Case Study of a Zero Liquid Discharge Facility in Textile Dyeing Effluents at Tirupur

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Section A: Introduction to TWIC

Genesis

- TWIC is a pioneering developer of water/waste water projects in India
- 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.. 1

Water Reuse

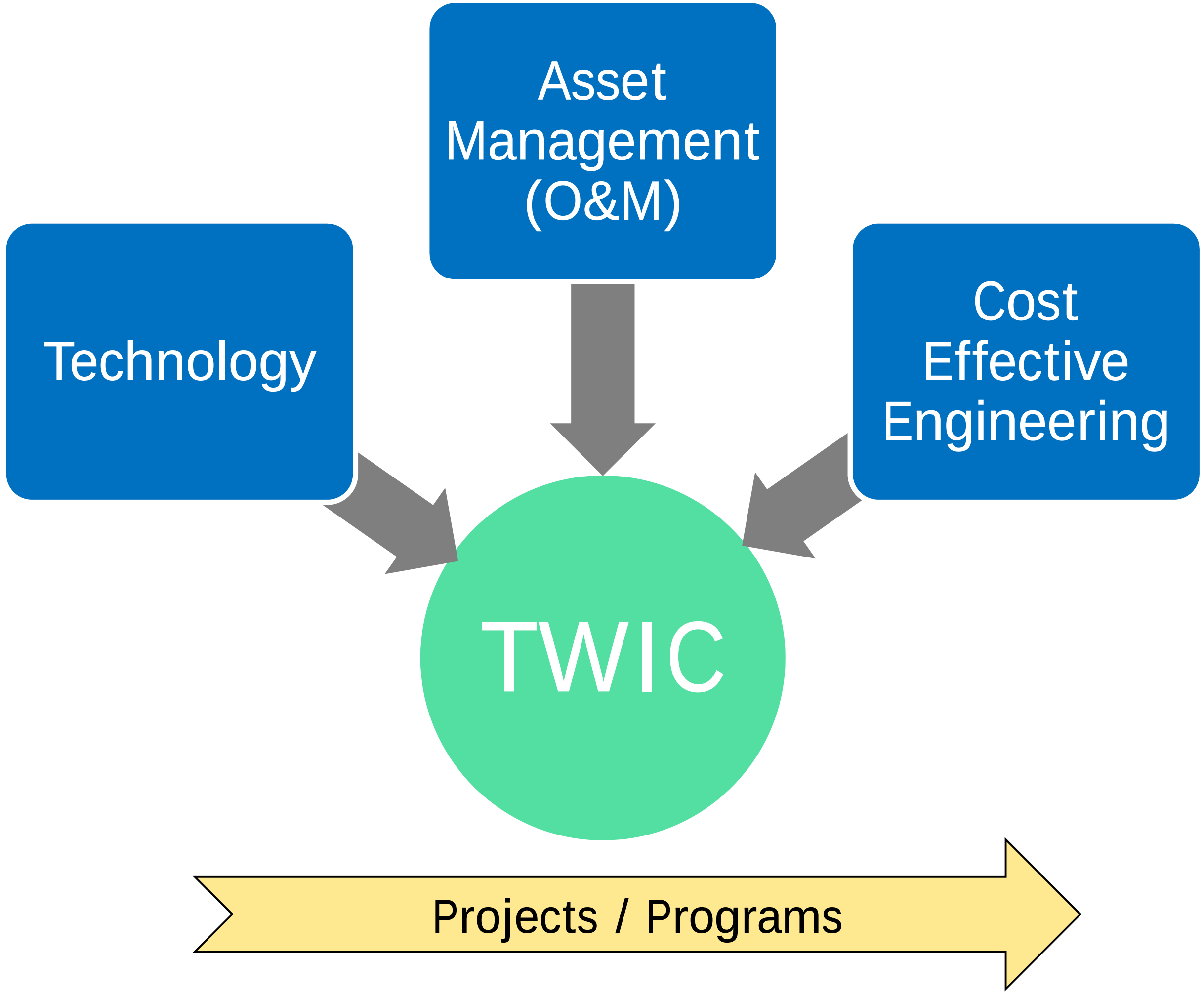
- Industrial Effluent
- Sewage Reuse
- Desalination

Urban Water

- Treatment Plants
- Urban Water Distribution

Focus Areas.. 2

Focus on water and waste water sector



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	Project Financing	Project Implementation	Project O &M
-Technology Solution, Development & Design -DPR Preparation -Procurement Services	-Financial Close -Investment -Lending	-Project Management -Implementation Supervision -Lenders Engineer	-Direct O&M -Supervision -Performance Audits -Energy Audits

Section B: Concept of ZLD

Concept of ZLD.. 1

- ZLD - stands for Zero Liquid Discharge – 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
  - Reverse Osmosis
  - Evaporator & Crystallizer

Need for ZLD

- 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.
- 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.**

International Context

- 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.
- 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.

