Environmental issues related with textile sector

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Dyeing Printing Finishing

Introduction

There are large number of mechanical and chemical proceseses involved in the textile industry and each process has a different impact on the environment. This impact starts with the use of pesticides during the cultivation of natural fibres, the erosion caused by sheep farming or the emissions during the production of synthetic fibres. From that moment on, a number of processes are applied, using thousands of different chemicals, to process the fibres and to reach the final stage of textile end product.

During the past few decades the awareness regarding environmental problems has increased considerably and has become an important issue in the textile trade due to various environmental and health legislations, and also environmental policy is increasingly dictated through market forces.

Many chemicals used in the textile industry cause environmental and health problems. These problems may occur during the production process, with respect to emissions or occupational health problems. Other problems caused by these chemicals appear due to their presence in the final product. However, worldwide environmental problems associated with the textile industry are typically those associated with the water pollution caused by the discharge of untreated effluent and those because of use of toxic chemicals especially during processing. These chemicals can harm consumer if retained in the fabric.

The textile industry is facing challenges due to social and environmental compliance issues from US and European buyers, as stated by Muhammad Latif, Chairman, FIEDMC, at a seminar on Meeting the Business Challenges through Social, Environmental and Code of Conduct Compliance, which was arranged by Bureau Verities Quality International.

The impact of environmental regulations on the textile sector of Pakistan can be classified according to many parameters. However, the major area of concern for the textile-processing sector is wastewater. Textile processing is a water intensive process. The wastewater generated by the industry is high in BOD, COD, pH, temperature, color, turbidity and toxic chemicals. The direct discharge of this wastewater on the water bodies like rivers etc. pollute the water and affect the flora and fauna.

These polluted effluent need to be treated chemically to remove the hazardous materials and chemicals so that the wastewater will comply with the prescribed limits and can be discharged into the public sewer or into aquatic bodies.

Impacts of colorants on the environment

Environmental problems associated with the textile industry are typically those associated with water pollution caused by the discharge of untreated effluent. effluent are generally hot, alkaline, and strong smelling, and coloured by chemicals used in coloring process. Some of the chemicals, including dyes and pigments, are toxic or can lower the dissolved oxygen content of receiving waters, threaten aquatic life and damage general water quality downstream. Effects on organisms in the environment can be either short term (acute) or long term (chronic).

In relation to the textile industry, four potential routes of colorants to enter the environment have to be considered.

- Through routine process effluent or emissions.
- Through disposal of surplus materials and process residues.
- Through accidental release.
- Through the disposal of used packages (Solid waste).

The environmental risk is a function of environmental exposure (concentration and duration) and polluting potential (hazard characteristics or toxicity). Hence, reducing the emissions into the various environmental pathways can reduce the environmental risk.

Polluting potential of colorants

Many add-ons in dyeing – namely carriers, dye-fixing agents, cationic retarders and heavy metal salts- are difficult to biodegrade and therefore have a negative impact on the environment. The most obvious source of non-metallic dye bath agents are additives to the dye bath used for pre or after treatments. These products pose a greater pollution threat than dyes themselves. Carriers used in the dyeing of polyester, insect proofing agent applied to wool in the dye bath and some classes of dyes all give off high AOX.

The toxic effect of heavy metals on animal and aquatic life is dependent on their physico-chemical form. In dye house effluent, heavy metals occur as a consequence of the heavy metals salts used in dyeing, the use of metal-complex dyes, or from the presence of impurities in dyestuffs.

It has been observed that dyeing losses contribute to only 10- 30% of BOD of the total, with respect to COD, the contribution of dyes themselves is around 2-5%, while that of dye bath chemicals is as high as 25-35%. Acetic acid (used in disperse dyes on polyester, cationic dyes on acrylic fibers and acid dyes on wool, silk and nylon) exerts a high BOD and can account for 50- 90% of dye house BOD.

Impact of the main solid wastes

The majority of textile solid wastes are fibres, yarns, fabrics, packaging waste, dye containers, chemical containers, dirt, waxes, wasted sludge and retained sludge, paper, cartons, etc. The hazardous solid wastes are the sludge, the dye and chemical containers, as they contain toxic material, and dealing with wastes for disposal may expose the workers to toxic effects.

Impact of noise

The noise level resulting from the machines used in the textile industry, especially from the dry processes, may violate the limit allowed by the law and cause hearing problems. The ring spinning machines, the open-end spinning machines, the winding machines, the looms, the sewing machines etc. work at very high speeds, thus exceed the allowed level of noise (90 decibels) and cause hearing troubles to the production workers.

