Introduction

June 1963 - May 1964

Severe Water Rationing - 4 hours of supply every 4 days
Introduction

• To prepare for the declining rainfall due to climate change and the rapidly increasing water demand in the Pearl River Delta region, the Government has formulated a Total Water Management (TWM) strategy.
Total Water Management

• Water Demand Management
  – To enhance public education on water conservation
  – To promote use of water saving devices
  – To enhance water leak control
  – To extend use of seawater for toilet flushing

• Water Supply Management
  – To strengthen protection of water resources
  – To actively consider water reclamation (including reuse of greywater and rainwater harvesting)
  – To develop the option of seawater desalination
Greywater provides a constant source of water for reuse.
Greywater

• Domestic wastewater excluding wastewater from toilet or urinal (blackwater - feces, urine and flushing water)

• Wastewater from
  – Showers, baths, washing basins
  – Clothes washing/laundry
  – Kitchens
Greywater Mining

Shower and washing basin wastewater
Laundry wastewater
Kitchen wastewater
Toilet Black water

Greywater Recycling System
Grey Water to be treated
Residual on Screens and biological sludge/membrane backwash water to be carried by Excess Grey Water

Grey Water Pipe
Black Water Pipe

Reclaimed Water
Potential Applications
– Unrestricted Non-potable Reuse

Toilet Flushing (for the remaining 20% areas without seawater flushing)

Irrigation for Plants & Green Roof

Makeup Water for Cooling Tower

General Cleaning (Car Washing & Street Cleaning)

Water Features

Fire Fighting
HKPC’s patented greywater recycling system
Greywater Applications
SAF + Hollow Fiber Membrane
Design Concept
Applications
Treatment Process

Submerged Aerated Filter (SAF)
- Media are installed for the attached growth of micro-organisms
- Can hold a large amount of biomass and have a much higher treatment efficiency

Micro-filtration (MF)
- Hollow fibre membranes of pore size 0.1-0.4 µm to separate clean water from the SAF effluent
- No sedimentation tank, so reducing the space required
- The treated water is crystal-clear, free of germs and odour
- Membrane can be automatically backwashed
Submerged Aerated Filter (SAF)

Packing Media
- PVC 60° cross-fluted media with large specific surface area up to 240 m²/m³
- Large voidage of >97%

Process Microbiology
- Micro-organisms grow and develop on the surface of media (biofilm)
- Decomposition of organic takes place in biofilm
- As the biofilm grows thicker, it will slough off from the media
- MLSS is much lower than that of activated sludge (~100 mg/L)
Microfiltration (MF)

- Typical fibre diameter ~1.0 mm
- Pore size 0.1–0.4 μm (smaller than bacteria)
- Water flow is outside-in
- Cross-flow filtration to suppress membrane fouling
- Auto-backwash and air scouring for membrane cleaning
Treatment Process

Disinfection
  – To maintain a residual chlorine level to prevent re-growth of bacteria in pipes, a certain amount of chlorine disinfectant is dosed

The whole treatment process has been patented
  – HK Short Term Patent No.: HK1095980
Case references in Hong Kong and Mainland

- **70 m$^3$/day**
  City University of Hong Kong (First installation in HK, 2009)

- **12 m$^3$/day**
  URA Redevelopment

- **1 m$^3$/day**
  Office building in HK

- **1 m$^3$/day**
  Office building in HK

- **30 m$^3$/day**
  Collaborated with 深圳建築科學研究院
  To build a demo plant in Shanghai

- **50 m$^3$/day**
  Public Estate in Tuen Mun (First installation for housing estate in HK)
Greywater Recycling System in CityU

Start Operation: September 2009

Designed Treatment Capacity: 7 m³/hr

Aim: Reduction of the use of city water for irrigation so as to achieve water conservation

Sources:

i) Washing basins in about 60 toilets
ii) Condensate from central air handling unit (AHU)
Location of the Plant
Plant Layout

Plant room:
- 15 m x 4.7 m (58 m² effective floor area)
- separated into 4 compartments
- 2.3 m headroom
System Outlook

