



## **8.5 CLEAN DRINKING WATER, SEWAGE TREATMENT AND HUMAN HEALTH**

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College Board Topics 8.11, 8.14, and 8.15

Related Readings Chapter 15, pages 413 – 416 and Chapter 14, pages 362-366

# Learning Objectives and Essential Knowledge

## ENDURING UNDERSTANDING

### STB-3


Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

## LEARNING OBJECTIVE

### STB-3.N

Describe best practices in sewage treatment.

### SUGGESTED SKILL

 *Visual Representations*

### 2.A

Describe characteristics of an environmental concept, process, or model represented visually.

## ESSENTIAL KNOWLEDGE

### STB-3.N.1

Primary treatment of sewage is the physical removal of large objects, often through the use of screens and grates, followed by the settling of solid waste in the bottom of a tank.

### STB-3.N.2

Secondary treatment is a biological process in which bacteria break down organic matter into carbon dioxide and inorganic sludge, which settles in the bottom of a tank. The tank is aerated to increase the rate at which the bacteria break down the organic matter.

### STB-3.N.3

Tertiary treatment is the use of ecological or chemical processes to remove any pollutants left in the water after primary and secondary treatment.

### STB-3.N.4

Prior to discharge, the treated water is exposed to one or more disinfectants (usually, chlorine, ozone, or UV light) to kill bacteria.

## ENDURING UNDERSTANDING

### EIN-3


Pollutants can have both direct and indirect impacts on the health of organisms, including humans.

## LEARNING OBJECTIVE

### EIN-3.D

Explain human pathogens and their cycling through the environment.

### SUGGESTED SKILL

 *Visual Representations*

### 2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

## ESSENTIAL KNOWLEDGE

### EIN-3.D.1

Pathogens adapt to take advantage of new opportunities to infect and spread through human populations.

### EIN-3.D.2

Specific pathogens can occur in many environments regardless of the appearance of sanitary conditions.

### EIN-3.D.3

As equatorial-type climate zones spread north and south in to what are currently subtropical and temperate climate zones, pathogens, infectious diseases, and any associated vectors are spreading into these areas where the disease has not previously been known to occur.

### EIN-3.D.4

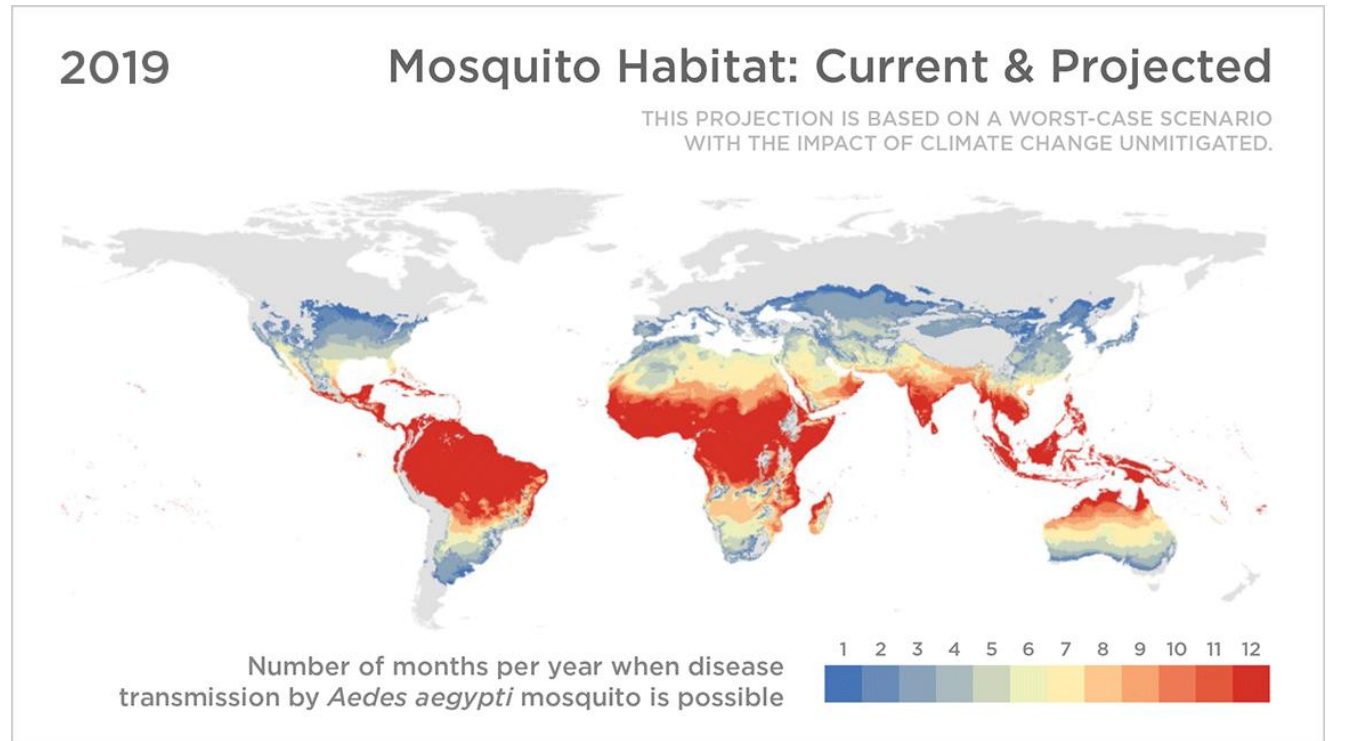
Poverty-stricken, low-income areas often lack sanitary waste disposal and have contaminated drinking water supplies, leading to havens and opportunities for the spread of infectious diseases.

