Multistage Hybrid Wetland Systems for Pig Wastewater Treatment

WEPA Group Workshop on Pig Wastewater Management in Asia

Chiang Mai, Thailand

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Introduction

Tusk Co., Ltd., The National Agriculture and Food Research Organization (NARO) and K.K. Satisfactory are jointly conducting a feasibility study “Dissemination of hybrid subsurface flow constructed wetland systems in Vietnam” under “Model Project for Improvement of Water Environment in Asia” commissioned by Ministry of the Environment, Japan.
Overview
Newly Constructed Wetland before operation
Wetland in operation after a few years
Types of constructed wetlands

Free water surface (FWS)
Sedge, cat-tail etc.

Vertical subsurface flow
Aerobic (oxidative)
Reeds, reed canary grass etc.

Horizontal subsurface flow
Anaerobic (reductive)
Reeds, reed canary grass etc.
Types of constructed wetlands and reed beds

- Surface flow
- Subsurface flow
- Vertical
- Horizontal
- Hybrid

Reed beds
Hybrid System/ Vertical and Horizontal subsurface flow

Vertical subsurface flow
Aerobic (oxidative)

\[ \text{C}_{\text{organic}} \rightarrow \text{CO}_2 \]

\[ \text{N}_{\text{organic}} \rightarrow \text{NH}_4^+ \rightarrow \text{NO}_3^- \]

Horizontal subsurface flow
Anaerobic (reductive)

\[ \text{NO}_3^- \rightarrow \text{N}_2 \]
Schematic diagram of a multi-stage hybrid wetland system

1. Pig Wastewater
2. Mixing Tank
3. Safety Bypass
4. Pump
5. Effluent

1st V bed Aerobic
2nd V bed Aerobic
3rd H bed Anaerobic
4th V bed Aerobic

Floating cover material (Supersol)

Sampling and flow measuring point
Siphon
Pump
Influent and Effluent
Safety bypass and floating material to avoid clogging

- Floating material (Supersol etc.)
- Surface partition for alternate drying
- Reinforced safety bypass

Density: 0.4 g cm$^{-3}$
Main design innovation

- **Bypass structure** for safety treatment
- **Floating cover material** on the bed surface

Advantages

- Able to increase organic load per area without clogging
- Available just after construction while growing reed and earthworm

Minimize the area and cost!
Multistage Hybrid Wetland Systems in Japan
Subsurface flow constructed wetlands in Japan as of August 2016

- **10th Mar. 2010** - Secondary & nonpoint
- **4th Nov. 2007** - Agr. Canal (nonpoint)
- **2nd Nov. 2006** - Dairy S
- **7th 2008** - Pig liquid food
- **9th Nov. 2009** - Pig urine
- **13th June 2011** - Dairy E
- **8th 2009** - Dairy
- **18th June 2015** - Household
- **15th Jan. 2012** - plastic bottle recycle
- **20th Aug. 2016** - Dairy Biogas liquid
- **3rd Aug. 2007** - Acid mine
- **12th May 2011** - Dairy G
- **5th May 2008** - Dairy N
- **1st Nov. 2005** - Dairy K
- **14th Aug. 2011** - Cheese R
- **11th Dec. 2010** - Chicken egg
- **16th Jul. 2012** - Domestic secondary

Legend:
- Low
- High
Multistage Hybrid Wetland Systems at Pig Farm O in Hokkaido

Pig farm O
Oct. 2009-

Daily Mean Temp. in Hokkaido
Annual: 5 to 7 °C.
Winter months: –8 to –6 °C.
Summer months: 18 to 21 °C.
Pig Farm O in Hokkaido

Total bed area : 1,472m²
Inflow rate : 12.2 m³/d
Influent: BOD 2,299 mg/L
NH₄-N 1,157 mg/l

150 - 180 sows
2,000 - 2,500 pigs

Since 2009
1st summer (July 2010) at Pig farm O
2\textsuperscript{nd} summer (July 2011) at Pig Farm O
Schematic diagram at Pig Farm O

