DEVELOPING INDUSTRIAL WATER POLLUTION CONTROL PROGRAMS

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A PRIMER

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Preface

IN recent years many books have been written on water pollution control. For the most part, however, these are designed for the environmental professional. The author felt that a basic description of industrial water pollution control would be useful to the management, legal, and regulatory professions. It is the intention of this volume to serve that purpose. For the reader interested in more in-depth material, a list of references is provided.

Introduction

OVER the past decade industrial water pollution control has undergone vast changes. Public Law 92-500 passed in 1972 primarily targeted conventional pollutants, such as biochemical oxygen demand (BOD) and suspended solids, and as a result, wastewater treatment plants were designed to meet these objectives. In recent years volatile organics, priority pollutants, aquatic toxicity, and toxicity in some heavy metals have received attention in specific industrial effluents.

In some cases nitrogen and phosphorus will have specific effluent limitations. If the wastewater contains volatile organics, such as benzene or toluene, these organics must be removed prior to biological treatment, or basins must be covered with off-gas treatment. The technology choice to meet these objectives in a cost-effective manner will be site specific. In 1976 EPA established effluent limitations for priority pollutants in the organic chemicals, plastics, and synthetic fiber industries (OCPSF). These are pollutant-specific guidelines expressed as an effluent concentration. Depending on the specific chemical involved, the biological treatment process or a source treatment technology may provide the most economical solution. Aquatic toxicity poses a major problem in industrial water pollution control. Because it is frequently nonspecific, it is difficult to identify appropriate cost-effective technologies. As a general rule, biological treatment should be the first option, with more costly physical chemical technologies employed only in those cases in which the toxicity-causing chemicals are nonbiodegradable.

It is important that heavy metals, if present, be removed prior to biological treatment. The reason for this is that metals will accumulate in the biological sludge, and as a result, retract ultimate disposal options.

Although the removal of nitrogen and phosphorus from municipal wastewaters is well understood, industrial wastewaters will frequently contain inhibiting chemicals. As a result, pretreatment may be required to achieve nitrification.

It is probably apparent that in most industrial wastewater applications a combination of waste minimization, water reuse and by-product recovery, and source treatment and end-of-pipe treatment must be evaluated to determine the most cost-effective solution for a specific application. Unlike municipal wastewater treatment, most solutions are site specific. This volume is not intended to solve specific problems but, rather, to offer the reader an approach to developing a cost-effective water pollution control program. A description of available technologies and their applications are presented. A list of references is provided for those who wish more engineering information on specific areas.

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CHAPTER 1

Water Quality Standards

WATER quality standards are usually based on one of two primary criteria: stream standards or effluent standards. Stream standards are based on dilution requirements for the receiving water quality based on a threshold value of specific pollutants or a beneficial use of the water. Effluent standards are based on the concentration of pollutants that can be discharged or on the degree of treatment required.

Stream standards are usually based on a system of classifying the water quality based on the intended use of the water.

Although stream standards are the most realistic in light of the use of the assimilative capacity of the receiving water, they are difficult to administer and control in an expanding industrial and urban area. The equitable allocation of pollutional loads for many industrial and municipal complexes also poses political and economic difficulties. A stream standard based on minimum dissolved oxygen at a low stream flow intuitively implies a minimum degree of treatment. One variation of stream standards is the specification of a maximum concentration of a pollutant (i.e., the BOD) in the stream after mixing at a specified low-flow condition.

Note that the maintenance of water quality and hence stream standards are not static but are subject to change with the municipal and industrial environment. For example, as the carbonaceous organic load is removed by treatment, the detrimental effect of nitrification in the receiving water increases. Eutrophication may also become a serious problem in some cases. These considerations require an upgrading of the required degree of treatment.

Effluent standards are based on the maximum concentration of a pollutant (mg/L) or the maximum load (lb/d) discharged to a receiving water. These Effluent guideline criteria (expressed as kilograms pollutant per unit of production) have been developed for each industrial category to be met by specified time periods.

The best practical technology (BPT) is defined as the level of treatment that has been proven to be successful for a specific industrial category and that is currently in full-scale operation. Sufficient data exist for this level of treatment so that it can be designed and operated to achieve a level of treatment consistently and with reliability. For example, in the pulp and paper industry, BPT has been defined as biological treatment using the aerated lagoon or the activated sludge process with appropriate pretreatment.

