Wastewater Treatment for Mega-Cities in the Developing World

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Outline

Public Health in Developing Countries

Staged Wastewater Treatment

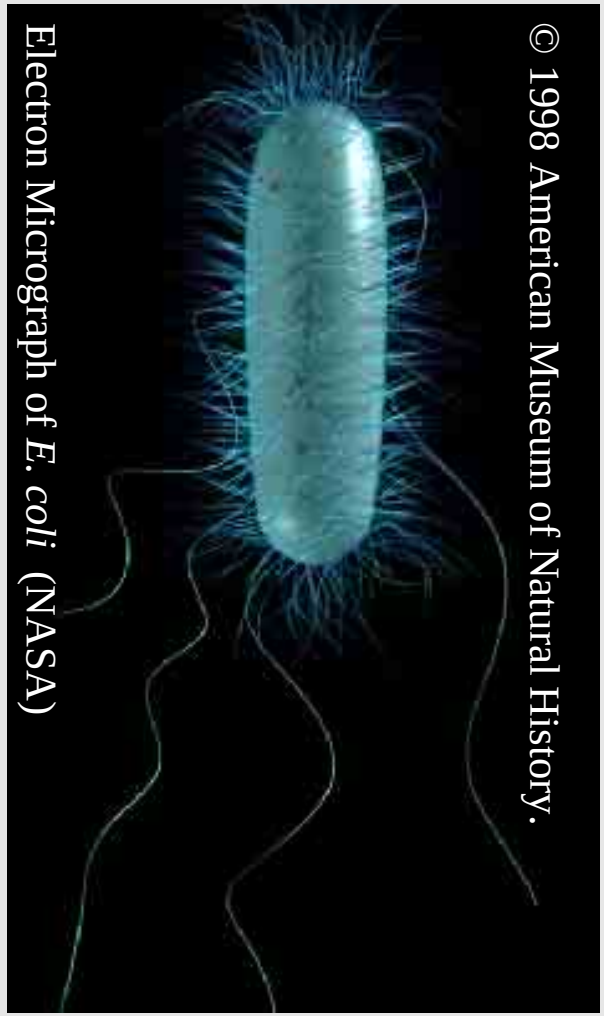
Chemically Enhanced Primary Treatment

Sanitation in Developing Countries

- 3 billion without appropriate sanitation
- 2 billion more urban dwellers in next 20 years
- 95% sewage untreated before discharge

