International Journal of Environmental Engineering and Management
ISSN 2231-1319 Volume 7, Number 1 (2016), pp. 25-33

http://www.ripublication.com

Zero Liquid Discharge (ZLD) in Industrial Wastewaters in India-Need for Sustainable Technologies and a Validated Case Study

S. Virapan[a], R. Saravanane[b] and V Murugaiyan[b]

[a]Joint General Manager, Larsen & Tourbo Limited, Chennai
Email id: virapans@gmail.com, Ph.+91 9444036627
[b]Professor, Dept of Civil Engineering, Pondicherry Engineering College, Puducherry
[c]Professor, Dept of Civil Engineering, Pondicherry Engineering College, Puducherry

ABSTRACT

Man needs Roti, Kapada and Makan (Food, clothing and shelter). The Kapada needs to be coloured else dirt shows up instantly and this results in residual colour and salt often in effluents. None of the individual effluent treatment plants (IETPs) or common effluent treatment plants (CETPs) in India have ever publicly staked a claim to their consistent ZLD achievement. It is all traceable to the famous Murphy's Law which says "If a thing can go wrong, it will" The textile industries of world's knitwear capital at Tiruppur in India are now languishing with only 30 % of installed production being permitted and that at Karur in India, another big capital of rugs having been totally closed down and the situation is other centers in Gujarat, Rajasthan, Maharashtra heading towards the similar fate. It is almost the same tale in the tannery sector. The bulk of CETPs are along the Palar River in the south of India. This monsoon dependant river has overland flows only for a couple of weeks in a whole year. The discharge of unsalted effluents all along has effectively closed down some of the intake wells in the river bed which were supplying drinking water to many towns. The UNIDO demonstrated a pilot plant for soak liquor evaporation by thin film spreading on roof top structures and spray systems finally culminating in solar ponds but then the USTDA which later on made a DPR for the ZLD of tannery CETPs and the PCB did not give weightage to this and perpetuated the thermal evaporators. The simple issue is while the pre-treatment of effluents by biological, chemical and membrane technologies for a true ZLD have been almost standardized it is the reject waters with salt concentrations and colours which are the problem. These are treated more in lapses or surreptitious discharges than concordant performances of salt-liquid separation and containment. A three phase mass transfer technology of falling film on drapes hung from a crib and cascading the reject effluents has been demonstrated by the Zuckerberg Institute for Water Research, Ben Gurion University and Middle East Desalination Research Center (MEDRC) as early as 2004 in Israel and the United Nations Industrial Development Organization (UNIDO) has demonstrated in field scale a non-mechanized nature based spray technology here in India way back in 2006 and, but still the thermal mechanized non-sustainable evaporators are being forced down on the industry by the Pollution Control Boards (PCBs) possibly driven by the marketing by the vendors. Written in this background, this article brings forth the validation of a modified falling film technology demonstrated on textile spent dye bath and another on reverse osmosis (R O) rejects. Whether this will pave the way for a renaissance and resurrect the industry or go the same way of the other earlier attempts is for the time to tell in the future. The author has the satisfaction that at least his Ph D work has resulted in this validated and sustainable option.

KEYWORDS: Closure of Textiles and Tanneries by Courts, ZLD, R O Rejects, Net Evaporator, Three phase mass transfer, Evaporation Index, O&M cost, Sustainable, MEDRC

THE PROPHECY OF MURPHY'S LAW AND ITS REALITY

The CETPs were sanctioned by the Government of India in 1997 with a technology of simple Lime-Ferrous precipitation and sludge dumping on the banks of the water courses. The discharge standards permitted total dissolved solids (TDS of 5000 mg/L when its own standards for other effluents were only 2100 mg/L. This violated its own law but also doled out 70 % of taxpayers' money as subsidies. The section 17 (f) of the 1974 water act mandates the PCB to evolve efficient methods of disposal, but then the PCB has done precious little-even as of today. The CETPs also did not take any initiative because of the Draconian law section 25 of Chapter-III of the Water Act which prohibits and initiative by the industry to try and in-house R&D. The court all of a sudden in 2010 ordered the closure of these CETPs as they have not met the ZLD. The travesty is there was no technology to achieve ZLD. Whereas the add on by way of membranes were somehow managed, the R O rejects was a mystery. The PCB for some reasons best known to it prevailed on the CETPs to buy the thermal evaporator from a specific vendor when their technology or equipment has not been proved. Till date these are camouflaged installations only. Thus Murphy's Law became a reality-at the expense of taxpayers' money and caused by none other than the PCB itself.

