Low-Carbon and Energy-Saving Approaches for Sewerage Systems in Japan

Hitoshi Nakazawa
Japan Sewage Works Agency
Contents

I. Sewerage Systems for Sound and Healthy Water Cycling and Resources/Energy Recycling
II. Present State of Sewerage Systems in Japan
III. Realization of Low-Carbon and Energy-Saving for Sewerage Systems in Japan
IV. Renewable Energy Utilization Technologies from Sewage Sludge
V. Recent Topics on Low-Carbon and Energy-Saving Projects for Sewerage Systems in Japan
1. Potential of sewerage systems as water reclamation & circulation and resources/energy recycle systems

(Water Cycling)
Water quality improvement
Reclaimed wastewater
Infiltration of stormwater

(Resources/Energy Recycling)
Biomass energy as
- digestion gas
- sewage sludge fuel
Phosphorus recovery
2. Roles of sewerage systems in water cycling system

(1) Adoption of suitable wastewater reclamation technologies to various utilization purposes

(2) Rainwater storage and utilization

(3) Infiltration for groundwater cultivation
# Water Quality and Facility Standards for Wastewater Reuse in Japan

<table>
<thead>
<tr>
<th>Standards Applying Location</th>
<th>Flushing Water</th>
<th>Sprinkling Water</th>
<th>Water for Landscape Use</th>
<th>Water for Recreational Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escherichia Coli</td>
<td>Not detectable</td>
<td>Not detectable</td>
<td>1,000CFU /100mL</td>
<td>Not detectable</td>
</tr>
<tr>
<td>Turbidity</td>
<td>2 degrees or less</td>
<td>2 degrees or less</td>
<td>2 degrees or less</td>
<td>2 degrees or less</td>
</tr>
<tr>
<td>pH</td>
<td>5.8-8.6</td>
<td>5.8-8.6</td>
<td>5.8-8.6</td>
<td>5.8-8.6</td>
</tr>
<tr>
<td>Appearance</td>
<td>Shall not be distasteful</td>
<td>Shall not be distasteful</td>
<td>Shall not be distasteful</td>
<td>Shall not be distasteful</td>
</tr>
<tr>
<td>Chromaticity</td>
<td>-</td>
<td>-</td>
<td>40 degrees or less</td>
<td>10 degrees or less</td>
</tr>
<tr>
<td>Odor</td>
<td>Shall not be distasteful</td>
<td>Shall not be distasteful</td>
<td>Shall not be distasteful</td>
<td>Shall not be distasteful</td>
</tr>
<tr>
<td>Facility Standards</td>
<td>-</td>
<td>Sand filtration, equivalent or better</td>
<td>Sand filtration, equivalent or better</td>
<td>Precipitation + sand filtration, equivalent or better</td>
</tr>
</tbody>
</table>
3. Concrete measures contributing to low-carbon society

(1) Energy-saving measures
   air diffuser, appropriate operation

(2) Renewable energy utilization from biomass and natural energies
   biomass: digestion gas (CH$_4$)
   biomass solid fuels
     (carbonized / dried sludge)
   natural energies:
     solar, hydro, wind power generation
     in wastewater treatment plant
II. Present State and Strategies on Sewerage Systems

1. Present state of sewerage systems in Japan

- Sewered population (March, 2010)
  Percentage of sewered population 73.7%
  Sewered population 93,600,000

- Reuse of reclaimed wastewater (FY2008)
  Annual treated wastewater amount (A)
    14,440 million m³/year
  Annual reuse amount of treated wastewater (B)
    202 million m³/year
  B/A (%) only 1.4 %
Wastewater Reuse in Respective Application (FY2008)

- Annual treated wastewater (A) 14,440 million m$^3$/year
- Annual reuse amount of treated wastewater (B) 202 million m$^3$/year

$\frac{B}{A} = 1.4\%$
II. Present State and Strategies on Sewerage Systems

Power consumption (FY2008)

(1) Annual power consumption in sewerage systems
7,210 million kWh/year (C)
= 0.7% of annual power consumption in Japan
* 90% of (C) was consumed
  in municipal wastewater treatment plants

(2) Unit power consumption per wastewater treated
0.5 kWh/m³
II. Present State and Strategies on Sewerage Systems

Sewage sludge generated (FY2008)

(1) Annual sewage sludge generated
2,468 thousand DS-ton/year

(2) Sewage sludge recycling rate 78%
   * Sludge recycling as a material for cement dominates a large percentage of sludge beneficial uses.
   ** Only 13.7% of sewage sludge generated is used as biomass energy sources for digestion gas (13.0%) and solids fuel (0.7%).
II. Present State and Strategies on Sewerage Systems