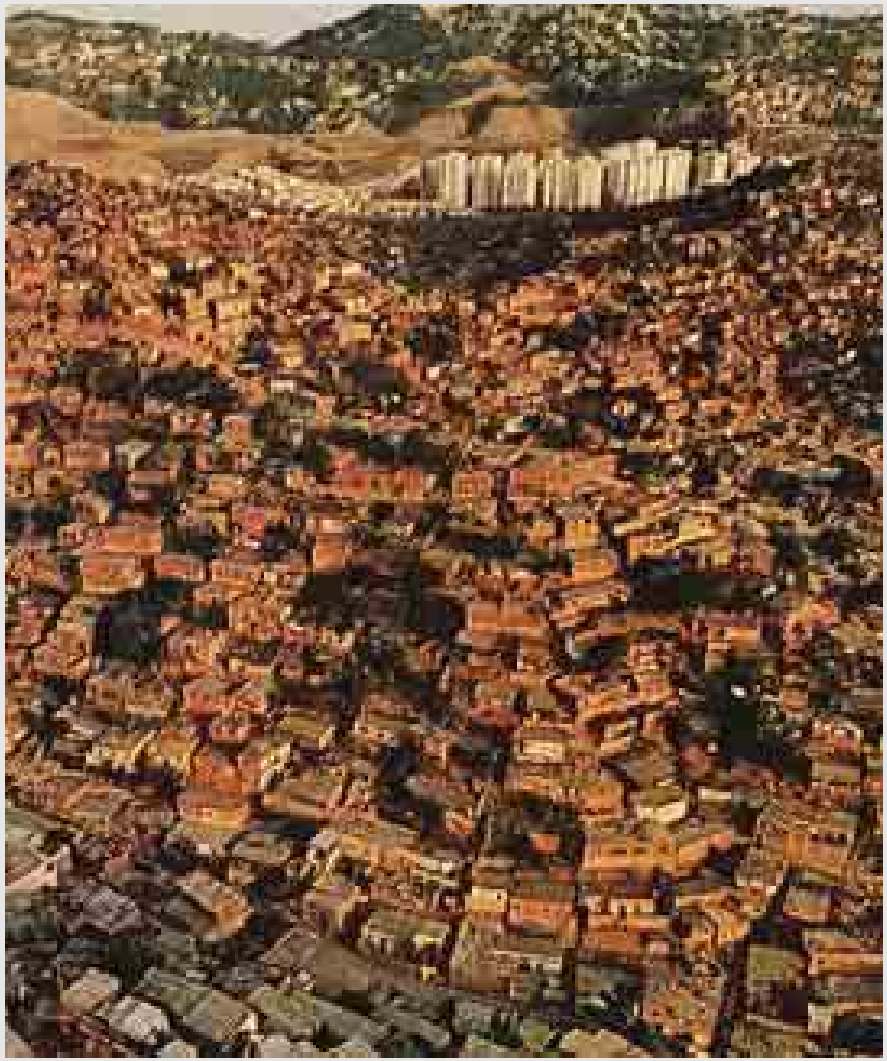
Sanitation Related Public Health

- Diseases
  - Water is Transmission Pathway:
- Women & children most affected
  - 1.5 million children die each year from diarrhoeal disease
- Large improvements conferred by appropriate water and sanitation
- Environmental quality benefits from sanitation



Electron Micrograph of *E. coli* (NASA)

Urban Areas & Slums



Sanitation & Development

- Costs of poor sanitation
  - Human morbidity (lost productivity; healthcare services)
  - Environmental degradation (loss of ecosystem services)
  - Foregone revenues
- Appropriate infrastructure alleviates poverty
  - Stimulates economic growth
  - Narrows socio-economic gap
  - Increases productivity
  - Improves health
- Women & children stand to gain most
  - Children more vulnerable to disease
  - Women have more contact with water/wastewater

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Constraints

- Objectives are to improve public health and environmental quality

- Strict environmental regulations
- Limited budgets, high costs
- Limited capacity/willingness to pay on consumer behalf

- Resulting “partial treatment” financially wasteful, no public health benefit, little environmental improvements

Constraints

- Limited cost recovery possibility
  - User charges incentive to serve users
  - User charges incentive to limit waste
  - But possible limited ability or willingness to pay (initially)
- Limited operating capacity
  - No previous experience with wastewater treatment
  - Simple treatment = learn basics and build-up capacity

$\Rightarrow$ Start with affordable tariffs (that fully recover O&M) and simple technology (for which capacity to operate easy & quick to build)

Non-Phased Development

- Initial wastewater treatment to high environmental standard
- Cost recovery through user charges difficult (no capacity/willingness to pay)
- Limited technical capacity for operations
- Only part of a city's wastewater can be collected and treated
- Wastewater treatment plants and infrastructure may not be operated properly
  - Not able to pay for O&M
  - Not technically able to properly operate

Phased Development

- Prioritization of problems to be tackled
- Comprehensive design of sanitation infrastructure and treatment
  - Meets environmental standards
  - Designed for future growth
- Staged implementation
  - Start with full wastewater collection and simple affordable treatment, build-up gradually
  - First priority is to treat 100% of wastewater to level where disinfection effective to mitigate public health problems
  - Subsequent implementation of planned/designed secondary treatment to comply with environmental regulations

