



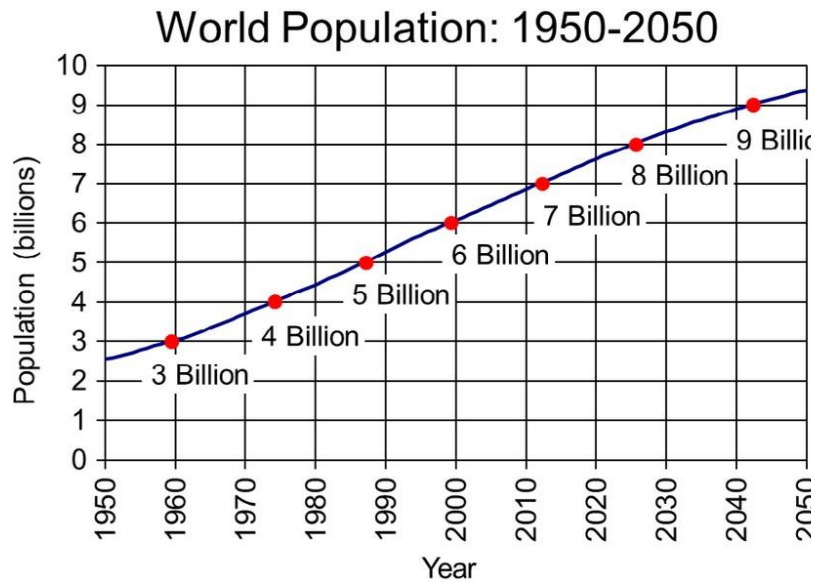
VERSO UNA FILIERA CIRCOLARE DEI TESSUTI
SOLUZIONI PER L'ECONOMIA CIRCOLARE IMPLEMENTATE NELLA FILIERA DEI TESSUTI
TECNOLOGIE PER LA CHIUSURA DEI CICLI MATERIALI ED ENERGETICI PER L'ECONOMIA
CIRCOLARE NEL SETTORE TESSILE

R. Mossotti CNR-STIIMA - Biella

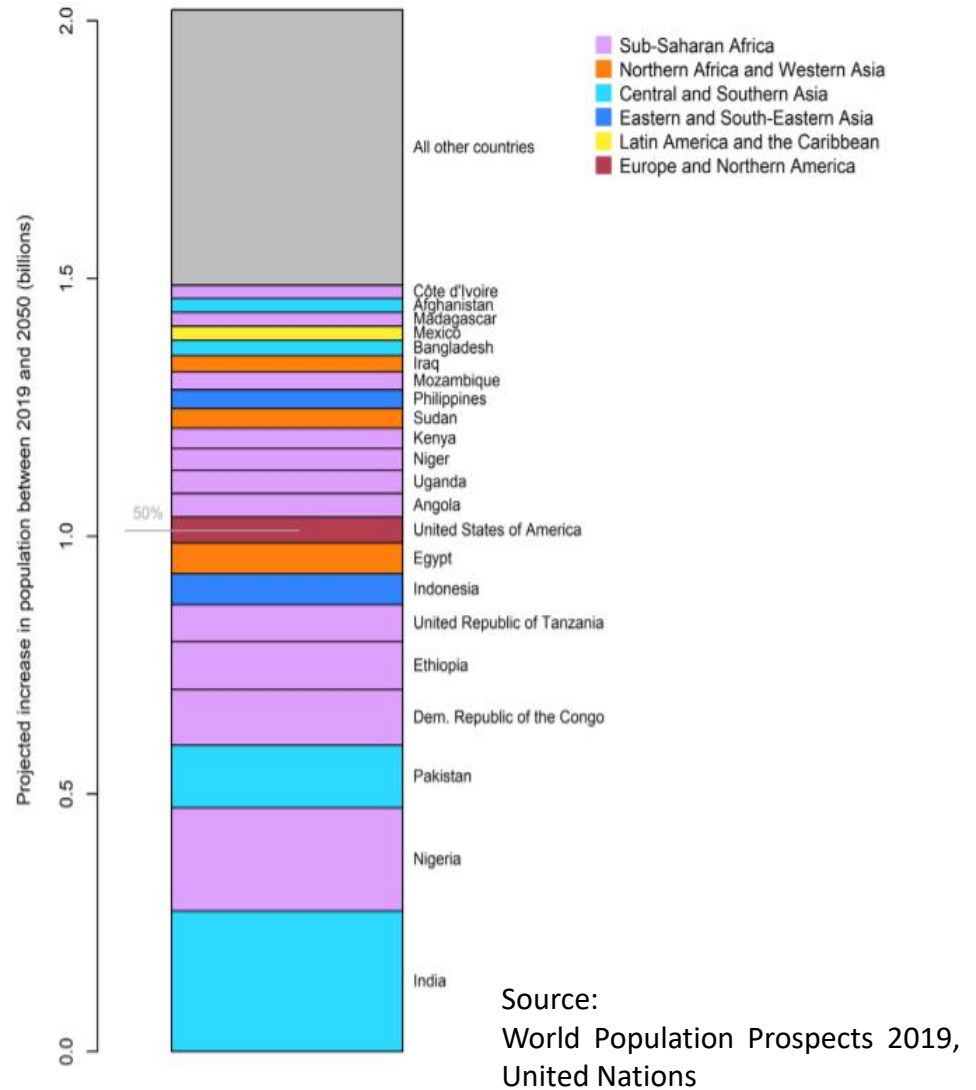
Obbligo di raccolta differenziata della frazione tessile dei rifiuti urbani, per una nuova filiera dell'economia circolare