WHY THE THERMAL EVAPORATOR FAILS-THE O AND M COST

The main reason was the financial inability of the industry to meet the operation and maintenance cost by way of electrical power as in Tables 1 and 2 hereunder.

Table 1: Electrical Power Consumption in ZLD Encompassing the Thermal Evaporator

Sl No	Component of ZLD	kWhr / cum of feed	% of effluent	Equivalent of raw
1	Primary Treatment like equalization, chrome precipitation, neutralization etc	0.9	100	0.9
2	Biological Treatment in aeration	1.5	100	1.5
3	Cross Flow membrane filtration	3.2	100	3.2
4	Reverse Osmosis desalting membrane filtration	2.4	100	2.4
5	Thermal evaporation	6.0	15	0.9
	Total / cum of raw effluent			**8.9**

Table 2: Operation and Maintenance (O&M) Cost in INR / cum of Feed

Sl No	Component of ZLD	With MVR +MEE (A)				With MEE only (A)			
		Chemical	Power	Steam	Total	Chemical	Power	Steam	Total
1	Primary Treatment	6.00	9.00	0.00	15.00	6.00	9.00	0.00	15.00
2	Biological Treatment	0.50	15.00	0.00	15.50	0.50	15.00	0.00	15.50
3	U F membrane	0.50	32.00	0.00	32.50	0.50	32.00	0.00	32.50
4	RO membrane	3.25	24.00	0.00	27.25	3.25	24.00	0.00	27.25
5	Evaporator	36.00	45.00	22.50	103.50	36.00	60.00	87.00	183.00
	Totals	46.25	125.00	22.50	193.75	46.25	140.00	87.00	273.25
Split up of Costs per Kl for Each Section									
		MVR+MEE				MEE only			
Primary		15.00				15.00			
Biological		15.50				15.50			
UF + RO membrane		59.75				59.75			
Evaporator		193.75				273.25			
The effluent going into evaporator as derived from R O reject is about 15 %. Thus, the equivalent cost for evaporator based on the raw effluent volume will be 15 % of the true evaporator O&M cost									
Evaporator O&M		29.00				41.00			
The total O&M cost		120.00				132.00			

(A)-MVR-Mechanical Vapour Recompression; MEE-Multiple Effect Evaporation
Source-Implementation of ZLD, N Abdur Rahman, LERIG-CLRI-2014

When the CETPs were set up initially for merely adding Lime and Ferrous Sulphate and discharging the treated effluent without removing the TDS, the O&M cost for the industry was only INR 15 per Kl of raw effluent. When suddenly the ZLD was slapped this shot to 120 / 132 at a 850 % jump. Clearly, the blame for not achieving the true ZLD will apportion to the PCB as well because it has not brought out a sustainable technology and became like the (in)famous Shylock of Shakespeare drama.

The Alternative System Demonstrated and Validated Now

The high salt wastewater is collected in a sump at ground elevation and is pumped up and sprayed as a thin nozzle spray on nettings hanging from a crib frame and slide down to get collected in the same sump. The thin film of the applied wastewater gets into a tree phase mass transfer wherein the aqueous content evaporates, the salt gets concentrated and slithers down due to the higher viscosity and the recirculation brings about repeated cycles of evaporation to keep on concentrating. A line diagram of the system is shown in Fig. 3 hereunder.

In the system in Fig.2, the evaporative surface in the netting is 1512 sqm as compared to only 67.86 sqm in the sump and it shows a significant increase in evaporative area compared top pan evaporation.

Figure 1: Photo plate of Net Evaporator at JITPPL at Jaipur for R O Rejects of Textile CETP
Top-Bird's eye view of evaporator showing the modular addition flexibility of technology upgrades sustainable locally.
Middle-The diffusion strategy of application of the R O rejects on top of the vertical faces of nettings to bring about maximization of resulting area of two phase mass transfer for a given volume of R O rejects on a specific area of the nettings.
Bottom-Transverse view of nettings showing the cross wind movement passages to enable the two phase mass transfer from the falling films of R O rejects on the sides of the nettings.
Photo Courtesy-The Managements of M/S Jaipur Integrated Textile Park Private Limited, Bagru, Rajasthan India, M/S Infrastructure Leasing and Financial Services & M/S the European Union.

