Optimizing Water Use & Associated Costs: A Water Audit Case Study by FICCI on a Cigarette Manufacturing Plant

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"Optimizing Water Use and practicing logical recycling & reuse by knowing Water & Wastewater Management Costs"

Sourcing & managing water is becoming increasingly difficult & hence important aspect for organizations. Also, Substantial costs are associated with water management, like rising water prices, water cess, cost of pumping, cost of water & wastewater treatment etc. The in-house expertise available towards water & wastewater management is generally limited therefore many organizations are looking for external expertise to assist them improve their water systems through detailed Water Audit Studies.

Water Audit –Potential of 30% freshwater reduction

FICCI conducted a detailed water audit study for a Cigarette Manufacturing Plant having water requirement of about 500 KLD (Kiloliters per day). The plant was producing approx. 11643 million cigarettes and 6238 tons of tobacco per annum. Due to the non-accessibility of river water and poor quality of available groundwater in the region the plant was facing various water related problems. The plant initiated various water saving schemes proactively and also approached FICCI for further improvement in their water management system. FICCI conducted a detailed water audit study for the plant taking into account water logistics, water costing at various use locations, wastewater quality, identifying water recycle & reuse opportunities and feasibility of practicing Rainwater Harvesting etc. The study came out with many cost effective schemes and modifications in the existing system with the potential of reducing freshwater consumption up to 30%. The plant implemented some of the suggested schemes within 6 months and achieved about 15% reduction in freshwater water consumption and substantial monetary savings.

Unwrapping Hidden Water Costs

During the water audit study at this plant many interesting facts were observed by the team related to water costs and wastewater treatment & reuse, which indicated that the industries needs to know their water management associated costs and should practice logical recycling & reuse of wastewater considering wastewater quality & regeneration costs. Examples are seen in many industries that the industry install wastewater treatment plant at tertiary level so as to recycle/reuse treated wastewater. Despite of industries incurring substantial costs in treating their wastewater; this 'costly resource' which could be reused for a 'high value use' is generally used for either landscaping/gardening or flushing toilets. It is seldom that the cost of water & wastewater is calculated by the unit at various use locations.

Initially, when the cost of fresh water was asked from the studied plant, they reported it Rs 0.20/m3 as water cess which they were paying to the Water Authority. However, the plant was unaware of the other associated water costs which they were bearing after procuring the water like cost of energy & water treatment chemicals etc. FICCI calculated the value added 'cost of water' at various water use locations for the plant considering the 'pumping costs' and 'water treatment chemicals costs'; the cost ranged between Rs 1.16/m3 to Rs 41.5/m3. The average water cost was calculated to be about Rs 13/m3 as discussed in article below.

Before water audit, the plant was under impression that they are paying only Rs 0.20/m3 for the fresh water withdrawal and therefore the motivation towards water saving was limited and even excess water was

pumped and used in many areas. After the value added costing, the unit understood that the cost of water from the 'procuring stage' to 'end use' increases manifolds and thereby optimizing water use and eliminating leakages & overflows is one of the key factor towards sustainable water management.

Therefore, the water cost analysis in industries at various water use location is necessary. We need to understand that any amount of excess water entering into our system is a 'burden' to the system as it involves various costs like water pumping costs, treatment cost, wastewater treatment & disposal costs and labor costs.

Water Audit – Key Observations

Some of the key observations made during the Water Audit Study of Cigarette manufacturing plant are shared in this article with the objective of experience sharing and analyzing the issue of water & wastewater costs and water logistic management.

