Industrial Water Reuse: Perspectives from Emerging Countries

WEBINAR
26 April 2022 | 10:00 BST
iwa-network.org/webinars

inspiring change
This webinar is being hosted by the Water Reuse Specialist Group and is the second of 4-part series titled “On the Road to Chennai 2023”.

1st webinar:

Next webinar: May 12
The IWA WRSG makes substantial contributions to critical elements of water reuse by organizing international and regional events (conferences, workshops, webinars, etc.) and preparing publications and technical guidance documents to further promoting various good practice.
Submit your abstract for the Conference by May 15!  

[https://iwareuse2023.com](https://iwareuse2023.com)
WEBINAR INFORMATION

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WEBINAR INFORMATION

- **‘Chat’ box**: please use this for general requests and for interactive activities.
- **‘Q&A’ box**: please use this to send questions to the panelists. (We will answer these during the discussions)

*Please Note*: Attendees’ microphones are muted. We cannot respond to ‘Raise Hand’.
AGENDA

- Welcome, introduction, housekeeping rules
  Olivier Lefebvre

- A short introduction to industrial water reuse
  Josef Lahnsteiner

- India ensuring industrial water security
  Nupur Bahadur

- Industrial Wastewater Reclamation, Windhoek Namibia
  James Villet

- Water reclamation to industrial user
  Varanon Laosuwan

- Poll and Q&A Panel Discussion

- Final remarks and conclusion
  Olivier Lefebvre
MODERATORS & PANELISTS

Olivier Lefebvre
National University of Singapore, Singapore

Nupur Bahadur
The Energy & Resources Institute, India

Josef Lahnsteiner
R&D bei WABAG, Austria

Varanon Laosuwan
WHA Utilities and Power, Thailand

James Villet
Ujams Wastewater Treatment, Namibia
LEARNING OBJECTIVES

1. Understand the negative impact associated with untreated industry wastewater and how to minimise environmental risks

2. Get an overview of the importance of industrial wastewater management and the challenges inherent to this type of wastewater

3. Learn about best practices of water reuse applicable in various geographical zones, with a particular focus on solutions tailored to emerging economies
SHARE YOUR THOUGHTS ON SOCIAL MEDIA

Tag @IWAHQ on social media and tell us:

Why water reuse is important?

How does it affect your life?

What is the main contribution to the SDG6 and the 2030 Agenda?

Don’t forget to include the hashtags #IWA & #WaterReuse.
A SHORT INTRODUCTION TO INDUSTRIAL WATER REUSE

JOSEF LAHNSTEINER
WABAG GROUP, AUSTRIA & INDIA
DRIVERS FOR INDUSTRIAL WATER REUSE

▪ Water Shortage caused by
  – Climate change
  – Population growth
  – Industrialization in developing and emerging economies

▪ Boost in water supply security
  – A shutdown of a production facility could cause an enormous financial damage

▪ Further economic reasons
  – Reclaimed water is normally cheaper than municipal water
  – Reduced wastewater discharge fees
  – Resource recovery

▪ Policies, regulations and guidelines
  – E.g. Treated Wastewater Reuse Policy for Tamil Nadu, India, 2019

▪ Brand protection
  – Green image
  – Reputational risk minimization – water can be a constraint upon growth
MAJOR INDUSTRIAL REUSE APPLICATIONS

- Reclaimed water reused as cooling make-up in
  - Power generation
  - Various processes such as oil refining

- Reclaimed water reused as boiler make-up in
  - Thermal power plants of utilities
  - Thermal power plants of various industries such as pulp and paper mills

- Reclaimed water reused for various purposes
  - Transport e.g. in mining
  - Washing e.g. in food industry
  - Quenching e.g. of refinery coke
  - Dust suppression e.g. in coal gasification
  - Maintaining pressure in oil recovery
  - Manufacturing e.g. of steel
SOURCES FOR INDUSTRIAL WATER REUSE

- Municipal (secondary) effluents
- Industrial “in-house“/on-site effluents
  - Secondary effluents from ETPs
  - Various pretreated and untreated process effluents
  - Cooling tower and boiler blow-downs
- Effluents from one industry reused in another industry
  - E.g. cross-sectional reuse at multi-company sites (industry parks)
CASE STUDY IN WEST AFRICA - NIGERIA

Nigeria
- Most populous country in Africa - 211 million
- Largest economy in Africa
- Worldwide 12th largest producer of petroleum

Dangote Group, founded by Aliko Dangote, is one of the largest companies in Africa
- Oil refining & manufacture of petrochemical products
- Fertilizer production
- Automotive supply industry
- Cement manufacturing
- Agriculture (tomato & rice farming, etc.)

Dangote Refinery & Petrochemical Complex (R & PC)
- Lagos State, Lekki Free Zone, Lekki peninsular south east of Lagos
- R & PC under construction, completion in Q.4 2022
- Largest single train refinery, 650,000 bdp
- Water management by raw water treatment, effluent treatment and water reclamation
DANGOTE WATER RECLAMATION SYSTEM

CTBD

BAF/BIOPUR®

CRWS

Oil & SS Removal

Sour Water

Stripping + Cyanide Removal

OWS

Oil & SS Removal + BPC + MBR/MARAPUR®

Spent Caustic

High Pressure WAO

SWW

Screening + MBR/MARAPUR®

Water Reclamation Plant

RO Reject Treatment

BBD

 Boiler Feedwater

To Sea Outfall
## Dangote Refinery - Oily Wastewater Stream

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Wastewater Characteristics</th>
<th>Treated Effluent Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>-</td>
<td>6 – 9</td>
<td>6 – 9</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>3,000 – 5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Oil &amp; Grease</td>
<td>mg/L</td>
<td>1,000 – 5,000</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>BOD$_5$ at 20 °C</td>
<td>mg/L</td>
<td>250 – 1,300</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>500 – 2,100</td>
<td>&lt; 50</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>100 – 500</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>Sulfides</td>
<td>mg/L</td>
<td>10 – 30</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Phenols</td>
<td>mg/L</td>
<td>10 – 100</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>mg/L</td>
<td>100</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>mg/L</td>
<td>10</td>
<td>&lt; 3</td>
</tr>
</tbody>
</table>

BOD – Biochemical Oxygen Demand  
COD – Chemical Oxygen Demand  
TSS – Total Suspended Solids
## Dangote Refinery- Reclaimed Water Standards

