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Review Article

Waste Management of Textiles: A Solution to The Environmental Pollution

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A B S T R A C T

Textile industry plays an important role in the economy of the country like India and it accounts for around one third of total export. Textile industry is one of the main source of pollution problem worldwide. Textile effluent is characterized by high BOD (from 700 to 2,000 mg/l) and COD loads, suspended solids, mineral oils and residual dye. 10-25% of textile dyes are lost during the dyeing process, and 2-20% is directly discharged as aqueous effluents in different environmental components. Traditionally produced fabric contains chemical residues, used during their manufacturing. These chemical residues may evaporate in air or may absorb through our skin thus causing allergy. According to a June 5, 2005 article in business week, the population allergic to chemicals will grow to 60% by the year 2020. The paper deals with the various operations involved in the textile industry and discusses about the water usage and wastewater characteristic of textile industry. It also gives a brief idea about the treatment technologies for treating waste water.

Keywords

Economy, pollution, BOD, COD, residual dye, effluents, allergy, wastewater

Introduction

The textile dyeing industry consumes large quantities of water and produces large volumes of wastewater from different steps in the dyeing and finishing processes. Wastewater from printing and dyeing units is often rich in color, containing residues of reactive dyes and chemicals, and requires proper treatment before being released into the environment. The toxic effects of dyestuffs and other organic compounds, as well as acidic and alkaline contaminants, from industrial establishments on the general public are widely accepted.

Increasing public concern about environmental issues has led to closure of several small-scale industries Babu, B. R et al., (2007).

Dyes are extensively used in the textile industry. The colour which dues impart to water bodies is very undesirable to the water user for aesthetic reasons (Chen, C.C et al 2005). Due to high concentration of organics in the effluents and higher stability of modern synthetic dyes, their discharges into rivers are harmful to aquatic life Acosta,D.R et al., (2005)., Denizil, A et al., (2000).The textile dyeing and printing industry have been recognized as one of the most polluting industries in India, which contribute towards the pollution of the water environment.

The main challenge for the textile industry today is to modify production methods, so they are more ecologically friendly at a competitive price, by using safer dyes and chemicals and by reducing cost of effluent treatment/disposal. Recycling has become a necessary element, not because of the shortage of any item, but because of the need to control pollution. There are three ways to reduce pollution: (1) use of new, less polluting technologies; (2) effective treatment of effluent so that it conforms to specified discharge requirements; and (3) recycling waste several times over before discharge (Sule, A .D and Bardhan, M.K. 1999). which is considered the most practical solution Babu, B. R et al (2007).

Operations in textile industry

The textile industry comprises a diverse and fragmented group of establishments that produce and/or process textile-related products (fiber, yarn, and fabric) for further processing into apparel, home furnishings, and industrial goods. Textile establishments receive and prepare fibers; transform fibers into yarn, thread, or webbing; convert the yarn into fabric or related products; and dye and finish these materials at various stages of production (Ghosh, P and Gangopadhyay, R. 2000).

Desizing

In this process, the sizing ingredients are removed from the grey fabric by dissolving them. This is necessary as the presence of sizing agents on the fabric hampers the penetration of other chemicals in the subsequent stages (Bhatia, S.C. 2007).

Scouring

The scouring process is carried out to remove impurities such as wax, fatty acids, oils, etc., present in the fabric. Scouring is carried out in alkaline conditions under high pressure and temperature. Alkaline waster with high BOD and COD is generated at this stage (Bhatia, S.C. 2007).

Mercerising

Mercerizing increases the tensile strength, luster and dye affinity of the fabric. The operation is accomplished by impregnating the cotton fabric with cold sodium hydroxide solution. This causes swelling of the fibre, which resulted in an increase in the dye intake. When increase in tensile strength is the main criteria, mercerizing is carried out in a tenter frame. Waste generated at this step is highly alkaline in nature. The fabric is taken for mercerizing depending upon the finishing requirements. This is done only for cotton fabrics (Bhatia, S.C. 2007).

Bleaching

Bleaching is carried out to destroy the coloring matter and whiten the fabric. Different chemicals such as hypochlorite's, hydrogen peroxides, etc., are used as bleaching agents. The process conditions during bleaching vary with the type of agent used. The waster- water from this section is alkaline in nature and contains chlorides and dissolved solids (Bhatia, S.C. 2007).

Dyeing

Dyeing is carried out to impart a solid all - over shade to the fabric. The main purpose of dyeing is to anchor dyestuff molecules to the textile fibres. Dye shades are obtained by treating the textile material with a solutions containing dyestuff and other auxiliary chemicals. Dyeing water – water is characterized by the presence of unexhausted dyestuff and other chemicals. The waste - water generally has high TDS, colour and BOD concentrations (Bhatia, S.C. 2007).

