

Various issues and new techniques in the scope of environment protection for textile sector

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Abstract

Natural resource depletion, air, water and land pollution, are examples of the environmental problems which have emerged as a result of intensified interventions into the environment. 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 various issues and new emerging techniques in the scope of environment protection for textile sector are reviewed.

Keywords: Environment, textile, clothing, environmental management, eco-textile.

Tekstil sektöründe çevre koruma kapsamında çeşitli yaklaşımlar ve konular

Özet

Doğal kaynakların bilişsizce tüketimi, hava, su ve toprak kirliliği çevreye yönelik yapılan yoğun baskuların bir sonucu olarak ortaya çıkmaktadır. Doğal kaynakların bilinçsiz kullanımı ve tahribatından sorumlu olan insanın aynı zamanda ekosistem içersinde en çok zarar göreninde olması çevresel sorumluluğun önemini artırmıştır. Çevre esaslı üretim stratejilerinde çevre koruma, ürünün tasarımından paketlenmesine kadar geçen işlemler esnasında önemsenmesi gereken ekonomik bir faaliyet olarak kabul edilmektedir. Bu çalışmada çevre koruma kapsamında tekstil sektöründeki çeşitli yaklaşımlar ve konular incelenmiştir.

Anahtar Kelimeler: Çevre, tekstil, konfeksiyon, çevre yönetimi, ekotekstil

1. Introduction

Increasing cost for waste disposal and emissions control, growing regulatory pressure, increasing concern regarding liabilities, and increasing customer demands for environmental quality are providing powerful incentives for companies to reduce or even eliminate adverse environmental impact of their products and processes (Zhang vd, 1999).

Although environment and development are generally not complementary, environmentally sound development is the current demand. Environment can be thought of as the stock of physical or social resources available at a given time for the satisfaction of human needs. This stock does

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change over time. The rates and kinds of change are important dimensions of environmental concerns. The resources available for the satisfaction of human needs comprise the physical environment. These resources include forests, minerals, air quality, water quality and quantity, adequate and reliable rainfall, and moderate temperature. Over time, new uses or new technologies can increase or deplete the available stock of resources. Recently, rapid industrialization, urbanization and other technological developments have exploited the available resources to a large extent. This has caused serious scarcity of important natural resources (Khan, et al, 2002).

In the late 1980's the environmental implications of resource and energy use emerged as a serious consideration, especially with the problem of acid rain in Europe and North America, and the growing awareness of the potential global greenhouse effect. These two problems joined the growing list of environmental problems arising from the disposal of wastes. Doubts arose about the ultimate ability of the earth's natural systems to deal with these wastes, and pressure was placed on manufacturers to reduce the environmental impacts of their products by going about things in different ways. The question arose as to contribution of less obvious steps in the whole journey of a product from raw material extraction, through manufacture, to final disposal. This led to the realization that the environmental impacts resulting from a product or service could only be properly understood after a comprehensive assessment in which all process steps from extraction through to disposal had been evaluated. As a result of this realization, firms producing various products changed their environmental policies. These policies are explained in six groups;

- Demonstrate environmental awareness,
- Comply with environmental regulations,
- Address customer concerns
- Mitigate environmental risks,
- Limit financial liability and
- Report environmental performances (Ross et al, 2002 ; Fitzgerald et al, 1999)

2. Scope of the Life Cycle Assessment (LCA)

LCA, as defined in 1990 by The Society for Environmental Toxicology and Chemistry (SETAC) is “a process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and materials used and wastes released to the environment; to assess the impact of those energy and material uses and releases to the environment; and to identify and evaluate opportunities to effect environmental improvements” (Azapagic, 1999). Soon afterwards, The International Organization for Standardization (ISO) made comprehensive study on the LCA methodology.

According to ISO14040 an LCA study contains the steps shown in Fig. 1 (Dahllof, 2003).