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>RO Feed Characteristics</th>
<th>Reclaimed Water Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>m³/h</td>
<td>-</td>
<td>1,200</td>
</tr>
<tr>
<td>pH</td>
<td>-</td>
<td>6.5 – 8.5</td>
<td>6.5 – 7.5</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>15 – 30</td>
<td>≤ 35</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>-</td>
<td>BDL</td>
</tr>
<tr>
<td>Conductivity at 20°C</td>
<td>μS/cm</td>
<td>-</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>Calcium</td>
<td>mg/L</td>
<td>144</td>
<td>-</td>
</tr>
<tr>
<td>Magnesium</td>
<td>mg/L</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>-</td>
<td>BDL</td>
</tr>
<tr>
<td>Total Reactive Silica</td>
<td>mg/L</td>
<td>15</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>Total Iron</td>
<td>mg/L</td>
<td>0.9</td>
<td>&lt; 0.03</td>
</tr>
<tr>
<td>Total Copper</td>
<td>mg/L</td>
<td>-</td>
<td>&lt; 0.003</td>
</tr>
<tr>
<td>Sodium</td>
<td>mg/L</td>
<td>318</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>KMnO₄</td>
<td>mg/L</td>
<td>47</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Oil Content</td>
<td>mg/L</td>
<td>-</td>
<td>BDL</td>
</tr>
<tr>
<td>TDS</td>
<td>mg/L</td>
<td>2,600</td>
<td>0.1</td>
</tr>
</tbody>
</table>

BDL – Below Detection Limit
KMnO₄ – Potassium Permanganate
TDS- Total Dissolved Solids
TSS – Total Suspended Solids
Cooling Tower Blowdown and UF Feed Collection Tanks
Ultrafiltration Process Unit (in installation phase)
DANGOTE WATER RECLAMATION PLANT

Installation of the Reverse Osmosis Process Unit
Key Issues for successful Industrial Water Reuse/Recycling

- Water reuse concepts must provide social, environmental and economical sustainability
- Water reclamation plant financing (BOT, etc.), is very important, particularly in developing countries
- In order to promote water reuse/recycling, longer pay back periods should be accepted by industrial investors
- The risk which is avoided by a higher industrial water supply reliability should be valued in feasibility studies
- Price of freshwater from public supply shouldn’t be subsidized (true cost of water)
Key Issues for successful Industrial Water Reuse/Recycling (continued)

➢ Proper Water Reclamation plant design
  • Use of existing experience
  • Pilot testing
  • Multiple barrier systems provide a high degree of safety
  • New technologies such as ceramic membranes

➢ Proper concentrate reuse and/or disposal concepts
  • “Brine mining” (e.g. selective recovery of salts)
  • Minimum Liquid Discharge
  • Proper treatment prior to discharge

➢ Proper operation by well trained and skilled personnel
  • Training abroad (outside of own plant)
  • Audits with regard to operation and maintenance
Thanks you for your attention!

Josef.Lahnsteiner@wabag.com
INDIA ENSURING INDUSTRIAL WATER SECURITY

DR NUPUR BAHADUR
THE ENERGY & RESOURCES INSTITUTE (TERI), NEW DELHI
Key drivers for ensuring Industrial Water Security in India

Category 1: Case Studies: Treated Industrial wastewater for reuse

Category 2: Case Studies: Reclaimed water for Industrial reuse

Category 3: Status of R&D in Industrial Water Reuse
KEY DRIVERS FOR ENSURING INDUSTRIAL WATER SECURITY IN INDIA

1. Industrial Water Demand

*Water demand of energy and industrial sectors*
(billion litres per day [BLD])

Source: India Infrastructure Report, 2011, Chapter 18
KEY DRIVERS FOR ENSURING INDUSTRIAL WATER SECURITY IN INDIA

2. Water stress and the need for industrial water supply security

3. Shortage of potable supply and the regional resource limitations i.e. droughts

4. Zero Liquid Discharge (ZLD) compliance as per the Central Pollution Control Board (CPCB), Govt. of India.

KEY DRIVERS FOR ENSURING INDUSTRIAL WATER SECURITY IN INDIA

- 5. Govt. of India Policies and Programs from time-to-time

- The Indian Constitution, 1950, Article 246 & 248
- The National Urban Sanitation Policy, 2008
- ZLD policy, 2016
- The Water (Prevention and Control of Pollution) Act, 1974
- The National Water Policy, 2012
- Tariff Policy, 2016
- The Environment (Protection) Act, 1986
- Namami Gange Mission, 2014-2023
- Swacch Bharat Mission, 2014-2019
- AMRUT Mission, 2015-2023
- Smart City Initiative, 2017-2023
TREATED INDUSTRIAL WASTEWATER FOR REUSE

**a. High Grade Water (COD <10 mg/L and TDS <250 mg/L)**
- Use in Boiler feedwater
- Use directly in process

**b. Medium Grade Water (COD <50 mg/L and TDS <500 mg/L)**
- Use in Cooling Tower plants, Scrubbers etc.
- Use directly for vessel washing, floor washing etc.

**c. Low Grade Water (COD <250 mg/L and TDS <2100 mg/L)**
- Use in horticulture development
- Dust suppression and common area sprinkling
- Use for construction purposes in nearby development

**TREATED MUNICIPAL WASTEWATER FOR INDUSTRIAL REUSE**

**a. High Grade Water (BOD <5 mg/L, COD <30 mg/L, TDS <250 mg/L)**
- Flushing
- Cooling tower/ HVAC - AHU Plants

**b. Moderate/ Low Grade Water (BOD < 30 mg/L, COD <150 mg/L and TDS <1000 mg/L)**
- Horticulture
- Floor washing
- Dust suppression
- Fire Fighting
Case Study 1: ETP/Recycling – IOCL Refinery, Paradip, Odisha

**Client:** Indian Oil Corporation (IOCL)

**Location:** Paradip, Odisha, India

**Project:** ETP & Recycling Plant for Refinery Complex Paradip, 54,000 m³/day

**Type:** EPC – turnkey execution

**Start-up:** 2015

What makes it UNIQUE?

- Largest industrial water recycling plant in India
- Achieving water recovery of around 75 per cent
- Exclusive treatment of effluents from various streams.
Effluents from various streams are treated exclusively.

**Effluent streams:**
- Oily water and contaminated rain water
- Salty oily water
- Stripped sour water
- Cooling tower blow down and side stream filter backwash
- Coke Pile surface water run-off
- Sulphidic and naphthenic spent caustic
- Landfill site leachate
- Sanitary wastewater
- Steam system blow down
- DM plant regeneration waste

**ETP - Main process steps:**
- API separator
- TPI Separator
- DAF system
- Intermediate equalization tank and slop oil tanks
- VOC treatment
- Biotower
- Aeration tank
- Secondary clarification
- Bio DAF
- Intermediate check basin for monitoring performance parameters

**TTP - Main process steps:**
- Rapid gravity sand filters
- Basket strainers
- Ultrafiltration
- Reverse Osmosis
- RO reject treatment in hard COD management unit before discharging into the sea.

