廢水處理及水相關之感染

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中區傳染病防治醫療網
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水質純化

水質純化的歷史

- 1905年以前
  - 水質之微生物檢驗並無一定之規則可循
  - 水質純化用的方法是filtration，用的指標是turbidity. 雖然filtration 可以有效降低水中之細菌量，但仍有很大量的細菌可以穿透過濾膜
- 1905
  - coliform-counting成為飲用水水質微生物檢驗之標準
  - 其數目代表水源遭糞便污染的程度
- 1910
  - chlorine被證實能有效用於消毒大量水

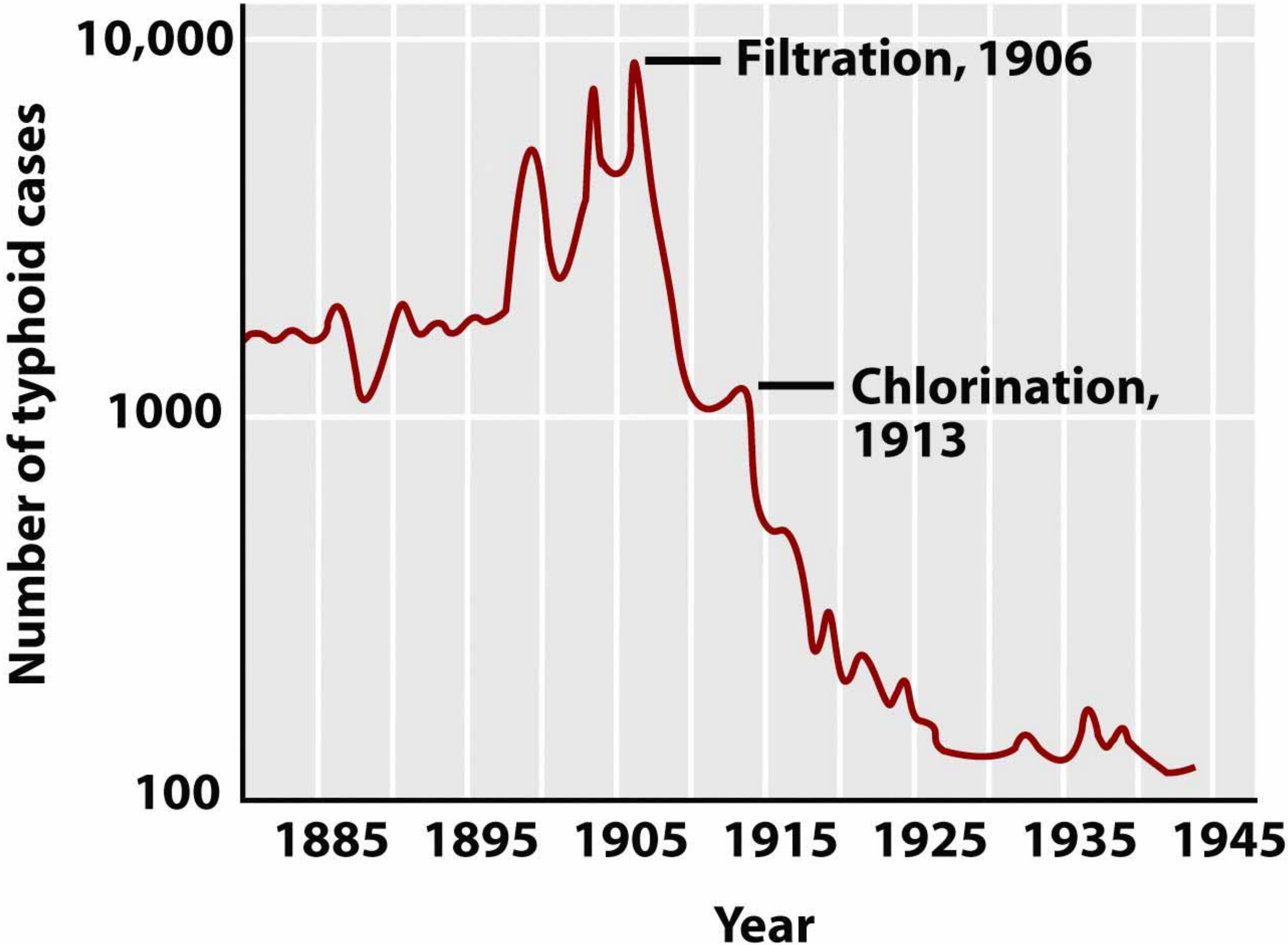


Figure 28-2 Brock Biology of Microorganisms 11/e

廢水處理

廢水處理之原則

- 經廢水處理廠處理過之廢水必須能夠直接排入河川、湖泊、或自來水處理場者
- 廢水處理之指標是降低Biochemical oxygen demand (BOD)到可接受之程度
- 廢水處理過程
  - Primary treatment: physical process
  - Secondary treatment: biological process
  - Tertiary treatment: physicochemical process