Benefits of ZLD

- To save costs and reduce the capacity needed, comprehensive water audits are usually performed which also ensure that the system deals only with the most polluting streams. Installing **ZLD** technology is therefore often 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 Textile Effluent Management Project, Tirupur.. 1

- Project: TWIC has developed and established 9 Textile dyeing CETPs with a 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 420 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.

Tirupur Textile Effluent Management Project, Tirupur.. 2

- Benefits of this Project:

  The project for ZLD is perhaps the first of its kind in the world. Key benefits of the project are

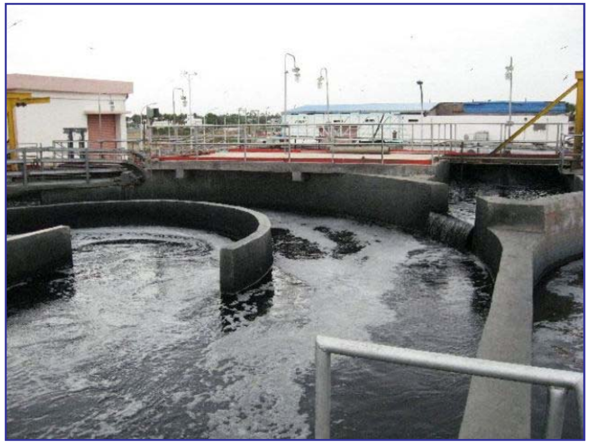
  - Recycling >98% of the water.
  - Reuse of > 90% of the salt.
  - Cleaning of the local environment

- Current status

  - TWIC has also developed an alternate technology called "Treated Brine Reuse Technology" which substantially reduces the dependence on evaporator.
  - 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.

O & M of Tirupur Textile CETP at Tirupur

Tirupur Textile Effluent Management Project, Tirupur.. 3

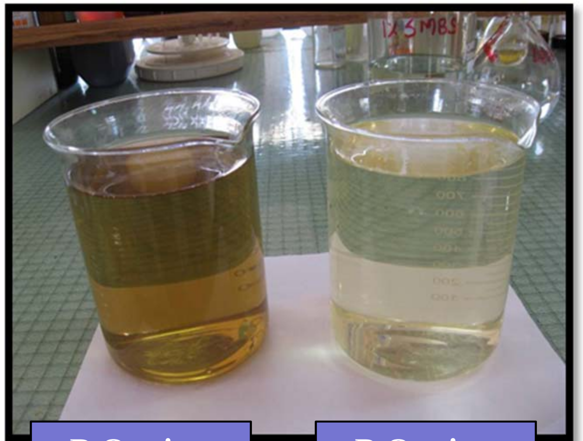


Pretreatment

Biological Treatment

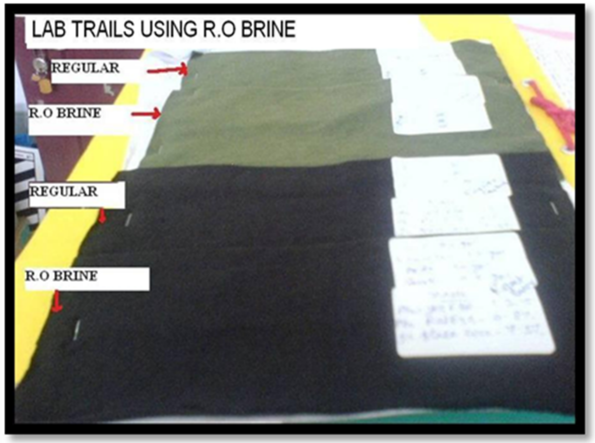
Reverse Osmosis

Untreated & Treated Effluent



R.O reject – before treatment

R.O reject – after treatment



Lab trails using RO brine

Brief History..1

- 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 water recovery system (using reverse osmosis) and the reject management system (based on evaporator)

- 450 units collectively have set up 20 CETPs while 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%)

