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Prediction of Textile Waste Profile and Recycling Opportunities in Turkey

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Abstract
Effective utilisation and disposal of textile wastes requires an accurate prediction of solid waste generation. This research predicted the waste quantity generated in households and in industrial facilities in Turkey via surveys, factory research and official databases. Recycling methods, products and the profile of recycling sector were investigated. Approximately 884,890 tonnes of textile waste was generated in 2009. Dialogue problems between manufacturers and recyclers as well as a lack of collection of post-consumer waste were the main reasons for the low recycling ratio.

Key words: *textile waste, industrial waste, recycling, environmental impact, waste management.*

Introduction

The global supply of fibres has increased from 52.6 million tonnes to 70.5 million tonnes in the last 10 years [1]. More production means more waste, as well as a larger environmental impact. Huge energy and water consumptions in processing stages, agricultural pollution and industrial and post-consumer textile wastes in municipal solid waste (MSW) streams are the main sources of pollution from textile manufacturing. Textile wastes comprise 1.0 - 5.1% of Municipal Solid Waste (MSW) compositions in the world regions [2], such as 7% of the Kaikoura landfill in New Zealand [3], 4.95% in US [4], 1.3% in Beijing, China [5], and 4.7% in Bhutan - including leather [6]. Although textile and apparel manufacturing has largely shifted to developing countries, textile waste remains a big concern both in developed and developing countries [7 - 9]. Some possible environmental impacts of solid textile wastes in MSW are green house gas emissions, silver and chromium emissions as well as pesticide residuals [10 - 12].

The extracted energy consumption to manufacture one tonne of cotton garments is 66,648 kWh and that to manufacture one tonne of polyester garments is 91,508 kWh. For the packaging, transport and sale of these garments an extra 30 – 40% of environmental burden from the manufacturing process should be added [13]. Cotton, which is one of the fibres most used, production requires 7,000 – 29,000 litres of water per kilogram of cotton [14]. World cotton production in 2009 was about 25.2 million tons. In addition, cotton accounts for 11% of all pesticides used every year. Most pesticides used in cotton production are hazardous [14], having a direct effect upon wildlife from accumulation in the biosphere. Fertilisers, cotton stalks generated from cotton cultivation [15] and cotton dusts, which can penetrate the head airways and enter the airways of the lungs, in ginning processes [16, 17] as well as emissions during cotton transportation are some of the other environmental problems that occur during cotton production.

Polyester, which is also one of the fibres most used, has low photo- and bio-degradadability, and the drilling and refining of oil also cause serious environmental problems [18, 19]. Although polyester and cotton fibres cover over 50 % of the world fibre production, other fibres such as viscose, flax and wool also have some environmental impacts. New Zealand is the world's third largest wool producing country [1]. In most countries, carbon dioxide forms the largest proportion of greenhouse gas emissions; New Zealand is unique in that 37% of its emissions come from methane released from livestock [20].

Production processes, spinning, weaving, wet processes and making up also have environmental impacts. According to the life cycle assessment (LCA) of a nylon/cotton jogging suit, production processes consume 17% of the total primary energy consumption and contribute 15 % of greenhouse gases [21]. Textile wastewaters can cause serious hazards for both surface and underground water [22].

When comparing virgin material energy consumption with recycled material energy consumption, it can be concluded that the reuse of 1 tonne of polyester garments only uses 1.8% of the energy required for the manufacture of these goods from virgin materials and the reuse of 1 tonne of cotton clothing only uses 2.6% of the energy required to manufacture it from virgin materials [13]. Therefore the prediction of production and post-consumer textile wastes is crucial in the aspect of recycling facilities.

Turkey is among the top ten textile and ready-made exporters in the world [23]; therefore textile waste and recycling ratios in Turkey will make a significant contribution to global figures.

The aim of the study was to analyse solid textile and apparel wastes in Turkey via surveys, factory research and official data. Recycling efforts and solid waste disposal methods were also investigated.