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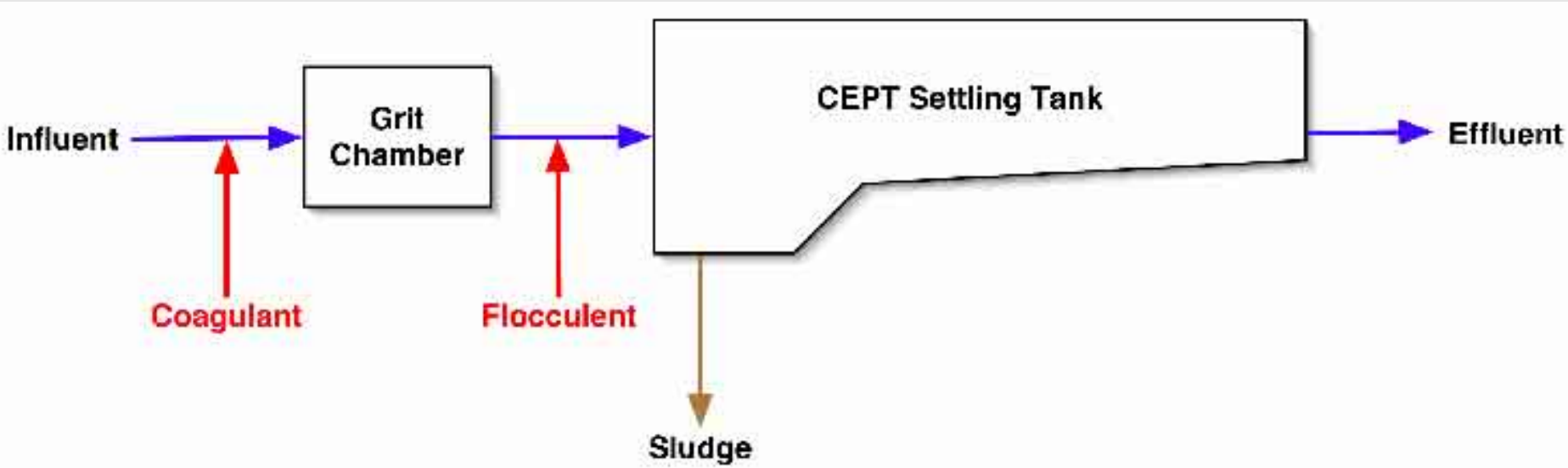
CEPT



- Chemicals added to clump smaller particles together into larger particles
- Larger particles settle faster
- Enhanced version of conventional primary treatment
- Can be followed by secondary treatment and/or outfall

Primary Efficiency

Conventional Primary Treatment

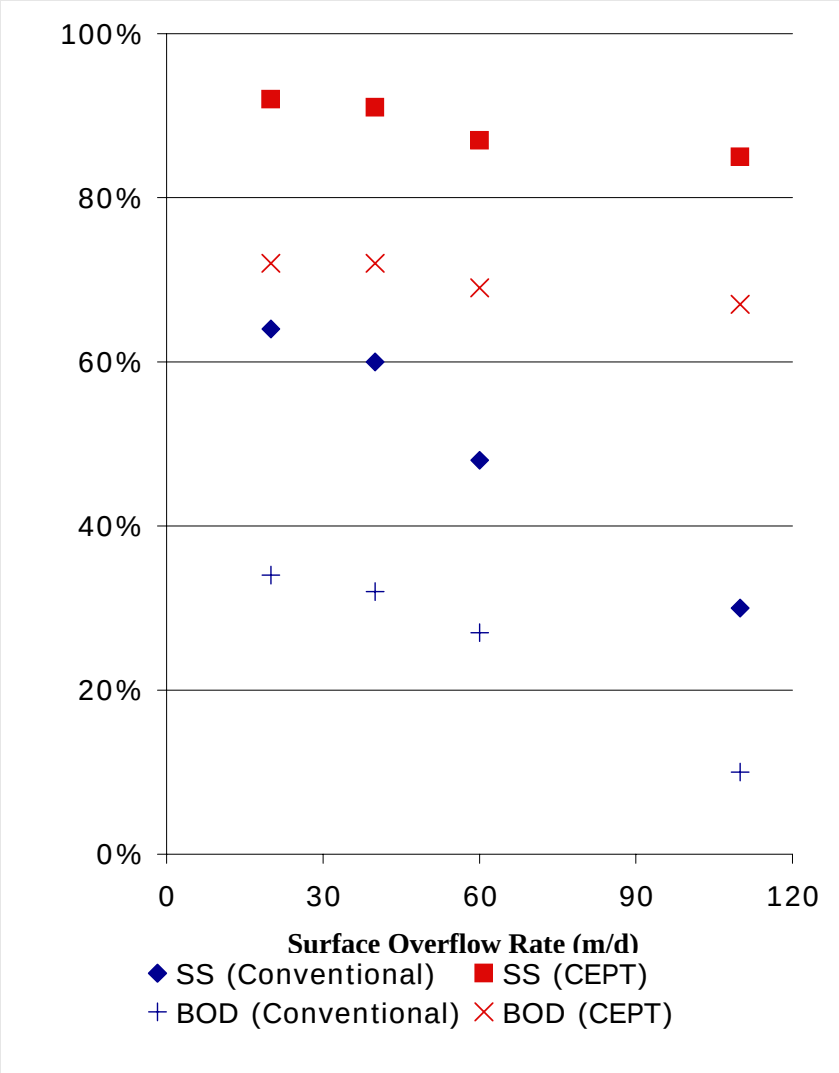
Overflow Rate (m/d)	% Removal			
	BOD	SS	Phosphorus	Pathogens
30–50	25–40	40–70	5–10	50–60

