Indian Case Study on ZLD - The Tirupur Textile cluster experience

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I. Sajid Hussain, Chief Operating Officer
Tamilnadu Water Investment Company Limited.
www.twic.co.in
sajidhussain@twic.co.in
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ZLD</td>
<td>Zero Liquid Discharge</td>
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<tr>
<td>CETP</td>
<td>Common Effluent Treatment Plant</td>
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<tr>
<td>TWIC</td>
<td>Tamilnadu Water Investment Company Limited</td>
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<tr>
<td>GoTN</td>
<td>Government of Tamilnadu</td>
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<tr>
<td>GoI</td>
<td>Government of India</td>
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<tr>
<td>O&amp;M</td>
<td>Operation &amp; Maintenance</td>
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<tr>
<td>ZWD</td>
<td>Zero Waste Disposal</td>
</tr>
<tr>
<td>TDS</td>
<td>Total Dissolved Solids</td>
</tr>
<tr>
<td>MLD</td>
<td>Million Litre per Day</td>
</tr>
<tr>
<td>MoEF</td>
<td>Ministry of Environment &amp; Forest</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>PMC</td>
<td>Project Management Consultant</td>
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<td>TNPCB</td>
<td>Tamilnadu Pollution Control Board</td>
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<tr>
<td>OCD</td>
<td>Optionally Convertible Debentures</td>
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<tr>
<td>MEE</td>
<td>Multiple Effect Evaporator</td>
</tr>
<tr>
<td>BDTRF</td>
<td>Brine Discharge Through Resin Filter</td>
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<tr>
<td>MVR</td>
<td>Mechanical Vapour Recompression</td>
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<tr>
<td>UF</td>
<td>Ultra Filtration</td>
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<tr>
<td>DST</td>
<td>Department of Science &amp; Technology</td>
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CONTENTS

- Section A : Introduction to TWIC
- Section B : Concept of ZLD
- Section C : Brief on Tirupur CETP’S
- Section D : Technical Challenges and how it was overcome.
Section E: Our Technical solution to the problem

Section F: Case Study of A Textile CETP - Arulpuram CETP

Section G: The Way Forward

Section H: Approach to ZLD

Section I: Conclusions
Section A: Introduction to TWIC
**Genesis**

- TWIC was formed to promote the first PPP in water Sector, namely the New Tirupur Water Project (185 MLD, 1000 Crore)

- Promoted by Infrastructure Leasing and Financial Services Limited (IL&FS) [54%] and Government of Tamil Nadu (GoTN) [46%]

- Over the last few years, TWIC has been in the forefront of a number of initiatives both in the urban water space as well management of industrial effluent
Focus Areas

Water Reuse:
- Industrial Effluent
- Sewage Reuse
- Desalination

Urban Water:
- Treatment Plants
- Urban Water Distribution
Life Cycle Approach to Projects

- Emphasis on Life Cycle Costs and Benefits (technology, O&M)
- Ability to structure and implement projects on a commercial basis

**Project Development**
- Technology Solution, Development & Design
- DPR Preparation
- Procurement Services

**Project Financing**
- Financial Close
- Investment
- Lending

**Project Implementation**
- Project Management
- Implementation Supervision
- Lenders Engineer

**Project O&M**
- Direct O&M
- Supervision
- Performance Audits
- Energy Audits
Section B: Concept of ZLD
Concept of ZLD

- ZLD – meaning zero discharge of wastewater from Industries.

- A ZLD system involves a range of advanced wastewater treatment technologies to recycle, recovery and re-use of the ‘treated’ wastewater and thereby ensure there is no discharge of wastewater to the environment.

- A typical ZLD system comprises of the following components:
  - Pre-treatment (Physico-chemical & Biological)
  - Reverse Osmosis (Membrane Processes)
  - Evaporator & Crystallizer (Thermal Processes)
Need for ZLD .. 1

- Most polluting industries such as Pharma, Pulp & Paper, Tanneries, Textile Dyeing, Chemicals, Power Plants etc generate wastewater with high salinity/TDS.

- Conventional ‘Physico-chemical-biological’ treatment does not remove salinity in the treated effluent. The TDS content is well above the statutory limit of 2100 mg/l.

- Discharge of saline but treated wastewater pollutes ground and surface waters.

- Several states in India including Tamilnadu are water stressed. Competing demands for water from agriculture and domestic use has limited industrial growth.
Need for ZLD .. 2

- TN has taken a lead on ZLD due to absence of fully flowing perennial river. Most rivers originate from neighboring states and water sharing is enmeshed in disputes. Several landmark pollution cases and court battles have hastened this, such as the Vellore and Tirupur court cases. Other states such as Gujarat and Karnataka also are now are considering ZLD.

- Location of industries in ‘Inland areas’ and issues related to sea discharge of ‘treated’ wastewater.

- High cost of water (> Rs. 40) and statutory regulations are prime drivers for ZLD.

- MAIN MOTIVATORS- Water Scarcity, water economics, regulatory pressure.
In the early seventies, increased salinity of the United States Colorado River, due to Power Plant discharges, created the regulatory context to push for ZLD in the US.

For new industrial projects, where gaining an approval for a discharge agreement might traditionally take five years, with ZLD it could be a matter of 12 months. As a result, ZLD technology effectively evolved in the US and later grew globally.

In Germany, stringent regulation in the 1980’s resulted in ZLD systems for Coal Fired Power Plants.

(Source GWI)
In China, a chemical company Yunnan Yuntianhua (YTH Group) for a Coal-to-Chemicals plant in an environmentally sensitive location, one of the largest grasslands in China (inner Mongolia) has gone in for ZLD. This is paving the way for more such projects in the region.

ZLD system for the tanning sector in Lorca, Spain is based on membrane techniques, designed to lower the water salinity to levels suitable for re-use at an agricultural and industrial level.
Benefits of ZLD

- Installing ZLD technology is beneficial for the plant’s water management; encouraging close monitoring of water usage, avoiding wastage and promotes recycling by conventional and far less expensive solutions.

