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An Approach for Sustainable Industrial Water Management: A Case Study

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Abstract **- This study is to evaluate the present water management practices followed at an industry by conducting facility survey and preliminary water audit. Based on the observation and audit, opportunities for water conservation, by adopting an integrated water management strategy was suggested. Also water Acts related to industrial water management was studies to understand its role in pressurizing industries for water stewardship. The work demonstrated that many opportunities existed to improve water conservation through technical, cultural and behavioural adaptations. These included the use of alternate water sources such as rainwater runoff, reuse of water within process units, and need for an overarching water policy to minimise water use and effluent discharge. A conceptual model for water metering and accounting was developed. To involve all the stakeholders for sustainable water management, an awareness program for the employees, interview with the water managers were conducted and their view and opinion on water management were given importance.**
Keywords: **Integrated approach, stakeholder, water acts, Water audit**

I.INTRODUCTION

Water is a shared resource that is under tremendous strain, as sectors, such as agriculture, industry, domestic and environment/ecology compete with each other for its use. With rapid industrialization, industrial demand for water is expected to increase by four-fold in the year 2050. Domestic and industrial water demands in Asia are growing rapidly at rates projected to range from 70 to 345 % between 1995 and 2025. Worldwide, the volume of water used by industries is estimated to rise significantly from 752 km^3/ year in 1995 to 1,170 km^3/year by 2025 (World Bank 1998). The industrial water demand is not only limited to direct water withdrawal for operational purposes at the facility level, but also spreads across watershed, sub–basin and basin-level as many industries rely heavily on the agricultural sector for their raw material inputs, as part of their supply chain.

In addition to water consumption, industrial water use is one of the main causes of water pollution today. Seventy percent of all industrial waste is dumped untreated into water bodies, resulting in water quality degradation.

In India, about 87 per-cent of the water is consumed for agriculture, followed by the industrial sector, which consumes about eight per cent. Industrial water use is closely linked to the economy of a country. As GDP increases, so will the industrial water consumption. Although industries make a significant contribution to economic growth, their non-compliance to pollution control measures has led to a continuously growing water pollution burden.

Higher water consumption in Indian industries is due to the sheer scale of inefficiency and waste in the industrial system, lack of proper information, dearth of price sensitive and predictive water management information and the lack of a proactive approach.

Industries require water that is reliable, accessible, and of acceptable quality, for its operations. Water scarcity and deteriorating quality, pose significant risks for companies. There are many examples closure of industries due to water crisis.

In order to mitigate the problems of water scarcity, an integrated approach is required, which focuses both on water conservation and on wastewater recycling.

The study aims at conducting a facility survey, preliminary water audit of an industry owned by the government which receives water from the municipal corporation for its industrial and domestic use within the industry and for its entire township.

II. LITERATURE REVIEW

The solution of sustainable industrial water management has to be achieved through a multifarious approach of not only improving the in-plant water use efficiency, but also to look beyond the paradigm of in-situ water management.(CSO Forum 2013 – 2014). Agana, *et al*., (2012) presents the application of Integrated Water Management Strategy consisting of water audit to completely characterize all water streams found at each production site, commercially available water pinch software was utilized to identify

possible water reuse opportunities and membrane process application, was deployed in series to systematically identify water conservation opportunities at two large Australian manufacturing companies. Barrington, *et al* .,(2013) investigated the use of water auditing techniques to examine water flows within a petroleum refinery south of Perth Western Australia, concurrently identifying practical ways for achieving water conservation. Both the primary and secondary level water audits indicated that there were a myriad of technical, cultural and behavioural issues preventing maximum water conservation on site. Federation of Indian Chambers of Commerce & Industry (2009) has submitted a report on Development of Water Accounting Guidelines for Different Sectors to Government of India. This Report identifies the water intensive industries and provides guidelines to develop a water balance, structure for water metering and monitoring to achieve zero discharge status. Chand *et al.,* in India Infrastructure Report (2011) highlight the Challenges and Implications for Water Pricing in industrial water demand. The authors conclude that though some of the issues related to the industrial water have been addressed in National Water Policy (NWP) 2002 but no clear vision for regulating and controlling industrial water use has been given. The key to the problem lies in effective management of water resources.

III. MATERIALS AND METHOD

A factory located at Chennai in India was selected for case study. The factory has a total area of 192.254 hectares .It provides the basic facilities like housing , school, hospital and other services to its more than 10,000 employees. It manufactures railway coaches. The study consist of conducting a survey to understanding the work processes, the role of water in each process, quality and quantity of water required and the quality of the wastewater discharged.

