جلسه ۶:

پارامترهای میکروبیولوژیک

درس: مهندسی تصفیه آب و فاضلاب

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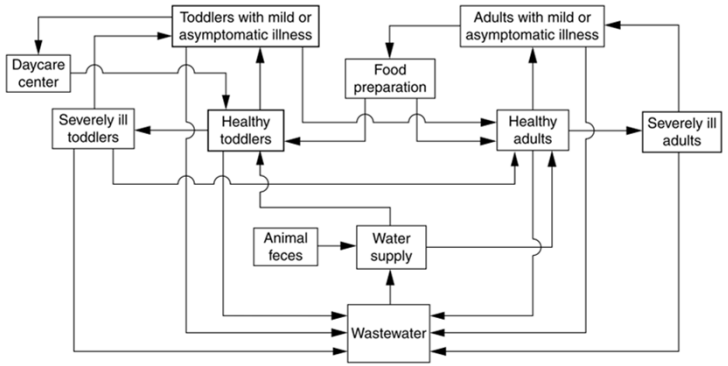
Disease transmission



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Some groups of waterborne pathogens

Group	Pathogen	Diseases and symptoms caused
Bacteria	*Salmonella*	Typhoid and diarrhea
	Shigella	Diarrhea
	Campylobacter	Diarrhea—leading cause in foodborne outbreaks
	Yersinia enterocolitica	Diarrhea
	Escherichia coli O157:H7 and other certain strains	Diarrhea, which can lead to hemolytic uremia syndrome in small children.
	Legionella pneumophila	Pneumonia and other respiratory infections
Protozoa	*Naegleria*	Meningoencephalitis
	Entamoeba histolytica	Amoebic dysentery
	Giardia lamblia	Chronic diarrhea
	Cryptosporidium parvum	Acute diarrhea, fatal for immunocompromised individuals
	Cyclospora	Diarrhea
	Microsporidia includes Enterocytozoon spp.	Chronic diarrhea and wasting, pulmonary, ocular, muscular, and renal disease
	Encephalitozoon spp.	
	Septata spp.	
	Pleistophora spp.	
	Nosema spp.	

Some groups of waterborne pathogens

Group	Pathogen	Diseases and symptoms caused
Cyanobacteria (blue-green algae)	Microcystis	Diarrhea from ingestion of the toxins these organisms produce
	Anabaena	Microcystin toxin is implicated in liver damage
	Aphantiomenon	
Helminths	*Ascaris lumbricoides*	Ascariasis
	Trichuris trichiora	Trichuriasis (whipworm)
	Taenia saginata	Beef tapeworm
	Schistosoma mansoni	Schistosomiasis (affecting the liver, bladder, and large intestine)
Viruses	Enteroviruses (polio, echo, coxsackie)	Meningitis, paralysis, rash, fever, myocarditis, respiratory disease, and diarrhea
	Hepatitis A and E	Infectious hepatitis
	Human Caliciviruses	
	Noroviruses	Diarrhea/gastroenteritis
	Sapporo	Diarrhea/gastroenteritis
	Rotavirus	Diarrhea/gastroenteritis
	Astroviruses	Diarrhea
	Adenovirus	Diarrhea (types 40 and 41), eye infections, and respiratory disease
	Reovirus	Respiratory and enteric infections

Protozoa vs. Bacteria

- Bacteria are simpler (first life forms)
- Protozoa and bacteria (usually) are unicellular, but protozoa are generally larger
- Protozoa feed on bacteria and other molecules by enveloping them
- Bacteria reproduce through binary fission, but protozoa have various methods
- Bacteria have no nucleus (prokaryote), but protozoa do (eukaryote)

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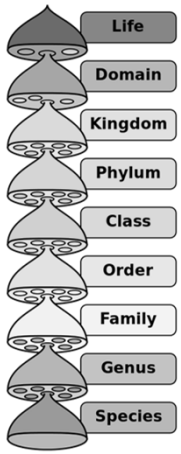
How to name living species

- According to convention, every biological species (except viruses because they are not living) bears a Latinized name that consists of two words.
- The first word is the genus (e.g., Giardia), and the second word is the species (e.g., lamblia).
- The first letter of the genus name is capitalized, and both the genus and species are either italicized or underlined (e.g., *Escherichia coli*)



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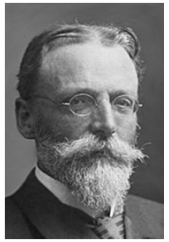
Cholera

- Historically, microorganisms were first identified as agents of waterborne disease during the cholera outbreak in England in the 1860s.



