water pollution in the world. Since stringent effluent limitations set by regulatory authorities can have a major impact on the local communities, a prudent regulatory decision on the needed levels of wastewater treatment is vital to countries where wastewater treatment may not be economically affordable. The objectives of the regulatory requirements must be clearly defined and implementable. The purpose of this chapter is to provide a basic understanding of effluent disposal standards.

In general, effluent limitations or standards are developed based on either technology-based standards or water quality standards. A technology-based standard is simply a minimum level of technology and pollution control performance that must be achieved by municipal wastewater treatment plants. However, it does not imply that dischargers should use state-of-the-art pollution control technology. In some developing countries, primary treatment or less than secondary treatment may be reasonable for certain water-bodies at this time since affordability can be an issue. Technology-based standards should also be independent of water quality standards that are designed to protect public water supplies and /or highly valued natural resources. A water quality-based limit is according to the water quality standards applicable to the receiving water, which is more stringent than technology-based standards. In the USA a technology-based standard for municipalities is secondary treatment which is the minimum standard independent of water quality standards. However, for water quality-limited streams, effluent limitations based on water quality standards are developed for each discharger using simple or complex water quality models depending

on the characteristics of the receiving water-bodies.

There are some variations among countries relative to effluent disposal limitations and requirements according to the condition of water quality, designated water uses, extent of water pollution degree and other institutional, legal and political reasons. However, there are common pollutants to be concerned about and they include suspended solids, organic matter, bacteria and nutrients. Unfortunately, the treatment levels for removing these pollutants vary depending on the desired effluent quality, which means the costs of the construction and operation and maintenance of wastewater treatment plants can become a major issue to many communities, especially in developing countries.

Effluent disposal standards have played a key role in controlling pollution discharges since the early 1970s in developed countries. Strict regulations of wastewater disposal have led these countries to a stage with only limited conventional water pollution problems. Effluent standards and regulations are currently designed towards the control of micro-pollutants, the impact of pollutants in sensitive areas or the pollution caused by the drainage of storm water. To control toxic chemicals entering municipal wastewater treatment plants from industrial facilities, an effective and enforceable industrial pretreatment program must be implemented. In addition, pollution prevention or cleaner production program should be an integral part of these industries. Developing countries, however, are under a constant and significant pressure to follow the international trends of frequently lowering the concentration limits, meanwhile being unable to reverse the continuous trend of environmental degradation.

1. Introduction

Adequate sanitation is vital to a healthy society. To protect public health and environment, human wastes must be properly collected, treated and disposed of. The level of wastewater treatment needed depends on the method of disposal which can be broadly classified into two categories, namely, surface water discharge and land application. Disposal to surface water-bodies, such as rivers, lakes, estuaries and oceans, is by far the most common approach in the world. A land application system refers to wastewater applied to land, and drains naturally to groundwater or surface waters. The scope of this chapter is to address surface water discharge only. In general, two types of effluent limitations for municipalities are set by regulatory agencies: technology-based standards (or effluent discharge standards used in some countries) and water quality-based limits (or in-stream standards or environmental standards in some countries). A technology-based standard is simply a minimum level of technology and pollution control performance that must be achieved by municipal wastewater treatment plants. A water quality-based limit is based on the water quality standards applicable to the receiving water, which is more stringent than technology-based standards. This limit may be necessary to protect a water body's designated uses (e.g., contact recreation and aquatic life), by which the discharged effluents are then regulated so as not to exceed the assimilative capacity of the receiving waters.

