Textile Industry and Environment

The rapid economic growth achieved by most of the developing countries after globalization has adversely affected the quality of the environment, imposed considerable social costs and livelihood impacts, and has become a major threat to sustainable development (World Commission on Environment and Development, 1987). Since the citizens of poor countries may not demand a high level of environmental quality, these countries take up export oriented manufacturing which is sometimes pollution intensive. It is extremely important for developing countries to achieve a critical level of economic growth to mitigate their unemployment and poverty. But the major challenge is to ensure development in an environmentally sustainable manner, so far to achieve a proper trade-off between environment and development. Normally developing countries may have reasonably good growth policies and strategies for agriculture, industry and infrastructure development, but not have a sound environmental management policy. The global diversification and shift of textile manufacturing and exports to developed and developing countries has had significant implications for the Indian textile sector.

The textile industrial growth and export in India has been appreciable during the last two decades. Since most of the textile centres have developed as small-scale clusters, pollution management and enforcement is not at a satisfactory level. Hence in many places the pollution load discharged into the environment has exceeded the assimilative capacity and caused severe degradation of the quality of the environment, and ultimately affected
different sectors like agriculture, domestic water supply, fisheries, public health and biodiversity. Even though these types of tradeoffs between development and environment are common in many countries, most of the research has emphasized either the development aspect or the environmental aspect, but not from a sustainable development perspective.

**Impact of Diversification of the Global Textile Industry**

During the last few decades, substantial global shifts have occurred in textile production and export. Before 1980, countries like Germany, Italy, France, UK, The Netherlands, and USA played a vital role in world textile and clothing exports. But by 1995, the dominance of these countries had substantially reduced and the share of developing nations, especially the Asian countries like China, Korea, Taiwan, India, Pakistan and Thailand had increased (Dicken, 1998). The main factor attributed to this shift is the cheap labour costs in developing nations compared to the western countries (Vijayabaskar, 2001). The environmental policies, which are relatively less stringent in developing nations, might also, have contributed to the shift in the location of textile manufacturing. During the post liberalization period of the Indian economy, the cotton textile and garment industries grew rapidly due to the availability of cheap labour and raw materials. The country has more than 9 million hectares of area under cotton cultivation and annual production of around 3 million tons of cotton (Compendium of Textile Statistics, 1999). These industries generate substantial employment, income, and foreign exchange.
It provides employment opportunities to 35 million people, particularly in the rural and remote areas of the country. Around 10 per cent of the excise revenue is obtained from the textile sector (Compendium of Textile Statistics, 1999; Ministry of Textiles, 1999). At present the textile industry accounts for about 14 per cent of the national industrial production and about 4 per cent of GDP. The Indian textile sector has been experiencing structural transformation through the reduction in the role of the organized mill sector and an increase of the small scale and cottage sectors (handlooms, power loom, knitwear and garment making units). These sectors are developing in a highly decentralized and flexible industrial networking manner as clusters. To some extent, the industrial policy adopted by the Government of India which emphasized the growth of small-scale industries (SSIs) has also favored the growth of textile industries as clusters. However, the wet processing (bleaching and dyeing) segment of the textile industry has caused severe environmental damage. The textile processing units use huge quantities of water and different chemicals. The effluents discharged by the units are generally hot, alkaline, strong smelling and colored. Some of the chemicals which are discharged are toxic too. Unfortunately, the majority of the textile units especially the smaller ones are not treating their effluents properly and the untreated or partially treated effluents are discharged into water bodies or on land and sometimes the effluent is used for irrigation (Mukherjee and Nelliyat, 2006). In many clusters around the country, textile effluents have caused serious environmental impacts at the regional level. The technological development in the wet processing segment of the textile industry is not at a satisfactory level. Most of the small units are using traditional processing technology, which are not environment friendly.
Textile consumers in Europe and USA have become more concerned about environmentally sound products with eco-labels. Consequently, the market for products produced in a environmentally friendly way is growing. After realizing the seriousness of the above issue, the Government of India and the textile industry took certain measures to meet the eco-labeling requirements. For eco-specification, several eco-testing laboratories were set up in various textile centres. Generally, the eco-mark schemes specified that “the products should be manufactured in an environmentally friendly way”. It means the product or its manufacturing activities should not create any environmental consequences for both the consumers of the product as well as the public through waste disposal.