Impacts of pollutants on health

The major sources of pollution in the textile industry, causing either acute or chronic effect are the cotton dust and fiber particulates from the dry processes, oil and acid/alkaline mists; solvent vapours; odours; dust and lint in the wet processes, and the nitrogen and sulphur oxides and other particulates from boilers.

The use of dyestuffs and pigments may cause a number of adverse effects to health. Health effects may be exerted directly at the site of application (effecting the workers) and later in the life cycle (effecting the consumers). Many chemicals used in textile processing have adverse effect on occupational and community health.

The surrounding area is also affected by the fiber fuzz in case of facilities not using scavenging systems, and depending on ventilation through factory windows. This situation may have effect on the respiratory diseases of people living in the area.

Summary of the emissions and their degree of pollution impact

Tables (1), (2), (3) and (4) summarize the emissions (wastewater, gaseous, particulates and solids) and their degree of pollution impact for the different textile processes (H=high, L=Low). These tables are given towards the end of the article.

Pollution prevention

The best way to reduce the impact of these dyes and chemicals on the environment is by reducing the amount released for treatment. Furthermore, conventional waste treatment often causes only a transfer of waste from one phase to another. Treatment usually results in the generations of solids, sometimes hazardous, which are buried in a landfill. Disposal of waste in a landfill can result in groundwater contamination, gas formation and problems with odors. In other words, waste treatment is not necessarily a cure. As regulations become more stringent, companies are forced toward more technologically sophisticated treatment methods. This results in an increased cost for waste management and at times forces companies to go out of business due to increase in cost of production. More and more companies realize that reducing the waste at the source is necessary to reduce the cost of treatment.

Pollution prevention (P2) is defined as those measures that eliminate or reduce pollution prior to off-site recycling or treatment. Pollution prevention does not only reduce water pollution, but also minimizes the release of pollutants to land and air. In the Pollution Prevention Act, the Congress defines a multimedia waste management hierarchy. Source reduction stands at the top of the waste management hierarchy and is followed by reuse and on-site recycling. Off-site recycling is not considered a pollution prevention measure.

Pollution prevention opportunities

Source reduction assessment involves the analysis of the textile wet processing. Operations to reveal measures that minimize substrate, chemical, water and energy consumption. Substitution of chemicals, process modifications and technology changes can increase the treat ability of the wastewater and can also reduce the pollution load.

Good housekeeping and raw material control can help to solve certain problems. Pollution prevention may result in several benefits for the textile processor, including:

1. Loss reduction.
2. Reduction of chemical, water and energy consumption, thereby resulting in savings, sometimes even increased production.
3. Reduced liability for waste produced.
4. Improved compliance with regulations.

Chemical Substitution

The objective of chemical substitution is to replace process chemicals having high pollutant ratio or toxic properties with others that have less impact on water quality or that are more amenable to wastewater treatment.

A number of processes chemical substitutions have been suggested or developed for the textile industry, and it is expected that this area will play a more important role in the future. The cost to substitute other chemicals and products for those containing toxic pollutants is usually much less than the cost to remove the pollutants from a mill's discharge via end-of-pipe treatment.

Foaming problems in treatment facilities and receiving streams have been solved by substituting biodegradable, low-foaming detergents for the so-called "hard" detergents.

Potentially toxic pollutants have been reduced or eliminated by substitution. For example, switching from chromate oxidizers to hydrogen peroxide or iodates eliminates chromium in dyeing processes. Mineral acids are substituted for high BOD acetic acid in dyeing processes, offering an advantage in terms of wastewater treatability. The substitution of mineral oils with nonionic emulsifiers for the more traditional olive oil in carding wool also results in lower pollutant levels.

Starch wastes from desizing are the single greatest source of BOD at many mills. Consequently, substitutes with low BOD, such as CMC and PVA, have become useful to reduce BOD loadings on wastewater treatment systems. Harsh chemicals used in textile wet processes are being substituted with a number of enzymes. Attempts are been made replacing sulphide based reducing agents for the dyeing of sulphur dyes for eco friendly reducing agents, such as the Glucose and Mercaptoethanol.

The American Textile Manufacturers Institute reported, "Substitution should assume the direction of easily treatable materials in terms of waste control technology and recoverability. Substitution, however, a careful evaluation should be made to assure that one pollution problem is not being substituted for another.

Process changes and new process technology

Process changes and the implementation of new process technology are modifications to the basic manufacturing operations of a mill. Some reduce water use and eliminate or minimize the discharge of high strength or toxic chemicals. Others provide for material and energy reclamation.

