Energy implications of Water use and pollution control in Textile industries
A case study of Tirupur

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NORWEGIAN EMBASSY

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Acknowledgement

This paper was written as part of the project 'Water, Energy, and Climate Interactions: Identifying Issues and Assessing Response Capacity at the State level' under the Program of Activities, Framework Agreement between the Norwegian Ministry of Foreign Affairs (MFA) and The Energy and Resources Institute (TERI), briefly referred to as the Norwegian Framework Agreement (NFA). We would like to thank the Norwegian MFA for their support.

1. Introduction

Energy and water are interdependent. The development, use, and waste generated by demand for both resources drive climate change. With the growing demand for both these resources, the nexus highlights the complex policy and management challenges for these resources that have traditionally been managed independent of each other (Hoover, 2009). Energy is required to secure, deliver, treat, and distribute water (Siddiqi and Anadon, 2011) and on the contrary, water is used, consumed, and often degraded to develop, process, and deliver energy for consumption (Rio Carrillo and Frei, 2009).

The textile industry is one of the largest consumers of water around the globe. Cotton production and processing is known to be water intensive and at the same time it affects the quality of water; the global consumption of cotton products requires around 256 Gm^3 of water per year (Chapagain, et al. 2005). As per WWF (2012), Cotton, one of the largest produced agricultural products in India, has around 59% share in the raw material consumption basket of the Indian textile industry. This paper tries to assess the water consumption and water-specific energy consumption in the textile industries of Tirupur from the perspectives of resource use efficiency, resource governance and management.

2. The Tirupur Textile cluster

Tirupur is popularly known as the “Banian City” of South India. The textile industry in Tirpur has undergone a significant transformation over the decades, from a few hosiery units in the early 1900s to becoming a prominent cluster of small and medium scale textile enterprises engaged in the production and export of a range of knitted apparels. The industrial policy adopted by the Government of India promoted the growth of small-scale industries, which consequently helped the growth of textile industries (Srinivas 2000; Nelliyat 2007).

It was only after the 1980s, that the export market began to expand and subsequently Tirupur emerged as the largest exporter of cotton knitwear from the country. The European Union is an important and a significantly large destination for Tirupur exports. The textile cluster of Tirupur has grown manifold and the graph (*ref. fig. 1*) describes the nature of growth that has come about. The Tirupur textile cluster contributes 56 per cent of the total cotton knitwear export from India (Nelliyat 2007).

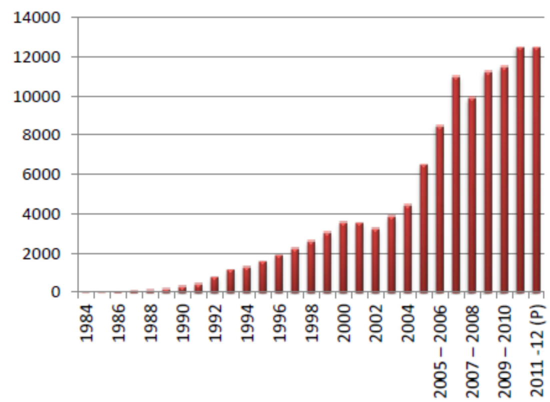

Figure 1: Year-wise export (in Rs. (crores))
Source: Tirupur Exporters Association (TEA), Tirupur

The textile industries in Tirupur mostly fall under the category of small scale and cottage sector industries (Srinivas, 2000). The industrial units are scattered in and around Tirupur including the neighbouring areas (*talukas*) of Somanur, Avinashi, Palladam and Koduvai. An important feature of the industry in Tirupur is that a lot of the units, largely sub-contracting units, are organized in household workshops, started mostly by enterprising individuals with their own funds. According to the Tirupur Exporters Association, there are more than 6000 units in the area as depicted in the table below (*ref. tab. 1*).

