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AQUAFIL
synthetic fibres and polymers

ENVIRONMENTAL PRODUCT DECLARATION for ECONYL® POLYMER

EPD®

CPC347-PLASTICS IN PRIMARY FORMS
PCR2010:16 VERS. 2.1

Revision 0, 15. November 2013
Certification No.: S-P-00500
Valid until: 15. November 2016

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 here the polymerization and production of polyamide 6, which started Aquafil 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 activities. The most significant diversification of the Company operation happened in 1995, when the Aquafil Group finalized the first privatization of a Public Company in the newly born Republic of Slovenija and started its Nylon Textile Filament Yarn specialty Business.

In the same period this process continued and the Company widened it's product offering, starting up a number of different Plants in Europe and entering, (with its "Polyamide products priority focus" always in mind) also the Engineering Plastics Business, supplying modified Polyamide Products to the Automotive, Electronic and Construction Industry.

It was also in those years that the Group started its internationalization process, with the creation of Aquafil USA, based in Cartersville (Georgia).

In the ten years between 2000 and 2010 the Group expanded its presence in all of the 3 key markets where it was operating (Carpet yarn, Textile yarn, Engineering Plastic) gradually becoming a global player. In 2013 Group sold Engineering plastic to DOMO and acquired DOMO's BCF bussiness: Xentrys.

The internationalization process was in-fact completed by significant investments in the Asian market, where in 2005 was established (Thailand), a manufacturing site for the processing and marketing of Carpet Yarn products (BCF) and in 2009 was started an ambitious manufacturing project in China, where a new plant was built and started up.

In parallel, but not secondary to its manufacturing and market growth focus, Aquafil launched in the last five years (2007-2011) a visionary project, driven by a genuine commitment, with resources and investment dedicated to the design, construction and start up of the **ECONYL® Regeneration System** (Polyamide post industrial and post consumer raw material recycling).

In the 2012 Consolidated Financial Statement the Group has 13 manufacturing plants and more than 2000 employees around the world, operating in 3 continents (Europe, America and Asia) and in 6 countries (Italy, Slovenia, Croatia, USA, Thailand and China).

IT OPERATES 2 DIFFERENT BUSINESS UNITS:

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

In 2008, during the engineering and design phase of the Aquafil **ECONYL® Regeneration System**, a further Business Unit was created, called Energy & Recycling.

This new Business Unit is dedicated to the promotion of sustainability and environmental issues. It has a transverse nature in respect to the 2 other manufacturing Business units, providing solutions and innovative technologies in the area of Energy, of Recycling and 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:** **Aquafil** Arco (Italy); **Julon** Ljubljana, Ajdovščina (Slovenia)

2.2 SPECIFICATION OF THE PRODUCT

This EPD refers to a PA6 polymer of 100% recycled with post consumer and post industrial recycled content (*DNV certificate no. 2808-2013-PC-ITA-DNV*), which is used in several sectors such apparel, resindential, automotive, fashion, sportswear, electrical, building construction and technical applications.

> This declaration refers to two polymers:

- **EC024 REG:** ECONYL® polymer 2,4 viscosity; produced in Julon plant (Slovenia Ljubljana)
- **EC027:** ECONYL® polymer 2,7 viscosity; produced in Aquafil plant (Italy Arco)

PRODUCT INFORMATION ON ECONYL® POLYMER 2,4 VISCOSITY:

- Trade name: EC024 REG
- 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 strenght 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)

PRODUCT INFORMATION ON ECONYL® POLYMER 2,7 VISCOSITY

- Trade name: EC027
- 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´
Tensile strenght at yield	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.

