From the doctoral research work by Pham Van Quan on Characterization of urban inundation impacts by distributed model simulation and pathogenic pollution monitoring in downtown of Hanoi
Introduction and background

General information

1. Covering more than 921 km$^2$, existing 05 main rivers and around 111 lakes and ponds within the city
2. Population density in downtown area is highest in Vietnam (17,489 person/km$^2$)
3. Annual average rainfall in Hanoi is 1,678 mm, annual temperature varies from 8$^\circ$C - 40$^\circ$C
Selected areas (L1 and S1 catchment)

**Inundated points**: Usually 30 points
- Inundation frequency 5 - 7 times/year
- Inundation depth: 0.5 - 1.2 m

**Drainage capacity**:
- Rainfall < 50 mm/hr

**Total area**: 3.76 km²
Sewerage system in Hanoi

- Storm water
- Public toilet and septic tanks
- Grey water
- Individual house and septic tanks
- Grey water
- Compact house and septic tanks
- Secondary and primary network managed by Hanoi Sewerage and Drainage Company
  - Fish pond
  - Irrigation channel
- Tertiary network managed by local Authority and community
  - Vegetable fields
- Wastewater reuse in peri-urban areas by farmer
Rainfall, June 18, 2008
(131.2 mm/ 2h)
30 inundated points
[www.vnn.vn]
Water quality monitoring in dry season

Objectives:
- To get overview of surface water pollution under dry weather condition in Hanoi
- To make clear self-purification process in Hanoi’s water body

Sampling points: 15 points, divided into 2 groups.
- Group 1: 11 points, in the downtown area where flood are usually taking place;
- Group 2: 4 points, belonged to To Lich river, the main sewerage river of Hanoi.
Typical Vietnam standards for surface water environment

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Classification</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>pH</td>
<td>-</td>
<td>6 - 8.5</td>
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<tr>
<td>BOD(_5) (20(^0)C)</td>
<td>mg/L</td>
<td>&lt; 4</td>
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<tr>
<td>COD</td>
<td>mg/L</td>
<td>&lt; 10</td>
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<tr>
<td>DO</td>
<td>mg/L</td>
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<td>SS</td>
<td>mg/L</td>
<td>20</td>
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<td>Ammonia as N</td>
<td>mg/L</td>
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<tr>
<td>Nitrate as N</td>
<td>mg/L</td>
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<tr>
<td>Total coliform</td>
<td>MPN/100 mL</td>
<td>5,000</td>
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### Sampling points and water quality data

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<tr>
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<tr>
<td>1</td>
<td>Kim Nguu river, Lo Duc gate</td>
<td>KN</td>
<td>7.8</td>
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<td>357.8</td>
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<td>2</td>
<td>Kim Nguu river, Mai Dong bridge</td>
<td>MD</td>
<td>8.0</td>
<td>3.3</td>
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<td>82.8</td>
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<td>Lu river, start point</td>
<td>LR</td>
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<td>35.4</td>
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<td>33000</td>
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<td>4</td>
<td>Lu - Set river flood way</td>
<td>LS</td>
<td>7.5</td>
<td>2.9</td>
<td>87.5</td>
<td>62.5</td>
<td>25.0</td>
<td>32.7</td>
<td>201000</td>
<td>75000</td>
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<td>5</td>
<td>To lich river, Vi gate</td>
<td>VG</td>
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<td>2.5</td>
<td>115.6</td>
<td>90.6</td>
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<td>36000</td>
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<td>2.4</td>
<td>90.6</td>
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<td>Bay Mau lake, inflow from drainage</td>
<td>7M in</td>
<td>7.5</td>
<td>3.1</td>
<td>156.3</td>
<td>132.8</td>
<td>23.4</td>
<td>19.2</td>
<td>4100</td>
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<td>5.3</td>
<td>29.7</td>
<td>10.9</td>
<td>18.8</td>
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<td>96.9</td>
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<td>23.7</td>
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<td>Thanh Nhan 1 lake, outflow</td>
<td>TN1 out</td>
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<td>9.7</td>
<td>40.6</td>
<td>25.0</td>
<td>15.6</td>
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<td>TN2 out</td>
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<td>7.9</td>
<td>34.4</td>
<td>20.3</td>
<td>14.1</td>
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<td>15</td>
<td>West lake, inflow from drainage</td>
<td>WL in</td>
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<td>5.0</td>
<td>46.9</td>
<td>28.1</td>
<td>18.8</td>
<td>24.8</td>
<td>94000</td>
<td>17000</td>
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</tbody>
</table>
Similarity of water quality of surface water in the Hanoi downtown

