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**
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
Outline

Public Health in Developing Countries
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Chemically Enhanced Primary Treatment
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

⇒ 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
Outline

Public Health in Developing Countries
Staged Wastewater Treatment
Chemically Enhanced Primary Treatment
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

<table>
<thead>
<tr>
<th>Overflow Rate (m/d)</th>
<th>% Removal</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>BOD</td>
</tr>
<tr>
<td>30–50</td>
<td>25–40</td>
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### Chemically Enhanced Primary Treatment

<table>
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<th>Overflow Rate (m/d)</th>
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<tr>
<td></td>
<td>BOD</td>
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<tr>
<td>60–120</td>
<td>40–70</td>
</tr>
</tbody>
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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

<table>
<thead>
<tr>
<th></th>
<th>Capital Costs (US$M/m³.s⁻¹)</th>
<th>O&amp;M Costs (US$M/m³.s⁻¹/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PT without Disinfection</strong></td>
<td>1.5</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>CEPT + Disinfection</strong></td>
<td>1.3</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>PT + AS + Disinfection</strong></td>
<td>5.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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