Methods

Data sources

Production quantities were vital to calculate waste amounts. Therefore official capacity data were obtained from the Union of Chambers and Commodity Exchanges of Turkey (TOBB), local chambers of industry and local organised industrial zones. A questionnaire about current production quantities and industrial waste details was also mailed to textile and apparel manufacturers. The rates of generated waste during textile and apparel processes according to manufacturing type, such as weaving, knitting and yarn production were calculated in factory studies.

Another survey about production capacities and methods was mailed to recycling enterprises. Municipal solid waste data were collected from the municipalities and the Turkish Statistical Institute (Turkstat).

Apparel capacity was determined with production pieces from the TOBB data base. The approximate weights of the

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pieces were calculated with factory data since the distribution of the piece size and weight in grams were not known.

Survey methodology

The first survey was designed to analyse the waste types generated, waste amounts and the waste disposal behaviours of manufacturers. Closed questions and open questions were used in the survey. Closed questions were chosen to help respondents select production, waste and waste disposal types. Open questions were included so manufacturers could explain their own opinions. A cover letter was attached to both surveys in order to explain the purpose, utility and sponsors of the study. The letter assured respondents that the answers would be held in strict confidence. A self-addressed stamped envelope was also added to increase the response rate. The Union of Chambers and Commodity Exchanges of Turkey sent the questionnaires to its members in order to increase the response rate. Some local chambers of industry, such as the Gaziantep Chamber of Industry and Usak Chamber of Industry also motivated their members to answer the questionnaires.

Approximately 340 manufacturers in different sectors participated in the survey from all regions of Turkey. The manufacturers were chosen randomly. The distribution of sectors is given in ***Figure 1***.

The questionnaire contained questions that examined the following parameters:

- waste amount generated
- waste types generated
- waste disposal attitudes and behaviours of manufacturers
- opinions and suggestions of manufacturers related to textile wastes

The second survey was prepared to examine the textile waste recycling sector in Turkey. Although much more open questions were used compared to the first survey, closed questions were also used. Approximately 58 recycling companies answered the questions. The following issues were included in the questionnaire:

- Production quantity (recycling capacity)
- Waste types used (waste source)
- Recycling methods
- Waste supply path (How they have got the wastes)
- Application fields of recycled products
- Unrecycled waste types
- Problems
- Suggestions.

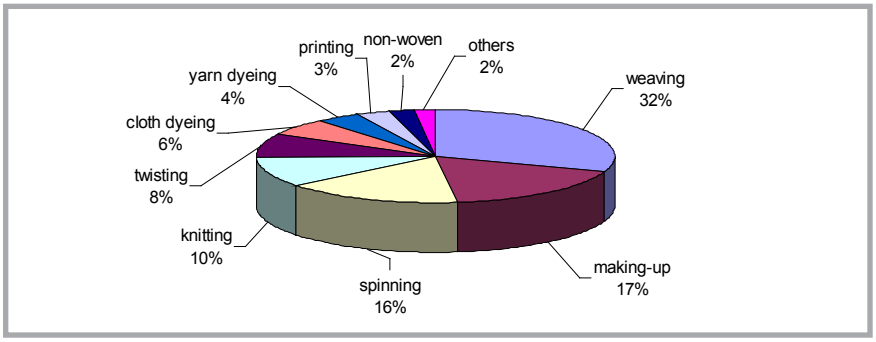

Figure 1. *Profile of participants.*

Table 1. *Generated waste ratios and waste amounts in textile processes; *Data obtained from SUSEB (Association of Man-Made Fibre Producers, in Turkey). **Waste ratios were determined in factory studies and in shrink values declared by local chambers of industry. Database of the Gaziantep Chamber of Industry, Karapınar Chamber of Industry, and Adana Chamber of Industry were used. ***Excluding hard waste and texturing waste; during the polymerisation process approx. 0.06% of hard waste; during texturing processes approx. 1 - 2% of yarn waste occurs.*