Table 1: Category-wise breakup of Textile units or plants

Operations	Number of Units
Knitting Units	1500
Dyeing and Bleaching	700
Fabric Printing	500
Garment Making	2500
Embroidery	250
Other Ancillary Units	500
Compacting and Calendaring	300
Total	6250

Source: Tirupur Exporters Association (TEA), Tirupur

3. *Industrial water-use: A supply driven approach*

In Tirupur, with the growth in the export of garments, there was a rapid expansion of the wet processing units, from 26 bleaching and dyeing units in 1981 to 702 in 2001 (Nelliyat 2007). With the increase in production in these units, the corresponding water requirement also increased manifold, from being 4.4 million litres per day (MLD) in 1980 to 86 MLD in 2000 and to a projected demand of 115 MLD post 2005 (*ref. fig. 2*) (Nelliyat 2007; Madhav 2008).

The growth in exports and the growth of the industry created a water crisis in Tirupur through over exploitation of groundwater and contamination of groundwater and other surface water bodies, by the dyeing and bleaching units. This scarcity led to the emergence of a private water supply industry, which extracted groundwater from the neighboring villages and talukas (primarily from agricultural fields) and supplied it to the industry, at a price higher than the municipality. Close to 2,000-3,000 Lorries with a capacity to transport 10,000 to 12,000 litres/trip used to make around 7 to 10 trips every day just to supply clean water for the wet processing industries (Eswaramoorthi et al. 2004). With the increasing shortage of good water and its cost, an industry lobby group, the Tirupur Exporters Association, approached the government of Tamil Nadu to provide a sustainable water supply to the textile industries (Institute of Water Policy, 2009).

In order to suffice the industrial water demand, a mega water supply project was conceived on a public-private-partnership basis under the BOOT (Build-Own-Operate-Transfer) model. After the completion of this project, water is being supplied to the industries, the residents of Tirupur and the surrounding areas including rural towns, villages and other settlements, by this new entity called New Tirupur Area Development Corporation limited (NTADCL). NTADCL is responsible for procurement, treatment and transmission of water, distribution of water to industries and the municipality for domestic consumption, and treatment of the collected sewage, and maintenance of the sewage treatment plants. The objective is to supply water from the river Cauvery, which is situated 55 kms away, to the tune of 185 MLD, out of which 125 MLD is to be supplied to the dyeing and bleaching industries, 25 MLD to residents of Tirupur and 35 MLD to the surrounding areas (Madhav 2008).

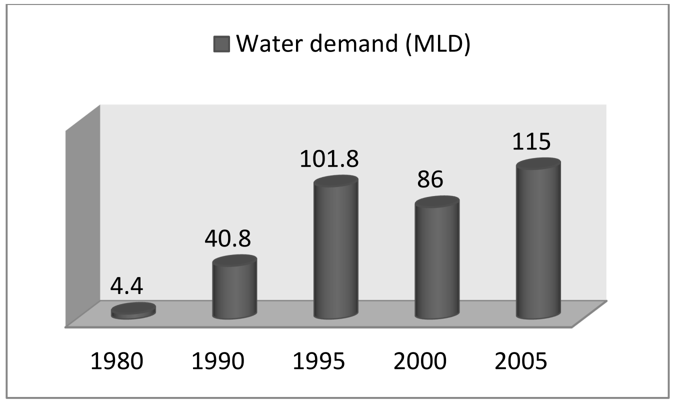

Figure 2: Growth in water demand - Tirupur Textile cluster
Source: (Nelliyat 2007; Madhav 2008)

4. *Tackling the menace of Industrial water pollution*

The bleaching and dyeing industries in Tirupur generate around 100 to 120 MLD of effluents and these effluents are reported to have a high Biological Oxygen demand (BOD), Chemical Oxygen Demand (COD), color, acids and salt content (Nelliyat 2007; Madhav 2008). The necessity for an effluent treatment plant was felt back in 1991 itself but it was only in 1997 that most of the dyeing and bleaching units started setting up common effluent treatment plants (CETP) or individual effluent treatment plants (IETP) following the order of the High court (Nelliyat 2007). Nonetheless, it is important to note that these effluent treatment plants were not able to effectively treat the effluent and the effluent had high (higher than acceptable levels) salt content, total dissolved solids (TDS) particularly the chlorides and sulphates, and other inorganic contaminants (Madhav 2008; Ranganathan et al. 2007; Nelliyat 2007).