The best available technology (BAT) is defined as the level of treatment beyond BPT that has been proven feasible in laboratory and pilot studies and that is, in some cases, in full-scale operation. BAT in the pulp and paper industry may include processes, such as filtration, coagulation for color removal, and improved in-plant control to reduce the wasteload constituents.

In general, effluent guidelines are developed by considering an exemplary plant in a specific industrial category and multiplying the wastewater flow per unit production by the effluent quality attainable from the specified BPT process to obtain the effluent limitation in pounds or kilograms per unit of production. The effluent limitations consider both a maximum 30-day average and a 1-day maximum level. In general, the daily maximum is 2 to 3 times the 30-day average. For example, the average wastewater flow from an exemplary plant is 30,000 gal/ton of production, and the average effluent BOD is 30 mg/L.

The effluent limitation can then be computed:

$$30{,}000\ (\text{gal/ton}) \times (8.34 \times 10^{-6}) \times (30\ \text{mg/L}) = 7.5\ \text{lb/ton}$$

It is recognized that the wastewater volume and characteristics from a specific industrial category will depend on factors, such as plant age, size, raw materials used, and in-plant processing sequences.

The U.S. Environmental Protection Agency (EPA) has also developed pretreatment guidelines for those industrial plants that discharge into municipal sewer systems. In general, compatible pollutants, such as BOD, suspended solids, and coliform organisms, can be discharged if the municipal plant has the capability of treating these wastewaters to a satisfactory level. Noncompatible pollutants, such as grease and oil and heavy metals, must be pretreated to specified levels. Rigid limitations have been developed for the discharge of toxic substances to the nation's waterways.

In several cases, such as shellfish areas and aquatic reserves, the usual water quality parameters do not apply because they are nonspecific as to detrimental effects on aquatic life. For example, chemical oxygen demand (COD) is an overall measure of organic content, but it does not differentiate between toxic and nontoxic organics. In these cases, a species diversity index has been employed as related to either free-floating or benthic organisms. The index indicates the overall condition to the aquatic environment. It is related to the number of species in the sample. The higher the species diversity index, the more productive the aquatic system. The species diversity index $K_D = (S - 1)/\log_{10} l$, where S is the number of species, and l is the total number of individual organisms counted.

Regulations establishing effluent limitations guidelines, pretreatment standards, and new source performance standards for the organic chemicals, plastics, and synthetic fibers (OCPSF) were promulgated in 1987. In these regulations, specific organic chemicals are defined by the EPA as priority pollutants as shown in Table 1.

TABLE 1. EPA List of Organic Priority Pollutants.

Compound Name
1. Acenaphthene
2. Acrolein
3. Acrylonitrile
4. Benzene
5. Benzidine
6. Carbon tetrachloride (tetrachloromethane)
Chlorinated benzenes (other than dichlorobenzenes)
7. Chlorobenzene
8. 1,2,4-Trichlorobenzene
9. Hexachlorobenzene
Chlorinated ethanes (including 1,2-dichloroethane, 1,1,1-trichlorethane, and hexachloroethane)
10. 1,2-Dichloroethane
11. 1,1,1-Trichloroethane
12. Hexachloroethane
13. 1,1-Dichloroethane
14. 1,1,2-Trichloroethane
15. 1,1,2,2-Tetrachloroethane
16. Chloroethane (ethyl chloride)
Chloroalkyl ethers (chloromethly, chloroethyl, and mixed ethers)
17. Bis(chloromethyl) ether
18. Bis(2-chloroethyl) ether
19. 2-Chloroethyl vinyl ether (mixed)
Chlorinated napthalene
20. 2-Chloronapthalene
Chlorinated phenols (other than those listed elsewhere; includes trichlorophenols and chlorinated cresols)
21. 2,4,6-Trichlorophenol
22. *Para*-Chloro-*neta*-cresol
23. Chloroform (trichloromethane)
24. 2-Chlorophenol

(continued)

TABLE 1. (continued).

