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AQUAFIL
synthetic fibres and polymers

ENVIRONMENTAL PRODUCT DECLARATION for ECONYL® POLYMER

EPD®

CPC347-PLASTICS IN PRIMARY FORMS
PCR2010:16 VERS. 2.11

Publication date: 17. December 2013
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Certification No.: S-P-00500
Valid until: 10. April 2020

COMPANY AND PRODUCT
Related information

Company and product Related information

1 THE COMPANY

Aquafil Group history began in 1969, when the Bonazzi family built the first manufacturing plant in Arco (Trentino Alto Adige region, Italy). In 1970, the Group began the polymerization and production of polyamide 6 at this facility, which started Aquafil's market share acquisition in the BCF yarn sector (polyamide yarn for textile flooring). During the '80s, significant investments allowed a consolidation and diversification of the Group's activities. The most significant diversification of the Group's operation occurred in 1995 when the Aquafil Group finalized the first privatization of a public company in the newly born Republic of Slovenia. This acquisition allowed Aquafil to start its Nylon Textile Filament (NTF) product area.

Meanwhile, the Group continued to widen its product offering by opening a number of production plants in Europe and entering (with its "Polyamide products priority focus" always in mind) the Engineering Plastics business to supply modified polyamide products to the automotive, electronics and construction industries with the 'polyamide products priority focus' always in mind. At the same time, the Group started its internationalization process with the creation of Aquafil USA, based in Cartersville, Georgia. (USA).

Between 2000 and 2010, the Group expanded its presence in all three key markets where it was operating (carpet yarn, textile yarn and engineering plastics), gradually becoming a global leader in the manufacturing of Polyamide 6 fibers. In 2013, the Group sold the Engineering Plastics division to DOMO and acquired DOMO's BCF business Xentrys.

The internationalization process continued by adding significant investments in the Asian market where, in 2005, a manufacturing facility was established in Thailand for processing and marketing BCF products for the carpet industry. In 2009, a new manufacturing facility was built in China to assist in the ever-growing Asian market.

From 2007-2011, Aquafil developed a visionary project aligned with its manufacturing and market growth focus. Driven by a genuine concern for the environment, resources and investments were dedicated to the design and construction of the **ECONYL® Regeneration System** (the recycling of pre- and post-consumer Polyamide 6 waste material), which launched in 2011.

As of 2014, the Group operates 15 manufacturing plants worldwide with more than 2,400 employees, in eight countries (Italy, Slovenia, Croatia, Germany, United Kingdom, USA, Thailand and China) on three continents (Europe, North America and Asia).

IT OPERATES 2 DIFFERENT PRODUCT AREAS:

- **BCF** *Carpet yarn for the flooring market*
- **NTF** *Special yarns for sportswear and fashion applications*

In 2008, during the engineering and design phase of Aquafil's **ECONYL® Regeneration System**, a third product area was created Energy & Recycling.

This Energy & Recycling product area is dedicated to the promotion of sustainability and environmental issues. It has a transverse nature in respect to the other product areas, providing solutions and innovative technologies in the area of energy, recycling and the promotion of the culture of sustainability.

2 SPECIFICATION OF MANUFACTURING COMPANY AND PRODUCT

2.1 SPECIFICATION OF MANUFACTURING COMPANY

- **Manufacturing company Aquafil S.p.A.**
- **Production sites involved in EPD:**
  AquafilSLO d.o.o - Ljubljana (Letališka cesta 15, 1000 Ljubljana, Slovenia) > process E & F
  AquafilSLO d.o.o - Ajdovščina (Tovarniška cesta 15, 5270 Ajdovščina, Slovenia) > process I
  Aquafil S.p.A. (Via Linfano 9, 38062 Arco, Italy) > process A
- **Production country: Italy, Slovenia**

Production sites AquafilSLO - Ljubljana, AquafilSLO - Ajdovščina, and Aquafil S.p.A are ISO 14001 certified.

