

# **APPENDIX C**

# Recycling Human Waste

Dr. Martin Atkinson-Barr

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## Objectives

- Establish facts on which Elected Representatives can make an informed decision.
- Provide public with rationale to allay unreasonable fears and make proper decisions about treated wastewater contact.
- Guidelines for better public health.

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## Presentation Roadmap

- Overview of waste stream.
- Pathogen flow.
- Disinfection methodologies.
- Infectious diseases.
- Existing legal framework.
- What's special about an elementary school?

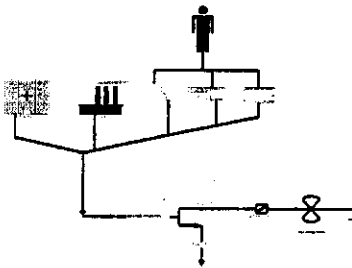
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## Waste Stream



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## Waste Sources

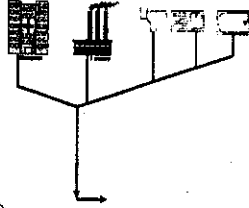
- 20 billion bacteria per person per day
- 9% of fecal mass is bacterial



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## Consequences of Mixing

- Adding chemicals can induce changes in bacteria
- Benign bacteria can acquire toxin-producing capabilities
- Bacteria can exchange survival abilities



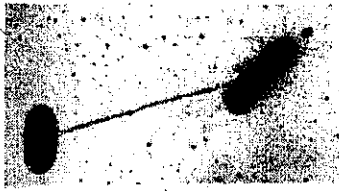
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## Bacterial DNA Transfer

- "Transformation" – uptake of naked foreign DNA
- "Transduction" – phage facilitated DNA transfer
- "Conjugation" – bacterial mating

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## Bacterial Mating



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## Review

- Dense bacterial and pathogen waste stream
- More dangerous through mixing

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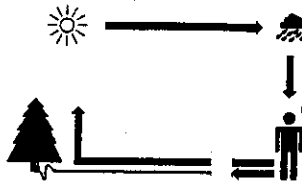
## Pathogen Flow

- Bacteria
- Viruses
- Parasites
- All human-host adapted
- Humans amplify adapted organisms

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## Closing the Circle (1)

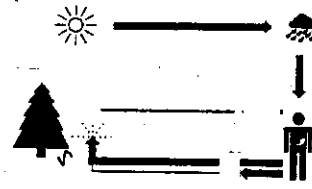
- Natural distillation, drip irrigation – the ideal solution



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## Closing the Circle (2)

- Spray irrigation – direct human contact



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## Cautions on Closing the Circle

- Cholera (1854)
- Kuru
- BSE – “mad cow” disease
- AIDS
- SARS?

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## Review

- Micro-organisms in human waste are host-adapted.
- Humans amplify adapted organisms.
- Water treatment, hygiene and host defenses all play a role in preventing infection.
- Issues of positive biological feedback are troublesome.

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## Cleaning Up the Waste Stream

- Sedimentation
- Oxidation
- Filtration
- Disinfection
- Application

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## Misuse of Coliforms

- Common and very well studied, present in large numbers in animal solid waste.
- Good to indicate contact with fecal material in source feeds.
- Not good to measure efficiency of disinfection – *but are used that way.*

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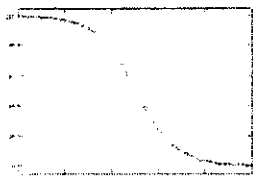
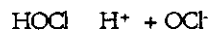
## Disinfection

- Chlorine or hypochlorite application
- Identical chemistry:



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## HOCl - disinfectant

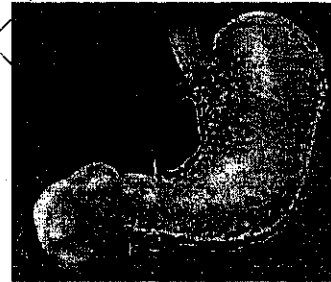


ACID

ALKALI

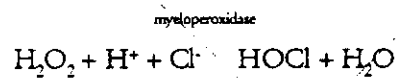
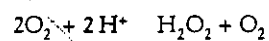
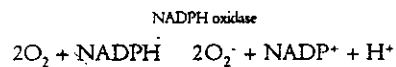
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## The Human Stomach



