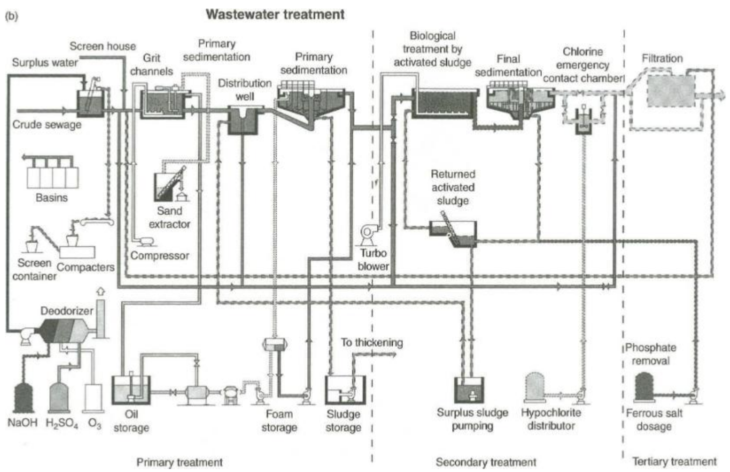
Wastewater Treatment Techniques

In the framework of the undergraduate course “Wastewater Treatment”



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What Is Wastewater?

"Wastewater," also known as "sewage," originates from household wastes, human and animal wastes, industrial wastewaters, storm runoff, and groundwater infiltration. Wastewater, basically, is the flow of used water from a community. It is 99.94% water by weight (Water Pollution Control Federation, 1980). The remaining 0.06% is material dissolved or suspended in the water. It is largely the water supply of a community after it has been fouled by various uses.

Sewage is 99.9% water with the material that requires to be removed amounting to just 0.1% by volume. This solid material is a mixture of faeces, food particles, grease, oils, soap, salts, metals, detergents, plastic, sand and grit .

Lin (2007); Gray (2005)

Types of wastewater

Types of wastewater include: municipal wastewater, industrial wastewaters, & mixtures of industrial/domestic wastewaters.

Typical industries include: slaughterhouses, dairies, meat/poultry-processing plants, rendering plants, and vegetable processing facilities.

The aims of wastewater treatment are:

(a) to convert the waste materials present in wastewaters into stable oxidized end products that can be safely disposed of to inland waters without any adverse ecological effects;
(b) to protect public health;
(c) to ensure wastewater is effectively disposed of on a regular and reliable basis without nuisance or offence;
(d) to recycle and recover the valuable components of wastewater;
(e) to provide an economic method of disposal;
(f) to comply with legal standards and consent conditions placed on dischargers.

Gray (2005)

After preliminary and primary treatment wastewater still contains significant amounts of colloidal and dissolved material that needs to be removed before discharge.

The problem for the engineer is how to convert the dissolved material, or particles that are too small to settle unaided, into larger particles so that a separation process can remove them. This is achieved by secondary treatment.

Chemical treatment using coagulants will deal with a portion of the colloidal solids, but a large portion of the polluting material will be unaffected. Also, the cost of continuous chemical addition and the problem of disposing of large quantities of chemical sludge makes this option normally unattractive.

Gray (2005)

Alternatively biological treatment can be used. This utilizes naturally occurring micro-organisms to convert the soluble and colloidal material into a dense microbial biomass that can be readily separated from the purified liquid using conventional sedimentation processes.

As the micro-organisms are literally using the dissolved and colloidal organic matter as food (substrate), the total volume of sludge will be far less than for chemical coagulation. In practice, therefore, secondary treatment tends to be a biological process with chemical treatment used for toxic wastewater treatment.

