

WASTEWATER ENGINEERING: AN OVERVIEW

Definition of wastewater

- Wastewater is defined as a combination of the liquid or water-carried wastes removed from residences, institutions, and commercial and industrial establishments, together with groundwater, surface water, and stormwater that may be present.

Goal of wastewater engineering

- The ultimate goal of wastewater engineering is the protection of public health in a manner commensurate with environmental, economic, social, and political concerns.

It is necessary to have knowledge of

1. Constituents of concern in wastewater
2. Impacts of the constituents
3. Transformation and long-term fate of the constituents
4. Treatment methods that can be used to remove or modify the constituents
5. Methods for beneficial use and disposal of solids

Treatment concept

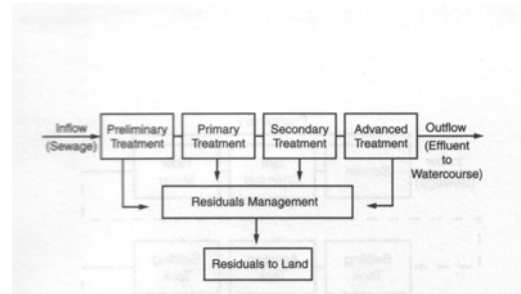
- Wastewater treatment facilities are designed to speed up the natural purification process that occurs in natural waters and to remove contaminants in wastewater that might otherwise interfere with the natural process in the receiving waters

Wastewater treatment systems

- Wastewater contains varying quantities of suspended and floating solids, organic matter, and fragments of debris
- Conventional wastewater treatment systems are combinations of physical, biological and sometimes chemical processes to remove these impurities

Treatment types

- Preliminary treatment
- Primary treatment (physical process)
- Secondary treatment (biological process)
- Tertiary or advanced treatment (combination of physical, chemical and biological process)



Wastewater Treatment Plant Design, 1993, Ed. Vesilind

Preliminary treatment goal

- Preliminary systems are designed to remove or cut up the larger suspended and floating materials, and to remove the heavy inorganic solids and excessive amounts of oil and grease
- The purpose is to protect pumping equipment and the subsequent treatment units

Preliminary treatment systems

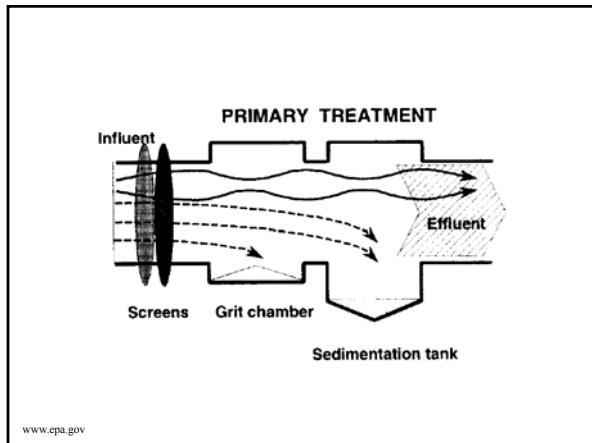
- Flow measurement devices and regulators
- Racks and screens
- Comminuting devices (grinders, cutters, and shredders)
- Flow equalization
- Grit chambers
- Pre-aeration tanks





Primary treatment systems

- The object of primary treatment is to reduce the flow velocity of the wastewater sufficiently to permit suspended solids to settle
- Floating materials are also removed by skimming



Primary clarification

- Primary clarification is achieved in large sedimentation basins
- The settled solids are collected by mechanical scrapers into a hopper and pumped to a sludge treatment unit
- Fats, oils, greases and other floating matter are skimmed off from the basin surface



Settling tanks

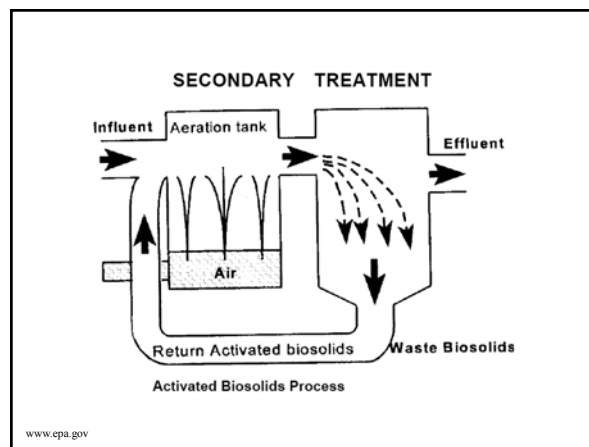
- Plain sedimentation
- Two story tanks
- Upflow clarifiers
- Septic tanks

Sedimentation removal efficiency

- 50-70 percent of TSS
- 25-35 percent of BOD₅
- 80-90 percent TSS with coagulants
- 10 percent of phosphorus

Secondary treatment systems

- After primary treatment, the wastewater still contains organic matter in suspended, colloidal and dissolved states
- Secondary treatment removes the soluble and colloidal organic matter using mainly biological processes



Biological treatment

- Biological treatment consists of application of a controlled natural process in which a very large number of microorganisms consume soluble and organic matter over a reasonable time

