Mitigation of COD and TP by Implementing Total Pollutant Load Management System in the Shiwha Coastal Reservoir

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2. Do we need TPLMS in the Shiwha Coastal Reservoir (SCR)?
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1. What is Total Pollutant Load Management System (TPLMS)?

- Korean Version of Total Maximum Daily Load (TMDL) in the USA
  “A plan for restoring impaired waters that identifies the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards (or water quality target)”

- Implemented in the designated “Special Management Area (SMA)” based on Marine Environment Management Act
  - Masan Bay (‘07~), Incheon-Shiwha Coastal Area (‘13~), Busan Coastal Area (‘15~), Ulsan Bay (‘18~), Gwangyang Bay (‘20~)
2. Do we need TPLMS in the SCR?

Figure from Lee et al. (2014)
- **US$1.6billion invested**
- **Tidal Power Plant** (254MW/d)
- **TPLMS**
  Implementation
- But, the water quality is still not enough for swimmable & fishable level

- **Shihwa STP(94)**
  $176 \times 10^3 m^3/d$
- **Discharge of STP effluent to out side of SCR(96)**
- **Extension of Shihwa STP(04)**
  $-103 \times 10^3 m^3/d$

- **Ansan Sewer Treatment Plant(STP) (87,93)**
  $-121 \times 10^3 m^3/d$
- **Discharge of STP effluent to out side of SCR(96)**
- **Extension of 1st Ansan STP(01)**
  $-264 \times 10^3 m^3/d$
- **Extension of 2nd Ansan STP (05)**
  $149 \times 10^3 m^3/d$

- **Designation as a special management area(SMA) (2000)**
- **Implementation of 1st phase of SCR environmental management master plan (01-06)**
- **Establishment of SCR watershed management committee(02)**
- **Implementation of 2nd phase of SCR environmental management master plan (07-11)**
- **Implementation of SCR TPLMS (13)**
2. Do we need TPLMS in the SCR?

Water quality improved by TPP operation
Considering anticipated development projects, water quality will degrade again!

High development pressure but little additional water control measures
3. How is it working?

SCR TPLMS long-term water quality target (Before 20yr)

“Water quality for Swimmable and Fishable”

[COD 2.0mg/L, T-P 0.05mg/L]

<Water quality standard: 「 Enforcement Decree of the Framework Act on Environmental Policy 」 attached list 1 Environmental standard for marine water quality II grade (2012.7. previous revision >
3. How is it working?

- Existing Monitoring Station
- New Monitoring Station from '11
- New Monitoring Station from '13

1st Phase Water Quality Targets

<table>
<thead>
<tr>
<th>Parameters (mg/L)</th>
<th>COD</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner zone</td>
<td>3.3</td>
<td>0.065</td>
</tr>
<tr>
<td>Outer Zone</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Target pollutants (COD, TP)
- Consider WQ problems & management condition

Target period (May ~ Aug.)
- Consider temporal WQ change

Target area (Middle-outer zone)
- Consider spatial WQ distribution

Lookout area (inner zone)
- Consider available WQ monitoring data

Calculation WQ target (3-years moving average of sites 1, 2, 3 monitoring data)
3. How is it working?
3. How is it working?

- **Base year**
  - Existing discharge load: 7,761.7 kg/d

- **Target year**
  - Load for uncontrollable development: 935.9 kg/d
  - Load for controllable development: 6.9 kg/d
  - Existing discharge load: 7,761.7 kg/d

- **Target year (Allocation load)**
  - Margin of safety: 381.1 kg/d
  - Allocation load: 7,241.3 kg/d
  - Load reduction target: 1,462.2 kg/d

- **Discharge load in Target year**: 8,703.5 kg/d
- **Total maximum daily load**: 7,622.4 kg/d
- **Allocation load**: 7,241.3 kg/d

**Allocation load** = Total maximum daily load \( \times (1 - \text{Safety factor}) \)

<table>
<thead>
<tr>
<th>Description</th>
<th>COD (kg/d)</th>
<th>TP (kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Maximum daily load</td>
<td>7,622.4</td>
<td>203.1</td>
</tr>
<tr>
<td>Margin of safety</td>
<td>381.1</td>
<td>10.1</td>
</tr>
<tr>
<td>Allocation load</td>
<td>7,241.3</td>
<td>193.0</td>
</tr>
</tbody>
</table>

- Margin of safety = Total maximum daily load \( \times \) safety factor(5%)
## 3. How is it working?

