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Environmental Protection and Waste Management in Textile and Apparel Sectors

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Abstract: The fact that humans, who are responsible for the misuse and destruction of natural resources, are the party suffering the greatest harm within the ecosystem has increased the importance of environmental responsibility even more. In environment-based production strategies, environmental protection has become an economic activity that needs to be taken into consideration through all processes from designing to packaging. In this study, where eco-textiles were dealt with in a comprehensive manner, it was emphasized that aiming at manufacturing a healthy final product would not be sufficient and that environmentally friendly practices would have to be used in the production process as well.

Key words: Ecological production, ecological clothes, eco-textiles, waste management

INTRODUCTION

In his strategic management for a small planet, Stead^[1] stated that the world public has moved from an understanding of improvement at all costs to an understanding of continuous and balanced improvement since 1970's. In modern times, environmental protection is being implemented not because it is enforced law, but as an administrative philosophy.

Rapid degradation in environmental conditions has changed at attitude of industrial managers toward ecological environment and had them consider ecology a significant factor while taking decisions related to industrial management^[2]. Parameters responsible for environmental pollution include chemicals discharged into air, water and soil as well as energy pollution. Noise pollution caused by poorly planned settlement programs is also included in this group. Furthermore, safety and health of those working in production is also taken into account.

One of the factors that affects success is the level of environmental quality and responsibility among competing companies. Companies are now well aware of the relationship between environmental quality and prospects within the framework of economic development^[3]. Consumer demands that guide companies now include certain environmental issues in addition to quality, cost and production flexibility. Demand for environmentally friendly products manufactured under natural conditions from food products to clothes has made companies more sensitive to the environment. In his

publication entitled Environmental Quality and Our Responsibilities, Apak^[4] stated that companies having environmentally friendly technologies and practices had a certain advantage over their rivals on international markets.

It is possible to encounter quite a number of studies on environmentally friendly production in textile and apparel sector in the literature. In their article entitled Ecology from Cotton to Garment, Ozdoğan *et al.*^[5] defined ecology in textile and mentioned products manufactured using material and methods that pose no harm to people and nature during the overall production process and while the product is being used. In his article entitled Ecological Labels and Ecological Textile Products in the European Union, Ergün^[6] dealt with labels used in ecological textile products, while Koç and Duru^[7] studied methods of various analyses and tests in their research entitled Eko-TEX Standard 100.

The present study deals with factors causing environmental pollution in the textile and apparel sector as well as responsibilities that should be assumed by companies. For this purpose, priority was given to issues such as environmentally friendly textile and apparel production and ecological standards. Moreover, sources of pollution at all stages of production and possibilities of eliminating these factors were also discussed.

ECOLOGY IN TEXTILE AND APPAREL

Eco textiles are textile products that can be manufactured, used and disposed of without upsetting

the ecological balance and impairing human health. Eco textiles cover products that are manufactured using materials and methods that do not pose any harm to people and nature from textile fibre production to the make up of the finished article and that can be disposed of without harming human health and nature.

Three main factors can be referred to while assessing the compatibility of a textile product to nature:

Production: Fibre production, dyeing process, plant protection, chemicals, energy and water consumption

Usage: Health effects related to dyes and chemicals, energy and maintenance

Waste disposal: Incineration, decomposition, recycling^[8].

Eco textile processes: Requirements to be fulfilled if a textile product is to be called ecological can be divided into three specific areas:

Production ecology: Production should not cause any harm to the environment and to humans during all stages of manufacture, from the textile fibre to the finished article. Causing no harm to the environment does not only mean not polluting the soil, air and water, but also covers reducing noise and using raw materials, auxiliary products, water and energy consciously. What is meant by causing no harm to humans is a number of environmental and human health issues including working conditions and working hours, refraining from employing children and protecting pregnant workers and new mothers.

Human ecology: It deals with the idea that clothes and other textile products in close contact with human skin should not cause any harm to people through physical contact, respiration or digestion. The main objective of human ecology was to determine whether any toxic materials exist in a textile product taking into account where it is used (children's clothes-adult clothes, underwear-outer garments, pillow cases, curtains) and at what concentration these materials are found in a product through a series of analyses.

Disposal ecology: This is concerned with the disposal of discarded textile products using certain techniques such as incineration, decomposition, accumulation without posing any threats to people and the environment. Due to the fact that the modern consumer is especially concerned about human ecology and that production ecology is complex, versatile and difficult to screen, studies have focused on human ecology in particular^[9].

Based on both the environmental impact of textile products and demands of the international market, apparel companies have been trying to obtain a certificate authorizing that their products have met the parameters laid down by ecological standards. These efforts for such a certificate mainly come from apparel manufacturers themselves because they have to account for the conformity of the goods and services they buy in the manufacture of the final product to ecological criteria^[10].