Figure 2: Photo plate of Net Evaporator for ZLD of Spend Dye bath at M/S Suntex Processing Mills, Chennai for 40 cum / day of wastewater at about 55,000 mg/L of TDS
Top-Bird's eye view showing the arrangement of net drapes one behind the other and perpendicular to the viewer and the author in the forefront
Bottom left-The suspension of drapes from a crib support with provision for easy access
Bottom right-Transverse view showing the texture for air passage through the drapes weave

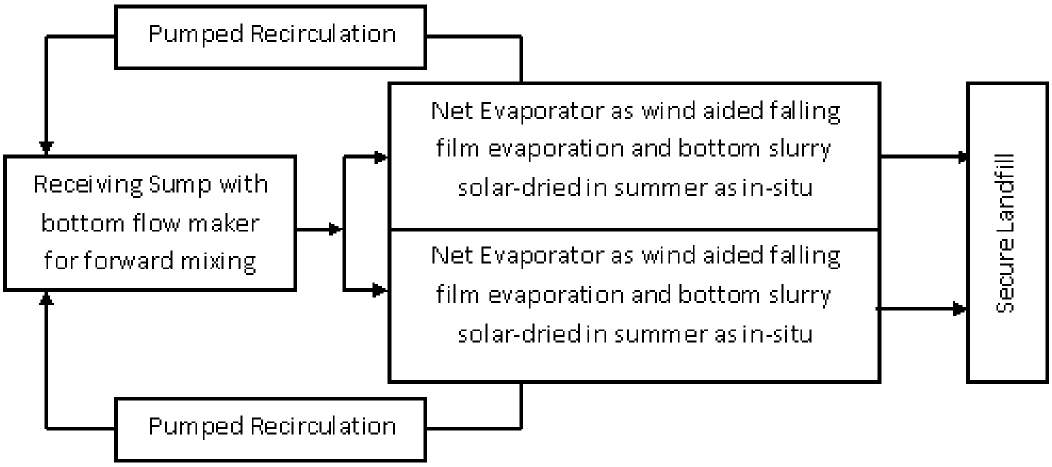
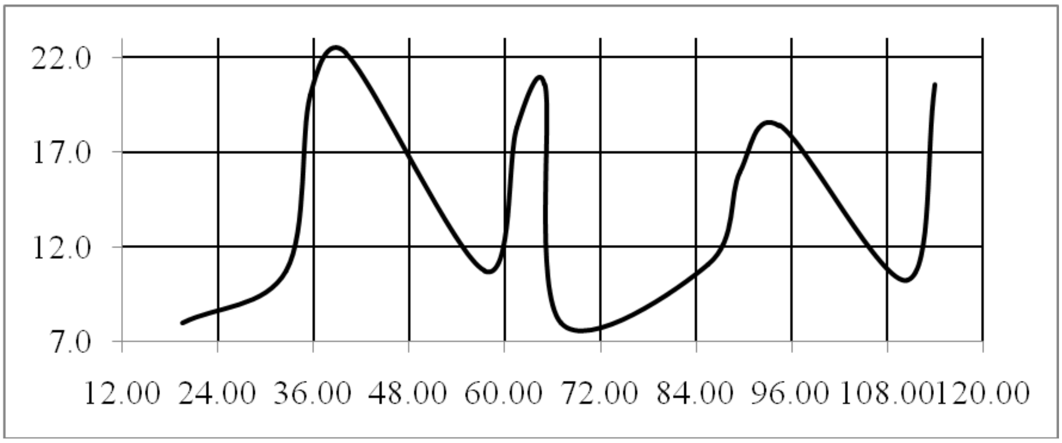


Figure 3: Schematic of the Demonstrated Alternative System for High TDS Wastewaters



X-axis, Cumulative Time in 24 hour Mode
Y-axis, Evaporation Index as multiple of Observed to Pan Evaporation.
Evaporative Index is evaporation times that of pan evaporation. For example, considering 35.5 to 40 hours, it is ((44-41.5)*(10)*24)/(4.5*6)=22.2 where 6by considering pan evaporation at 6 mm / day during the study from meteorological data.