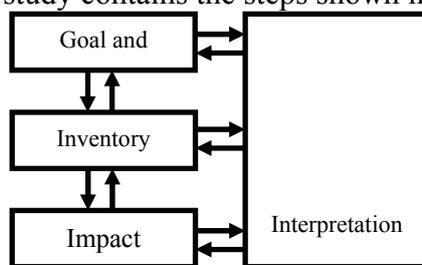


Fig.1: Phases of an LCA (Dahllof, 2003).

Life cycle assessment (LCA) studies the environmental aspects and potential impacts throughout productivity a product's life from raw material acquisition through production, use and disposal (i.e. from cradle-to-grave) and additionally LCA is a quantitative environmental performance tool, essentially based around mass and energy balances but applied to a complete economic system rather than a single process [Finnveden, 1998 et all; Azapagic, 1999). An LCA includes four phases:

- a) Goal and scope definition.
- b) Inventory analysis, involving the compilation and quantification of inputs and outputs for a given product system throughout its life-cycle.
- c) Life-cycle impact assessment, aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system. This phase may include elements such as:
 - Classification (assigning of inventory data to impact categories),
 - Characterization (modeling of the inventory data within impact categories),
 - Valuation.

Common impact categories are:

- Stratospheric ozone depletion (CFC-11 equivalents)
- Climate change (CO₂ equivalents)
- Photo-oxidant Creation Potential (Ethylene equivalents)
- Acidification (SO₂ equivalents)
- Eutrophication of waters (PO₄ equivalents).

d) Interpretation, in which the findings of either the inventory analysis or the impact assessment, or both, are combined in line with the defined goal and scope (Dahllof, 2003 ; Finnveden, 1998 et all).

Fig 2. illustrates the stages in the LCA of a product. According to Fig 2, life cycle of a product contains process or activity from extraction of raw materials to final disposal, including manufacturing, transport, use, re-use, maintenance and recycling (Azapagic, 1999). While chemical or process engineering is normally concerned with the operations within system boundary, LCA considers the whole material energy supply chains, so that the system of concern becomes everything within system boundary. The material and energy flows that enter, exist in or leave the system include material and energy resource and emissions to air, water and land. These are often referred to as environmental burdens and they arise from activities encompassing extraction and refining of raw materials, transportation, production, use and waste disposal of a product or process The potential effects of the burdens on the environment, i.e. environmental impacts, normally include global warming potential (GWP), acidification, ozone depletion (OD), eutrophication etc. (Azapagic et all, 1999).

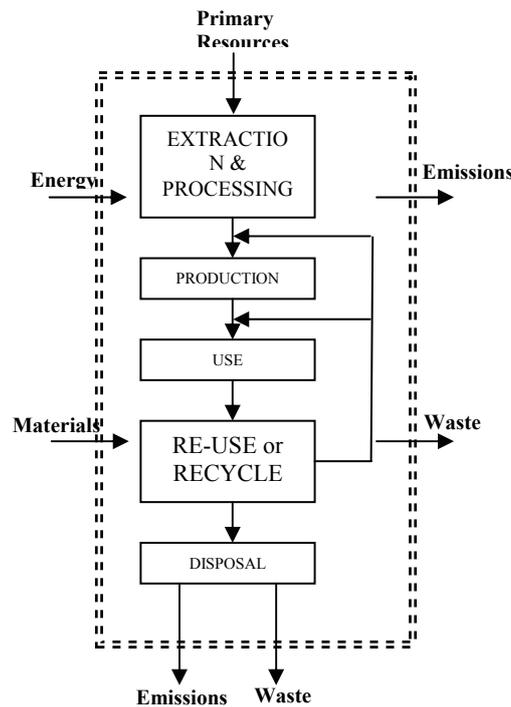


Fig: 2. Stages in the LCA of a product (Azapagic et al, 1999).