Piggery slurry

1st Vr
572m²

2nd Vr
446m²

Lagoon reservoir
≈ 700m³

3rd V
184m²

4th H
195m²

5th V
75m²

Solid – liquid separation

1

2

3

4

5

6

Pumice L
10-50mm

Pumice M
5-10mm

Pumice S
1-5 mm

Pumice L
10-50mm

Pumice M
5-10mm

Pumice S
1-5 mm

Pumice M
5-10mm

Pumice S
1-5 mm

Pumice M
5-10mm

Pumice L
10-50mm

Pumice S
1-5 mm

Floating cover (Supersol)

Pumice L
10-50mm

Pumice M
5-10mm

Pumice S
1-5 mm

Pumice M
5-10mm

Pumice S
1-5 mm

Pumice L
10-50mm

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Pumice M
5-10mm

Pumice S
1-5 mm

Sampling point

Siphon

Pump

Recirculation pump

Vr: Vertical flow with recirculation, V: Vertical flow, H: Horizontal flow
Samples taken from Pig Farm O

<table>
<thead>
<tr>
<th>Item</th>
<th>unit</th>
<th>Influent</th>
<th>Effluent</th>
<th>rate %</th>
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</thead>
<tbody>
<tr>
<td>BOD</td>
<td>mg/L</td>
<td>1859</td>
<td>36</td>
<td>98.1%</td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>6116</td>
<td>362</td>
<td>94.1%</td>
</tr>
<tr>
<td>SS</td>
<td>mg/L</td>
<td>1693</td>
<td>37</td>
<td>97.8%</td>
</tr>
<tr>
<td>TN</td>
<td>mg/L</td>
<td>1374</td>
<td>398</td>
<td>71.0%</td>
</tr>
<tr>
<td>TP</td>
<td>mg/L</td>
<td>155.1</td>
<td>14.3</td>
<td>90.8%</td>
</tr>
<tr>
<td>Coliform</td>
<td>i/L</td>
<td>30004</td>
<td>102</td>
<td>99.7%</td>
</tr>
</tbody>
</table>
Cost comparison between activated sludge*

From the open database of Livestock Industry’s Environmental Improvement Organization (LEIO), Japan.

*swine wastewater treatment, under the condition that the influent and effluent BOD conc. is the same.

*1US$ = 108JPY
Multistage Hybrid Wetland Systems in Vietnam
Multistage Hybrid Wetland Systems in Vietnam

Thai Nguyen Province/ May 2015～

Hai Duong Province/ May 2013～
Phuoc Tien Pig Farm in Thai Nguyen Province

Total bed area : 1,868m²
Inflow rate : 180 m³/d

4,000 pigs/year
Since 2015
Layout of MSHWS at Phuoc Tien Pig Farm
Influent and Effluent sampled at Phuoc Tien Pig Farm/TSS

QCVN 62-MT:2016/BTNMT
A: wastewater as being discharged into water resources used for the purpose of domestic water supply
B: wastewater as being discharged into water resources not used for the purpose of domestic water supply
Influent and Effluent sampled at Phuoc Tien Pig Farm/BOD$_5$

QCVN 62-MT:2016/BTNMT
A: wastewater as being discharged into water resources used for the purpose of domestic water supply
B: wastewater as being discharged into water resources not used for the purpose of domestic water supply
Influent and Effluent sampled at Phuoc Tien Pig Farm/COD

QCVN 62-MT:2016 BTNMT
A: wastewater as being discharged into water resources used for the purpose of domestic water supply
B: wastewater as being discharged into water resources not used for the purpose of domestic water supply
Influent and Effluent sampled at Phuoc Tien Pig Farm/T-N

QCVN 62-MT:2016/BTNMT
A: wastewater as being discharged into water resources used for the purpose of domestic water supply
B: wastewater as being discharged into water resources not used for the purpose of domestic water supply
Influent and Effluent sampled at Phuoc Tien Pig Farm/Coliforms

QCVN 62-MT:2016/BTNMT
A: wastewater as being discharged into water resources used for the purpose of domestic water supply
B: wastewater as being discharged into water resources not used for the purpose of domestic water supply
Advantages of subsurface flow constructed wetland

- Inexpensive (esp. in terms of operation cost)
- Labor-saving
- High flexibility in response to changes in wastewater level and amount
- Purification capability with a smaller area than that for the surface flow type
- All-year-round purification even in cold regions during winter
- Fewer pests, mosquitoes, flies, etc.
Thank you very much!

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