### EIN-3.D.5

Plague is a disease carried by organisms infected with the plague bacteria. It is transferred to humans via the bite of an infected organism or through contact with contaminated fluids or tissues.

# Pathogens and Vectors

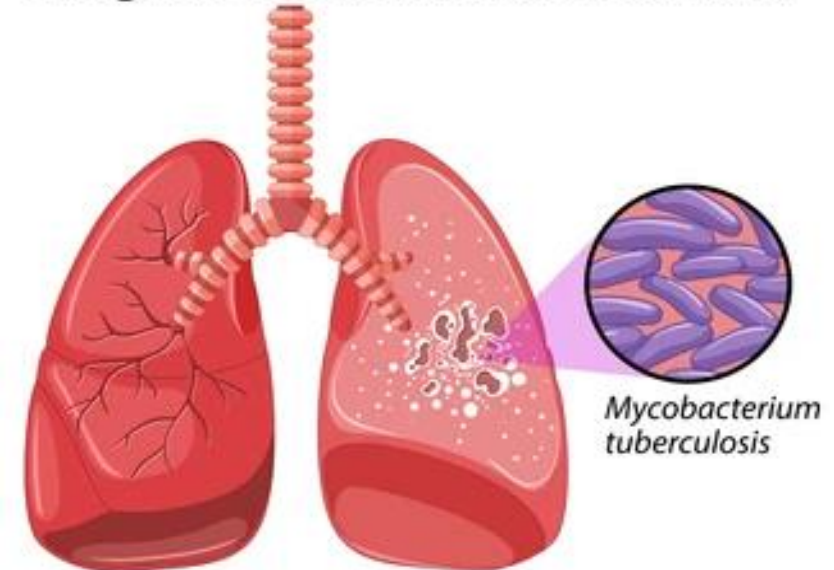
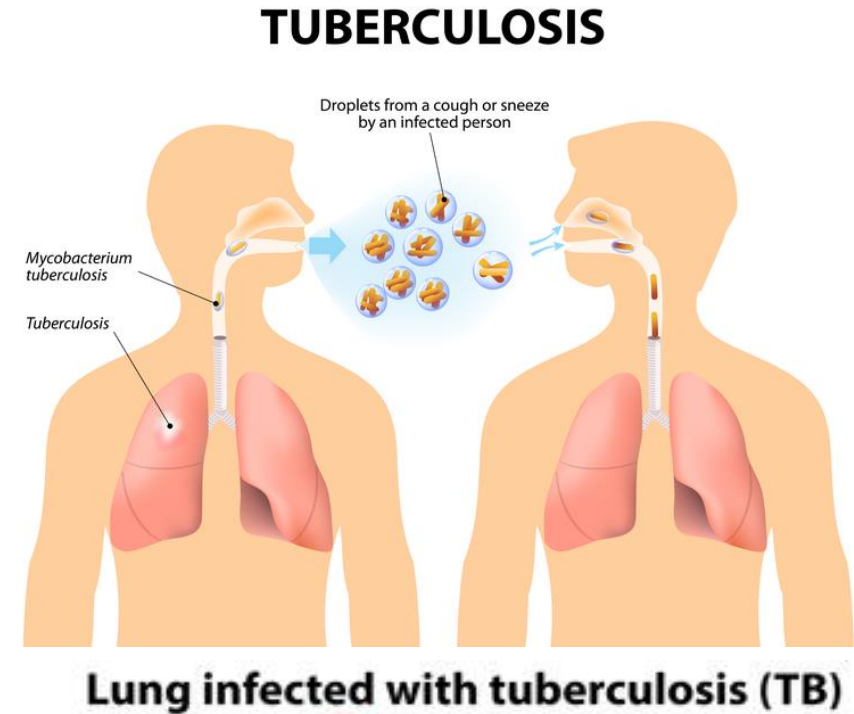
- **Pathogen**; a living organism (virus, bacteria, fungus, protist, worm) that causes an infectious disease
  - **Infectious diseases** are capable of being spread or transmitted (HIV, ebola, Covid-19); noninfectious diseases are not transmissible (heart disease, asthma, cancer, diabetes)
  - Pathogens adapt and evolve to take advantage of humans as hosts for their reproduction and spread (Covid-19 is a SARS-associated coronavirus that evolved to become especially effective at surviving and reproducing in humans).



