Wastewater characterization and its impacts to the performance of wastewater treatment plant in Hanoi City, Vietnam

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Introduction
Objectives of the study
Methodology and scope of the study
Results and discussions
Among existing systems, the proportion of wastewater flow being conveyed by the combined sewerage systems (CSS) is 92%, representing a total treated volume of ~6000,000 m³/day.

By 2013, there were 17 municipal Wastewater Treatment Plants (WWTP) and at least 31 WWTPs under construction, design and operation.

Many of the recently installed WWTPs in Vietnam were designed based on typical wastewater characteristics for Combined Sewage Systems and include parameter values such as BOD₅: 150-250 mg/l, COD: 250-350 mg/l, and NH₄-N: 15-35 mg/l.

It is reported that in operation they receive significantly different influent loads.
A combined system collecting industrial, domestic wastewaters as well as the management of storm water and surface water run-off.

Most urban house have a flush toilet with a connection to the septic tank.

Effluent (septic) is discharged into sewer lines and semi-open drainage canals then rivers.

Wastewater quality and quantity are seasonal fluctuated.

An understanding of the nature of wastewater is essential in the design and operation of collection, treatment, and disposal facilities.
Urban sewage system – Combined drainage system

- Street sewers
- Catchment basin A
- Main trunks
- Urban canal, rivers
- Catchment basin B
- Equalization lake
- PS
- RIVER
## Current applied technologies:

- AO/AAO processes.
- SBR

This study therefore was conducted to characterize wastewater quality in Hanoi City, Vietnam.

### Wastewater Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Wastewater (design value) (mg/L)</th>
<th>Vietnamese discharge standard QCVN 40/2011- BTNMT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class A (mg/L)</td>
<td>Class B (mg/L)</td>
</tr>
<tr>
<td>COD</td>
<td>225-350</td>
<td>50</td>
</tr>
<tr>
<td>BOD</td>
<td>150-250</td>
<td>30</td>
</tr>
<tr>
<td>TSS</td>
<td>180-250</td>
<td>50</td>
</tr>
<tr>
<td>T-N</td>
<td>25-40</td>
<td>20</td>
</tr>
<tr>
<td>NH4-N</td>
<td>15-35</td>
<td>5</td>
</tr>
<tr>
<td>T-P</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>
This study investigates the influent to Hanoi’s first large scale wastewater treatment facility (Yen So WWTP).

This WWTP collects influent sewage from the Kim Nguu open channel sewer (11 km in length) feeding to the 200,000 m³/d WWTP.

Catchment basin is a densely-populated area of ~596 ha.

The results will be reviewed in relation to the achievement of the required consent and the potential impact the nature of the influent will have on the WWTP design requirements.
Yen So WWTP

- Capacity: 200,000 m³/day
- Activated Sludge Process (SBR)
The sampling of the Kim Nguu inlet to Yen So WwTP
Grab samples were collected along the Kim Nguu canal
Samples of the WwTP performance (daily composite samples).
Low BOD (45 mg/l), low TSS (46 mg/l), a relatively high nitrogen (TKN 40 mg/l; NH4-N 36 mg/l), and a high proportion of NH4-N (90%).

COD:BOD ratio: 1.5 - 5.1 (average 2.9)

BOD:NH4-N ratio of 1.4 → A significant impact on the design and performance of a wastewater treatment plant
A consistent relationship BOD vs TSS, and low BOD, TSS content confirm TSS is largely independent of the BOD and associated with fine colloidal material that is slow to settle.

No clear relationship between BOD and N compounds.

A clear linear relationship between TKN vs NH4-N → nitrogen is largely soluble and readily available.
### Influenced by wet weather conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Wet Season (April - October)</th>
<th>Dry Season (November - March)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average mg/l</td>
<td>5%ile mg/l</td>
</tr>
<tr>
<td>BOD</td>
<td>40</td>
<td>21</td>
</tr>
<tr>
<td>COD</td>
<td>109</td>
<td>72</td>
</tr>
<tr>
<td>TSS</td>
<td>45</td>
<td>32</td>
</tr>
<tr>
<td>TKN</td>
<td>31</td>
<td>17</td>
</tr>
<tr>
<td>NH₄-N</td>
<td>27</td>
<td>14</td>
</tr>
<tr>
<td>Total Phosphorous</td>
<td>7.2</td>
<td>3.2</td>
</tr>
</tbody>
</table>

**Relationships:**

- COD:BOD: 3.0 | 1.5 | 5.3 | 2.9 | 1.5 | 4.8
- TSS:BOD: 1.3 | 0.6 | 2.4 | 1.2 | 0.4 | 2.6
- NH₄-N of TKN: 87% | 74% | 96% | 93% | 86% | 96%

[Graph 1: 7 Day Ave BOD (mg/l) vs 7 Day Totalised Rainfall (mm/d)]

[Graph 2: 7 Day Ave NH₄-N (mg/l) vs 7 Day Totalised Rainfall (mm/d)]
Most parameters have lower concentrations during the wet season due to freshwater ingress.

The exception is TSS, where there is no measurable difference in between the dry and wet seasons, suggesting that any dilution effect from the ingress is compensated for by additional scoured solids or run-off solids. The solids reaching the intake of the works are largely fine colloidal solids with low settling characteristics.

In wet season, TKN and NH$_4$-N levels are reduced on average by 12 and 13 mg/l respectively.

On average 10 mm of rain will result in a 1.5 mg/l reduction of NH$_4$-N, and 2.4 mg/l reduction of BOD.
Average BOD and NH4-N in Kim Nguu canal were 17 and 10 mg/l respectively, higher compared to its tributaries.

The trends for each parameter followed similar trends in concentration throughout the year.
**Seasonal changes**

- **Jan - Apr:** the average BOD and NH4-N drop and COD:BOD ratio increase. Low BOD and still relative high NH4-N represents a significant total nitrogen treatment challenge.

- **May-Aug:** reduction of soluble NH4-N. BOD increase for the first 2 months, and BOD dropping in July-Aug.

- **Sep-Dec:** BOD and NH4-N increase at a rate 1.8 and 1.3 mg/l-week. But BOD:N ratio is less than the theoretical $\geq 2.5-3.0$ BOD:N ratio normally required to sustain denitrification.
Treatment performance

- When high COD: NH4-N, there is sufficient organic material to effect denitrification to satisfy the TN requirements.

- When COD: NH4-N ratio is reduced, and particularly < 4.0, effluent NO3-N increase when the influent ammonia levels are also high (≥40 mg/l) → insufficient organic material in influent to support the required level of denitrification.

- As influent COD: NH4-N reduced further, NH4-N in effluent may also not meet the requirements.
The nature of sewage in combined systems in Vietnam cities can be significantly different to the norms specified for wastewater treatment. There is insufficient organic material to sustain denitrification process, requiring supplemental BOD in order to guarantee compliance.

Data shows the impact of an extended dry season on reducing the BOD:NH$_4$-N ratio and adding further risk to the nitrogen compliance.

Long retention times in collection channels can lead to the settlement and degradation of organic materials. Additionally, with the preference and obligation to utilise septic tanks, the organic load is further reduced and the release of soluble nitrogen could be enhanced.

The challenge to the design and regulatory process is the imposed compliance standards in Vietnam. It is difficult to achieve TN standard without the supplement of external BOD.

For Vietnam there has been a gradual relaxation of the compliance requirements for nitrogen management, but potentially this has not progressed far enough to match the current available sewage and treatment technologies.