## Microbiological Aspects of Drinking Water Treatment

CE421/521 Environmental Biotechnology Tim Ellis October 12, 2006

## Overview

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water has the greatest impact on

human health for > 50% of world's population

worldwide d\_\_\_\_\_ due to contaminated drinking water are approximately 14,000 - 25,000 per day

drinking

25% of h\_\_\_\_\_ b\_\_\_\_ occupied by people infected with waterborne illnesses
 currently the world's population that lack's a\_\_\_\_\_ to "safe" drinking water is 18% or 1.1 billion (Johannesburg World

Summit on Sustainable Development, 2002)

## World Water

- 2.5 billion are without proper s\_
- More than 5 million people die each year from diseases caused by u\_\_\_\_\_ drinking water, lack of sanitation, and insufficient water for h\_\_\_\_\_. In fact, over 2 million deaths occur each year from water-related diarrhea alone. At any given time, almost half of the people in developing countries suffer from waterrelated d\_\_\_\_\_.
- Insufficient s of water and sanitation disproportionately affect women, children, and the poor. The majority of deaths from water-related diarrhea are among children under 15, and women.
- Agriculture accounts for more than \_\_\_\_\_ percent of global water consumption. The inefficient use of water for irrigation has led to depletion of groundwater resources in many of the world's most important agricultural regions, and is the primary source of g\_\_\_\_\_ pollution in parts of Europe, the US, and Asia.



## World Water



During the 1990s, about \_\_\_\_\_ million people in developing countries gained access to improved drinking water, 2 demonstrating the possibility for major improvements in safe water access worldwide.

At the Millennium Summit in September 2000, world leaders agreed to the goal of h\_\_\_\_\_, by 2015, the proportion of people without access to safe drinking water and sanitation. To meet this goal, an additional 1.6 billion people will need access to adequate water, and 2 billion will need improved sanitation. The annual investment required to meet the goal is estimated to be \$\_\_\_\_\_ billion, nearly twice the LEADING IRRIGATION COUNTRIES

current level of investment.

Country	irrigated Area (1,000 Square Kilometers)	inigated Land as a Percentage of Cropiand	Water Used In Irrigation (Cubic Kilometers)	Percentage of all Water Withdrawais used for Irrigation
World	2,296	19	2,236	69
China	513	52	400	87
India	490	29	353	93
United States	209	11	196	42
Pakistan	163	BD	151	97
Mexico	62	25	67	86
Egypt	33	100	47	86

## World Water

Within 25 years, half the world's population could have trouble finding enough fresh water for d\_\_\_\_\_\_ and i\_\_\_\_\_ (BBC News, Wednesday, 15 December, 1999, CU study).

- a third of the world's people already live in regions considered to be "water-stressed" - where there is not enough, or barely enough water to go around.
- Areas at risk Waterways under most pressure included:
  - China's Y\_\_\_\_\_ River basin,
  - the Z\_\_\_\_\_ River in Africa,

and the rivers that lead into the Aral Sea in Central Asia.
 (Most of the water from those sources is used for irrigation, not drinking)



## to protect public health



## need for multiple barriers to contamination:

- s \_\_\_\_\_ protection, land use restrictions
- livestock r\_
- collection, treatment, and d\_\_\_\_\_ of wastewater
- treatment, disinfection, and d
- prevent cross c\_

## Microbiological Quality of Source Water



want to find best possible s\_influence of

quality

- p\_\_\_\_\_ sources (wastewater treatment plant discharges)
- non-point source discharges (agricultural runoff, stormwater runoff, street runoff, s\_\_\_\_\_\_tank effluent)
- ø a\_\_\_\_\_ pollution
- bird and animal f\_



## Microbiological Quality of Source Water



#### surface water systems

comprise approximately 6,000 c water systems and serve a population of approximately 155 million people

affected by both p\_ sources

#### and non-point

Lake d

 – leads to an increase in turbidity and pathogens



## Microbiological Quality of Source Water

contaminated groundwater can be a concern

🥘 U

non-c\_

\_\_\_\_ groundwater \_\_\_\_\_ groundwater

🥘 n\_

🧶 a

other contaminants (inorganics, e.g., fluoride, and organics)



## **Overview of Water Treatment**

Conventional S \_\_\_\_\_ Water Treatment

- raw water p\_\_\_\_\_
- 🧖 S\_\_\_\_\_
- pretreatment (optional)
  - pre-a
  - prec\_\_\_\_\_
- // rapid m\_\_\_\_\_
- s\_\_\_\_\_ mix coagulation/flocculation
- 🧶 S
- 🥟 f 🧼 d\_\_\_\_\_
- 🧖 S 🧔 d





## **Overview of Water Treatment**

### Conventional Groundwater Treatment Plant

- aw water p\_\_\_\_\_
- rapid mix I \_\_\_\_\_ addition
- slow mix coagulation/flocculation
- Sedimentation
- filtration
- Ø Disinfection
- storage
- distribution



#### Viruses

 e\_\_\_\_\_\_ present at levels of 3 - 20 pfu per 1000L in finished water in Payment, 1989 study
 normally viruses will be removed in n\_\_\_\_\_ water treatment plant operation

#### Virus Survival in WTP pfu/1000 L (page 328 in Bitton)

Raw Water	Sedimentation	Filtration	Ozonation
10 /	~75	0 1	
6 1	<ul><li>&lt;23</li><li>132</li></ul>	9.1 <1	<1
100	75	<7	<1
90	5	<1	<1
10	20	3	<1
30.7	10	5	<1

Cryptosporidium and Giardia lamblia \_\_\_\_\_ to detect routinely 🧼 d Opportunistic Pathogens waterborne, can cause s infections Psudomonas putida Alcaligenes Acinetobacter Flavobacterium Legionella • can be i\_\_\_\_\_ from air conditioning or shower heads

Storage of Raw Water — can result in reductions of pathogens (approximately \_ log)
 t \_\_\_\_\_\_

s\_\_\_\_\_
 s\_\_\_\_\_
 p\_\_\_\_\_



- Prechlorination can lead to increased
  d\_\_\_\_\_\_byproducts
  Coaculation Elocculation (alum ferric)
- Coagulation Flocculation (alum, ferric chloride, polyaluminum chloride)
  - will achieve significant reductions in t\_ (and consequently pathogens)
    - b\_\_\_\_\_ : 90% removal
    - v\_\_\_\_: 90-99% removal
    - protozoan c\_\_\_\_\_: 90% or greater removal

### Softening will achieve significant reductions in t\_\_\_\_\_: 60-70% viruses: 96-99% removal Filtration requires adequate c\_\_\_\_\_ to be effective: ø p\_\_\_\_\_ removal with f\_\_\_\_\_ but without coagulation: 1-50% poliovirus removal with filtration and with coagulation: 90-99% Cryptosporidium o removal with filtration without coagulation: 90%

## Surface Water Treatment Plant

Surface Water Treatment for Turbidity and Color Removal



# Groundwater Treatment Plant

Treatment of Groundwater for Hardness Removal



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## Membrane Processes



## Membrane Processes



## Water Treatment Plants