An example to environmental standards on a regional basis is the Eco Management and Audit Scheme EMAS, which was set up by the European Union. The international environmental management scheme is called ISO 14000. This scheme was prepared by a technical committee working on the issue of Environmental Management within the framework of the United Nations Conference on Environment and Development, held from June 3 through June 14 in 1992 in Rio de Janeiro, Brazil^[11]. Environmental Management Standards were prepared so as to control the impact of textile production on the environment. Companies are awarded internationally-accepted references according to these standards that include audit, determination of life cycle, environmental labeling and environmental performance assessments.

The Eco-Tex 100 Standard, a normative document on textile ecology, was issued by a group of 13 European textile institutes^[12]. According to those standards, product classes include products with direct contact to skin, textile products for babies, bed sheets-quilt covers, home textiles and product without skin contact. Then the test criteria were determined. Border values of substances threatening human health as well as various test techniques were also specified in the standards. Companies that comply with these requirements in their production processes are entitled to obtain this standard label (Fig. 1). Clothes with direct contact to skin, baby clothes, bed sheets and quilt covers have more sensitive border values. Border values of various chemical substances that are included in the Eco-Tex 100 Standard are shown in Table 1^[13].

Greenspot, which is a packaging scheme implemented in recent years with the aim of protecting the environment and CE Mark which is a European Marking of Conformity, were both introduced as required applications and also compelled manufacturers exporting goods to the European Union member countries to fulfill necessary requirements^[14].

POLLUTING FACTORS DURING PRODUCTION

Each operational step that a raw textile material passes through from the moment it enters a textile or apparel establishment until it becomes a finished article is

Table 1: Criteria for Eco-Tex 100 standard

| Product groups | Garments for baby and kids | Garments connected with skin | Garments unconnected with skin | Decoration Products |
|---------------------------------------|----------------------------|---------------------------------------|--------------------------------|---------------------|
| Chemical substances | | | | |
| pH | 4.0-7.5 | 4.0-7.5 | 4.0-9.0 | 4.0-9.0 |
| Formaldehyde | 20 (ppm) | 75 (ppm) | 300 (ppm) | 300 (ppm) |
| Extractable heavy metals | | | | |
| Antimony | 5.0 | 10.0 | 10.0 | 10.0 |
| Arsenic | 0.2 | 1.0 | 1.0 | 1.0 |
| Lead | 0.2 | 1.0 | 1.0 | 1.0 |
| Cadmium | 0.1 | 0.1 | 0.1 | 0.1 |
| Chromium | 1.0 | 2.0 | 2.0 | 2.0 |
| Chromium VI | | Below the determining limit 0.5 (ppm) | | |
| Cobalt | 1.0 | 4.0 | 4.0 | 4.0 |
| Copper | 25.0 | 50.0 | 50.0 | 50.0 |
| Nickel | 1.0 | 4.0 | 4.0 | 4.0 |
| Mercury | 0.02 | 0.02 | 0.02 | 0.02 |
| | | Pesticides (for natural fibers) | | |
| Total (included PCP/TeCP) | 05. | 1.0 | 1.0 | 1.0 |
| Pentachlorophenol (PCP) | 0.05 | 0.5 | 0.5 | 0.5 |
| Tetra chlorophenol (TeCP) | 0.05 | 0.5 | 0.5 | 0.5 |
| Dyes | | | | |
| Degradable aryl amine | 20 (ppm) | 20 (ppm) | 20 (ppm) | 20 (ppm) |
| Carcinogen dyes | Not used | | | |
| Allergic dyes | % 0.006 | % 0.006 | % 0.006 | % 0.006 |
| Chlorine organic carrier | 1.0 (ppm) | 1.0 (ppm) | 1.0 (ppm) | 1.0 (ppm) |
| Biocide finishing | Not used | | | |
| Flame retardant finishing | Not used | | | |
| Organic tin compounds | | | | |
| TBT | 0.5 | 1.0 | 1.0 | 1.0 |
| DBT | 1.0 | | | |
| PVC | | | | |
| DINP, DNOPP, DEHP, DIDP, BBP, DBP | 0.1 | | | |
| Fastnesses | | | | |
| Water | 3 | 3 | 3 | 3 |
| Acidic sweet | 3-4 | 3-4 | 3-4 | 3-4 |
| Basic sweet | 3-4 | 3-4 | 3-4 | 3-4 |
| Dry rubbing | 4 | 4 | 4 | 4 |
| Wet rubbing | 2-3 | 2-3 | 2-3 | 2-3 |
| Spittle | Stable | | | |
| Volatile emissions mg m ⁻³ | | | | |
| Toluol | 0.1 | | | 0.1 |
| Styrene | 0.005 | | | 0.005 |
| Vinylcyclohexene | 0.002 | | | 0.002 |
| 4 Phenylcyclohexene | 0.03 | | | 0.03 |
| Butadiene | 0.002 | | | 0.002 |
| Vinylchloride | 0.002 | | | 0.002 |
| Aromatic hydrocarbons | 0.3 | | | 0.3 |
| Volatile organics | 0.5 | | | 0.5 |
| Odor test (no abnormal odor) | | | | |

a potential source of pollution. Polluting sources as well as measures to minimize them are given below in brief.