- In 1884, Theodor Escherich, isolated an organism from the feces of a cholera patient, which he initially thought was the cause of cholera. Later similar organisms were found in feces of every healthy individual. The organism was eventually named after him—Escherichia coli or E. coli.

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E. Coli

- E coli is a generally harmless bacteria but some strains are pathogenic.
- A particular strain, E. coli O157:H7, causes acute bloody diarrhea, and in some cases (5%) red blood cells are destroyed and the kidneys fail. One of the highest mortality rates of all waterborne diseases is due to this.
- A known source of the dangerous E. coli O157:H7 is in healthy cattle. Transmission can occur by ingestion of undercooked beef or raw milk.

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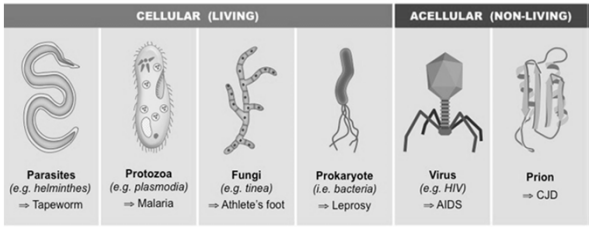
Other common pathogens

- Giardia lamblia is the most common protozoa infection
- Cryptosporidium (especially the pavum and hominis species) is in the form of an oocyst. It enters animals and causes cryptosprridiosis which leads to sever diarrhea and presently has no pharmaceutical cure
- G. lamblia has been detected in treated wastewater effluent and is much more resistant to disinfection with chlorine than is bacteria.
- Chlorination is not effective on cryptosporidium.

Indicator organisms

- The number and variety of microbes that may be present in wastewater is huge so measuring all possible pathogens is either impossible or impractical.
- Thus, tests for surrogate microorganisms (known as indicator organisms) are used



The ideal indicator

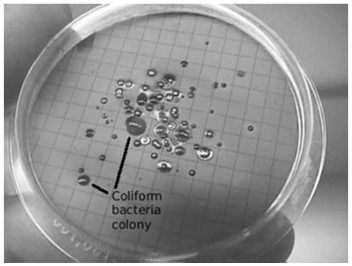
- Is present when fecal contamination is present (is a member of the intestinal microflora of warm-blooded animals)
- Is present in larger numbers than the target pathogen
- Exhibits greater (or the same) survival than the target
- Does not have a culturing procedure that is dangerous to laboratory scientists
- Can be isolated and quantified quickly, easily, and cheaply, compared to the target

Choosing an indicator

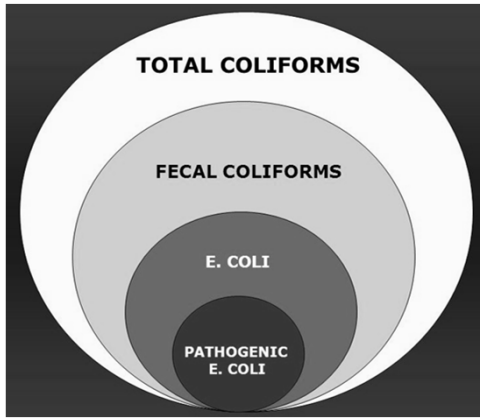
- To date, no ideal indicator organism has been found.
- Each person excretes 100-400 billion coliform bacteria per day, in addition to other kinds of bacteria. Thus, the presence of coliform bacteria has been taken as an indication that pathogenic organisms are also present, and the absence of coliform bacteria has been taken as an indication that the water is also free from disease producing organisms.
- The measurement and control of total coliforms (rather than only fecal coliforms) during disinfection is considered to be a more stringent treatment goal

Total coliforms

- Specific bacteria are difficult and time consuming to isolate and identify, so microbiologists have developed the "total coliform test" to simplify the task.
- The total coliform group can survive longer in water than most disease-causing organisms and are easier to identify. The absence of total coliform is, therefore, considered evidence of bacteriologically safe water.