A. Facility Survey

Direct Observation and readings from the available flow meters and for the unmetered water where it was difficult to measure the quantity was derived with the understanding of the process and its water need. A flow diagram was prepared indicating the sources of water supply and its distribution to various units. The daily demand of water is estimated as 12 lakhs litres for the factory. The major part of water is supplied by the municipal corporation accounting to 7 lakhs litres per day. The secondary source is a lake situated near the factory from which 5 lakhs litres are pumped. The water is stored in ground level reservoirs at various locations and then pumped to overhead tanks. Reverse osmosis plant of various capacities are used to treat the municipal water and supplied for drinking to nearly 120 Sintex tanks of capacity 1000 litres each with RO point to the employees. The corporation water is used for industrial purpose like coolant, humidifiers; washing of process lines and process equipment, and also for domestic purpose like for washing uniforms, wash rooms etc. The lake water is used for gardening and for firefighting.

B. Preliminary Water Audit

The water audit as stated by American Water Works Association, 2006, typically traces the flow of water from the site of water withdrawal or treatment, through the water distribution system, and into customer properties. The water audit usually exists in the form of a worksheet or spread sheet that details the variety of consumption and losses that exist in a community water system.

Inputs from the facility survey and with the data collected, average water use per day, water use pattern, wastewater generation, grey water generation were recorded.

IV. RESULTS AND DISCUSSION

The results of the preliminary water audit is presented in Pie chart and tabulations to identify the possible interventions where would be conserved or used efficiently.

1. Water consumption Scenario

It is observed that the daily average consumption of municipal water is nearly 71 percentages as shown in the fig 1.

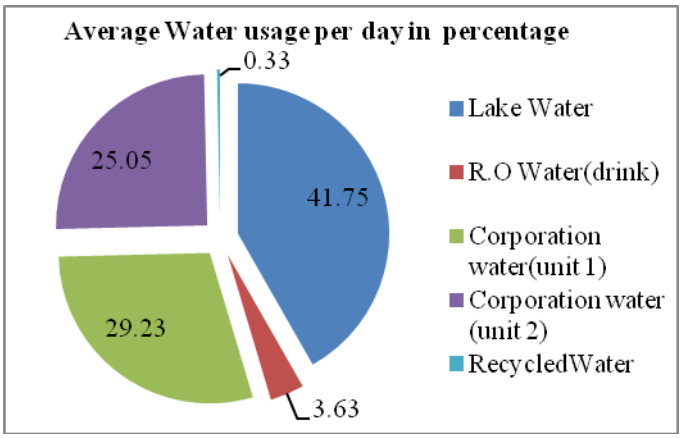

Fig.1 Average Water usage per day in percentage based on the nature of water

Less than one percent of the recycled water is used. Many opportunities exist in the industry were more recycled water would be used.

2. Water use pattern in various units in the industry

It is observed that 64.72 percentage of water is used for domestic purpose only as shown in the fig 2. With efficient water saving equipment and by sensitizing the employees on water needs the domestic water would be used more effectively. The greywater generated from the domestic water would be used for landscaping the factory and its surrounding areas.

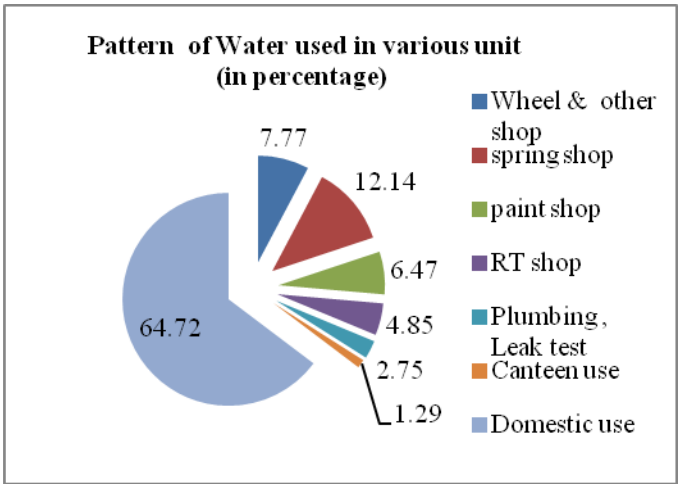

Fig. 2 Percentage of Water used in various unit of the factory.

3. Wastewater generation collection and treatment various units in the industry

The various processes use water and generate wastewater. Each of the wastewater generated has different characteristics depending on the generation point. The main source of waste water is the paint shop and the Road and Transport shop where the coaches are painted and vehicles are cleaned respectively. Wastewater generated from other shop where water is used as dust collectors, coolants etc. Major pollutants present in the untreated wastewaters generated in the industry includes, total dissolved solids (524 mg/l); oil and grease (> 10 mg/l); zinc (6 mg/l).Wastewater is also generated from the canteen which serves meals for approximately 4000 employees.

The effluents are treated in decentralized and common effluent treatment plant based source. The result after treatment shows that the effluent treatment plant is effective. The recycled water is used into the process and used for fire hydrant.