Different countries may have different systems and standards to implement effluent disposal standards. In the USA under the National Pollutant Discharge Elimination System (NPDES) of the Clean Water Act of 1972, all point sources must have a permit for discharge into waters of the United States. The 1972 Clean Water Act, and subsequent reauthorization of the Act through 1987, has mandated national polices to restore and maintain the integrity of the nation's water quality to meet specific goals and objectives. Based on these goals, designated beneficial uses and water quality standards have been established to support aquatic life and protect the quality of surface waters for human consumption. Typical beneficial uses include recreation, agriculture, fishery, public water supply and navigation. In the European Union (EU), a Water Directive has been developed to regulate dischargers to the surface waters, by which the waters are classified into three classes, i.e., sensitive, normal and less sensitive. Different waters are subject to different minimum requirements of treatment for municipal wastewater and thus different standards of enforcement. Generally, standards for sensitive waters, which are subject to eutrophication and require restriction of the concentrations of total phosphorus (TP) and total nitrogen (TN), are more stringent than other discharges. For less sensitive waters, there are requirements for chemical oxygen demand (COD) without pH. Typical less sensitive areas may include open bays, estuaries and other coastal waters with a good water exchange and not subject to eutrophication or oxygen depletion or which are unlikely to become eutrophic or to develop oxygen depletion due to the discharge of municipal wastewater.

In Japan, the Water Pollution Control Law was enacted in 1971 to control water discharges from industries and businesses to public waters in response to the growing threat of pollution to human health and environment. In addition, specific regulations, with focus on different receiving water-bodies (e.g., lakes, coastal seas and groundwater) and pollutants (toxic substances and nutrients), were subsequently developed to reflect the requirements of water quality control. Through this law, national effluent disposal standards were established and prefectures were authorized to set more stringent ones when necessary in order to regulate wastewater discharged from factories and business establishments into public water bodies. Later, a wide range of total pollutant load control programs was also introduced to further reduce pollution discharges to enclosed water bodies including lake, reservoirs, narrow bays and semi-enclosed seas.

2. The Regulation of Conventional Pollutants

Although effluent disposal standards may vary from country to country, some may even be established by the jurisdiction of local regulatory agencies, the basic conventional pollutants are the same which include suspended solids, organic matter, bacteria and nutrients. Their quantities in the water-bodies indicate the degrees of pollution. Unfortunately, sometimes it is not economically feasible to simultaneously address all pollutants of concern because the costs of removal for these pollutants increase as the treatment level increases (e.g. primary, secondary, tertiary treatment, etc.). In developing countries, this problem could be addressed through plant upgrading in phases with a compliance schedule. The first phase could be primary treatment, which removes some organic matter and suspended solids. The second phase could be secondary treatment, which removes most of the organic matter and suspended solids. The final phase could be advanced treatment, which removes nutrients and toxic chemicals. A brief discussion of each conventional pollutant is presented in the following:

Suspended Solids-- Suspended solids, including oil, grease and floating solids are to be controlled in discharge because, they present an unsightly view, create sludge deposits and demand of oxygen in a water-body. They are also often found to be rich in heavy metals, toxic chemicals and sometimes phosphate due to adsorption.

Organic matter-- Degradable organic matter as measured by biochemical oxygen demand (BOD) or COD can impact water quality via deoxygenation which is caused by microorganisms that use the oxygen in water to breakdown organic matter. Its regulation has thus always been the primary concern in effluent disposal standards. Depending on the designated uses, in general, a minimum of 5.0 mg/l of dissolved oxygen must be maintained to provide a healthy aquatic environment. Since the early 1980s, organic pollution problems have been controlled and/or reduced in most of the developed countries due to required treatment of wastewater prior to discharge. However, in many developing countries organic pollution is still a serious problem due either to lack of wastewater treatment facilities or to improper operation and maintenance of wastewater treatment plants owing to inadequate funding.

Bacteria-- Waterborne infectious diseases are a health concern when the receiving water is employed as a water supply resource for bathing or water-contact sports, and the bacterial content, is measured by the number of coliform indicator organisms. Since municipal wastewaters may carry human pathogens excreted from infected individuals, disinfection is necessary to reduce transmission of infectious diseases when human contact is likely. Although the need for disinfection is site specific, in the USA disinfection is required for most of the municipal dischargers. Among different types of disinfection, chlorine has been the most popular disinfectant in the world. However, due to the toxicity of chlorine residuals injurious to aquatic life, in the USA a maximum admissible level of total residual chlorine is imposed on municipal dischargers when chlorination is employed. In some cases, dechlorination is required due to stringent chlorine residual limits. Depending on the water quality standards, the fecal coliform limits for municipal wastewater range from less than 2.2 colonies/100ml up to 5000 colonies/100 ml, with 200 colonies/100ml being the most common limit. In developing countries where wastewater disinfection may be too costly and not affordable, a seasonal disinfection requirement may be considered