Figure 4: Variation of Evaporation Index with Cumulative Time in the Study System

INFERENCES

The following inferences manifest themselves:

There are rising and falling trends in EI in the day and night hours and reinforces the concept brought of Dalton who cited the solar radiation and sky radiation as influencing factors. The solar radiation is at its maximum during day time when the sunlight is impacting the evaporative surfaces. The corollary is also answered by way of the EI results in night hours.

There are trends of high EI during the higher TDS values in the beginning and the TDS increase. It however becomes a question of finding answers to the question of the same value of EI at differing TDS values also.
It reveals the need to embark on this much needed line and identify a regimen for pilot testing to get at hard core basics than getting mired into dexterous mathematical models by contriving relationships of parameters in arbitrary terms.
Many an industry has felt the negative impact of ZLD as there are no reliable answers to R O rejects management. The phase separation system as now evaluated is actually an ad-hoc installation from which workable inferences have been extracted.
The O&M cost of this evaporation system is hardly INR 10 per Kl of its feed compared to INR 180 for the thermal evaporator and thus this system needs to be supported by the PCB.

ADVANTAGES

1. Eliminates steal generators as induced thermal evaporative operation
2. Eliminates complicated mechanical and electrical infrastructure
3. Eliminates metal scaling and corrosion problems
4. Eliminates dependence on specialist trained high-skill operators
5. Eliminates dependence of vendors for equipment repairs and renewals
6. Eliminates back up high energy diesel generator sets
7. Eliminates need to keep the set-up “warm” even during “no-Reject” periods
8. Eliminates O&M costs as close to about INR 200 / kilolitre of R O Rejects
9. Eliminates random specifications as there is no BIS code of practice
10. Completely nature based system with two phase fluid-air mass transfer
11. Permits switch-on and switch-off as and when needed
12. System uses only an ordinary centrifugal foot mounted pump set
13. The nettings are readily available off the shelf green-house nettings
14. Efficiency can be maximized using spray nozzles for application on nettings
15. Rainy days also bring about evaporation and does not need shut down
16. Temporary roofing using tarpaulins over truss work protects from direct rainfall
17. O&M cost is a maximum of INR of only about Rs 15 / kilolitre of R O Rejects
18. System can be fabricated by locally available masons and fabricators
19. Permits preventive maintenance by removing and re-erecting the nettings easily
20. Above all can be locally designed, built and operated even in remote locations

CONCLUSIONS

The textile and tannery sector in India is facing a survival crunch on the ZLD front due to the insistence of thermal evaporators by the PCBs when dealing with the R O reject effluents. The system now demonstrated and validated can help reverse this trend as the O&M cost is hardly INR 10 / Kl of feed to the system as compared to INR 130//KL for the thermal evaporator system. Besides, the system is not dependant on vendors and can be fabricated locally as well.

REFERENCES

1. Government of India, Water Prevention and Control of Pollution Act (2), 1974, chapter 4, powers and functions of the Board, clause (g)
2. Palar, TNPCB told to close tanneries polluting Palar, India Environment Portal, Website http://www.indiaenvironmentportal.org.in/taxonomy/term/769
3. Vellore citizens welfare forum vs. Respondent: Union of India & Ors. Date of judgment: 28/08/1996
4. Supreme Court of India, Noyyal Aytacurdhars Vs Tiruppur Textile Industries, Judgement in Civil Appeal no.6776 of 2009 @ special leave petition (civil) no. 6963 of 2007
5. Rao, N.S., R.T.N. Venkateswara, G.B. Rao and K.V.G. Rao, Impact of reject water from the desalination plants on ground water quality, Desalination 78 (1990), pp. 429-437.
6. Accelerated Evaporation of Saline Streams in Solar Pans, UNIDO, mm Regional Programme for pollution control in the tanning industry in South East Asia, US/RAS/92/120, September, 2001
7. J.Gilron Ben Gurion University, Israel, The Middle East Desalination Research Center, Muscat, Sultanate of Oman, MEDRC Series of R&D Reports, MEDRC Project: 00-AS-020 Zuckerberg Institute for Water Research, November 2004
8. Mohamed, A.M.O., M. Maraqa and J. Al Handhaly, Impact of land disposal of reject brine from desalination plants on soil and groundwater, Desalination 182 (2005), pp. 411-433.
9. Ligy et al., Performance evaluation of a solar and wind aided cross-flow evaporator for RO reject management. Desalination 317 (2013), pp 1-10