The continuous discharge of effluents has caused severe damages to the soil, ground water, nearby aquatic systems and receiving bodies like Orathupalayam dam located at the downstream of river Noyyal, which in turn has adverse impacts on the agricultural lands irrigated by these waters (Madhav 2008; Ranganathan et al. 2007). The groundwater quality around the cluster of bleaching and dyeing units is heavily polluted and is regarded as unfit for domestic, industrial and agricultural activities (Madhav 2008). According to another estimate, between the year 1980 and 2002, the cumulative pollution load discharged by the wet processing industries in Tiruppur was around 2.87 million tonne of total dissolved solids (TDS), like chloride and Sulphate, and around 80 per cent of this load has accumulated in the Tiruppur area (Nelliyat 2007). Another study by Rajaguru et al. (2002) indicates that the ground water in the Tirupur area contains substances that are capable of inducing DNA damage in human cells. The pollution caused by these industries has adversely impacted many sectors, in agriculture the yields in the area have reduced with the productivity of certain crops having declined; it has led to the increase in water-borne diseases such as diarrhea, typhoid, malaria, jaundice and skin allergies; has adversely impacted the cattle, animals, birds and the fish; and has led to drinking water contamination and also scarcity in the region (Nelliyat 2007; Madhav 2008).

Concerned with the growing pollution problem, a case was filed in the Madras High Court against the polluting industries by many farmers of the region. Consequently, an order was issued by the Madras High Court mandating the installation of zero liquid discharge facilities in all the wet-processing industries. Following this order, the industries with assistance and financial support from the Tamil Nadu Water Investment Corporation Limited (TWICL), set up effluent treatment plant facilities (Madhav 2008). Subsequently, many of the dyeing units which failed to set up these facilities within the stipulated time period were shut down by the Tamil Nadu Pollution Control Board. In the present situation, only the CETPs and the IETPs with the zero liquid discharge facility are operating[1].

5. Results

Water Consumption in the wet processing textile units

According to Nelliyat (2007), the water requirement for processing a kilogram of cloth in the wet processing industries has reduced over the past couple of decades. The consumption was around 226.5 litres of water per kg of fabric in 1980 and in 2000 it was around 144.8 litres per kg of fabric, and this decline is attributed to the improvement in processing technology, low availability of good quality water and also the increase in the cost of water transportation (Nelliyat 2007). It was also estimated that the average water requirement for dyeing a kg of cloth was 175 litres in small and medium level units which depended on winches, as compared to 120 litres per kg in the larger units that relied on soft flow machines, which use less water for processing (Nelliyat 2007).

The present study tried to assess water consumption for the Wet processing textile units based on the primary data collected during the field visits to four different Textile industry units in Tirupur. Among the 4 units visited, 2 were integrated units (comprising almost all the textile processes in the same company) and 2 were specialist dyeing and bleaching units (carrying out only the wet processes of dyeing and bleaching). Primary data was collected from the unit on various parameters like water consumption, wastewater generation, fabric consumption and other parameters, on a per day basis. The data gathering was done through structured interviews with plant technicians, supplemented by perusal of maintenance reports.

The main input product used in the wet processing industries (for the processes of dyeing and bleaching) is Grey fabric. The dyed or bleached fabric is further printed depending on the requirement. Once the garment is stitched, it further undergoes a washing process. Ideally, these comprise the wet-processes in a textile industry. The resource flow diagram *(ref. fig.3)* elaborates the sequence of processes, and the water and fabric use there-in.

The results of the study for the water consumption in the textile industrial units visited are as stated in table 2.