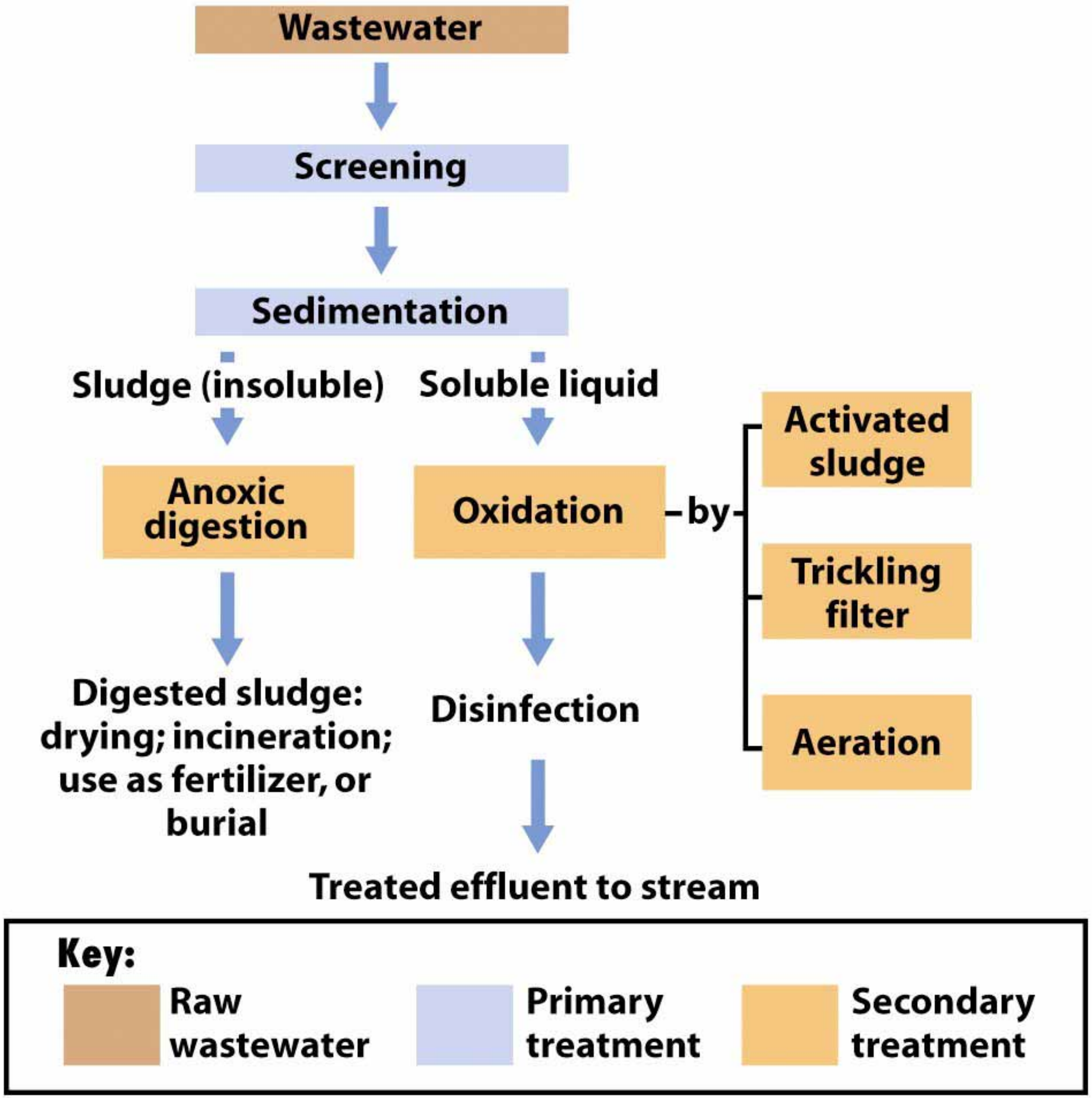


Figure 28-3 Brock Biology of Microorganisms 11/e