2.2 SPECIFICATION OF THE PRODUCT

This EPD refers to a PA6 polymer of 100% recycled with post-consumer and post-industrial recycled (certified by independent third party DNV 18590-2008-PC-ITA-DNV), which is used in several sectors such as apparel, residential, automotive, fashion, sportswear, electrical, building construction and technical applications.

> This declaration refers to two polymers:

- ECONYL® polymers 2,4 viscosity; produced in AquafilSLO plant (Slovenia Ljubljana)
- ECONYL® polymers 2,7 viscosity; produced in Aquafil plant (Italy Arco and Slovenia Ljubljana)

A) PRODUCT INFORMATION ON ECONYL® POLYMER 2,4 VISCOSITY:

- Trade name: ECONYL® polymer 2,4 viscosity
- ISO code: PA6
- IUPAC name: poly(hexano-6-lactam)
- CAS number: 25038-54-4
- GHS classification: not dangerous

TECHNICAL SPECIFICATION	TEST METHOD	VALUE
Density	ISO 1183	1,14 g/cc
Melt flow rate	ISO 1133	59,1 cc/10´
Tensile strength at yield	ISO 527	78,48 MPa
Glass transition temperature for amorphous polymers	ISO 11357	226 °C
Deflection temperature under load	ISO 75	180 °C (0,45 MPa)

B) PRODUCT INFORMATION ON ECONYL® POLYMER 2,7 VISCOSITY

- Trade name: ECONYL® polymer 2,7 viscosity
- ISO code: PA6
- IUPAC name: poly(hexano-6-lactam)
- CAS number: 25038-54-4
- GHS classification: not dangerous

TECHNICAL SPECIFICATION	TEST METHOD	VALUE
Density	ISO 1183	1,14 g/cc
Melt flow rate	ISO 1133	33,6 cc/10´
Mechanical properties: Tensile	ISO 527	75,99 MPa
Glass transition temperature for amorphous polymers	ISO 11357	222 °C
Deflection temperature under load	ISO 75	180 °C (0,45 MPa)

3 DECLARED UNIT

Declared unit is 1 kg of granules delivered.

