Microbes and wastewater treatment

Wastewater treatment

- wastewater treatment practice started in beginning of 20th century
- mainly because of increased awareness of role of microbes in disease
- following discovery **that cholera is a waterborne disease** (in 1854 Snow noted a relationship between cholera epidemics and consumption of water from certain wells in London. Father of epidemiology)

Pathogens and parasites in domestic wastewater

- differ in incidence (# of individuals with disease in a population)
- prevalence (% of individuals with disease in a population)
- virulence (dose of infectious agent necessary for infecting host and causing disease)
- mode of transmission (person to person, waterborne, foodborne, airborne, vector-borne, fomites)

Major waterborne diseases found among major types of microbes

- **bacteria**
  - **fecal matter contains up to 10^{12} bacteria (or bacteria ~ 9% by wet wgt)**
  - **pathogens: e.g. *Salmonella typhi, Shigella, Vibrio cholera*, pathogenic strains of *Escheria coli* and other species causing gastroenteritis**

Major waterborne diseases found among major types of microbes

- **viruses**
  - **~ 140 types of enteric viruses (enter body orally, multiply in gastrointestinal tract and excreted in large numbers in feces of infected individuals)**
  - **although minimum infectious dose controversial generally lowe that bacterial pathogens**
  - **e.g. hepatitis A, viral gastroenteritis (rotaviruses)**

Major waterborne diseases found among major types of microbes

- **protozoans**
  - **most protozoan parasites produce cysts able to survive outside host under adverse conditions**
  - **encystment triggered by factors such as lack of nutrients, accumulation of toxic metabolites or host immune response- excystment under appropriate conditions**
  - ***e.g. Giardia, Cryptosporidium, Entamoeba, Naegleria***

Wastewater treatment objectives

- **Removal/inactivation of pathogenic microbes and parasites**
- **reduction of organic content**
- **removal/reduction of trace organics that are recalcitrant to biodegradation and may be toxic or carcinogenic**
- **removal/reduction of toxic metals**
- **removal/reduction of nutrients (N,P) in order to reduce pollution of receiving waters**

Wastewater treatment process

- **Microorganisms play a critical role**
- **especially if wastewater material to be removed is organic in nature**

Levels of sewage treatment: Primary

- **a multi-step process employing both physical and biological steps**
- **primary treatment of sewage involves only physical separations (grates, screens to remove large objects then effluent left to settle of a # of hours to allow suspended solids to settle**

Levels of sewage treatment: Secondary

- **majority of sewage processing plants in industrialized countries also employ secondary (but there are lots of exceptions especially in coastal towns!)**
- **secondary reduces the BOD to reasonable guideline levels**
- **secondary is closely tied to microbiological processes**

Levels of sewage treatment: Secondary

- **aerobic secondary treatment**
  - **several types: a trickling filter bed of crushed stone ~ 2m thick**
  - **more common activated sludge where wastewater is mixed and aerated in a large tank, some processes actually force pure O2 to accelerate biodegration**

Levels of sewage treatment: Secondary aerobic

- **slime forming bacteria *Zooglea* sp. grow and form flocs (“zoogloeas”) which form the substratum for a variety of microbes e.g. protozoa,**
- **effluent holding flocs is pumped into a holding tank “clarifier” where flocs settle**
- **some of the floc returned to aerator for inoculum while rest sent to anaerobic digestor**

Levels of sewage treatment: Secondary aerobic

- **residence time in activated sludge tank ~ 5-10 hrs too short for complete oxidation**
- **main process is adsorption of soluble OM on to floc and incorporation of soluble into microbial biomass**
- **BOD of liquid reduced (75-90%) but overall total BOD slightly**
- **main process of total BOD degradation occurs in anaerobic digestor where floc transferred**

Biology of activated sludge

- **oxidation (soluble OM converted to new cell mass) and flocculation (separation of newly formed biomass from treated effluent)**
- **activated sludge contains a wide range of prokaryotic and eukaryotic organisms**
- **bacteria mainly gram negative**
- **Protozoans, rotifers predators**

Levels of sewage treatment: Secondary

- **<u>anaerobic secondary treatment</u> = semi-continous large tanks "sludge digestors"**
- **usually employed for materials that have much insoluble (such fibers and fiber or concentrated industrial wastes)**
- **process involves 1) initial digestion of macromolecular matertial by extracellular enzymes to soluble materials 2) fermentation of soluble mat. to fatty acids, H_2 and CO_2 3) conversion of H_2 plus $C0_2$ and acetate to CH_4 by methanogens**

Levels of sewage treatment: Secondary anaerobic

- anaerobic secondary treatment
- treated material removed periodically so "semi-continuous" with retention time of 2-4 weeks

Levels of sewage treatment: Tertiary

- the most complete method and most expensive step
- physicochemical process employing precipitation, filtration, chlorination, to reduce levels of nutrients, especially P and N from final effluent to meet levels set by water quality guidelines (or aquatic life guidelines) but also toxins, pathogens

General references

- Bitton, G. 1999. Wastewater microbiology. Wiley & Sons. New York. 578 pp.
- various web sites with images of sewage treatment plants and schematics of processes (e.g. www. haifa.wwtp.co.il/
- http://sewage.net/ve/aerobichuman/
- American waterworks association