

Going Eco, Doing Dutch



Availability of recycled and sustainable natural fibers

An analysis

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1. Textile materials

The amount of textiles fibers produced is increasing year by year by 3-4% on a global basis.

1000 tons

	Raw cotton (5)	Raw wool (3) (6)	Man-made fibres (1)						TOTAL	
			Synthetics (2)			Cellulosics				TOTAL
			Yarn	Staple	TOTAL	Yarn	Staple (4)	TOTAL		
1900	3162	730	-	-	-	1	-	1	1	3893
1910	4200	803	-	-	-	5	-	5	5	5008
1920	4629	816	-	-	-	15	-	15	15	5460
1930	5870	1002	-	-	-	205	3	208	208	7080
1940	6907	1134	1	4	5	542	585	1127	1132	9173
1950	6647	1057	54	15	69	871	737	1608	1677	9381
1960	10113	1463	417	285	702	1131	1525	2656	3358	14934
1970	11784	1659	2399	2419	4818	1392	2187	3579	8397	21840
1980	13844	1599	4743	5882	10625		3557	3557	14182	29625
1985	17383	1744	5811	7307	13118		3218	3218	16336	35463
1986	15339	1789	6046	7630	13676		3178	3178	16854	33982
1987	17670	1832	6378	8098	14476		3236	3236	17712	37214
1988	18366	1886	6947	8285	15232		3284	3284	18516	38768
1989	17431	1955	7246	8472	15718		3284	3284	19002	38388
1990	18997	1927	7173	8201	15374		3145	3145	18519	39443
1991	20793	1779	7369	8358	15727		2897	2897	18624	41196
1992	17990	1719	7786	8549	16335	692	2045	2737	19072	38781
1993	16673	1673	8016	8506	16522	670	2083	2752	19274	37620
1994	18695	1554	9293	9152	18445	672	2204	2877	21322	41571
1995	19962	1486	10169	9021	19190	667	2347	3014	22204	43652
1996	18960	1476	12180	10285	22466	649	2211	2859	25325	45761
1997	19849	1440	13778	11241	25020	625	2271	2896	27915	49204
1998	18429	1382	15084	11505	26589	591	2142	2733	29322	49133
1999	19176	1380	16203	12011	28214	520	2117	2637	30851	51407
2000	18901	1357	17551	12737	30288	498	2297	2795	33083	53341
2001	21237	1309	17719	12596	30315	483	2201	2684	32999	55545
2002	19142	1254	19031	13213	32244	466	2276	2742	34986	55382
2003	20430	1233	20016	13753	33769	485	2399	2883	36652	58315
2004	26126	1221	21403	14705	36108	498	2654	3152	39260	66607
2005	24763	1228	22706	15431	38137	455	2699	3154	41291	67282
2006	26452	1229	24155	15752	39907	448	2858	3306	43213	70894
2007	26150	1200	26562	16596	43158	447	3088	3535	46693	74043
2008	23330	1100	25750	15331	41081	398	2836	3234	44315	68745
2009	22000	1080	26551	15964	42515	359	3530	3889	46404	69484
2010	24450	1062	30509	16887	47396	377	3686	4063	51459	76971
2011	26925	1068	33106	17662	50768	387	4113	4500	55268	83261
2012	26785	1073	36133	18522	54655	401	4783	5184	59839	87697
2013	25270	1097	38817	18653	57470	404	5358	5762	63232	89599
2014	25635	1095	41454	18593	60047	411	5561	5972	66019	92749

Source: <http://www.cirfs.org/KeyStatistics/WorldManMadeFibresProduction.aspx>

In 2014 nearly 93 million tons of fibers were produced of which 60 million tons of polyester, 25,6 million tons of cotton, 6 million tons of man-made cellulosic fibers (viscose) and 1.1 million tons of wool. The amount of natural fibers produced is more or less constant at a level of 25 - 30 million tons/year. The production of man-made cellulosic fibers is steadily increasing over the last 10 years. It is believed that this trend will not change in the coming years. This implies that the importance of synthetic fibers will grow in the next decades.

The amount of fibers that are recycled are not included in the statistics. This amount is considerable as a large part of the textile waste collected is reused (as product) or recycled (as secondary raw materials). The recycled materials are used mainly in technical applications for sound and thermal insulation (e.g. in the automotive industry, in (dish) washing machines, as carpet underlayment, etc.) as well as for pressure distribution in furniture and mattresses.

As the statistics are not very clear about the amount of textiles that are recycled, an estimation is made on the actual amount of discarded textile materials in The Netherlands with an outlook to the waste collection in Europe and the amount available for mechanical textile recycling.