- High operating costs can be justified by high recovery of water (>90-95%) and recovering of several by products from the salt.

- A more sustainable growth of the industry while meeting most stringent regulatory norms.

- Possibility of use of sewage for recovery of water, for Industrial and municipal use, using ZLD technologies.

- Reduction in water demand from the Industry frees up water for Agriculture and Domestic demands.
Challenges in ZLD

- “Is the Holy Grail of Industrial wastewater Treatment...” Global Water Intelligence.

- ZLD results in generation of hazardous solid wastes creating disposal challenges- need to think of Zero Waste Disposal (ZWD) Plants. Generate products/ by-products out of the waste.

- Economic viability- cost and availability of water, regulatory pressure are the real driving force.

- High Carbon foot print- is this environmentally sustainable?

- High Operating cost and financial impact on the industry and its Regional/ National/Global competitiveness.

- Technology shortcomings.
Section C: Brief on Tirupur Textile CETP’s
Tirupur is a dry region with no perennial rivers.

Originally, economy was only rain fed agriculture.

Repeated failure of crops saw a shift to trade in cotton in 1960s.

During 1980s, production of low valued cotton hosiery items was started.

Today Tirupur hosiery and knit wear export contributes nearly 2% of total foreign exchange earnings of the country.
Brief History

- Based on the directions of the Madras High Court and TNPCB in 2005, the bleaching and dyeing units in Tirupur implemented CETPs and IETPs to meet the Zero Liquid Discharge (ZLD) norms.

- The broad technology adopted by the effluent treatment plants consists of a pre-treatment system followed by a water recovery system (using reverse osmosis) and the reject management system (based on evaporator).

- 450 units collectively have set up 20 CETPs while the balance 150 units have set up their own individual effluent treatment plants (IETPs). TWIC was engaged by 9 CETPs.

- The total investment in this treatment system is estimated to be Rs.800 crores (for 20 CETPs). This investment has been largely funded by the bleaching and dyeing units (20 to 30%) and the balance has been arranged through commercial banks as loans (70 to 80%).
Technical approvals for DPRs for the above CETPs were obtained either through Anna University, Madras or IIT, Madras as required by the TNPCB. Ministry of Environment and Forests (MoEF) was also obtained. TNPCB has also provided these CETPs with consent to establish (CTE) and consent to operate (CTO) certificates.

The Pre-treatment Section and R.O successfully commissioned and operated since October 2008 (>2 ½ yrs) in TWIC CETPs.

Evaporator commissioned after receipt of TNPCB CTO in Jan 2010. The evaporator which has been installed did not meet the desired requirements and consequently industries had been facing difficulty in operating the ZLD project to full capacity.
TWIC also developed alternate solution which would reduce load on the evaporator. These proposals had been submitted to TNPCB by the CETPs for approval.

In Oct 2010, GoTN/GoI sanctioned Rs 320 Cr as subsidy for the 20 CETPs. So far 50% of the amount has been disbursed.

In August 2010, a petition of contempt of court was filed in the Madras High Court in August 2010. While disposing of the case after various hearings, Madras High Court closed all the industries in Tirupur through the order of January 31, 2011.

The order stated that in case the industries have to reopen and conduct trial runs, they would need to satisfy the TNPCB and the court appointed committee of their readiness.

TWIC made a presentation to GoTN in June 2011 on re-opening of CETPs for demonstration of ZLD based on “brine reuse technology”. It was proposed to demonstrate this in one CETP for a 3 month period and thereafter on successful demo, implement the same in other CETPs. Required funding for modifications was also indicated. This was accepted by GoTN and necessary orders for demonstration at Arulpuram CETP and also funding for 20 CETPs was announced.
Tirupur Textile Effluent Management Project, Tirupur.. 1

- Project: TWIC has developed and established 9 Textile dyeing CETPs with capacities ranging from 3 MLD to 11 MLD (Combined Capacity 53 MLD) in Tirupur based on Zero Liquid Discharge. The major components are BIOT, RO, Evaporator and Pipeline.

- Project Cost: Rs 572 Crores

- TWIC Role: TWIC has supported the Client in the following areas,
  - Preparation of Detailed Project Report
  - Selection of Technology & Preparation of Project Specification
  - Design Engineering, Procurement of contractor
  - Arranging Finance for the project
  - Implementation Supervision
  - O&M for 15 yrs as Independent Operator as advised by GoTN.
Benefits of this Project:
The project for ZLD is perhaps the first of its kind in the world. Key benefits of the project are
- Recycling >98% of the water.
- Reuse of > 90% of the salt.
- Cleaning of the local environment

Current status
- TWIC has also developed an alternate technology called “Treated Brine Reuse Technology” which substantially reduces the dependence on the evaporators.
- Technology demonstration has enabled reopening of the dyeing units after closure by high court.
- This has been successfully demonstrated at Arulpuram CETP and is now being implement in the remaining 6 TWIC developed CETPs.
Tirupur Textile Effluent Management Project, Tirupur.. 3

- Pretreatment
- Biological Treatment
- Reverse Osmosis

- Untreated & Treated Effluent
- RO reject – before treatment
- RO reject – after treatment
- Lab trails using RO brine
O & M of Tirupur Textile CETP at Tirupur
# Funding Pattern of TWIC CETPs

<table>
<thead>
<tr>
<th>Means of Funding</th>
<th>Original Project Cost (Rs. in Crores)</th>
<th>Additional Project Cost (Rs. in Crores)</th>
<th>Total Cost (Rs. in Crores)</th>
<th>Overall %</th>
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<tr>
<td>GoI / GoTN</td>
<td>ASIDE</td>
<td>40.00</td>
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<td>GoI /GoTN Special Grant</td>
<td>168.52</td>
<td>307.52</td>
<td>53.74 %</td>
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<td></td>
<td>Interest free loan from GoTN</td>
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<tr>
<td>Industry</td>
<td>Promoters Contribution</td>
<td>63.29</td>
<td>114.58</td>
<td>20.02 %</td>
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<td>Loans</td>
<td>Loan from Bankers</td>
<td>126.80</td>
<td>126.80</td>
<td>22.16 %</td>
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<td>TWIC</td>
<td>TWIC OCD</td>
<td>23.29</td>
<td>23.29</td>
<td>4.07 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>421.87</strong></td>
<td><strong>150.29</strong></td>
<td><strong>572.19</strong></td>
<td><strong>100 %</strong></td>
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CETP Treatment Scheme