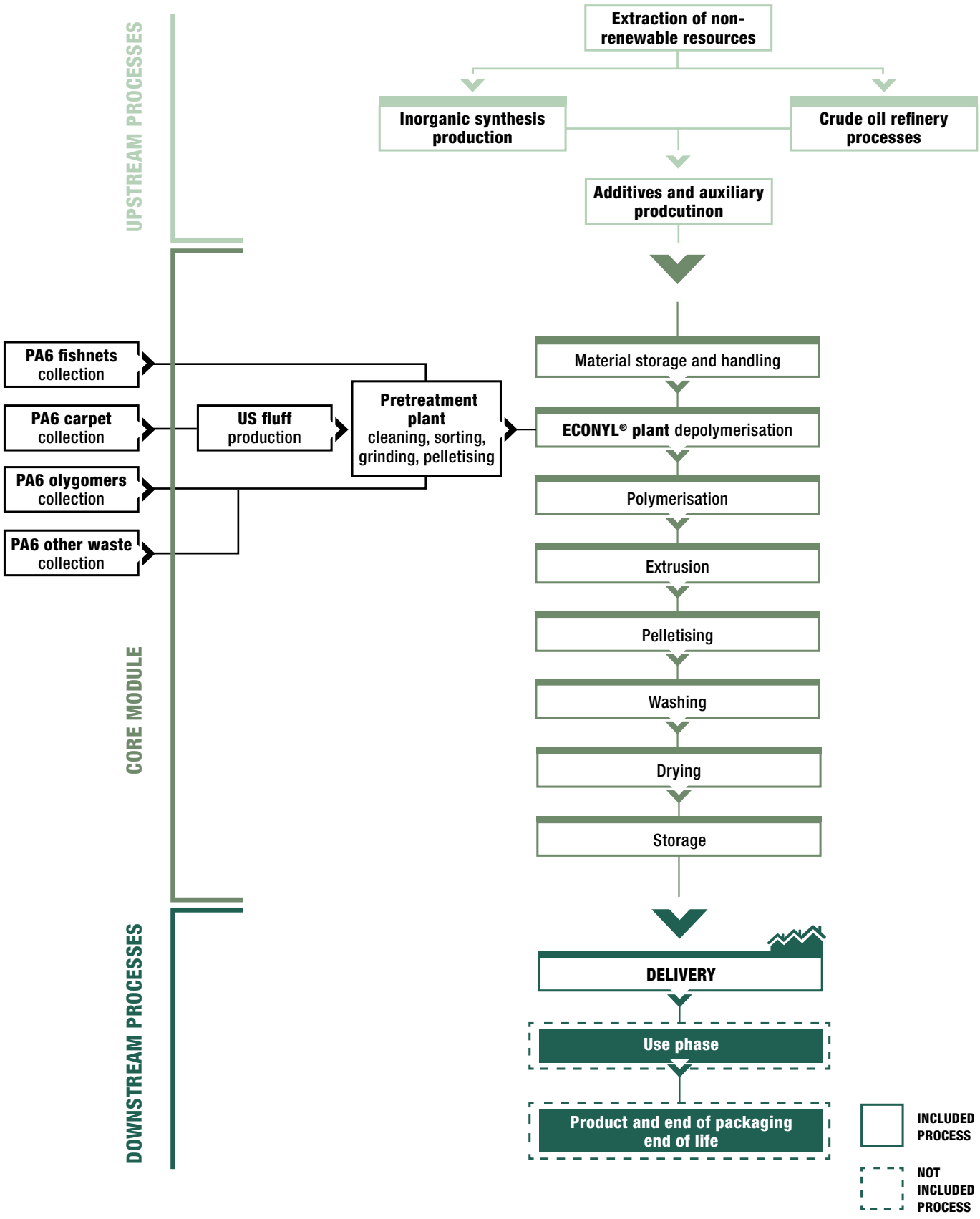
4 CONTENT OF MATERIALS AND CHEMICAL SUBSTANCES

MATERIAL	% OF MATERIAL BY WEIGHT	OF WHICH RECYCLED %
Polyamide 6	100	100
of which post consumer %		min. 50
of which pre consumer %		max.50

5 UNITS AND QUANTITIES

SI units are used.

