Industrial Wastewater Management in Urban Areas

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- About 38,254 million litres per day (mld) of wastewater is generated in urban centres comprising Class I cities and Class II towns.
- The municipal wastewater treatment capacity developed so far is about 11,787 mld, that is about 31 per cent of wastewater generation in these two classes of urban centres.
- The existing treatment capacity is just 21 per cent of the present sewage generation.

*(2011 Statistics)*
Industrial Wastewater in Urban Areas

• About 22,900 MLD of domestic wastewater is generated from urban centres while 13,500 MLD of industrial wastewater is generated.

• The treatment capacity available for domestic wastewater is only for 5,900 MLD, against 8,000 MLD of industrial wastewater.

• Thus, there is a huge gap (and therefore opportunity) in treatment of domestic wastewater.
• Projected municipal and domestic water demand will is expected to double by 2030, to 108 billion m³ (7% of total demand), while projected demand from industry will quadruple to 196 billion m³ (13%), pushing overall demand growth close to 3% per annum.
Figure 5: Industrial water demand in India

Source: India Infrastructure Report, 2011, Chapter 18
Water Stress

• With a growing population, the per capita availability of water has dropped from 1,816 cubic metres in 2001 to 1,545 cubic metres in 2011.

• The average per capita supply to these households is well below the recommended 135 litres per day in many cities.

• India is expected to add approximately 404 million new urban dwellers between 2015 and 2050.

• This rapid urban growth will be linked with higher industrial output and greater energy demand.
Decentralized and Centralized Treatment Strategy

- Decentralized strategy reduces transportation costs with some disadvantage of economies of scale
- Decentralized water treatment systems (DEWATS) with aerobic treatment are actively adopted in India
- Due to the small-scale size of their plants, however DEWATS can be successfully employed in the peri-urban areas
- At larger scale application there is a wide scope for utilization of advanced technologies like the Membrane Bioreactors (MBR) apart from established technologies such as Activated Sludge and Variants
Importance of Pretreatment prior to Sewer Discharge

- Some basic treatment required for protection of the conveyance system
  - pH 5.5 to 9
  - Temperature less than 45
  - O&G less than 20 mg/l
Meeting Industrial Water Demand from Sewage Reclamation

• In many cities, reclaimed water could be cheaper than standard piped water supplied by the utility.

• With industrial tariffs trending upwards, utilities are facing increasing pressure to recover costs, and reclaimed water will be increasingly competitively priced.

• Industries are usually clustered in the outskirts of cities so that distribution of reclaimed water may be comparatively inexpensive.

• Reclaimed water is a reliable This forces industries to rely on private water suppliers.

• In some areas, bans on groundwater use by industries are being introduced.
Figure 1: Schema of the industrial reuse of reclaimed water in a city.
Figure 2: Schema of the municipal wastewater reuse
Indian standards (IS) for quality tolerances for a few industrial uses are

- IS: 201 Water quality tolerances for the textile industry
- IS: 2724 Water quality tolerances for the pulp and paper industry
- IS: 3957 Water quality tolerances for ice manufacture
- IS: 4251 Water quality tolerances for the processed food industry
- IS: 4700 Water quality tolerances for the fermentation industry
Policies

- The National Urban Sanitation Policy (NUSP) of 2008 addresses reuse of wastewater as an important factor in helping to meet the environmental targets of the city.

- The NUSP recommends the Service Level Benchmarks defined by the Ministry of Urban Development (MoUD) and recommends a minimum of 20% reuse of wastewater in every city.

- The National Water Policy of 2012 encourages recycling and reuse of water after treatment to specified standards as well as preferential tariffs that incentivize treated wastewater over freshwater. However, there are no specifics on legal frameworks or implementation mechanisms.
**Figure 3: Government scheme to support urban wastewater reuse**

**Step 1:** Study reuse potential and scope at the city level and prepare ‘city wastewater reuse plan’

**Step 2:** Define quality standards for STW and industrial grade treated wastewater

**Step 3:** Empanel technology providers for implementation of reuse projects

**Step 4:** Undertake feasibility study for identified reuse projects

**Step 5:** Develop capital incentive schemes to support reuse projects

**Step 6:** Arrange loan-guarantees for debt financing from International Development Agencies (IDA)

**Step 7:** Prepare draft contract documents and templates for engaging private developers

**Step 8:** Support state governments and urban local bodies in implementation
Singapore’s NEWater4 Reuse of treated wastewater

- Singapore imports water from Malaysia and has very limited sources of water within its boundaries.

- Since 1958, the country has consistently sought to improve its water security by improving rainwater harvesting and through source diversification. Reuse of treated wastewater is one of the four ‘national taps’, alongside desalination, rainfall and imports.

- NEWater contributed towards one-third of the water supplied in Singapore
NEWater plants use an advanced tertiary treatment process that has three stages — microfiltration/ultrafiltration, reverse osmosis, and ultraviolet treatment.

Reuse approach: NEWater is directly supplied to industries to meet the nonpotable water demand, which accounts for 55% of the total water demand. Only a small proportion of NEWater is used to augment freshwater in reservoirs for indirect potable reuse.