Figure 3: Resource Flow Diagram

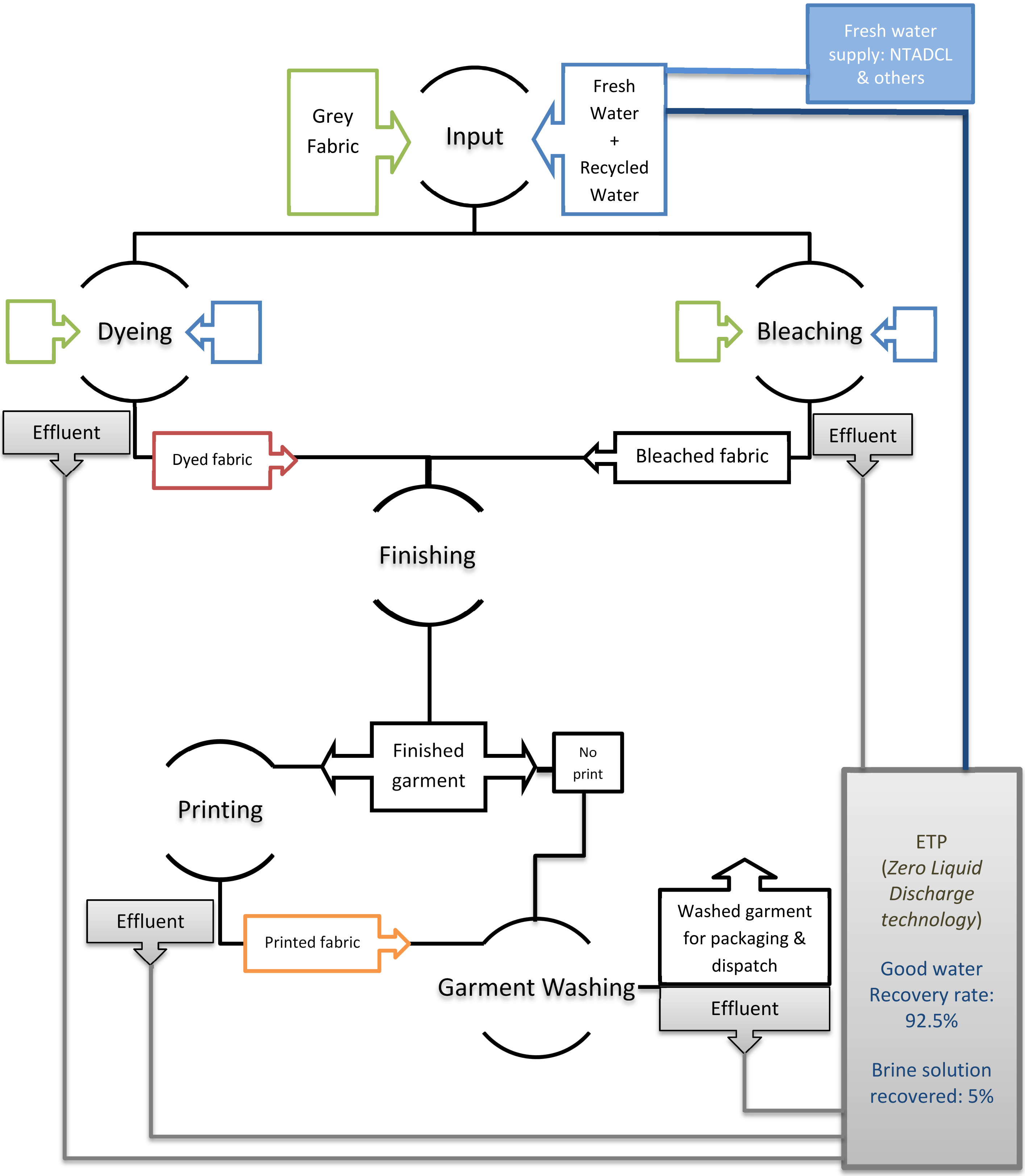

Table 2: Water Use in the Textile Units

Sl. No.	Name of the Textile Unit	Process	Quantity of fabric processed (in tonnes/day)	Water Use				Effluent generated (KLD)
				Quantity of fresh water used (KLD)	Quantity of recycled water used (KLD)	Percentage of fresh water (make-up water) used	Total quantity of water used (KLD)	
1	M/s. Jeyavishnu Texprocessors Private Limited	Bleaching	5	14.5625	80.4375	8.4901	529	496.5
		Dyeing	8	30.35	403.65			
2	M/s. Kongoor Textile Process	Bleaching	5	14.375	73.125	9.0379	428.75	400
		Dyeing	6.5	24.375	316.875			
3	M/s. SCM garments private limited	Bleaching	5	13.946875	56.428125	13.0224	399.825	356.675
		Dyeing	6.26	21.62	232.83			
		Printing (including washing)	6	16.5	58.5			
4	M/s. Scott garments limited (unit-9)	Bleaching	4	12.45	95.55	9.9177	698.5	651
		Dyeing	6	25.7625	419.7375			
		Printing	5	12.8125	12.1875			
		Washing	4	18.25	101.75			