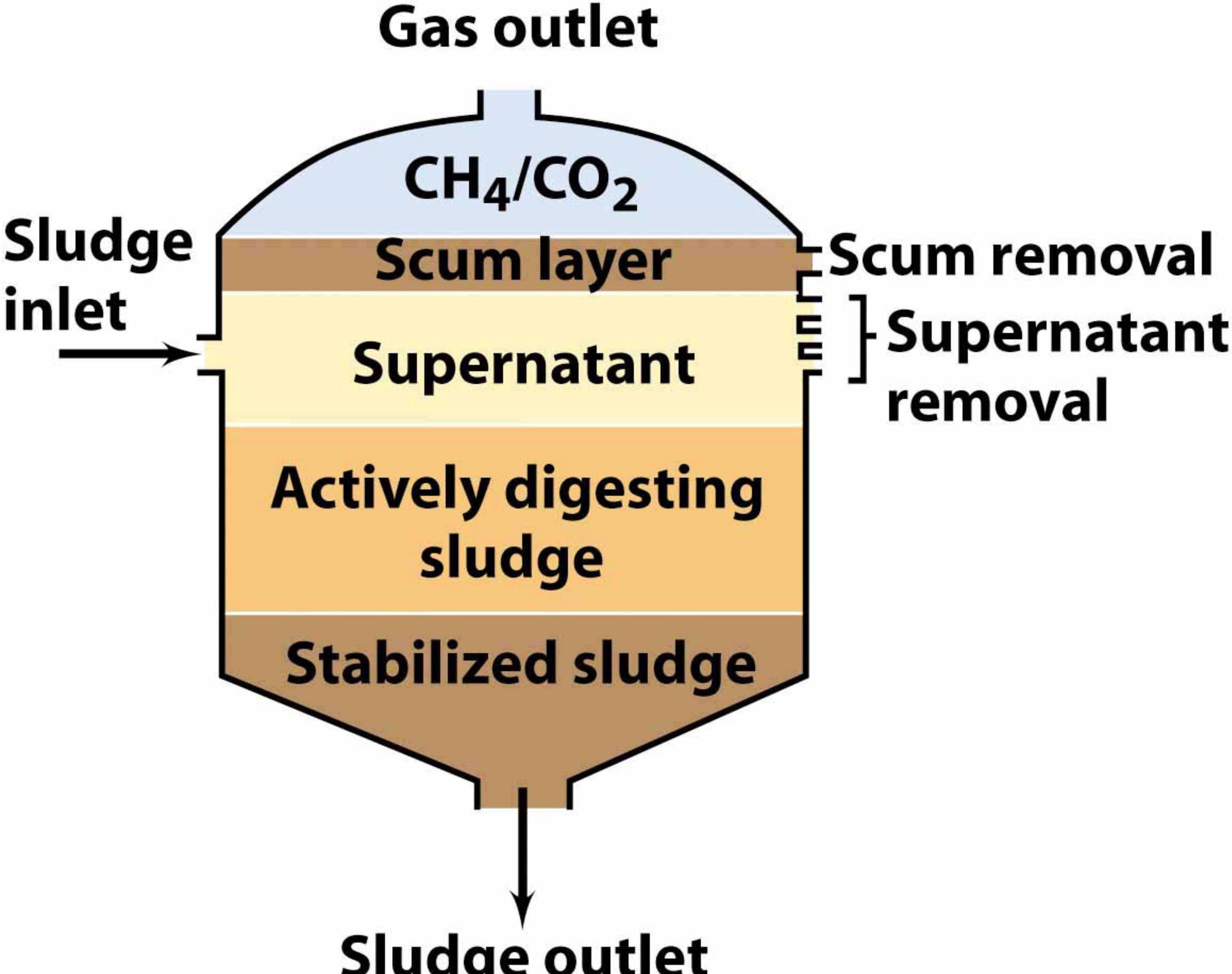
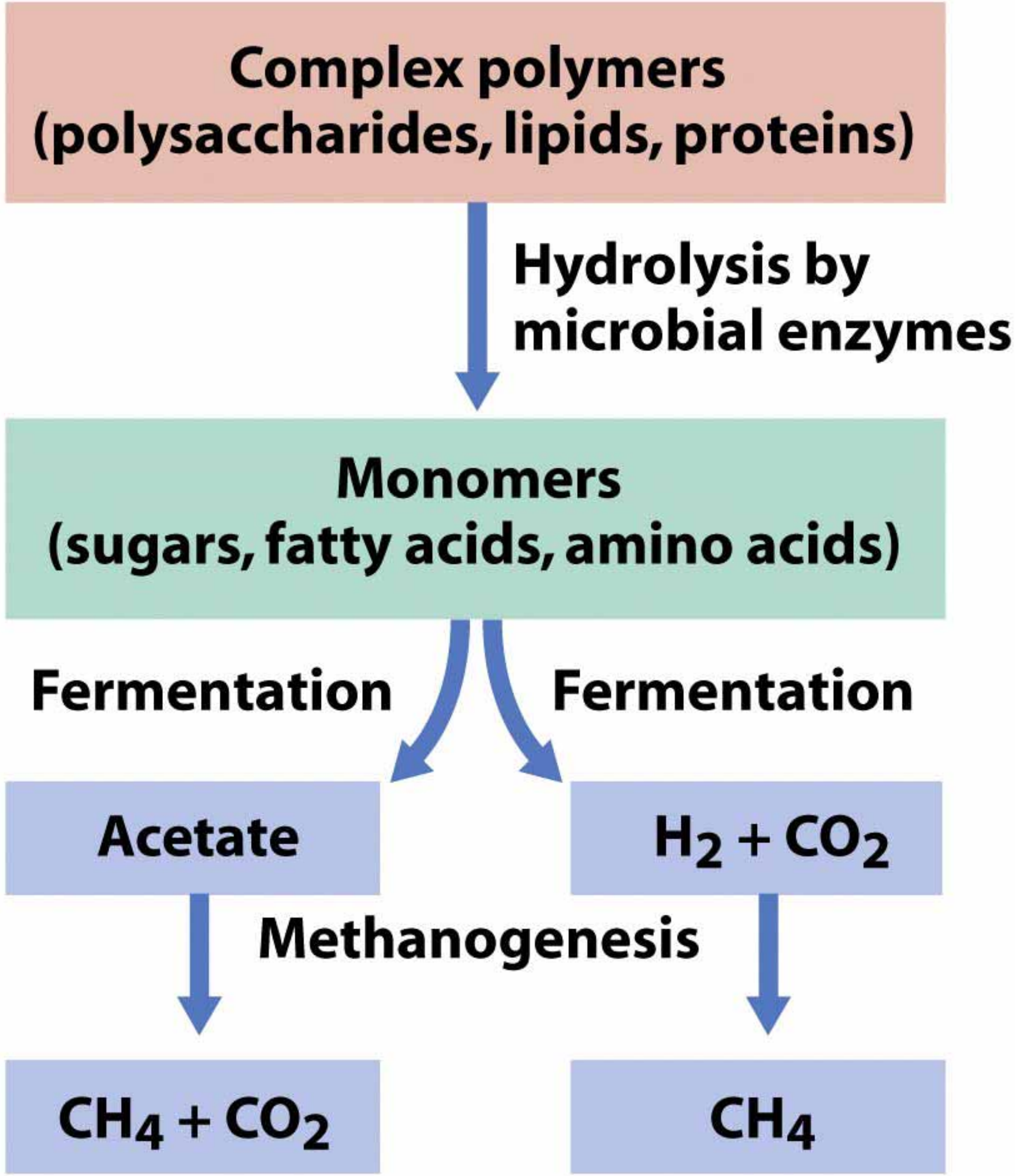