SESSIONE II - IL POST CONSUMO, RIUSO E RICICLO

WORLD POPULATION



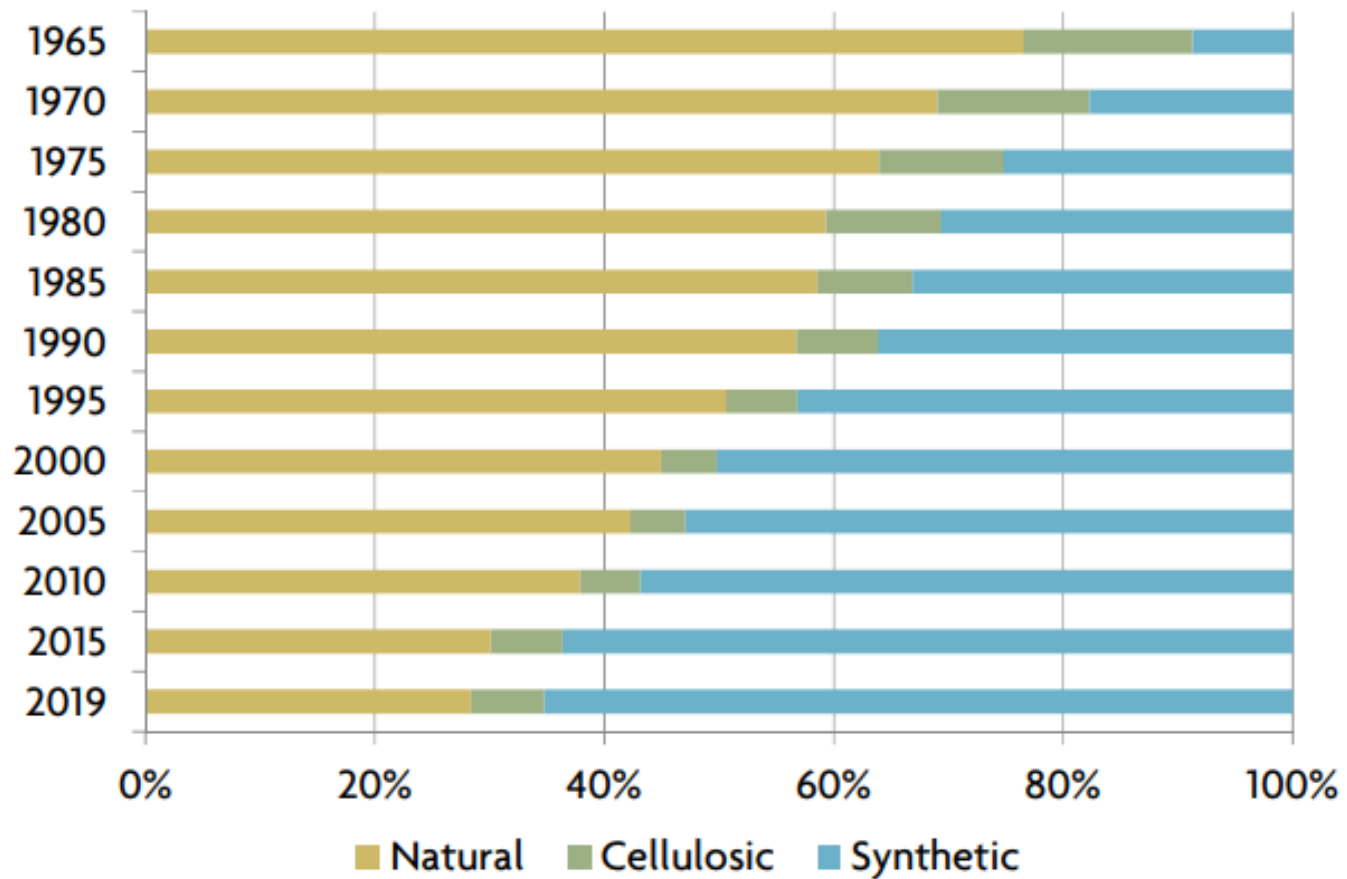
Source US Course Bureau; International Population Databas



Twenty-two countries will account for around 1.5 billion of the total 2.0 billion people expected to be added to the world between 2019 and 2050

SYNTHETIC CLOTHING ?

Market share of major fibres types



Source: The Fiber Year Consulting, Issue 20 2020

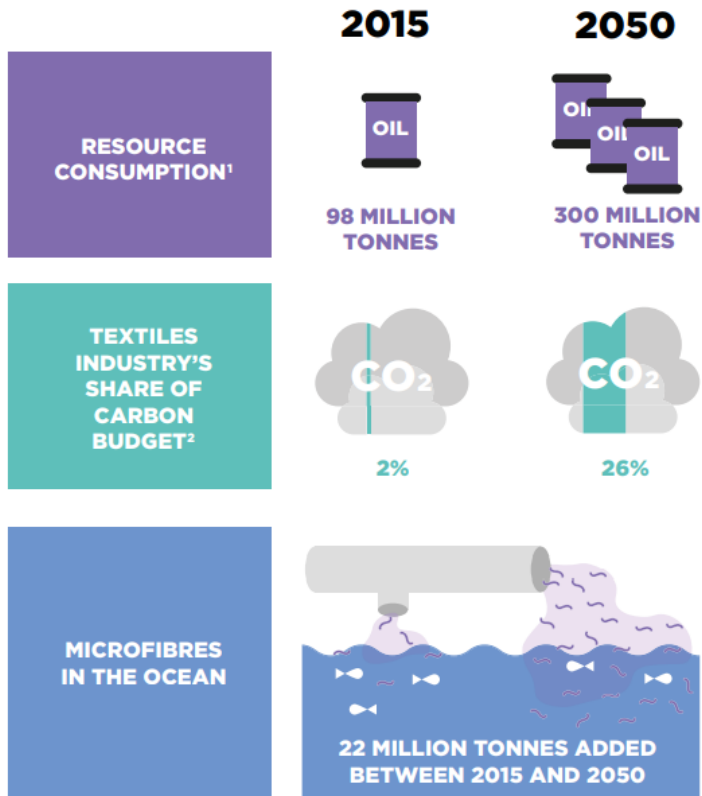
EFFECT of CLOTHING SYSTEM

Resource consumption

Environmental pollution

Negative social impact

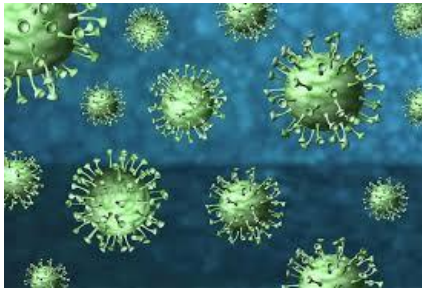
TEXTILES INDUSTRY ARE SET TO DRASTICALLY INCREASE BY 2050



- Consumption of non-renewable resources of the textiles industry, including oil to produce synthetic fibres, fertilisers to grow cotton, and chemicals to produce, dye, and finish fibres and textiles.
- Carbon budget based on 2 degrees scenario

Source: Circular Fibres Initiative analysis – for details see Part I

WE HAVE NOT PLANET B



The COVID-19 pandemic provides a stark example of the complex links between the environment, our social systems, and our health, with factors causing the disease attributed to environmental pollution resulting from human activity.