Brief History..2

- 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

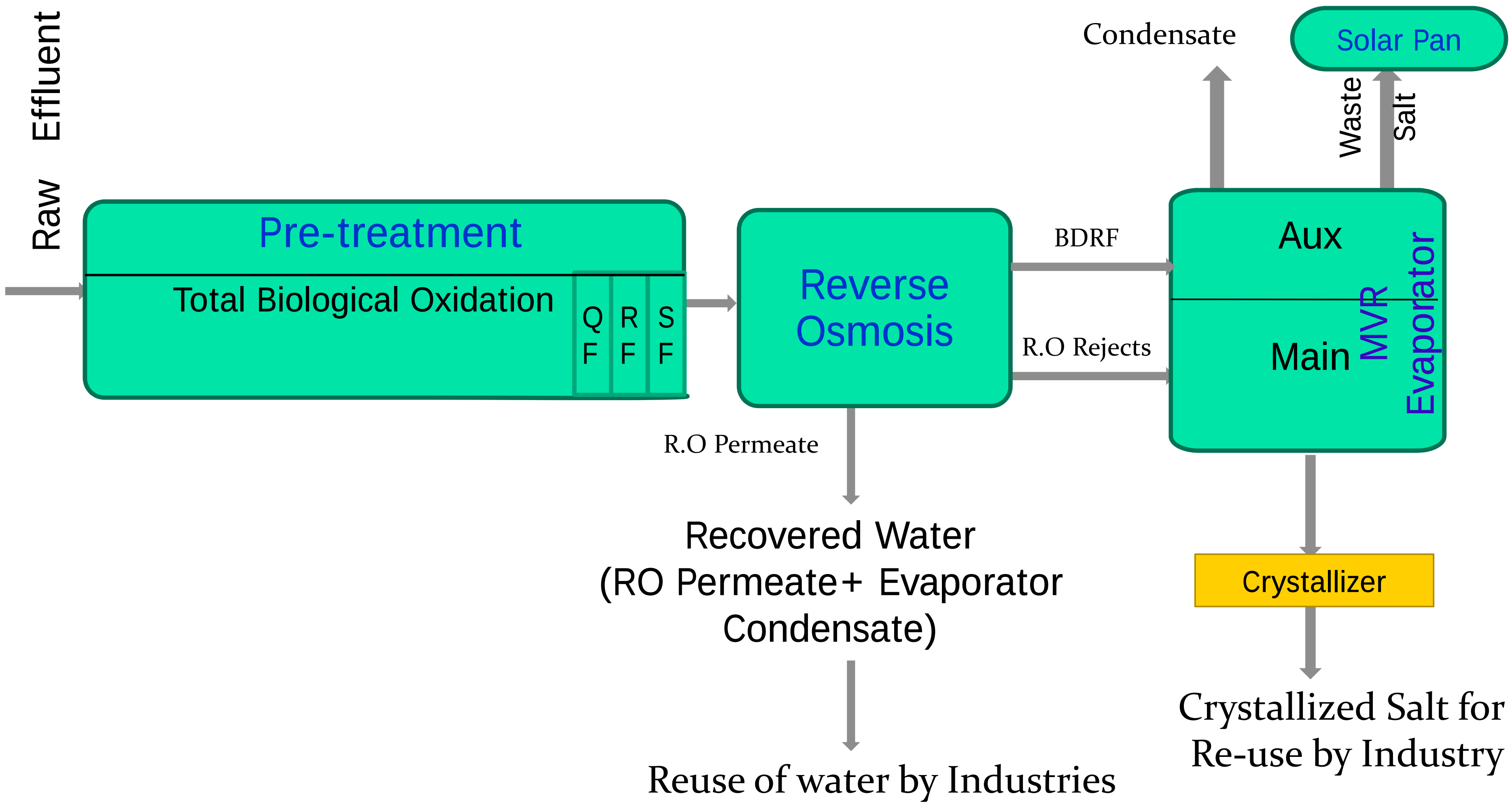
Fig: Biological Oxidation Tank equipped with diffused aeration system at Tirupur site

Brief History..3

- 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.

Technical Challenges and how it was overcome

CETP Treatment Scheme



Nature of the Problem in the Evaporator.. 1

- **<u>Design Performance:</u>**

  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.

Fig: MVR type Evaporator System installed in all CETPs

- **<u>Reasons for the Choice of MVR</u>:**
  - 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.

Nature of the Problem in the Evaporator.. 2

- **Actual Performance of MVR:**
  - MVR Feed at 80-85% of design
  - MVR Recovery at <70% (due to elevation in b.p).
  - 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 atleast 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?

Our Technical Solution To The Problem

How is salt used in Dyeing?