**Pre-treatment**
- Total Biological Oxidation

**Reverse Osmosis**
- R.O Permeate
- Recovered Water (RO Permeate + Evaporator Condensate)
- Reuse of water by Industries

**Aux**
- Condensate

**MVR Evaporator**
- Solar Pan
- Waste Salt
- Crystallizer (MEE)
- Crystallized Salt for Re-use by Industry
Unit Processes ..1

- **Storage & Homogenization Tank:**
  - Flow: Homogeneous & Constant Flow
  - HRT: 24 hrs
  - Type: Race track type
  - Mixing: Flow mixers & Flow jets
  - Power for mixing: 2.7 W/m³
    (based on tank volume)

- **Neutralization:**
  - HRT: 0.2 – 0.5 hrs
  - pH to be maintained: 7 – 8
BIOT:

- Type: Low loaded Activated Sludge Plant
- Aeration: Disc type Diffused Aeration
- HRT: 48 hrs
- F/M: 0.03 – 0.06
- MLSS: 3000 – 5000 mg/l
- Blower Type: Positive displacement
- Mixing: Flow mixers, banana leaf type
- DO : 2 – 3 mg/l
- Power requirements
  - Flow makers: 1.8 W/m³ (based on tank volume)
  - Blowers: 0.654 KW/m³ (based on inflow)

Secondary Clarifier:

- SOR: 0.5 m³/m²/hr
- HRT: 6 hrs
- Dimension: 30m dia x 3.5m SWD
Unit Processes ..3

- **Hypo Treatment System:**
  - HRT: 2 hrs min
  - Dosing: NaClO, H₂SO₄

**Filtration Section:**
- **Quartz Filtration:**
  - Type: Quartz
  - Filtration Velocity: 7 – 10 m/hr

- **Resin Filtration:**
  - Type: Strong Base Anion
  - Bead Size Range: 0.45 - 1.2 mm
  - Purpose: Removal of Colour & Organics
  - PUROLI TE A120S is a polystyrene, macro porous, weak base, tertiary amine, anion exchange resin

- **Softener Resin Filtration:**
  - Type: Weak Acid Cation
  - Purpose: Removal of Calcium and magnesium ions

\[
2 \text{RCOO} - \text{Na} + \text{M} (\text{HCO}_3) \rightarrow \text{RCOO M OOC R} + 2\text{H}_2\text{O} + 2\text{CO}_2 \\
2 \text{RCOO} - \text{Na} + \text{CaCl}_2 \rightarrow \text{RCOO Ca OOC R} + 2\text{NaCl}
\]
### Unit Processes

#### Ultra Filtration:
- SDI : < 3
- Dosing : NaOCl, H₂SO₄, SMBS
- Selection based on extensive piloting.

<table>
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<tr>
<th>Membrane</th>
<th>Hyflux/ GE</th>
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<tr>
<td>Hitech/ Inge/ Qua/ Norit</td>
<td>O/I operation</td>
</tr>
<tr>
<td>Type</td>
<td>Net Flux</td>
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<tr>
<td>I /O operation</td>
<td>&lt;40 LMH</td>
</tr>
<tr>
<td>Type</td>
<td>MWCO</td>
</tr>
<tr>
<td>I /O operation</td>
<td>10 - 200 KD</td>
</tr>
<tr>
<td>O/I operation</td>
<td>&lt;30 LMH</td>
</tr>
<tr>
<td>60-120 KD</td>
<td></td>
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</table>

#### Reverse Osmosis:
- Membrane : Filmtec/ Hydranautics
- Type : Polyamide membrane
- Stage : 4 Stage
- Flux : < 15 LMH, 85% recovery. Additional R.O stage planned for increasing recovery to 92%
Unit Processes ..5

- Brine Treatment:

- Reactor Clarifier:
  - Purpose: Resin & softener regenerate liquor treatment for softening and colour removal
  - Dosing: Lime, soda ash, Polyelectrolyte NaOCl, H₂SO₄
Mechanical Vapor Recompression (MVR-E):

Fig: MVR type Evaporator System installed in all CETPs

Steam Consumption: 0.026 Tons/cu.m
Multiple Effect Evaporator (MEE):

- Dosing: HCl / H$_2$SO$_4$, Defoamer, Antiscalents
- Steam Consumption (FFE & FCE): 0.48 ton / m$^3$
- Salt production: 27 tones/day (on 5.5 MLD feed Basis)
- Residue in Solar pan: 6 tones/day (On 5.5 MLD Feed Basis)
Adiabatic Chiller

- Type: Adiabatic Vacuum continuous Crystallizer
- Operating Temperature: 10 Deg C
- Steam: 950 Kgs/hr.
- Vacuum: 0.9 Kg/cm²
- Recovery: 40% (single pass) - 60% of Sulphates.
Centrifuge

- Type: Pusher Type basket centrifuge.
- Capacity: 2 T/hr
- Basket sieve size: 100 Micron
- Glauber’s salt: >98% Purity. T. Hardness: Nil
Section D: Technical Challenges and how it was overcome
Mechanical Vapour Recompression Type Evaporator (MVR-E)

Feed

Vacuum pump

Heat exchanger

Condensate pump

Recirculation pump

Condensate tank

To crystalliser section

Concentrate pump

MVR fan

55°C

55°C

57.5°C

180 mbar

200 mbar

ΔT = 2.5°C

57.5°C

200 mbar
Nature of the Problem in the Evaporator

- **Design Performance:**
  The Main MVR-Evaporators was designed to handle 15% of the R.O reject. The Auxiliary Evaporator is designed to handle 2% of the regenerate liquor from Softener and Decolourant Resin filters. The MVR-Evaporator is designed for an overall recovery of >87.5% as condensate. The remaining concentrate was to be evaporated in an MEE along with crystallization of salt.