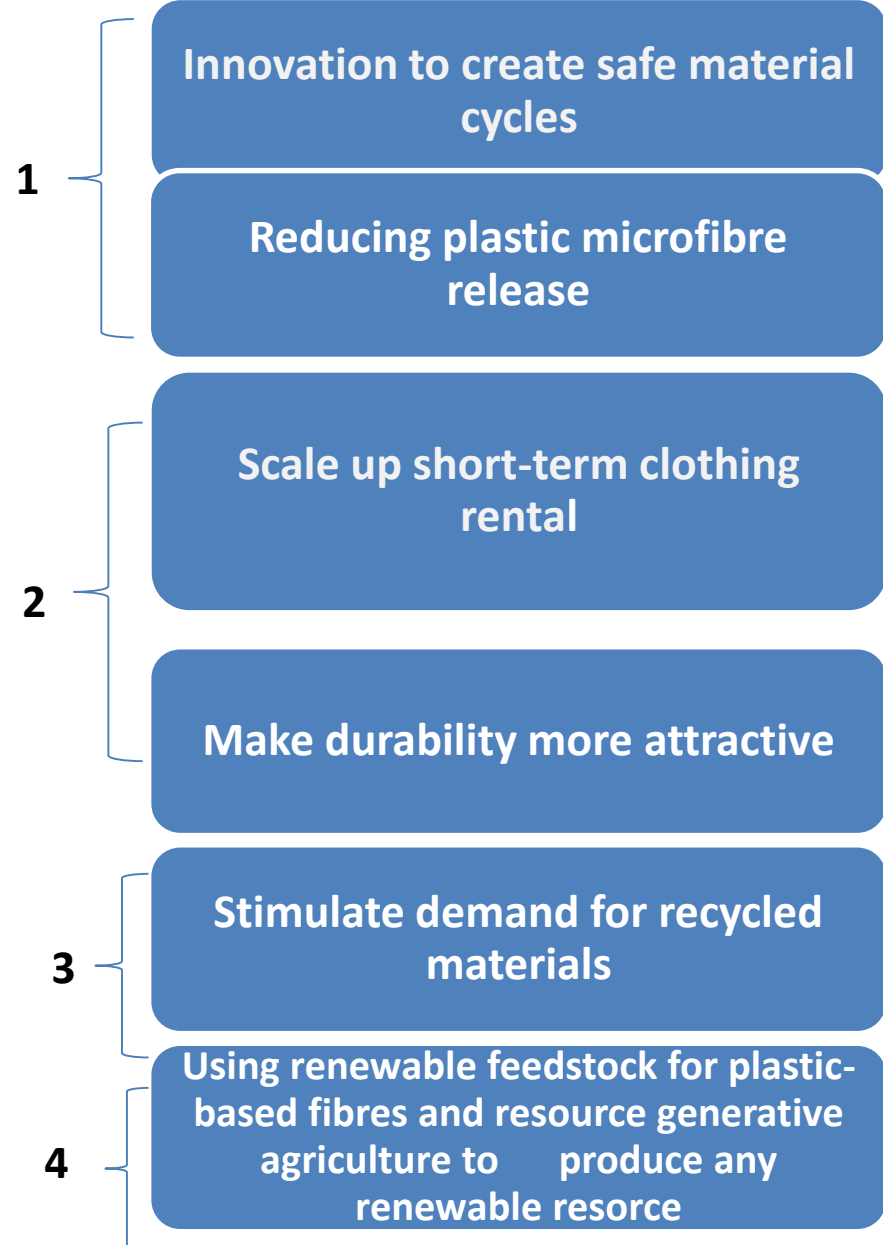
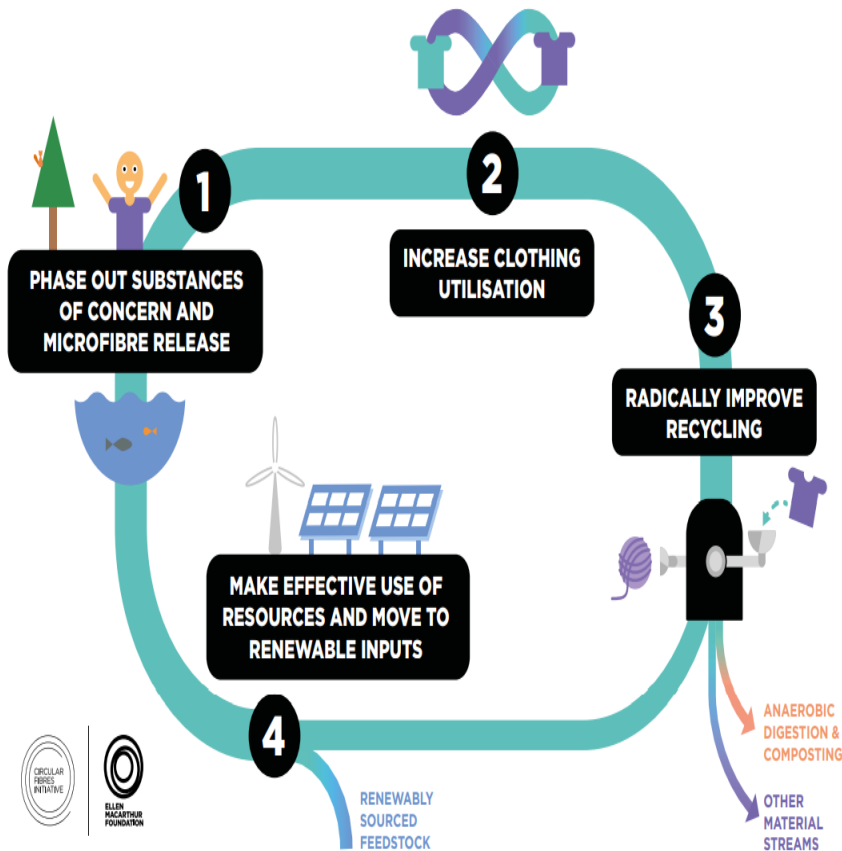
“There is a clear link between the state of the environment and the health of our population.