*Unfortunately, in the Indian textile industry eco-labeling criteria are applied only to the product quality and not to the manufacturing related pollution or process aspects.*

“Tiruppur” - The Fastest Growing Industrial City

Tiruppur is a textile city located on the banks of Noyyal River, Tamil Nadu, South India falling between 11.1075°N 77.3398°E (www.fallingrain.com). It has an average elevation of 295 meters (967 feet). Tiruppur has the largest and fastest growing urban agglomerations in Tamil Nadu, India (Fig. A) which is also the textile hub and a vast generator of employment for *unskilled temporary workers*. Tiruppur has gained universal recognition as the leading source of Hosiery, Knitted Garments, Casual Wear and Sportswear. Tiruppur stands as the life for millions of people in Tamil Nadu. The knitwear industry which is the soul of Tiruppur has created millions of jobs for all class of people. There are nearly about 3000 sewing units, 450 knitting units, hundreds of dyeing units and
Figure A: Location of Tiruppur in Tamil Nadu, India
other ancillary units which are uncountable. The annual forex business for the year 2008 stands at INR. 8,000 crore. Due to the climate and availability of raw material and work force Tiruppur has had made a large contribution to the export of knitwear garments and is known by various names such as "Dollar City", "Knit City", "Cotton City" and mainly "History Centre"(The Noyyal River and Tiruppur -www.boloji.com).

**Growth of the Textile Industry in Tiruppur**

Industrial growth started in Tiruppur in 1930. The electrification of the town during the late 1930’s, the removal of the ban on import of new machines in 1952, the shifts from farm to factories during 1960s, the industrial unrest which existed in West Bengal in 1968, the growth of ancillary units during 1970s, and the encouragement provided by government towards export in the early 1980s, are important landmarks in the history of the growth of the hosiery industry in Tiruppur (Swaminathan and Jeyaranjan, 1995; Vijayabaskar, 2001). The transformation of Tiruppur from a village agrarian economy to the ‘Knitwear capital of India’ occurred within a very short period of three to four decades. The hot climate and good quality of water, easy availability of raw material (cotton), skilled labour, good infrastructure facilities, industrial networking, institutional support, and export culture, are some of the reasons for the rapid industrial growth of Tiruppur (Nelliyat, 1995; Nelliyat, 2005). The city contributes 56 per cent of the total cotton knitwear export from India. Yarn making, weaving/knitting (cloth making) are the major activities at the first stage in the hosiery industry (Fig. B).
Figure B: Major Activities in Tiruppur Hosiery Industry (Source: Nelliyat, 2005)
Wet Processing and Water Demand in Tiruppur

Wet processing (bleaching and dyeing) is a sub-sector of the hosiery industry. After the export boom started in the 1980s, the number of wet processing units rapidly increased in the Tiruppur cluster. In 1981, there were only 26 bleaching and dyeing units in Tiruppur. But the number had increased to 324 in 1991 and 702 in 2001 and beyond several thousand by 2010. The majorities of the units are small in size and function as job workers for the hosiery industry. Most of the units are located on both sides of the Noyyal river which is convenient to discharge the effluent. Low investment, bright future of coloring in clothing industry, good profit margins and prior experience in textile processing, are some of the factors which encouraged the entrepreneurs to select textile processing from other segments of the hosiery industry.