- **Reasons for the Choice of MVR:**
  - Typically replaces 4 or 5 stage of MEE.
  - Polymeric Heat Exchangers not prone to corrosion and replaceable.
  - Lower O&M cost than MEE due to lower steam requirements.

Fig: MVR type Evaporator System installed in all CETPs
Nature of the Problem in the Evaporator

- Actual Performance of MVR:
  - MVR Feed at 80-85% of design
  - MVR Recovery at <70% (due to elevation in b.p resulting in lowering of \( \Delta T \)).
  - Reduced recovery resulted in lower TDS in the concentrate and higher volume, resulting in overloading of the downstream MEE/Crystallizer.
  - No glauber Salt crystallization. Reduced recovery in MVR required additional MEE stages and an Adiabatic Chiller to achieve desired feed volume, recovery and concentration to achieve crystallization.
  - Inability to handle BDTRF (decolorant and Softener resin regenerate) liquor due to choking of the polymeric heat exchangers due to higher hardness and organics.
  - Based on the above situation it was estimated that two streams of Seven effect Evaporators for MVR concentrate and BDTRF+Chiller Mother liquor will be required which will not only increase the capital cost by Rs. 10 Crores per MLD but also increase the operating cost to Rs. 300-350 per m3 of reject for evaporation and crystallization.
Other issues with Evaporator.. 1

- Use of the conventional Sodium Chloride based dyeing is problematic since crystallization of Chloride salt will produce a salt contaminated with Hardness and Colour due to its crystallization nature.

- Although the industry has accepted to use Sodium Sulphate for dyeing, the effluent typically contains Chlorides too (about 20% of the total salt load). Therefore it is a mixed salt.

- Separate crystallization strategies are required for Sulphate (adiabatic chiller) and the mixed salt (from the mother liquor of the chiller).

- >99% purity sodium sulphate can be obtained by Chilling, however the mother liquor of the chiller will be a mixed salt and will be contaminated with Hardness & Colour and therefore unfit for reuse.

- At best 80% of the sulphate (or 60% of the total salt assuming 80:20 ratio of Sulphate : Chloride) can be recovered in the adiabatic chiller. Meaning at least 40% of the total salt in the effluent which is present in the chiller mother liquor would be a mixed salt and will need to be evaporated. Since mother liquor will have high, hardness, colour, silica etc, this will be a waste salt unfit for reuse.
Other issues with Evaporator.. 2

- R.O Rejects contain Hardness, Organics, Silica and other contaminants which affect Evaporator performance as their concentration increases during evaporation.

- Possibility of salt produced being contaminated with above contaminants. Waste salt disposal is an issue.

- High Scaling (due to hardness) and corrosion (due to chlorides) resulting in poor performance and life of equipment.

- Crystallization of mixed salt in industrial effluent difficult and not easily predictable unlike single salts. Formation of complex double salts.

- Very high operating costs. Typical crystallization costs after MVR is in the range of Rs. 600 to 650 per m3 of feed.

- Ideal solution would be one which eliminates the Evaporator! But can we?
Section E: Our Technical Solution To The Problem
How is salt used in Dyeing?

- Sodium Chloride or Sodium Sulphate salts used.
- Salt added to water in a bath to prepare a solution. Typical concentrations are 40 – 90 gpl depending on Light, Medium or Dark shades.
- Dyes are added to the saline bath.
- The Salt “drives” the dye onto the fabric.
- If we give salt as a solution (brine) to the CETP member dyeing units, we can eliminate or reduce the load on the Evaporator!
Can we use Liquid Brine directly?

- Yes, but there are issues:
  - **Quality** (Contains contaminants such as Hardness, Organics, Colour and therefore these needs to be removed. Also the Strength of salt to match with that required in the dye bath which is again based on the desired shade.)
  - **Quantity** (The volume of brine has to be lower than the dye bath volume required in dyeing units).

- Therefore an Brine treatment system is required to improve quality and reduce volume!
REVISED TREATMENT SCHEME
Proposed Technological Solution.. 1

- Direct re-use of Treated brine is proposed as a solution to the problem.

- This has the following advantages:
  - Eliminates large additional modifications required to make the Evaporator functional.
  - Reduces O&M cost by about Rs. 50/KI
  - Reliable and Easy to operate Technology.
  - Various components of the Technology proposed after extensive pilot trials.
  - Successful dyeing Trials done in all CETPs and bulk operations done in 3 CETPs in 30 dyeing units using water tankers for transportation.

Fig : FABRICS DYED BY LAB DIP METHOD
The brine treatment system consists of components for improving the quality (colour, Hardness etc) and reducing the volume. These components are as follows:

- Brine Treatment System.
- BDTRF treatment System
- Hypo dosing System
- Ultra Filtration
- Additional R.O Stage
Alternate Options evaluated: Nano Filtration 1 (After Secondary Treatment prior to R.O)

**Feed**
- 5500 m³/d
- TDS: 6590 mg/l
- Cl⁻: 3066 mg/l
- SO₄²⁻: 800
- T.H: 100-150
- 36 Tons/d Salt

**Recovery**
- 93.07%

**NF (3 Stages)**

**Permeate**
- 5137 m³/d
- TDS: 4994 mg/l
- Cl⁻: 2813 mg/l
- SO₄²⁻: 76
- T.H: -47 to 70

**Reject**
- 363 m³/d

**TDS**
- 27735 mg/l
- Cl⁻: 6338 mg/l
- SO₄²⁻: 10489
- T.H: 820 to 1220
- 10.6 Tons/d Waste Salt

**Advantages**
- Better quality brine from R.O rejects.
- R.O membranes more protected due to NF.

**Disadvantages**
- Additional~6% volume of rejects to be evaporated.
- High Hardness, Colour, Organics will make this liquor difficult for evaporation. L-S softening will be required.
- 10.6 tons/day (30%) waste salt generated.
- Colour usually passes thru NF after an year of operation.
- Decolourant Resin & Softener filters cannot be eliminated or by-passed from the process.
Alternate Options evaluated: Nano Filtration 2 (After existing R.O.)