Everyone must understand that by taking care of our planet we are not only saving ecosystems, but also lives, especially the ones who are the most vulnerable. The European Union is devoted to this approach and with the new Biodiversity Strategy, the Circular Economy Action Plan and other forthcoming initiatives we are on the path to build a more resilient and healthier Europe for European citizens and beyond.”

Stella Kyriakides, Commissioner for Environment, Oceans and Fisheries



AMBITIONS FOR A NEW TEXTILE ECONOMY



Source: Ellen MacArthur Foundation, A new textiles economy: Redesigning fashion's future, (2017, <http://www.ellenmacarthurfoundation.org/publications>)

BACHGROUND

- **MICROPLASTIC definition:** Material consisting of a solid polymer containing particles, to which additives or other substances may have been added, and where $\geq 1\%$ w/w particles have:
 - (i) all sizes $1\text{nm} \leq x \leq 5\text{mm}$,
 - (ii) for fibers, a length of $3\text{nm} \leq x \leq 15\text{mm}$ and a length/diameter ratio >3 .
- Polymers that occur in nature that have not been chemically modified (other than by hydrolysis) are excluded, as are polymers that are (bio)degradable.

[SOURCE: ECHA - ANNEX XV Restriction Report - Microplastics, 22 August 2019, par 1.2.2.1]

BMBF research focus "Plastics in the Environment"

Cross-cutting issue "Methods for sampling, sample preparation and analysis (incl. reference materials)"

Table 1: Particle size classification

Classification		Large microplastics	Microplastics					
Particle size classes	μm	5,000 – 1,000	1,000 – 500	500 – 100	100 – 50	50 – 10	10 – 5	5 – 1
Average particle size	μm	3,000	750	300	75	30	7.5	3
Mass of an individual particle*	mg	14.13	0.221	0.014	2.2E-04	1.4E-05	2.2E-07	1.4E-08
Number of particles in 14,13 mg	Number	1	64	1,000	6.4E+04	1.0E+06	6.4E+07	1.0E+09

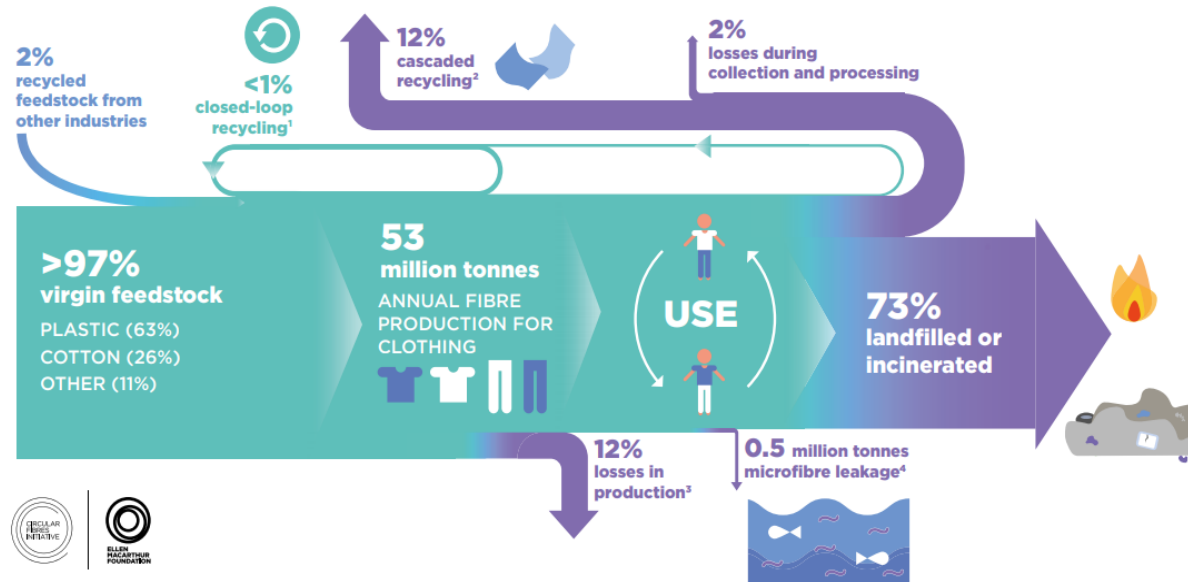
* Assuming a density of 1 g/ml.

MPs VECTORS OF ENVIRONMENTAL POLLUTION

- **Microplastics** are particularly **worrying** because **water treatment plants do not take them into account** in their management processes and **they are deposited in waterways and sewage sludge**.
- The main mechanisms responsible for the degradation of plastics in the marine environment are **light-induced degradation** and **biodegradation**. These processes are retarded in seawater due to lower temperatures and lower oxygen concentrations.
- Due to their hydrophobic nature, microplastics can easily absorb Persistent Organic Pollutants (POPs) already present in the marine ecosystem and they can be ingested by marine biota and in particular by “filter feeders”.

What are the sources of release of MpS in a clothing life cycle ?