Relation



Choosing an indicator

- While coliform bacteria serve well as indicators of bacterial pathogens, they may not predict the removal of enteric (fecal) protozoa, viruses, and helminths.
- A conservative standard for clean water would be a total coliform count of ≤ 1 coliform/100 mL (USA).
- In Iran if the wastewater has ≤ 1000 total coliform/100mL (and ≤ 400 fecal coliform/100mL) it can be discharged
- More recently, Giardia and Cryptosporidium have also been proposed as indicators in developed countries.

Real example

ردیف	عنوان آزمایش	واحد	نتیجه	نوع روش	شماره روش	محدوده قابل قبول	عدم قطعیت
۱	شمارش کل کلیفرمها	MPN/100ml	93	Multiple Tube Technique	ISIRI 3759	——	——
۲	شمارش کلیفرمهای مدفوعی	MPN/100ml	93	Multiple Tube Technique	ISIRI 3759	——	——
۳	شمارش استرپتوکوکهای مدفوعی	MPN/100ml	——	Multiple Tube Technique	9230 B	——	——
۴	شمارش باکتری های هتروتروف	CFU/ml	——	Pour Plate Method	9215 B	——	——
۵	جستجو و شمارش استافیلوکوکوس	——	——	Multiple Tube Technique	9213 B	——	——
۶	جستجو و شمارش سودوموناس	——	——	Multiple Tube Technique	9213 F	——	——
۷	شمارش تخم انگل	/1000 ml	——	——	——	——	——
۸	شناسایی باکتری های احیاء کوگرد	——	——	——	——	——	——
۹	TBC	CFU/ml	——	——	——	——	——
۱۰	E.Coli	——	23	——	——	——	——

ازمایش کننده
کارشناسان بخش

تایید کننده (مسئول بخش)
طاهره نشاطی

تصویب کننده (مدیر کرشد)
علی عاکوبر

State-of-the-art targets

- The theoretical model of Regli proposes an annual risk of 10^{-4} of infection to be acceptable for drinking water.
- This means that less than one person per 10,000 consumers will be infected per year. While only a small percentage (~1 %) of infections result in disease.
- This leads to the following concentration in drinking water after treatment (unit operations + disinfection):

Viruses	**< 1 per**	**1,000 m^3**
Giardia	**< 1 per**	**100 m^3**
Cryptosporidium	**< 1 per**	**10 m^3**

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Enterococci

- Two strains of fecal streptococci, *S. faecalis* and *S. faecium*, are the most human specific members of the fecal streptococcus group.
- Used in conjunction with fecal coliform to determine the source of recent fecal contamination (man or farm animals)
- EPA recreational water quality criteria:

CRITERIA ELEMENTS	Recommendation 1 Estimated Illness Rate 36/1,000		Recommendation 2 Estimated Illness Rate 32/1,000	
Indicator	GM (cfu/100 mL)	STV (cfu/100 mL)	GM (cfu/100 mL)	STV (cfu/100 mL)
Enterococci (marine & fresh)	35	130	30	110
E. coli (fresh)	126	410	100	320

N

Organism	Concentration in raw wastewater, MPN/100 mL[b]	Median infectious dose number (N_{50})
Bacteria		
Bacteroides	10^7–10^{10}	
Coliform, total	10^7–10^9	
Coliform, fecal[c]	10^5–10^8	10^6–10^{10}
Clostridium perfringens	10^3–10^5	1–10^{10}
Enterococci	10^4–10^5	
Fecal streptococci	10^4–10^6	
Pseudomonas aeruginosa	10^3–10^6	
Shigella	10^0–10^3	10–20
Salmonella	10^2–10^4	
Protozoa		
Cryptosporidium parvum oocysts	10^1–10^5	1–10
Entamoeba histolytica cysts	10^0–10^5	10–20
Giardia lamblia cysts	10^1–10^4	< 20
Helminth		
Ova	10^0–10^3	
Ascaris lumbricoides		1–10
Virus		
Enteric virus	10^3–10^4	1–10
Coliphage	10^2–10^4	

[a]Adapted in part from; Feacham et al. (1983); NRC (1996); Crook (1992).
[b]MPN = most probable number.
[c]*Echerichia coli* (enteropathogenic).