Printing

Printing produces coloured patterns on the fabric. It is carried out using print containing dyestuff, pigments and other auxiliary chemicals. Different types of printing, that is, block printing, screen priming, etc., are used to produce the coloured patterns on the textile materials. Large volumes of coloumes of coloured waste - water with a high BOD are generated from the print section (Bhatia, S.C. 2007).

Finishing

When of textile material has been scoured, bleached, dyed and printed, it has to be finished. This stage includes the final operations necessary for making the textile presentable ad attractive. The finishing operations include (Bhatia, S.C. 2007).

•Drying
•Providing dimensional stability
•Calendaring
•Softening

Water Usage

The water requirement for textile processing is large and varies from one mill to another and this depends on factors like: (a) source of water and its availability; (b) the quantity and quality of the fabrics produced; and types of processing and its sequence. The water usage for different purposes in a typical cotton textile mill and synthetic textile processing mill is given in Table 1. To produce one metre of finished cloth the water consumption is in the range of 12 to 65 litres. The longer the processing sequence, the greater will be quantity of water used. The processing of yarn also requires equally large volume of water. Bilk of the water consumed in the washing of the fabric at the end of each process (Birdie. G.S, Birdie. J.S. 2006).

Textile waste water characteristics

Composite textile wastewater is characterized mainly by measurements of biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS) and dissolved solids (DS). Typical characteristics of textile industry wastewater are presented in Table 3. Results in Table 1 show a large extent of variation from plant-to-plant and sample-tosample. As presented in Table 3, COD values of composite wastewater are extremely high compare to other parameter. In most cases BOD/COD ratio of the composite textile wastewater is around 0.25 that implies that the wastewater contains large amount of no biodegradable organic matter. Sule. A .D and Bardhan. M.K. (1999).

Table.1 Water Usage in Textile Mills (clause 3.1)

Sl.No.	Purpose	Cotton textiles	Synthetic textiles
		Percent	Percent
(i)	Steam generation	5.3	8.2
(ii)	Cooling water	6.4	--
(iii)	demineralised water of specific processes	7.8	30.6
(iv)	Process water (raw water)	72.3	28.3
(v)	Sanitary use	7.6	4.9
(vi)	Miscellaneous and fire fighting	0.6	28.0

Table.2 Water Consumption in Textile Mills (clause 3.1.1)

Sl.No.	Production m/day	Kg/day	Water consumption m^2/day (gross)	m^2/100 kg of Cloth
(1)	(2)	(3)	(4)	(5)
(i)	200000	42000	2400 to 2700	57 to 65.5
(ii)	220000	12000	2250	187.5
(iii)	220000	2500	15400	600
(iv)	45000	7500	1830	244
(v)	40000	66700	1100	164
(vi)	*	6150	2620	261
(vii)	65000+	7000	5700	800

* Average for a group of 25 textile mills.

Table.3 Composite Textile Wastewater Characteristics

S.No.	Parameters	Values
1	pH	7.0-9.0
2	Biochemical Oxygen Demand (mg/L)	80v – 6,000
3	Chemical Oxygen demand (mg/L)	150-12,000
4	Total suspended solids (mg/L)	15-8,000
5	Total dissolved Solids (mg/L)	2,900-3,100
6	Chloride (mg/L)	1000-1600
7	Total Kjeldahl Natrogen (mg/L)	70-80
8	Colour (Pt-Co)	50-2500

Source: Al-kdasi *et a*l., 2005.

Table.4 Specific pollutants from textile and dyeing processing operations

S.No.	Process	Compounds
1	Desizing	Sizes, enzymes, starch, waxes, ammonia.
2	Scouring	Disinfectants and insecticides residxies, NaOH, surfactants, soaps, fats, waxes, pectin, oils, sizes, anti-static agents, spent solvents, enzymes.
3	Bleaching	H_2O_2, AOX, sodium silicate or organic stabiliser, high pH.
4	Mercerizing	High pH, NaOH
5	Dyeing	Colour, metals, salts, surfactants, organic processing assistants, sulphide, acidity/ alkalinity, formaldehyde.
6	Printing	Urea, solvents, colour, metals.
7	Finishing	Resins, waxes, chlorinated compounds, acetate, stearate, spent solvents, softeners.

Source: All`egre et al.,2006

Table.5 Treatment Process for Treating Waste-Water From Textile Units (Carmen, Z. and Daniela, S. 2012)