4 CONTENT OF MATERIALS AND CHEMICAL SUBSTANCES

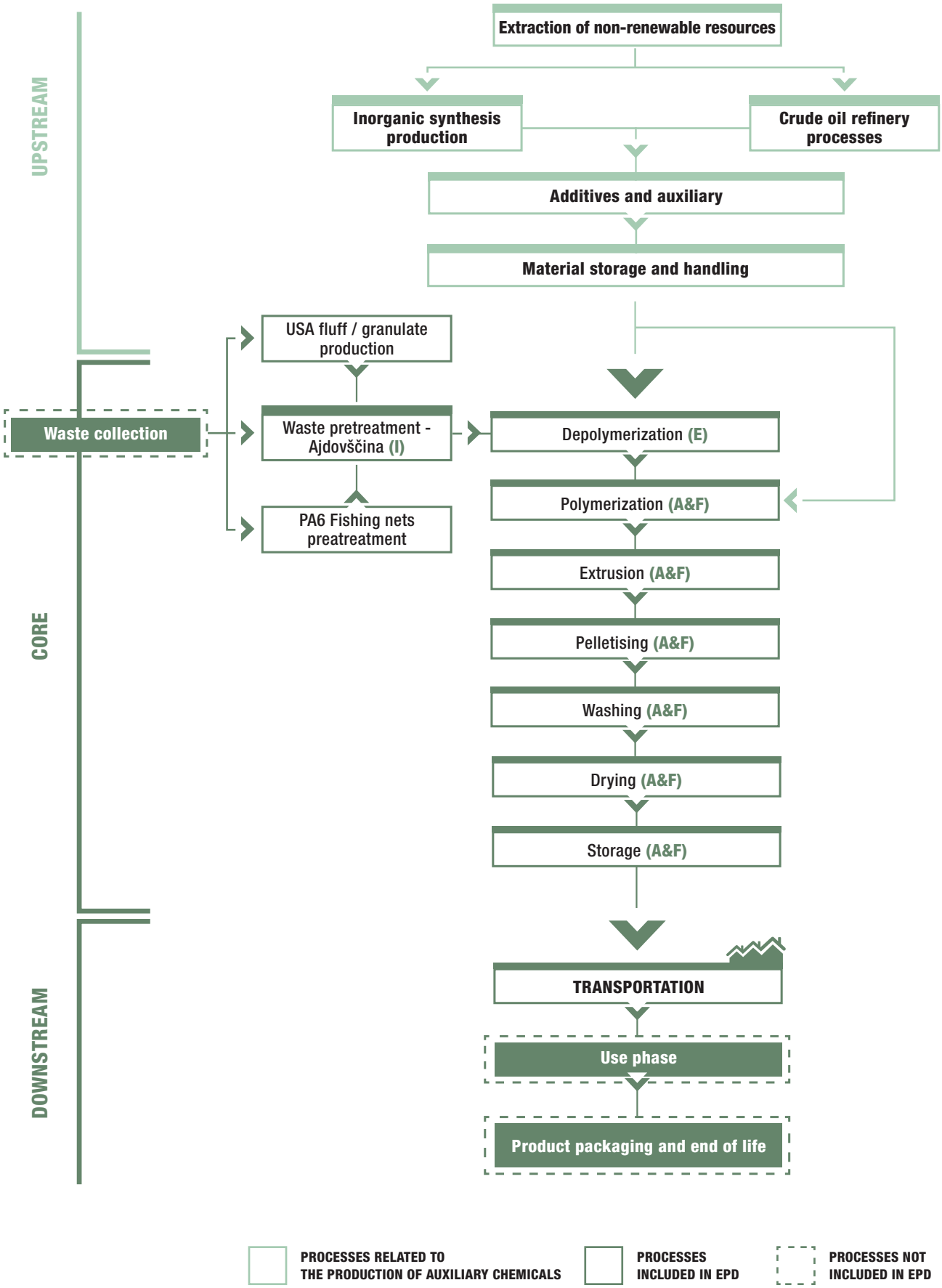
MATERIAL	% OF MATERIAL BY WEIGHT	OF WHICH RECYCLED %
Polyamide 6	100	100

ECONYL® polymers do not contain any materials / substances hazardous to health and the environment (carcinogenic, mutagenic or toxic to reproduction, allergic, PBT, vPvB).

5 UNITS AND QUANTITIES

SI units are used.

6 GENERAL SYSTEM BOUNDARIES



In general, Life Cycle Inventory data for a minimum of 95% of total inflows (mass and energy) to the upstream and core module is included.
Auxiliary materials (such as absorption agent, adhesive …) for which good quality databases were not available, are not included in the study, however are not exceeding the threshold defined above.
All energy inflows are considered in the study.
Primary packaging material was considered; polymerization process: tank truck.

6.1 UPSTREAM PROCESSES

Upstream processes include:

- *Extraction of non-renewable resources*
- *Additives and auxiliaries production*
- *All relevant transportation*

All energetic input flows (electricity, heating fuels, steam...) to the upstream processes are considered. All emissions to air, water and soil and treatment of waste and wastewater generated are considered as well.

6.2 CORE PROCESSES

The Core Process analysis takes into account resources, as well as electricity and fuels, transportation of materials, emissions and waste that go into or are given off during the production of ECONYL® polymer.
Transportation of all input materials is included.

In particular core processes include:

- *Transportation of all input materials*
- *Waste materials that are entering into pretreatment plant and are constituted of three main types of waste:*
  - ***A)*** *PA6 fishing nets collected worldwide.*
  - ***B)*** *PA6 carpet collected and shaved to obtain PA6 fluff or granules.*
  - ***C)*** *Oligomers and other plastics waste generated by polymer industries.*

  Depending on the type and shape of waste, it can be cleaned, sorted, grinded, washed, granulated, and/or pelletized.
  All waste material is characterized with the specific feedstock energy entering the system, and the process is described by means of energy use and emissions.