Textile materials: Solid wastes from textile and apparel factories are made up of textile materials and supplies that do not meet the required quality standards or remain after being used in production. Poor quality raw materials should not be accepted if textile companies would like to achieve better, more efficient and faster production operations and to minimize the amount of waste they

generate. Materials that remain after being used should be sorted carefully during production and related industrial establishments should be contacted to seek ways of reusing these materials. Various accessories are used while the fabric is transformed into a garment. If a garment is to be described as environmentally friendly, every single piece of the garment should be environmentally sound and fulfill environmental requirements. Especially, buttons, metals in zippers, nickel in buckles, chromium in leather accessories, neopran-based adhesives, rubber



Fig. 1: Eco-Tex standard 100 label

in sponges and hooks in underwear fall in this category. There are certain restrictions on some substances these products contain

Water: A great amount of water is used in textile finishing and dyeing. Depending on the technical specifications of the machines, the amount of water used for 1 kg finished article varies between 100 and 400 L. Economizing on water usage minimizes not only water consumption but also waste management costs.

Chemicals and dyes: The burden of dealing with pollution can be reduced by choosing chemical and dyeing substance that can be effective even when used in minimum quantities. Addition of the water, chemical substance and colouring agents disappearing from the dye bath makes it possible for the dye liquor to be used over and over again, thus reducing dyeing costs. Repeated use of dye baths acts as a preliminary refining process for dyeing plants discharging their waste into general refining systems. Some chemical substances are used to offset the relative impact of other chemicals. Textile products are treated with various basic and acidic substances during the finishing process. Basic and acidic residues that might remain on a textile product could irritate the skin in a humid environment. So as to eliminate this inconvenience, the pH value of the product should be so arranged that it matches the normal pH value of the human skin (approximately pH=5.5)^[13]. Textile products that are washed and neutralized in this manner do not normally create any problems related to pH values.

Heavy metal ions can enter a textile product through fibres or dyes that are used. Due to their toxic effects, heavy metals are permitted to exist in textile products up to certain limit values. These heavy metals include arsenic, lead, cadmium, cobalt, chromium (total), chromium VI, nickel, copper, mercury and antimony. Reports related to allergic reactions and serious diseases caused by

formaldehyde in textile products first appeared in the media in 1960's. Formaldehyde concentrations in the air exceeding 0.5 ppm cause irritation in mucosal membranes and the respiratory system. Pesticides are widely used in the production of plant fibres and especially in cotton cultivation as well as animal fibers. Textile products bearing Eco-labels are supposed to contain minimum amounts of pesticide residues. Certain preservatives (fungicides, antibacterial chemicals) prevent mould formation in raw materials and finished articles during lengthy shipments^[16].

Machine park and maintenance: Machines designed to economize on water, chemicals, dyes and energy should be chosen during feasibility studies. It is extremely important that these machines should not reduce production quality, cause any time and labour loss and contaminate the product or the waste material due to leaking, overflowing and dripping. Therefore, it is necessary that maintenance and repair work for these machines be conducted periodically.

SOCIAL RESPONSIBILITY OF COMPANIES

Along with today's consumer demands such as good quality, low price and made-to-order clothes, the concept of clean cloth has also emerged as an important concept in textile production. This is related to textile products that do not pollute the environment, pose any problems to human health and violate the social rights of employees who are supposed to work under internationally accepted work and social standards. Public reaction against clothes manufactured by companies that fail to comply with these requirements may affect the market share of these companies negatively. For commercial customers and manufacturers, this could discredit their trademarks and cause sales to drop^[17].

First of all, national legal directives pertaining to protection of the environment must be implemented.

Contamination of underground water reservoirs and drinking water by chemicals must be prevented and the personnel responsible for storing and disposing these chemicals must possess required qualifications. It would be much better if the chemical waste is disposed of by a specialized firm.

Chemical substances must not be mixed with other waste materials.

Storing and burning wastes in open areas must be prohibited.

Waste materials must be kept in safe areas in a way that they would not pose any threat to employees. For instance, keeping such waste in the corridors or on the

landings could block emergency exits, causing a safety hazard.