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## HOCl in the Stomach



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## The Stomach as an Antibacterial Bath

- Kills organisms by HOCl and enzymes
- Highly acidic pH = 2
- Muscular sac that mixes and digests food
- Thought to be sterile until 1990s
- Protects from ingested infections
- Not always effective

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## For better health

- Avoid overuse of antacids
- Do *not* use antacids as calcium supplements
- Regular users of acid-blocking drugs can should be tested for gastric infection

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## Review

- Disinfection in the stomach is a *superset* of the disinfection process used in water treatment (including swimming pools).
- Organisms that survive gastric juice will survive water treatment.
- Acidity is essential to HOCl disinfection.

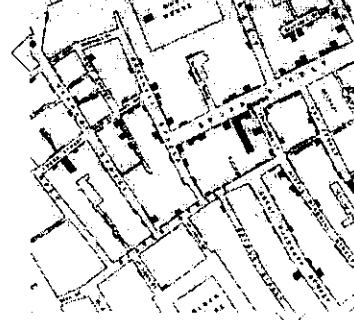
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## Point Source – Cholera 1854



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## Drinking Water Chlorination

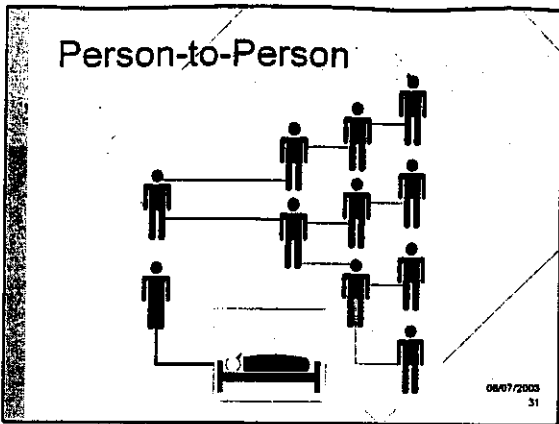
- Persons with functional defenses can tolerate moderate, even severe, contamination
- Everyone, at some time, will have impaired defenses
- High childhood mortality prior to chlorination

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## Point Source



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### Pathogens Resistant to HOCl

7A. Microbial Pathogens in Drinking Water Systems

The incidence of waterborne disease in the U.S. is highly uncertain. While the health effects caused by drinking water pathogens are generally known, limited information is available on the doses and conditions that produce effects. Limited information is also available on alternative disinfection methods for pathogens resistant to the conventional chlorine-based disinfection methods. Research is needed in the following areas: . . .

<http://es.epa.gov/ncercqa/rfa97/aparta97.html>

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"The safety of drinking water is compromised by pathogenic microorganisms resistant to standard disinfection methods. Research is required on the efficacy of ultraviolet radiation (pulsed and continuous) as a disinfectant in drinking water from various groundwater and surface water sources, including those that may pose limitations."

<http://es.epa.gov/ncercqa/rfa97/aparta97.html>

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### *Helicobacter Pylori* A Pathogen That Lives in the Stomach

- Discovered by Dr. Barry Marshall in 1984
- Not generally accepted until 1991
- Causes chronic illness
- Eliminated with special antibiotic combinations
- Transmitted by contaminated water or contact
- Class 1 carcinogen
- 50% of world's population infected

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### *H. Pylori* pathogenesis

- Mild acute symptoms: low grade nausea, stomach lining becomes gray & "punky"
- After ~10 years causes stomach and duodenal ulcers
- After ~30 years is associated with gastric cancer

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### Reported Diseases

	Symptoms	Physician	Reported linked to source
Mild Acute	GI	No	No
Severe Acute	Fever, GI	Yes	Some
Acute Death	Death	Yes	Yes
Mild Chronic	Fatigue Malaise	Y/N	No
Severe Chronic	Major disease	Yes	No
Chronic (death)	Death	Yes	No

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## Review

- We must be especially careful to avoid point sources of infection
- Contaminated water targets people with compromised defenses
- Chlorination reduces most pathogens but some are more resistant than others
- Bacteria can produce chronic diseases
- Most events will not be reported

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## Title 22 Code of Regulations

- Legislative Intent  
Recycled water is not equivalent to potable water.  
The public is to be informed when recycled water is in use.