Technological advances in fibers, process chemicals, other raw materials and processing equipment are constantly occurring and, in general, these changes are resulting in lower hydraulic and conventional pollutant loadings. Solvent processing is an example of a new process technology. It involves the use of a non-aqueous solvent such as perchloroethylene to scour and dye fabric. Because the solvent has a high vapor pressure (compared to water), it is possible to vaporize it more easily and recover it for reuse. It has not, however, achieved the original expectations of performance, except for specialized processing and small batch operations.

Effective applications include solvent scouring of wool fabric and some synthetic knit fabrics and solvent finishing of upholstery, drapery, synthetic knits, and fabrics that are sensitive to water. There are a number of reasons for the limited application of solvent processing to date. The most troublesome problem is that the value of the recovered solvent is often less than is necessary to make the process economically feasible. Another problem is the emission of unrecovered solvent to the work place or the atmosphere.

Dystar has patented an electrochemical dyeing process that it developed jointly with the textile machinery manufacturer **Thies GmbH & Co.** and the institute of textile chemistry and textile physics at the university of Innsbruck in Dornbirn Austria. According to the company, the process uses an electric current instead of chemical reducing agents, giving it a number of technical, economic and ecological benefits. Dystar have developed a vat dye, Indanthrane blue E-BC, specifically for this electrochemical dyeing process. The dye liquor used in electrochemical dyeing with Indanthrane blue E-BC can be reused in an unlimited number of times and contamination of dye house effluent is close to zero.

Supercritical CO_2 is one of the most popular fluids currently used in manufacturing processes. It is non toxic, non hazardous and low cost and environment friendly. Moreover, by reducing the pressure at the end of the process, dye and CO_2 can be recycled.

Standard reactive dyeing procedures require high levels of water, salt and alkali, which leads to very large volumes of effluent. **Specialty Chemical Group** introduced more environmentally friendly method of fabric pre treatment that lead to complete elimination of salt and alkali, lower water volumes and reduced process times. Thus several green chemistry reductions (waste, energy, raw materials) are achieved.

The latest textile processing equipment offer lower water and chemical usage. For example, pressure dye machines use dyestuff more efficiently, reduce water requirements and reduce the level of toxic dye carriers required in atmospheric dyeing.

It is reasonable to expect that the textile processing equipment of the future will be even more efficient in the use of water, chemicals and energy. Exceptions include new water jet weaving technology, requires additional water, although the wastewater generated is relatively low in pollutant concentration.

Kyungwon Enterprise Co. of South Korea has developed a washing machine that does not require detergents to clean cloths. In this machine water is transformed into an electronically charged liquid that cleans goods with same power as that of a conventional synthetic detergent powder. These make washing easier, cheaper and environment friendly.

Integrated eco- balancing approaches

- Raw material uses should be zero residues.
- Rigid procedures, requiring the use of only specific chemicals and specific methods should be converted into flexible ones to facilitate substitution of non-eco friendly chemicals by their safe counterparts from time to time.
- Green Technology or Clean Technology should be practiced.
- Product (GNP) of a nation should be increased by substantially reducing the quantities of inputs.
- Eco friendly index of product must include its shelf life period and extend of eco friendliness of degradation products.
- Eco friendly machinery and processes should be used.

Environmental restrictions

Besides several global environmental restrictions some new regulation and/or standard have been enforced on the textile sector.

REACH

REACH is a new European Union regulation concerning the Registration, Evaluation, Authorization and Restriction of Chemicals. It came into force on 1st June 2007 and replaces a number of European Directives and Regulations with a single system. The main aim is to safeguard human health and environment through the better and earlier identification of the properties of chemical substances and to promote the use of alternative methods for the assessment of the hazardous properties of substances.

Global Organic Textile Standard (GOTS)

Organic cotton is grown using methods and materials that have low impact on the environment with the organic production systems replenishing and maintaining soil fertility reducing of the use of synthetic pesticides, fertilizers and building a biologically diverse agricultural system.

The aim of Global Organic Textile Standard is to define requirements to ensure organic status of textiles, from harvesting of the raw materials, through environmentally and socially responsible manufacturing up to labeling in order to provide a credible assurance to the end consumer.

Starting point of the Global Organic Textile Standard development was the Intercot Conference 2002 in Düsseldolf, Germany. The version 2.0 of the GOTS was published in 2008.

Wal Mart was the first large-scale enterprise that committed towards the GOTS followed by various competitors and brands.