Figure 28-5b Brock Biology of Microorganisms 11/e



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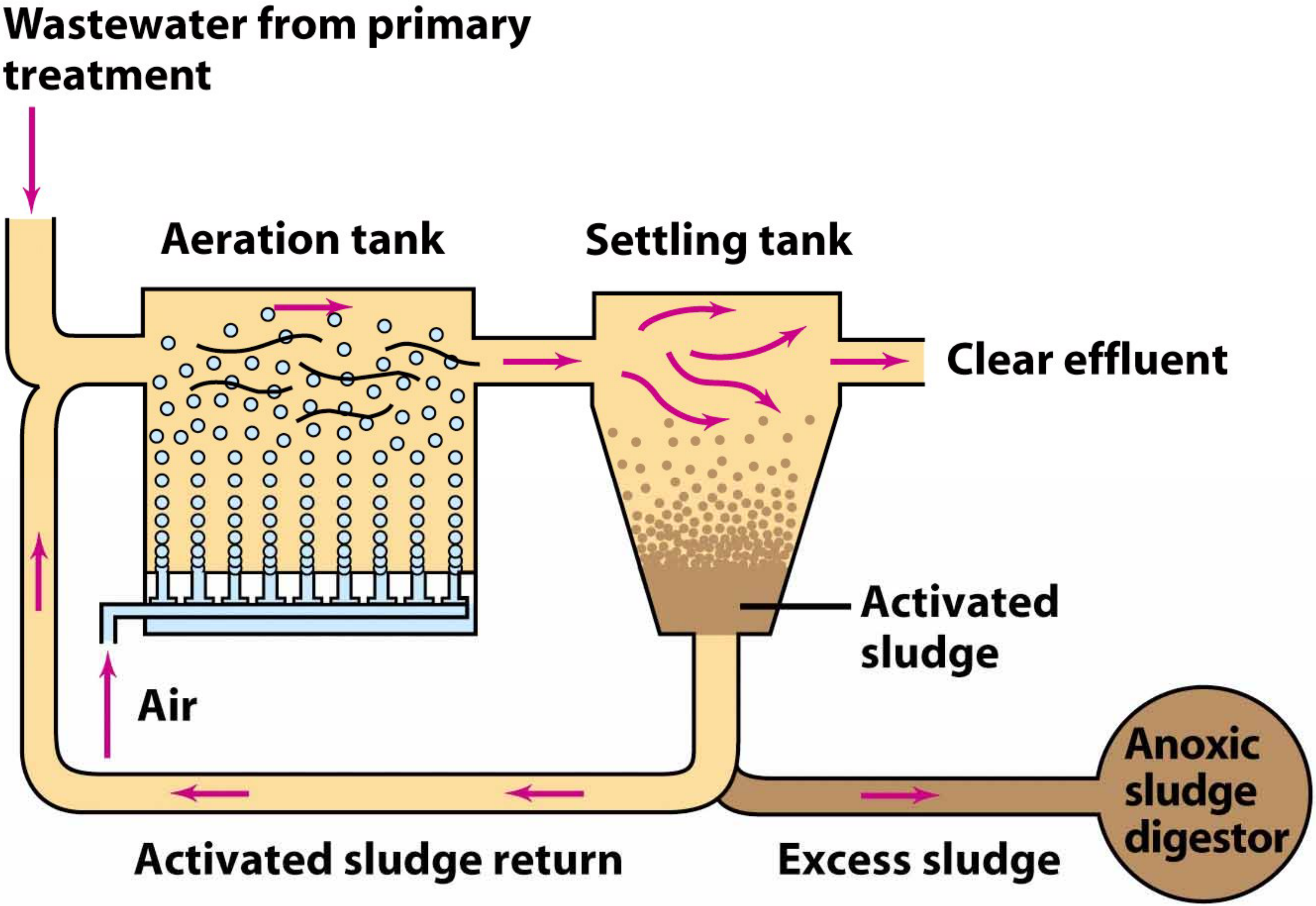


Figure 28-6c Brock Biology of Microorganisms 11/e

飲用水純化

飲用水純化

- 先以物理及化學的方法去除掉水中之生物及有機無機污染物
- 為了保持水源及輸送系統中均有足夠之餘氯量，大部分之自來水廠均會在水中打入氨氣，使之與氯形成穩定的chloramine