Gray (2005)

Major unit processes in wastewater treatment

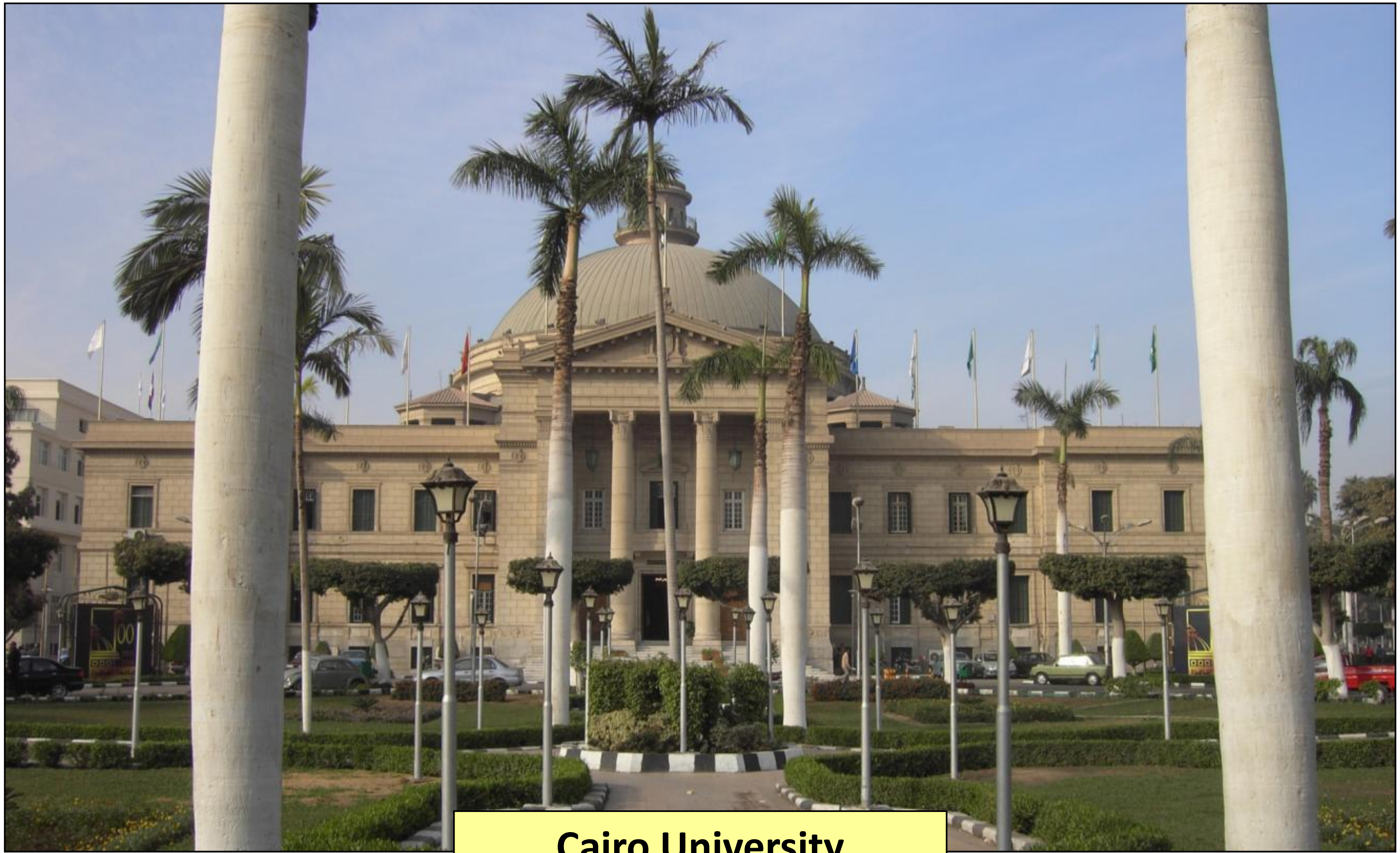
Process	Description
Physical unit processes	
Balancing	Where the flow of wastewater produced is variable over time, balancing tanks are used to ensure a constant flow and consistent quality of wastewater is pumped forward for treatment. This reduces both the capacity and cost of treatment
Screening	Screens remove large particles from wastewater. Used early in treatment to protect other treatment processes. Screens can be stationary, vibrating or rotating drums
Sedimentation	Special tanks to separate organic and inorganic solids from liquids
Flotation	Small air bubbles introduced at the base of a tank become attached to suspended particles and float. The particles are then skimmed off the surface as a sludge. Used extensively in dairy, paper, meat packing and paint industries
Hydrocyclone	Removal of dense particles (e.g. sand, grit and glass) from wastewaters is achieved as it enters a conical tank tangentially. As the wastewater spirals through the tank, particles are thrown against the wall by centrifugal forces and fall to the base (point) of the cone from where they can be removed
Filtration	Treated wastewater can be passed through a fine media filter (e.g. sand) in order to further reduce suspended solids concentration (<20 $mg\,l^{-1}$). High-performance filters using synthetic fibres to remove particles between 1 and 500 μm from treated wastewater or process streams
Centrifugation	Separation of solids from liquids by rapid rotation of the mixture in a special tapered vessel. Solids are deposited as a thick sludge (20–25% dry solids) either against the inner wall or at the base. Widely used in pharmaceutical, pulp, paper, chemical and food industries, and for dewatering sewage sludge
Reverse osmosis	Under pressure (1500–3000 kPa) water is driven through a semi-permeable membrane with extremely small pores to concentrate ions and other particles in solution and to purify the water. Used to remove and recover contaminants from process waters before discharge to sewer
Ultrafiltration	Similar to reverse osmosis. Particles of 0.005–0.1 μm are removed as they are forced through a micro-porous membrane at pressures up 3000 kPa. Used for removal and recycling of colloidal material including dyes, oils, paints and even proteins from cheese and whey from wastewaters. Able to remove the smallest micro-organisms including viruses and pyrogenic macromolecules
Micro-filtration	Similar to ultrafiltration except used to recover large particles (0.1–5 μm) at lower pressures (100–400 kPa). Widely used in food and drink industry. Micro-porous filters can also be used for the disinfection of process waters and effluents

