Holistic Water Management
8 December 2020

Water quality in Saigon River (Vietnam): modeling scenarios by C-GEM
Summary

1. Introduction of Ho Chi Minh City and Saigon River
2. Objectives
3. Implementation of C-GEM model
4. Three scenarios of WWTPs construction
5. Conclusion and perspectives
1. Introduction: Distribution of megacities

Estuarine and coastal areas → 67% of the megacities

(Glasow et al., 2013)
1. Introduction

Ho Chi Minh City (HCMC):
• Economic capital of VN
• 9M inhabitant, 3.4%/yr
  *(GSO Vietnam, 2019)*

Water issues in HCMC:
• Water pollution in *urban canals*
• Lacking wastewater treatment plants (WWTPs)
  → 80% WWs into canals, rivers
  *(Nguyen et al., 2020)*
1. Introduction

Saigon River:
- Tropical estuary (dry and wet season)
- Tidal regime from East Sea Vietnam
- Connects to urban canals, Dongnai River

Water quality in Saigon River:
- Urban section
  - NH$_4$ (1.5mg/L), TOC (10 mg/L)
  - O$_2$ (<1.5 mg/L), high Chl-a (100 ug/L)
→ High risk of eutrophication in Saigon River

(Nguyen et al, 2019)

New WWTPs for safety of water resources
2. Objectives

Based on WWTP construction plan (*decision n°24/QĐ-TTg approved by Prime Minister, 2010*)
→ Three scenarios 2015, 2025 and 2050
→ Using the estuarine biogeochemical model (C-GEM)

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Installation Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>8M</td>
<td>2.3 billion USD for 12 WWTPs (2.8M m³/d) (900 USD for 1 m³ wastewater)</td>
</tr>
<tr>
<td>2025</td>
<td>11M</td>
<td></td>
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<tr>
<td>2050</td>
<td>23M</td>
<td></td>
</tr>
</tbody>
</table>
3. C-GEM model

Carbon-Generic Estuary Model (C-GEM)
1D, reactive-transport model

Applying C-GEM for Saigon River in dry season

Vietnam Center
For monitoring
Monthly

Volta et al., 2016
3. Model validation

Hydrodynamics and transport module

Saltwater intrusion

Simulation
Observation

Simulation (mean + std)
Observation

Pre-conference “Water, Megacities and Global Change”
3. Model validation

Model performance:
- Coefficient correlations: (0.6 to 0.9)
- Percentage bias: <20% (except PO₄)

Biogeochemical processes

→ Nitrification is the main factor of DO depletion in Saigon River

Nguyen et al. in prep, STOTEN
3. Model results

- 30 km of pollutant cloud
- Movement in 10 km
### 4. Scenarios

#### WWTPs construction scenarios

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>2015</th>
<th>2025</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population&lt;sup&gt;a&lt;/sup&gt; (million inhabitant)</td>
<td>8.4</td>
<td>11.0</td>
<td>23.0</td>
</tr>
<tr>
<td>Number of WWTPs&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>WWTPs treatment capacity (m&lt;sup&gt;3&lt;/sup&gt;d&lt;sup&gt;-1&lt;/sup&gt;)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>171 000</td>
<td>1,253,000</td>
<td>2,813,000</td>
</tr>
<tr>
<td>Population connected to WWTPs (%)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10%</td>
<td>57%</td>
<td>61%</td>
</tr>
<tr>
<td>TN flux from canals to river (tonNd&lt;sup&gt;-1&lt;/sup&gt;)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>51.0</td>
<td>42.7</td>
<td>80.9</td>
</tr>
<tr>
<td>TP flux from canals to river (tonPd&lt;sup&gt;-1&lt;/sup&gt;)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>13.6</td>
<td>11.4</td>
<td>21.6</td>
</tr>
<tr>
<td>TOC flux from canals to river (tonCd&lt;sup&gt;-1&lt;/sup&gt;)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>10.9</td>
<td>7.2</td>
<td>22.5</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>28</td>
<td>28</td>
<td>28+1.5&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Freshwater inflow (m&lt;sup&gt;3&lt;/sup&gt;s&lt;sup&gt;-1&lt;/sup&gt;)&lt;sup&gt;g&lt;/sup&gt;</td>
<td>17.6</td>
<td>17.6</td>
<td>17.6</td>
</tr>
</tbody>
</table>

<sup>a</sup>: HCMC Statistical Yearbook, 2017, <sup>b</sup>: Tran Ngoc et al., 2016, <sup>c</sup>: total water consumption (200 liters/capita/day),<br><sup>d</sup>: Calculated based on removal efficiency, <sup>e</sup>: MONRE et al., 2016, <sup>f</sup>: Bindoff et al., 2019, <sup>g</sup>: Tran Ngoc et al., 2016

Based on HCMC’s development plan
Calculation of lateral inputs
Keep the same forcings + climate change effect in 2050
4. Scenarios

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<thead>
<tr>
<th></th>
<th>2015</th>
<th>2025</th>
<th>2050</th>
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<tbody>
<tr>
<td>DO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₄</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOC</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PO₄</td>
<td></td>
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- **2025**: improvement in water quality
- **2050**: return to bad condition
  - 12 WWTPs will **not be enough** for 23M inhabitants in 2050
  - NH₄ **always high** in 3 scenarios
Conclusions

Key findings based on C-GEM simulation:
1. Impact of urban discharge to water quality in Saigon River
2. Main process to hypoxia in urban section: nitrification (high NH$_4$)
3. 12 WWTPs in 2050 will not be enough

Suggested solutions:
1. Improving NH$_4$ treatment capacity of WWTPs
2. Alternative urban wastewater management (Nature-based Solutions - NBS)

Illustration by Masi et al 2018
Thank you for your attention!

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