GLOBAL MATERIAL FLOWS FOR CLOTHING



- 1 Recycling of clothing into the same or similar quality applications
- 2 Recycling of clothing into other, lower-value applications such as insulation material, wiping cloths, or mattress stuffing
- 3 Includes factory offcuts and overstock liquidation
- 4 Plastic microfibres shed through the washing of all textiles released into the ocean

Source: Circular Fibres Initiative analysis – for details see Appendix B

USE (Shedding from wearing cloths and washing)

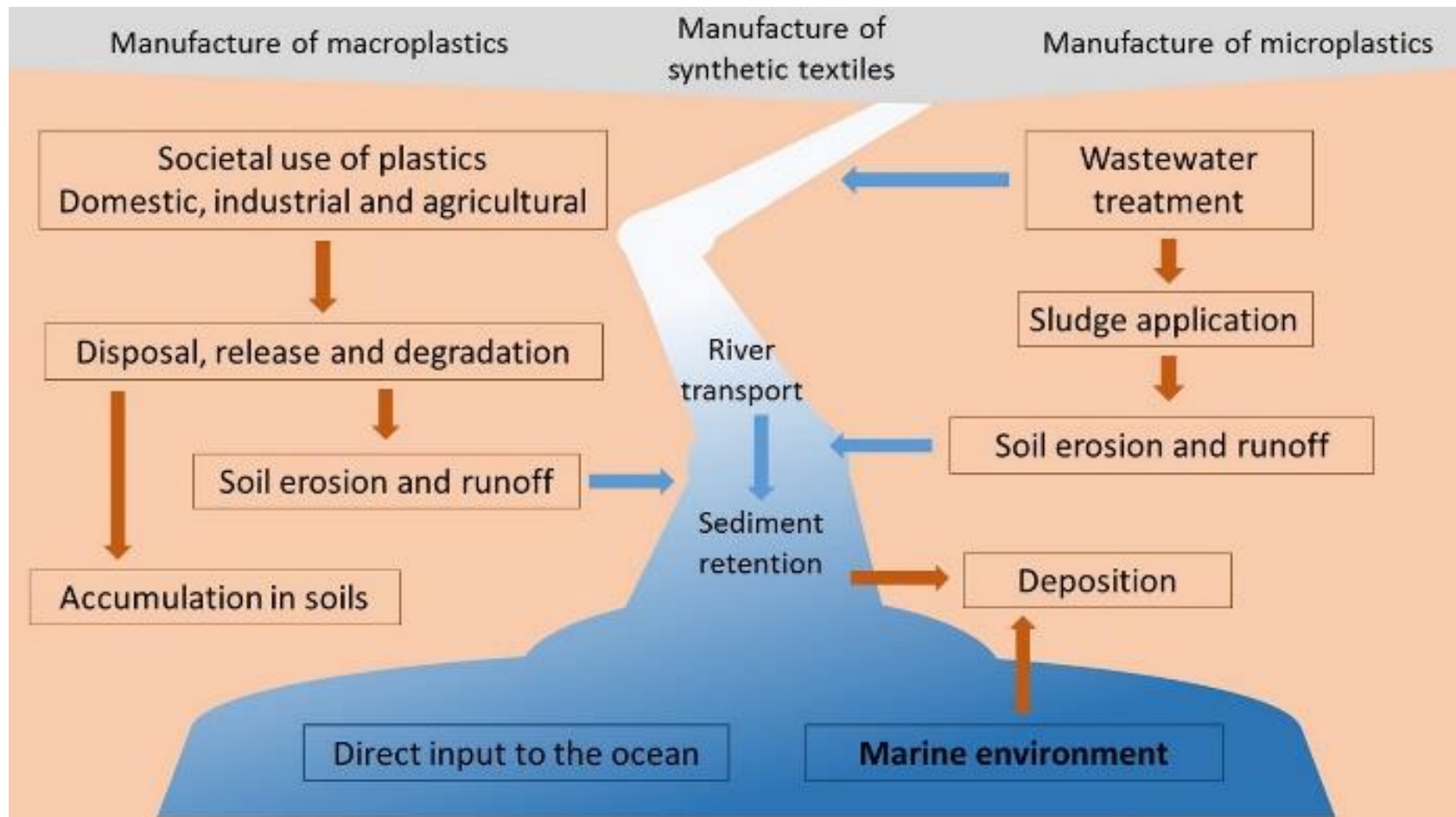
Textile Processing

Recycling of clothing into the the same or similar quality application

Recycling of clothing into, lower value application

Landfill textle waste

Environmental fate



Environmental fate of microplastics (image from Horton et al., 2017)