Figure 28-8a Brock Biology of Microorganisms 11/e

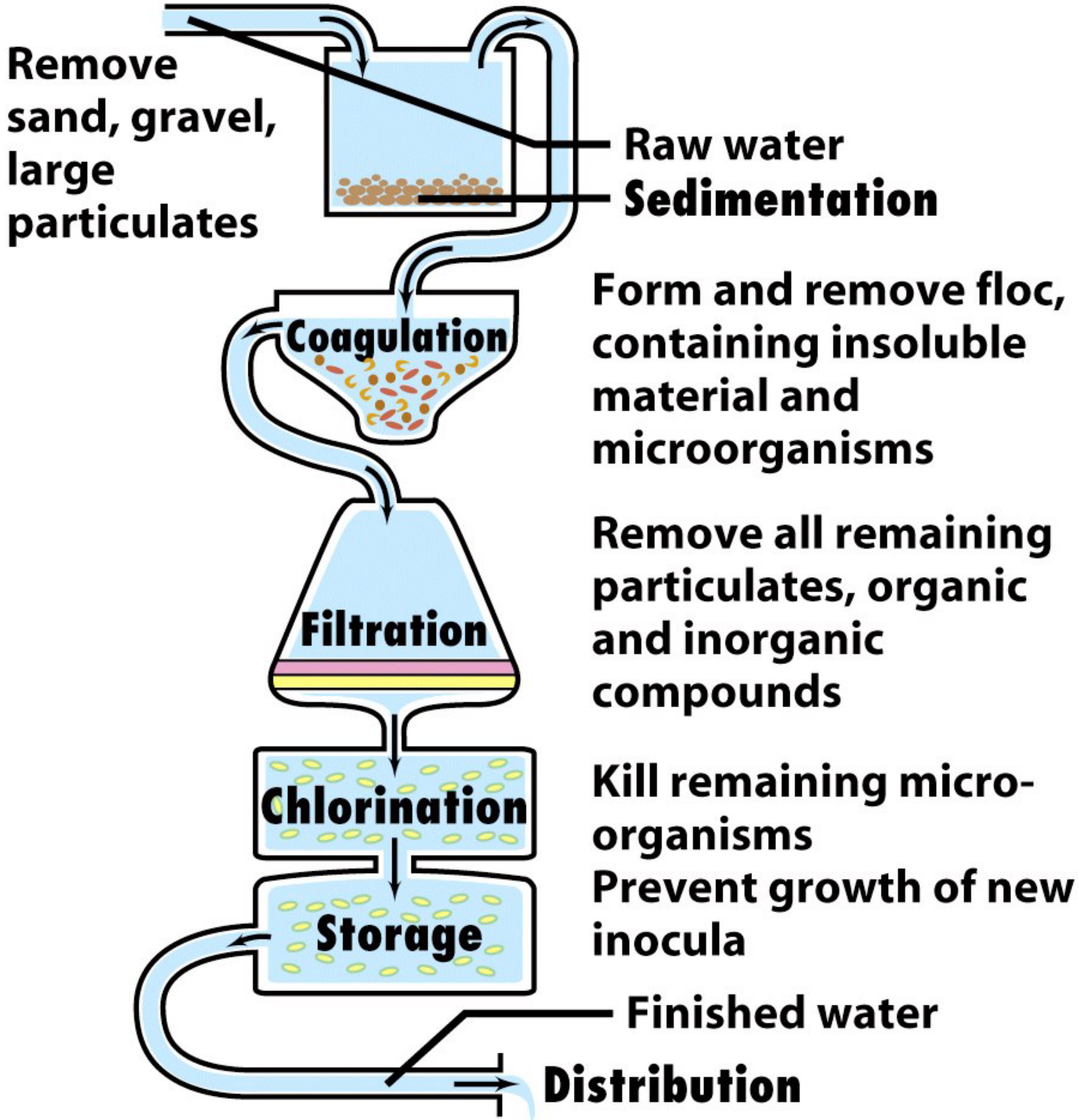


Figure 28-8b Brock Biology of Microorganisms 11/e

飲用水純化過程

- 先將天然水引進沉澱池，沉澱池中會加入 anionic polymers, alum (aluminum sulfate), and chlorine，這些添加物均會與水中雜質作用形成沉澱(flocculation)
- 經初步沉澱處理的水會再流入凝結池(coagulation)，利用alum and anionic polymers將浮游之顆粒再一次清除，經此兩步驟處理之水稱為potable或finished water，已完全沒有化學及生物之污染

水相關之感染

水相關之感染

- 一般用水及飲用水均有可能造成微生物感染，但其數目相對於用水量是非常稀少的
- 但是沒有足夠淨水設備或沒法得到充足飲用水的區域卻是傳染病散播之溫床

Table 28.1 Infectious disease outbreaks associated with drinking water in the United States[a]

Disease	Agent	Outbreaks	Cases
Salmonellosis	*Salmonella* species	2	208
Giardiasis	*Giardia intestinalis*	6	52
Cryptosporidiosis	*Cryptosporidium parvum*	1	5
Acute gastro-intestinal illness	*Escherichia coli* O157:H7	4	60
	Campylobacter jejuni	2	117
	E. coli O157:H7 and *C. jejuni*	1	781
	Small round virus	1	70
	Norwalk-like viruses	3	356
	Unknown	17	416

[a] Compiled from data provided by the Centers for Disease Control and Prevention for 1999–2000. There were a total of 37 outbreaks and 2065 cases of infectious disease due to drinking water contamination by infectious agents. Regulated community-owned water systems were responsible for 237 cases (11.5%). Noncommunity water systems such as those in some factories, schools, and on cruise ships accounted for 1425 cases (69%). Individual water supply systems such as wells, springs, and streams accounted for 403 cases (19.5%).

Table 28.2 Infectious disease outbreaks associated with recreational water in the United States[a]

Disease	Number of outbreaks	Percent
Gastroenteritis[b]	74	46.8
Dermatitis/keratitis[c]	50	31.6
Meningoencephalitis[d]	22	13.9
Other[e]	12	7.6

[a] Compiled from data provided by the Centers for Disease Control and Prevention for 1989–2000.

There were 158 outbreaks of recreational waterborne disease, or about 13 outbreaks per year.

[b] Most cases of gastroenteritis were due to *Cryptosporidium parvum* (Section 28.6), *Escherichia coli* O157:H7 (Section 29.8), or a Norwalk-like virus (Section 28.8).

[c] Most cases of dermatitis were caused by *Pseudomonas aeruginosa*.

[d] Meningoencephalitis was caused by the ameba *Naegleria fowleri* (Section 28.8).

[e] Other diseases include leptospirosis caused by *Leptospira interrogans*, Pontiac fever due to infection by *Legionella* (Section 28.7), and acute respiratory infections of unknown cause.

Cryptosporidiosis

Background

Cryptosporidiosis is a major cause of morbidity and mortality in animals and humans.