- Effluent
  - 7M in
  - MD
  - WL in
  - LQ out
  - 3M out

- Overflow group
  - TN2 out
  - 7M out
  - TQ
  - TN1 out

- Polluted river group
  - VG
  - LR
  - YS
  - LS

- Influent
  - MG
  - KN

- Highly polluted group

Ward method / Normalized data / Squared Euclidean Distance

- Rainfall: 402 mm
- Depth 0.5 - 1.2 m
- Duration 3-10 days

9 sampling locations
- 4 inflow water to lakes
- 5 road runoff
Inundation situation and health risk due to poor water quality
### Water quality of inundation water event on Oct 31, 2008

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>T-N (mg/L)</th>
<th>NH₄⁺-N (mg/L)</th>
<th>COD (mg/L)</th>
<th>SS (mg/L)</th>
<th>E. coli (CFU/mL)</th>
<th>T.coliform (CFU/mL)</th>
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<tr>
<td>1-Nov</td>
<td>S-TDT</td>
<td>18.7</td>
<td>13.5</td>
<td>93</td>
<td>334</td>
<td>18,000</td>
<td>64,000</td>
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<tr>
<td>1-Nov</td>
<td>S-NLB</td>
<td>10.8</td>
<td>8.5</td>
<td>126</td>
<td>228</td>
<td>7,000</td>
<td>49,000</td>
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<tr>
<td>3-Nov</td>
<td>S-NLB</td>
<td>11.8</td>
<td>7.4</td>
<td>80</td>
<td>336</td>
<td>5,000</td>
<td>20,000</td>
</tr>
<tr>
<td>1-Nov</td>
<td>S-NK</td>
<td>10.2</td>
<td>2.3</td>
<td>120</td>
<td>326</td>
<td>5,000</td>
<td>59,000</td>
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<tr>
<td>1-Nov</td>
<td>S-QTG</td>
<td>14.6</td>
<td>2.2</td>
<td>102</td>
<td>212</td>
<td>1,000</td>
<td>33,000</td>
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<tr>
<td>1-Nov</td>
<td>S-TBT</td>
<td>13.7</td>
<td>6.5</td>
<td>77</td>
<td>228</td>
<td>2,000</td>
<td>27,000</td>
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<tr>
<td>3-Nov</td>
<td>S-TBT</td>
<td>14.3</td>
<td>6.2</td>
<td>56</td>
<td>148</td>
<td>10,000</td>
<td>48,000</td>
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<td>3-Nov</td>
<td>L-7M in</td>
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<td>7.6</td>
<td>17</td>
<td>258</td>
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<td>3-Nov</td>
<td>L-3M in</td>
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<td>10.1</td>
<td>11</td>
<td>286</td>
<td>3,000</td>
<td>20,000</td>
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<tr>
<td>3-Nov</td>
<td>L-3M out</td>
<td>12.7</td>
<td>10.4</td>
<td>14</td>
<td>236</td>
<td>10,000</td>
<td>19,000</td>
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<tr>
<td>3-Nov</td>
<td>L-ND in</td>
<td>8.8</td>
<td>5.1</td>
<td>20</td>
<td>208</td>
<td>1,000</td>
<td>20,000</td>
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<tr>
<td>3-Nov</td>
<td>L-TQ in</td>
<td>9.3</td>
<td>7.6</td>
<td>68</td>
<td>276</td>
<td>1,000</td>
<td>13,000</td>
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</tbody>
</table>
Similarity of sampling locations under different weather conditions
Water qualities during inundation at different sampling points

- Water quality standard for Class B
- NO₃-N standard
- NH₄-N standard
- T. coli standard
- T. coliform

Graphs showing comparison of water quality indicators such as T-N, T-CO₂, NO₃-N, NH₄-N, and T. coli concentrations in inundated and runoff water.
Simulation of inundation by simulation model

Inundation event in Aug 27-28, 2003

Inundation record by Hanoi Drainage Company

Inundation depths from 1-D simulation results
Inundation map with different return periods for 2-days design rainfall

- 1 year: 69mm
- 5 years: 95mm
Overlapping inundation depths with water monitoring data
Promotion of water quality study

- Idea on integrated study of Flood and Water Quality
- Case study is needed
- Candidate basins?
Integrated study of Flood and WQ

1. Selection of points: hot spots, references
2. Sampling procedure: sampling kits, selected water quality parameter
3. Pollutant sources identification: Point and non-point pollution sources

Tool and Strategy
- Watershed-based hydrological model in association with water quality model
- WQ mapping with flood/inundation areas
Integrated study of Drought and WQ

- Water quality change between drought and non-drought years
- Different water usage and their resources
- Eutrophication occurrence during drought