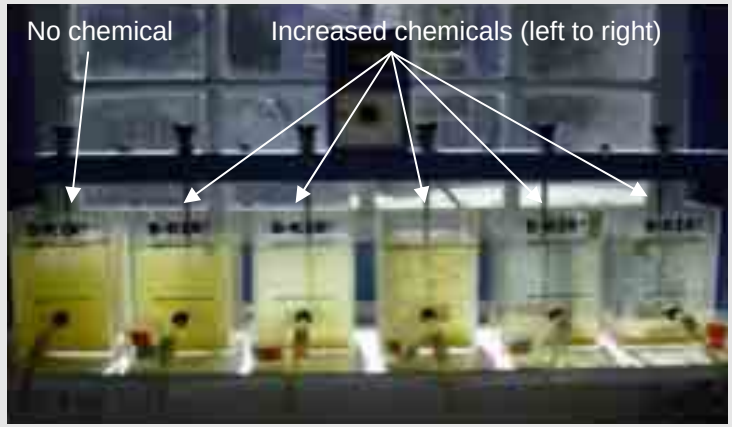
Chemically Enhanced Primary Treatment

Overflow Rate (m/d)	% Removal			
	BOD	SS	Phosphorus	Pathogen
60–120	40–70	60–90	70–90	80–90