Waste water must be treated at a waste water treatment plant, liquid and solid oil must be passed through separate filters. They must be emptied and cleaned regularly and the contents must be disposed of properly. Figure 2 shows chemical substances stored under improper condition as they are stored in an open area don't have covers and the place is not a safe storage area.

WASTE MANAGEMENT IN TEXTILE AND APPAREL INDUSTRY

Wastes are generated during the following three stages in the lifecycle of the product:

- Manufacture
- Usage
- Discarding the textile product as waste.

As a result of disposal and discharge of waste materials freely, hazardous substances in the waste contaminate the soil; furthermore, this pollution can be carried down through underground layers with the help gravitation. Therefore, waste collection areas turn into chemical reactors that cannot be controlled easily and these uncontrolled piles of waste materials become potential explosives. Rehabilitation of waste collection areas requires funds reaching great dimensions. The sole solution for discarded materials that cannot be recycled in or outside the plant is to convert these materials into heat energy and minimize the risks involved by means of anti-leakage measures.

The 5R principle used in waste management can also be applied to textile and apparel wastes. These can be given briefly as follows:

- Reduce
- Reuse
- Recover
- Replace
- Recycle

Fabric wastes (Fig. 4) generated in textile and apparel factories can be divided into 4 groups:

- Fabric type (woven fabric, knit fabric)
- Fabric size (~ pieces of fabric larger or smaller than 40x40 cm)
- Fabric content (% cotton, cotton + pes combination, wool combination, fabrics with lycra)
- Fabric colour



Fig. 2: Chemical substances stored under improper condition



Fig. 3: Shoddy machine



Fig. 4: Fabric wastes

Figure 3 shows the shoddy machine used in the recycling processes in textiles, while Fig. 4 displays fabric wastes made into bales in an apparel factory.

In order to increase sales of an apparel product and make it more attractive to customers, a variety of smart-looking materials and accessories are used in packaging. Although it is known for a fact that packaging materials and accessories are quite important as part of successful

sale strategies, it should be kept in mind that some of these materials have nothing to do with the functional use of the product. In the end, these will be nothing but wastes and will have to pass through certain recycling processes. Therefore, it would be better to assess this matter with respect to environmental protection and protection costs, do away with packaging materials and accessories not related with the functional use of product and develop new techniques to increase sales.

Collecting waste regularly at the end of the useful working life-span of a product is one of the most important functions of waste management. Considering the fact that in Europe, alone 3.5 ton of garment waste is collected annually; such organizations deserve to be assessed in a separate study.

THE WASTE RECYCLING EXCHANGE

Waste materials generated during the production process of a plant can be used as raw materials in another. For this reason, the Waste Recycling Exchange was established within the framework of environmental protection practices so as to reuse the wastes generated during the production processes in various other sectors of the industry.

The waste recycling exchange provides the following advantages to companies:

- The exchange reduces extra spendings of the company for the disposal of wastes.
- Purchase of these wastes by another company converts these into an investment.
- Financial burden brought about by storing these wastes is automatically eliminated.
- Joining the exchange contributes to environmental protection initiatives.
- A large number of prospective purchasers increase the financial value of these wastes. Certain pieces of information should be presented to the waste recycling exchange about the waste materials generated during the production process.
- Type and composition of the waste material
- Possible pollution data
- Frequency of waste generation
- Quantity
- Form of shipment
- Type of packaging

Some of the wastes from the textile and apparel industry that can be reused by the exchange are as follows:

- Cotton seeds from cotton gin mills (used in oil and feed factories)
- Greasy cotton and blend waste discarded by cotton yarn and cotton production facilities
- Waste materials such as comber waste, off-combing, plucked yarn (used in rough yarn factories)
- Carpet hems from carpet factories (raw material for bed fibre factories)
- Fents, fabric hems and sewing yarn discarded by apparel companies
- Sacks, empty barrels, drums and cardboard boxes^[18].

CONCLUSIONS

Increasing environmental problems have urged companies manufacturing goods to meet basic necessities of people to turn their looks to environment-based management strategies. This new approach also forms the basis of ecological production. The main objective of ecological production is to adopt and implement certain strategies that can make maximum use of nature without upsetting the ecological balance.

Owing to changing demand and technologies, textile and apparel product, which are among the basic necessities of people, can negatively effect the environment as well as humans during the production, usage and disposal stages. The share of environmentally friendly eco-textiles within international textile and apparel trade has been increasing so as to minimize hazardous effects. Importance attached to environmental protection by consumers (end users) and their understandings of responsibility have provided great contributions to this issue. Further improvement of the present level of ecological consciousness will help parties involved in various processes in textile trade and production to establish more efficient and to-the-point environmental quality standards.

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