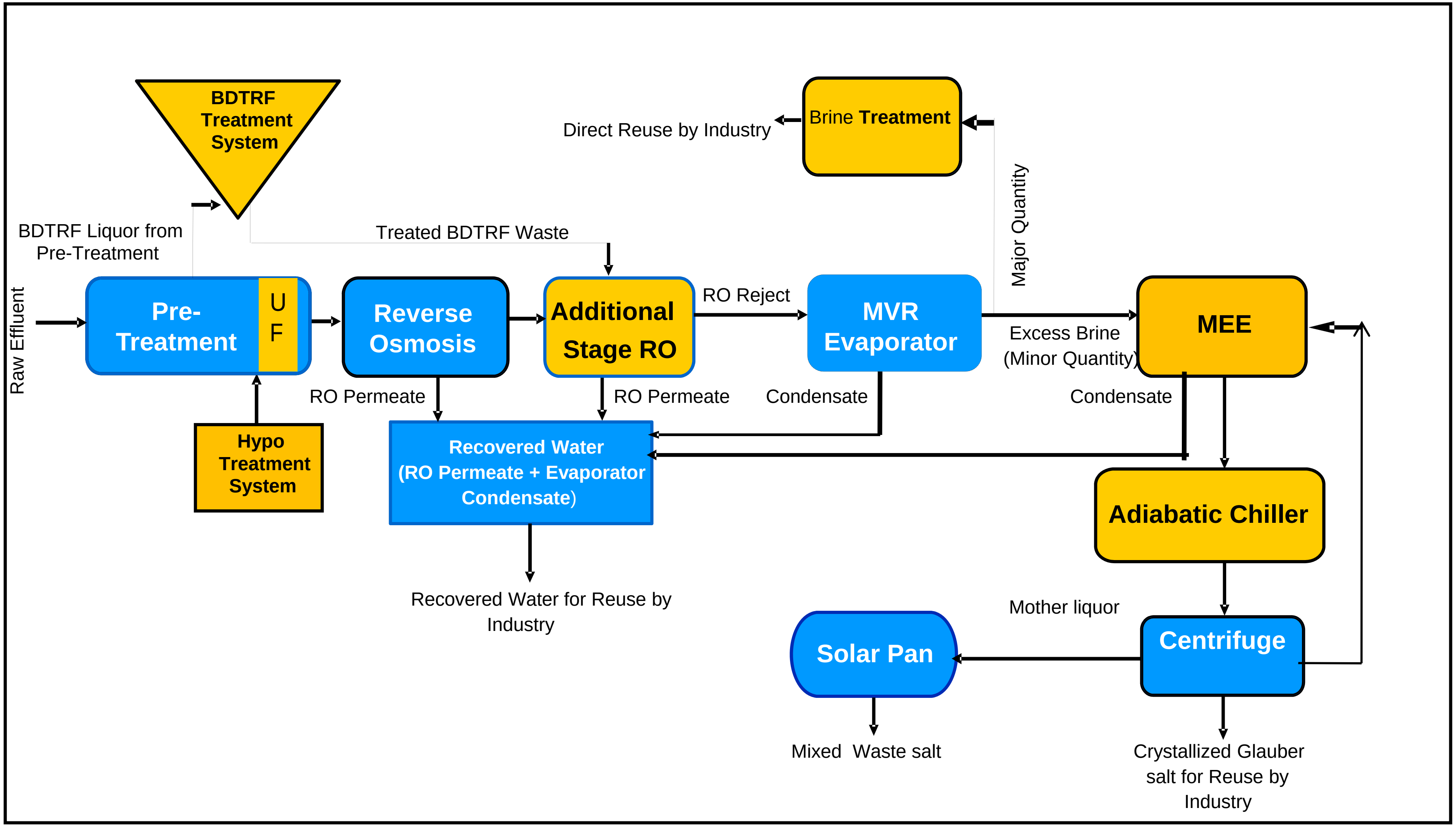
- Sodium Chloride or Sodium Sulphate salts used.
- Salt added to water in a bath to prepare a solution. Typical concentrations are 40 – 90 gpl depending on Light, Medium or Dark shades.
- Dyes are added to the saline bath.
- The Salt “drives” the dye on to the fabric.
- If we give salt as a solution (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/Kl
  - 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