2. Textile recycling in The Netherlands

2.1 Introduction

The collection of discarded textile products from consumers has a long history. Well known are in the older days the ragmen, which came with horse and carriage to collect discarded textile products from door to door. The collected textiles were recycled into materials for cleaning rags and respun into yarns. After the second world war, this occupation slowly died out. It was replaced in the nineteen sixties by more commercial organisations.

The ragmen were used to pay a small amount for the textiles they collected. As textile waste collection is nowadays the task of municipalities, organisations have to ask for a permit to collect discarded textile products. In some cases municipalities start a tender procedure and await the best offer from organisations to collect the textile waste. Prices up to 60 €cents per kilo are paid in some cases to collect the textile waste materials.

2.2 Textile collection in The Netherlands

Post consumer textile recycling in The Netherlands is mainly dominated by a small number of charity organisations like Sympany, Reshare (Salvation Army), Sams Kledingactie and some commercial textile recyclers like De Boergroep (Curitas) , Van Gansewinkel and Sita. Discarded textiles are collected in large bins, located mostly in the neighborhood of shopping centers, collected during actions (curbside collection) or collected by retail organisations (WE, H&M, C&A, ...). The latter are mostly connected to I:CO, which in turn is a daughter company of SOEX, one of the largest textile recycling companies in the world.

The collected textiles are mostly sold to textile sorting companies.

3. Textile recycling in Europe

3.1 Introduction

There are no reliable and recent data available on the textile waste collection in Europe. Oakdene Hollins has made an overview on the UK situation in 2006 (http://www.oakdenehollins.co.uk/pdf/defr01_058_low_grade_clothing-public_v2.pdf), which was further elaborated in 2009 (http://randd.defra.gov.uk/Document.aspx?Document=EV0421_8745_FRP.pdf).

Also an overview on textile recycling in the Scandinavian countries was published in 2014 (<http://norden.diva-portal.org/smash/get/diva2:721017/FULLTEXT01.pdf>).

An overview of the central European situation was made in 2005 in the framework of the French Ouvertes-project (http://www.textile-recycling.org.uk/Report_Ouvertes_Project_June2005%5B1%5D.pdf).

In the Netherlands, about 90.000 tons of discarded clothing from households is collected (status 2013: <http://www.textielrecycling.nl/uploads/Bestanden/FFact%20Textiel%20rapport%2007.pdf> in Dutch). This implies that the collection rate in the Netherlands is about 35%. In this recent report also the trade streams are mapped. This report was made in order to establish the potential deficit when more textiles would be collected and the revenues would drop due to a decrease in quality and market prices. It was concluded that there is a serious risk of such a deficit in the middle to long term future.

More general reports state that only 25% of the total amount of textiles in Europe is recycled (http://www.foeeurope.org/sites/default/files/publications/foee_report_-_less_is_more_0.pdf). This is limited to textiles used by households.

The Ellen MacArthur foundation states that textiles recycling could generate an extra turnover of 70 billion dollar, when more textile materials are collected and processed (<http://www.ellenmacarthurfoundation.org/news/new-report-towards-the-circular-economy-vol-2>). There is a huge opportunity in textiles by creating a circular system. The Saxcell-process (chemical recycling of post-consumer cellulose textiles) is an essential part in the circular system of cellulosic textiles materials.

The amount of cotton and other cellulosic fibers in textile waste is not known. Therefore in this report a more qualitative approach has been used to estimate the availability of discarded cellulose based textiles.

3.2. Textile collection

The amount of textiles used in Europe is estimated at 25 kg/person.year (12,5 million tons in Europe). Of this amount roughly 50% is consumer related like clothing, household linen and curtains (see also: http://nordicfashionassociation.com/sites/default/files/tn2012545_web.pdf for the use of textiles in the Nordic countries). The other 50% are technical textiles for use in many different sectors like automotive, agriculture, geo-textiles, etc. Most of the technical textiles are based on synthetic materials.

Discarded textile products are collected in a number of ways:

- curbside collection, mostly by charity organizations
- textile containers, mostly found at shopping malls
- collection by retailers in cooperation with third parties, in many cases I:CO (part of SOEX)
- collection by commercial waste processors
- collection at clothing (work wear) lease companies.

Textile collection systems and results differ from country to country. Mostly the collection systems are meant to collect post consumer textiles, except for the collection systems of commercial waste processors who mainly source industrial and post industrial waste. The fate of most of the commercial collected discarded textile products is incineration or dumping into landfills. These materials are mostly synthetic products.