Production Type	Production amount (tons/year) in 2009	Waste ratio, %**	Waste amount (tons/year), average value
(Cotton) carded yarn including ring spinning	288,940	12-20.6	46,230
(Cotton) combed yarn including ring spinning	79,836	23-50.6	29,939
(Cotton) open-end yarn	303,607	10-19.2	43,944
Worsted yarn	68,283	21-33	18,436
Woollen yarn	302,005	up to 40	120,802
Polypropylene yarn	310,000 (SUSEB)*	14	43,400
Acrylic yarn	308,000 (SUSEB)*	10-13	35,420
Polyester yarn	360,000 (SUSEB)*	3***	10,800
Polyamide yarn	77,600 (SUSEB)*	3	2,328
Chenile, fancy yarns, hand knitting yarns, embroidery yarns	293,806	8-13	30,849.5
Cotton weaving	26,214	Yarn waste:1-2/ Trimming:1-6	Yarn waste: 393 Trimmings: 917
Wool weaving	600	Yarn waste:1-2/ Trimming:1-6	Yarn waste: 9 Trimmings: 21
Man-made yarn weaving	121,314	Yarn waste:1-2/ Trimming:1-6	Yarn waste: 1,819 Trimmings: 4,245
Knitting	581,632	2-4	29,081
Knitting garment	70,000	3-23	9,100
Nonwoven	55,625	~ 5	2,781
Cloth dyeing	188,184	0,5-2	2,351.5
Ready made (except garment)	301,083	2-15	10,537
Apparel garment	137,113	2-20	15,082
Total	3,873,842		458,485

Determination of generated waste ratio

Generated wastes were weighed for each production step in the factory studies and waste rates were calculated as follows:

$$WR = GW/IM \times 100 \qquad (1)$$

where: WR - Waste ratio, GW - Generated waste, IM - Input material.

The allowable wastes (shrinkages) of each manufacturing process for local chambers of industry were also evaluated.

Results and discussion

In total, 340 textile and apparel manufacturers and 58 textile recyclers, who recycle almost 85 % of all textile waste in Turkey, responded to the questionnaires.

Industrial waste types and sources

Industrial waste types were determined by factory studies and manufacturer responses. Waste quantities were calculated using the TOBB data.