Simple technologies
Low energy and operator skill requirements

Primary Treatment

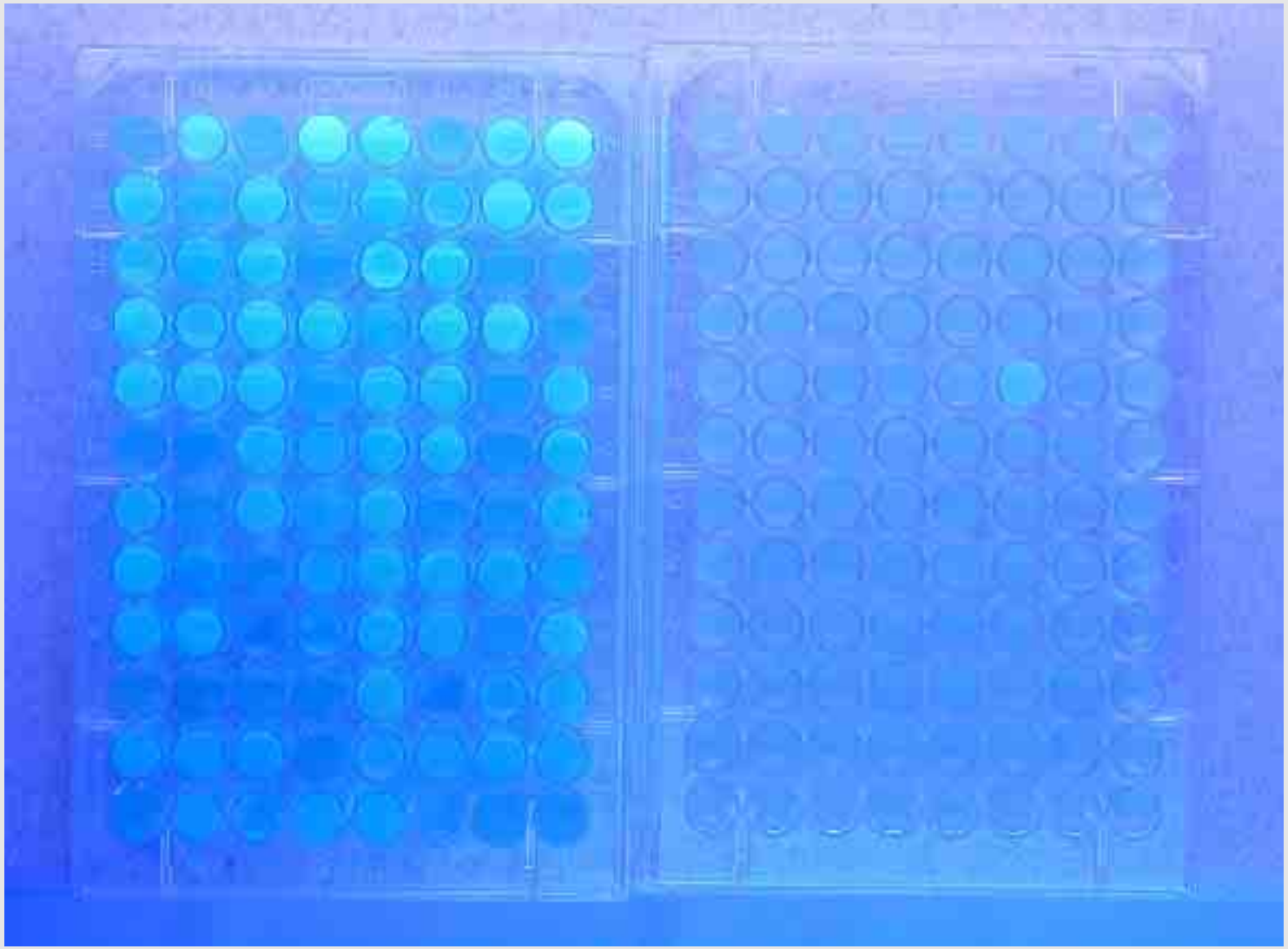




- CEPT vs. Conventional Primary
  - Higher BOD & SS removal
  - Operates at higher overflow rate
  - Smaller area requirement
  - Lower Capital Cost
  - Greater resilience to flow variation
  - Reduced size of subsequent secondary treatment
  - Effluent can be disinfected
  - Larger amount of sludge produced
  - Higher O&M (chemicals)

Bench-Scale CEPT

Disinfection of CEPT Effluent



Cost Comparison

	Capital Costs (US$M/$m^3.s^{-1}$)	O&M Costs (US$M/$m^3.s^{-1}$/yr)
PT without Disinfection	1.5	0.2
CEPT + Disinfection	**1.3**	**0.5**
PT + AS + Disinfection	5.0	1.0

Construction costs based on plant capacity;

O&M costs based on average daily flow (1/2 plant capacity).

Advantages of CEPT as 1st Stage

Effluent can be disinfected

2x-3x conventional primary surface OFR

Approaches biological secondary treatment removal efficiencies for BOD and TSS

Reduces size of subsequent treatment

High phosphorus removal

Conclusion

- Appropriate wastewater treatment & collection is desirable and has high Return on Investment
- Recovery of Operation & Maintenance costs through user fees critically important
- Tradeoffs necessary between desire for high environmental standards, affordability and technical capacity

→ **PHASED DEVELOPMENT**

- CEPT is a flexible and low-cost treatment technology
- Appropriate for initial stage