The quantity of cloth processed by these units is more than 15,000 tonnes per month. For processing, various chemicals such as soda ash, dyes and bleaching agents are used and their consumption rate has increased over time in proportion to the quantum of cloth processed. Much of the chemicals and acids used for processing are not retained in the cloth but discharged as waste material, which ultimately leads to high pollution load in the effluents. For textile processing, water is an unavoidable input factor. Corresponding to the growth in the volume of cloth processed, the quantity of water consumed by the processing units has also increased over time from 4.4 million litres per day (mld) in 1980 to 40.8 mld in 1990 and to 86 mld in 2000.
Earlier industries extracted their required water from the Noyyal river or their own wells. But from early 1990s onwards due to water quality degradation in Tiruppur, substantial quantity of fresh water (91 per cent of the total demand) is transported from peripheral villages through tankers. The continuous functioning of the ‘water market’ has adversely affected the ground water availability of the villages and in many places ground water tables have declined. Recently, industries are also getting water through the Tiruppur Area Development Project’s water supply scheme (2007) to transport water from the Cauvery river. The water requirement per kilogram of cloth processed has shown a declining trend from 226.5 litres per kg in 1980 to 144.8 litres per kg in 2000. Low availability of good quality water in the Tiruppur area, increase in the cost of water transportation, and the technology improvements in processing are some of the reasons attributed to the reduction in water usage per kilogram of cloth processed. The average water requirement for dyeing one kilogram of cloth is 175 litres in small and medium level units, but only 120 litres per kg in larger units. Processing technology is the major determinant factor in water requirement. Generally, smaller units exclusively depend on winches, while larger units depend on soft machines, which use less water for processing (Nelliyat, 2007).

**Environmental Management and Pollution Abatement**

The processing units in Tiruppur generate/discharge more than 85 mld of effluents. The effluents carry considerable volume of chemicals used in different processing stages in the units. Due to the continuous discharge of effluents for over a decade, the magnitude of
pollution has increased in the Tiruppur area resulting in environmental degradation. Progress towards the effluent treatment programme was negligible till 1996. Subsequently in 1997, High Court issued an order for the closure of industries that lacked any effluent treatment plants. This forced other struggling units to construct effluent treatment plants. At present, the units are treating their effluents either through Individual Effluent Treatment Plants (IETPs) or Common Effluent Treatment Plants (CETPs). Over 40% of the units are treating their effluents through CETPs while the rest have individual effluent treatment plants. Due to scale economies, CETPs should be preferable to smaller units. But, size has not been the major factor in the choice of common versus individual effluent treatment plants. The majority of the units who prefer IETPs were not familiar with the advantages of CETPs at the time of their decision. But some of the units who were familiar with the merits of CETPs preferred IETPs, mainly because the CETPs were located far away from their premises and due to less faith in collective action. On the other hand, some of the units which preferred CETPs were well aware of the economies of CETPs including the subsidy factor. Besides, they felt that if they provided the initial equity and monthly subscription to CETP they would be free from their responsibility regarding effluent treatment. A few units functioning on leased land or in congested areas were compelled to join CETPs since they did not have their own land for constructing individual treatment plants. Ideally CETPs are preferable in a small scale industrial cluster like Tiruppur for many reasons including economies of scale in treatment, easy monitoring and enforcement, and better scope for implementing advanced treatment methods like Reverse Osmosis (RO). But, in Tiruppur less than the expected entrepreneurs joined the CETPs.
Unfortunately the present effluent treatment system is insufficient for reducing the Total Dissolved Solids (TDS), particularly the chlorides and sulphates. Since there is no subsidy for operation or maintenance cost, many industries are not willing to operate their effluent treatment plants. Besides, the Tamil Nadu Pollution Control Board (TNPCB) did not take any serious action against the industry when they violated the standard (effluent norms). Normally, the further expansion and efficiency improvement in the treatment system is difficult for small units. Since the TDS discharge is unabated, the impact associated with it is substantial.

**Environmental Impact and Damage Cost of Pollution**

The environmental problems in Tiruppur area are due to the accumulation of effluents in the soil and water. From 1980 to 2002, the cumulative pollution load discharged by the Tiruppur units, is estimated to be 2.87 million tonne of TDS like chloride and sulphate. Around 80 per cent of the pollution load has accumulated in the Tiruppur area. Rainfall (annual average of 617 mm) has only a marginal effect in reducing the severity of the impact.

**Evidence Abounds**

Reports clearly prove the accumulation effect of pollution in Tiruppur area and downstream of the Noyyal basin. A number of ground water studies have been carried out by academic institutions and government agencies in recent years (Ground Water Pollution
studies carried out by Government Departments, 1983 to 2004). The major conclusions of these studies are as follows:

- Open wells and bore wells in and around Tiruppur and the downstream stretch of Noyyal exhibit high levels of TDS (most areas > 3000 mg/l and some places even up to 11,000 mg/l) and chloride (generally > 2000 mg/l and certain areas up to 5000 mg/l) due to industrial pollution.