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## Use Area Requirements

- g) All use areas where recycled water is used that are accessible to the public shall be posted with signs that are visible to the public, in a size no less than 4 inches high by 8 inches wide, that include the following wording:  
RECYCLED WATER - DO NOT DRINK.

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## Review

- State law recognizes that reclaimed water is *not* equivalent to potable water.
- State law requires that persons be notified when they are in an area where reclaimed water is in use.

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## Elementary Schools

- Mandated attendance every weekday
- 4 -10 year olds without parental supervision
- Poor personal hygiene
- Undeveloped immune system
- Unable to read and comprehend signage
- Essential element of general public health

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## Conclusion

- The risks of reclaimed water must be taken seriously.

*Reclaimed water is not sterile  
It derives from a human-pathogen rich source*

- People should take appropriate precautions - hygiene.

*Especially when they may have impaired defenses*

- Young children cannot meet these requirements.

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## 7A. Microbial Pathogens in Drinking Water Systems

The incidence of waterborne disease in the U.S. is highly uncertain. While the health effects caused by drinking water pathogens are generally known, limited information is available on the doses and conditions that produce effects. Limited information is also available on alternative disinfection methods for pathogens resistant to the conventional chlorine-based disinfection methods. Research is needed in the following areas:

In many cases, the causative agents for waterborne disease outbreaks have not been identified. Emerging pathogens, such as Cyclospora and Helicobacter pylori, could play a role in many of these outbreaks. Efficient methods for measuring the incidence and viability of pathogens in water are needed to assist in identifying the causative agents in future outbreaks. For example, research is needed to develop and field test a practical method for determining the viability and occurrence of Cyclospora in drinking water. Research is needed to determine Helicobacter occurrence patterns in raw water via the development and field testing of a suitable recovery and culture assay method. Innovative proposals for methods development for other emerging pathogens are also encouraged. These methods should be useful for dose-response and exposure estimates for risk assessment.

Research is needed to develop an understanding of the risks associated with exposure to primary waterborne pathogens (e.g., Giardia, Cryptosporidium, and enteric viruses) and to emerging pathogens (e.g., Cyclospora, Mycobacteria, Helicobacter pylori, microsporidia, caliciviruses, adenovirus 40/41, and coxsackievirus B) as a function of such susceptibility factors as age (e.g., children), nutrition, protective immunity, and behavioral patterns.

The safety of drinking water is compromised by pathogenic microorganisms resistant to standard disinfection methods. Research is required on the efficacy of ultraviolet radiation (pulsed and continuous) as a disinfectant in drinking water from various groundwater and surface water sources, including those that may pose limitations. In addition, research is needed on the optimal ultraviolet light wavelengths for inactivating specific species. Also needed is a better understanding of why pulsed UV light has a more destructive impact on cyst viability than continuous UV light.

<http://es.epa.gov/ncerqa/rfa97/eparfa97.html>

## PUBLIC HEALTH CONCERNS FOR RECYCLED WATER

Redwood City Council

Paul W. Lofholm, PharmD., FACA

June 9, 2003

I am Dr. Paul W. Lofholm, a practicing pharmacist and owner of several pharmacies in Marin County, a Member of the California Pharmacist Association Board of Trustees, and a Clinical Professor of Pharmacy at UCSF, UC Davis and UOP. I am here to discuss the options available to the Redwood City Council as to water resources for the City. I am aware of the water deficit that the City faces relative to its allotment from the Hetch Hetchy system and its impact on future building permits. While this quantity of water issue is important to the citizens of this City, of equal importance is the quality of the water especially from a public health perspective. While the intended use of the recycled water is for landscaping purposes, the safety of this supply in the face of recreational use by citizens and children urgently needs scientific study if this proposal is to move forward. The uncertainties of both acute and long-term toxicity are problematic; the general issues are of concern to both DHS and EPA. They each have working groups trying to get a handle on this safety issue while the Redwood Shores Homeowners and the Redwood City Council are asked to approve recycled water use without the benefit of good science.