USE: INFLUENCE OF WASHING CONDITIONS

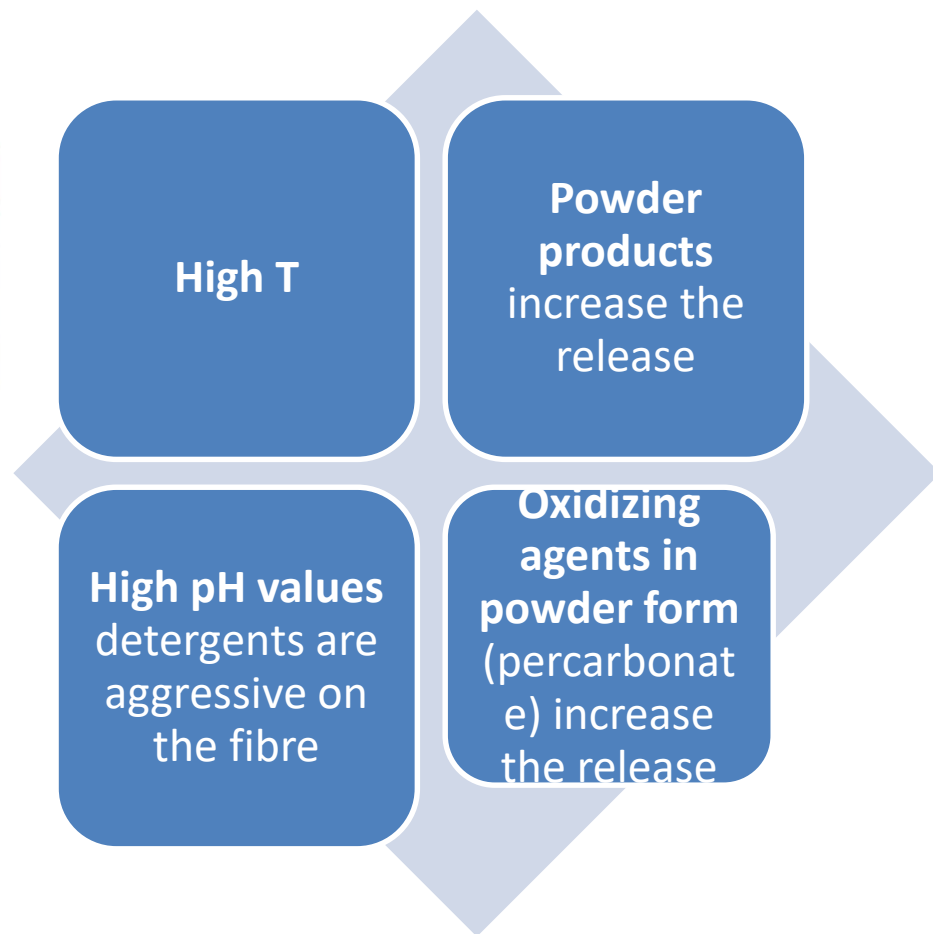
mechanical action parameters

	LEG 1 Cotton cycle 40 °C	LEG 2-LEG 3 Silk Delicate cycle 30 °C
Main wash length	1h 30 min	43 min
Still drum length	16 min	22 min
% still drum	18 %	51 %
Number of inversion	321	253

Load: 2 kg
Replicates: 4
Washing cycles: 1 - 5



BOSCH model WAW286H8 laundry machine



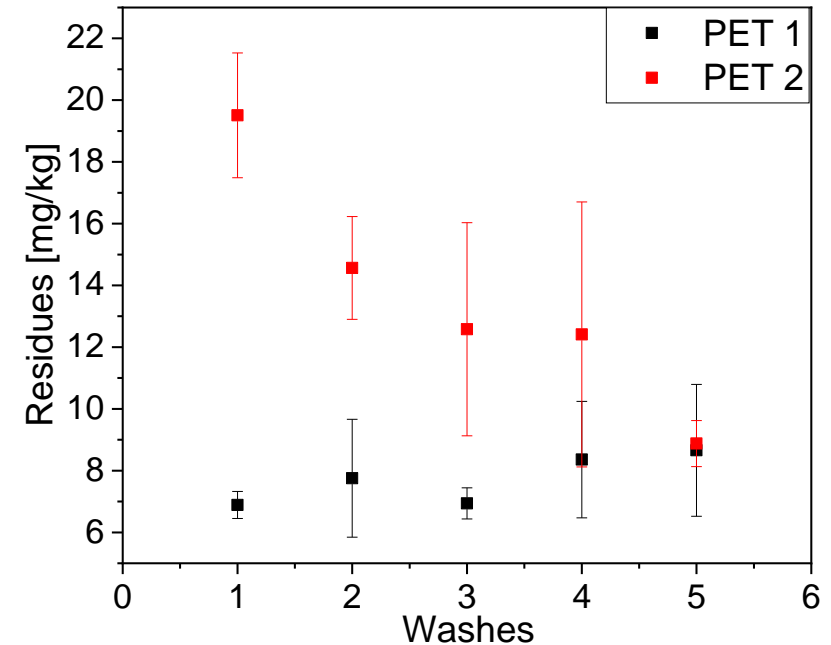
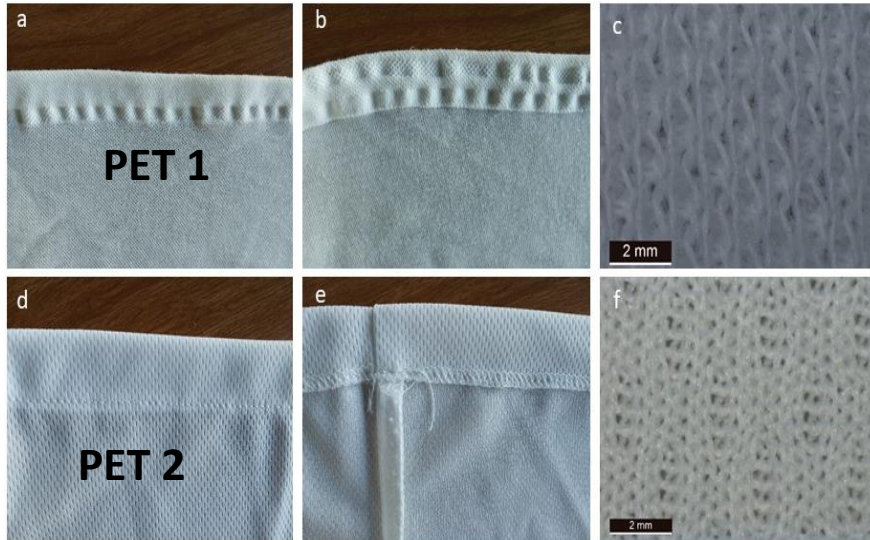
Source: G. Dalla Fontana et al, 2020; LIFE13 ENV/IT/001069 MERMIDS

TREND OF MICROPLASTICS RELEASE

Design textile parameters affecting shedding from clothing

- **Fiber Length** - Shorter fibers increase the probability of the fibers to migrate to the textile surface and increase pilling;
- **Yarn twist** - Twisting the yarn increases resistance and elasticity. This produces a more compact yarn with less shedding;
- **Linear density (yarn count)** - More thickness implies more fibers and evidently more shedding.
- **Fabric density** - Greater number of yarns per unit length creates a tighter structure and decreases the probability of shedding.
- **Textile auxiliaries** - Different chemicals can be used against abrasion. This protects the textile during the mechanical strain in washing machines.
- **Textile geometry** – Knitted fabric shows higher microplastic release propensity than Woven Fabrics.
- **Pilling Tendency** as a consequence of the geometrical structure and fiber constitution of the fabric, higher pilling values are connected to the fiber release increase
- **Mechanical Factors during Yarn Production.** This phenomenon suggests also a secondary influence linked to the chemical and mechanical stresses related to yarn production

INFLUENCE OF SEWING ON MICROPLASTIC RELEASE DURING WASHING



- **PET 1** fabric sewn with double heat-sealing.
- **PET 2** fabrics sewn with 100% polyester thread (staple fiber) using an overlock machine.