**ETP & Recycling Plant for Refinery Complex**
54,000 m³/day

**Water Recycling**
Case Study 2: ETP/Recycling – Balkrishna Industries, Bhuj, Gujarat, India

Manufacturing Process and Water Consumption Area

1. TYRE PLANT
   - Input/Output: Rubber, Carbon, Process Oil, Chemicals
   - Processes: Mixing, Calendering & Extrusion, Bead, Rim, & Tread etc.
   - Output/Output: Mixed Rubber, Green Tire

   Steam & Hot Water for Tyre Curing
   - Cured Tyre: Wastewater (Recycle), Steam Condensate Water (Recycle)
   - Water for Cooling Purpose in Cooling Tower, TCU, Air Washer, AHU & Chiller (Evaporation loss & Blow Down Recycle)

2. POWER PLANT
   - Fuel: Coal/Off Gas
   - Processes: WTP Treated Water (For Industrial Use), WTP Rejected Water (Recycle)
   - Output/Output: Boiler Blow Down (Recycle), Boiler Blow Down (Recycle)
   - Power: Low Pressurized Steam for Tyre Plant
   - Steam Condensate Water (Recycle)
   - Water for Cooling Purpose (Evaporation loss & Blow Down Recycle)

3. CARBON BLACK PLANT
   - Input: CBFI
   - Processes: Reactor/Bag Filter
   - Output: Carbon Black, Water with Molasses
   - Blow off Water (in from of Steam) along with Air from Bag Filter

Inspiring change
# Wastewater Source & Management

<table>
<thead>
<tr>
<th>Source of Waste Water</th>
<th>Treatment Facility provided &amp; Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industrial</strong></td>
<td>1. ETP 1 (1320 KLD) with Second Stage RO for Tire &amp; CPP</td>
</tr>
<tr>
<td></td>
<td>2. ETP 2 (90 KLD) with Second Stage RO for Carbon Black</td>
</tr>
<tr>
<td></td>
<td>3. Second Stage RO Reject from both ETPs is clubbing together at one common reject recycle RO.</td>
</tr>
<tr>
<td></td>
<td>4. Reject of Third Stage Recycle RO is feeding to MEE.</td>
</tr>
<tr>
<td></td>
<td>5. Treated water Recycling back to Industrial process</td>
</tr>
<tr>
<td></td>
<td>6. ETP Sludge &amp; MEE Salt sent to TSDF for disposal</td>
</tr>
<tr>
<td><strong>Domestic Sewage</strong></td>
<td>With 600 KLD STPs of combine capacity, treated water is being utilized for flushing &amp; gardening purposes.</td>
</tr>
</tbody>
</table>

## SCHEMATIC FLOW DIAGRAM OF CPP- ETP AND SECOND STAGE RO

[Diagram of wastewater flow process]
# Daily Water Monitoring & Review Mechanisms

## Electricity (PGVCL + Own Generation)

<table>
<thead>
<tr>
<th>Particular</th>
<th>UoM</th>
<th>Target</th>
<th>Sep'20</th>
<th>June'21</th>
<th>July'21</th>
<th>Aug'21</th>
<th>24</th>
<th>25</th>
<th>26</th>
<th>27</th>
<th>28</th>
<th>Avg/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGVCL</td>
<td>KwH</td>
<td>43724</td>
<td>76172</td>
<td>80772</td>
<td>72000</td>
<td>115320</td>
<td>100440</td>
<td>98280</td>
<td>95400</td>
<td>104280</td>
<td>100337</td>
<td></td>
</tr>
<tr>
<td>Power Plant (CPP)</td>
<td>KwH</td>
<td>417201</td>
<td>443628</td>
<td>446181</td>
<td>451086</td>
<td>442720</td>
<td>447088</td>
<td>444528</td>
<td>451216</td>
<td>451728</td>
<td>432382</td>
<td></td>
</tr>
<tr>
<td>Solar Power</td>
<td>KwH</td>
<td>4340</td>
<td>4423</td>
<td>3569</td>
<td>3130</td>
<td>3435</td>
<td>4194</td>
<td>3505</td>
<td>2336</td>
<td>3714</td>
<td>3260</td>
<td></td>
</tr>
<tr>
<td>4.2 MW DG</td>
<td>KwH</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</table>

## Specific Ratios

<table>
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<tr>
<th>Particular</th>
<th>Unit</th>
<th>Target</th>
<th>Sep'20</th>
<th>June'21</th>
<th>July'21</th>
<th>Aug'21</th>
<th>24</th>
<th>25</th>
<th>26</th>
<th>27</th>
<th>28</th>
<th>Avg/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>KwH/MT</td>
<td>910</td>
<td>1058</td>
<td>976</td>
<td>946</td>
<td>980</td>
<td>1060</td>
<td>1010</td>
<td>1014</td>
<td>1015</td>
<td>1046</td>
<td>1007</td>
</tr>
<tr>
<td>Coal</td>
<td>Kg/MT</td>
<td>401</td>
<td>450</td>
<td>402</td>
<td>401</td>
<td>429</td>
<td>409</td>
<td>429</td>
<td>409</td>
<td>404</td>
<td>401</td>
<td>417</td>
</tr>
<tr>
<td>Steam</td>
<td>MT/MT</td>
<td>2.6</td>
<td>2.6</td>
<td>2.29</td>
<td>2.28</td>
<td>2.44</td>
<td>2.33</td>
<td>2.44</td>
<td>2.33</td>
<td>2.30</td>
<td>2.29</td>
<td>2.37</td>
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</table>

## Coal-Power Ratio

<table>
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<th>Particular</th>
<th>Unit</th>
<th>Target</th>
<th>Sep'20</th>
<th>June'21</th>
<th>July'21</th>
<th>Aug'21</th>
<th>24</th>
<th>25</th>
<th>26</th>
<th>27</th>
<th>28</th>
<th>Avg/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Available</td>
<td>Days</td>
<td>29.88</td>
<td>29.76</td>
<td>29.98</td>
<td>29.89</td>
<td>30.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Power Cost

| Production (Tons.)            | Rs/kwh | 3.77     | 4.33   | 4.32   | 4.77   | 4.94   | 4.94  | 4.94  | 4.92  | 4.93  | 4.98  |

## Average Compound Stock in MT-

| Production (Tons.)            | Rs/kwh | 1578     | 1974   | 1887   | 2072   | 1864   | 1939  | 1945  | 2005  | 2118  | 388.96 |

## WTP - WATER QUALITY & CONSUMPTION

<table>
<thead>
<tr>
<th>Description</th>
<th>Raw Water</th>
<th>Process Water</th>
<th>Plant Water</th>
<th>DM Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>8.1</td>
<td>8.49</td>
<td>9.7</td>
<td>8.22</td>
</tr>
<tr>
<td>TDS</td>
<td>486</td>
<td>32.6</td>
<td>142</td>
<td>4.05</td>
</tr>
<tr>
<td>Chlorides</td>
<td>170</td>
<td>10</td>
<td>38</td>
<td></td>
</tr>
</tbody>
</table>

## Carbon Black Plant

### ETP

- Water coming to ETP: KL

### ZLD

- Total ZLD Product Water (RO+MEE): KL

### Carbon plant

- Raw Water: KL

### Fresh water

- From R-1,R-2 & R-4: KL

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**Inspiring change**

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### SPECIFIC WATER CONSUMPTION DATA

<table>
<thead>
<tr>
<th>Plant / Area</th>
<th>Year 2020</th>
<th>Year 2019</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tire Plant</td>
<td>3.78 KL / MT</td>
<td>4.63 KL / MT</td>
<td>18%</td>
</tr>
<tr>
<td>Carbon Black</td>
<td>4.11 KL / MT</td>
<td>4.83 KL / MT</td>
<td>15%</td>
</tr>
<tr>
<td>Power Plant (CPP)</td>
<td>0.42 KL / MW</td>
<td>2.49 KL / MW</td>
<td>83%</td>
</tr>
</tbody>
</table>