Proposed Technological Solution.. 2

- 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

<u>Fig: BRINE BEFORE AND AFTER TREATMENT</u>

Section D : Case Study of Textile CETP

- Arulpuram CETP

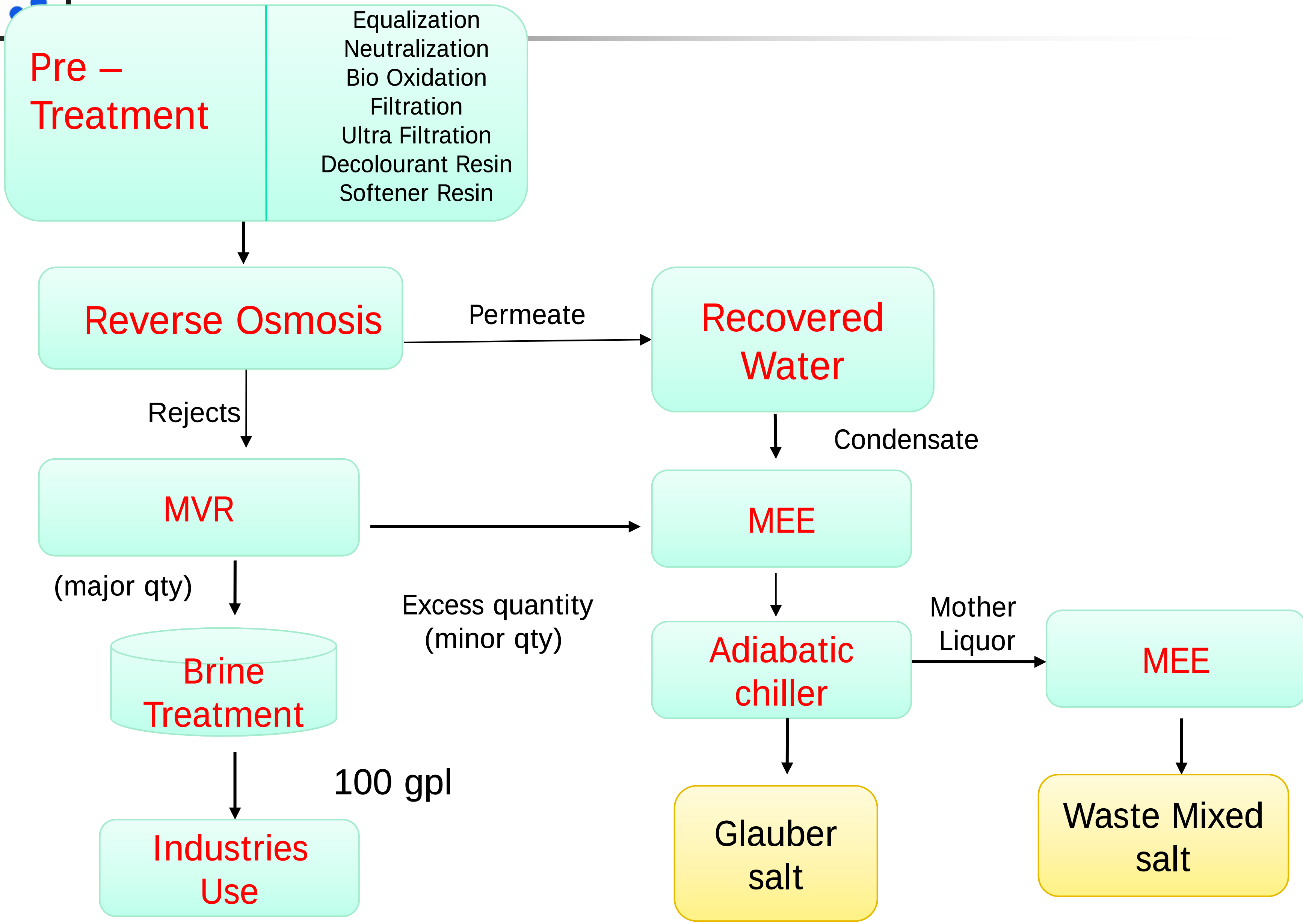
Brief on Arulpuram CETP

- **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 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**: 24^{th} Aug’ 2011
- **Expected Date of Project Completion**: Feb’13
- **Current Status**: Operating successfully under ZLD mode at 70% of design Capacity.

Combined Effluent Characteristics

Sl.No	Parameters	Range
1	pH	8.5- 10
2	BOD	400 - 500
3	COD	1000-1200
4	TSS	200-300
5	TDS	6000 - 7000
6	Cl^-	400-700
7	SO_4^{2-}	2500-3100
8	Total Hardness as $CaCO_3$	100 - 150
All values are expressed in mg/l except pH		

Process Flow diagram of Textile CETPs



Brief Summary Performance of Arulpuram CETP

Month	Raw effluent received (m3)	Recovered water sent to member units (m3)	Brine solution sent to member units (m3)	Water Content in Glauber salt (m3)	Total recovery (m3)	Wastage to solar pans (m3)	Total Recovery %
October-2012	83225	78708	3041	131.1	81880	453	**98.9%**

