CHALLENGES AND OUTLOOK RELATED TO MUNICIPAL SEWAGE SLUDGE MANAGEMENT IN JAPAN

Jun TSUMORI, P.E.Jp
Team Leader of Recycling Research Team,
Construction Materials and Resources Research Group,
Public Works Research Institute, Tsukuba, Japan
OVERVIEW

• Introduction
  • Background
  • Current Status

• Challenges
  • Japanese endeavor to enhance sufficient sludge management
  • Promising advanced technologies in Japan

• Way forward

• Conclusion
INTRODUCTION: JAPAN

<table>
<thead>
<tr>
<th></th>
<th>Present</th>
<th>Target</th>
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</thead>
<tbody>
<tr>
<td>Energy Self-sufficiency:</td>
<td>6.0 %</td>
<td>Under Consideration</td>
</tr>
<tr>
<td></td>
<td>(2012)</td>
<td>(in 20 years)</td>
</tr>
<tr>
<td>GHG Emissions:</td>
<td>+ 2.8 %</td>
<td>- 3.8 %</td>
</tr>
<tr>
<td>Final Disposal Amount:</td>
<td>19 m t</td>
<td>25 m t &gt;</td>
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STATUS ON MUNICIPAL SEWERAGE IN 2013

- Sewered Population: 76.3%
- Wastewater Treatment Plants: 2,134
- Treated Wastewater: 14 billion c.m
- Final Disposal of Sludge: 2.2 million DS-t
Generated Sludge Volume: 2.2 m DS-t
Material Reuse Ratio: 77 %
# Sewage sludge treatment in Japan

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<tbody>
<tr>
<td>Dewatering</td>
<td>Landfill</td>
<td></td>
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<td></td>
<td></td>
<td>Now in Japan there is few case of landfill by dewatered sludge.</td>
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<tr>
<td>Incineration</td>
<td>Land fill (as ash)</td>
<td></td>
<td>1963</td>
<td>1980</td>
<td></td>
<td></td>
<td></td>
<td>Multi hearth Incinerator (Total over 30 sets were installed)</td>
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<tr>
<td></td>
<td>Ash utilization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fluidized bed incinerator (Total 252 sets were installed.)</td>
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<tr>
<td>Melting</td>
<td>Slag utilization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>After 2011, there is no new construction.</td>
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<tr>
<td>Carbonization</td>
<td>Utilization (fertilizer)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil improvement/Agricultural utilization</td>
</tr>
<tr>
<td></td>
<td>Fuel utilization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bio- charcoal utilization</td>
</tr>
</tbody>
</table>

- **Dewatering**: Landfill

- **Incineration**: Land fill (as ash)
  - 1963
  - 1980
  - 1974
  - Fluidized bed incinerator (Total 252 sets were installed)
  - Advanced fluidized bed incinerator 2009

- **Melting**: Slag utilization
  - 1982
  - 2011

- **Carbonization**: Utilization (fertilizer)
  - Soil improvement/Agricultural utilization
  - Bio- charcoal utilization 2012
MOST OF SLUDGE IS INCINERATED IN JAPAN DUE TO LANDFILL LIMITATION

Source: Japan Sewage Works Association (2004)
JAPANESE ENDEAVOR TO ENHANCE SUFFICIENT SLUDGE MANAGEMENT
BASIC ASPECTS OF ENHANCING SUFFICIENT SLUDGE / BIOSOLIDS MANAGEMENT

• Enhancing Energy Efficiency,

• Accelerating exploitation as Renewable Energy, and

• Advancing development for Cost Reduction of Recycling Technologies
AMENDMENT TO THE EXISTING POLICY FRAMEWORK

- Laws and regulations

- Technical guidelines by Japan Sewage Works Association
  - Planning, Design, Construction and O&M, and

- Technical Specifications by Japan Sewage Agency and Major Municipalities
  - Materials, facilities, electricity and buildings etc.
NATIONAL DEMONSTRATION PROJECT (B-DASH PROJECT) LAUNCHED IN 2011

Breakthrough by Dynamic Approach in Sewage High Technology

<table>
<thead>
<tr>
<th>Development Theme</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<td>4</td>
<td>2</td>
<td>5</td>
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<table>
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<tr>
<th>Adopting Technologies</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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</thead>
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<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>6</td>
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<thead>
<tr>
<th>Budget (Million USD)</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<tr>
<td></td>
<td>22</td>
<td>27</td>
<td>38</td>
<td>38</td>
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</table>
<Case Study> Total Optimization for Sludge Incineration

① Self-controlled dewatering  ② Energy-saving incineration  ③ Binary waste heat power generation

- Improvement of three individual processes
- Optimization of operation by total system control

Dewatering system control panel  Incineration system control panel  Power generation system control panel

Total control
PROMISING ADVANCED TECHNOLOGIES IN JAPAN RELATED TO THE WORKING GROUPS

- Digestion (Working Group 3)
- Thermal process (Working Group 5)
- Thickening and dewatering (Working Group 6)
- Inorganics & nutrients recovery (Working Group 7)
Advanced sewage sludge treatment technologies in Japan