Specific Water in year: Total Fresh Water (Industrial + Domestic) consumed / Total Production

**Good practices led to better water management as follows:**

1. Tire Plant & Carbon Black Plant focused on **reduction of water consumption by leakage arrest & optimisation of water uses** by re-use at different area.
2. Power Plant, reduced water consumption by optimisation of water use, and also by **elimination of water uses point like replacement of Water Cooling with Air Cooling.**
3. Company installed Third stage common reject recycle water RO system to **enhance recycling capacity** up to 98%.
4. In gardens, company introduced system for **collection of run-off water and re-uses**, resultant in to reduction of use of fresh water.
5. **Increase in rain water holding capacity** 14 times (new holding capacity is 56,700 KL), installed pumping & filtration system and started use of rain water in industrial process @ 140 KLD which is **3.5% of total Fresh water requirement.**
Case Study 1:
STP/Recycling – Surat Municipal Corporation, Surat, India

Liquid waste management activities

- Population catered: 99.5% * of present population
- Sewage Collected & Treated: 970 MLD
- Length of sewer network: > 2022 km
- Sewage Pumping Stations: 63 Nos (2109 MLD)
- Sewage Treatment Plants: 11 Nos (1655.5 MLD)
- Treated Wastewater
  - Recycled & Reused: 319.00 MLD
- SCADA system for operations monitoring and efficiency enhancement

* Before city limit extension

- Re-use of treated water
- **Recovery of 100% O&M costs** of networks/STPs/FSTPs
- Complaint Redressal mechanism
- Safe discharge of sewage from CT/PT/IHHL
- Safe cleaning of Sewer and Septic tanks
- Sufficient capacity of desludging vehicles
Treated Wastewater Reused: 319.00 MLD

1. Textile Clusters – 160 MLD
2. Industrial Use – 112 MLD
3. Rejuvenation of Lakes – 2 MLD
4. Bio-diversity park – 0.5 MLD
5. Dream City Project – 0.5 MLD
7. Waste to Compost Facility – 1 MLD
8. Agriculture – Mass Plantation – 28 MLD
9. Gardening, Traffic Circles, Road dividers etc through Tanker Filling Station – 10 MLD
10. Next up Coming - Construction Purpose, Metro Rail Project, Bio-diversity park, Watering of Trench Lines, Rejuvenation of Lakes with heavy water Board – 20 MLD
COSTS

- Total O & M Cost towards maintaining complete sewerage system – INR 110.00 Cr (USD 14.38 Million) (Including O & M and Electricity Cost)
- Total Tertiary Treatment Plant Capacity: 115 MLD (40+35+40) plus 10% additional capacity on demand.
- Capital Project Cost: INR 314.39 Cr (USD 41.11 Million)
- O & M Cost: INR 300 crore (USD 39.22 Million) (For 10 Years)
- Total Recycle water Supplied to Industries till Date : 1,08,604.29 ML

REVENUE

- Started with INR 18.20 per KL (USD 0.24) in year 2014, rate increased yearly based on actual increase in O & M cost & RBI indexation, present rate of Treated Wastewater is @ INR 31.82 per KL (USD 0.42)
- Annual Revenue Generation: INR 140 Cr (USD 18.30 Million)

Such examples are also there in other cities like Indore, Prayagraj, Nagpur etc.
Case Study 2: STP/Recycling – NMCG, MoJS, GoI and IOCL, Mathura Refinery, India

What makes Namami Gange Program UNIQUE?

- An integrated river conservation mission for the Ganga basin (River Ganga flows 2500 Kms, across 11 States)
- With a holistic approach, works on pollution abatement, improving ecology and flow, strengthening R&D and knowledge base and people-river connect
MATHURA SEWAGE PROJECT

- First Project under the concept of One city – One operator under HAM.
- Paradigm shift – Integration of existing sewage infrastructure with the development of new STPs.
- Re Use of Water for ensuring sustainability of assets and resources.

**Project features:**

- Development of 30 MLD STP at Masani zone
- Rehabilitation of 3 existing STPs - (16 MLD UASB & 14.5 MLD WSP at Trans Yamuna and 6.5 MLD WSP at Masani) & associated infrastructure
- Development of 20 MLD TTP for supply of water to Mathura Refinery of IOCL.
- IOCL to share full O & M cost and partial capital cost of TTP through water tariff.

**Payment Arrangements with IOCL:**

- **Power charges** of INR 42.67 Cr **(USD 5.56 Million)** and **O & M cost for TTP** at INR 39.72 Cr **(USD 5.18 Million)** borne by Mathura Refinery of IOCL.
- IOCL to pay a tariff of Rs 8.70 per KLD of water consumed towards the portion of capital cost.
- Under a tripartite agreement between IOCL, NMCG and UP Jal Nigam.
- **Volume of water to be supplied to Mathura Refinery: 20 MLD**
- Water to be delivered at Gokul Barage from which IOCL will use the existing infrastructure to pump to the refinery premises.
- Payment to the contractor is independent of the payment received from IOCL.
### Case Study 3:
STP/Recycling – Chennai Metropolitan Water Supply & Sewerage Board, Chennai

**WATER SUPPLY IN CHENNAI**
Diversified Sources of Supply to Become *Future-Ready*

<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desalination</td>
<td>16%</td>
<td>2 Seawater Desalination Plants 100 MLD Each</td>
</tr>
<tr>
<td>Recycled Wastewater</td>
<td>10%</td>
<td>For Industries, Power plants, Landscaping, Urban Horticulture</td>
</tr>
<tr>
<td>Reservoirs</td>
<td>65%</td>
<td>5 Reservoirs Combined capacity of 12.5 Tmcf</td>
</tr>
<tr>
<td>Groundwater</td>
<td>9%</td>
<td>Well Fields, Agricultural Wells, Bore Wells</td>
</tr>
</tbody>
</table>

Chennai, India
WATER RECYCLING FOR INDUSTRIAL WATER SECURITY
SETTING BENCHMARK FOR URBAN WATER GOVERNANCE
45 MLD Koyambedu TTRO, Chennai, India

➢ Secondary treated Municipal Wastewater treated upto **potable standards**
➢ Multistage Treatment scheme: **Ultrafiltration (UF) & Reverse Osmosis**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influent</th>
<th>Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>20 mg/l</td>
<td>BDL</td>
</tr>
<tr>
<td>TDS</td>
<td>1500 mg/l</td>
<td>&lt;70 mg/l</td>
</tr>
<tr>
<td>COD</td>
<td>160 mg/l</td>
<td>BDL</td>
</tr>
</tbody>
</table>