Reception/Biological Tanks

Membrane Filtration Unit
### Reclaimed Water Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Water Quality</th>
<th>HK Technical Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.4–8.2</td>
<td>6 ~9</td>
</tr>
<tr>
<td>Colour (Hazen unit)</td>
<td>&lt;5</td>
<td>≤20</td>
</tr>
<tr>
<td>Odour (Odour unit)</td>
<td>--</td>
<td>≤100</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>&lt;0.1–0.3</td>
<td>≤5</td>
</tr>
<tr>
<td>Conductivity (µS/cm)</td>
<td>67–410</td>
<td>--</td>
</tr>
<tr>
<td>Biochemical oxygen demand (BOD₅)/(mg/L)</td>
<td>&lt;3–8</td>
<td>≤10</td>
</tr>
<tr>
<td>Chemical oxygen demand (mg/L)</td>
<td>&lt;5–29</td>
<td>--</td>
</tr>
<tr>
<td>Ammonia nitrogen (mg/L)</td>
<td>&lt;0.05–0.2</td>
<td>≤1</td>
</tr>
<tr>
<td>Anionic Surfactant (mg/L)</td>
<td>0.1–0.3</td>
<td>--</td>
</tr>
<tr>
<td>Suspended solids (mg/L)</td>
<td>&lt;5</td>
<td>≤5</td>
</tr>
<tr>
<td>E. Coli (cfu/100 mL)</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Total residual chlorine (mg/L)</td>
<td>System outlet 1.0–1.8</td>
<td>System outlet≥1.0 , End of pipe≥0.2</td>
</tr>
</tbody>
</table>
Performance

Membrane Feed Water

Membrane Product Water
Reclaimed Water Quality

COD of Reclaimed Water

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent COD</td>
<td>mg/L</td>
<td>30–380</td>
</tr>
</tbody>
</table>

![Line Graph showing COD (mg/L) from Aug-09 to Feb-11 with fluctuations within the range of 30–380 mg/L](image)
Reclaimed Water Quality

Ammonia Nitrogen of Reclaimed Water

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent Ammonia Nitrogen</td>
<td>mg/L</td>
<td>4.1–5.3</td>
</tr>
</tbody>
</table>

Graph showing the average ammonia nitrogen concentrations from August 2009 to February 2011, with a range of 0.3 to 0.8 mg/L.
Reclaimed Water Quality

Colour of Reclaimed Water

Pt-Co Unit

Aug-09  Oct-09  Dec-09  Feb-10  Apr-10  Jun-10  Aug-10  Oct-10  Dec-10  Feb-11
Reclaimed Water Quality

_E.Coli_ of Reclaimed Water

![Graph showing E.Coli levels in reclaimed water over time. The graph indicates a consistent level of E.Coli (1.0 CFU/100mL) from August 2009 to February 2011.](image-url)
## Running Cost

<table>
<thead>
<tr>
<th>Source</th>
<th>Cost (HK$ per m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity cost</td>
<td>~1.2</td>
</tr>
<tr>
<td>Chemical cost</td>
<td>~0.2</td>
</tr>
<tr>
<td>Consumables and membrane replacement</td>
<td>~0.45</td>
</tr>
<tr>
<td>Reclaimed water from greywater recycling (Tuen Mun Project)</td>
<td>~ HK$ 1.85</td>
</tr>
</tbody>
</table>

Money saving from greywater recycling = HK$ (4.58+2.92–1.85)

(with effect from 1st April 2017) = HK$ 5.65 /m³ reclaimed water
## Reference costs from local installations

<table>
<thead>
<tr>
<th>Project</th>
<th>Capacity (m³/day)</th>
<th>Capital Cost (HK$)</th>
<th>Recurrent Cost (HK$/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>City University of Hong Kong</td>
<td>70</td>
<td>$0.9 Million</td>
<td>$3 k</td>
</tr>
<tr>
<td>EMSD Headquarters</td>
<td>30</td>
<td>$1 Million</td>
<td>-</td>
</tr>
<tr>
<td>TKO Area 86</td>
<td>440</td>
<td>$6.7 Million</td>
<td>$20 k</td>
</tr>
</tbody>
</table>
Major Constraints of Greywater Recycling in HK

• Space constraint
  – Conventional/off-the-self systems would not be compact and flexible enough to fit into the congested space

• Operation requirement
  – Need simple and forgiving operation to minimize operator attendance

• Reclaimed water quality for hygiene concerns
  – Need sophisticated treatment processes to provide safe reclaimed water complying to Technical Specifications