State of Sewage Sludge Beneficial Use (FY2008)

Recycling rate: 78%
(Landfill and coastal reclamation: 23%)

Biomass energy sources: 13.7%

- Solid fuel: 0.7%
- Digestion gas: 13.0%
- Agricultural use: 9.7%
- No biomass use (construction material): 76.6%

Annual recycled sewage sludge: 1,770,000 DS-t/year
II. Present State and Strategies on Sewerage Systems

2. Fundamental strategies on sewerage systems in Japan

(1) Realization of safe living
   Flood control, Seismic countermeasure, Water system risk reduction

(2) Creation of favorable environment
   - Water quality improvement in public waters
   - Creation of sound and healthy water circulation
   - Creation of resources and energy recycle

(3) Realization of comfortable and active living
1. Fundamental strategies
(1) Drastic energy saving measures
(2) Effective use of biomass energy

2. Solutions to realization of low-carbon and energy-saving approaches
(1) Energy-saving measures to reduce greenhouse gas emissions by energy and fuel consumption
   Greenhouse gas: CO₂, CH₄ and N₂O
(2) Renewable energy utilization from biomass
   Digestion gas, Sewage sludge fuel
1. Sewage sludge fuel conversion technologies
   (1) Sludge carbonizing
   (2) Sludge drying
### Characteristics of conventional biomass solid fuels

<table>
<thead>
<tr>
<th></th>
<th>Carbonized sludge</th>
<th>Dried and pelletized sludge</th>
<th>Coal (example)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calorific value (MJ/kg)</td>
<td>10～15</td>
<td>15～19</td>
<td>26</td>
</tr>
<tr>
<td>Water content (%)</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Ash content (%)</td>
<td>50</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>High specific gravity</td>
<td>0.4</td>
<td>0.6</td>
<td>-</td>
</tr>
<tr>
<td>Odor</td>
<td>Negative</td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td>Self-heat generation</td>
<td>Positive</td>
<td>Negative</td>
<td>-</td>
</tr>
</tbody>
</table>
IV. Realization of Low-Carbon and Energy Saving

Image of a biomass-fuel conversion project

**Sewerage operators**
- Wastewater treatment plant
- Centralization of sludge
- Nearby wastewater treatment plants
- Carbonization facility

**Electric utilities operator**
- Biomass fuel
- Coal thermal power plant
- Carbonization facility

*Image showing the integration of sewerage and electric utilities in biomass-fuel conversion projects.*
2. Biogas utilization technologies

(1) Biogas power generation
(2) Biogas power generation using fuel cells
(3) Supply of fuel for natural gas vehicles
(4) Supply of biogas as low material for urban gas supply

3. Gasification technologies

(1) Sewage sludge gasification furnace
Biogas recovery system in WWTP

Supply to power company

Increase of energy self-sufficiency

Solubilization by heating

Anaerobic digester

Heat supply

Gas separation

Biogas refinery

Biogas storage

Generator

Supply of biogas

Dewatering

Garbage, food processing factory waste

Sidestream treatment by anammox

Beneficial use

Filtrate

WWTP
Innovation in low-carbon and energy-saving technologies

(1) Energy-saving measures
   Centrifuge for dewatered sludge with lower water content

(2) New energy utilization
   Small hydropower generation

(3) B-DASH Project by MILT (FY2011 -)
   Breakthrough by Dynamic Approach in Sewerage High Technology Project
Overall image of innovative technology
by METAWATER Co., Ltd. & Japan Sewage Works Agency

Wastewater treatment system
Energy conservation

- Ultrahigh solids-liquid separation

Sludge treatment system
Energy creation

- High-efficiency high-temperature digestion

Power supply and control system

- Smart power generation system
- Hybrid type generator
- Plant operation optimizing control

[ Wastewater Treatment ] Recycle water, Environmentally sound water
Energy conservation through reduction of inflow loads

[ Sludge Treatment ] Electric power, Resources, Heat
Energy creation through maximization of biomass intake
Measures to facilitate Low-Carbon and Energy-Saving water use in semiarid areas

Osamu ITAGAKI : Senior Researcher, Climate Change Adaptation Research Group / Water Management and Dam Div. , River Dep. , National Institute for Land and Infrastructure Management.
Location of Syria

* Base map (Syria (orthographic projection).svg) is downloaded from Creative Commons.
Outlines of Syria (1)*

- Capital city: Damascus
- Area: 185 thousand km² (about a half of Japan)
- Population: 22.5 million (2010)
- Official language: Arabic
- Religion: Islam (86%), Christian (8%)