➢ **Treated Water supplied to Industrial Clusters in South Chennai**
➢ Ensuring Industrial Water Security, **Promotes Municipal-Industrial Partnerships**
➢ **Robust Revenue Generation model** from sale of treated wastewater
➢ Chennai Metro **sells treated water** to SIPCOT @ **INR 80/KL (USD 1.05)**, payback period of 4 years
Challenges in Industrial Wastewater Treatment, ZLD & Reuse

(1) Colour, COD & toxicity,
(2) Sludge,
(3) Low biodegradability, lack of shock load bearing capacity
(4) Fouling, choking, high O&M costs of membranes
(5,6) Highly resource & energy intensive tertiary treatment, which makes ZLD costlier, unsustainable, unacceptable and non-compliant
TERI ADVANCED OXIDATION TECHNOLOGY

Breaking of chemical bonds, & mineralization of pollutants in effluents

PROCESS FLOW DIAGRAM

- Raw Effluent
- Collection cum Equalisation Tank
- Primary Treatment cum Settling Tank
- Nanomaterial Mixing Tank
- Photocatalytic Reactor
- Air Blower
- Nanomaterial Recovery Unit
- Recovered Nanomaterial
- Treated Water

- Conduction Band
- Valence Band
- e⁻ → O₂⁻
- Oxidation
- CO₂, H₂O, NH₄⁺, NO₃⁻, SO₄²⁻, Cl⁻
Case Study 1: Treating Industrial Wastewater at different stages as per requirement

**TADOX® in Textiles WWT**

- Pre Treated: 5 h
- Post Treated: b. Post treated

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Parameter (mg/l)</th>
<th>Pre Treated</th>
<th>Post Treated</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>7.62</td>
<td>9.1</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Conductivity (μmho/cm)</td>
<td>3470</td>
<td>130</td>
<td>96%</td>
</tr>
<tr>
<td>4</td>
<td>TSS</td>
<td>850</td>
<td>4</td>
<td>99.53%</td>
</tr>
<tr>
<td>5</td>
<td>TDS</td>
<td>3823</td>
<td>163.3</td>
<td>96%</td>
</tr>
<tr>
<td>6</td>
<td>Chloride</td>
<td>240</td>
<td>30</td>
<td>88%</td>
</tr>
<tr>
<td>7</td>
<td>Hardness</td>
<td>60</td>
<td>ND</td>
<td>100%</td>
</tr>
<tr>
<td>8</td>
<td>BOD₃</td>
<td>255</td>
<td>12</td>
<td>95%</td>
</tr>
<tr>
<td>9</td>
<td>COD</td>
<td>1360</td>
<td>128</td>
<td>91%</td>
</tr>
</tbody>
</table>

**TADOX® in Oil & Gas WWT**

- Pre Treated: 3 h
- Post Treated: B

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Pre-TADOX</th>
<th>Post-TADOX</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.16</td>
<td>8.91</td>
</tr>
<tr>
<td>BOD₅, mg/L</td>
<td>20.96</td>
<td>41.96</td>
</tr>
<tr>
<td>COD, mg/L</td>
<td>128</td>
<td>80</td>
</tr>
<tr>
<td>TDS, mg/L</td>
<td>7041</td>
<td>3357</td>
</tr>
<tr>
<td>Oil &amp; Grease, mg/L</td>
<td>588</td>
<td>31.20</td>
</tr>
<tr>
<td>Zn, mg/L</td>
<td>0.20</td>
<td>0.05</td>
</tr>
<tr>
<td>Pb, mg/L</td>
<td>0.40</td>
<td>Nil</td>
</tr>
</tbody>
</table>

**TADOX® in Pharmaceutical WWT**

- Pre Treated: 3 h
- Post Treated: b. Finally Treated

**TADOX® for MEE Condensate**

- Pre Treated: 6 h
- Post Treated: 

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Pre-TADOX</th>
<th>Post-TADOX</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>10.95</td>
<td>9.01</td>
</tr>
<tr>
<td>Color, Pt-Co Colour Units (CU)</td>
<td>92.21</td>
<td>10.5</td>
</tr>
<tr>
<td>Total Dissolved Solids (TDS), mg/L</td>
<td>228</td>
<td>144</td>
</tr>
<tr>
<td>Total Suspended Solids (TSS), mg/L</td>
<td>157</td>
<td>106</td>
</tr>
<tr>
<td>Turbidity, NTU</td>
<td>5.31</td>
<td>2.02</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD), mg/L</td>
<td>2430</td>
<td>580</td>
</tr>
<tr>
<td>Nitrate, mg/L</td>
<td>65.01</td>
<td>45.3</td>
</tr>
<tr>
<td>Phosphate, mg/L</td>
<td>0.265</td>
<td>0.23</td>
</tr>
</tbody>
</table>
### PHYSICAL CHARACTERISTICS

#### STP Inlet

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.2</td>
</tr>
<tr>
<td>Colour, Hazen</td>
<td>292.4</td>
</tr>
<tr>
<td>TDS, mg/L</td>
<td>342.0</td>
</tr>
<tr>
<td>Total Solids, mg/L</td>
<td>780.0</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>438.0</td>
</tr>
</tbody>
</table>

#### Direct TADOX®

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.0</td>
</tr>
<tr>
<td>Colour, Hazen</td>
<td>1.4</td>
</tr>
<tr>
<td>TDS, mg/L</td>
<td>91.3</td>
</tr>
<tr>
<td>Total Solids, mg/L</td>
<td>101.0</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>9.7</td>
</tr>
</tbody>
</table>

#### Current Conventional Treatment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.2</td>
</tr>
<tr>
<td>Colour, Hazen</td>
<td>116.4</td>
</tr>
<tr>
<td>TDS, mg/L</td>
<td>368.0</td>
</tr>
<tr>
<td>Total Solids, mg/L</td>
<td>650.0</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>282.0</td>
</tr>
</tbody>
</table>

#### STP Outlet

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.0</td>
</tr>
<tr>
<td>Colour, Hazen</td>
<td>&lt;1</td>
</tr>
<tr>
<td>TDS, mg/L</td>
<td>119.0</td>
</tr>
<tr>
<td>Total Solids, mg/L</td>
<td>132.0</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>13.0</td>
</tr>
</tbody>
</table>

#### TADOX® @ Polishing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.8</td>
</tr>
<tr>
<td>Colour, Hazen</td>
<td>&lt;1</td>
</tr>
<tr>
<td>TDS, mg/L</td>
<td>119.0</td>
</tr>
<tr>
<td>Total Solids, mg/L</td>
<td>132.0</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>13.0</td>
</tr>
</tbody>
</table>
## Chemical Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>STP Inlet</th>
<th>Direct TADOX®</th>
<th>Current Conventional Treatment</th>
<th>TADOX® @ Polishing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COD, mg/L</strong></td>
<td>352.00</td>
<td>21.50</td>
<td>88.00</td>
<td>24.0</td>
</tr>
<tr>
<td><strong>BOD, mg/L</strong></td>
<td>115.00</td>
<td>&lt;2</td>
<td>32.00</td>
<td>&lt;2</td>
</tr>
<tr>
<td><strong>NO₃, mg/L</strong></td>
<td>17.51</td>
<td>6.19</td>
<td>14.10</td>
<td>2.99</td>
</tr>
<tr>
<td><strong>PO₄, mg/L</strong></td>
<td>4.45</td>
<td>0.08</td>
<td>0.50</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>NO₂, mg/L</strong></td>
<td>0.11</td>
<td>0.75</td>
<td>0.19</td>
<td>0.11</td>
</tr>
<tr>
<td><strong>NH₄, mg/L</strong></td>
<td>7.20</td>
<td>3.40</td>
<td>3.20</td>
<td>2.10</td>
</tr>
</tbody>
</table>