Textile collection systems are under development in many countries. The aim is to increase the amount of textiles collected and to reduce the amount of municipal solid waste. In general the textile fraction is about 4-5% of the total volume of the municipal solid waste. In the Netherlands the target set for 2025 is to reduced the amount of municipal solid waste from 500 kg per person per year to less than 100 kg. It is obvious that besides prevention (e.g. less packaging waste) recycling of materials will play an important role in achieving these goals. For textile wastes from households these new waste regulations will give rise to a increase in the amount collected and most probably a reduction in the quality of the products. This will give rise to a reduction in the percentage of rewearable clothing and a rise in the materials recycling. In many municipalities action plans have been started in the last years to implement the new waste regulation directives. An example is the Twente Textile Circle (<http://www.kringloopwinkels.nl/nieuws/de-cirkel-wordt-rond-textiel-blijft-in-twente/> (in Dutch)). Also in the Amsterdam region initiatives have been started to increase textile recycling and become a materials recycling hub (<http://www.amsterdameconomicboard.com/nieuws/13590/circulaire-textielketen-biedt-perspectief>).

3.3 Textile sorting and further processing

The collected textiles are normally sold to textile sorting companies. These sorting companies sort the products in 2 sorting steps in more than 200 different product categories and qualities. In the first sorting step, the reusable products are separated from the non reusable products. The reusable products are in the second sorting step sorted in many fractions on quality, product category and

potential country of export. The non reusable products are sorted on downgrade recycling potential, for instance materials for the wiping cloth industry, and materials composition. The sorted materials are sold to rag pulling companies. These products are mechanically recycled into fibers (and pieces of yarn) and are used in non-wovens or felts for insulation in the automotive, bedding, carpet and furniture industry.

The first shift of textile sorting has to be done manually and is very skilled work. Also the second sorting of the reusable products in manual labor and can't be automated. For the second sorting step of the non reusable textile products an automated sorting machine is developed, which is able to sort the materials on composition. This sorting machine is first developed to a prototype in the Identitex project (http://cordis.europa.eu/result/rcn/80681_en.html). This prototype was further optimized in the Eco-innovation project Textiles for Textiles (<http://ec.europa.eu/environment/eco-innovation/projects/en/projects/t4t>) and turned into a commercial machine by a consortium lead by Wieland Textiles (textile sorting company) and Valvan (machine constructing company). The sorting machine is sold under the brand name Fibersort (<http://www.valvan.com/uncategorized/introducing-the-fibersort/>).

The automatic sorting of non reusable textile products will increase the reproducibility, quality and availability of materials for recycling. The Saxcell process will benefit in the future from this development.

Options for materials recycling of post-consumer textile products, including the mechanical recycling and the chemical recycling, have been described in a concise report by Alcon Advies commissioned by Click-NL Next Fashion (http://www.clicknl.nl/nextfashion/wp-content/uploads/sites/5/2015/06/Rapport_TextielRecycling_def.pdf (in Dutch)).

4. Materials supply for recycling

The Saxcell process uses discarded cellulose based textile material. In order to make an estimation on the amount of suitable textile waste available from post-consumer sources, a number of assumptions have to be made on the collection rate and the composition of the discarded textiles collected.

With respect to the collection rate the starting point is the study of the FOEE which stated that in 2010 the collection rate of textiles is 25% (foee report "less is more" (situation 2010)), than the total amount of collected discarded textiles from households can be calculated.

Calculation of textiles collected		
Number of Citizens in EU-27	500	million
Textile use per person/yr	12,5	kg
Collection rate	25	%
Total amount collected	1562,5	million kg

With respect to the composition of the collected waste, a study of Oakdene Hollins (presentation Nick Morly at the Eurartex working group TFE1 in February 2015) reveals that the global composition of discarded textiles collected at UK households is:

- cotton 43%
- polyester 16%
- viscose 9%
- acrylic 9%
- wool 9%
- polyamide 8%
- polypropylene 3%
- linen 2%

It is expected that this composition will be more or less representative for the textile waste composition in Europe. That implies that about 50% of the textile waste collected at households is cellulose based. This would imply that the collected amount of cellulose based textile waste in the EU-27 is about 780 million kilo's.

Of the post-consumer textiles collected about 50% is used as second hand clothing. As direct product reuse is a better solution compared to the recycling of materials, as well for environmental as for economical reasons, this implies that the current amount of cellulose waste suitable and available for recycling is about 390 million kg per year.