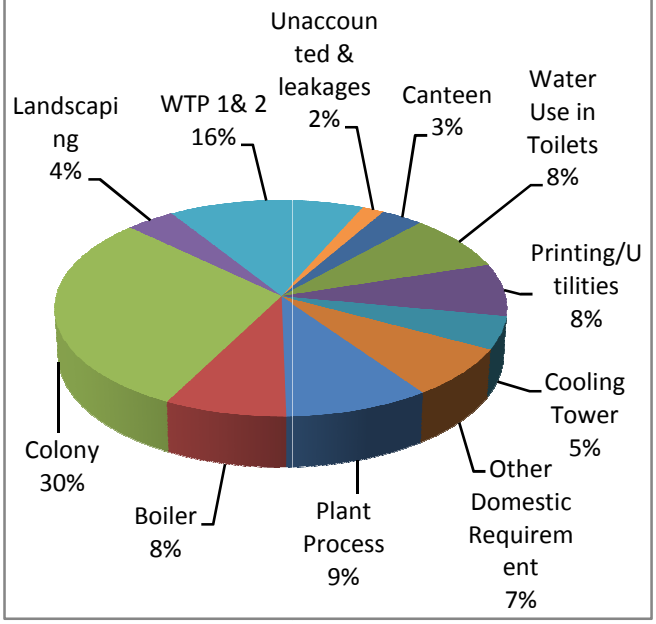
Water Use Pattern and Water Costs

The total water requirement of the studied Plant was measured to be about 510 m3/day which includes 420 m3/day of groundwater and 90 m3/day of recycled water. The groundwater was drawn from the 2 nos. of bore-wells and it contained high Iron and TDS levels which needs to be removed before its use in various sections of the plant. The plant had installed 2 nos. of Water Treatment Plant (WTP 1 & WTP-2) for treating the bore well water. The WTP 1 consists of Multi Grade Filter (MGF), Iron Removal Filter (IRF) and Softener Unit and the treated water from WTP 1 was used for Plant Canteen, drinking, printing section and for the plant colony requirements. The WTP 2 also consists of a MGF, IRF, Softener and RO (Reverse Osmosis) Plant. The treated water from WTP 2 is used for Plant Process (Process Humidification /Spraying) and for steam generation in boilers. The water use pattern for the plant is shown in table 1 & fig 1.

Table 1: Water Usage Areas

S.No.	Water Usage Area	Water Consumption (m^3/day)
1	Canteen	17
2	Water Use in Toilets (Mainly Recycled Water)	43
3	Printing/Utilities	40
4	Cooling Tower	25
5	Other Domestic Requirement	38
6	Plant Process	48
7	Boiler	40
8	Colony	151
9	Landscaping (Recycled Water)	20
10	WTP 1& 2	79
13	Unaccounted & leakages	9
	Total	**510**

Fig: 1 Water Usage Pattern in the Plant



The water use pattern was prepared through detailed field studies and water flow measurements using ultrasonic flow meter and bucket & stop watch method. It depicts the quantity of water used at various use

locations. In addition to water balance & water use pattern, FICCI also calculated the cost of water at each location considering cost of pumping & chemicals costs as shown in Table 2 & Figure 2.

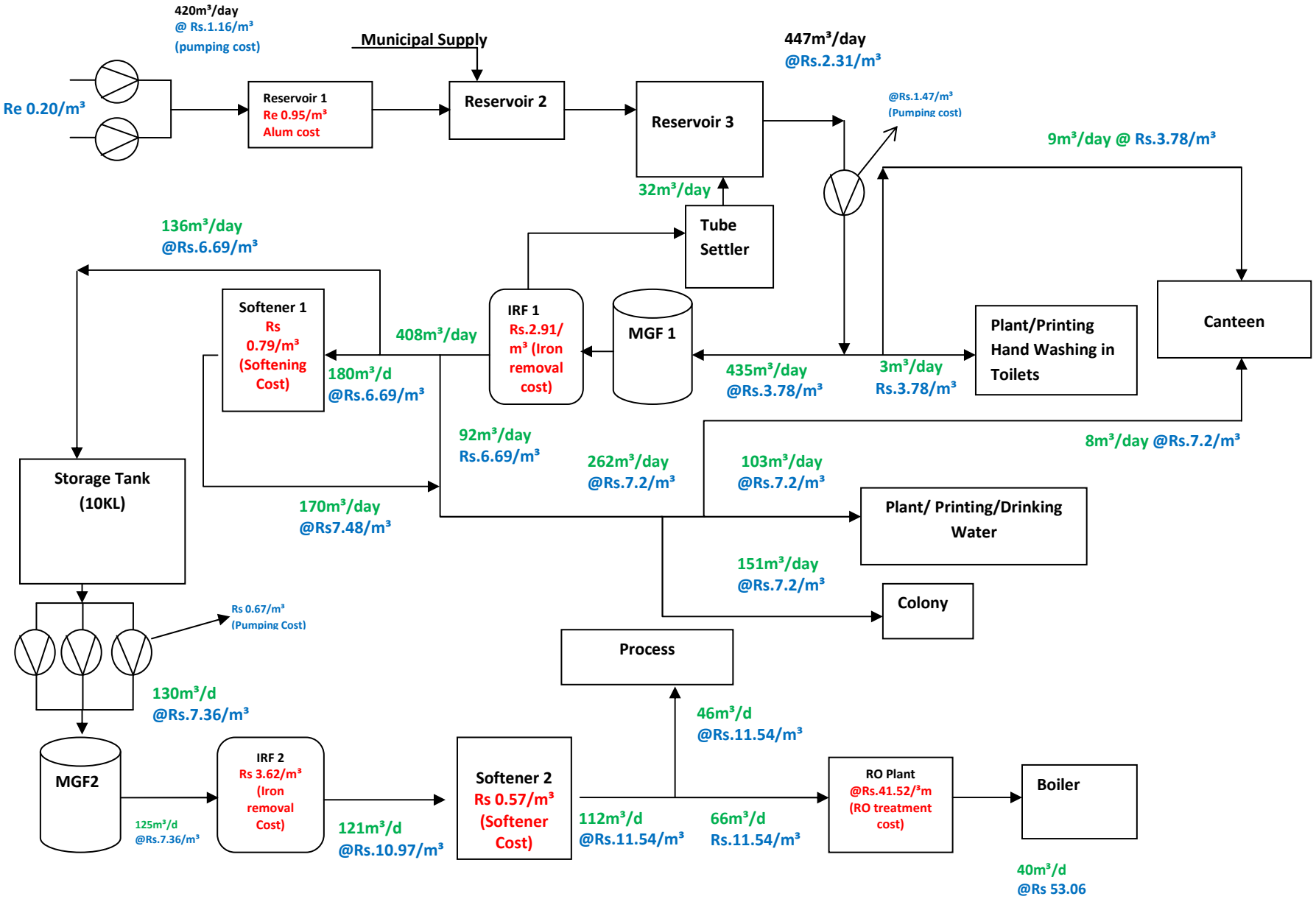
Table 2: Water Cost at each use location considering pumping & water treatment costs