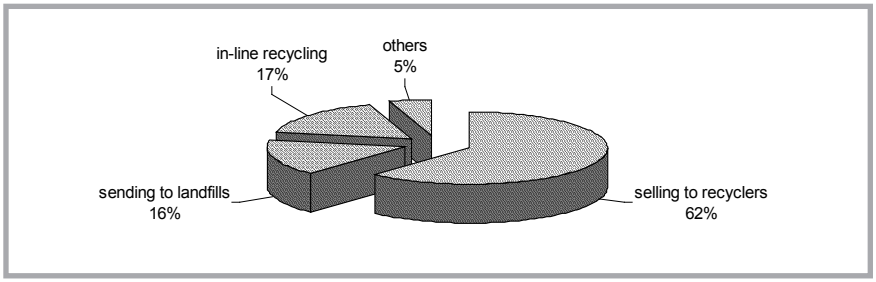

Figure 2. *Disposal behaviours of manufacturers.*

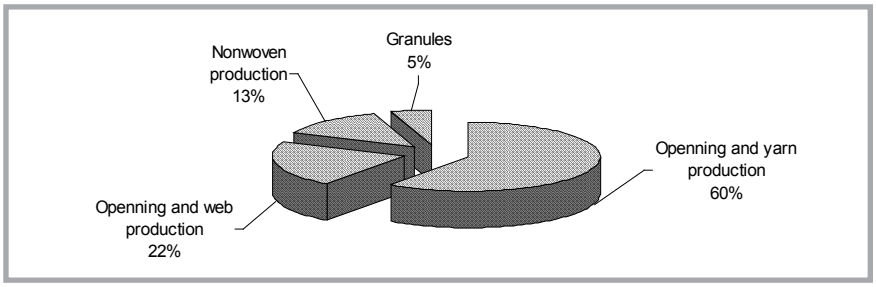

Figure 3. *Waste recycling methods according to the survey.*

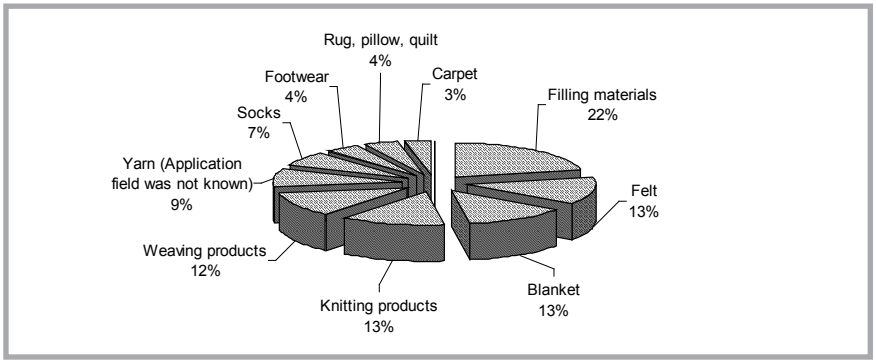

Figure 4. *Application fields of recycled materials according to the survey.*

Table 2. *Total textile waste amount of selected municipalities (tons/year).*

Municipality	Total waste generated in tons in 2008 (Turkstat, 2010)	Textile wastes in MSW (%, in weight)	Textile wastes (tons) in MSW
Municipality of Uşak	109.331	2	2.186
Metropolitan Municipality of Adana	771.361	2	15.427
Metropolitan Municipality of Gaziantep	279.919	3	10.545
Metropolitan Municipality of İstanbul	5.215.122	3,4	173.740
Metropolitan Municipality of Bursa	624.772	4,7	29.364
Metropolitan Municipality of Kayseri:	423.959	3,1 (Turkstat, 1996)	13.142
Total	7.424.464		244.404

Four main types of solid textile waste were generated during textile processes according to factory studies:

- Fibre wastes, which were mostly produced during yarn and non-woven production.
- Yarn wastes, which were mostly produced during yarn, weaving and knitting processes.
- Fabrics which were produced during non-woven, weaving, knitting and wet processes as well as for ready-made clothing.
- Other wastes, such as polymer wastes, were not incorporated into this study.

In total, 384,369 tonnes/year of fibre and yarn waste and 74,115.5 tonnes/year of cloth waste (or trimmings) were produced in Turkey in 2009 according to the calculations using TOBB data. The distribution of waste according to process is shown in ***Table 1*** (see page 17).

Fibre was the most common waste type generated since during yarn production it is difficult to use short fibres in the spinning process.

Manufacturers were also asked about their disposal behaviours, the results of which are shown in ***Figure 2***.

Textile waste is a cheaper feedstock for some processes, and thus 62% of the manufacturers preferred to sell their waste. Actually this was an encouraging result in terms of the environment and the economy. During yarn spinning processes, especially in natural fibre processes, 10 - 40% of the waste generated and in-line recycling was the most common recycling method in spinning processes. Fibre wastes were also the most used according to the recycler survey. Overall, 36% of the recyclers used fibre/yarn wastes, 33% - fibre, yarn and trimming waste, 24% - trimmings and 7% of the recyclers used other types of wastes (unknown materials).

Recycling methods and application fields of recycled materials

Mechanical methods were the most common method according to recycler survey; as seen in ***Figure 3*** ninety-five percent of the recyclers used mechanical methods (see ***Figure 3***).

Yarn production was the most common recycling method, where 66% of the recyclers used open-end technology. Polyamide fibre, yarn and cloth wastes were remelted and the granules were used in the plastic industry as plugs, doorknobs and armrests, as well as for many other uses, for example PET bottles mixed with PET fibre, yarn and cloth wastes. Then the blend is extruded to produce yarns.

Applications for the recycled materials according to the survey results are shown in ***Figure 4***.

Filling materials are used in mattresses, furniture, coats and for many other uses. Felts are produced as insulation material, floor-coverings and automotive textiles, among other uses. Recycled coarse yarns are knitted to produce jumpers, tricot fabrics, socks and other forms of clothing. Weaving products are mainly used in furnishings, especially in upholstery fabrics.

Textile waste in Turkey landfills

The following municipalities have the most important textile industry regions in Turkey. ***Table 2*** shows the textile waste portion of municipal solid waste, which also includes industrial wastes.

