Evaluation of pollution reduction scenarios in Saigon River by an estuarine biogeochemical model

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Context

- Water quality of Saigon River (Southern Vietnam) has been affected by wastewater from Ho Chi Minh City (HCMC, +8M inhabitants, 2016).
- The risk of estuarine pollution is expected to increase in the coming years, under the impact of HCMC megacity's development [1].
- In response to the current and future major sources of urban wastewater, ten new wastewater treatment plants (WWTP) will be constructed.

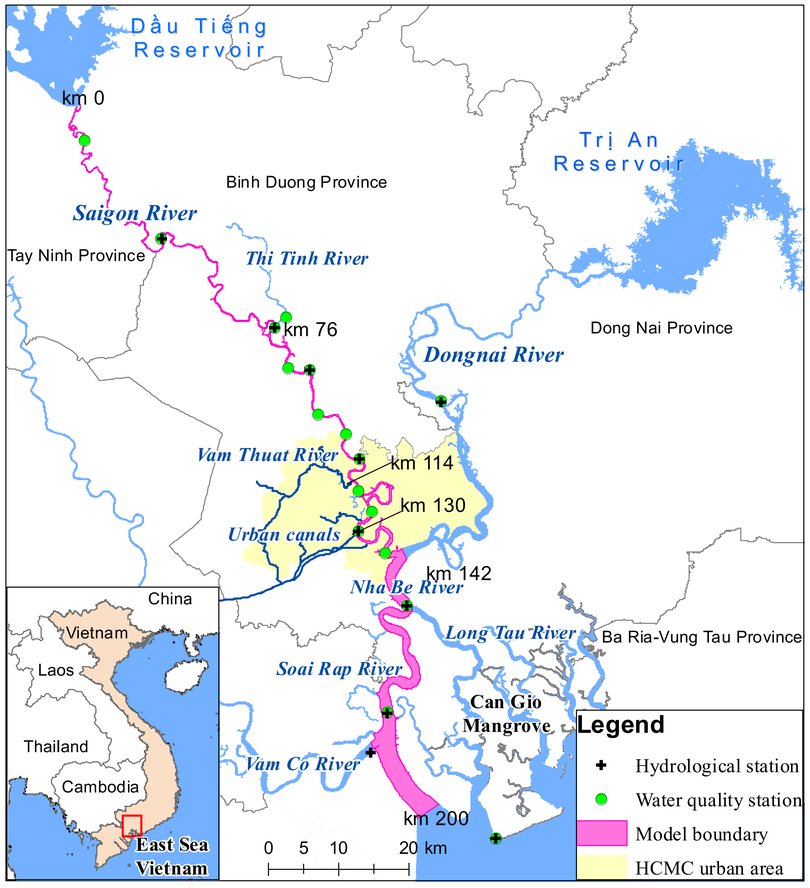

Figure 1. Map of Saigon River Estuary and monitoring stations (by CEM, CARE)

Objectives

- This study aims evaluating the water quality in Saigon River Estuary under the impact of urban wastewater from HCMC by using the Carbon Generic Estuarine Model (C-GEM).
- Three scenarios respectively for 2, 4 and 12 WWTPs will be evaluated.

Carbon-Generic Estuary Model (C-GEM)

C-GEM is an one-dimensional,generic, reactive-transport model, computationally efficient which reduces data requirements based on the relationship of (i) estuarine geometry (Eq. 1), (ii) hydrodynamics and transport, (iii) biogeochemical processes [2].