3. Environmental Issues for Textile Processing

In absolute numbers, textile fiber consumption increased from 29.4 million tons in 1980 to about 52 million tons in 2001. These figures, together with the facts that conventional cotton cultivation is highly environmentally impacting and synthetic fibers are made of fossil resources, indicate that the environmental problems associated with textiles are increasing. Owing to the large amounts of chemicals used, discharges to water are of great environmental concern for the textile industry and textile users. Cleaning of clothes is, for instance often considered problematic for the environment. Another aspect making the problem with chemical discharges to water important is that a substantial part of the textile industry is situated in the developing world, where the wastewater treatment possibilities are limited. In the agriculture step for the production of natural fibers, chemicals such as pesticides and nutrients are also emitted to water and soil, causing problems affecting biodiversity and human health. Water use for cotton cultivation is in many cases unsustainable. It can cause depletion of water resources or salinization of the soil. (Dahllof 2004). In general, textile industry produces yarn, fabric and garment and naturally consumes natural resources. The raw materials used for the textile products include both natural and synthetic fibres and fibre mixtures. The general textile product chain is shown in the fig 3. (Nieminen, 2003).

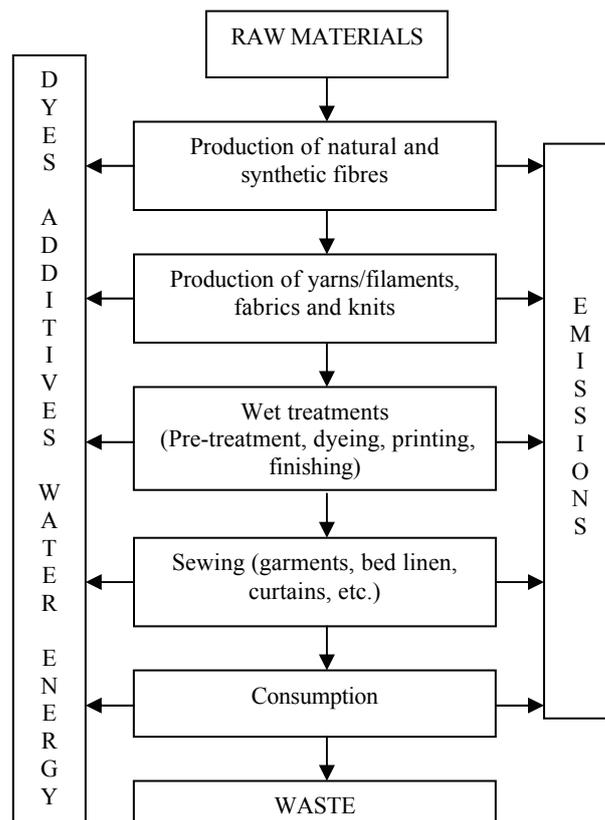


Fig. 3: Textile product chain (Nieminen, 2003).

As it is shown in Fig 3 the stages in the manufacturing of textile products affect the nature and require using the large quantity natural sources

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 (Hilden, 1992).

4. Eco Textile Processes

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.

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 is 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 (Türkey, 1997).

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 (Ünlütürk, 1994).

Textile wet processes consume dyes, auxiliaries, chemicals, detergents and finishing agents in the conversion of raw materials to finished product. The specific water use varies from 60 to 400 l/kg of fabric, depending on the type of fabric wet application. Generally, textile effluents are highly coloured and saline, contain non-biodegradable compounds, and are high in Biological and Chemical Oxygen Demand (BOD, COD). These factors combine to present numerous operational problems in municipal wastewater treatment works, which are biological processes and not intended for the breakdown of complex organic molecules. The presence of metals and other dye compounds inhibits microbial activity and in some cases

may cause failure of biological treatment systems. Various indicators may be used to classify strength of effluent from the textile process; these are shown in Table 1 (Wynne et al, 2000).