- **Vector**; a living organism (rat, mosquito) that carry and transmit infectious pathogens to other organisms
  - Climate change is shifting equatorial climate zones north and south away from the equator; this brings warmer temperatures to subtropical and temperate regions.
  - Warmer temperatures allow pathogens and their vectors (mosquitos) to spread north & south to parts of the world previously too cold.

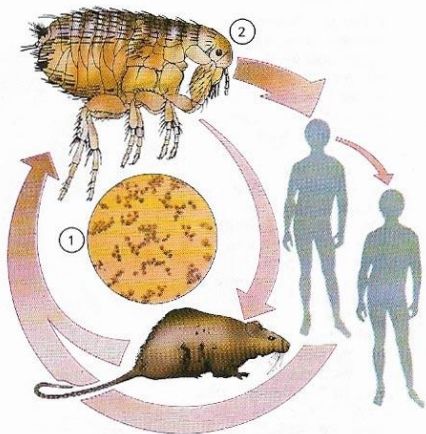
# Tuberculosis (TB)

- Bacterial (pathogen) infection that targets the lungs.
  - Transmitted by breathing bacteria from body fluids (resp. droplets) of an infected person, which can linger in air for hours
  - Causes night sweats, fever, coughing blood; treatable in developed nations with access to powerful antibiotics
- Leading cause of death by disease in the developing world ~ 9 million cases per year and 2 million deaths (for comparison ~ 2.8 million global deaths from Covid-19)



# Common infectious disease spread by vectors

- **Plague;** bacterial (pathogen) infection transmitted by fleas (vector) that attach to mice & rats (vectors as well).
  - Transmitted by flea bite, rodent contact or contaminated human fluids.
  - Aka “bubonic” or “black” plague; modern antibiotics are highly effective against it, but some isolated instances still occur.



- **Malaria;** parasitic protist (pathogen) infection caused by bite from infected mosquitoes (vector).
  - Most common in sub-Saharan Africa (& other tropical regions); recurring flu-like symptoms; mostly kills children under 5.
- **West Nile;** virus (pathogen) infection caused by bite from infected mosquitoes (vector).
  - Birds are the main host, but the virus can be transmitted to humans by mosquitoes that bite infected birds and then bite humans.
  - Causes brain inflammation, which can be fatal.
- **Zika Virus;** virus (pathogen) infection caused by bite from infected mosquitoes (vector) & sexual contact with infected individuals.
  - Causes babies to be born with abnormally small heads and damaged brains; can be passed from mother to infant.
  - No known treatment currently, so prevention is focused on eliminating mosquito populations.