The kind of sealing during eco-design of the clothing could increase the sustainability of a textile product or process before launching it on the market.

FOCUS: Application of Technology

The determination of the factors that influence the release of microplastics from textiles give necessary information to establish an ecodesign of the product e del ciclo produttivo del manufatto

At present many approaches can be applied for the quantification and identification of microplastics, there are no precise guidelines to follow for microfiber preparation and their quantification in different samples.

GOALS

- An innovative approach is based on spectroscopic measurements. **Identification of microplastics by using molecular spectroscopy (MicroFtIR and MicroRaman).**

CEN-ISO 4484

Textiles — Microplastics from textile sources — Part 2: Qualitative and Quantitative evaluation of microplastics

Quali-quantification of MPs, identification of morphological and dimensional distributions including the evaluation of the surface and weight of each polymer and for each particle dimensional class.

UNI - ITALY

Evaluation of microplastics of textile waste effluent, discharged industrial water cycle, air in workplaces **could be analyzed and compared allowing to carry out a balance of the MPs** of:

1. a specific fibre production.
1. a specific textile production.
2. of textile products during their life cycle as garments.
3. of any other textile processes / semi-finished / finished products of a virgin or recycled fibre.

Standard Method Proposed:

The method is applicable to the determination of microplastics in different Textile matrices:

- **Liquid Sample**

TEXTILE *wastewater
from domestic
washing machines*

TEXTILE *water
processes*

Discharged industrial
water cycle

- **Solid Sample**

Microplastic Residue
obtained from
domestic washing
machine

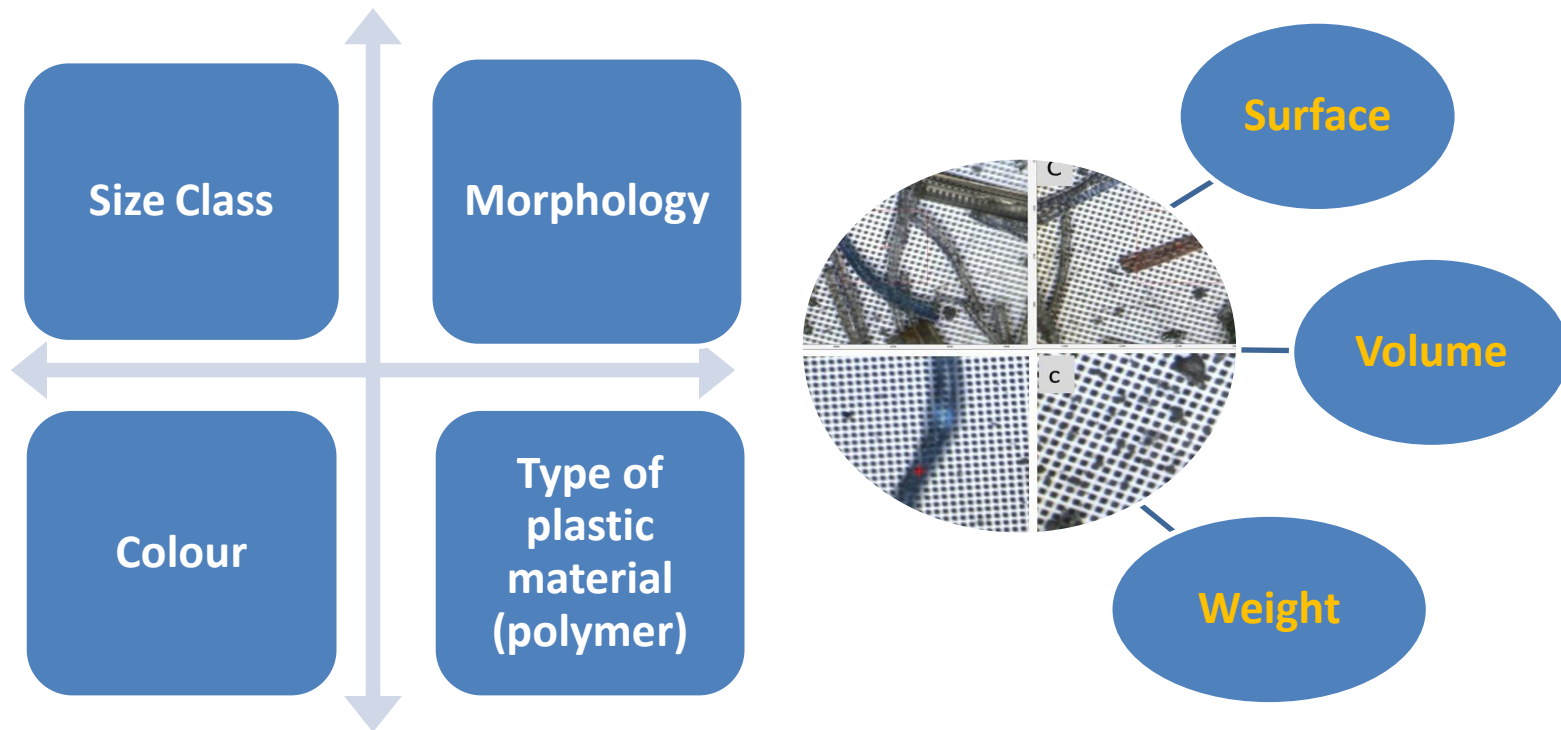
- **Air Sample**

Air in workplaces



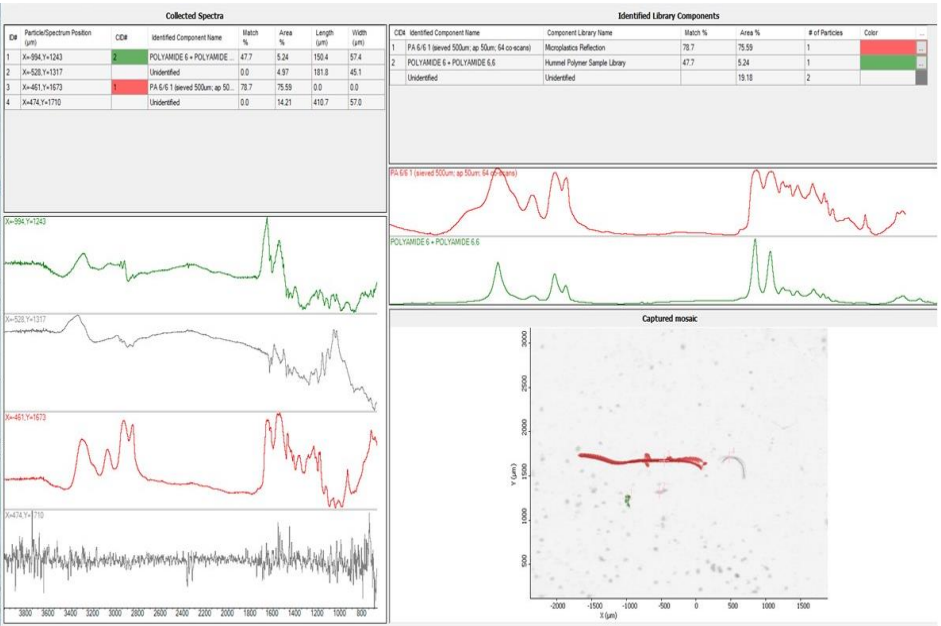
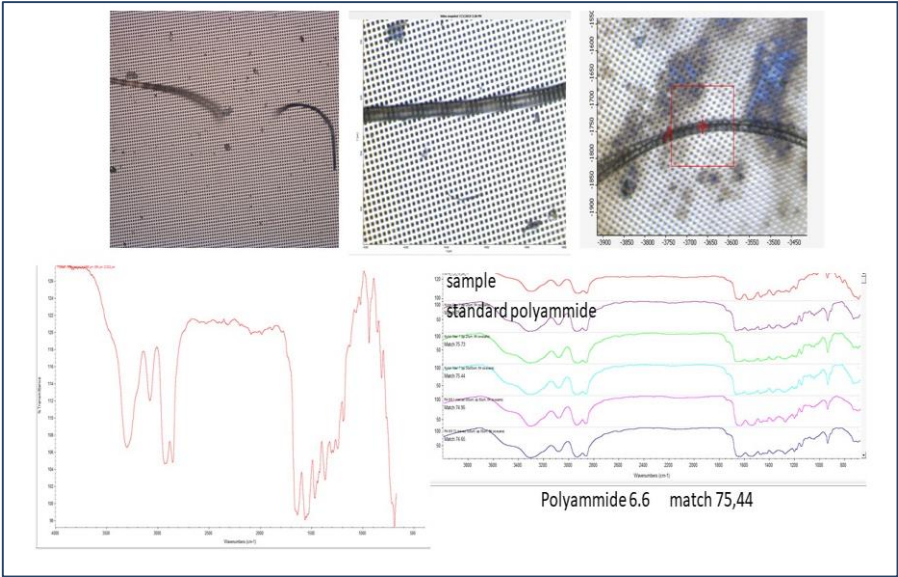
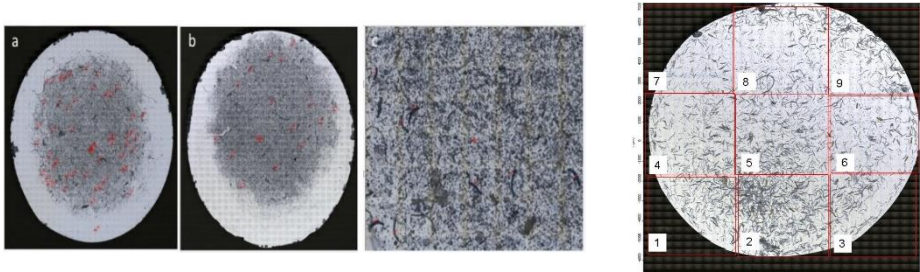
Standard Method Proposed:

The method is able to provide information about **Microparticles** such as:



OM and Molecular spectroscopy: counting and identification of microplastics

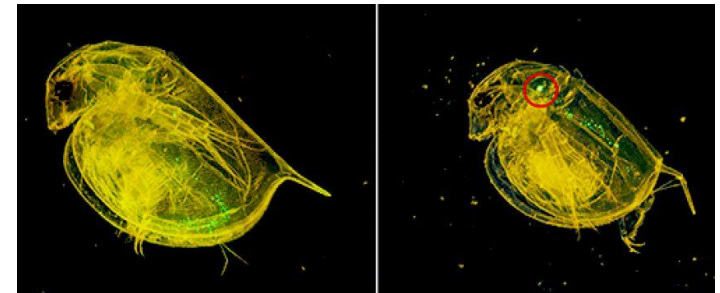
- Image analysis: particle size, area
- Counting of the particles
- Identification of polymer quality



BIOMARKERS ON SENTINAL ORGANISM

1. activity of the antioxidant enzyme catalase (CAT), as biomarker of cellular stress;
2. activity of glutathione-S-transferase (GST), as biomarker of cellular stress;
3. protein carbonylation content (PCC), as biomarker of oxidative damage;
4. micronucleus test (MN), as biomarker of genotoxicity;
5. acetylcholinesterase activity (AChE), as biomarker of neurotoxicity.

Daphnia magna



Biomarkers/Enzymes highlight the microplastic impact at

1. cellular level
2. molecular level
3. organ and individual level.

MPs

physical / chemical/
environmental
contaminants

BRI BIOMARKER RESPONSE INDEX

$$\text{BRI} = \frac{\sum (\text{AL biomarker}_x \text{ score } t=21 * \text{biomarker}_x \text{ weighting})}{\sum \text{biomarker}_x \text{ weighting}}$$

AL = alteration level score;

x = considered biomarker score;

t = time point at the end of exposure (t = 21 days)

- It allows the comparison of the toxicity of different samples, obtaining a hazard scale.
- It can be used as a useful tool for stakeholders and control agencies



Sistemi e Tecnologie Industriali Intelligenti
per il Manifatturiero Avanzato
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GRAZIE PER L' ATTENZIONE