**Advantages**
- Better quality brine.

**Disadvantages:**
- Additional ~9% volume of rejects to be evaporated.
- High Hardness, Colour, Organics will make this liquor difficult for evaporation.
- L-S softening will be required prior to evaporation. Huge sludge generation.
- 28.37 tons/day (80%) waste salt generated.
- Brine strength very low at 23 gpl.
- Fresh salt needs to be added in dyeing units, not environmentally sustainable.
- Colour usually passes thru NF after an year of operation.

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**Flowchart Details:**
- **Feed:** 840 m³/d
- **TDS:** 43120 mg/l
- **Cl⁻:** 19703 mg/l
- **SO₄²⁻:** 5270 mg/l
- **T.H:** 667-1000 mg/l
- **36 Tons/d Salt**

**Recovery** 40.47%

**NF (1 Stage) Feed:** 840 m³/d
- **TDS:** 43120 mg/l
- **Cl⁻:** 19703 mg/l
- **SO₄²⁻:** 5270 mg/l
- **T.H:** 667-1000 mg/l
- **36 Tons/d Salt**

**Permeate:** 340 m³/d
- **TDS:** 23071 mg/l
- **Cl⁻:** 13281 mg/l
- **SO₄²⁻:** 135 mg/l
- **T.H:** -200 to 300 mg/l

**Reject:** 500 m³/d
- **TDS:** 56736 mg/l
- **Cl⁻:** 24069 mg/l
- **SO₄²⁻:** 8761 mg/l
- **T.H:** 1000 to 1500 mg/l
- **28.37 Tons/d Waste Salt**
Section F : Case Study of A Textile CETP

- Arulpuram CETP
**Brief on Arulpuram CETP**

- **Design Capacity**: 5500 m³/d
- **No. of Member Units**: 15
- **Type of Dyeing**: Knitted fabric (mainly cotton)
- **Current processing capacity**: 3850 m³/d (70%)
- **Project Status**: Phase I modifications completed. Phase II ongoing.
- **Original Cost of Project**: 55 Crores
- **Additional Cost for Modifications**: Rs. 15 Cr
- **Technology Status**: DPR Approved & ZLD demonstration evaluated by Anna University. Also evaluated by Dept. of Science and Technology and recommended to Ministry of Textiles, New Delhi.
- **Date of Commencement of ZLD demonstration**: 24th Aug’ 2011
- **Current Status**: Operating successfully under ZLD mode at 70% of design Capacity
### Combined Effluent Characteristics

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<th>Sl. No</th>
<th>Parameters</th>
<th>Range</th>
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<td>pH</td>
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<tr>
<td>2</td>
<td>BOD</td>
<td>400 - 500</td>
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<td>3</td>
<td>COD</td>
<td>1000 - 1200</td>
</tr>
<tr>
<td>4</td>
<td>TSS</td>
<td>200 - 300</td>
</tr>
<tr>
<td>5</td>
<td>TDS</td>
<td>6000 - 7000</td>
</tr>
<tr>
<td>6</td>
<td>$\text{Cl}^-$</td>
<td>400 - 700</td>
</tr>
<tr>
<td>7</td>
<td>$\text{SO}_4^{2-}$</td>
<td>2500 - 3100</td>
</tr>
<tr>
<td>8</td>
<td>Total Hardness as $\text{CaCO}_3$</td>
<td>100 - 150</td>
</tr>
</tbody>
</table>

All values are expressed in mg/l except pH
Process Flow diagram of Textile CETPs

Pre - Treatment
- Equalization
- Neutralization
- Bio Oxidation
- Filtration
- Ultra Filtration
- Decolourant Resin
- Softener Resin

Reverse Osmosis
- Permeate
- Rejects

MVR
- (major qty)
- Condensate

Brine Treatment
- Industriess Use
- 100 gpl

Recovered Water
- Condensate

MEE
- Adiabatic chiller
- Glauber salt

MEE
- Mother Liquor
- Waste Mixed salt
## Brief Summary Performance of Arulpuram CETP

<table>
<thead>
<tr>
<th>Raw effluent received (m³/month)</th>
<th>Recovered water sent to member units (m³/month)</th>
<th>Brine solution sent to member units (m³/month)</th>
<th>Total recovery (m³/ month)</th>
<th>Wastage to solar pans (m³/ month)</th>
<th>Total Recovery %</th>
</tr>
</thead>
<tbody>
<tr>
<td>85225</td>
<td>78708</td>
<td>3041</td>
<td>81749</td>
<td>453</td>
<td>95.9%</td>
</tr>
</tbody>
</table>

### Average Raw effluent Salt concentration (gpl) and Brine solution concentration (gpl)

<table>
<thead>
<tr>
<th>Average Raw effluent Salt concentration (gpl)</th>
<th>Average Brine solution concentration (gpl)</th>
<th>Salt received (Raw effluent received X Raw effluent concentration) (Tones/month)</th>
<th>Salt sent to member units as Brine (Brine solution sent to member units X Brine concentration) (Tones/month)</th>
<th>Salt in recovered water sent to member units (Recovered water sent to member unit X Recovered water concentration) (Tones/month)</th>
<th>Glauber salt produced with 55 % moisture (Total Glauber salt X 45%) (Tones/month)</th>
<th>Total recovered (Brine solution salt + Salt in recovered water + Salt without moisture) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.74</td>
<td>104</td>
<td>575</td>
<td>316</td>
<td>13</td>
<td>131</td>
<td>460</td>
</tr>
</tbody>
</table>
### Stage wise Quality Details