The actual amount of cellulosic textile waste available for recycling will be higher as B2B-use of textiles does not appear in the statistics. Large amounts of cotton based textiles are available from

textile leasing firms. Products like bed linen, towels and work wear used by professional users are discarded through the textile leasing and textile maintaining firms. A large % of those discarded materials find their way to the wiper industry but also quite a lot of those products are destructed and incinerated due to security reasons. This is especially the case when the products have company specific details like labels, logo's or even colors.

For the other fibers(synthetics and wool) the amount available for (mechanical and chemical) recycling will be more or les comparable to the amount of cellulose waste, that is about 400.000 tons a year. Most of these materials will be com e available in fibre mixtures. These materials will be mainly mechanically recycled and the fibers will be predominantly used in insulation materials. Only a small part of this waste will be suitable for high end recycling and be used in the spinning of yarns.

It is expected that the amount of post consumer textiles collected will increase quite drastically compared to the situation in 2010, due to recycling schemes and targets in many European countries. In the Netherlands an action plan is in place to double the amount of collected post-consumer textiles. In France, Eco-TLC is expecting a rise in the collection volume with 50% in the next 5 year s (reference year 2014: http://www.ecotlc.fr/ressources/Documents_site/RA_Eco_TLC_2014_web.pdf and more than 2.5 times the volume in 2010). Therefore an increase of the post consumer textiles collection to 40% in 2020 seems to be realistic. At the same time it is expected that the export of rewearable clothing will reduce to 45% due to a decrease in quality, the increase in the supply, the economic situation and monetary depreciation of the local currencies in the destination countries of the rewearable clothing (African countries, India, Ukraine).

Therefore it might be expected that the amount of cellulose based discarded textiles will increase in the next years to 687,5 million kg per year in 2020. This shows also the urgent need for increased attention for the recycling of cellulose based textiles materials. Recycling and especially chemical recycling (Saxcell) can offer a solution for the high end recycling (upcycling) of this enormous stream of waste material.

Calculation of cellulose textiles for recycling		
Number of Citizens in EU-27	500	million
Textile use per person/yr	12,5	kg
Collection rate	40	%
Cellulose textile based waste	50	%
Suitable for materials recycling	55	%
Total amount cellulose textile for materials recycling	687,5	million kg

5. Availability of sustainable natural fibers

Most of the mechanical recycled textile fibers have to be blended with longer virgin fibers in order to be able to spin a decent yarn. In order to produce the most sustainable yarns, the virgin fibers have to be sustainable as well. The most sustainable virgin fibers are fibers like hemp and flax, which can be grown in Europe. These crops need no fertilizers, no pesticides and no irrigation. Besides the yield of fibers per ha is quite high. Besides fibers, these crops also produce seeds, which are used for edible oils (linseed oil, hemp oil). Hemp offers even more useable by-products like wood (to be used in the paper and building industry) and green leaves, which are used as cattle feed.

The production of hemp in Europe is estimated at 13.300 ha with a potential yield of 2000 kg of fibers per ha, or 26.600 tons/yr (<http://eiha.org/document/record-cultivation-of-industrial-hemp-in-europe-in-2016/>). As most of the fibers are not used for textile production, the actual yield is much smaller. Most hemp fibers are used in composites for the automotive industry.

Stexfibers (<https://www.stexfibers.com/about>) has developed a process for the cottonization of hemp. Cottonization is needed in order to split hemp fiber bundles in individual fibers and to reduce the length of the fibers in such a way that they can be spun on an open-end spinning machine. Therefore the fiber length has to be reduced to less than 50 mm.

Flax is also grown on a quite a large scale in Europe. In France, Belgium and the Netherlands about 115.000 ha of flax is grown, with a potential of 138.000 ton of fibers (<http://www.mastersoflinen.com/fre/lin/19-la-carte-du-lin>). Most fibers are exported to China. As most of the flax is grown for linseed oil, a lot of flax straw is available. Research is carried out to improve the retting of the straw by enzymes, in order to be able to use the flax straw fibers in the textile industry.

6. Conclusions

It is not easy to establish the amount of textile waste that is collected in Europe as recent data on collection, reuse and composition are not available. However using the existing literature sources a educated guess can be made on the availability of cellulosic textile waste that is collected and available for the Saxcell process.

It was calculated that the amount of collected discarded cellulosic textile waste materials in Europe is at the moment (2015) about 380 million kilo's. It is expected that this amount will grow considerably in the next years due to an increase in collection volumes and a slight reduction in the % of textile products that can be reused directly.

The recycled fibers can be mixed with sustainable cellulose fibers produced in Europe, notably flax and hemp. The production of these fibers is increasing and for the moment sufficient amounts are available to be blended with recycled fibers to obtain good quality yarns.