Emissions from the textile industry take the form of liquid effluents, wet fabric/fibre wastes from dye processes, solid wastes from the dry processes, hazardous wastes and air emissions. Liquid effluents contain many different components such as: dyes and chemicals, leveling and dispersing agents, alkalis and salts, metals and acids . Table 2 shows the effluent characteristics from the textile industry (Wynne et al, 2000).

Table 1 Overall effluent characteristic for textile mills (Wynne et al, 2000).

Determinant	Woven Fabric	Knit Fabric	Yarn Dyeing /Finishing
Biological Oxygen Demand(mg/l)	550	250	200
Suspended Solids (mg/l)	185	300	50
Chemical Oxygen Demand (mg/l)	850	850	524
Sulphide (mg/l)	3	0-2	-
Colour (ADMI)	325	400	600
PH	7-11	6-9	7-12
Water Use (l/kg)	297	277	297

In addition to high volumes of liquid effluent (wet processes have a high specific water usage), solid wastes comprising waste fibre and fabric, paper waste, sludge from effluent treatment and dyebath wet wastes are also produced. Most dyes are not readily biodegradable. The microbial populations present in the aerobic systems of municipal works cannot breakdown the molecules that cause colour in the effluent. Some dyes though, particularly those containing the azo bond, may be partially reduced by anaerobic microbes in biological systems. Other dyes may be adsorbed onto the sludge in the digesters or sludge beds of aerobic systems. Generally, acid and reactive dyes have poor adsorption capabilities due to their solubility in the effluent. Direct, disperse and vat dyes are readily adsorbed onto the sludge (Wynne et al, 2000).

Table 2. Effluent characteristics from the textile industry (Wynne et al, 2000)

Process	Effluent Composition	Nature
Sizing	Starch, waxes, carboxymethyl cellulose (CMC), polyvinyl alcohol (PVA), wetting agents	High in BOD, COD
Desizing	Starch, CMC, PVA, fats, waxes, pectins	High in BOD, COD, SS, DS
Bleaching	Sodium hypochlorite, chlorine, sodium hydroxide, hydrogen peroxide, acids	High alkalinity, high SS
Mercerising	Sodium hydroxide, cotton wax	High pH, low BOD, high DS
Dyeing	Dyestuffs, oxidizing agents, acetic acid detergents	Strongly coloured, high BOD, DS, low SS, heavy metals
Printing	Pastes, urea, starches, gums, oils, binders, acids, thickeners, cross-linkers, reducing agents, alkali	Highly coloured, high BOD, oily appearance, SS
Finishing	formaldehyde Inorganic salts	Slightly alkaline, low BOD

5. New Emerging Techniques for Environment Friendly Textiles

Enzyme catalysed finishing processes: Enzymes act as biocatalysts activating and accelerating chemical reactions, which would otherwise normally need more energy. In the textile finishing processes at present many enzymes are used and are under study for natural fibres. For example amylases for the desizing of starch, cellulases for biofinishing, etc. are state of the art, whilst enzymatic mixtures for cotton scouring, enzymes for cotton bleaching, wool scouring and anti-felting, silk degumming as well as flax softening are still in development (Nieminen et al, 2007).

Plasma technology: A plasma, which consists of a mixture of partially ionised gases is able to cleave covalent chemical bonds and thereby to modify the surface of textiles. Generally for the treatment of textile surfaces the corona and low-pressure plasma are used. The treatment can be performed on natural and synthetic fibres as a pre-treatment step (e.g. wool degreasing, desizing), to change the fibre wettability (hydrophobic/-philic properties), as a pre-treatment for the dye process (increase in dyestuff affinity, improved dye levelling properties), anti-felt finishing in wool or to increase the stability of textiles against aggressive media. Several lecturers have established that corona and atmospheric plasma treatments are useful techniques and that they are clearly supporting the classic pre-treatment process

by which water and energy may be saved.