6 GENERAL SYSTEM BOUNDARIES



6.1 UPSTREAM PROCESSES

Upstream processes include:

- *Extraction of non-renewable resources*
- *Aditives and auxiliaries procuction*
- *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*
- *Secondary raw materials that are entering into pretreatment plant and are constituated of three main types of waste:*
  - ***A)*** *PA6 fishnets collection: they are collected worldwide*
  - ***B)*** *PA6 carpet are collected, after shaved to obtain PA6 fluff. Later are pelletised to simplify handling of material.*
  - ***C)*** *Olygomers are waste generated by polymer industries to produce PA6 and collected and partly grinded to get suitable dimension.*

  All of them are characterized with the specific feedstock energy entering the system, and the process are described by means of energy use (according to the local energy mix) and emissions.
- *ECONYL® plant operation*
  - ***A)*** *depolymerisation step (where specific mix of waste is trasformed back into secondary raw material - caprolactam)*
  - ***B)*** *purification step of caprolactam*
- *Polymer production*
  - ***A)*** *polymerisation*
  - ***B)*** *extrusion*
  - ***C)*** *pelletising*
  - ***D)*** *washing*
  - ***E)*** *drying*
- *Storage and packing of polymers.*

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

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® poylmer production at the **plant level**, detailed data and information were collected both from ECONYL® polymer manufacturing facilities (Ljubljana, Slovenia and 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, pre treatments, 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 the plant is described using 2012 (polymerization Julon, polymerisation Aquafil, general aspects) and 2009 (last monitoring campaign for polymerisation Julon) data, while for the specific ECONYL® pretreatment process (secondary materials supply and use) data are from 2013 (january -june) and for ECONYL® depolymerisation process the most recent monitoring campaign of august 2013, representing current and also future situation.

All the data are given for an average ECONYL® polymer which is constituated of 10% by mass of
ECO24 REG (Julon polymer) and 90% by mass of ECO27 (Aquafil polymer) and is representing the production ratio of 2012.

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*
- **4. Direct electricity consumption** *Table 4*
- **5. Water use** *Table 5*

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

RENEWABLE RESOURCES					
		UPSTREAM PROCESSES	**CORE** PROCESSES	**DOWSTREAM** PROCESSES	**TOTAL**
TOTAL RR MATERIAL RESOURCES [G]		-	-	-	-
Energy resources for energy conversion purpose [MJ]	Solar	<0,05	2	<0,02	**2**
	Hydropower	<0,1	1	<0,0003	**1**
	Wind	<0,05	<0,5	<0,001	**<0,5**
	Biomass	<0,06	<0,04	0	**<0,06**
	Other	0	<0,004	0	**<0,004**
TOTAL RR ENERGY RESOURCES [MJ]		**<0,1**	**3**	**<0,1**	**3**

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 PROCESSES	**CORE** PROCESSES	**DOWSTREAM** PROCESSES	**TOTAL**
NR MATERIAL RESOURCES [G]				
Inert rock*	203	6,39E+03	1	**6,59E+03**
Limestone (CaCo3)	57	38	<0,1	**95**
Sodium Chloride	34	20	<0,01	**54**
Soil	1	23	<0,01	**24**
Natural aggregate	45	29	<0,01	**74**
Clay	11	2	<0,002	**13**
Others	5	13	<0,2	**18**
TOTAL NR MATERIAL RESOURCES [G]	**356**	**6,51E+03**	**1**	**6,87E+03**
NR ENERGY RESOURCES - FOR ENERGY CONVERSION PURPOSE [G]				
Hard coal	21	620	<0,03	**641**
Crude oil	32	87	6	**125**
Lignite	31	85	<0,04	**116**
Natural gas	18	90	<0,5	**108**
Other	<0,01	<0,1	<0,001	**<0,1**
TOTAL NR ENERGY RESOURCES [G]	**102**	**882**	**6**	**990**

totals may not match, because of rounded data.
**more than 90% of inert rock consumption is related to coal / lignite extraction*

The figures in the tables above, referring to the resources consumption, are mainly related with depolimerization phase.