Secondary treatment processes

- Attached growth (trickling filters, rotating biological contactors, intermittent sand filters)
- Suspended growth (activated sludge, contact stabilization tanks, sequencing batch reactors, aerobic and anaerobic digesters, anaerobic filters, stabilization ponds and aerated lagoons)



Removal efficiency

- Secondary treatment processes may remove more than 85 percent of BOD₅ and TSS
- However, they are not effective for the removal of nutrients (N and P), heavy metals, nonbiodegradable organic matter, bacteria, viruses, and other microorganisms

Advanced treatment

- Advanced water treatment is defined as the methods and processes that remove more contaminants from wastewater than the conventional treatment
- Since 1970's, the use of advanced wastewater treatment facilities has increased significantly in North America

Advanced treatment goal

- The goal is to remove nitrogen, phosphorus, and suspended solids (including BOD₅) and to meet certain regulations for specific conditions
- There are strict rules and regulations regarding the removal of SS, organic matter, nutrients, specific organic compounds, and refractory organics that cannot be achieved by conventional secondary treatment

Advanced processes

- Chemical coagulation of wastewater
- Wedge-wire screens
- Granular media filters
- Diatomaceous earth filters
- Microscreening
- Ultrafiltration and nanofiltration

Nutrient control

- Nitrogen control – biological assimilation, nitrification, denitrification, ion exchange, breakpoint chlorination, and air stripping
- Phosphorus removal – chemical precipitation or biological uptake, reverse osmosis, ultrafiltration, oxidation ditch, Bardenpho process, anaerobic/oxidation (A/O) process

Toxic compounds and refractory organics

- Removal of some groups of toxic compounds and refractory organics can be achieved by activated carbon adsorption, air stripping, activated sludge, powder activated carbon processes and chemical oxidation
- Conventional primary and secondary treatment processes may also be used

Previous Canadian Water Quality Guidelines

- The federal Department of Health and Welfare developed **unenforceable guidelines**, and the provinces were free to determine whether the guidelines are adopted.
- Canadian guidelines specified MAC or IMAC

Wastewater Systems Effluent Regulations

- The Wastewater Systems Effluent Regulation was published in the Canada Gazette Part II on July 18, 2012
- The regulation establishes minimum treatment across the Canada
- The regulation will apply to systems designed or collecting and average daily volume of 100 m³ or more influent per year

New requirements

- The average carbonaceous biochemical oxygen demand (CBOD) ≤ 25 mg/L
- The average concentration of suspended solids (TSS) ≤ 25 mg/L
- The average concentration of total residual chlorine ≤ 0.02 mg/L
- Maximum concentration of unionized ammonia in the effluent ≤ 1.25 mg/L

Standards in other places

- US federal standards – BOD 30 mg/L and TSS 30 mg/L for secondary effluent
- Illinois – BOD 20 mg/L, TSS 25 mg/L
- EU – BOD₅ < 25 mg/L, COD < 125 mg/L, SS < 35 mg/L, N < 10 mg/L, P < 1 mg/L

Health and environmental concerns

- All microbial and chemical contaminants of health significance. Recent concerns include:
 - Emerging pathogens
 - NDMA
 - Endocrine-disrupting chemicals
 - VOC's
 - Chlorine residuals
 - Disinfection byproducts (DBPs)

New directions and concerns

- Changing nature of the wastewater
- Emerging health and environmental concerns
- Problem of industrial wastes
- Impact of new regulations
- Aging infrastructure
- Treatment plant performance and reliability
- Combined sewer overflows
- Odor control

Future trends in wastewater treatment

- Vortex separators
- High rate clarification
- Membrane bioreactors
- Pressure driven membrane filtration (ultrafiltration and reverse osmosis)
- Ultraviolet radiation (LP and MP lamps)

Wastewater reclamation and reuse

- There is not enough supply of fresh water
- Treated wastewater can be used as a resource
- Mostly nonpotable uses such as landscape and agricultural irrigation
- Also nonpotable industrial uses (boiler water and cooling water)
- Concerns about potential health effects continue

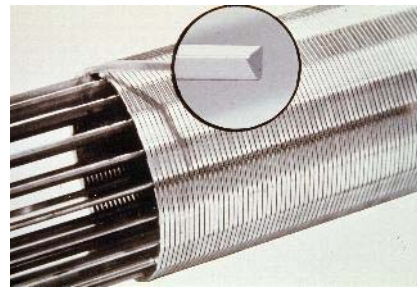
Biosolids and residuals management

- Biosolids treatment and management is one of the most difficult and expensive problems in wastewater engineering
- Wastewater solids can be used beneficially after further treatment and stabilization
- Land application, landfilling and incineration are common disposal options

Sources

- Wastewater Engineering: Treatment and Reuse – Metcalf & Eddy
- Wastewater Treatment Plant Design – WERF
- Theory and Practice of Water and Wastewater Treatment – Ronald L. Droste
- Water Supply and Pollution Control – Viessman and Hammer

Wedge-wire screens



<http://www.screenservices.com/>