The supply of process water to these industries comes from two sources; the primary is the recycled water from the Water Treatment Plant (with Zero Liquid Discharge technology) of these units and the secondary source being the NTADCL, which supplies fresh water. The Zero Liquid Discharge technology is capable of processing the effluent to recover 92.5% of it as good water, 5% as brine solution and the rest is discarded in the form of mixed salt and through evaporation in the solar pond. The recycled water is pumped back to the wet-processing unit. Make-up water is required (sourced from NTADCL and others) to compensate the loss of water during the wet-processing stages, through evaporation and during wastewater recycling (minimal compared to process water loss). The figures for process water consumption and fabric processed is as depicted in the table above.

From the above table, it is evident that the make-up water required varies across industries from 8.5% to 13%. The variation could be due to the technology used in these industries, or the changes in the day-to-day processes (like variation in the quantity of fabric processed under different operations like dyeing, bleaching, etc.). It could be said that the process of wastewater recycling in these industries has led to the reduction of the fresh water demand by almost 87% to 91.5%, given that all the effluent generated is recycled. This essentially reduces the demand on the surface water bodies and groundwater table, by the industry.

5.1. *Energy consumption of Water-use in the wet-processing Textile units*

Energy is largely consumed in the Textile industry; nevertheless our focus here is only to determine the energy consumption specifically for the different processes of water-use in these plants. Energy consumption here has been calculated based on the study of one of the industrial units mentioned above, i.e. M/s. Scott garments limited (unit-9). Primary data was gathered from this unit during a field visit, based on the daily maintenance reports[2] kept with the unit, for period of three months. A detailed observation of the machinery in the dyeing, bleaching and garment washing sections of the unit were carried out to record the technical specifications of the different equipment (like pumps, etc.) in the machines. Along with the technical specifications (like power rating, type of motor, etc.), the average duration of operation of the equipment during one batch was recorded through interviews with the technicians in the plant. These parameters recorded were further used to arrive at an estimate for process-specific energy consumption for water-use, by multiplying the power rating (wattage) of the electrical equipment with the duration of their operation. There-in, the water-specific energy consumption was calculated by deducting the energy consumption of the equipment used for non-water-use purposes from the total energy consumption calculated earlier. Taking an average for the data collected for a period of 3 months, the figures for energy consumption for water-use are as described below.

Firstly, it is important to note that the average daily water consumption in the unit was found to be around 422.38 KLD (this figure ignores the water consumed in the printing section of this industry as the energy consumption for water-use in the printing section is negligible[3]). Out of the 422.38 KLD, 340.82 KLD is used in the dyeing and bleaching operations and 73.9 KLD is used in the garment washing sections. Now, for energy consumption, it was found that an average of 1548.5 kWh was used daily for the entire processes of dyeing and bleaching; out of this water-specific energy consumption (for purposes like water pumping, circulation, etc.) was found to be 1316.225 kWh/day or 3.86 kWh/KLD. In the garment washing process, high capacity industrial washing machines are used and most of the energy consumption in these machines is for water-use[3]; it was found that an average of 397.5 kWh/day or 5.38 kWh/KLD of electricity were used. Taking into consideration the combined processes of dyeing, bleaching and garment washing, it was found that an average of

1713.725 kWh/day or 4.1 kWh/KLD was used specifically for purposes of water-use.

The effluent generated from all these processes is recycled in the Effluent Treatment Plant (ETP), which is equipped with a Zero Liquid Discharge technology. The energy consumption of the ETP is found to be around 3237.44 kWh/day or 8 kWh/KLD for recycling on an average 402.84 KLD of wastewater in a day. It should be noted here that the energy consumption for wastewater recycling is the highest among all the processes, almost double that of the same in the combined processes of dyeing, bleaching and washing.