Recycled water is water that has been treated to remove certain noxious contaminants. Historically the Department of Health Care Services (DHS) and Water Quality Agencies have been given responsibility to—among other things—regulate water quality including inorganic chemical limits like salt concentrations, suspended materials levels in the water (Turbidity), and markers for bacteria (Coliforms) and markers for viruses (Polio virus). Unfortunately recycled water does not have the quality of drinking water, nor does it meet the standards of such water. To quantitate the risk of recycled water for example, the Environment Protection Agency (EPA) has established a standard for risk of infection from recycled water; it is 1 case of infection from this water source per 10,000 persons per year. Likewise the EPA published a "Drinking Water Contaminant Candidate List" to assist the EPA in prioritizing the scientific work to be done. The List contains Microbiological contaminants like Helicobacter which causes peptic ulcer disease in humans and Echoviruses or Coxsackieviruses which cause brain infections, generalized weakness in infants, rashes, heart inflammation, lung symptoms or conjunctivitis. Also on the Water Contaminant Candidate List are chemical contaminants such as Tetrachloroethylene, which is used in aerosolized dry cleaning products. It causes liver toxicity and cancer similar to other chlorinated hydrocarbons. Also on the Contaminant Candidate List is Boron, which is common to Redwood Shores and causes gastrointestinal symptoms, seizures, and kidney problems. Or Manganese, which is associated with the development of neurological diseases such as Parkinsonism is on the list to be studied. Likewise perchlorate has been found in a number of water sources and in 20 states now including California. The EPA has mapped the locations of wells contaminated in the Santa Clara Valley for example. The health risk from this chemical, which was used in the rocket fuel industry, is the interference with Iodide uptake in the thyroid leading to Thyroid gland failure. Thus the City Council and the citizens it represents face a risk from recycled water which includes Microbiologic contaminants and chemical contaminants, whose long-term effects are only just beginning to be studied. Why should anyone take this health risk when other measures such as desalination or water conservation are available? As a health professional it simply does not make any sense to me to expose the 15,000 citizens of Redwood City to a subtle yet persistent health risk.

A second public health concern is the chemical contamination contained in the recycled water. The current Standards have no monitoring parameters in place for a variety of chemicals, pharmaceuticals, disinfectants, or other hazardous chemicals. The USGS has recently conducted a survey of US waterways to detect such "new" contaminants and to ultimately increase surveillance over wastewater effluents. For example caffeine has been studied as a marker of wastewater decontamination, and this chemical is readily identified in recycled waters. Caffeine is present in the sewerage and it is present in what comes out of the sewer treatment water flows. Likewise hormones (estrogen disruptors), Cleaning solvents, Trichloroethylene, and some inorganic chemicals like perchlorate and hexavalent chromium, and other trace minerals have been detected. The Cholesterol drug, Lipitor is found in the recycled water and its toxicity to organisms is unknown at this time. This is the first step, Detection. The subsequent steps include acute and long term toxicity studies to determine what effect these contaminants may have on all

forms of life: plant, aquatic, wildlife, and human exposure. Especially interesting to me is the effect of estrogens on plant and animal life. Estrogens stimulate growth-that may be an advantage if you are trying to grow plants or crops, but it may a disadvantage if breast tissue or uterus lining or male sex organs are influenced. What are the health consequences of low-level estrogens in the Redwood Shores environment? Are estrogens a growth stimulant or a carcinogen? We need the science to study the effect of the contaminant on our environment.

From the pharmacists point of view we too are concerned about sewer contamination. Given the EPA's position of classifying pharmaceutical waste as hazardous, and the California Legislature's ban on Health Facilities dumping pharmaceuticals into the waste stream, Pharmacists are beginning to educate the public about appropriate drug disposal. This action is one small step in reducing the pharmaceutical load at the sanitary district's facility. I have advocated that all Health Facilities that I consult to, to sign contacts with Pharmaceutical Waste Haulers to haul off their pharmaceutical waste. Furthermore in my own store, I have offered the public a place to drop off their unwanted pharmaceuticals for waste disposal.

The Recycled Water Task Force has called for increased funding to study the problem, to improve the technology and to make recycled water safer from the public health standpoint. Until the science has been completed on what comes out of the recycled water facility, my recommendation to this Council is to proceed cautiously and on the side of conservatism to mitigate any ecological disasters while science figures out the most effective way to assure the quality of any recycled water. There are too many unknown health risks from contaminants to recommend that any citizen unnecessarily expose himself or herself to recycled water at this time. Quality Water Standards for Contaminants must be adopted to assure the citizens that there public health will not be adversely effected.

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