**Notes:**
- **COD, mg/L:** 21.50 (94% removal), <2 (99% removal), 24.0 (93% removal)
- **BOD, mg/L:** <2 (99% removal), <2 (99% removal), <2 (99% removal)
- **NO₃, mg/L:** 6.19 (65% removal), 2.99 (83% removal), 2.99 (83% removal)
- **PO₄, mg/L:** 0.08 (98% removal), 0.03 (99% removal), 0.03 (99% removal)
- **NO₂, mg/L:** 0.75 (53% removal), 0.11 (53% removal), 0.11 (53% removal)
- **NH₄, mg/L:** 3.40 (53% removal), 3.40 (53% removal), 3.40 (53% removal)
### Biological Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>STP Inlet</th>
<th>Direct TADOX®</th>
<th>Current Conventional Treatment</th>
<th>TADOX® @ Polishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>E Coli, MPN/100ml</td>
<td>1.32 x 10^4</td>
<td>ND</td>
<td>6.0 x 10^4</td>
<td>ND</td>
</tr>
<tr>
<td>Total Coli, MPN/100ml</td>
<td>8.9 x 10^4</td>
<td>3</td>
<td>2.3 x 10^4</td>
<td>1</td>
</tr>
<tr>
<td>Total Aerobic Count, CFU/ml</td>
<td>7.13 x 10^5</td>
<td>7</td>
<td>6.07 x 10^4</td>
<td>5</td>
</tr>
<tr>
<td>SARS CoV2</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>E Coli, MPN/100ml</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Total Coli, MPN/100ml</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total Aerobic Count, CFU/ml</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>SARS CoV2</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
</tbody>
</table>
### Micropollutant Characteristics (μg/L)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>STP Inlet</th>
<th>Direct TADOX®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caffeine (CFF)</td>
<td>2.34</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Naproxen (NPX)</td>
<td>1.32</td>
<td>0.11</td>
</tr>
<tr>
<td>Bisphenol A (BPA)</td>
<td>0.42</td>
<td>0.09</td>
</tr>
<tr>
<td>Sulfamethoxazole (SMX)</td>
<td>0.18</td>
<td>0.06</td>
</tr>
<tr>
<td>Acetaminophen (ACN)</td>
<td>12.40</td>
<td>0.19</td>
</tr>
<tr>
<td>Ibuprofen (IBU)</td>
<td>34.50</td>
<td>0.71</td>
</tr>
<tr>
<td>Diclofenac (DCF)</td>
<td>91.23</td>
<td>1.20</td>
</tr>
</tbody>
</table>

### Current Conventional Treatment

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>24 h</th>
<th>3 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caffeine (CFF)</td>
<td>0.83</td>
<td>0.07</td>
</tr>
<tr>
<td>Naproxen (NPX)</td>
<td>0.78</td>
<td>0.08</td>
</tr>
<tr>
<td>Bisphenol A (BPA)</td>
<td>0.324</td>
<td>0.05</td>
</tr>
<tr>
<td>Sulfamethoxazole (SMX)</td>
<td>0.17</td>
<td>ND</td>
</tr>
<tr>
<td>Acetaminophen (ACN)</td>
<td>11.20</td>
<td>0.23</td>
</tr>
<tr>
<td>Ibuprofen (IBU)</td>
<td>28.10</td>
<td>0.63</td>
</tr>
<tr>
<td>Diclofenac (DCF)</td>
<td>83.20</td>
<td>0.98</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENT

- IWA Water Reuse Specialist Group
- National Mission for Clean Ganga (NMCG), MoJS, Govt. of India
- DST-Water Mission, Water Technology Initiative (WTI), Ministry of Science & Technology, Govt. of India
- Chennai Metropolitan Water Supply & Sewerage Board, Chennai
- VA Tech Wabag, Chennai
- Balkrishna Industries (BKT), Bhuj, Gujarat
- Surat Municipal Corporation, Surat
- Indian Oil Corporation Ltd. (IOCL), Mathura
- All other partners and funders
INDUSTRIAL WASTEWATER RECLAMATION, WINDHOEK NAMIBIA

JAMES VILLET
UJAMS WASTEWATER TREATMENT COMPANY. WINDHOEK, NAMIBIA

inspiring change
UJAMS WATER RECLAMATION PLANT

- Operated by Ujams Wastewater Treatment Company (UWTC) for a period of 21 years according to the BOOT contract signed with City of Windhoek (PPP)
- Commercial operation since 14th November 2014
- Design Treatment Capacity of 5.2 ML/day
- Designed to receive wastewater from Windhoek’s Northern & LaFrenz Industrial Areas
- Waste Producers: Meatco (abattoir), Namibia Breweries Ltd (brewery), Nakara (tannery), Namibia Beverages (Coca Cola)
- Designed for operation up to the year 2035, Ujams employs the use of a diversion valve to channel municipal waste from the Klein Windhoek and Eros residential areas to meet design treatment capacities at present.
FINE SCREEN & GRIT PROCESS

Fine Screen
- 5mm Bar spacing
- Differential Level Cleaning
- Compactor to remove excess water

BOOT contract specifications:
- 25% Dry Solids

Plant Achievement:
- Average 55% DS for period 2014 to date.

Grit Removal
- 650m³/h circular flow chamber
- Mixer with scraper blades
- Grit slurry pumped to classifier
- Cleaned Grit conveyed into skip

BOOT contract specifications:
- 25% Dry Solids

Plant Achievement:
- Average 80% DS for period 2014 to date.
DWBT & FINE SIEVE PROCESS

DWBT
- 1225 m³ volume, 3-4 hours retention time
- 2 x Mixers and 1 x submersible aerator
- pH stabilisation – HCl and NaOH dosing
- Cl₂ neutralisation – Sodium Metabisulphite

Plant Loading Profile:
- COD: 1500 - 4500 mg/l
- NH4: 60-120 mg/l
- TKN: 100 – 175 mg/l
- TP: 65 – 155 mg/l
- PO4-P: 25 – 55 mg/l

Fine Sieve
- Texture Mesh size: Fine Sieve – 500 µm
- CIPs with KOH solution to remove FOG

BOOT contract specifications:
- 25% Dry Solids

Plant Achievement:
- Average 27% DS for period 2014 to date.
BIOLOGICAL & MBR PROCESS

Biological
- 2 trains in parallel operation
- Denitrification chambers with mixers
- Nitrification chambers with fine bubble dome diffusers
- Sludge Retention Time design – 12 days. Typical SRT 8-10 days
- Aeration achieve 1.0 mg/l O₂

MBR
- 4 trains Zeeweed 500D membranes
- MCs - weekly per MBR train. NaOCl and Citric Acid
- 12m filtration, 60s relaxation, 45s backflush per 5 cycles of filtration
- 2 x RC’s conducted annually.