Nutrients-- Excessive amount of nutrients (primarily nitrogen and phosphorus) into lakes, reservoirs, and streams can cause eutrophication. Municipal wastewater and runoff from agricultural fields and golf courses are some of the major nutrient sources due to human activities. A reduction of effluent nutrient content before discharge will be necessary if wastewater is the major source of pollution. In the EC Directive, for instance, there is a requirement for nutrient removal in sensitive water bodies, including those that (i) are found to be eutrophic or may become eutrophic if protective action is not taken; and (ii) are intended for the abstraction of drinking waters and could contain more than 50 mg/l of nitrates if action is not taken. Tables 1 and 2 list the required treatment levels according to its Articles 4 and 5 and Annex II. The "end of the pipe" treatment of nutrient removal is very costly which may involves a combination of biological, chemical and physical treatment. In the USA the number of municipal wastewater treatment plants with nutrient removal has steadily been increased since the 1980s. In some developing countries, nutrient removal from municipal wastewater could be considered as a long-term goal. However, there are pollution prevention activities that should be evaluated for controlling nutrients. For example, one of the phosphorus sources in municipal wastewater is phosphate detergents. In the USA up to 50% reduction of phosphorus in municipal wastewater has been observed following the bans on phosphate detergents. Currently there are more than 20 states in the USA that have banned phosphate detergents. Some EU member states also have taken the same action in order to control eutrophication problems. There are places in the world, where phosphorus pollution exists, and they are still using phosphate detergents partly due to public resistance to the relatively high costs associated with non-phosphate detergents and other factors. Since non-point sources such as agricultural runoff can contribute significant nutrients to the streams and lakes, it may not be appropriate to impose nutrient effluent limits on municipal dischargers, if the major contributors are in fact agricultural sources.

Parameters	**Concentration**	**Minimum Percentage of Reduction** [1]
Biochemical oxygen demand (BOD_5 at 20 °C) without nitrification [2]	25 mg/l	70-90 40 under Article 4 [2]
Chemical oxygen demand (COD)	125 mg/l	75
Total suspended solids	35 mg/l 35 under Article 4 [2] (more than 10000 p.e.) 60 under Article 4 [2] (2000-10000 p.e.)	90 [3] 90 under Article 4 [2] (more than 10000 p.e.) 70 under Article 4 [2] (2000-10000 p.e.)

Notes:

[1] Reduction in relation to the load of the influent.

[2] The parameter can be replaced by another parameter, i.e., the total organic carbon (TOC) or total oxygen demand (TOD) if a relationship can be established between BOD_5 and the substitute parameter.

[3] This requirement is optional. Analyses concerning discharges from lagoon shall be carried out on filtered samples; however, the concentration of total suspended solids in unfiltered water samples shall not exceed 150 mg/l.

Table 1: Requirements for discharges from all urban wastewater treatment plants in the EC Directive

Parameters	**Concentration**	**Minimum Percentage of Reduction** [1]
Total phosphorus	2 mg/l (10 000 - 100 000 p. e.) 1 mg/l (more than 100 000 p. e.)	80
Total nitrogen [2]	15 mg/l (10 000 - 100 000 p. e.) 10 mg/l (more than 100 000 p. e.) [3]	70-80

Notes:

[1] Reduction in relation to the load of the influent.

[2] Total nitrogen is the sum of total Kjeldahl-nitrogen (organic N + NH_3), nitrate (NO_3)-nitrogen and nitrite (NO_2)-nitrogen.

[3] Alternatively, the daily average must not exceed 20 mg/l. This requirement refers to a water temperature

of 12° C or more during the operation of the biological reactor of the wastewater treatment plant. As a substitute for the condition concerning the temperature, it is possible to apply a limited time of operation, which takes into account the regional climatic conditions. This alternative applies if it can be shown that paragraph 1 of Annex I.D is fulfilled (which have been adapted by 98/15/EEC).

Table 2: Requirements for discharges from urban wastewater treatment plants to sensitive areas that are subject to eutrophication

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Biographical Sketches

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