# Coronaviruses have evolved from animal hosts to infect humans

- **Coronaviruses** are thought to have first appeared in bats and spread to other animal hosts.
  - Human contact with bats is limited and unlikely source of coronavirus transmission to humans.
  - Other species, which humans more commonly come in contact with, can act as a **reservoir species** in which coronaviruses mutate to infect that species as well as humans.
- **Severe Acute Respiratory Syndrome (SARS-CoV)** was likely transmitted from palm civets to humans in southern china (2003)
- **Middle East Respiratory Syndrome (MERS)** was likely transmitted to humans from dromedary camels in Saudi Arabia (2012)
- **Severe Acute Respiratory Syndrome (SARS-CoV-2)**, is suspected of having been transmitted to humans by pangolins or minks???, (2020)
- Once mutated to infect human hosts, coronaviruses are primarily transmitted by touching or inhaling fluids from an infected person.
  - Coronavirus symptoms include fever, cough and shortness of breath. Pneumonia is common, but not always present.
  - Gastrointestinal symptoms, including diarrhea, have also been reported.
  - Some patients are asymptomatic.

# Infectious Disease and Development

- Less developed, poorer countries typically have higher rates of infectious disease.
  - Less sanitary waste disposal; pathogens can reproduce in open waste areas where children may play or animals may scavenge & pass to humans.
  - Less access to healthcare facilities and antibiotic medications to treat infectious diseases caused by bacteria & other pathogens
  - Lack of treatment/filtration for drinking water & sewage treatment exposes people to bacterial and viral pathogens in water, often resulting from contamination with human waste.
  - Tropical climates & more open-air living can expose people to vectors like mosquitoes; less money for vector eradication (spraying mosquito breeding grounds)



# Common Waterborne Infectious Diseases

- **Dysentery:** bacterial infection caused by food or water being contaminated with feces
  - Causes intestinal swelling and can result in blood in feces
  - Results in severe dehydration due to diarrhea (fluid loss)
  - Kills 1.1 million people annually, mostly in developing countries with poor sanitation and limited access to water filtration
- **Cholera:** bacterial infection caused by drinking infected water, often from contamination with human feces.
  - Extremely contagious
  - Vomiting, muscle cramps and diarrhea; can cause severe dehydration