By 2060, it is estimated that approximately 70% of water demand in Singapore will be non-domestic, and NEWater capacity would be expanded to provide for 55% of total water demand.
The cost of producing NEWater is in the range of 0.30–0.50 SGD per cubic metre, lower than the cost of producing desalinated water (0.50–1.00 SGD per cubic metre).

The tariff for NEWater is set at 1.9 SGD per cubic metre and reflects the full life cycle cost of producing and supplying NEWater.

There are four NEWater plants in Singapore with a combined production capacity of 531 million litres per day (MLD). A further 227 MLD is expected to come online by the end of 2016. Two plants are operated by the Public Utility Board (PUB), the public water utility of Singapore, while the other two are operated by private companies under the Design Build Own Operate (DBOO) model.
Since 2008, Beijing has actively invested in water reuse projects and, as a result, reclaimed water accounted for approximately 22% of total water supplied in 2014.

Beijing has developed a wastewater reuse network that includes many treatment plants with capacities ranging from 60 kilolitres per day (KLD) to 60 MLD. The larger plants are owned and operated by the local government.

Beijing has also taken the PPP route to develop reuse projects. However, given that the water tariffs are very low, these PPPs cannot be financially viable, but for the generous subsidies and annuity payment that the local government offers.
Reuse of wastewater is not new to India but then there are challenges

• Chennai Petroleum Corporation Ltd (CPCL) built a wastewater reuse plant in 1991. However, the idea did not garner mainstream appeal for several reasons:

• There is no clear policy environment to encourage and support reuse projects.

• With low sewerage network coverage and insufficient Sewage Treatment Plant capacity, there hasn’t been much Secondary Treated Water available for reuse.

• STW is being used for agriculture in many places. Redirecting STW for industrial reuse may face opposition from the public.

• Most cities apply a differential tariff for domestic and industrial water consumers, with the industrial tariff significantly higher than the domestic tariff. By switching to reclaimed water, utilities will have to forego some of this additional revenue.

• Surplus freshwater availability in some smaller cities and towns has made utilities complacent and over dependent on freshwater sources.
The Government of India has emphasised reuse of reclaimed water in many urban development schemes such as Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Swachh Bharat Mission, Smart Cities Mission and the Namami Gange programme.

Sewerage coverage and treatment capacity are consistently improving across urban India. The cost of wastewater reuse technologies is falling. As a result, reuse projects have been undertaken in some cities such as Nagpur, Surat and Visakhapatnam. However, some of these projects are still facing challenges.
Examples

- Surat Municipal Corporation (SMC) built a 40 MLD reuse plant in 2014 to supply reclaimed water to Pandesara Industrial Estate.

- Chennai Metro Water Supply and Sanitation Board (CMWSSB) awarded a PPP-based reuse project contract in 2016 to develop 45 MLD reuse capacity on the design, build, and operate (DBO) model to supply non-potable water to industries.

- Bengaluru’s water utility has built a 10 MLD tertiary treatment plant at Yellahanka that supplies reclaimed water to Bengaluru International airport.

- Maharashtra Generation Company (MAHAGENCO) and Nagpur Municipal Corporation (NMC) have jointly invested in a reuse project where treated water from an STP is further treated and used as cooling water.
How much the industry pays for water?

• The conventional sources of water for industries include municipal water supply, private tankers, and direct extraction from freshwater sources. The least cost option is direct groundwater extraction which is regulated in most cities. Thus, the most reliable option for industries is municipal water supplied by utilities.

• The industrial water tariff in most metropolitan cities and industrial towns range from 0.29 USD per kilo litre (KL) to 2.21 USD per KL. The weighted average of industrial water tariff is approximately 0.68 USD per KL

• In times of water scarcity, when municipal water is in short supply, industries resort to buying water from private water tankers which are priced at 0.83 USD per KL and above
Figure 6: Water tariff in major Indian cities

<table>
<thead>
<tr>
<th>City</th>
<th>Water Tariff (INR/ KL)</th>
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<tbody>
<tr>
<td>Madurai</td>
<td>60</td>
</tr>
<tr>
<td>Coimbatore</td>
<td>60</td>
</tr>
<tr>
<td>Chennai</td>
<td>60</td>
</tr>
<tr>
<td>Jaipur</td>
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<tr>
<td>Pune</td>
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<td>Mumbai</td>
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<tr>
<td>Bengaluru</td>
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<td>Vadodara</td>
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<td>Surat</td>
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<tr>
<td>Delhi</td>
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<tr>
<td>Visakhapatnam</td>
<td>36</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>120</td>
</tr>
</tbody>
</table>
Figure 7: Cost of producing treated wastewater

Source: Inputs from Eco Protection Engineers Pvt. Ltd, Chennai.
Reuse projects must study the market demand profile and choose a specific grade of water that will provide maximum financial returns. In this regard, Grade III water produced after RO stage seems to be the most feasible option for reuse systems.