S.No.	Treatment Methodology	Treatment stage	Advantages	Limitations
		Physico– chemical treatment		
1	Priecipitation, coagulation flocculation	Pre/ main treatment	Short detention time and low capital costs. Relatively good removal efficiencies	Agglomerates separation and treatment. Selected operating condition
2	Electrokinetic coagulation	Pre/ main treatment	Econominally feasible	High sludge production
3	Fenton process	Pre/ main treatment	Effective for both soluble and insoluble coloured contaminants. No alternation in volume	Sludge generation, problem with sludge disposal. Prohibitively expensive
4	Ozonation	Main treatment	Effective for azo dye removal applied in gaseous state: no alteration f volume	Not suitable for dispersed dyes. Releases aromatic dyes. Short half- life of ozone (20 min)
5	Oxidation with NaOCl	Post treatment	Low temperature requirement initiates and accelerares azo-bond cleavage	Cost intensive proves. Release of aromatic amines
		Adsorption with solid adsorbents such as:		
6	Activated carbon	Pre/ post treatment	Economically attractive. Good removal efficiency of wide variety of dyes	Very expensive; cost intensive regeneration process
7	Peat	Pre treatment	Effective adsorbent due no cellular structure. No activation required	Surface area is lower than activated carbon
8	Coal ashes	Pre treatment	Economically attractive. Good removal efficiency	Larger contact times and huge quantities are required. Specific surface area for adsorption are lower than activated carbon
9	Wood/ chips/ wood sawdust	Pre treatment	Effective adsorbent due to cellular structure. Economically attractive. good adsorption capacity for acid dyes	Long retention time and huge quantities are required
	Silica gels	Pre treatment	Effective for basic dyes	Side reactions prevent commercial application
	Irradiation	Post treatment	Effective oxidation at lab scale	Requires a lot of dissolved oxygen (O_2)
	Photochemical process	Post treatment	No sluge production	Formation of by products
	Electrochemical oxidation	Pre treatment	No additional chemicals required and the end	Cost intensive of by products

			products are non – dangerous/ harzardous	
	Ion exchange	Main treatment	Regeneration with low loss of adsorbents	Specific application not effective for all dyes
Biological treatment				
1	Aerobic process	Post treatment	Partial or complete decolourization for all classes of dyes	Expensive treatment
2	Anaerobic process	Main treatment	Resistant to wide variety of complex coloured compounds. Bio gas produced is sued for stream generation	Longer acclimatization phase
3	Single cell (fungal, algal & Bacterial)	Post treatment	Good removal efficiency for low volumes and concentrations. Very effective	Culture maintenance is cost intensive. Cannot cope up with large volumes of WW.
Emerging treatments				
1	Other advanced oxidation process	Main treatment	Complete mineralization ensured. Growing number of commercial application Effective pre- treatment	Cost intensive process
2	Membrane filtration	Main treatment	Removes all dye types; recovery and reuse of chemicals and water	High running cost concentrated sludge production. Dissolved solids are not separated in this process
3	Photocatalysis	Post treatment	Process carried out at ambient conditions. Inputs are no toxic and inexpensive. Complete mineralization with shorter detention times	Effective for small amount of coloured compounds. Expensive process.
4	Sonication	Pre treatment	Simplicity in use. Very effective in integrated systems	Relatively new method and awaiting full scale application.
5	Enzymatic treatment	Post treatment	Effective for specifically selected compounds	Enzyme isolation and purification is tedious

Production of textile industry pollution

Textile Printing and dyeing processes include pre-treatment, dyeing and printing, finishing. The main pollutants are organic matters which come from the pre-treatment process of pulp, cotton gum, cellulose, hemicellulose and alkali, as well as additives and dyes using in dyeing and printing processes. Pre-treatment wastewater accounts for about 45% of the total, and dyeing/printing process wastewater accounts for about 50%~55%, while finishing process produces little. The chroma is one pollutant of the wastewater which causes a lot of concerns. In the dyeing process, the average dyeing rate is more than 90%. It means that the residual dyeing rate in finishing wastewater is about 10%, which is the main reason of contamination. According to the different dyes and process, the chroma is 200 to 500 times higher than before Wang, Z et al. The potential specific pollutants from textile Printing and dyeing is shown in Table 7.

Treatment Technologies

The textile dyeing wastewater has a large amount of complex components with high concentrations of organic, high-color and changing greatly characteristics. Owing to their high BOD/COD, their coloration and their salt load, the wastewater resulting from dyeing cotton with reactive dyes are seriously polluted. As aquatic organisms need light in order to develop, any deficit in this respect caused by colored water leads to an imbalance of the ecosystem. Moreover, the water of rivers that are used for drinking water must not be colored, as otherwise the treatment costs will be increased. Obviously, when legal limits exist (not in all the countries) these should be taken as justification. Studies concerning the feasibility of treating dyeing wastewater are very important. All`egre et al., 2006. Some selected treatment processes for dyes and colour removal of industrial wastewater applied over the time into different textile units are summarized in Table 5.

Textile industry consumes large amount of water. It takes about 12 to 65 litres of water to produce one metre of finished cloth and about 500 gallons to produce enough fabric to cover one sofa. Half a billion people already live in regions prone to chronic drought and by 2025; this figure is likely to have increased five folds. Global consumption of fresh water is doubling every 20 years. Keeping all this in mind it becomes extremely important to conserve water. The textile sector will continue to be vitally important in the area of water conservation due to its high consumption of water. Joints efforts are needed by water technologists and textile industry experts to reduce water consumption in the industry. While integrated approach should be adopted to treat and recycle water in the industry.

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