• Economic viability
  – Need reduced capital investment to encourage greywater recycling
  – Need to minimize operating cost to achieve net money saving
Greywater Recycling System in CityU

CityU system has demonstrated that:

• Very little space required
  – System is very compact and flexible, and can be fit into a 58 m² basement plant room

• Minimal operation & maintenance
  – Consistently superior reclaimed water quality with little operator attendance for over 5 years

• Relatively low capital investment
  – System cost : less than HK$1 million

• Operation cost
  – ~HK$1.5/m³ resulting in a net money saving of HK$6/m³
Greywater Recycling System in Tuen Mun

Start Operation: November 2018
Designed Treatment Capacity: 5 m³/hr

Aim: Reduction of the use of city water for irrigation so as to achieve water conservation

Sources:
Shower trays, water basins of tenants’ toilets, floor drain of tenants and washing machine
Greywater Recycling System in Tuen Mun
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<td>Turbidity (NTU)</td>
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<td>Biochemical oxygen demand (BOD5)/(mg/L)</td>
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<td>Ammonia nitrogen (mg/L)</td>
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<tr>
<td>Total residual chlorine (mg/L)</td>
<td>System outlet 1.01.8</td>
<td>System outlet≥1.0 , End of pipe≥0.2</td>
</tr>
<tr>
<td>Threshold Odour Number</td>
<td>&lt;1</td>
<td>≤ 100</td>
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<tr>
<td>Legionella Bacteria Count</td>
<td>&lt;10</td>
<td>≤ 10 ( cfu/ml)</td>
</tr>
<tr>
<td>Heterotrophic Colony Count</td>
<td>&lt;1</td>
<td>≤ 100,000 ( cfu/ml)</td>
</tr>
</tbody>
</table>
## Standard Packaged Systems

<table>
<thead>
<tr>
<th>System Model</th>
<th>Operating Hours</th>
<th>Reclaimed Water</th>
<th>Reclaimed Water for</th>
<th>No. of User</th>
<th>Reception Tank Required</th>
<th>Product Tank Required</th>
<th>Space Required</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hourly Flow Rate</td>
<td>Daily Flow Rate</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>m³/hr</td>
<td>m³/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>GW-01</td>
<td>5~10</td>
<td>0.1</td>
<td>1</td>
<td>200</td>
<td>27</td>
<td>Up to 27</td>
<td>0.2</td>
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<td>GW-05</td>
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<td>0.5</td>
<td>5</td>
<td>1,000</td>
<td>130</td>
<td>Up to 130</td>
<td>2</td>
</tr>
<tr>
<td>GW-10</td>
<td></td>
<td>1</td>
<td>10</td>
<td>2,000</td>
<td>130~260</td>
<td>130~260</td>
<td>3</td>
</tr>
<tr>
<td>GW-20</td>
<td></td>
<td>2</td>
<td>20</td>
<td>4,000</td>
<td>260~530</td>
<td>260~530</td>
<td>5</td>
</tr>
<tr>
<td>GW-50</td>
<td></td>
<td>5</td>
<td>50</td>
<td>10,000</td>
<td>530~1,330</td>
<td>530~1,330</td>
<td>5</td>
</tr>
<tr>
<td>GW-100</td>
<td></td>
<td>10</td>
<td>100</td>
<td>20,000</td>
<td>1,330-2,660</td>
<td>1,330-2,660</td>
<td>5</td>
</tr>
</tbody>
</table>

1. 5L/m²/d
   Reference: Project Profile of “Rainwater and Greywater Recycling in Tseung Kwan O (TKO) Area 86 Property Development”

2. 37.5 L/head/day
   Reference: Baseline WC Water Use in BEAM Plus for Existing/New Buildings Version 1.2
Layout Sample

Capacity: 1 m³/hr
Capacity: 1 m³/hr
Major Potential Users in Hong Kong

- School and university campuses
- Youth campsites and sports centres
- Residential and commercial buildings (esp. green buildings)
- Hotels
- Shopping centres
Potential Market in Mainland China

- Starred hotels and resorts
- Large shopping centres (including hypermarkets and department stores)
- Factories and worker dormitories
- Small residential communities
- Commercial buildings in urban areas
Q & A