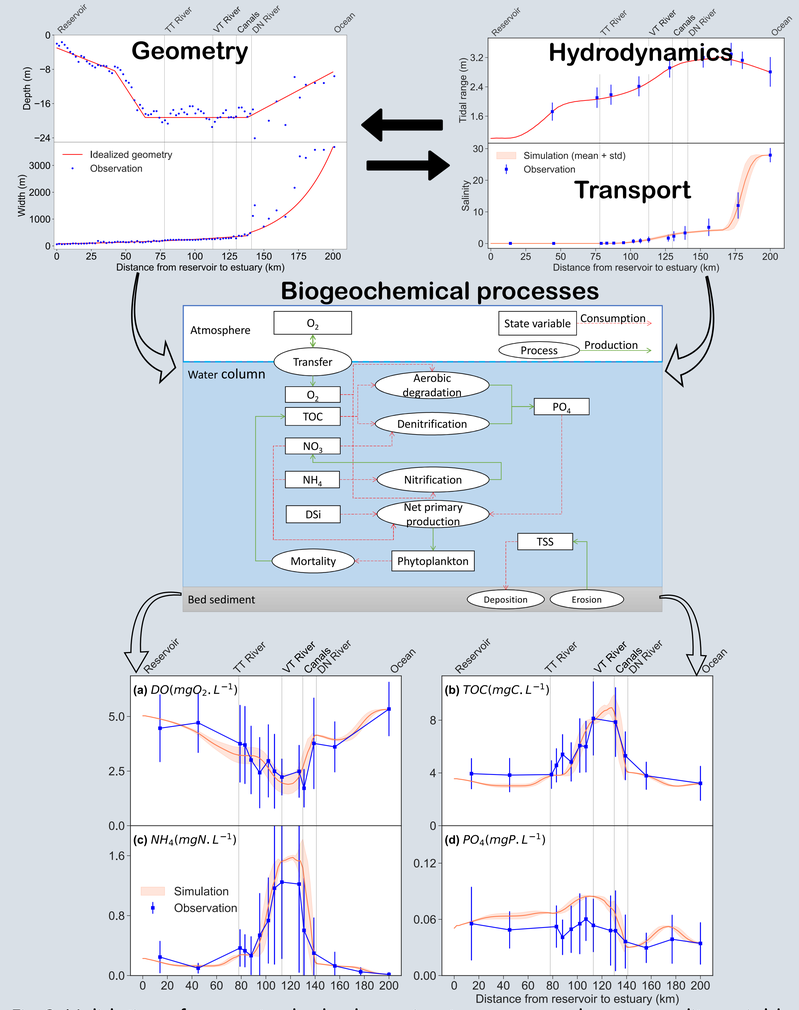

Fig 2. Validation of geometry, hydrodynamics, transport and water quality variables in Saigon River Estuary in dry season 2014 - 2017

- Model was validated by comparing with monitoring data of 13 stations along Saigon River Estuary in the dry seasons 2014 - 2017 (Fig. 1).
- Model performance: coefficient correlations (R^2) are from 0.6 to 0.9, the percentage bias is less than 20% (except PO_4).

WWTPs construction scenarios

Scenarios	2015	2025	2050
Population [a] (million inhabitant)	8.4	11.0	23.0
Number of WWTPs[b]	2	4	12
WWTPs treatment capacity (m^3d^{-1})[b]	171 000	1,253,000	2,813,000
Population connected to WWTPs (%)[c]	10%	57%	61%
TN flux from canals to river ($tonNd_{-1}$)[d]	51.0	42.7	80.9
TP flux from canals to river ($tonPd^{-1}$)[d]	13.6	11.4	21.6
TOC flux from canals to river ($tonCd^{-1}$)[d]	10.9	7.2	22.5
Temperature (°C)	28	28	28+1.5[e]
Tidal Range (m)	2.80	2.80	2.80 + 0.02[f]
Freshwater inflow (m^3s^{-1})[g]	17.6	17.6	17.6

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

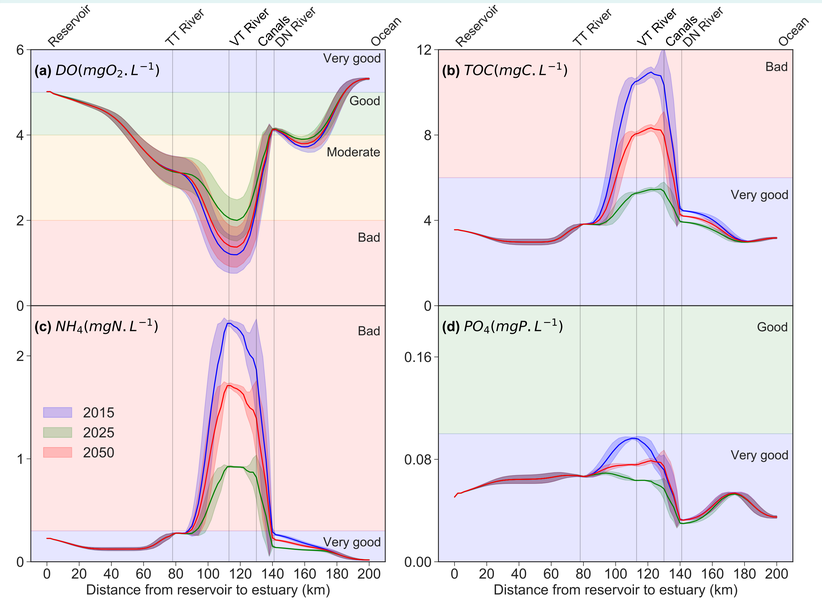

Fig 3. Simulated water quality variables along Saigon River Estuary in three scenarios

Conclusions

- C-GEM allows to evaluate the dynamics of water quality in Saigon River Estuary under various conditions of pollution input.
- Scenario in 2025 (treated 57% wastewater of 11M inhabitants) shows an improvement in water quality in urban section of Saigon River.
- Scenario in 2050, low dissolved oxygen and high NH_4 can be existed even with 12 WWTPs (treated 61% wastewater of 23M inhabitants)
- Implementing alternative urban wastewater management (e.g. Nature based Solutions) will be the effective solution in improve water quality in urban section of the Saigon River than just constructing new WWTPs.

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[1] Nguyen et al. (2020) "Nutrient budgets in the Saigon–Dongnai River basin: Past to future inputs from the developing Ho Chi Minh megacity (Vietnam)." River Research and Application.
[2] Volta et al. (2014). C-GEM (v 1.0): a new, cost-efficient biogeochemical model for estuaries and its application to a funnel-shaped system. Geoscientific Model Development.