Cryptosporidiosis in humans has been reported from more than 90 countries in six continents (Fayer et al, 2000)

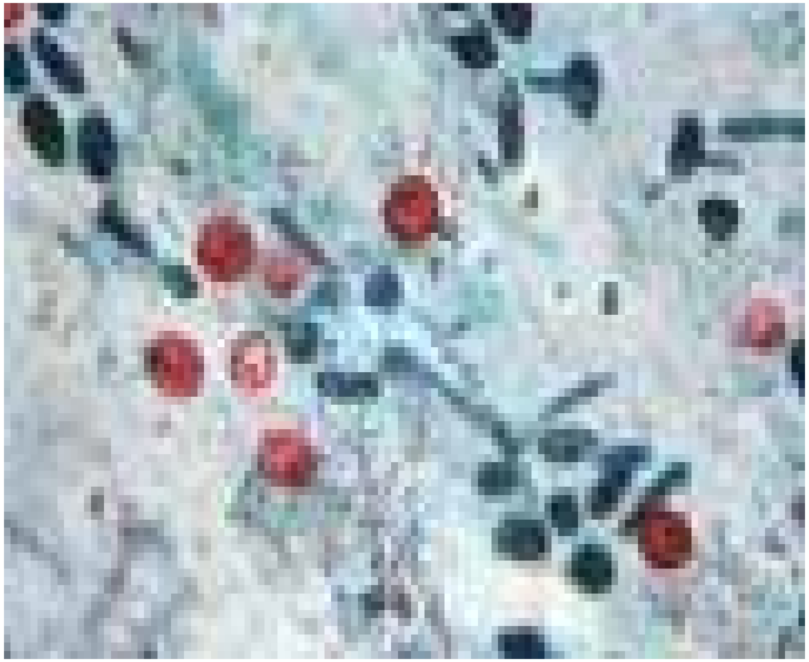
Cryptosporidium is found in surface waters throughout the entire United States

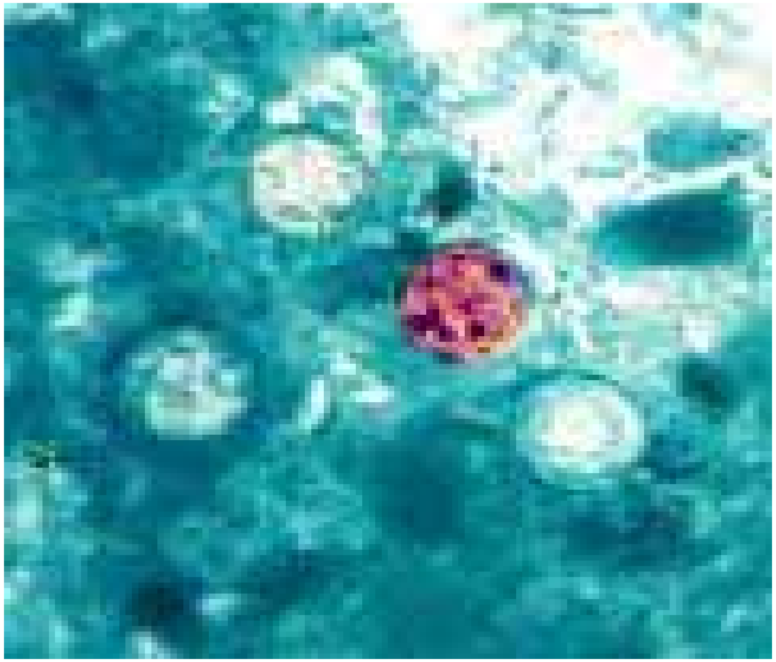
Estimated 6.1% and 2.1% of immunocompetent patients (24% and 14% of HIV+) with diarrhea in developing and developed countries, respectively, had Cryptosporidium infections (Adal et al, 1995)

Background

- Serosurveys indicate up to 20% in US, 65% in rural China, and 90% in parts of urban Brazil experience infection by young adulthood (Caccio, 2005)
- Children younger than 2 years of age have higher prevalence than adults
- Marked seasonality in US
- During 1991-2000, Cryptosporidium was identified as a causal agent of 37.7% of reported recreational water-associated and 8.5% of drinking water-associated outbreaks of gastroenteritis in US (MMWR, January, 2005)

Cryptosporidium *Cyclospora*





The Pathogen: I

- Cryptosporidium spp. first identified as cause of human illness in 1976
- All species are obligate intracellular parasites that infect gastrointestinal tract of vertebrates
- C. hominis, previously known as genotype I, is anthroponotic and exclusively causes human infections
- C. parvum, previously known as genotype II, is zoonotic and infects humans and animals. This species could be differentiated only by molecular techniques

The Pathogen: II

- *Combined* C. parvum and hominis *cause 90% of human cases worldwide*
- C. hominis *is more prevalent in North and South America, Australia, and Africa*
- C. parvum is *more prevalent in Europe*
- *Geographic variations exist within a country* (McLauchlin et al, 2000); C. parvum *in humans is more common in rural than urban areas* (Learmonth et al, 2004).
- C. hominis *appears to be predominantly responsible for waterborne outbreaks* (Rose et al, 2002)

The Pathogen: III

- The eggs, or oocysts, of the protozoa are shed in the feces of infected humans or animals
- Oocysts may remain infective up to 6 months in the moist environment outside body
- Cryptosporidium is resistant to disinfections with chlorine or chloramine, or common hospital disinfectants. It can be inactivated by UV radiation, ozone, and chlorine dioxide (Chen et al, 2002), or removed from contaminated water by filtration

The Pathogen: III

- Inactivation times for Cryptosporidium, Giardia, and E.coli are 7 days, < 1hr, and < 1min, respectively, at 1 mg/L free available chlorine
- Hyperchlorinaton: maintain free chlorine levels of 20 ppm for 8 hrs (一般自來水之餘氯 < 1ppm)

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Epidemiology: I

- The largest known outbreak of cryptosporidiosis occurred in 1993, in Milwaukee, Wisconsin, when over 400,000 people were infected from contaminated drinking water
- Besides drinking water, outbreaks have been associated with recreational water facilities, daycare centers, and food
- Outbreaks have been attributed to ingestion of contaminated apple juice, chicken salad, milk, and food prepared by ill food handler; growing data suggests that raw vegetables and shellfish could be the vehicle of Cryptosporidium transmission

Epidemiology: II
(Mode of Transmission)