- *ECONYL® plant operation*
  - ***A)*** *washing (if and when necessary)*
  - ***B)*** *depolymerization (where specific mix of waste is transformed back into secondary raw material - caprolactam)*
  - ***C)*** *purification of caprolactam*
- *Polymer production*
  - ***A)*** *polymerization*
  - ***B)*** *extrusion*
  - ***C)*** *pelletizing*
  - ***D)*** *washing*
  - ***E)*** *drying*
- *storage and packing of polymer.*

6.3 DOWNSTREAM PROCESSES

Downstream processes include transportation to average retailer / distribution platform:

- *300 km by truck*

Use phase and end of life of product is not included.

ENVIRONMENTAL PERFORMANCE

Related information

Carpet by Interface from the Human Nature Collection, Made with ECONYL® yarn

7 ENVIRONMENTAL PERFORMANCE RELATED INFORMATION

The environmental burden of the product has been calculated according to the general rules of the EPD (Environmental Product Declaration) International Programme and PCR 347 (Plastics in primary forms).

This declaration is based on the application of Life Cycle Assessment (LCA) methodology to the ECONYL® polymer life-cycle system. The LCA report constitutes the most important background document to support environmental communication about ECONYL® and its environmental life-cycle burden.

To assess the burden of ECONYL® polymer production at the plant level, detailed data and information were collected both from ECONYL® polymer manufacturing facilities (Ljubljana – Slovenia, Arco - Italy) and from production facilities of raw material suppliers.

Customized LCA questionnaires were used to gather in-depth information about all aspects of the production system (for example, raw materials specifications, pretreatments, process efficiencies, air emissions, waste management), ultimately providing a complete picture of the environmental burden of the system.

The use phase and end of life is not included in the study, while distribution scenario is set to 300 km via truck cistern to distribution platform.

The detailed environmental performance of the ECONYL® polymer is presented for the three phases, Upstream, Core and Downstream.

ECONYL® production process is continuously improved and this analysis took into consideration the most representative and specific data available.

From a general point of view all of the plants are described using primary data from January 2016-December 2016, with exception of ECONYL® plant energy consumption. Primary data for this process is considered from January 2017-February 2017, to catch the latest improvements of recently implemented projects.

All the data are given for an average ECONYL® polymer which is constituated of 48% by mass of ECONYL® polymer produced in AquafilSLO - Ljubljana and 52% by mass of ECONYL® polymer produced in Aquafil Arco and is representing the production ratio of 2016.

7.1 RESOURCES

RESULTS ABOUT THE USE OF RESOURCES ARE SPLIT INTO FOUR SECTIONS:

- **1. Renewable resources** *Table 1*
- **2. Non-renewable resources** *Table 2*
- **3. Secondary resources** *Table 3*
- **3. Direct electricity consumption** *Table 4*
- **4. Water use** *Table 5*

>**TABLE 1.** TOTAL RENEWABLE RESOURCES FOR PRODUCTION OF 1 kg OF AVERAGE ECONYL® POLYMER *(rounded values).*

RENEWABLE RESOURCES					
		UPSTREAM	CORE	DOWSTREAM	TOTAL
TOTAL RR MATERIAL RESOURCES [g]		-	-	-	-
Energy resources for energy conversion purpose [MJ]	Solar	0,1	5,3	0,01	**5,5**
	Hydropower	0,02	3,6	2,65E-04	**3,7**
	Wind	0,04	2,4	2,08E-04	**2,5**
	Biomass	3,63E-04	0,08	0	**0,1**
	Other	3,00E-04	1,20E-03	1,12E-05	**1,51E-03**
TOTAL RR ENERGY RESOURCES [MJ]		**0,2**	**11,5**	**0,02**	**11,6**

totals may not match, because of rounded data.