Month	Average Raw effluent Salt concentration (gpl)	Average Brine concentration (gpl)	Salt received (Raw effluent received X Raw effluent concentration) (Tones)	Salt sent to member units as Brine (Brine solution sent to member units X Brine concentration) (Tones)	Salt in recovered water sent to member units (Recovered water sent to member unit X Recovered water concentration) (Tones)	Glauber salt produced with 45 % moisture (Total Glauber salt X 55%) (Tones)	Total Salt recovered (Tones)	Salt recovery (Brine solution salt + Salt in recovered water + Salt without moisture) (%)
October-2012	6.74	104	561	316	22	160	499	**88.9%**

Stage wise Quality Details

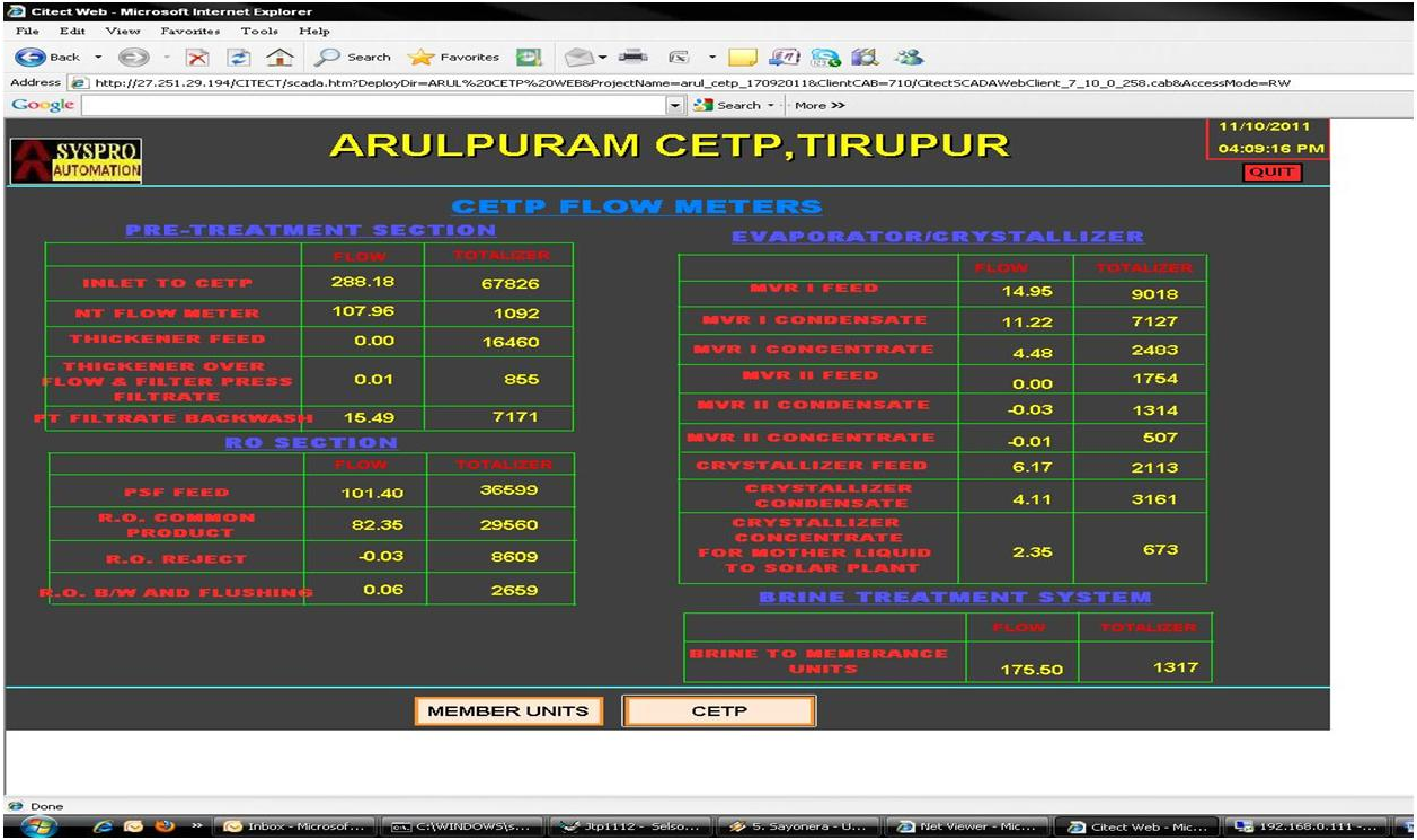
S.No	Parameter	Influent	Recovered Water	Brine Solution (MVR Concentrate)
1	pH @ 25^{0}C	9.0	7.0	5.5
2	TDS	6744	282	103972
3	Chloride as Cl^-	734	45	11976
4	Sulphates as $SO_4 2^-$	3142	52	56459
5	BOD @ 20^{0}C	251	BDL	129
6	COD	1034	BDL	178
7	TH as CaCO3	111	NIL	Pale Yellow