WG3  Digestion

- Outside-type Digester Mixer
- Digestion (Methane Fermentation Process)
Outside-type Digester Mixer (NAS-E)

◆ Background
  • Easy installation to existing gas mixing digester
  • Less energy consumption

◆ Solution
  • Outside type digester mixer

◆ Effect
  • 1/3 energy consumption compared to gas mixing
  • Easy maintenance

◆ Reference
  • Location: Ryojima WWTP (Matsumoto city)
  • Circulating flow: 9m³/min
Digestion (Methane Fermentation Process)

◆ Back Ground
  • Much sludge generated from WWTPs
  • Drastic reduction of cost for sludge treatment is required

◆ Solution
  • Steel digester tank with high functionality
  • Low-power impeller agitator

◆ Effect
  • 40% reduction of dehydration sludge
  • Create renewable energy “Biogas”
  • Enable sedimentation level measurement

◆ Reference
  • Nambu-plant (from Dec. 2011 to Feb. 2013)
  • Higashinada-plant (from April 2012)
### WG5 Thermal process

**Incineration**
- Advanced Incineration Technology
- Pressurized Fluidized Bed Incineration
- Power Generation System with Sewage Sludge Incineration

**Sludge melting**
- Sludge melting technology

**Gasification**
- Gasification Technology

**Carbonization**
- Carbonization Technology
- Sludge fuel conversion technology
Advanced Incineration Technology

◆ Back Ground
  - Much GHG discharged from WWTPs
  - 24% by N$_2$O of incineration process
    (N$_2$O has 310 times as high GHG effect as CO$_2$)

◆ Solution
  - Multi-Layer Incineration Technology
  - Partially higher temperature zone

◆ Effect
  - 80% reduction of N$_2$O
    (Greenhouse gas reduction)

◆ Reference
  - Nambu Sludge Plant #3
    (since June 2009)
Pressurized Fluidized Bed Incineration technology

**Back ground**
- Compact facility
- Power saving
- Fuel saving
- GHG reduction

**Solution**
Applying Pressurized furnace

1) Pressurized fluidized bed furnace system consist of combination of fluidized bed furnace, which is the most suitable furnace for sewage sludge incineration, and turbo charger.
2) Sewage sludge is combusted under plus pressure (130 to 150 kPaG) and pressurized flue gas compressed air for furnace by using turbo charger.
3) Because flue gas is pressurized, flue gas is emitted by its force.

**Effect, compared to conventional Fluidized bed**

- **Compact**
  As 40% of flue gas volume is reduced, equipments size are also compacted

- **Save Fuel**
  Around 10% of fuel consumption is reduced.

- **Save Power**
  40% of electrical power is reduced.

- **GHG reduction**
  Because of forming high temperature zone, 50% of $N_2O$ is reduced.

**References**
- Tokyo metro. (Kasai), 300ton/d, 1 train
- Tokyo metro. (Miyagi), 300ton/d, 1 train
- Kanagawa pref., 100ton/d, 1 train
- Kofu city, 60ton/d, 1 train
- Osaka pref., 100 ton/d, 1 train
POWER GENERATION SYSTEM WITH SEWAGE SLUDGE INCINERATION

● Background
  • Demand for renewable energy
  • Needs for CO₂ reduction

● Solution
  • Low water content dewatered
  • Low power furnace
  • Steam power generation

● Effect
  • Power generation: >100kW
  • Supplying surplus power outside

● Project
  • Location: Wakayama Central WWTP
  • Capacity: 35 wet-t/day
  • National high-technology promotion project entrusted by NILIM, Japan
    (Still from June 2013)
**Sludge melting technology**

**Back ground**
- NO disposal area for sludge
- Sludge utilization as construction material.
- Heavy metal leakage problem

**Solution**
- Sludge melting
- Heavy metal solidification in slag.
- Sludge vitrification and utilization

**Effect**
- Prevent heavy metal leach out
- Utilization of melting slag
- Minimize $N_2O$ (GHG) in emission

**References**
- Kyoto Pref., Vortex melting 150 ton/d, 2 trains
- Osaka city, Vortex melting 150 ton / d, 5 trains
- Chiba city, Vortex melting 15 ton / d, 1 train
- Hyogo pref., Coke bed melting 180 ton / d, 3 trains
- Osaka pref., Coke bed melting 50 ton/d, 2 trains, 75 ton/d, 1 train
- Osaka pref., Coke bed melting 80 ton / d, 1 train, 110 ton/d, 2 trains
- Nagano Pref., Ash melting plant 3 ton / d, 1 train

*Example of Melting plant, Vortex melting*

*Vortex melting facility*  
*Melting slag*
◆ **Background**
  - Demand for renewable energy
  - Needs for CO₂ reduction

◆ **Solution**
  - Sludge gasification
  - Fuel gas power generation

◆ **Effect**
  - Power generation: 150kW
  - CO₂ reduction: 12,500 t/year

(in total of WWTP)

◆ **Project**
  - Location: Kiyose WWTP
  - Capacity: 100 wet-t/day
  - Operation: from 2010 for 20 years
Carbonization Technology (WtE tech.)