Municipal solid waste generally consisted of that generated from residential and commercial areas and industries in Turkey [24]. The ratio of textile wastes in MSW was mainly higher for cities that have textile industry regions. Although used clothing and other textiles also appeared in the MSW streams, the ratio was lower than those for Europe and the US. This result likely occurred due to economic reasons and consumer attitudes. For example the lifetime of clothing may be longer than the those in Europe and US, and in Turkey used clothes might be given more frequently to charity shops, relatives or low income households instead of throwing them away. Textile waste amounts in MSW also changed according to living standards, climatic conditions, seasons and industrial facilities [24, 25]. Textile waste ratios in MSW were lower in other municipalities, such as the Municipality of Gümüşhane, where the ratio was 1.4% [25] or in the Municipality of Kırıkkale, where the ratio was 3.19% [26], or at the Municipality of Çorlu, where the ratio was 1.41% [27].

According to the Turkstat database, the amount of textile waste brought to controlled landfills was 287,105 tonnes, which comprised 2.62% of the total municipal waste at controlled landfills in 2008 - there is not any newest data in Turkstat [28]. No textile waste was recorded at incineration and composting facilities in 2008, however, some wastes were burned in open areas, some were dumped into rivers and on the ground, and some were buried in the ground [29]. The distributions of ultimate disposal methods are shown in ***Table 3***.

The manufacturers also declared their waste disposal behaviours (***Figure 3***) in the survey. When these ratios were applied to industrial wastes from the TOBB data, the data presented in ***Table 4*** are obtained for 2009:

Household textile wastes

Since non-hazardous industrial wastes and household wastes are generally landfilled together in Turkey [24], municipality waste values can lead to errors. To eliminate this problem, a study carried out in Çorlu-Turkey [27] was used as a data source for textile wastes generated in households. In this study, different income districts were evaluated for different seasons and wastes were collected before they were sent to the dump site. According to this study, an average of 1.41% of the total municipality wastes included textile wastes generated in households [27]. The amount of municipal waste per capita for Turkey was 1.15 kg in 2008 (There were no data for 2009), and for the Turkish population in December 2009 it was 72,561,312 [30]. Therefore the total textile waste generated in households per year can be calculated as follows:

$$\text{Total textile waste in households} = (0.014 \times 1.15\ \text{kg} \times 365 \times \times 72{,}561{,}312) / 1000 = = 426{,}406\ \text{t/y}$$

Consumer waste was not found in the recycling facilities since there was not a collection process in Turkey. Household and industrial waste values were surprisingly similar. Unrecorded production and illegal industrial waste disposal ultimately reduced the real industrial waste amounts.

Conclusions

Overall, 426,406 tonnes of textile waste was produced in households and 458,484 tonnes of production waste was generated by the textile industry, which added up to a total 884,890 tonnes generated in 2009 by Turkey. The real waste figures were also larger than the official records due to unrecorded production. Therefore the waste amount estimated, environmental impacts and financial damage were higher.

According to the manufacturer survey, the raw materials most used were cotton, which was 29% of raw materials used, and polyester, which was 24% of raw materials used. When these ratios were applied to total household textile waste (426,406 tonnes) and textile waste in landfills (73,357 t), it was calculated that 144, 931 tonnes of cotton and 119,943 tonnes of polyester might have been wasted in 2009 together with other wasted textile raw materials.

Table 3. *Ultimate disposal methods for industrial textile wastes (Turkstat).*

Disposal methods	%
Dumping site	46.64
Controlled landfill	37.94
Incineration	7.62
Composting	-
Stored within the establishment	4.60
Used as filling material	2.26
Dumping in an open area	0.83
Dumping into the sea, river and lake	0.02
Others	0.09

Table 4. *Waste disposal behaviours according to the survey and TOBB data.*

Disposal method	Weight, tonnes	%
Sold to recycling enterprises	284,260	62
Recycled within the facility	77,942	17
Dropped on landfills	73,357	16
Unknown ways	22,924	5
Total	**458,485**	**100**

Some environmental impacts of unutilised cotton textile wastes in Turkey

Turkey is the 7th cotton producer in the world [31]; therefore some environmental impacts were evaluated according to cotton production.