Compound Name
Dichlorobenzene
25. 1,2-Dichlorobenzene
26. 1,3-Dichlorobenzene
27. 1,4-Dichlorobenzene
Dichlorobenzidine
28. 3,3′-Dichlorobenzidine
Dichloroethylenes (1,1-dichloroethylene and 1,2-dichloroethylene)
29. 1,1-Dichloroethylene
30. 1,2-*trans*-Dichloroethylene
31. 2,4-Dichlorophenol
Dichloropropane and dichloropropene
32. 1,2-Dichloropropane
33. 1,2-Dichloropropylene (1,2-dichloropropene)
34. 2,4-Dimethylphenol
Dinitrotoluene
35. 2,4-Dinitrotoluene
36. 2,6-Dinitrotoluene
37. 1,2-Diphenylhydrazine
38. Ethylbenzene
39. Fluoranthene
Haloethers (other than those listed elsewhere)
40. 4-Chlorophenyl phenyl ether
41. 4-Bromophenyl phenyl ether
42. Bis (2-chloroisopropyl) ether
43. Bis (2-chloroethoxy) methane
Halomethanes (other than those listed elsewhere)
44. Methylene chloride (dichloromethane)
45. Methyl chloride (chloromethane)
46. Methyl bromide (bromomethane)
47. Bromoform (tribomoethane)
48. Dichlorobromomethane
49. Trichlorofluoromethane
50. Dichlorodifluoromethane
51. Chlorodibromomethane
52. Hexachlorobutadine
53. Hexachlorocyclopentadiene
54. Isophorone
55. Napthalene
56. Nitrobenzene

TABLE 1. (continued).

Compound Name
Nitrophenols (including 2,4-dinitrophenol and dinitrocresol)
57. 2-Nitrophenol
58. 4-Nitrophenol
59. 2,4-Dinitrophenol
60. 4,6-Dinitro-o-cresol
Nitrosamines
61. N-Nitrosodimethylamine
62. N-Nitrosodiphenylamine
63. N-Nitrosodi-n-propylamine
64. Pentachlorophenol
65. Phenol
Phthalate esters
66. Bis (2-ethylhexyl) phthalate
67. Butyl benzyl phthalate
68. Di-n-butyl phthalate
69. Di-n-octyl phthalate
70. Diethyl phthalate
71. Dimethyl phthalate
Polynuclear aromatic hydrocarbons (PAH)
72. Benzo(a) anthracene (1,2-benzanthracene)
73. Benzo(a) pyrene (3,4-benzopyrene)
74. 3,4-Benzofluoranthene
75. Benzo(k)fluoranthene (11,12-benzofluoranthene)
76. Chrysene
77. Acenaphthylene
78. Anthracene
79. Benzo(ghi)perylene (1,12-benzoperylene)
80. Fluorene
81. Phenanthrene
82. Dibenzo(a,h) anthracene (1,2,5,6-dibenzanthracene)
83. Indeno (1,2,3-cd) pyrene (2,3-o-phenylenepyrene)
84. Pyrene
85. Tetrachlorethylene
86. Toluene
87. Trichlorethylene
88. Vinyl chloride (chlorethylene)
Pesticides and metabolites
89. Aldrin
90. Dieldrin
91. Chlordane (technical mixture and metabolites)

(continued)

TABLE 1. (continued).

Compound Name
DDT and metabolites
92. 4,4-DDT
93. 4,4′-DDE (*p,p*′-DDX)
94. 4,4′-DDD (*p,p*′-TDE)
Endosulfan and metabolites
95. α-Endosulfan-alpha
96. β-Endosulfan-beta
97. Endosulfan sulfate
Endrin and metabolites
98. Endrin
99. Endrin aldehyde
Heptachlor and metabolites
100. Heptachlor
101. Heptachlor epoxide
Hexachlorocyclohexane (all isomers)
102. α-BHC-alpha
103. β-BHC-beta
104. χ-BHC (lindane)-gamma
105. δ-BHC-delta
Polychlorinated biphenyls (PCB)
106. PCB-1242 (Arochlor 1242)
107. PCB-1254 (Arochlor 1243)
108. PCB-1221 (Arochlor 1221)
109. PCB-1232 (Arochlor 1232)
110. PCB-1248 (Arochlor 1248)
111. PCB-1260 (Arochlor 1260)
112. PCB-1016 (Arochlor 1016)
113. Toxaphene
114. 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)

The chemicals are regulated as a concentration level in the effluent. In most cases, these levels are in the microgram per liter range.

Recent air pollution regulations limit the amount of volatile organic carbon (VOC) that can be discharged from wastewater treatment plants. Benzene is a particular case in which air emission controls are required if the concentration of benzene in the influent wastewater exceeds 10 mg/L.

The water quality criteria for various industrial uses are summarized in Table 2. The surface water quality criteria for public water supplies are as follows:

- Color should not exceed 75 units, and odors should be virtually absent.