Water Usage Area	Water Consumption (m^3/day)	Cost (Rs./m^3)	Cost (Rs/day)
Canteen	9	3.78	34
	8	7.2	58
Hand washing/Toilets	3	3.78	11
Drinking Water	103	7.2	742
Tobacco Processing Division	46	11.54	531
Boiler	40	53	2120
Process Humidification	2	41.52	83
RO-1	24	41.52	996
WTP-1&2(MGF& IRF)	36	3.26	117
Soft.1&2	9	0.57	5
	10	0.79	8
Colony	151	7.2	1087
Total	**441**		**5792.51**

It was amazing to know that the initial cost of ground water at the rate Rs 0.20/m3 increased at each level of water pumping & treatment. As the plant was a 'food grade' unit, it needs to maintain the high water purity for the processes and other important locations. Since the bore-well water was high in Total Dissolved Solids (850-950 mg/l) and had high iron content, it requires water softening as well as iron removal treatment. The unit had also installed a RO plant to remove the Total Dissolved Solids (TDS) for use in the boilers. Also the water was pumped at various levels from bore-wells to reservoirs/storage; storage to water treatment plant I & 2; from WTP to user area etc. adding to energy costs.

The water cost analysis makes it easier to understand the 'value' of water at used location and also highlights the associated monetary savings if water consumption is reduced. This also helps in motivating the plants to implement water saving schemes as pay back periods gets reduced.

Figure 2: Water Treatment Cost of the Plant



Wastewater Recycle/reuse and its Costs

The water management costs also include the treatment & disposal of wastewater. Therefore, the costs of wastewater reuse & recycle were also calculated. Total effluent generation of the plant was about 140 KLD. Wastewater was generated from different sections which includes Canteen, Boiler, process, RO unit, Softner-1, Softner-2, Domestic activities and Cooling Tower. The wastewater generated from the various sections was treated in Effluent Treatment Plant (ETP) to meet the discharge norms and subsequently in ERS (Effluent recycling System) plant for reuse in the unit. The ETP consists of equalization tank, aeration tank, secondary clarifier, flash mixture, flocculator and sand bed filter. The effluent was treated at the rate of Rs. 1.54/m3 at ETP and the electrical cost of operating the ETP is Rs. 14.8/m3. Therefore, the Total Cost of Effluent Treatment at ETP comes out to be Rs. 16.35/m3.

Some of the treated water at ETP is supplied to ERS Plant for further purification and use as Cooling Tower Make-up water. The ERS Plant consists of one MGF, two Ultra-Filtration and 3-stage RO unit. The cost of treatment at ERS includes the Chemical Treatment cost with Sodium Hydroxide, Sodium Hypochlorite, HCl & Antiscalant and Electrical Cost for running of ERS. The effluent is treated at the rate of Rs. 88/m3 at ERS and the electrical cost of operating the ERS is Rs. 22/m3. Therefore, the Total Cost of Effluent Treatment at ERS comes out to be Rs. 110/m3.