S.NO	Parameter	Recovered Glauber Salt
1	Purity (%) as Sodium Sulphate @ 105^{0}C	98.5%
2	TH as CaCO3 (mg/l)	Nil

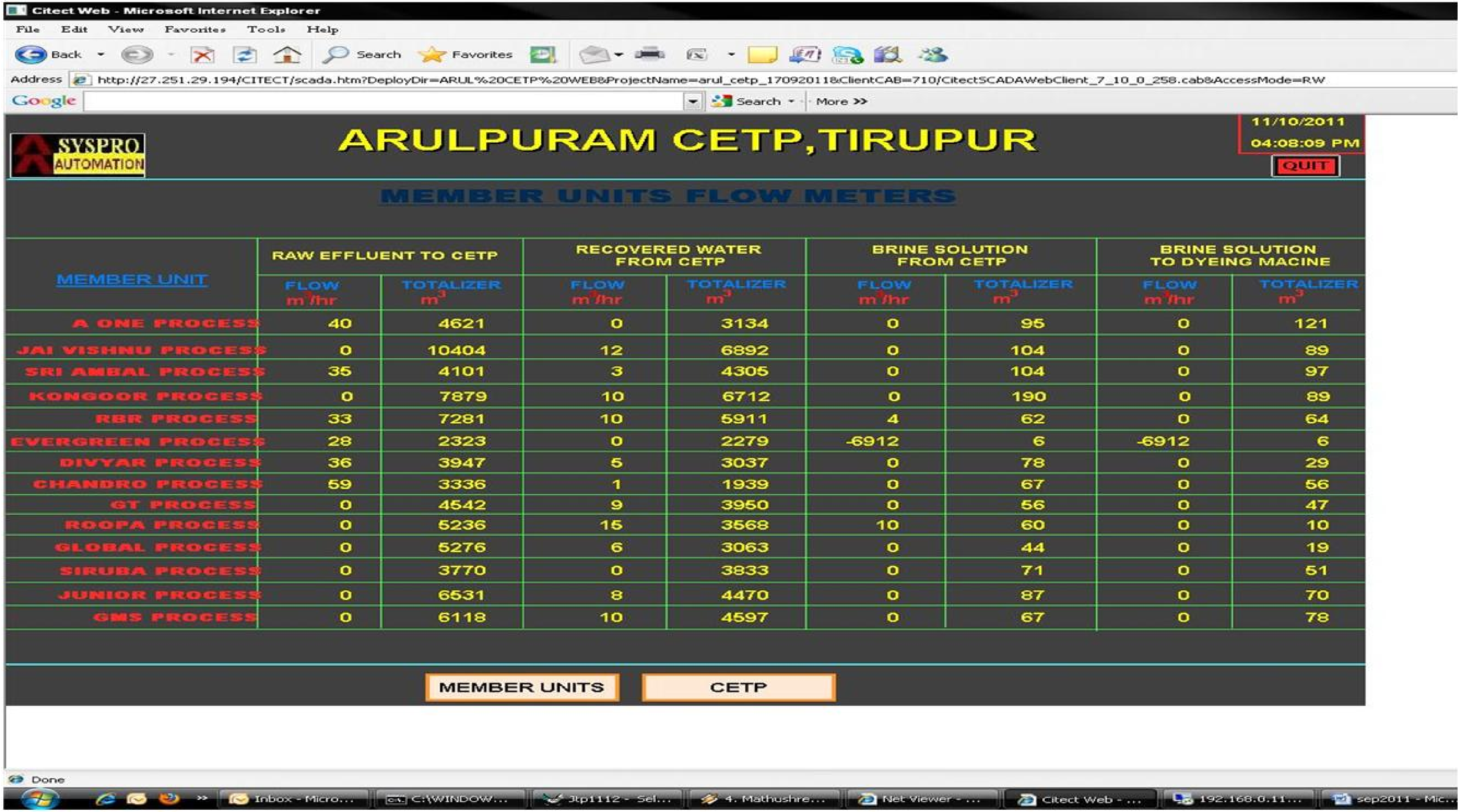
Approvals & Inspections done for the Arulpuram Demo

- DPR Approved by CES, Anna University
- Evaluation of the demonstration done by Anna University and report dated 31st Oct'11 Submitted to TNPCB.
- Evaluation also done by Secretary DIST, 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.
- 24 hrs online Flow metering of raw, recovered water, brine and freshwater in each dyeing member units & over 20 flow meters in the CETP uploaded continuously to a dedicated website/ CETP Server.