<table>
<thead>
<tr>
<th>S.No</th>
<th>Parameter</th>
<th>Units</th>
<th>Influent</th>
<th>Recovered Water</th>
<th>Brine Solution (MVR Concentrate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH @ 25°C</td>
<td></td>
<td>9.0</td>
<td>7.0</td>
<td>5.5</td>
</tr>
<tr>
<td>2</td>
<td>TDS</td>
<td>mg/l</td>
<td>6744</td>
<td>170</td>
<td>103972</td>
</tr>
<tr>
<td>3</td>
<td>Chloride as Cl⁻</td>
<td>mg/l</td>
<td>734</td>
<td>34</td>
<td>11976</td>
</tr>
<tr>
<td>4</td>
<td>Sulphates as SO₄²⁻</td>
<td>mg/l</td>
<td>3142</td>
<td>19</td>
<td>56459</td>
</tr>
<tr>
<td>5</td>
<td>BOD @ 20°C</td>
<td>mg/l</td>
<td>251</td>
<td>BDL</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>COD</td>
<td>mg/l</td>
<td>1034</td>
<td>BDL</td>
<td>1820</td>
</tr>
<tr>
<td>7</td>
<td>TH as CaCO₃</td>
<td>mg/l</td>
<td>111</td>
<td>BDL</td>
<td>129</td>
</tr>
<tr>
<td>9</td>
<td>Total Alkalinity as CaCO₃</td>
<td>mg/l</td>
<td>1538</td>
<td>48</td>
<td>178</td>
</tr>
</tbody>
</table>
Quality of Recovered Glauber Salt:

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Parameter</th>
<th>Recovered Glauber Salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Purity (%) as Sodium Sulphate @ 105(^0)C</td>
<td>98.5%</td>
</tr>
<tr>
<td>2</td>
<td>TH as CaCO(_3) (mg/l)</td>
<td>Nil</td>
</tr>
</tbody>
</table>
Approvals & Inspections done for the Arulpuram Demo 1

- DPR Approved by CES, Anna University
- Evaluation of the demonstration done by Anna University and report dated 31\textsuperscript{st} Oct’11 Submitted to TNPCB.
- Evaluation also done by Secretary DST, GoI, who submitted his recommendation to MoT, GoI.
  - Also two members of the Technical committee constituted by MoT also visited and have submitted their satisfactory recommendations to MoT.
  - Following the above MoT advised all CETPs to follow TWIC Technology with TWIC as the Operator.
Inspections were also done by court appointed Monitoring Committee and the Flying Squad and other officials of TNPCB.

**Monitoring by PCB:** 24 hrs online Flow metering of raw, recovered water, brine and freshwater (4 Nos) in each dyeing member units & over 20 flow meters in the CETP uploaded continuously to a dedicated website / CETP Server.
### CETP Flow Meters

<table>
<thead>
<tr>
<th>Section</th>
<th>Flow</th>
<th>Totalizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet to CETP</td>
<td>288.18</td>
<td>67826</td>
</tr>
<tr>
<td>NT Flow Meter</td>
<td>107.96</td>
<td>1092</td>
</tr>
<tr>
<td>Thickener Feed</td>
<td>0.00</td>
<td>16480</td>
</tr>
<tr>
<td>Thickener Over Flow &amp; Filter Pressed Filtrate</td>
<td>0.01</td>
<td>955</td>
</tr>
<tr>
<td>PT Filter Backwash</td>
<td>16.49</td>
<td>7171</td>
</tr>
</tbody>
</table>

### RO Section

<table>
<thead>
<tr>
<th>Product</th>
<th>Flow</th>
<th>Totalizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSF Feed</td>
<td>101.40</td>
<td>36699</td>
</tr>
<tr>
<td>R.O. Common Product</td>
<td>82.35</td>
<td>29660</td>
</tr>
<tr>
<td>R.O. Reject</td>
<td>-0.03</td>
<td>8609</td>
</tr>
<tr>
<td>R.O. B/W and Flushing</td>
<td>0.06</td>
<td>2659</td>
</tr>
</tbody>
</table>

### Evaporator/Crystallizer

<table>
<thead>
<tr>
<th>Product</th>
<th>Flow</th>
<th>Totalizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVR I Feed</td>
<td>14.95</td>
<td>9016</td>
</tr>
<tr>
<td>MVR I Condensate</td>
<td>11.22</td>
<td>7127</td>
</tr>
<tr>
<td>MVR I Concentrate</td>
<td>4.48</td>
<td>2483</td>
</tr>
<tr>
<td>MVR II Feed</td>
<td>0.00</td>
<td>1754</td>
</tr>
<tr>
<td>MVR II Condensate</td>
<td>-0.03</td>
<td>1314</td>
</tr>
<tr>
<td>MVR II Concentrate</td>
<td>-0.01</td>
<td>607</td>
</tr>
<tr>
<td>Crystallizer Feed</td>
<td>6.17</td>
<td>2113</td>
</tr>
<tr>
<td>Crystallizer Condensate</td>
<td>4.11</td>
<td>3161</td>
</tr>
<tr>
<td>Crystallizer Concentrate for Mother Liquid to Solar Plant</td>
<td>2.36</td>
<td>673</td>
</tr>
</tbody>
</table>

### Brine Treatment System

<table>
<thead>
<tr>
<th>Brine to Membrane Units</th>
<th>Flow</th>
<th>Totalizer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>175.60</td>
<td>1317</td>
</tr>
</tbody>
</table>
### Arulpuram CETP, Tiruppur