Process	*Description*
Adsorption	Activated carbon or synthetic resins are used to remove contaminants by adsorption from liquids. Used primarily for the removal of organics from industrial process and wastewaters
Chemical unit processes	
Neutralization	Non-neutral wastewaters are mixed either with an alkali (e.g. NaOH) or an acid (e.g. H_2SO_4)to bring the pH as close to neutral as possible to protect treatment processes. Widely used in chemical, pharmaceutical and tanning industries
Precipitation	Dissolved inorganic components can be removed by adding an acid or alkali, or by changing the temperature, by precipitation as a solid. The precipitate can be removed by sedimentation, flotation or other solids removal process
Ion-exchange	Removal of dissolved inorganic ions by exchange with another ion attached to a resin column. For example, Ca an Mg ions can replace Na ions in a resin thereby reducing the hardness of the water
Oxidation reduction	Inorganic and organic materials in industrial process waters can be made less toxic or less volatile by subtracting or adding electrons between reactants (e.g. aromatic hydrocarbons, cyanides, etc.)
Biological unit processes	
Activated sludge	Liquid wastewater is aerated to allow micro-organisms to utilize organic polluting matter (95% reduction). The microbial biomass and treated effluent are separated by sedimentation with a portion of the biomass (sludge) returned to the aeration tank to seed the incoming wastewater
Biological filtration	Wastewater is distributed over a bed of inert medium on which micro-organisms develop and utilize the organic matter present. Aeration occurs through natural ventilation and the solids are not returned to the filter
Stabilization ponds	Large lagoons where wastewater is stored for long periods to allow a wide range of micro-organisms to breakdown organic matter. Many different types and designs of ponds including aerated, non-aerated and anaerobic ponds. Some designs rely on algae to provide oxygen for bacterial breakdown of organic matter. Sludge is not returned
Anaerobic digestion	Used for high-strength organic effluents (e.g. pharmaceutical, food and drink industries). Wastewater is stored in a sealed tank which excludes oxygen. Anaerobic bacteria breakdown organic matter into methane, carbon dioxide and organic acids. Final effluent still requires further treatment as has a high BOD. Also used for the stabilization of sewage sludge at a concentration of 2–7% solids

Gray (2005)

7 Videos

Thank You!



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