Plant Achievement:
- 200 – 300 lm²hbar
UV DISINFECTION & CWST PROCESS

UV
- Second microbiological barrier.
- CIPs with citric acid every 3 months
- BOOT contract specifications
  - Faecal coliforms < 200 CFU/ml

Plant Achievement:
- Faecal Coliforms <1 CFU/100ml
- Somatic Coliphages <1PFU/100ml

CWST
- Effluent discharge - Klein Windhoek river.
- Supporting the rehabilitation of the Upper Swakoppoort River Basin System.
- Effluent quality meets the BOOT contract specifications > 99.0% of the operational period.
- Plant production average at 92% of design capacity from 2014 to date.
PERMEATE & MBR PERFORMANCE

Permeate Quality Profile:

COD: 40-50 mg/l
BOD5 < 2 mg/l
NH4 0.1-0.5 mg/l
TKN 1-3 mg/l
TP 0.2-0.5 mg/l
PO4-P 0.1-0.3 mg/l

MBR Performance Profile: lm²hbar

2014: 400
2015: 373
2016: 342
2017: 327
2018: 314
2019: 297
2020: 284
2021: 271
PERMEATE POTENTIAL REUSE OPTIONS

- Planned Eros Golf Course and existing Windhoek Golf Course
- Dust Suppression - A1 dual carriage highway construction
- Private use with Gantry installation
- Dobra Informal Settlement use of flowing water
- Informal Farming water reuse for Cattle and Goats and RO system for vegetable production
- Mining operations, Mittel and Lodestone Mines
- Formal agriculture reuse
UWRP PHASE 2 POSSIBILITY

- Increasing plant capacity- 6250 m$^3$/day.
- Biogas production through anaerobic digestion of sludge with Co-substrates from identified industries.
- Produce 100% of power required on site, daily power demand, 7-8 MWh/day.
- Solar drying installation will receive dewatered stabilized sludge
- Secondary usage of stabilized dried sludge. Filler material for construction.
- Plant could become a net zero CO$_2$ emitter in future.
WATER RECLAMATION TO INDUSTRIAL USER

MR. VARANON LAOSUWAN
WHA UTILITIES & POWER PCL, THAILAND
ABOUT WHAUP

▪ WHAUP is the Flagship Company in Utilities and Power Business of WHA Group

**Logistics**
- #1 Logistics developers, with more than 2.5 million sqm under owned and managed
- Built-to-Suit (BTS): Providing the premium and world-class logistic facilities and factories for lease that match requirements in terms of location, design, and expansion of clients’ businesses
- Warehouse Farm: Combination of Built-to-Suit and Ready-Built Projects in the same strategic location.
- Built-to-Own (BTO): Warehouse or factory customized to client’s special needs then transfer the asset to the client
- Potential geographical expansion in cross-border provinces and overseas investment

**Industrial Development**
- #1 Industrial Estate Developer
- 12 Industrial Estates in Thailand’s and Vietnam’s most strategic industrial locations
- Ample Land stock – Net developed/to develop industrial land in Thailand approx. 7,700 in existing strategic industrial estates and over net 3,500 rai to develop in the 3 upcoming industrial estates plus another commercial land approx. 2,700 rai
- WHA Industrial Zone - Nghe An Phase1 in Vietnam, covering a gross area of 145 ha or 900 rai, is now completed. 56% of the sellable land has been leased. For Phase2 of WHA Industrial Zone -Nghe An, covering 355 Ha or 2,200 rai, will start construction in early 2022
- Ready-Built factory & warehouse in IEs and logistic park
- Potential geographical expansion in cross-border provinces and overseas investment

**Utilities & Power**
- Exclusive utilities provider in the industrial estates with high margin products and steady growth
- Active power investor with strategic partnership with reputable partners.
- 135 mm$^3$ utility sales & management volume in Thailand and Vietnam in 2021
- 607 Operational Equity MW* and growing to 642 Equity MW by 2022 from projects under construction and in pipeline.

* As of 31 December 2021

**Digital Platform**
- To be one-stop service for Data Center developer and provider by way of business collaboration with reputable partners
- Be part of the Government Initiative to promote digital economy
ABOUT WHAUP

▪ Business Overview

Utilities Business

Sole provider of utilities to manufacturers/ factories in WHA ID’s Industrial Estates with a concrete plan to capture increasing demand from heavy users and expand outside i.e. other IEs, non-IE area and international

- Raw Water
- Industrial Water
  - Process water
  - Clarified water
- Demineralized Water
- Wastewater Treatment
- Reclaimed Water

Power Business

Active power investor with strategic partnership with leading Thai and international power companies

- Conventional
- Industrial Waste to Energy
- Renewable

Raw Water

- Natural Gas

Water Sale and Management Volume

Water Sale and Management Volume

- 110 million m³
- 114 million m³
- 135 million m³

2019
2020
2021

Installed Equity MW under Operation

- 559 MWeq
- 590 MWeq
- 607 MWeq

* Data as of Q4/2021
ABOUT WHAUP

Business Overview - Vietnam

- **WHA Nghe An Industrial Zone 1**
  (100% Shareholding equity)
  - Increasing water distribution volume and utilization of wastewater treatment capability from the commissioning of customers’ plants

- **Cua Lo Water Plant**
  (47% Shareholding equity)
  - Expanding capacity to accommodate the expanding demand from industrialization and urbanization

- **Duong River Surface Water Treatment Plant**
  (34% Shareholding equity)
  - Increasing customers base and water supply coverage areas to nearby provinces (Bac Ninh, Hung Yen)

- **WHA Nghe An Industrial Zone 1**
  - 110 Million m³/year Water Distribution Capacity
  - Tenants occupy >50% of leasable area

- **Hanoi**
  - 4.4 Million m³/year Water Distribution Capacity

- **Bac Ninh**
  - 4.7 Million m³/year Water Distribution Capacity

- **4.7 Million m³/year**

- **Actively exploring for greenfield utilities project and M&A opportunities in Vietnam**
UTILITIES BUSINESS IN THAILAND

- WHAUP provides utilities services to 11 operating WHA Industrial Estates plus developing Zones (SIL Phase 2, IER and Vietnam) in the future.