a) Since 1 kg of cotton fibres requires approximately 2.4 kg of harvested seed cotton [32], at least 347,834 tonnes of cotton should be harvested to get 144,931 tonnes of cotton fibre. Cotton production requires 7,000 – 29,000 litres of water per kilogram of cotton, therefore 2.4 -10.9 billion m^3 water was also wasted (textile processing wastes were neglected).
b) Almost a third (29 percent) of the pesticides in Turkey are applied to cotton, which has caused a substantial loss of wild-life in areas such as Çukurova (in Turkey), where large quantities of pesticides are used on cotton [33,34] Unutilised 347,834 tonnes of harvested cotton caused excess pesticide use.
c) In Turkey fertilisers used in cotton production are mainly nitrogen based [35], and an average of 8,993tonnes/year of nitrogen leached into water bodies due to cotton production in the period of 1997-2001. The average cotton production was 2,199,990 tonnes/year for the same period [36]. Therefore, 0.004 tonnes of nitrogen leached into the water bodies for one tonne of cotton. The reuse of 144, 931 tonnes of cotton fibre (347,834 tonnes of harvested cotton) could diminish leached nitrogen by approx. 1391 tonnes.

Suggestions

- Local authorities may collect textile wastes in households in a fashion similar to collecting glass and plastic wastes. Also textile banks could be placed in cities.
- Collection and sorting can be done by private enterprises which already collect other wastes in municipalities in Turkey.
- Textile production wastes could be collected from textile factories that are separated from facilities that collect other wastes. Clean and known sources of waste will ensure that waste quality will be high; therefore the sorting cost will also be reduced.
- Locally organised industrial zones which are responsible for waste collection in Turkey could therefore be responsible for collecting and storing textile wastes.
- Textile recyclers have been unable to find enough waste so they have imported wastes, as declared in the survey. However, approximately 500,000 tonnes of waste was disposed, and there is an apparent lack of communication between manufacturers and recyclers. Manufacturers and recyclers should communicate with each other via associations established in their industrial zones.
- Collected post consumer wastes may also be added to the industrial wastes that are sent to recyclers.