<table>
<thead>
<tr>
<th>MEMBER UNIT</th>
<th>RAW EFFLUENT TO CETP</th>
<th>RECOVERED WATER FROM CETP</th>
<th>BRINE SOLUTION FROM CETP</th>
<th>BRINE SOLUTION TO DYEING MACHINE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FLOW m³/hr</td>
<td>TOTALIZER m³</td>
<td>FLOW m³/hr</td>
<td>TOTALIZER m³</td>
</tr>
<tr>
<td>A ONE PROCESS</td>
<td>40</td>
<td>4621</td>
<td>0</td>
<td>3124</td>
</tr>
<tr>
<td>JAI VISHNU PROCESS</td>
<td>0</td>
<td>10404</td>
<td>12</td>
<td>6992</td>
</tr>
<tr>
<td>SRI AMBAL PROCESS</td>
<td>35</td>
<td>4101</td>
<td>3</td>
<td>4306</td>
</tr>
<tr>
<td>KONGOR Process</td>
<td>0</td>
<td>7879</td>
<td>10</td>
<td>6712</td>
</tr>
<tr>
<td>RR PROCESS</td>
<td>33</td>
<td>7361</td>
<td>10</td>
<td>6911</td>
</tr>
<tr>
<td>EVERGREEN PROCESS</td>
<td>28</td>
<td>2323</td>
<td>0</td>
<td>2279</td>
</tr>
<tr>
<td>DIVYAK PROCESS</td>
<td>36</td>
<td>9247</td>
<td>6</td>
<td>3037</td>
</tr>
<tr>
<td>CHANDRO PROCESS</td>
<td>59</td>
<td>3336</td>
<td>1</td>
<td>1939</td>
</tr>
<tr>
<td>GT PROCESS</td>
<td>0</td>
<td>4542</td>
<td>9</td>
<td>3950</td>
</tr>
<tr>
<td>ROOPA PROCESS</td>
<td>0</td>
<td>6236</td>
<td>15</td>
<td>3686</td>
</tr>
<tr>
<td>GLOBAL PROCESS</td>
<td>0</td>
<td>5276</td>
<td>6</td>
<td>3063</td>
</tr>
<tr>
<td>SIRUBA PROCESS</td>
<td>0</td>
<td>3770</td>
<td>0</td>
<td>3833</td>
</tr>
<tr>
<td>JUNIOR PROCESS</td>
<td>0</td>
<td>6831</td>
<td>0</td>
<td>4470</td>
</tr>
<tr>
<td>GMS PROCESS</td>
<td>0</td>
<td>6118</td>
<td>10</td>
<td>4597</td>
</tr>
</tbody>
</table>

**Member Units**

- **Member Units**
- **CETP**
# O&M Cost (Rs/m³) for 5.5 MLD capacity

<table>
<thead>
<tr>
<th>S.No</th>
<th>Description</th>
<th>Operating Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td><strong>Variable Cost</strong> <em>(Power, Diesel, Chemicals, Cartridge Filter, Sludge Handling Charges, Maintenance &amp; Firewood Cost)</em></td>
<td>125-150</td>
</tr>
<tr>
<td>II</td>
<td><strong>Fixed Cost</strong> <em>(Power, Manpower Cost, Replacement, Standard Maintenance, Lab Chemicals, Admin &amp; Statuary)</em></td>
<td>25-50</td>
</tr>
<tr>
<td></td>
<td><strong>Total Operating Cost (Rs/m³)</strong> <em>(Excluding Depreciation &amp; Finance Cost)</em></td>
<td>150 - 200</td>
</tr>
<tr>
<td>III</td>
<td><strong>Recovery Cost (Rs/m³)</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 Cost of recovered Water *(Including brine), Rs. 70/Kl @ 98% recovery</td>
<td>68.6</td>
</tr>
<tr>
<td></td>
<td>2 Cost of recovered Sodium Sulphate salt @ Rs. 10/Kg for 90% recovery of salt</td>
<td>63.0</td>
</tr>
<tr>
<td></td>
<td><strong>Total Recovery Cost (Rs/m³)</strong></td>
<td>131.6</td>
</tr>
<tr>
<td></td>
<td><strong>Net Operating Cost (Rs/m³)</strong></td>
<td>30 - 70</td>
</tr>
</tbody>
</table>
## Financial Impact of ZLD for a Textile CETP

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Items</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Capacity of CETP</td>
<td>5500 m3/d</td>
</tr>
<tr>
<td>2</td>
<td>Water consumption for dyeing</td>
<td>50 L/Kg of Fabric</td>
</tr>
<tr>
<td>3</td>
<td>Total production capacity per day</td>
<td>110 tonnes</td>
</tr>
<tr>
<td>4</td>
<td>Processing cost of dyed fabric –</td>
<td>80 Rs/Kg</td>
</tr>
<tr>
<td>5</td>
<td>Processing Cost per day</td>
<td>Rs. 88Lakhs</td>
</tr>
<tr>
<td>6</td>
<td>Cost of ZLD system @ Rs. 30-70 Rs/KL net for 5.5 MLD</td>
<td>Rs. 1.65 – 3.85 Lakhs</td>
</tr>
<tr>
<td>7</td>
<td>Cost of ZLD per Kg of dyed fabric</td>
<td>1.5 to 3.5 Rs/Kg</td>
</tr>
<tr>
<td>8</td>
<td>% of ZLD cost on Processing Cost of dyed fabric</td>
<td>1.9 – 4.37%</td>
</tr>
</tbody>
</table>

### Basis

<table>
<thead>
<tr>
<th></th>
<th>1:3.5</th>
<th>1:5</th>
<th>1:8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquor Ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Consumption</td>
<td>40</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>Hrs of Operation</td>
<td>6-8</td>
<td>8-10</td>
<td>10-12</td>
</tr>
</tbody>
</table>

### Shade

<table>
<thead>
<tr>
<th></th>
<th>L</th>
<th>M</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing Rs/Kg</td>
<td>40-60</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>
Recognition

- **Government of Tamilnadu** (G.O 132 dtd 31.12.12)
  - Has nominated TWIC as PMA for implementing on behalf of the government for the following:
    - Dedicated agency for development and O&M of CETPs for GoTN
    - Industrial water supply through Reuse of Sewerage water and Desalination.