Log removal

- Because pathogens exist in large number, their removal or inactivation is often expressed as log removal:

$$\text{Log removal} = -\log\left(\frac{\text{conc}_{\text{out}}}{\text{conc}_{\text{in}}}\right) \qquad (3\text{-}1)$$

For example, if the concentration of *Giardia lamblia* is reduced from 100/L in the influent to 1/L in the effluent by activated sludge treatment process, the log removal due to the treatment is

$$\text{Log removal} = -\log\left(\frac{1}{100}\right) = 2 \text{ or } 99\% \text{ removal}$$

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Natural processes

- In receiving waters, natural processes tend to reduce the concentrations of enteric microorganisms due to dilution and die-off.
- The natural inactivation or die-off rate is usually reported in terms of the time required for a 90 percent reduction in the viability of the microbial population.
- It is known that enteric pathogens generally survive longer at lower temperatures.

Freshwater survival rate

Microorganism	Time reported for 90 percent reduction in viable concentrations
Coliforms	0.83 to 4.8 d at 10 to 20°C, avg. 2.5 d
E. coli	3.7 d at 15°C
Salmonella	0.83 to 8.3 d at 10 to 20°C
Yersinia	7 d at 5 to 8.5°C
Giardia	14 to 143 d at 2 to 5°C 3.4 to 7.7 d at 12 to 20°C
Enteric viruses	1.7 to 5.8 d at 4 to 30°C

[a]Adapted from Feachem et al. (1983); Korhonen and Martikainen (1991); Kutz and Gerba (1988); McFeters and Terzieva (1991).

Removal after unit operations

Pathogen removal

Organism	Removal of organism for given treatment process, log units					
	Primary	Secondary		Tertiary		Advanced
	Plain sedimentation	Activated sludge	Trickling filter	Depth filtration	Microfiltration[b]	Reverse osmosis[c]
Fecal coliforms	<0.1–0.3	0–2	0.8–2	0–1	1–4	4–7
Salmonella	<0.1–2	0.5–2	0.8–2	0–1	1–4	4–7
Mycobacterium tuberculosis	0.2–0.4	0–1	0.5–2	0–1	1–4	4–7
Shigella	<0.1	0.7–1	0.8–2	0–1	1–4	4–7
Campylobacter	1	1–2		0–1	1–4	4–7
Cryptosporidium parbum	0.1–1	1		0–3	1–4	4–7
Entamoeba histolytica	0–0.3	<0.1	<0.1	0–3	2–6	>7
Giardia lamblia	<1	2		0–3	2–6	>7
Helminth ova	0.3–1.7	<0.1	1	0–4	2–6	>7
Enteric viruses	<0.1	0.6–2	0–0.8	0–1	0–2	4–7

[a]Adapted in part from Crook (1992).
[b]Wide range of values due to differences in performance of membranes from different manufacturers and imperfections or failure of the membrane (see Example 8-4 in Chap. 8).
[c]In theory, reverse osmosis should remove all organisms, however, due to imperfections or failure of the membrane some organisms may pass through with the permeate stream (see Example 8-4 in Chap. 8).

تکلیف

- هر دانشجو تا جلسه آینده می بایست یک مقاله یا منبع موثق تحویل دهد که در آن میزان باکتری یا ویروس یا انگل یا ... از یک نمونه آب در آن بیان شده باشد
- لطفا فایل را پرینت نکنید (برای حفظ محیط زیست) و آن را تا قبل از شروع جلسه بعد ایمیل کنید
- پس از شروع کلاس جلسه بعد، دیگر تکلیف پذیرفته نمی شود
- اگر مقاله یا منبعی بیاورید که با دانشجوهای دیگر یکسان باشد، نمره بین شما تقسیم خواهد شد (نصف، یا ثلث یا ربع یا ...)