Alternative textile auxiliaries : There is a multiplicity of alternative textile auxiliaries, which could lead, in the future, to the prevention and reduction of environmental pollution. Such an auxiliary is the biopolymer

chitosan, which is the deacetylated derivate of chitin (component of crustacean shells). Chitosan is easy to handle, non-toxic to humans and biologically degradable and can be used to improve the staining of yarns or fabrics, to create a permanent antimicrobial effect, and as a softening agent; in wastewater treatment it can be used as a precipitation agent.

Due to its high adhesion power, chitosan can also be used as a sizing agent as an alternative to the poorly biodegradable synthetic sizing agents like PAC, PVA, CMC. In the frame of a research project different sizing recipes based on chitosan were developed by ITV-Denkendorf (D) (Stegmaier et al, 2004). Thereby, the sizing agents had to fulfil special properties such as good miscibility with other (cheaper) sizing agents, good water solubility, wettability and desizibility. Furthermore, the elongation property of the size film and the float viscosity had to be taken into consideration.

Different sizing agent recipes were developed and tested in lab experiments. The tests showed a higher tension strength of the chitosan films compared to starch and PVA films, a breaking elongation of the chitosan films (8-10%), which is considerably higher than the tensile elongation (3-4%). In mixtures with starch, the addition of chitosan led to an increase of the tensile strength and the elongation ability. Industrial experiments in different German textile mills were carried out. For instance for a cotton warp (20 tex) by the use of a sizing agent consisting of starch/chitosan/wax instead of starch/carboxymethylcellulose/ wax, the tests showed that the number of end breaks could be decreased from 2.8 to 1.6 per 100,000 picks. Thus the weaving efficiency could be improved by about 2.9-4.8 % (Nieminen et al, 2007).

Ultrasonic treatments: Ultrasonic treatments improve the dispersion of dyestuffs and auxiliaries and enhance their ability to emulsify and solubilise. The main environmental benefits achievable in textile

finishing are the energy savings (lower process temperatures and shorter cycle times) and the reduction in consumption of auxiliaries (Nieminen et al, 2007).

Electrochemical dyeing : For vat and sulphur dyeing, an attractive alternative technique for the reduction and oxidation of the dyes is the application of electrochemical methods instead of the conventional chemical reducing and oxidation agents. By the electrochemical technique the reducing agent is continuously regenerated at an electrode, which allows full recycling of the dye bath

and of the reducing agent (Nieminen et al, 2007).

Use of supercritical CO₂ in dyeing processes: Supercritical fluids are capable of dissolving organic molecules of low to medium polarity. Supercritical CO₂ is an appropriate solvent to disperse dyestuffs and fat and therefore,

can be used for dyeing of textile substrates, especially of PES and PP fibres. The advantages of the use of CO₂ is that the medium is non-toxic, the water consumption and gas emissions are almost zero, no drying step is necessary after dyeing, levelling and dispersing agents are not needed at all or they are added in very small amounts (Abele et al, 2002).

Fuzzy logic: Significant improvements in process reliability are achievable with the use of fuzzy logic (i.e. expert systems based on self-learning software systems). The main advantages to be expected are the improved process control, which subsequently can result in

increased productivity and enhanced quality of the final product. Indirect environment benefits are associated with the potential savings in energy and chemicals (auxiliaries) as a result of the improved process control (Nieminen et al., 2007).

On-line monitoring: The on-line monitoring can clearly increase the process reliability, save energy and auxiliaries and/or reduce the amount of rework. Examples for this are the monitoring of COD in a rinsing bath, concentration of oxidised or reduced agents on the textile or redox-potential during vat dyeing. An interesting example is the Sicam-Telecoll-System developed by ITV-Denkendorf (D), which regulates on-line the size add-on and thus allows reduction of the sizing agent consumption up to 20% and increases the weaving efficiency. On-line camera systems and colorimeters can be used to detect on-line faults of dyed and/or coated materials (Stegmaier et al., 2002)