- Fecal-oral route with ingestion of viable oocysts
- Person-to-person
- Animal-to-person (calves, rodents, puppies, kittens, etc.)
- Animal-to-animal
- Food borne
- Waterborne
- Autoinfection in humans

Epidemiology: III

- Incubation period of cryptosporidiosis is probably 1-12 days, on average 7 days
- Communicability starts with the onset of symptoms when oocysts appear in the stool; excretion of infectious oocysts lasts at least for 2 weeks or more. 10-30 oocysts are sufficient to cause infection in immunocompetent person
- Susceptibility: all are susceptible, especially children, elderly, and immunocompromised
- Reservoir: humans, cattle, domesticated animals

Epidemiology: IV

- The low infectious dose, protracted communicability, and chlorine resistance make Cryptosporidium ideally suited for transmission through drinking and recreational water
- Estimated 60,320-301,600 cases of cryptosporidiosis occurred in US in 2002 (extrapolated from 3,016 cases reported to CDC)

USEPA Method 1623

- Detection method approved by US Environmental Protection Agency (USEPA)
- Method requires water filtration on to a filter medium; the material that remains on the filter media is eluted and any oocysts are separated using magnetic beads conjugated to anti-Cryptosporidium antibodies. The oocysts are stained with fluorescently labeled monoclonal antibodies, and the sample is then examined microscopically and compared to specified criteria for size, shape, color and morphology

Limitations of Method 1623

- The test commonly used in US is limited by speed, accuracy, and complexity
- Recovery efficiency varies widely
- Method does not specify a mechanism for assessing the viability and infectivity of the oocysts detected, or the Cryptosporidium species
- Logistical limitations

Detection

- The level of detectable Cryptosporidium oocysts in water samples that poses no public health risk is unknown
  - Outbreaks associated with drinking water occurred in UK despite the peak oocyst count's being within the statutory standard (1 per 10L).
  - No episodes of illness in the community have been reported when high oocyst counts have been detected in treated water (Howe et al, 2002)
  - Public Health importance of low levels of Cryptosporidium as well as the optimal water sampling during the outbreak needs to be defined

Clinical Manifestations

- In immunocompetent
  - self-limiting, usually watery diarrhea for 10-14 days (range 2-28)
  - Variable from asymptomatic oocyst shedding to severe disease that may last up to 3 months
  - Also include abdominal pain, flatulence, loss of appetite, nausea/vomiting; may have low-grade fever, fatigue, myalgias, anorexia, headache
- In immunocompromised
  - particularly HIV+, disease is severe, often chronic, incurable, and life-threatening

Laboratory Diagnosis: I

- Oocysts in stool or intestinal fluid by light microscopy with or without staining or by fluorescent antibody assays (DFA or IFA)
- Oocyst or sporozoite antigens in stool or intestinal fluid by immunodiagnostic methods, like EIA
- Parasite DNA in stool, intestinal or other body fluid, or in tissue sample by PCR
- Life-cycle stages in tissue samples

Laboratory Diagnosis: II

- DFA is most specific and sensitive detection method; only PCR can be used to speciate Cryptosporidium
- The test for Cryptosporidium detection by the laboratory must be specifically requested
- Examination of multiple specimens may be necessary
- Stool antigen detection is not more sensitive than microscopy
- Serologic testing (IgM, IgG) has no diagnostic application

Treatment

- In most immune-competent hosts
  - no therapy except maintenance of adequate hydration
- Nitazoxanide (Alinia)
  - treatment of immune-competent children < 12 years of age.
  - clinical and parasitological response rate of 80% and 70%, respectively (Bailey, Erramouspe, 2004)
- Other medications used in immune-compromised patients include spiramycin, newer macrolides, and paromomycin

Prevention

- Good hand hygiene
- Prevent contamination of recreational water
- Prevent infection caused by water that might contaminated
- Prevent infection caused by eating food that might be contaminated
- Prevent contamination during sexual activity
- Additional prevention for persons with compromised immune system

Hot Tubs Diseases

Possible Problems

- Burns*
- Folliculitis
- Inhalational injuries from chemicals*
- Humidifier lung
- Hot water fever
- Legionellosis
- Hot tub lung

Hot Tub Folliculitis

- "Hot tub buns"
- Most commonly caused by *Pseudomonas aeruginosa*
- Pruritic erythematous papule which can progress to erythematous macules or pustules.
- Typically appears in 48 hours
  - Range of 6 hours to 5 days
    - One report of 14 days post exposure

Hot Tub Folliculitis

- Typically distributed over axilla, abdomen and buttocks area.
- Has been confused with: insect bites, hives, allergy, staphylococcal infection, chicken pox, contact dermatitis, and herpes
- Resolve spontaneously within a period of seven to 10 days.

Hot Tub Folliculitis

- Attack rate of 7 to 100%
- Risk factors: crowding, frequent and long hours in tubs (superhydration of skin), snug one piece bathing suits
- Even seen in people who don’t wear suits
- Showering may not be protective
- Seasonal – winter months higher

Hot Tub Folliculitis

- Mild fever and malaise may occur
- Other associated symptoms include: earache, sore throat, sore eyes, conjunctivitis, lymphadenopathy, rhinitis, swollen and painful breasts, nausea, vomiting, abdominal cramps, malaise, fatigue, headache, chills

Tubs have a Capacity!

Bacterial Loads[1]

Water Sample	Tap (n=34)	Tub (n=43)[2]
Average cfu/ml	1.38×10^2	2.17×10^6
Low Sample cfu/ml	0 (68% of samples)	700
High Sample cfu/ml	3500	1.48×10^7 (10% of samples $>10^7$)

[1] Moyes, RB unpublished data

[2] Private n = 22, hotel n = 21)

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Bacterial Analysis of Whirlpool Tub Water Samples

	% of positive samples
Enterics[1]	95% (41 of 43)
Fungi	81% (25 of 31)
Staphylococcus aureus	34% (13 of 38)
Pseudomonas aeruginosa	16% (7 of 43)
Other Pseudomonas sp.	56% (24 of 43)
Legionella sp.	36% (8 of 22)

[1] includes *E. coli*, *P. mirabilis*, *Y. pseudotuberculosis*, *Shigella* sp, *Serratia* sp, *Klebsiella* sp.