4. Source of Greywater generation and rainwater harvest system

Greywater is the domestic wastewater from bathrooms (such as basins, showers and baths), laundry fixtures (such as clothes washing machines and laundry troughs) and kitchen facilities (such as sinks and dishwashing machines). With minimum treatment, greywater can be recovered and used for applications such as toilet flushing and gardening. 64.72 percent of water is used for domestic purpose which contributes to greywater. Table 1 shows the greywater generation details.

TABLE I GREYWATER GENERATION

Source of greywater	Quantity of water generated (m^3 per day)
Domestic utilities	400
Kitchen (handwash , utensils wash)	20

The rainwater from the factory roof is collected and let into the nearby *Nallah* . Chennai city receives an average rainfall of 1.3 m per year. However, this rainfall occurs in short spells of a few days on an average Chennai receive rainfall for 300 hours throughout the year. Due to lack of augmentation structures, rainwater in drained into the sea.

TABLE II RAINWATER HARVEST POTENTIAL

Source	Type of roof	Runoff coefficient	Roof Area (m^2)	Mean rainwater supply (m^3 per year)
Factory Roof	Galvanized	0.8	325659	338685.4
Administrative building	Tiles	0.7	56000	50960

On an average 1067.52 m^3 of rainwater and is available per day. Approximately 1,50,000 litres of water per day is available. This water can be used for purpose not in direct contact with human like for flushing of toilet, for the purpose of leak test of coaches which consumes 17,000 litres per day. This would help in reducing the cost on purchase of water. Also this volume of water would be available to the corporation for drinking water supply to nearly 1000 consumers with an average of 135 lpcd daily.

5. Cultural and Behavioral Consideration

Treated water meant for drinking is mismanaged by the employees by using it for washing purpose. Water is considered as the cheapest input in the production process. Semi structured interview conducted to the water managers shows that little importance is given to water, as it is not a raw material for this industry. The managers cite that less important is given to water management as it does not contribute to the production process directly.The managers agree that water auditing by external agencies, outsourcing the water and wastewater management would improve efficiency of water utilization. The organization should adopt a water policy and conduct periodic awareness program. Also the employees are provided water at very subsidized cost for their residence.

6. Water metering and Accounting

Based on the preliminary audit a conceptual model for water metering and accounting for the industry is drawn as shown in fig 3. This model takes into account the Zero waste discharge by recycling all the used water, keeping account of all water use by metering the water consumption.

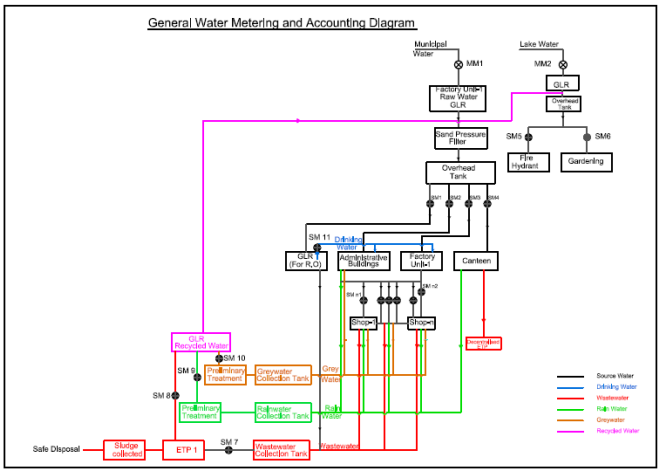

Fig. 3 General Water Metering and Accounting Diagram

7. Critical Analysis of Water Act related to Industrial Water Management

The Water (Prevention and Control of Pollution) Act - 1974 amended in 1988; The Water (Prevention and Control of Pollution) Cess Act 1977 amended in 1992; The Water (Prevention and Control of Pollution) Cess (Amendment) Act, 2003. The Environmental (Protection) Act1986 are few acts related to industrial water management and pollution control. Study of these acts shows certain laggings like ; there is no separate provision for collecting penalties related to water pollution it is collected as arrears to land revenue. The act related to water cess is more of a revenue-generating legislation than a measure to restrict the consumption of water by industrial units. Precautionary And Polluter Pays Principle though accepted as part of the law of the land it needs to be strictly implemented. National Manufacturing policy 2011 emphasis on environmental and water audit.

A bottom-up or decentralized regulation involving civic society and local communities would prove more effective in compelling the industries to adopt pollution standards.

V. CONCLUSION

This study highlights that a lot of opportunities exist for the industries to reduce the overall water footprint and would sustain in terms of water by adopting an integrated approach of reduce , recycle and reuse with the involvement of the stakeholder namely the employees , middle level managers and the policy makers. This would help them to cope with the increasing demand of water with the decreasing supply of water contributed due to factors like climatic variation, more competition for this scarce resource. A bottom-up or decentralized regulation involving civic society and local communities would prove more effective in compelling the industries to adopt pollution standards. Reduction of tariffs on the import of pollution control equipment could create incentives for increased pollution abatement and higher quality. Also this approach would help them to obtain the status of zero discharge status and make them a water stewardship.

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