It was surprising to see that the unit was using ERS treated water @ Rs 110/m3 for cooling tower makeup in the name of 'effluent reuse' whereas this purified water could have easily be used as boiler feed water as high value use.

Rationale of Wastewater Reuse/recycle

It was also observed that the plant was practicing various 'wastewater recycle & reuse' schemes evolved irrationally leading to poor performance of ETP & ERS. For example the unit was using ERS RO reject water having TDS in the range of 3880 mg/l for flushing the toilets and the sewage generated from the toilets (with high TDS) is taken directly into the Aeration tank of ETP. The aeration tank is receiving effluent form equalization tank having TDS in the range of 1200-2000 mg/l. It results in sudden increase of TDS load on the aeration tank which hampers the performance of the biological treatment and removal of BOD. Since the existing ETP is not equipped to remove TDS from the effluent the treated effluent from the ETP contains the TDS in the range of 3100-3400 mg/l. The TDS from ERS RO reject keeps on moving from sewage water to aeration tank to flocculation & filtration etc. Therefore it is suggested that the unit should not use high TDS sewage water in the ETP Aeration Tank or should stop using high TDS water for flushing to improve the performance of existing ETP.

Waste Minimization and water reduction in Tobacco Processing Division

It is observed that the tobacco Processing division uses about 50 KLD of water in various sections mainly for cleaning & washing activities. The conveyor belts in each line are cleaned once per day with soft water. The machines are also cleaned by automated system 2-3 times per day. The drains in the tobacco Processing division are supposed to be cleaned by ETP recycled water however it was noticed that due to non-availability of ETP recycled water at some points and lack of awareness among workers, the drains were cleaned by soft

water in an inefficient way. The hose pipes in the tobacco Processing division lack nozzles and have water flow rates in the range of 17-20 l/min leading to use of large quantities of water. It is also observed that substantial quantities of tobacco dust falls from conveyor belts during the processing and significant quantities of tobacco dust is sticking to the machines & conveyor belts which gets washed away during cleaning & washing activities. The tobacco dust is responsible for increasing the TDS levels in the wastewater. The TDS of the tobacco Processing division wastewater collection tank was measured to be about 2200 mg/l. Therefore it is suggested that the unit should take the following steps for waste minimization & reduction of water use:

- **Dry Removal of tobacco dust from conveyor belts & floors:** The tobacco dust from conveyor belts should be removed by using dry cloth before washing it with water. The tobacco dust from the floor should be lifted & collected in the container for reuse. The practice of 'dry cleaning' followed by 'wet cleaning' will reduce the tobacco dust in the wastewater resulting in reduced TDS & Biochemical Oxygen Demand (BOD) load in the ETP by 30-50%.
- **Use of Water Efficient spray nozzles for cleaning in tobacco Processing division:** The hose pipes used for cleaning in the tobacco Processing division should be fitted with efficient spray nozzles which uses less water (8-10 l/min) and more effective for cleaning purposes. This will reduce the water consumption by 10% in the tobacco Processing division. For application of conveyor belt washing - Flat fan spray nozzles can be used across the belt. Water consumption is about 9 LPM at 2.0 kg/cm sq. pressure.

Water Saving in the Canteen

It was observed that the canteen consumes about 17 KL per day catering to about 1200 employees. The major consumption points in the canteen were drinking & cooking, Utensil & Floor Washing and Hand washing. It was observed that about 8 nos. of taps with 15-24 lpm flow rate are dedicated for hand washing which has drinking water quality. The drinking water was also available inside the canteen in 3-4 drinking water containers. The utensil washing taps (about 8 nos.) were having high water flow rate about 25-33 lpm. Also the canteen drains do not have proper mesh for retaining the washed food particles. The Canteen generates about 13 KLD of wastewater which contains food particles & oil which increases its BOD.

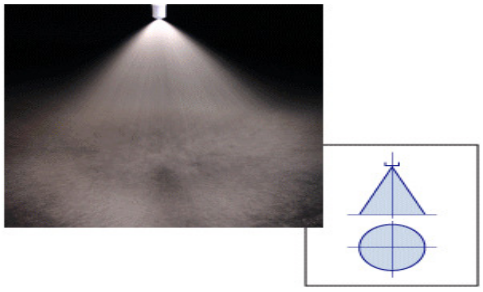
Therefore it is suggested that the following steps should be taken by the unit to reduce the water consumption and its wastage:

- **Separating Hand-wash water from drinking water and Use of Efficient Low-Flow aerated water taps for hand-washing:** The 8 nos. of hand washing taps should not receive drinking water quality water and should be used only for hand washing. The drinking water is already available inside the canteen in the drinking water containers. It was observed that in the canteen about 8 nos. of taps (having drinking water quality) with 15-24 lpm flow rate are dedicatedly used for hand washing. Therefore it was suggested to use efficient low-flow aerated taps for hand washing having flow of about 8-10 lpm instead of existing 15-24 lpm. This will reduce the water flow by 50% and will save about 1.5 KLD.