Nosocomial Whirlpool Tub Infections

- Hematology and Oncology unit
- Infections include sepsis, line infections, wound infections – not folliculitis
- Epidemic strain found in drain
  - contiguous with tub, closing 2.5 cm below tub level
- Significant risk of infection from tub use

Nosocomial Whirlpool Tub Infections

- Contact time was acceptable
- Could not scrub area – biofilm or slime layer was protecting organism
- New water became colonized with organism
- Outbreak stopped when tubs removed

Aerosol-related Infections

- Legionella pneumophila
  - Pontiac fever – milder illness with flu-like symptoms
  - 20 persons who used both a whirlpool and swimming pool at a hotel.
  - L. pneumophila isolated from whirlpool water only, not pool.

Legionella

- Factors that enhance colonization and amplification in man-made water environments include:
  - Temperatures of 25º – 42ºC
  - Stagnation
  - Scale and sediment
  - Presence of certain free living amoeba
    - Support intracellular growth of legionellae

Hypersensitivity Pneumonitis

- Associated with *Mycobacterium avium* complex
- Considered a hypersensitivity reaction as opposed to an infection
- Misdiagnosed as atypical pneumonia, acute asthma with pneumonia, sarcoidosis, eosinophilic bronchiolitis

Hypersensitivity Pneumonitis

- Predominate symptom is dyspnea
- Will include fever (38^{o}C), chills, malaise, headaches, weight loss, dry cough and rhinorrhea
- Hot tub water not changed frequently enough (8 months in one case)
- Mycobacteria isolated from several of the tubs

Hypersensitivity Pneumonitis

- X-ray – bilateral infiltrates; bilateral patchy nodular infiltrates; widespread miliary nodular changes; worsening diffuse bilateral alveolar inflitrates
- Biopsy – well-formed non-necrotizing and focally necrotizing granulomatous inflammation with virtually all the granulomas centered on the small airways, with focal intrabrochiolar localization, obliterating the lumens

Hypersensitivity Pneumonitis

- Previous treatment history was prednisone and / or antibiotics
- Many cases kept using hot tub to help relieve symptoms!
- Once tub use stopped (sold, converted to indoor garden) symptoms resolved usually on their own

Hypersensitivity Pneumonitis

- Organisms recovered in one tub included:
  - M. avium complex, Pseudomonas sp. Penicillium sp, and Scopulariopsis sp.
- M. avium complex is resistant to chlorination and can be found in domestic water

Humidifier Lung

- Hypersensitivity pneumonitis associated with the inhalation of contaminated water from air-conditioning systems, and domestic, office, and industrial humidifiers.
- Has been reported in showers, at a swimming pool, and in a sauna

Humidifier Lung

- Organisms implicated:
  - Thermophilic Actinomyces, Sphaeropsidales, Penicillium sp, protozoa, Pullulalria and Klebsiella oxytoca

Unknown Etiology

- 12 persons in Texas guest ranch
- Symptoms included exhaustion, sore muscles, headache, chills, and fever
- One lady reported a miscarriage during her illness
- Clinical specimens negative for L. pneumophila, influenza, parainfluenza, adenovirus.
- Hot tub had been drained, refilled and hyperchlorinated before culture could be done.

Amoebae

- Finnish study found 7 of 11 whirlpools contained amoebae.
- Microbiological quality of water was good in 71% of tubs with amoebae
- Both samples with P. aeruginosa had amoebae
- Filtering and chlorination is unable to destroy cysts.

Amoebae

- Amoebae proliferate in filter
  - Need to wash regularly by reverse flux
- Conclusion was that contact lenses should not be worn when swimming or bathing in public pools, because of theoretical risk of keratitis.

Hydrotherapy Tubs

India Medico Instruments

Hydrotherapy tubs

- Generally one person at a time
- Need to be drained, cleaned and disinfected between patients
- If jetted, must circulate disinfectant through jets
- Important to ensure proper contact time and dilution of disinfectant

Birthing Tanks

- Have seen *P. aeruginosa* infections in neonate from tank water
- Water and walls will be contaminated with skin flora and blood during labor and delivery.
- Follow manufacturer's instructions for selection of disinfection method and agent

Footbaths/Foot Spas

Footbaths/Foot Spas

- Outbreaks have been seen
  - Texas, California
- Mycobacterium fortuitum and other related mycobacteria
- Look like spider bites that eventually grow, produces pus, can scar
- Don't shave before your pedicure

Footbaths/Foot Spas

- Between customers: drain, wash and disinfect
- End of each day, remove filter screen, wash system, disinfect
- Every other week clean with bleach solution, then soak for 6 hours

Disinfectants

- Calcium, lithium and sodium hypochlorite, chloroisocyanurates and chlorine gas
- Chlorine – activity is shortened by:
  - Aeration,
  - Agitation
  - High temperatures
  - High numbers of bathers

Disinfectants

- Bromine
  - Forms bactericidal bromamines
  - Some problems with contact dermatitis
- Iodine
  - Does not bleach hair, swim suits or cause eye irritation
  - Gives water a greenish-yellowish cast

Culturing Frequency

- Depends on state of tub, can look only for Pseudomonas, or total and fecal organisms
- Rapid method described using adenosine triphosphate (ATP) which showed good correlation to standard plate counts, but also detected non-coliform bacteria

懇 請 賜 教