- Wastewater Treatment Plant
  - System: Constructed Wetlands
  - WHA ESIE1
    - Capacity: 18,200 m³/day
  - Water Treatment Plant
    - System: Hydro Ripple
    - WHA ESIE1
      - Capacity: 54,000 m³/day
    - WHA CIE2
      - Capacity: 12,000 m³/day
    - WHA ESIE2
      - Capacity: 6,000 m³/day

- Wastewater Treatment Plant
  - System: Aerated Lagoon
  - WHA CIE2
    - Capacity: 1,600 m³/day
  - WHA ESIE2
    - Capacity: 10,000 m³/day
  - Water Treatment Plant
    - System: Hydro Ripple
    - WHA CIE2
      - Capacity: 6,000 m³/day
WHAUP provides utilities services to 11 operating WHA Industrial Estates plus developing Zones (SIL Phase 2, IER and Vietnam) in the future.
WHAUP WATER & WASTEWATER INNOVATION TIMELINE

The collaboration with AIT regarding the state of the art wastewater treatment system “Vertical Flow Constructed Wetland: VFCW”

- **2000**: The first VFCW plant has been constructed in ESIE (Rayong) as the first large scale constructed wetland in Thailand which also proven to treat wastewater in industrial estate
- **2001**: The first VFCW plant was introduced to ESIE (Rayong) in order to service the “second grade water” to the manufacturer
- **2015**: At WHA SIL, the first Hybrid RBC (Rotating Biological Contractor) has been implemented to improve the efficiency of the wastewater treatment system
- **2016**: WHA initiated the corporate CSR: Clean Water for Planet in order to integrate group’s expertise and innovation on water & wastewater to others
- **2016**: The first 7,500 cmd of Wastewater Reclamation plant using Submerged UF and RO has been constructed and then COD in the next year
- **2017**: WHAUP’s DRW “The Real Sustainable Resource for Future Development” has been awarded in 2021 SET Innovation Company Award
- **2019**: Demineralized Reclamation Water (DRW) has been introduced and start service to the Power plant in WHA EIE
- **2019**: WHA initiated the corporate CSR: Clean Water for Planet in order to integrate group’s expertise and innovation on water & wastewater to others
- **2021**: Inspired change

The first Wastewater recycle plant was introduced to ESIE (Rayong) in order to service the “second grade water” to the manufacturer.

- **1997**: The largest industrial central wastewater treatment plant by Activated Sludge (AS) – 60,000 cmd at WHA EIE
- **2019 - 2021**
CONCEPT OF WHAUP’S SUSTAINABLE INNOVATION

Sustainable Water Resource Management

Circular Economy

Innovative Corporate Culture
CONCEPT OF WHAUP’S SUSTAINABLE INNOVATION

A. Conventional Water Management

- Reservoir
  - Raw water
- Central WTP
- Industrial Users
  - WHAUP’s Demineralized Plant
  - Reclamation Plant
  - RO Water
- Central WWTP
- Environment

- Pain points:
  - No space to expand utilities area
  - Cannot focus on the core business

B. Change to the Sustainable Water Resource Management

- Reservoir
  - Raw water
- Central WTP
- Industrial Users
  - WHAUP’s Demineralized Plant
  - Reclamation Plant
  - RO Water
- Central WWTP
- Environment

- Strong points:
  - Better water quality
  - Lower cost
  - Environmental-friendly method

- Invested by Government
- Conflict of users (Industrial vs Domestic)
- Drought Situation
CONCEPT OF WHAUP’S SUSTAINABLE INNOVATION

Change to the Sustainable Water Resource Management

Wastewater Treatment Plant
Activated Sludge Process

Feed in
treated water

Industrial Users

Demineralized Plant Capacity 12,000 cmd

8,400 cmd

Mixed Bed Polisher
final polishing done by Cation and Anion to remove remaining ions in water prior to use

Demin water storage tank
Total Volume: 400 cu.m.

Mixed Bed Unit
50/50 mixture of Cation and Anion resin combined in ion-exchange column

Reclamation Plant Capacity 25,000 cmd

UF Membrane Unit
To reduce remaining turbidity in water
- Membrane Type: Submerged
- Filtration mode: Outside-in
- Operating Flux: 52 LMH
- Recovery rate: 94%

RO Unit
To reduce total dissolved solids (TDS)
- Flux rate: 15.7 LMH
- Production capacity: 25,000 m3/d
- System recovery rate: 66%
- Projected salt rejection: ≥ 95%
WATER RECLAMATION

- WHA EIE (Map Ta Phut): Total Water Solutions

- Water Reclamation Plant: Capacity 25,000 m³/day
- Water Demineralized Plant: Capacity 12,000 m³/day
- Water Treatment Plant: Capacity 98,400 m³/day
  System: Hydro Ripple
- Central Wastewater Treatment Plant: Capacity 60,000 m³/day
  System: Activated Sludge
- Water Reclamation Plant: Capacity 25,000 m³/day
- Water Demineralized Plant: Capacity 12,000 m³/day
WATER RECLAMATION

Basic System Flow diagram of Water Reclamation System

- WHA EIE Wastewater Treatment Plant Capacity 60,000 m³/day
- Water Reclamation Plant Capacity 25,000 m³/day
- Industrial Users
- Feed in Treated Water
- UF Feed Pumps
- RO Tank
- RO Membrane Unit
- UF Tank
- UF Membrane Unit

“Reclaimed water” High Quality Industrial water to Factories

Wastewater Treatment Plant Activated Sludge Process

Effluent Tank
WATER RECLAMATION

- Water Reclamation to Industrial User

Concept is the solution to enhance the proven water technologies and expertise in water businesses of WHAUP

**HIGHER QUALITY AT LOWER PRICE**: USER enjoy the higher quality of industrial water at the lower price compared to existing provider during the contractual period.

**CONCENTRATE ON CORE BUSINESS**: Because the product is RO quality, in general no need for further treatment works, give USER more time to strengthen and focus on core business process and mission.

**ENVIRONMENTAL IMPACT MITIGATION**: Implementing this solution will minimize the impact to environment and social significantly as the wastewater to be discharged to public is reduced substantially. USER can claim the use of reclaimed water as one of its effort in taking care environment & water resources.

**SECURE FOR FUTURE RESOURCES**: Particularly in EEC & High consumption area, water resources is limited, water reclamation will be the solution to secure the sustainability development for industrial users.
WATER RECLAMATION TO INDUSTRIAL USER

- Thailand Largest Water Reclamation Plant in WHA EIE (Map Ta Phut)

- Demineralized Water for GPSC
WATER RECLAMATION TO INDUSTRIAL USER

- Premium Clarified Water from Water Reclamation Plant
  Gulf VTP and Gulf TS1&2

  Location: ESIE (Rayong)
  Capacity: 5,200 m³/day
  System: RO Unit + UF Membrane Unit
  Product type: Premium Clarified Water

Gulf TS3&4 (Under construction)

Location: WHA ESIE1
Capacity: 3,800 m³/day
System: RO Unit + UF Membrane Unit
Product type: Premium Clarified Water
WATER RECLAMATION TO INDUSTRIAL USER

- Asia Industrial Estate Water Reclamation and Demineralized Plant (Under construction)

Location: Asia industrial estate
Capacity: 2,200 m3/day (expanded to 7,500 m3/day)
System: RO Unit + Mixed Bed Unit
Product type: Demineralized Water
Thank You
Participate in the poll and share your answer with us!
UPCOMING WEBINARS

Stay tuned for our next webinars:

Monitoring, Modelling and Mitigating Nitrous Oxide

Process Emissions - Masterclass 2

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