Conveyance can be bundled with treatment in reuse projects, but the risk involved in building and operating conveyance infrastructure is steep. Therefore, this conveyance cost has to be subsidised either upfront or through annuity payments to the private operator.

Reuse project contracts could be bundled with STP O&M contracts.
• This model assumes that the utility shall enter into a buy-back agreement with the private developer and shall offtake the predefined quantity of reclaimed water from the tertiary treatment plant (TTP) at predefined quality levels. The model excludes the end user and has only two key stakeholders

• 1. Water utility/ULB: Provides land either within existing STP or outside for installation of tertiary treatment modules. The utility is the enforcer of the contract terms and also ensures quality compliance and supervises operations. The utility supplies STW/sewage, as the case may be, and provides full buy-back guarantee for reclaimed water produced by the developer.

• 2. Private sector developer: Invests in building treatment and conveyance infrastructure to the utility’s water storage reservoir, and operates the same for a fixed term, after which it transfers the assets to the utility. The ideal private developer is a technology provider who also has civil construction and O&M capabilities.
Figure 12: Project structure of the RUB model

Project SPV
- Supply of treated water at defined quality
  - Annuity and Volumetric fee
  - Land + supply of sewage
- Investment in treatment facilities and conveyance + managing O&M
  - Technology company
  - Civil contractor
  - Private developer
  - O&M company

Utility/water supply company
- Immediate payment for quantum of water taken
  - Long-term supply contract
  - Monthly/quarterly Payment for use of water
  - On-demand water

Water supply contractor
- Industrial association
  - And/or
  - Large industrial unit
    - And/or
    - State Industrial Authority
- Construction companies
- Car service companies/garages
- Bulk consumers for non-potable purpose

Dividends
Three party fixed price (TPFP) model

- This model is designed to use STW from existing STPs (owned by utilities) and would treat it to produce industry grade water for a single entity, which could be one industry or an industrial zone. These three players—utility, developer, and industrial entity—enter simultaneously into long-term contracts, assuring supply of STW and reclaimed water at predetermined rates and quality levels.
The Three Stakeholders

1. Water utility/ULB: Provides land either within existing STP or outside for installation of tertiary treatment modules. The utility is the enforcer of the contract terms and will also ensure quality compliance and oversee operations. The utility makes a net annuity payment to the private developer to ensure a guaranteed minimum revenue for the developer. Utility also has rights to levy penalties on the private developer for delays, quality non-compliance, and breach of contract.

2. Private sector developer: Invests in building treatment and conveyance infrastructure to the customer gate, and operates the same for a fixed period, after which it transfers the assets to the utility. The developer could also be given responsibility for the operation of the STP

3. Industrial bulk consumer: A single entity with large water requirement that provides assured purchase guarantee for reclaimed water at a predefined quality, quantity, and tariff. The private developer would study the quality of STW from existing STP and would choose the most appropriate technology mix for the treatment plant based on the need of the bulk consumer. A Special Purpose Vehicle (SPV), fully owned by the private developer, will be established. The utility will provide land for reuse plant and transfer operational responsibility to the SPV. The private developer will operate the TTRO plant and will supply the agreed quantity of treated water to the bulk consumer, and will also sell additional treated water available in bulk or retail to other consumers. After the end of the term period, the SPV shall transfer all assets back to the utility.
Figure 9: Project structure of the TPFP model

- Utility/water supply company
  - Net annuity payment with min guarantee
  - Land for STP and supply of sewage
  - Technology company
  - Civil contractor
  - Private developer
  - O&M company
  - Equity investment in treatment facilities + conveyance + managing O&M of STP & TTP

- Project SPV
  - Volumetric payment for water consumed
  - Long-term supply contract
  - Dividends

- Immediate payment for quantum of water taken
  - Industrial association
    - And/or
    - Large industrial unit
    - And/or
    - State Industrial Authority

- Water supply contractor
  - Construction companies
  - Car service companies/garages
  - Bulk consumers for non-potable purpose
Figure 8: Schema of the TFPF model

1. Water utility/municipality
   1. Existing STP
   2. Additional module for treating water to desired quality
   3. Private sector investment

2. On-demand water for other uses
   Min?
   Min guaranteed off take by large industrial consumer

3. Large industrial consumer
**Figure 10:** Risk profile of the TPFM model

**Advantages and challenges:** In addition to the benefits of reuse discussed earlier, this project structure offers specific advantages to all stakeholders involved:
This model is designed such that the end user industry will purchase STW from utilities at a defined cost and will invest in conveyance mains. The end user industry will then hire the services of a technology provider to build and operate the reuse plant for its internal consumption. There are two main stakeholders in this model.

1. Water utility/ULB: Supplies STW from existing STPs to the end user industry and charges a minimal volumetric charge for the STW supplied at the end user point.

2. Private sector developer: Invests in conveyance mains to bring STW to its premises and in TTP to produce industry grade water for its own consumption.

The end user industry will engage one or more technology firms through performance-based service contracts for the construction and operation of the conveyance mains and treatment plants. The design risk here will lie with the end user company that will have to undertake a detailed study of its water demand and technology options available.
Thank you