Out of the total electricity used in the above processes, 58.5% is sourced from the grid and the remaining 41.5% is sourced from the in-house Diesel generators. Apart from the electricity used in the above processes, thermal sources such as coal are directly used to produce steam that is used in the processes of dyeing and bleaching. It was found that on an average 184.4 kg of coal is used to produce 1 ton of steam. On the whole, the installation of the ZLD unit in the plant has significantly increased its energy consumption.

6. *Water supply management and pollution control: an incoherent course*

A reading of the earlier sections clearly highlights that the decisions taken regarding the management of water supply and pollution abatement have been incoherent with each other. The contexts in which the decisions pertaining to the above issues were made have been described earlier. This section tries to critically analyze the roles of the stakeholders and their decisions.

Firstly, let us examine the case of NTADCL. There are several factors that led up to the establishment of NTADCL, which are described as follows. The scarcity of good quality water threatened the survival and growth of a textile industry that was showing exponential growth. An erratic domestic water supply, in which water was supplied only for a few hours at a time and only once in three or four days, sometimes as infrequent as once in seven days; this was compounded by the fact that Tirupur had a floating population of 150,000. Confronted with a water crisis in the midst of a booming textile industry, the government decided to conceive a water supply scheme that had the potential to not only solve the water shortage problems of the domestic and industrial sectors but at the same time to attract huge investments for the textile sector and make it competitive in the international markets. The approach taken by the government was largely supply driven without much emphasis on demand side interventions.

It is argued that the actual demand for water is much lower than what was projected during the design of the project (Institute of Water Policy, 2009). The quantum of water required by industries was assessed to be around 108 MLD but even after a year of the project's implementation the actual withdrawal of water stood at 75 MLD (Madhav 2008). Therefore, it could be said that the project indirectly encouraged higher water use and increased water demand by the textile industry. In fact, as per Kothandaraman and Kumar (2008), NTADCL had incentivized increased water use by installing a 10 percent discount for users drawing beyond their declared amount of water, for the entire quantity of water and not just the excess water withdrawn (Madhav 2008); this was following the closure of several wet-processing units due to the strict enforcement of water pollution standards that had reduced the water demand significantly. Though NTADCL has succeeded in solving the water scarcity problem in Tirupur, it clearly doesn't seem to have encouraged water-use efficiency or conservation in the textile industry. On the other hand, it threatens the sustainability of water resources in the long run by relegating optimal water use. It is also important to note here that such planning of water supply projects ignore the consequent energy implications.

Even though the water scarcity problem was solved, the pollution problem continued to persist since the existent effluent treatment technology then was incapable of arresting inorganic contaminants (K. Ranganathan et al., 2007) and also that many of the wet processing units were unwilling to operate their treatment plants due to the lack of subsidy for their operation and maintenance, which further went unchecked by the Tamil Nadu Pollution Control Board (Nelliyat, 2007). This situation of unabated pollution instigated the Noyyal River Ayacutars Protection Association to file a writ petition in the Madras high court, the Court based on the recommendations of the expert committee appointed by it ordered the mandatory installation of Zero Liquid Discharge facilities for the recycling of wastewater by the wet-processing industries (Nelliyat, 2007). Though the motive and intention behind the court's order is hardly questionable, the role of the court in prescribing a particular technical solution to the problem is debatable. This case where the court clearly exceeds its functionary ambit to guide a policy on environmental management is tantamount to judicial activism. Rosencranz and Jackson (2003) arguing regarding the Delhi pollution case discuss that the court by assuming the role of agencies and guiding policies through its orders risks making decisions that may ultimately harm the nation. They further argue that the court's decision threatens the evolution of the constitution and institutional capacity for effective environmental management. In the case of Tirupur, the court's order not only has a significant potential to reduce pollution but at the same time to reduce water demand (by about 87% to 91%) by the industries.

6.1. Trade-offs due to judicial intervention

Judicial intervention in terms of recycling and reuse of water has resulted in water conservation and prevention in pollution of water bodies. However, this has questioned the existence of a mega water supply project that was constituted to suffice the water demand of the textile industry in Tirupur area; the reduced industrial water demand arising out of the court's order is likely to threaten the sustainability of this project, as revenue generation from water supply would fall and the infrastructural capacity would be underutilized. Moreover, this has resulted in high energy consumption for wastewater recycling (almost double that of the combined processes of dyeing, bleaching and washing). This increased energy consumption would not only lead to increased carbon emissions at the Thermal power plant but also increased water consumption at the Thermal power plant since a significant amount of water is consumed to produce this power (Rio Carrillo and Frei, 2009). It would be further necessary to study these problems in detail as well as the other potential environmental impacts due to this order.