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References

1. Engelhardt A. *International Fiber Journal* 2010; 25(3): 4-21.
2. Pipatti R, Sharma C, Yamada M. Waste Generation, Composition and Management Data, 2006 IPCC Guidelines for National Greenhouse Gas Inventories. http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf
3. Ministry for the Environment Manatū Mō Te Taiao, Solid Waste Audits for Ministry for the Environment Waste Data Programme 2007/08. http://www.mfe.govt.nz/publications/waste/solid-waste-audits-2007-008/kaikoura/page6.html.
4. United States Environmental Protection Agency, Solid Waste Emergency Response (5306P), Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2008, EPA-530-F-009-021. http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2008rpt.pdf
5. Qu X, Li Z, Xie X, Sui Y, Yang L, Chen Y.*Waste Management* 2009; 29: 2618-2624.
6. Phuntsho S, Dulal I, Yangden D, Tenzin UM, Heart S, Shon H, Vigneswaran S . *Waste Management & Research* 2010; 28: 545-551.
7. Morley N, Slater S, Russell S, Tipper M, Ward GD. *Recycling of Low Grade Clothing Waste*. Oakdene Hollins Ltd, Salvation Army Trading Company Ltd Nonwovens Innovation & Research Institute Ltd, DEFR01 058 Low Grade Clothing – Public,2006.
8. Allwood JM, Laursen SE, Malvido C, Bocken NMP. Well Dressed? The present and future sustainability of clothing and textiles in the United Kingdom, Institute for Manufacturing, Cambridge, ISBN 1-902546-52-0, 22-25, 2007.
9. Hussey C, Sinha P, Kelday F. 8th European Academy Of Design Conference, Aberdeen, 2009, Responsible Design: Re-Using/Recycling Of Clothing..
10. Tsiliyannis CA *Waste Manage. Res*. 1999; 17: 231-241.
11. Singhi G, Iyer GV. *Environmental Monitoring and Assessment* 2004; 96: 163–181.
12. Eckelman MJ, Graedel TE. *Environ. Sci. Technol.* 2007; 41: 6283-6289.
13. Woolridge AC, Ward GD, Phillips PS, Collins M, Gandy S. *Resources, Conservation and Recycling* 2006; 46: 94-103.
14. Soth J, Grasser J, Salerno R, Thalmann P. *The impact of cotton on fresh water resources and ecosystems a preliminary synthesis*. Background Paper, WWF International, Gland, Switzerland, 1999.
15. Van Dam JEG. Workshop on utilisation of coton plant by-produce for vaule added products, Mumbai, 2003, CIRCOT, Availability of cotton stalks for industrial board production in India. (CFC Technical Mission Report by ATO bv, Wageningen, The Netherlands).
16. United States Environmental Protection Agency, Office of Air Quality Planning and Standards Emission Factors and Inventory Group, Emission Factor Documentation for AP-42 Section 9.7, Cotton Ginning, Final Report, 1996. http://www.epa.gov/ttn/chief/ap42/ch09/bgdocs/b9s07.pdf
17. WHO/SDE/OEH/99.14. Hazard Prevention and Control in the Work Environment: Airborne Dust. http://www.who.int/occupational_health/publications/en/oehairbornedust.pdf
18. Rao PS, Ansari MF, Gavane AG, Pandit VI, Nema P, & Devotta S. *Environ. Monit. Assess*. 2007; 128: 323-328.
19. Cheon JY, Lee ÆJY. & Lee ÆKK. *Environmental Geology* 2004; 45: 869–883.
20. http://www.teara.govt.nz/en/atmosphere/3/4/1
21. Lauresn SE, Hansen J, Knudsen HH, Wenzel H, Larsen HF, Kristensen FM. EDIPTEX: Environmental assessment of textiles. Danish Environmental Protection Agency, working report 24, 2007.
22. Kos L,Perkowski J, *Fibres & Textiles in Eastern Europe* 2009; 17, 5(76): 99-105.
23. World Trade Organization (WTO), (2011). Statistics: World merchandise export by major product group, 2009, http://www.wto.org/english/res_e/statis_e/its2010_e/its10_merch_trade_product_e.pdf
24. Berkun E, Aras E, Nemlioglu S. Disposal of solid waste in Istanbul and along the Black Sea coast of Turkey. *Waste Management* 2005; 25: 847-855.
25. Nas S, Bayram A. *Waste Management* 2008; 28: 2435-2442.
26. Kayalak TC. *Environmental and Economical Aspects for The Disposal of Municipal Solid Waste in Kirikkale City.* Master Thesis, Gazi University Institute of Science and Technology, Ankara, 2007 pp. 65-66,.
27. Tınmaz E, Demir İ. *Waste Management* 2006; 26: 307–314.
28. Turkish Statistical Institute, Amount of disposed/recovered waste brought to controlled landfill sites by type of waste and disposal/recovery methods, Ankara,2008, Turkey http://www.tuik.gov.tr/VeriBilgi.do?tb_id=10&ust_id=3
29. Turkish Statistical Institute, Amount of waste by disposal methods and industry group, Turkstat, 2008, http://www.turkstat.gov.tr/VeriBilgi.do?tb_id=10&ust_id=3
30. Turkish Statistical Institute, Press release, 2010; 15.
31. U.S. Cotton Market Monthly Economic Letter - June 10, 2011, http://www.cottoninc.com/MarketInformation/MonthlyEconomicLetter/#3
32. Kalliala E. *The ecology of hotel textiles and textile services*. Institute of Fibre, Textile and Clothing Science, Tampere, Finland. Publication no: 214, 1997.
33. Uluatam SS. *Improvement of Water and Soil Resources, Ankara,State Hydraulic Works*, III, 1994. Protection measures for environmental problems due to water development in the Southeastern Anatolia Project regionpp. 1119-1130.
34. Harmancioglu N, Alpaslan N, Boelee E. *Irrigation, health and environment: A review of literature from Turkey*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 21 p. (IWMI working paper 6), 2001.
35. Yilmaz I, Akcaoz, H, Ozkan B. *Renewable Energy* 2005; 30: 145–155.
36. Chapagain AK, Hoekstra AY, Savenije HHG,Gautam R. *Ecological Economics* 2005; 60: 186-203.

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