- **Government of India**
  - TWIC’s technology for ZLD recognized by Ministry of Textiles and has been evaluated and accepted by the Dept. of Science and Technology (DST).
  - TWIC has been a Knowledge partner to the Ministry of Textiles.
Section G: The Way Forward for Tirupur CETPs
<table>
<thead>
<tr>
<th>Environmental Sustainability Issues</th>
<th>Aspects</th>
</tr>
</thead>
</table>
| 1. Cleaner Production Technologies | 1. Low Salt dyeing to further reduce TDS  
2. Use of Eco-Friendly dyes  
3. Promotion of Eco-labels |
| 2. Hazardous Waste Disposal & Management | 1. Avoid or reduce generation of mixed Waste Salt, particularly from chloride effluent based evaporator system and disposal to TSDF.  
2. Explore possibility generation of products from the mixed salt.  
3. Shift to Zero Waste Disposal (ZWD) from Zero Liquid Discharge (ZLD) |
<table>
<thead>
<tr>
<th>Environmental Sustainability Issues</th>
<th>Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Energy Savings</td>
<td>1. Reducing Energy consumption/ Carbon Foot Print in processes, avoidance of firewood, use of</td>
</tr>
<tr>
<td></td>
<td>2. Cogen, solar &amp; wind energy</td>
</tr>
<tr>
<td>4. Eco-restoration of Noyyal River</td>
<td>1. Dam &amp; River clean up</td>
</tr>
<tr>
<td></td>
<td>2. Soil remediation of contaminated agricultural lands</td>
</tr>
<tr>
<td></td>
<td>3. Restoring the tanks &amp; canals- basin management</td>
</tr>
<tr>
<td></td>
<td>4. Development of Salt tolerant wet land</td>
</tr>
<tr>
<td></td>
<td>5. Industry &amp; Agriculture to work together with Government on all the above</td>
</tr>
</tbody>
</table>
Section H : Approach to ZLD
Approach to ZLD.. 1

- **Technology**

  - Need for **extensive piloting** before implementation to demonstrated Techno-commercial feasibility.
  
  - **One Size does not fit all:** Need to remember “not all Textile dyeing effluent are same” or “not all Tannery effluent are same” or “not all paper industries are same” or “not all ZLD are same”.
  
  - Since almost no EPC company provides ‘in-house’ all components of ZLD, there is an extensive need for integrating the complete process components to avoid problems. Therefore the Consultant should assure process performance guarantees.
  
  - Not just **water balance but material balance** for several critical parameters (not just TDS!) a must for correct process design.
Approach to ZLD.. 2

- **Internal recirculation:** Quality and quantity of backwash/regeneration/CIP/cleaning on the entire treatment process to be carefully accounted for in process design.

- System design should be based on high ‘Reliability Index’.

- **High Process Flexibility** to be built in for various components to handle variations in effluent quality/individual component performance. Design should be based on multiple process streams including standby and downtime.

- Must focus on reduction of brine concentrate to reduce the need for evaporation and crystallization. Higher recovery in R.O possible subject to osmotic pressure limitations, but with elimination of Hardness, silica, foulants. High Pressure R.O systems available and are cost effective such as DTRO (90 – 160 bar).
Approach to ZLD…3

- Avoid Evaporator usage due to high Carbon footprint (cannot justify the environmental gains of ZLD) and associated technical issues with evaporation of mixed salts in wastewater, as far as possible.

- **Think “Zero Waste Discharge” to achieve Zero Liquid Discharge**. Focus on salt recovery and reuse, salt separation and reduced sludge generation.

- **O&M**
  - Need for independent (for CETPs) and Professional O&M.
  - Most CETPs /ETPs are poorly managed and there is complete lack of certified ETP operator courses and dearth of well trained manpower.
  - Expenditure on O&M is an issue.
Role of regulator

The PCB has essentially been a regulator without offering any “Technical Solutions” or advice. In some cases instead of applying standards based on ‘Best Available Technology”, the environmental standards have exceeded them. The result is that the PCB is not only battling against pollution but is also facing a slew of court cases. Monitoring ‘round-the-clock’ such a large number of industries are also not practical. Unequal application of law results in shifting of pollution to neighboring states or even districts.

The TNPCB is trying to address this issue by setting up a Center for Technology Development, Demonstration and Dissemination (CETEDDD) in collaboration with IIT Chennai. The COO, TWIC is an adviser.
Section I : CONCLUSIONS
Conclusions

- ZLD is a Technological Challenge, and the focus must be on Zero Waste Disposal (ZWD).

- Extensive research and piloting necessary for every single case for Technology selection and financial viability.

- Brine Concentration, Evaporation and Crystallization and disposal still a major issue. Focus must be on recovery and reuse of salts.

- Water Scarcity, Water economics and regulatory pressure are the main drivers of ZLD and will determine financial viability.
<table>
<thead>
<tr>
<th>Name</th>
<th>I. Sajid Hussain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation</td>
<td>Chief Operating Officer</td>
</tr>
<tr>
<td>Contact address</td>
<td>Tamilnadu Water Investment Company Ltd,</td>
</tr>
<tr>
<td></td>
<td>&quot;Polyhose Towers&quot;(SPIC Annex BLDG)</td>
</tr>
<tr>
<td></td>
<td>1st Floor, No.86, Mount Road,</td>
</tr>
<tr>
<td></td>
<td>Guindy, Chennai – 600 032</td>
</tr>
<tr>
<td>Email</td>
<td><a href="mailto:sajidhussain1@twic.co.in">sajidhussain1@twic.co.in</a></td>
</tr>
<tr>
<td>Phone</td>
<td>044 – 223561890/91</td>
</tr>
<tr>
<td>Mob</td>
<td>+91 9940676679</td>
</tr>
<tr>
<td>Website</td>
<td><a href="http://www.twic.co.in">www.twic.co.in</a></td>
</tr>
</tbody>
</table>

**THANK YOU**

31/01/2014

International Conference on “Green Enterprises and Green Industrial Parks”