SCADA – Arulpuram CETP.. 1



SCADA – Arulpuram CETP.. 2



MEMBER UNIT	RAW EFFLUENT TO CETP FLOW m^3/hr	RAW EFFLUENT TO CETP TOTALIZER m^3	RECOVERED WATER FROM CETP FLOW m^3/hr	RECOVERED WATER FROM CETP TOTALIZER m^3	BRINE SOLUTION FROM CETP FLOW m^3/hr	BRINE SOLUTION FROM CETP TOTALIZER m^3	BRINE SOLUTION TO DYEING MACINE FLOW m^3/hr	BRINE SOLUTION TO DYEING MACINE TOTALIZER m^3
A ONE PROCESS	40	4621	0	3134	0	95	0	121
JAI VISHNU PROCESS	0	10404	12	6892	0	104	0	89
SRI AMBAL PROCESS	35	4101	3	4305	0	104	0	97
KONGOOR PROCESS	0	7879	10	6712	0	190	0	89
RBR PROCESS	33	7281	10	5911	4	62	0	64
EVERGREEN PROCESS	28	2323	0	2279	-6912	6	-6912	6
DIVYAR PROCESS	36	3947	5	3037	0	78	0	29
CHANDRO PROCESS	59	3336	1	1939	0	67	0	56
GT PROCESS	0	4542	9	3950	0	56	0	47
ROOPA PROCESS	0	5236	15	3568	10	60	0	10
GLOBAL PROCESS	0	5276	6	3063	0	44	0	19
SIRUBA PROCESS	0	3770	0	3833	0	71	0	51
JUNIOR PROCESS	0	6531	8	4470	0	87	0	70
GMS PROCESS	0	6118	10	4597	0	67	0	78

O&M Cost (Rs/m3) for 5.5 MLD capacity

S.No	Description	Operating Cost
I	**Variable Cost**	
	Power, Diesel, Chemicals, Cartridge Filter, Sludge Handling Charges, Maintenance & Firewood Cost	**112.4**
II	**Fixed Cost**	
	Power, Manpower Cost, Replacement, Standard Maintenance, Lab Chemicals, Admin & Statuary	**34.5**
	Basic Operating Cost (Rs/m3)	**146.9**
III	**Depreciation Cost**	**16.6**
IV	**Financial Cost**	**17.7**
	Total Operating Cost (Rs/m3)	**181.2**
V	**Recovery Cost (Rs/m3)**	
1	Cost of recovered Water(INCLUDING BRINE), Rs.70/Kl @98% recovery	68.6
2	Cost of recovered Sodium Sulphate salt @ Rs.10/Kg for 90% recovery of salt	63.0
	Total Recovery Cost (Rs /m3)	**131.6**
	Net Operating Cost (Rs/m3)	**49.6**

Financial Impact of ZLD for a Textile CETP

S.NO	Items	Unit
1	Capacity of CETP	5500 m3/d
2	Water consumption for dyeing	60L/Kg of Fabric
3	Total production capacity per day	92 tonnes
4	Processing cost of dyed fabric –	80 Rs/Kg
5	Processing Cost per day	Rs. 74 Lakhs
6	Cost of ZLD system @ Rs. 49.6 Rs/KL net for 5.5 MLD	Rs. 2.73 Lakhs
7	Cost of ZLD per Kg of dyed fabric	2.97Rs/ Kg
8	% of ZLD cost on Processing Cost of dyed fabric	3.7%

Basis

Liquor Ratio	1:3.5	1:6	1:8
Water Consumption	40	60	80
Hrs of Operation	6-8	8-10	10-12

Shade	L	M	D
Processing Rs/Kg	40-60	80	100

Section E : The Way Forward

THE WAY FORWARD.. 1

Environmental Sustainability Issues	Aspects
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. Generation of mixed Waste Salt, particularly from chloride effluent based evaporator system and disposal to TSDF. 2. Generation of products from the mixed salt.

THE WAY FORWARD.. 2

Environmental Sustainability Issues	Aspects
3. Energy Savings	Reducing Energy consumption/ Carbon Foot Print in processes, avoidance of firewood, use of solar & wind energy.
4. Eco-restoration of Noyyal River	1. Dam & River clean up 2. Soil remediation of contaminated agricultural lands 3. Restoring the tanks & canals- basin management 4. Development of Salt tolerant wet land 5. Industry & Agriculture to work together with Government on all the above

THANK YOU

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