<table>
<thead>
<tr>
<th>Discharge Load (kg/d)</th>
<th>Gunpo</th>
<th>Siheung</th>
<th>Ansan</th>
<th>Hwaseong</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allocation COD load</td>
<td>PS</td>
<td>NPS</td>
<td>PS</td>
<td>NPS</td>
<td>PS</td>
</tr>
<tr>
<td></td>
<td>90.7</td>
<td>162.9</td>
<td>119.2</td>
<td>961.9</td>
<td>301.7</td>
</tr>
<tr>
<td>Allocation TP load</td>
<td>PS</td>
<td>NPS</td>
<td>PS</td>
<td>NPS</td>
<td>PS</td>
</tr>
<tr>
<td></td>
<td>1.89</td>
<td>3.35</td>
<td>3.09</td>
<td>19.41</td>
<td>3.11</td>
</tr>
<tr>
<td></td>
<td>10.7</td>
<td>162.9</td>
<td>119.2</td>
<td>961.9</td>
<td>301.7</td>
</tr>
</tbody>
</table>

- PS: Point Source, NPS: Non-Point Source

Non-point source load >> Point source load
3. How is it working?

<table>
<thead>
<tr>
<th>Measures</th>
<th>Gunpo</th>
<th>Siheung</th>
<th>Ansan</th>
<th>Hwaseong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension or changing of treatment area</td>
<td>489.4</td>
<td>12.06</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Construction or extension of STP, advanced treatment</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NPS treatment facilities</td>
<td>-</td>
<td>-</td>
<td>11.3</td>
<td>0.23</td>
</tr>
<tr>
<td>NPS treatment facilities (development area)</td>
<td>4.5</td>
<td>0.12</td>
<td>0.5</td>
<td>0.02</td>
</tr>
<tr>
<td>Wetland operation improvement</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Natural purification in stream</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sewer maintenance</td>
<td>-</td>
<td>-</td>
<td>0.2</td>
<td>0.01</td>
</tr>
<tr>
<td>Road sweeping</td>
<td>5.2</td>
<td>0.07</td>
<td>17.2</td>
<td>0.54</td>
</tr>
<tr>
<td>Dredging contaminated sediment</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sum</td>
<td>499.1</td>
<td>12.25</td>
<td>29.2</td>
<td>0.80</td>
</tr>
</tbody>
</table>
3. How is it working?

- 1st phase water quality targets were accomplished!
3. How is it working?

- Establishment of committee in watershed level → **Bottom-up approach** for management with stakeholders

- Stakeholder’s participation from planning to evaluation → **Roles and responsibilities sharing** for implementation of TPLMS

- Implementing the **adaptive management** → Discussion of scientific uncertainty to derive the best solution through technical advisory committee
4. What will happen (Challenges)?

- 2nd phase TPLMS focus on the inner area where mixing is limited

### Parameters (mg/L)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>2nd Phase Water Quality Targets</th>
<th>1st Phase Water Quality Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inner</td>
<td>Outer</td>
</tr>
<tr>
<td>COD</td>
<td>5.7</td>
<td>3.1</td>
</tr>
<tr>
<td>T-P</td>
<td>0.123</td>
<td>0.053</td>
</tr>
</tbody>
</table>
4. What will happen (Challenges)?

- Large-scale development which was delayed by recent economic downturn, will be resumed during 2\textsuperscript{nd} phase TPLMS
- Development control is difficult because of permits were already issued
- The pollutant load will increase by large-scale development projects
- If developer refused to agree, additional load reduction measures will be difficult to apply because the EIA processes have been done

Enhanced EIA consultation and Advanced measures for load reduction should be enforced in the early planning stages
4. What will happen (Challenges)?

- Discharged of STP effluent to out side of SCR
  → PS load reduction measures (Strengthen effluent regulation, water reuse and others) can not affected in SCR water quality improving

- NPS was main source to affect in SCR water quality
  → Amount of NPS load reduction is generally small and applicable NPS measures are inefficient

Implementation of practical load reduction measures are required such as designation of NPS management area
4. What will happen (Challenges)?

- Less financial support for load reduction facilities installation
- Authorities of major load management measures are belong to other ministries: PS treatment facilities (MOE), NPS treatment in agriculture (MAFRA)
- MOF do not have own incentive for TPLMS support
- Lack of connection between MOF department (e.g. coastal management, permission of private uses of public water, resource development) and TPLMS

Require establishment of effective cooperating system with MOE and other ministries, and development of MOF own incentive to support TPLMS implementation
5. Conclusions

- Implementation of TPLMS was required to improve water quality even though the planned development projects are conducted.
- 1st phase of TPLMS was successful mainly because of background effects (dilution effects of tidal power plant operation) and delayed large scale development projects because of the recent economic setback.
- 2nd phase of TPLMS are more challenging because:
  - Water quality targets were additionally set in the inner area where tidal mixing is limited.
  - Load reduction measures for nonpoint sources are inefficient (high cost & low reduction amount).
- Pollution source control measures (ex: easy development pressure) and innovative nonpoint source control measures (ex: designation of nonpoint source management area) are required.