TECHNOLOGIES THAT MOVE POLLUTANTS FROM ONE ENVIRONMENTAL COMPONENT TO ANOTHER: PHYSICAL METHODS

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Keywords: water pollution control, physical unit operations, screening, sedimentation, grit removal, flotation, filtration, flow metering, flow equalization, mixing, gas transfer

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Summary

In this chapter, the physical technologies most widely used in the field of water and wastewater treatment, which are normally known as unit operations, are introduced. These include (1) screening, (2) sedimentation, (3) grit removal chamber, (4) flotation, (5) filtration, and others such as (1) flow metering, (2) comminution, (3) flow equalization, (4) mixing, (5) gas transfer, etc. The definition for each unit operation, its basic pollutants removal mechanisms, its applications in water and wastewater treatment, and the main design information of some of them are discussed individually.

1. Introduction

Generally, those technologies used for removing the pollutants from wastewater in which change is brought about by means of or through the application of physical forces are known as unit operations or physical technologies. These technologies were originally derived from observations of the physical world, and they were the first treatment methods used in water and wastewater treatment. Today, physical unit operations form the basis of most process flow diagrams.

The physical technologies or unit operations most commonly used for removal of pollutants from wastewater include: (1) screening, (2) sedimentation, (3) grit removal chamber, (4) flotation, (5) filtration, etc. In this chapter, each unit operation mentioned above will be described, and the fundamentals involved in the engineering analysis of each will be discussed.

There are some other physical technologies commonly used in wastewater treatment, such as (1) flow metering, (2) comminution, (3) flow equalization, (4) mixing, (5) gas transfer, etc. But since these technologies are not directly used to remove pollutants from wastewater, they are normally used as just assistances to the treatment process; so we will just give a very brief introduction to each of them in this chapter.

The principal applications of these operations are summarized in Table 1.

Operation	**Application**
Screening	Removal of coarse and settleable solids by interception (surface straining)
Sedimentation	Removal of settleable solids and thickening of sludge
Flotation	Removal of finely divided suspended solids and particles with densities close to that of water. Also thickens biological sludge.
Filtration	Removal of fine residual suspended solids remaining after biological or chemical treatment.
Flow metering	Process control, process monitoring, and discharge reports
Flow equalization	Equalization of flow and mass loadings of BOD and suspended solids.
Comminution	Grinding of coarse solids to a more or less uniform size.
Mixing	Mixing chemicals and gases with wastewater, and maintaining solids in suspension.
Gas transfer	Addition and removal of gases.

Table 1: Applications of physical unit operations in wastewater treatment

2. Screening

A screen is a device with openings, generally of uniform size, that is used to retain the coarse solids found in wastewater, to protect the pipes and pumps behind in the treatment process. In most situations, screening is the first unit operation encountered in wastewater treatment plants.

The screening element may consist of parallel bars, rods or wires, grating, wire mesh, or perforated plate, and the openings may be of any shape but generally are circular or rectangular. A screen composed of parallel bars or rods is called a *bar rack* (sometimes called a *bar screen*). The materials removed by these devices are called as *screenings*. According to the method used for cleaning them, bar racks and screens are designated as manually cleaned or mechanically cleaned, and the removed materials are called manual screens and mechanical screens respectively. Typically, bar racks have clear openings (spaces between bars) of 15 mm or more. Screens have openings of less than 15 mm.

The main types of screening devices now in use in water and wastewater treatment plants are described briefly in Table 2.

Type of screening	Screening surface			Application
	Size classification	Size range (mm)	Screen material	
Bar rack	Coarse	15~40	Steel, Stainless-steel	Pretreatment
Screens:				
Inclined (Fixed)	Medium	0.25~2.5	Stainless-steel wedge-wire screen	Primary treatment
Inclined (Rotary)	Coarse	0.8×2.3×50	Milled bronze or copper plates	Pretreatment
Drum (Rotary)	Coarse	2.5~5.0	Stainless-steel wedge-wire screen	Pretreatment
	Medium	0.25~2.5	Stainless-steel wedge-wire screen	Primary treatment
	Fine	6~35μm	Stainless-steel and polyester screen cloth	Removal of residual secondary suspended solids
Rotary disk	Medium	0.25~10	Stainless-steel	Primary treatment
	Fine	0.025~0.5	Stainless-steel	Primary treatment
Centrifugal	Fine	0.05~0.5	Stainless-steel, polyester, and various other fabric screen cloths	Primary treatment, secondary treatment with settling tank, and the removal of residual secondary suspended solids

Table 2: Description of screening devices used in water and wastewater treatment

Screens and bar racks are normally located at intakes from rivers, lakes, and reservoirs for water treatment plants or at the wet well into which the main trunk sewer discharges for a wastewater treatment plant. They are also located before pumps in the storm water and wastewater lifting stations. They can remove coarse debris (such as rages, solids, and sticks), which may damage pumps or clog downstream pipes and channels. The spacing of the bars may be coarse, with 50-150 mm openings; medium, with 20-50 mm openings; or fine screens, with openings of 10mm or less.

To prevent the settling of coarse matter, the velocity in the approach channel to the screens should not be less than 0.6m/s. The ratio of the depth to width in the approach channel ranges from 1 to 2. The head loss through the screens is a function of the flow velocity and the openings in the screens. Screenings are generally collected and hauled away to an incinerator or landfill disposal site.

Screens for water treatment plants. When raw water is being withdrawn from the surface of a river, coarse screens (75mm or larger) are installed to prevent the intake of the small logs or other floating debris. For a submerged intake from a reservoir or lake, smaller coarse screens can be used. Screens at these intakes are usually not cleaned mechanically, and they are usually followed by other screens with smaller openings which are installed in the water treatment plant. The screens at the treatment plant may be mechanically or manually cleaned depending on the size of the openings and the quality of the raw water.

Quantities of screenings collected at water treatment installations are highly variable depending on the openings of the bars and screens, the raw water source, and even the different seasons in a year. Screenings may be washed back into the water body.

Screens for wastewater treatment plants. Coarse screens with openings from 50-150 mm are used ahead of raw wastewater pumps. Screens with smaller openings (25 mm) are suitable for most other devices or processes. A screen with smaller openings would be installed at the beginning of the treatment plant after the water is pumped from the trunk sewer or influent wet well, which are protected by coarse bar racks. At medium to large installations, mechanically cleaned screens are used to reduce labor costs, provide better flow conditions, and improve capture.

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Biographical Sketch

Jiane Zuo is an associate professor of environmental engineering at the Department of Environmental Science and Engineering, Tsinghua University, Beijing, China. He received his B. S. degree in environmental engineering from Tsinghua University in 1991, and his master and Ph. D. degree in environmental engineering from Tsinghua University simultaneously in 1996. His main research interests are in the area of wastewater biological treatment, anaerobic biotechnologies including UASB and EGSB reactors for high-strength organic wastewater treatment, anaerobic fermentative hydrogen production, cultivation and formation mechanisms of anaerobic granular sludge, anaerobic ammonia oxidation, anaerobic biodegradation of chlorinated organics, simultaneous nitrification and denitrification in a CAST reactor, cultivation of methanogenic granules at lower pH (~6.0) value, anaerobic population structures in granular sludge by using molecular tools including FISH, PCR and DGGE. He has authored or coauthored more than 40 technical publications and two reference books on anaerobic biotechnology. He has accomplished or is undertaking many Chinese national research projects in the area of wastewater treatment. He has been in charge of teaching of the course of "Wastewater Biological Treatment Engineering" for undergraduates in Tsinghua University since 1999.