**Background**
- Demand for renewable energy
- Needs for CO₂ reduction

**Solution**
- Sludge carbonization
- Bio-charcoal for co-combustion

**Effect**
- Power generation: 4,600 MWh/year
- CO₂ reduction: 8,000 t/year
  (in total of WWTP and Power plant)

**Reference**
- Location: Kinuura Tobu WWTP
- Capacity: 100 wet-t/day (Bio-charcoal 8 t/day)
- Operation: from 2012 for 20 years
Sludge fuel conversion technology

**Back ground**
- Thermal recycle between Sewage treatment Plant and Power plant.
- Keep higher calorie in fuel product.
- Reduce odor in fuel product.

**Solutions**
- Applying low temperature carbonization. (250 to 350 °C carbonization)
- Supplying fuel product to power plant as fuel.

**Effects**
- Promotion of recycling sewage sludge
- Reduction of Greenhouse gas
  in both Sewage treatment plant and Power plant.

**References**
Hiroshima City, 50ton / day, 2 units
Kumamoto City, 50ton / day, 1 unit
Osaka City, 150ton / day, 1 unit
Yokohama City, 150ton / day, 1 unit
Kyoto pref., 50ton / day, 1 unit
WG6 Thickening & Dewatering

Thickening
- Rotary Fin Sludge Collector

Dewatering
- Centrifugal Dewatering machine
- ISGK Screw Press(Dewatering Machine)
Rotary Fin Sludge Collector (RFC)

◆ Background
  • Poor settleability in gravity thicker
  • Much energy consumption of mechanical thickening

◆ Solution
  • Sludge collector with rotary fin

◆ Effect
  • 10 – 20% higher concentration of thickened sludge
    (Certified by JIWET*)

◆ Reference
  • Tank diameter: $\phi$ 7.0m – 17.0m
  • Units: 14 units

*JIWET: Japan Institute of Wastewater Engineering and Technology
Centrifugal Dewatering Machine (SDR Impact)

◆ Background
  • Cost reduction of sludge disposal
  • Needs for CO₂ reduction

◆ Solution
  • Inject inorganic coagulant directly to the “dry beach” area

◆ Effect
  • 7 – 10 point lower water content
    (68 – 75% water content)
    (Joint research with JS*)

◆ Reference
  • Capacity: 5 – 40 m³/h
  • Units: 36 units

*JS: Japan Sewage Works Agency
ISGK Screw Press (Dewatering Machine)

◆ Background
  • Needs for energy saving
  • Needs for easy overhaul

◆ Solution
  • Metal filter
  • Simple structure

◆ Effect
  • Low water consumption
  • Low electric power consumption
  • Overhaul cost reduction

◆ Reference
  Approx. 300 units in Japan
  Approx. 70 units outside of Japan
WG7  Inorganics & nutrients recovery

**Phosphorus Recovery**
- Phosphorus Recovery from Incineration Ash
- Phosnix® Phosphorus Recovery as struvite
- Phosphorus Recovery as HAP from Black Water
**Background**

- Lack and price increase of natural phosphorus ore
- High P ratio in incinerated ash

**Solution**

- Alkaline Dissolution Technology
- Regeneration of P and neutralized ash

**Effect**

- Recycled P: Raw material of fertilizer
  (certified by MAFF*)
- Neutralized Ash: suitable for cement

**Reference**

- 5 wet-ton/day plant (Gifu prefecture)
  (Operation started in 2010)

* MAFF: Ministry of Agriculture, Forestry, and Fisheries
Phosnix® Phosphorus Recovery as Struvite

◆ Background
- Drying up high-grade P resources
- Clogging trouble in sludge treatment facilities in SWTP

◆ Solution
- Application of Struvite recovery system in SWTP

◆ Effect
- Recovery of fertilizer grade Struvite (certified by MAFF)
- Prevention of Scaling trouble
- Reduction of Phosphorus discharge

◆ Reference
- Shinjiko Tobu SWTP (500m³/day × 2) (Since 1998)
- Ono SWTP (300m³/day)

Recovered Struvite

Shinjiko Tobu Project
Phosphorus Recovery as HAP from Black Water

◆ Background
  • Drying up high-grade P resources

◆ Solution
  • Application of HAP recovery system

◆ Effect
  • Recovery of fertilizer grade HAP (certified by MAFF)
  • Reduction of surplus sludge

◆ Project
  • Senboku City (60m³/day)
  • Kushimoto Town (45m³/day)
  and 3 projects

 Recovered HAP

Senboku City Project
WAY FORWARD IN JAPANESE WASTEWATER TREATMENT PLANTS

- Evolving into urban centers as energy supply and material recycling hubs.
CONCLUSION

• Energy security and global warming as well as Natural resource conservation are crucial issues to share the earth.

• Sludge Treatment Plants are responsible for saving energy and reducing Green House Gas emissions, and have great potential as distributed urban energy and material recycling hubs.

• To boost performance of each sludge treatment process in terms of energy sufficiency and GHG reduction must be considered in ISO/TC275 discussion to contribute our future.
THANK YOU FOR YOUR KIND ATTENTION!

For email contact: recycle@pwri.go.jp