6.2. Need for integrated water energy planning

It could also be argued here that the Government of Tamil Nadu and the other stakeholders of NTADCL should have explored the option of wastewater recycling before mooting the plan for setting up of a mega water supply scheme. A look at the development of all these events makes it clear that there has been a disjointed approach to managing the water supply and the pollution problem, i.e. the supply side and demand side management. A consideration of the government's approach that has largely emphasized on supply side management, in conjunction with its' lax action toward pollution monitoring and control earlier on, makes evident the inherent flaws for sound environmental management and resource sustainability in the government's actions. In contrast, the court's decision, though sound in the context of regional water resources sustainability, fails to deliberate upon the issue of environmental sustainability on a macro-scale along the entire life-cycle.

In the end, it is very important to highlight that the management of water supply and effluent discharge in Tirupur, be it by the government or the judiciary, did not take into consideration the consequent energy implications of their decisions. Therefore, in corroboration with the findings of this study, it is highly recommendable that the planning, management and policy decisions regarding water supply and effluent discharge should consider the energy implications along the entire life-cycle. In the future, it would be prudent, if the government and its concerned bodies are proactive and foresighted in policy planning and management with regard to the issues discussed above rather than ignoring responsibility so as to necessitate judicial intervention to set-right environmental wrongs.

7. Conclusion

The evolution of events with regard to water supply and effluent management leading up to the current situation in Tirupur has diverse reasons for their genesis and multidimensional implications as discussed in detail in the earlier sections.

From the perspective of water resources sustainability, the judicial intervention mandating the use of Zero discharge technology, is highly beneficial as it reduces the fresh water demand by the wet-processing industries, thus lowering the stress on regional fresh water bodies. In spite of its potential to control pollution (water) at the regional level, it is likely to lead to air and water pollution elsewhere (Thermal power plants). Hence, it could be concluded that the court's order is not entirely environmentally benign but nonetheless alternatives can definitely be found to further counter such negative environmental implications.

In the current context of Tirupur, it would be advisable to source the energy required for operating ZLD-based ETP units, partially at least from renewable sources like solar, wind, bio-mass, etc. In today's scenario, the industries can also source this renewable power through instruments like Renewable Energy Certificates (REC) from renewable energy producers elsewhere. An estimate of the energy demand needs to be done for a scenario where all the ETPs are operating the ZLD technology and further the feasibility of different renewable sources under this scenario needs to be checked.

Also, in order to save energy, reduce water use and prevent pollution, alternative dyeing technologies which use supercritical fluids like supercritical carbon dioxide (SCD) as solvent instead of water can be adopted in the commercial textile applications. The technology has various positive environmental effects such as, drastically reduced water consumption, and reduced hazardous industrial effluent, also economic benefits include increased productivity and energy savings (Smith et al. 2000).

On the other hand, looking at the policy planning and institutional role in environmental management in Tirupur, it could be deduced that the governments' earlier approach to addressing the problems of water supply and effluent discharge has not been effectively managed. NTADCL, conceived through government intervention, in its role of supplying water to the Tirupur textile industries doesn't seem to have encouraged water-use efficiency. The failure of the government and its bodies to effectively check pollution by the textile industries and accordingly regulate and manage this pollution resulted in the judicial intervention to safeguard the environment. Therefore, there needs to be a proactive policy planning and institutional accountability on the part of the government, for a holistic and effective environmental management. The role of the judiciary in directing policies by prescribing technical solutions to environmental problems needs to be studied contextually but nonetheless the prerogative of making such policies should lie with the Executive.

End notes

[1] Based on the interviews with the government functionaries and industry associations

[2] Daily maintenance reports are used to record the data regarding various parameters like electricity, water and coal consumption, etc., in the different departments of the units

[3] Based on the consultation with the plant technicians and review of secondary literature

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