- High concentration of heavy metals in ground water including zinc, chromium, copper, and cadmium.

- The open and bore wells located around 4 kms radius of an irrigation reservoir at Orathapalayam (Dam) are highly polluted with high TDS level and concentration of various salts.

- The establishment of effluent treatment plants in Tiruppur has not had any positive impact on the ground water quality.

- The studies also show that the available ground water is not suitable for domestic, industrial or irrigation use.

- The pollution (EC/TDS) concentration in Noyyal river is low till the river reaches Tiruppur. But it increases considerably in the Tiruppur area, due to textile effluent discharge, and continues up to the Orathapalayam dam. But after Orathapalayam there is some improvement in river water quality.

- Pollution concentration in the river is greater in summer than winter.

- The existing moderate flow in the Noyyal river is not sufficient for diluting the pollutants.
• River and reservoir are not fit for aquatic organisms including fish.

• Concentration of high TDS and chloride at the tail end of the Noyyal at the confluence point with the Cauvery river – major source of water resource for the entire state of Tamil Nadu.

• Except for the rainy season when there is some dilution, the surface water is unfit for irrigation.

The soil quality study (SS & LUO, 2002) also indicated the magnitude of pollution. The surface and sub-surface soil samples analyzed based on pH show that the majority of the samples are alkaline (pH > 8.5) or tending to alkaline (pH 8 - 8.5).

**Ever Widening Circle**

The pollution impact is experienced by different sectors (agriculture, fisheries, domestic and industrial water supply, human health, and bio-diversity) in the Tiruppur area and downstream of the Noyyal River. In agriculture, since the ground water and surface water sources (irrigation tanks and reservoirs) are not fit for cultivation, farmers incur heavy losses. The surface water is injurious to agriculture (Electrical Conductivity- EC > 3 mmhos/cm), in an area of 146.3 km² and critical (EC 1.1 to 3 mmhos /cm) in 218.3 km² (SS & LUO, 2002; Nelliyat, 2003). The saline sensitive crops like paddy and banana have completely disappeared from the pollution affected villages. Besides, the productivity of certain crops has declined considerably. The estimated overall annual damage cost in the agriculture sector was INR. 35.29 crore and the capitalized value at 12 per cent is estimated to be INR. 234.54 crore (Madras School of Economics, 2002).
It clearly reveals that the industrial growth, especially during the last two decades, in Tiruppur imposes high social cost at regional level, and hence may be unsustainable. The positive contribution of the industry (economic indicators) and negative implications of industrial growth on the environment (environmental indicators) are clearly evident from the audit. The pollution load discharged in the last few decades is more than the assimilative capacity of the environment. Hence considerable amount of pollution accumulation (mainly deterioration in the quality of ground water and soil) has occurred in the Tiruppur area. It can be concluded on the basis of the economic and environmental indicators that the industrial growth in Tiruppur may not be environmentally sustainable. Under normal conditions, the industry benefits entrepreneurs, exporters, overseas importers and consumers, government, and labourers in different geographical areas. But the social costs of pollution, in the form of natural resource degradation, affect a large number of people living in and around Tiruppur. Even though, the trickle down effects of Small Scale Industries (SSIs) like hosiery are substantial one cannot ignore the environmental issues associated with industrial growth.

To some extent the over-all economic benefit of the industry has undervalued the environmental costs. However, the environmental cost, borne by the downstream communities who have no connection with the industries is a major concern. Moreover the physical environment (ground water, river, ponds, soil and biodiversity) of the entire region may be losing its ecological value in an irreversible manner. However huge tasks
and court orders compelled Industries and the Government to install Effluent Treatment Plants, little or no reversibility is witnessed in the remediation of the pollution caused to the resources. This is because, existing conventional treatment facilities (Fig. C) comprises the basic physico-chemical processes for the color removal from dyes containing effluents (Churchley, 1994; Vandevivere et al., 1998; Swaminathan et al., 2003; Behnajady et al., 2004; Wang et al., 2004; Golab et al., 2005; Lopez-Grimau and Gutierrez, 2005). Extensively used coagulation / flocculation techniques produce large amounts of sludge, which requires safe disposal. Adsorption and, to a certain extent, membrane filtration techniques lead to secondary waste streams which need further treatment. These constraints have led to the consideration of Advanced Oxidation Processes (AOP) and biological methods as attractive options for the treatment of dye-containing wastewaters. AOP are defined as those processes that use strong oxidizing agents (H$_2$O$_2$, Fenton’s reagent) or heterogeneous photo catalysts such as TiO$_2$, ZnO$_2$, Mn and Fe in the presence or absence of an irradiation source.