>**TABLE 2.** TOTAL NONRENEWABLE RESOURCES FOR PRODUCTION OF 1 kg OF AVERAGE ECONYL® POLYMER *(rounded values).*

MATERIAL RESOURCES [g]				
	UPSTREAM	CORE	DOWSTREAM	TOTAL
NR MATERIAL RESOURCES [g]				
Inert rock	536	2,39+03	1	**2,92E+03**
Limestone ($CaCo_3$)	31	30	0,05	**62**
Soil	7	68	8,85E-03	**75**
Natural aggregate	10	67	4,17E-03	**78**
Clay	11	38	1,28E-03	**49**
Quartz	8	28	1,62E-03	**36**
Others	0	11	0,3	**11**
TOTAL NR MATERIAL RESOURCES [g]	**605**	**2,63E+03**	**1**	**3,23E+03**
NR ENERGY RESOURCES - FOR ENERGY CONVERSION PURPOSE [g]				
Hard coal	9	279	0,03	**351**
Crude oil	49	88	6	**111**
Lignite	10	11	0,03	**26**
Natural gas	28	113	0,4	**133**
Peat	0,01	0,05	5,15E-04	**0,07**
Uranium	2,45E-04	3,02E-04	1,66E-06	**7,59E-04**
TOTAL NR ENERGY RESOURCES [g]	**95**	**491**	**6**	**592**

totals may not match, because of rounded data.

>**TABLE 3.** TOTAL SECONDARY RESOURCES FOR PRODUCTION OF 1 kg OF AVERAGE ECONYL® POLYMER (recycled waste)

	Units	UPSTREAM	CORE	DOWSTREAM	TOTAL
Average ECONYL® polymer	g	0	1715	0	**1715**

>**TABLE 4.** TOTAL DIRECT ELECTRICITY USED FOR PRODUCTION OF 1 kg OF AVERAGE ECONYL® POLYMER

	Units	UPSTREAM	CORE	DOWSTREAM	TOTAL
Average ECONYL® polymer	kWh	0	0,869	0	**0,869**

>**TABLE 5.** WATER USED FOR PRODUCTION OF 1 KG OF AVERAGE ECONYL® POLYMER

	Units	UPSTREAM	CORE	DOWSTREAM	TOTAL
Total consumption	litre	7,98	10,29	0,03	**18,3**
Direct consumption	litre	0	8,76	0	**8,76**

totals may not match, because of rounded data.

7.2 POTENTIAL ENVIRONMENTAL IMPACT

>**TABLE 6.** TOTAL ENVIRONMENTAL IMPACT FOR PRODUCTION OF 1 kg OF AVERAGE ECONYL® POLYMER *(rounded values). CML2001, January 2016*

	Units	UPSTREAM	CORE	DOWSTREAM	TOTAL
Global Warming Potential (GWP)*	g CO_2 eq	190	1531	19	**1740**
Acidification Potentials	g SO2 eq	1,2	4,4	0,1	**6**
Photochemical Ozone Creation P.	g Ethene eq	0,1	0,4	0,01	**0,5**
Eutrophication Potentials	g Phosphate eq	0,06	1,7	0,02	**1,7**

totals may not match, because of rounded data
**emissions and removal of fossil and biogenic carbon are considered*

Waste raw materials have very little influence on the indicators above. Depolymerization process (with specific concern to coal-based steam production) and thermal recovery of depolymerization waste is a primary contributor to GWP. In addition, use of auxiliary chemicals used for depolymerization process is significantly contributing to Eutrophication Potential.

7.3 OTHER INDICATORS

>**TABLE 7.** RECYCLED MATERIAL CONTENT FOR PRODUCTION OF 1 kg OF AVERAGE ECONYL® POLYMER

	Units	UPSTREAM	CORE	DOWSTREAM	TOTAL
POST CONSUMER	%	-	min.50	-	**min. 50**
POST INDUSTRIAL	%	-	max.50	-	**max. 50**

>**TABLE 8.** WASTE AT PRODUCTION OF 1 kg OF AVERAGE ECONYL® POLYMER

	Units	UPSTREAM	CORE	DOWSTREAM	TOTAL
Hazardous waste	g	0,06	64,60	3,74E-04	**64,66**
Nonhazardous	g	619	2,81E+03*	0,95	**3,43E+03**

**more than 80% of the waste is generated by extraction of coal and lignite-stockpile goods deposited*

>**TABLE 9.** WASTE SUBJECT TO RECYCLING OF 1 KG OF AVERAGE ECONYL® POLYMER

	Units	UPSTREAM	CORE	DOWSTREAM	TOTAL
Hazardous waste	g	0	61,4	0	**61,4**
Nonhazardous	g	0,2	70,6	0	**70,8**

The impacts related to the management of the waste all along the life cycle are included in the impact assessment reported in chapter 7.2.