>**TABLE 3.** TOTAL SECONDARY RESOURCES FOR PRODUCTION OF 1 KG OF AVERAGE ECONYL® POYLMER-WASTE INPUT

	Units	**UPSTREAM** PROCESSES	**CORE** PROCESSES	**DOWSTREAM** PROCESSES	TOTAL
Average ECONYL® polymer	g	1378	0	0	**1378**

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

	Units	**UPSTREAM** PROCESSES	**CORE** PROCESSES	**DOWSTREAM** PROCESSES	TOTAL
Average ECONYL® polymer	kWh	0	1,3	0	**1,3**

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

	Units	**UPSTREAM** PROCESSES	**CORE** PROCESSES	**DOWSTREAM** PROCESSES	TOTAL
Average ECONYL® polymer	litre	1	56	<0,02	**57**

7.2 POTENTIAL ENVIRONMENTAL IMPACT

>**TABLE 6.** TOTAL ENVIRONMENTAL IMPACT FOR PRODUCTION OF 1 KG OF AVERAGE ECONYL® POLYMER

	Units	**UPSTREAM** PROCESSES	**CORE** PROCESSES	**DOWSTREAM** PROCESSES	TOTAL
Global Warming Potential (GWP) from fossil fuels	g CO_2 eq	304	3331	19	**3655**
Ozone Depletion Potential	g CFC-11 eq	0	0	0	**0**
Acidification Potentials	g SO_2 eq	4	9	<0,2	**13**
Photochemical Ozone Creation P.	g C_2H_4	<0,3	<0,7	<0,02	**1**
Eutrophication Potentials	g PO_4-- eq	2	1	<0,03	**3**
Abiotic depletition potential	g Sb eq	<0,002	<0,0006	0	**<0,002**

totals may not match, because of rounded data.

Waste raw materials have very little influence on the indicators above, depolimerization (with specific concern to coal based steam production) are primary contributors to GWP. Also use of auxiliary chemical used for depolymerisation process is significatntly contributing to Eutrophication Potential.

7.3 OTHER INDICATORS

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

	Units	**UPSTREAM** PROCESSES	**CORE** PROCESSES	**DOWSTREAM** PROCESSES	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** PROCESSES	**CORE** PROCESSES	**DOWSTREAM** PROCESSES	TOTAL
Hazardous waste	g	<0,3	14	<0,0004	**14**
Non hazardous	g	207	6,5E+03*	1	**6,7E+03**

**almost 90% of the waste is generated by extraction of coal and lignite-stockpile goods deposited.*

The impacts related to the management of the waste all along the life cycle are included in the impact assesment reported in chapter 7.2.
Waste generation includes:

- *all waste that is subject to recycling in regeneration and manufacturing stage of core process*
- *waste deposited without further treatment all along the life cycle stages; sourcing from commercial database*
- *all waste that it's end of life is unknown all along the life cycle stages; sourcing from commercial database*

>**TABLE 9.** WASTE AT PRODUCTION OF 1 KG OF AVERAGE ECONYL® POLYMER *(waste subject to recycling in regeneration and manufacturing stage)*

	Units	**UPSTREAM** PROCESSES	**CORE** PROCESSES	**DOWSTREAM** PROCESSES	TOTAL
Hazardous waste	g	0	8	0	**8**
Non hazardous	g	0	66	0	**66**

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

	Units	**UPSTREAM** PROCESSES	**CORE** PROCESSES	**DOWSTREAM** PROCESSES	TOTAL
Non renewable energy resources	MJ	36	39	<0,3	**75**
Renewable energy resources	MJ	<0,3	4	<0,02	**4**

> TECHNOLOGY APPLIED:

chemical depolymerisation and subsequent purifcation step.

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

72%

> DESTINATIONS OF FRACTIONS NOT RECOVERED:

- *Waste material of fishnets; recyled / WtE*
- *Waste metal; recycled*
- *Waste sludge; WtE*

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 added value.

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

The European Commission has estimated that the EU discards 5.8 million tonnes 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 tonnes 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 tonnes of fibre was used around the world. This means that the EU and the USA in one year alone discarded 18.5 million tonnes = 26% of annual global fibre 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

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. 2.1

Independent verification of the declaration and data, according to ISO 14025:

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Third party verifier:
Bureau Veritas Group
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