* Data book of the world (2011) (Ninomiya Shoten publishers Co., Ltd.)
Outlines of Syria (2)*

Exports from Japan to Syria (2009)
26.1 billion yen (Motorcars 41.6%, Tyres 17.6%, Machinery 12.7%, Electric devices 6.7%, Buses and trucks 6.1%)

Imports from Syria to Japan (2009)
3.4 billion yen (Processed petroleum 78.3%, Raw cotton 10.1%, Soap 1.8%)

* Data book of the world (2011) (Ninomiya Shoten publishers Co., Ltd.)
Outlines of hydrology and water use in Syria (1)

- About a half of the land is in semiarid (Al Badiah) basin.
- We can see rainfall from the autumn to the spring. The annual average rainfall around the center of Damascus is about 200–250 mm, and there is snowfall in the winter.
- There are some international rivers flowing in Syria. e.g. Euphrates, Tigris, Orontes.
- A large part of water is used for agriculture.
Outlines of hydrology and water use in Syria (2)

- Under water shortage, farmers tend to use water as much as possible.
- Most of the water use depends on the ground water etc. drawn by pumps.
- When the rate of fuel for pumps had risen dramatically, the tendency to decrease the operation time of pumps became stronger. Also, interest in the efficient irrigation techniques became stronger among the farmers.
- Disposed sewage water is reused in agriculture.
Memories of water service in Syria (1)

As a resident at fourth floor of an apartment near the center of Damascus.

1. We basically received the tap water before noon. Each house has the tank on the rooftop of the building for reserving water before noon, and we use the water reserved in the tank in the afternoon. The source of the tap water in my district was springs in the suburbs of Damascus. If the basin had received much rainfall and the ground water level near the spring was high, the pressure of the tap water would be higher, and the duration of water service would be longer, sometimes 24 hours a day.
Memories of water service in Syria (2)

2. We reserved drinking water in a portable tank in the kitchen before noon, or purchased bottled water (spring water in Syria).

3. When the water service was limited (e.g. in late summer), it was difficult to reserve water in the tank on the rooftop of the building because of the lack of the tap water pressure. Every house had a small pump near the divergence of the water pipe to increase the tap water pressure.

4. The rate of water was very cheap compared with that of electricity etc..
Measures to facilitate Low-Carbon and Energy-Saving water use in Syria (1)

- Since there are wide semiarid areas under water shortage, water saving and conservation is more emphasized than Low-Carbon and Energy-Saving water use. e.g. Syria-Japan technical cooperation project on Development of Efficient Irrigation Techniques and Extension in Syria (DEITEX).
- Since most of the water use is depending on the ground water etc. drawn by pumps, water saving directly connects with Low-Carbon and Energy-Saving by saving the fuel.
Measures to facilitate Low-Carbon and Energy-Saving water use in Syria (2)

- Continuous collection of the hydrological data (e.g. rainfall, ground water level), analysis of those data, and integrated water resources management contributes to Low-Carbon and Energy-Saving water use by efficient water resources distribution etc. (e.g. decrease of pump up, decrease of water treatment). e.g. Syria-Japan technical cooperation project on Water Resources Information Center (WRIC).
Farmland in Rural Damascus

With water, it has become green.
A well at a water service station in semiarid areas
Agricultural portable pumps along a river

Dayr Az Zawr
Sewage disposal plant in Rural Damascus
Irrigation canal from the sewage disposal plant (1)
Irrigation canal
from the sewage disposal plant (2)
An intake pit of the irrigation canal
Irrigation by the water from the sewage disposal plant
Ground water observation station (1)

Rural Damascus
Ground water observation station (2)

Rural Damascus
River flow observation station (1)
River flow observation station (2)

Damascus
Meteorological observation station
Rainfall observation station
Evaporation observation station

Lattakia
A windmill near a dam in semiarid areas
Solar cells at a water service station in the semiarid areas
The conclusion (1)

• Since most of water is drawn by pumps, water saving directly connects with Low-Carbon and Energy-Saving by saving the fuel.
• To facilitate Low-Carbon and Energy-Saving water use, it is needed to continuously collect basic hydrological data (e.g. rainfall, ground water level), analyze them, and manage water resources in an integrated way.
The conclusion (2)

- Reuse of disposed sewage water in agriculture may contribute to Low-Carbon and Energy-Saving water use with careful management.
- Generating facilities by windmill, or by solar cells have been partially introduced. It may contributes to Low-Carbon and Energy-Saving if the maintenance system of the facilities is available.