>**TABLE 10.** PRIMARY ENERGY DEMAND PRODUCTION OF 1 kg OF AVERAGE ECONYL® POLYMER

	Units	UPSTREAM	CORE	DOWSTREAM	TOTAL
Non renewable energy resources	MJ	37,99	16,35	0,26	**54,60**
Renewable energy resources	MJ	0,16	11,53	0,01	**11,70**

> TECHNOLOGY APPLIED:

chemical depolymerization and subsequent purification step.

> PERCENT OF RECOVERED MATERIALS IN RESPECT OF THE TOTAL WASTE TREATAED:

57% (this percentage includes the total weight input of post-consumer waste which consists also from other components as PA6, such as PP, backing of carpets...)

> DESTINATIONS OF FRACTIONS NOT RECOVERED:

- *Waste plastics other than PA6; recycled / WtE; EU*
- *Waste metals; recycled; EU*
- *Waste sludge; WtE; EU*
- *Waste calcuim carbonate; landfill; USA*

8 DIFFERENCES VERSUS PREVIOUS VERSION OF EPD

Main reduction of impact on GWP compared to previous version of EPD is due to the change of the AquafilSLO-Ljubljana supplied steam mix. In the previous version of EPD steam mix supplied was 10% biomass and 90% coal and, now it is a mix of 40% biomass and 60% of coal allocated to AquafilSLO- Ljubljana plant. Moreover, energy efficiency projects were implemented in AquafilSLO and also better separation of input waste components, before being depolymerized in ECONYL® plant, was further developed. This consequently decreased the impacts of sludge waste management generated by depolymerization stage; thus, energy and material efficiency are increased in depolymerization stage.

ADDITIONAL INFORMATION

Additional information

This chapter is intended to provide specific additional information about the ECONYL® Regeneration System as well as some comments of its environmental benefit.

In 2009, we set ourselves the challenge of collecting waste material all over the world and turning it into recycled polymers. It is possible to mention other environmental benefits, besides those appreciated from the impact categories investigated in the present study. In fact, part of virgin raw materials extraction and natural resources exploitation is prevented by the use of waste otherwise disposed of.

The European Commission has estimated that the EU discards 5.8 million tons of textiles and apparel every year, 75% of this is sent to landfill or incinerated, but the vast bulk is destined for landfill. The USA generates 12.7 million tons of textile waste; of this only 14.9% is recycled (US Environmental Protection Agency, 2009), which means more than 85% is waste, again largely being sent to landfill.

To put this number in context, in 2009 a total of 71.6 million tons of fiber was used around the world. This means that the EU and the USA in one year alone discarded 18.5 million tons is equal to 26% of annual global fiber usage.

Another aspect not directly emerging from the present study, which is worth a mention, is the contribution to the prevention of oceans pollution from the collection of fishnets in their end-of-life.

References

Bibliography:
LCA report, REV.5, 30. May 2017
ISO 14025:2006
EN 15804:2012
General Programme instructions 2.5
CPC347-Plastics in primary forms
PCR2010:16 vers. 2.11

For data elaboration, the following tools are used:
Software: Gabi 8,5
Database: Gabi professional database – pack 35

This declaration and further information about it are available at www.environdec.com

> Specific requirements
The calculation of the environmental impact of the product was conducted according to the general EPD® requirements.

> Contacts
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> Independent verification
CPC347/PCR2010:16 vers. 2.11
Independent verification of the declaration and data, according to ISO 14025:
☐ INTERNAL X EXTERNAL

Third party verifier:
Bureau Veritas, accredited by SWEDAC
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Valid until: 10. April 2020