- **Use of Efficient spray nozzle in water taps for utensil cleaning & fine mesh for controlling food particles in the wastewater:** It was observed that the canteen has 8 nos. of utensil washing taps (having filter water quality) with high flow rates of about 25-33 lpm. About 9 KLD of water is used for utensil washing & floor cleaning using these taps. The excess flow in the water taps was leading to water wastages. Therefore it was suggested that the 8 nos. of utensil cleaning taps should be replaced by efficient spray type taps having flow of about 15 lpm instead of existing 25-33 lpm. This will reduce the water flow by 40-50% and will save about 3.6 KLD. The unit should install fine mesh at utensil washing drains for controlling entry of food particles in the wastewater. For Utensil washing umbrella shape spraying pattern nozzles may be used. Single nozzle consumes 2.5 LPM water at 2.5 kg/cm sq. pressure. More than one nozzle can be fitted in one header as per requirement (M.O.C. of nozzles- SS 304). Full cone spray type nozzles can also be used for washing & rinsing purposes as shown below:

- **Full Cone Spray Nozzles**





FICCI Water Audit other Recommendations

FICCI studied all the sections of the plant and suggested various schemes focusing at demand side management; modifications for improving ETP performance; Energy saving opportunities; recycle & reuse opportunities; zero discharge schemes etc. with the potential of reducing more than 30% of fresh water consumption in the plant. Some of the schemes implemented by the unit to achieve 15% reduction in fresh water consumption are summarized below with payback period and benefits.

FICCI Water Audit Recommendations implemented by the unit

S.No.	Recommendations	Annual Water/Energy Saving	Investment (Rs in lakhs)	Annual Monetary Saving (Rs in lakhs)	Pay Back Period (Yrs)
I	**DEMAND SIDE MANAGEMENT & WATER SAVING OPPORTUNITIES**				
1	**Water Saving in the tobacco Processing division** • Dry Removal of tobacco dust from conveyor belts & floors before washing with water spray • Use of Water Efficient spray nozzles for cleaning in tobacco Processing division instead of conventional water pipes	1750 (5 KLD)	0.18	0.5	0.36
3	**Water Saving in the Canteen** • Use of Efficient Low-Flow aerated water taps for hand-washing • Separating Hand-wash water from drinking water • Use of Efficient spray nozzle in water taps for utensil cleaning	1400 (4 KLD)	0.20	0.31	0.6
4	**Water Saving in the Reservoirs** • Cover reservoirs to minimize evaporation losses & avoiding falling dirt in the Reservoirs	474 KL (1.3 KLD)	0.04	0.01	4
6	**Plug Leakages**	1640 KL (4.8 KLD)	0.03	0.09	0.33
II	**ENERGY SAVING OPPORTUNITIES**				
13	Segregation of High TDS streams (softner 1 & 2, RO 1 rejects, CT & Boiler blow down)and bypassing the Aeration Tank &	24500 KWH (70 KWH/day)	0.50	1.34	0.3

	Secondary Clarifier in ETP to put it into flash mixture				
III	**RECYCLE & REUSE OPPORTUNITIES**				
14	Installing Automatic pH Control System for adjusting the pH of ERS permeate for its reuse in AC Cooling towers as make-up water	7000 KL (20 KLD)	0.50	0.15	3.3
IV	**OTHER SUGGESTIONS**				
18	Stop the practice of adding un-quantified Ferric Alum in the Reservoir no. 1		-	1.4	Immediate
19	Prepare & Maintain log-books for all main pumps & monitor pump performances regularly				

CONCLUSION

The above case study shows that the Water Audits are important for improved & sustainable water management in the water using organizations. However, to maximize the benefits, water audit needs to be conducted by experience & qualified service provider. A Water audit must integrate water/wastewater costs & logistic in addition to other activities. A water audit conducted with logical approach will not only help in water saving but also help in energy conservation, reduced effluent generation and associated treatment costs, thus reducing unit cost of production. Therefore, the industries especially water intensive sector needs to know their water management associated costs to practice rational recycling & reuse of wastewater considering wastewater quality & regeneration costs. A detailed water audit study can be an important tool to optimize water use and its associated costs.

About the Authors



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