Advanced oxidation processes: Advanced oxidation processes are already applied in textile waste water treatment for destruction of the residual organic load and/or decolouration based on the UV-activated photolysis of hydrogen peroxide and ozone. Depending upon the working conditions, the COD load and the colour can be reduced by over 95% (Marte et al., 2004)

6. Conclusion

The points of environmental protection have led the firms to be more sensible about environment. Nowadays, customers prefer environment friendly products and the textile firms have to consider these kinds of demand and improve more sensitive production strategies on environment protection. Activities aimed at environment protection and emerging cleaner technologies are in a key position when striving towards zero emissions in textile processing. Eco-production, eco-design, eco-efficiency, green engineering concepts aim to decrease emissions and to intensify the use of energy and material resources. It is also important to identify the most polluting stages of textile processing, with the help of life cycle assessment methodology, in order to focus the development of new technologies correctly.

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ÖNSÖZ

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Üniversiteli olmak bir ayrıcalıktır. İster öğrenci, ister çalışanı, isterse yönetici ve akademik personeli olsun, ayırım yapılmaksızın, üniversiteli ayrıcalıklı, diğer bir deyişle farkındalık özelliğine sahip olmalıdır. Çünkü; üniversiteli olmak hassas olmak, toplumun hassasiyetini hissetmek, olaylar karşısında duyarlı olmak, olaylara tarafsız bir gözle bakmayı bilmek, aydın olmak, ülke sorunlarını yakinen takip edip bu sorunların çözümüne ilişkin düşünce üretmek, görevini benimsemek ve sorumluluk kabul eden insan olmak demektir. Üniversiteli olanın, hiçbir sorun karşısında **“bana ne”** deme lüksü yoktur.

Üniversiteli insan; okuyan, yazan, günlük gazeteleri okumayı ve haberleri izlemeyi ihmal etmeyen, topluma danışmanlık görevini aksatmayan, insanları aydınlatacak fikirler üreten, bu fikirlerini sergilediği yazılarını takip eden ve kendi gibi hassas toplumlar yaratan insan olmak zorundadır.

Bir üniversite mensubu, her sabah evinden çıkarken onu birilerinin takip ettiğini, örnek olma kimliğinin olduğunu, hareketlerini, giydiği kıyafetlerini ve insanlara karşı davranışlarının örnek olduğunu aklından çıkarmamalıdır. Bu örneğin kendisine yüklediği sorumluluğu içinde hissetmeli ve davranışlarını buna göre düzenlemelidir. Nasıl ki, bir devlet büyüğü, toplumun çok iyi tanıdığı önemli bir şahsiyet, ya da bir sanat ve kültür insanı hareketlerini kontrol etmek ve ona göre davranmak zorunda ise üniversiteli olanlar da bu sorumluluğu yerine getirmek zorundadırlar. Onlar, canları istese de, toplumun tasvip etmediği hareketleri ve davranışları sergileyemezler.

Üniversitede yönetici ve akademik personelinin sorumluluğu biraz daha zordur. Çünkü; örnek olma yanında; bunun anlamını, önemini, önderlik ettiği genç kuşaklara da öğretmesi, benimsetmesi ve düşüncelerinin gelecek kuşaklara aktarılmasını sağlayacak kuşaklar yetiştirmek zorundadırlar. Nice yönetici insanlar, akademisyenler vardır ki; sözleri, tavır ve hareketleri, düşünceleri, kendinden sonra onlarca yıl, hatta yüzlerce yıl geçmesine rağmen, toplumda hala konuşulur, paylaşılır, yazdıkları okunur, fikirleri değerlendirilir ve yeni kuşaklara aktarılır. Bunun adına kısaca **“iz bırakmak”** denir. Toplumda iz bırakmak, unutulmamak her bilim adamının ve yöneticinin arzusu ve hedefi olmalıdır.

(*): Mütevelli Heyet Başkanı