These involve mainly the generation of (OH) radical for the destruction of refractory and hazardous pollutants (Vandevivere et al., 1998; Alaton et al., 2002; Al-Kdasi et al., 2004). These methods do not produce solid waste. However, both AOP and membrane filtration methods are energy and cost intensive. Biological methods are generally considered environmentally friendly, as they can lead to complete mineralization of organic pollutants at low cost. Synthetic textile dyes in general are xenobiotic in nature; only one natural azo compound (4–4’ dihydroxy azo benzene) has been reported so far (Gill and Strauch, 1984). Thus they can be expected to be recalcitrant to biodegradation.
Figure C: Existing Physico-chemical Textile Effluent Treatment Process. *Courtesy: Ion Exchange (India) Ltd.*
It is generally observed that dyes resist biodegradation in conventional activated sludge treatment units (Stolz, 2001). It is now known that several microorganisms, including fungi, bacteria, yeasts and algae, can decolorize and even completely mineralize different class of dyes under certain environmental conditions. Many reviews are available on the physicochemical and microbiological methods for decolorization of dyes (Banat et al., 1996; Delee et al., 1998; Vandevivere et al., 1998; O'Neill et al., 1999; McMullan et al., 2001; Stolz, 2001; Rai et al., 2005; Van der Zee and Villaverde, 2005). Biotreatment offers a cheaper and environmentally friendlier alternative for the textile effluent and metal removal. The ubiquitous nature of microorganism makes them invaluable tools in the effluent biotreatment (Olukanni et al., 2006). A number of biotechnological approaches have been suggested by recent research as of potential interest in combating this pollution source in an eco-efficient manner (McMullan et al., 2001).

Bacteria capable of dye decolorization, either in pure cultures or in consortia, have been reported (McMullan et al., 2001; Pearce et al., 2003). The utilization of microbial consortia offers considerable advantages over the use of pure cultures in the degradation of synthetic dyes (Junnarkar et al., 2006). Different strains may attack dye molecule at different positions or may use decomposition products produced by another strain for further decomposition (Forgacs et al., 2004). Although microbial systems have already been described for remediation of metals- and- dye contaminated soil and water (Robinson et al., 2001; Ali et al., 2008), there is still a need for research to unravel the potential of various microbes for the rehabilitation of our natural resources especially pertaining to Tiruppur District of Tamil Nadu, India.
The present investigation is an attempt towards ecofriendly solution for the large scale problem (effluent) prevailing due to the operation of textile dyeing units. It is focused on the isolation of dye decolorizing microorganisms (especially Bacteria) from contaminated soil of industrial areas of Tiruppur district, Tamil Nadu, India and the ability of these isolates to degrade the chosen commonly used dyes (reactive and disperse group of dyes) has been analyzed. The success of the treatment process is based on the subsequent usage of the treated water for irrigation and other life supporting activities. Though microorganisms are found everywhere in nature, constant exposure to the synthetic chemicals drive these microorganisms to evolve and become capable of decolorizing and detoxifying the color chemicals. It has been a hypothesis for the study, that microorganisms (especially bacteria) are under constant exposure to the synthetic chemicals alone, can be of effective use against the textile industry mediated water pollution. However huge the task is, the work has been designed to meet the following targets in achieving our goal.

1. *Isolation and screening of potential bacteria from the Textile Industrial grounds of Tiruppur, Tamil Nadu, India for the decolorization of commonly used Disperse and Reactive dyes.*

2. *Optimization of culture conditions for the decolorization and elucidation of the degraded compounds.*


4. *Effect of biologically treated effluent on the growth and yield of the chosen plants - Brassica Nigra (Mustard) and Cyamopsis tetragonolobus (Cluster-Beans) in comparison to irrigation with normal water.*