Leading suppliers such as **Huntsman** (formely Ciba), **Dystar, BASF** already actively advertise compliance of a range of their products with the GOTS and circulate their corresponding approved positive lists to agents and clients worldwide.

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Table (1) Major constituents and characteristics of wastewater from wet processing of cotton and blend (World Bank, Paris Commission, Helsinki Commission)

Process	Major Constituents	Characteristics	Pollution impact Low, Medium, High
Sizing	Starch derivatives Semi-synthetic sizing agents (CMC) Synthetic sizing agents (PVAs, polyacrylates) Additives : Urea, Glycerin Waxes and Oils Preserving agents	BOD COD Temperature	H M L M H H H
Desizing	Acids or Enzymes	BOD (30-50% of total) COD Temperature (70-80oC)	H H
Scouring	Saponified waxes, oils, fats Surfactants Alkali High temperature	Oily fats BOD (30% of total) pH (high) Temperature (70-80°C)	H H H H
Bleaching	Residual bleaching agents stabilizers, surfactants wetting agents,mild alkalinity	Peroxide! pH Temperature	L M H
Mercerisation	Alkali (NaOH) Surfactants	BOD pH (high) Dissolved matter	H H H
Dyeing	Dyestuffs (direct, vat,reactive, sulphur, pigment) Electrolytes,Carriers Acids and alkali Heavy metals Oxidizing agents Reducing agents Surfactants, Levelling agents	Toxicity BOD (6% of total) Suspended solids pH Strong colour	H H H H H
Printing	Dyestuffs Alkali, Acids Reducing agents Thickeners CH_2O,Urea and Salts	Toxicity COD BOD pH Suspended solids Strong colour	M/H H H H H H
Finishing	Acid catalysts Surfactants, Softeners, Lubricants and Metal salts	Alkalinity BOD (low) Toxicity	L L H

Table (2) Major constituents and characteristics of wastewater from wet processing of wool and blends (World Bank, Paris Commission, Helsinki Commission)			
Process	**Major Constituents**	**Characteristics**	**Pollution Impact Low, Medium, High**
Scouring	Alkali, grease, coloured material	BOD (high), Grease, High alkalinity Temperature (40-50^{o}C)	H H
Bleaching	SO_2 or H_2O_2	BOD (low)	L
Dyeing	Acid or metal dyes Acetic acid or H_2SO_4 Salts Surfactants Insect-proofing agents	pH (low) BOD (medium) Toxicity	H M H

Table (3) Major gaseous and particulate emissions in the textile industry (World Bank, Paris Commission, Helsinki Commission)		
Source	**Pollutants**	**Pollution Impact Low, Medium, High**
Cotton treatment (carding, combing, preparation and fabric manufacturing)	Particles	H
Sizing of natural cellulose fabrics	Nitrogen oxides, Sulphur oxides, Carbon monoxide	L
Bleaching with chlorine compounds	Chlorine, Chlorine dioxide	M
Dyeing Disperse dyeing using carriers Sulphur dyeing Aniline dyeing	Carriers H2S Aniline vapours	H H H
Printing	Hydrocarbons, ammonia	H
Finishing Resin finishing Heat setting of synthetic fibres	Formaldehyde Carriers, Polymers, lubricating oils	H H

Table (4) Sources of solid waste in textile manufacturing (World Bank, Paris Commission, Helsinki Commission)		
Source	**Type of solid waste**	**Pollution impact low, medium, high**
Mechanical operations of cotton synthetics: Yarn operations Knitting Weaving	Fibres and yarns Fibres and yarns Fibres, yarn, cloth scraps	L L L
Dyeing and Finishing of Woven Fabrics: Sizing,desizing, mercerizing, Bleaching, washing, Chemical finishing, Mechanical finishing, Dyeing and/or printing.	Cloth scraps Flock Dye and chemical containers	L L H
Dyeing and Finishing of Carpets: Tufting, Selvage trim, Fluff and shear, Dyeing, printing and finishing,	Yarns and sweepings Selvage Flock Dye and chemical containers	L L L H
Dyeing and Finishing of Yarn and Stock	Yarns, dye and chemical containers	H
Wool scouring	Dirt, wool, vegetable matter, waxes	H
Wool fabric dyeing and finishing	Flocks, seam, fabric, fibres, dye and chemical containers	H
Wastewater treatment	Fibres, sludge	H
Packaging	Paper, cartons, plastics, ropes	L
Workshops	Scrap metal, oily rags	L