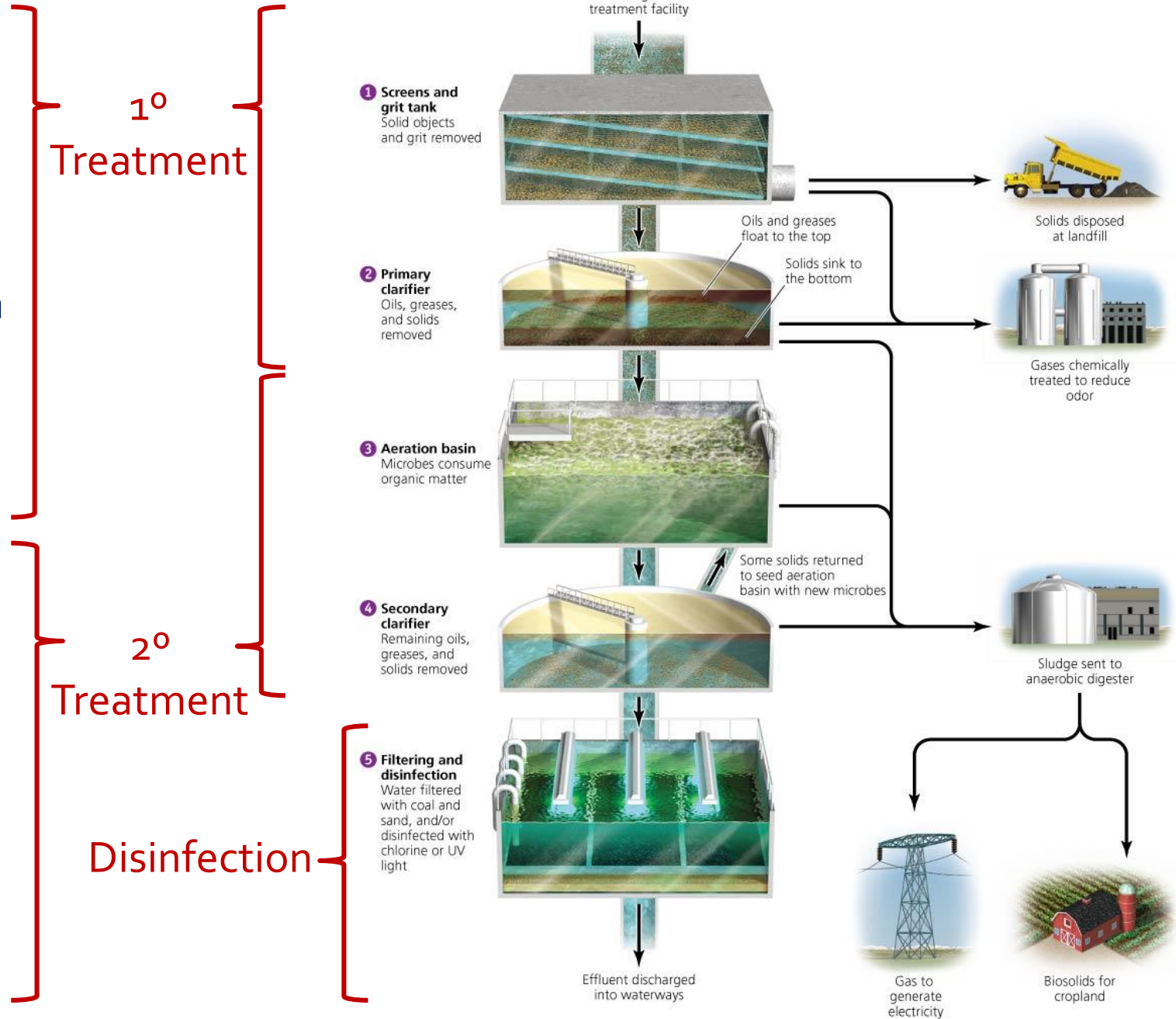


# Sewage treatment can reduce contamination of surface water

The sewage treatment process:

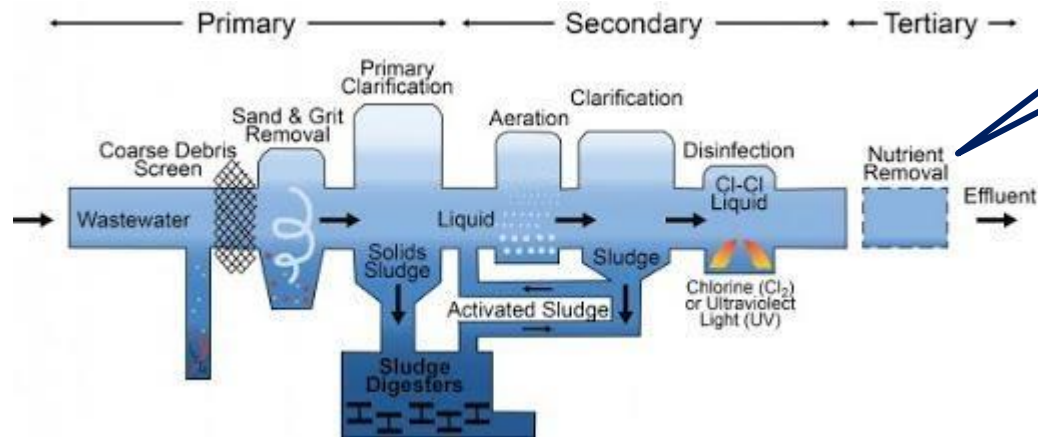
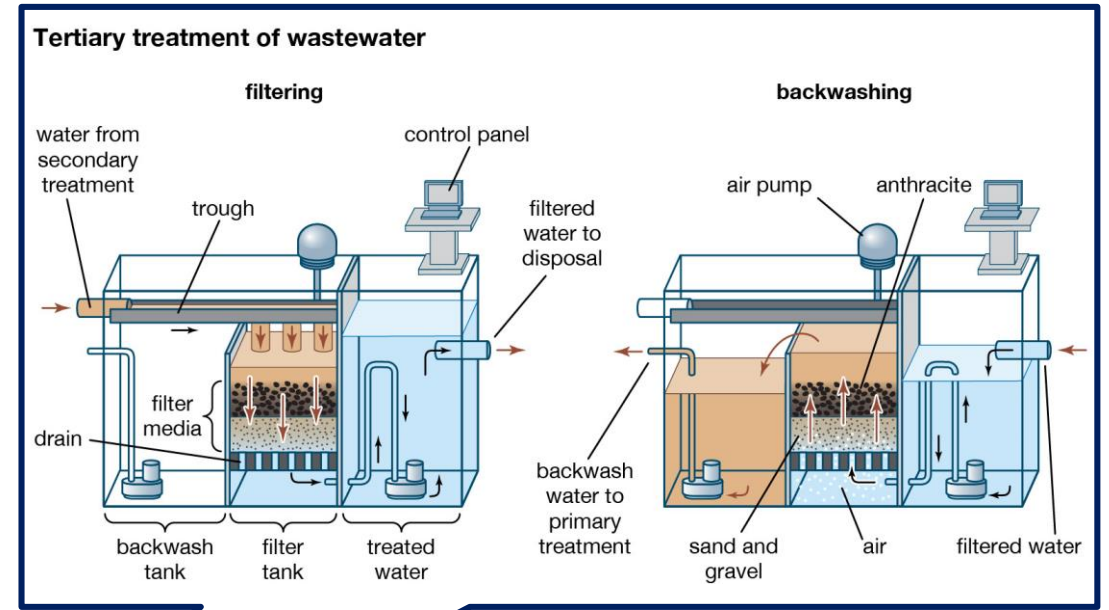
- **Primary treatment:** physical removal of large debris (TP, leaves, plastic, sediment) with a screens or grates.
- **Secondary treatment:** biological breakdown of organic matter (feces) by bacteria; aerobic process that requires O<sub>2</sub>
- **Tertiary Treatment** (optional): chemical treatment to reduce nutrient pollution (nitrate, phosphate, ammonia)
- **Disinfection:** UV light, ozone, or chlorine is used to kill bacteria or other pathogens
- **Effluent** (treated sewage) is discharged into bodies of surface water.
- **Sludge** (solids) is disposed of in landfills, or sent to an **anaerobic digester** to break down further
  - Solids remaining after anaerobic digestion are sometimes spread on agricultural fields
  - Anaerobic digestion generates methane gas which may be used to generate electricity

- Screens or grates filter out large solids (paper, plastic).
- Grit chamber allows sediment (sand, gravel) to settle out & be removed.
- Oils and greases are skimmed from the top; primary sludge is collected and disposed of or sent to anaerobic digester.
- $O_2$  is bubbled into aeration tank filled with bacteria that break down organic matter into  $CO_2$  and nutrients like N & P.
- Secondary treatment removes 70% of P and 50% of N; DOES NOT remove POPs such as medications or pesticides.



# Tertiary Treatment

- Effluent that is discharged into surface waters with elevated nitrate/phosphate levels often leads to eutrophication.
- **Tertiary treatment** uses charcoal filters to remove more of the nitrates & phosphates from secondary treatment discharge.
  - Expensive and not always used
  - Constructed wetlands can provide nutrient removal while increasing wetland habitat
    - Example: Santee lakes



# Legislation protects water quality in the United States

- ***Clean Water Act (1972)***

- Regulates the discharge of pollutants into the waters of the United States, including the discharge of treated wastewater effluent.
- Sets water quality standards for surface waters.
- Requires a permit to discharge any pollutant from a point source into surface waters.

- ***Safe Drinking Water Act (1974)***

- Authorizes the EPA to set national health-based standards for drinking water to protect against contamination of drinking water supplies.
- Sets enforceable maximum contaminant levels for specific contaminants in drinking water.
- Sets required methods for treating drinking water.
- Requires reports on treatment methods and contaminant levels to be made publicly available.

