Overview of Jakarta Water Quality Statement under Urban Development

Pingping Luo
Postdoctoral Fellow, UNU-IAS
March 14, 2016
Project Work Plan

Data collection and estimation
- Climate change
- Land use
- Population
- Master plan
- etc.

Model development
- Water quality model
- Inundation model
- Risk assessment model

Scenario analysis
- Simulation of future water environment

Benefit analysis
- Economic evaluation of improving water environment

Dissemination and outreach
- Database development
- Capacity development
- Publications
Contents

- 1. Brief Profile of Jakarta
- 2. Urban development
- 4. Water quality statistical and index analysis
- 5. Conclusion
1. Profile of Jakarta
Indonesia's total land area is 1,919,317 square kilometres (741,052 sq mi).

Source: World Bank, 2009
1. Jakarta officially known as the Special Capital Region of Jakarta is the capital and largest city of Indonesia.

2. Officially, the area of the Jakarta Special District is 662 km² (256 sq mi) of land area and 6,977 km² (2,694 sq mi) of sea area.

3. Jakarta is divided into five *kota* or *kotamadya* ("cities" – formerly municipalities).

Greater Jakarta (*Jakarta Raya*) is the urban agglomeration surrounding Jakarta, the combination of Jakarta + Bogor + Depok + Tangerang + Bekasi cities (Kota) and Regencies (Kabupaten) and called as JABODETABEK.

As Greater Jakarta continued its rapid growth and sprawl over the *decades*...
The Greater Jakarta

The Major Ciliwung River catchment and other river catchments located in Jabodetabek (Greater Jakarta)
1. Industry and housing development has been increased due to economic boom between 1972-1990s

2. After 2000, the city urban development is focus on the surrounding cities of Jakarta, such as Bogor, Depok, Tangerang and Bekasi

3. Jakarta’s population has increased from about 8.3 millions (2000) into 10,075 million (2014)

4. Jakarta, has faced tremendous urban development and changes; built up areas in Jakarta has increased

This increase has not been supported by the increases of environmental service capacities to support the consequence of the development. Thus, environmental problems related to clean water provision, waste water production, and treatment as well as disasters such as flooding and landsubsidence, have become commons in Jakarta.
2. Urban development

Landuse Change

Red color is the urban area,
Green color is the vegetation area
Yellow color is the paddy field and other area
3. Major Urban Water Issues of Jakarta

Environment

1. Lack of solid waste management & volume of solid waste in 2008: 29.364 m³/day
2. Water pollution: concentration of COD, Ni, Cu, Zn, Hg above standard
3. Environmental impacts and diseases
4. Rise of sea level
5. Land Subsidence
6. Destruction of conservation area on the ground, coastal side, sea and islands
7. Lack of sanitation, green open space

Water Resource

1. Flood caused by backwater, river flooding, clogged drainage system
2. Low quality and quantity of clean and raw waters especially in north Jakarta
3. Limited coverage of piped wastewater network
4. Excessive extraction of groundwater that causes land subsidence
5. Intrusion of sea water
3.1 Water Resource Issue: Floods

Jakarta’s geographical and topographical setting as a Delta City makes it vulnerable to flood problems, this is due to:

1. Traversed by 13 rivers to Jakarta Bay
2. Part of Northern Jakarta lies in lowlands and frequently influenced by tidal condition causing backwater.

This condition is exacerbated by external factors:

1. Climate change: sea level increase and changes in rainfall intensity and pattern
2. Continuous land subsidence at a rate of as much as 10 cm/year in certain part of north Jakarta
3. Increase of impervious areas
4. Fragment design without taking into account future development
3.2 Water Demand & Supply

Conditions:

1. Contamination of water sources: upstream reservoirs and groundwater
2. High proportion of population without water services (50%)
3. Competition with irrigation

Demand management, reduction of losses, and new storage and long distance transmission of raw water for urban uses are urgent requirements to meet growing needs.

Water supply from Citarum river (Jatiluhur Dam) & other places to DKI Jakarta Province
Urban water quality statement in Jakarta

- Much of the city—and even good neighborhoods in North and or South Jakarta—still depend on bore well.
- Only 1.9 percent of the population of Jakarta is served by a city sewerage system.
- Most households rely on on-site sanitation, but on-site septic tanks and cesspits are often connected to street drains leading directly back to the region’s water system.
- Most industries in Jabodetabek have no wastewater treatment plants.
- 80 percent of groundwater in Jakarta is polluted

Source: Florian Steinberg, 2007; Mike Douglass, 2005
4 Water quality statistical and index analysis in Jakarta
Mann Kendall Test for trend analysis

\[ n(n-1)(2n+5) - \sum_{i=1}^{e} t_i(t_i - 1)(2t_i + 5) \]

\[ Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{e} t_i(t_i - 1)(2t_i + 5)}{18} \]

\[ S = \sum_{g=1}^{n-1} \sum_{i=g+1}^{n} \text{sgn}(x_i - x_g) \]

\[ \text{sgn}(\varphi) = \begin{cases} 
1 & \text{if } \varphi > 0 \\
0 & \text{if } \varphi = 0 \\
-1 & \text{if } \varphi < 0 
\end{cases} \]

MKT is a non-parametric statistical procedure used to test for trends in time series data (Yu et al., 1993). The null hypothesis in the Mann-Kendall test is that the data are independent and randomly ordered, i.e. there is no trend or serial correlation structure in the time-series (Hamed and Rao, 1998; Xu et al., 2010). For independent and randomly ordered data in a time-series \( X_i \{X_i, i = 1, 2, \ldots, n\} \), the null hypothesis \( H_0 \) is tested on the observations \( X_i \) against the alternative hypothesis \( H_1 \), where there is an increasing or decreasing monotonic trend (Yu et al., 1993). Gibert (1987) divided \( n \) (number of values) \(<10\) and \( n \geq 10\) to calculate the normal approximation \( Z \).

\[ Z = \begin{cases} 
\frac{S-1}{\sqrt{Var(S)}} & \text{if } S > 0 \\
0 & \text{if } S = 0 \\
\frac{S+1}{\sqrt{Var(S)}} & \text{if } S < 0 
\end{cases} \]

\( e \) is the number of tied groups and \( t_i \) is the number of data values in the \( i \)th group.

If the normal approximation \( Z \) test (\(|Z| \leq Z_{\alpha/2}\)) and the cumulative standard normal distribution \( \Phi \left( \Phi(Z_{\alpha/2}) = \alpha/2 \right) \), the \( H_0 \) hypothesis is adopted. The \( \alpha \) is the probability level of rejecting the null hypothesis \( H_0 \) when it is true. The \( Z \) value shows the statistical trend. If \( Z < 0 \), it indicates a decreasing trend and if \( Z > 0 \) it indicates an increasing trend.
Water quality sampling stations

Source from Government observation
4 Water quality statistical and index analysis in Jakarta

Data

Sen's estimate

99 % conf. min

99 % conf. max

95 % conf. min

95 % conf. max

Residual

BOD (mg/L)

Times

Data

Sen's estimate

99 % conf. min

99 % conf. max

95 % conf. min

95 % conf. max

Residual

BOD (mg/L)

Times

Data

Sen's estimate

99 % conf. min

99 % conf. max

95 % conf. min

95 % conf. max

Residual

BOD (mg/L)

Times

Data

Sen's estimate

99 % conf. min

99 % conf. max

95 % conf. min

95 % conf. max

Residual

BOD (mg/L)

Times
Water quality trend analysis
Pollution Index formula is described in below:

\[
PI = \sqrt{\frac{(Ci/Lij)^2_M + (Ci/Lij)^2_R}{2}}^{1/2}
\]

Description:
PI = Pollution Index
Ci = value of particular water quality parameter
Lij = value standard of particular water quality parameter (Government Regulation of Indonesian Republic No. 80, 2001)
M = Maximum value of Ci/Lij
R = Mean value of Ci/Lij
Based on BPLHD Pollutant Index from 2004-2009, most of the river water quality in Jakarta were highly polluted.
Jakarta city with high population density face a serious problem on water resources.

Urban development has made the water stress and water pollution in Jakarta city.

Based on the statistic analysis, significantly decrease trend was found on the most of 43 observed water quality stations. But some of the stations have the some extreme value of water quality.

The surface water quality in Jakarta city is in heavy polluted condition. The most ground water quality is also with polluted condition.
Thank you very much for your kind attention!
<table>
<thead>
<tr>
<th>Indonesia Acronym</th>
<th>Indonesia full name</th>
<th>English mean or name</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPU</td>
<td>Dinas Pekerjaan Umum</td>
<td>Public Works Agency</td>
</tr>
<tr>
<td>BAPPENAS</td>
<td>Badan Perencanaan Pembangunan Nasional</td>
<td>National Planning Board in the Ministry of National Development Planning</td>
</tr>
<tr>
<td>BAPPEDA</td>
<td>Badan Perencanaan Pembangunan Daerah</td>
<td>Regional Planning &amp; Development Agency</td>
</tr>
<tr>
<td>DK</td>
<td>Dinas Kebersihan</td>
<td>Cleansing Agency</td>
</tr>
<tr>
<td>BPLHD</td>
<td>Badan Perlindungan Lingkungan Hidup Daerah</td>
<td>Regional Environmental Agency</td>
</tr>
<tr>
<td>PD PAL JAYA</td>
<td>Perusahaan Daerah</td>
<td>Regional Company</td>
</tr>
</tbody>
</table>