Microplastics' Contamination: State of the Art

Francisco Belzagui Elder
francisco.belzagui@gmail.com
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Introduction

- Small plastics’ fragments
- Everywhere ➔ Pollutants (recently)
- Ubiquity in the Oceans ➔ More than “macroplastics” (by number)
- Microfibers (textile)

Recommendations

Hypotheses
Definitions

- **Length**
  - < 5 mm: Most accepted (NOAA*)
  - < 1 mm: No minimum

- **Synthetic Polymers**
  - < 5 mm in longest dimension
  - Sub-groups: 1-5 mm; 0,1-0,9 mm…
  - polyester, polyethylene, polypropylene...
  - All kind of polymers!

* National Oceanic and Atmospheric Administration
Definitions

- **Shapes**
  - Fragment
  - Film
  - Fiber
  - Granulate

- **Examples**
  - Fragmented plastics
  - “Microfibers”
  - Pellets, Microbeads

Microplastics & Microfibers

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1. Introduction
2. Microplastics’ State of the Art
3. Textile Microfibers
4. Conclusions
Definitions

- **Primary**
  Manufactured in a MP length

- **Secondary**
  Fragmented
Definitions

- **Primary**
  Released **TO the environment** in a MP length

- **Secondary**
  Generated **IN the environment** (fragmentation)

Mismanaged Plastic Waste
Definitions

- **Primary**
  Released **TO the environment** in a MP length

- **Secondary**
  Generated **IN the environment** (fragmentation)

Before & After Environment ➔ Recommended Definition

Potential Secondary MPs
Sources’ Estimations

- **Primary vs. Secondary**

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>15% (1.5 MMt/year)</td>
</tr>
<tr>
<td>Secondary</td>
<td>85% (4.8 MMt/year)</td>
</tr>
</tbody>
</table>

General plastics considered as Secondary MPs

NO normalized methodologies!!!

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Sources’ Estimations

- **Primary vs. Secondary**

<table>
<thead>
<tr>
<th>Source</th>
<th>Primary (%)</th>
<th>Secondary (%)</th>
<th>Amount (MMt/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>15%</td>
<td>85%</td>
<td>1.5</td>
</tr>
<tr>
<td>Primary</td>
<td>30%</td>
<td>70%</td>
<td>2.5</td>
</tr>
</tbody>
</table>

*Underestimated* NO normalized methodologieS!!!

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Sources’ Estimations

- **Primary MPs**
  7 Main contributors

  - Synthetic Textiles
  - Tire Dust
  - City Dust
  - Road Markings
  - Marine Coatings
  - Personal Care Products
  - Pellet Spills

First estimations same order of magnitude 0.95-1.50 MMt/yr

Boucher & Friot (2017)

Eunomia (2016)
Sources’ Estimations

Boucher & Friot (2017)
Total = 1.50 MMt / year
MFs = 0.25 - 0.75 MMt/year

Eunomia (2016)
950 kt / year
MFs = 0.15 MMt/year
Sources’ Estimations

>97% virgin feedstock
PLASTIC (63%)
COTTON (26%)
OTHER (11%)

53 million tonnes
ANNUAL FIBRE PRODUCTION FOR CLOTHING

USE

73% landfilled or incinerated

12% losses in production

0.5 million tonnes microfibre leakage

2% losses during collection and processing

12% closed-loop recycling

<1% cascaded recycling

2% recycled feedstock from other industries
## Sources’ Estimations

- **Potential Secondary MPs**

<table>
<thead>
<tr>
<th>Source</th>
<th>Plastic waste to the Oceans in Million tons/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jambeck et al. (2015)</td>
<td>4.80 – 12.70</td>
</tr>
<tr>
<td>Sherrington et al. (2016)</td>
<td>5.42 – 19.70</td>
</tr>
<tr>
<td>Eunomia (2016)</td>
<td>11.25</td>
</tr>
</tbody>
</table>

*Jambeck et al. (2015)*
Sources’ Estimations

- Potential Secondary MPs

Jambeck et al. (2015)
Sources’ Estimations

- Potential Secondary MPs

Schmidt et al. (2017)
Sources’ Estimations

- Potential Secondary MPs

Waste Management Global Efforts ➔ Considerable Reduction

Schmidt et al. (2017)
Distribution (General Pathways)

(Arrows’ sizes do not reflect flow rates)
Distribution (e.g.)

1 to 35% of Microplastics in (1) will remain in the liquid effluent. Most microplastics will be transferred to the sludge.
Distribution

• **Aquatic**
  - In almost every sample
  - Remote places

• **Marine Environments**
  - Small
  - Ubiquitous

Tibet

Potential **BIG** Problem
Distribution

- Marine Environments

Floating MPs

<table>
<thead>
<tr>
<th>Location</th>
<th>Fragment (%)</th>
<th>Film (%)</th>
<th>Fishing Line (%)</th>
<th>Fishing Line (%)</th>
<th>Foam (%)</th>
<th>Granule (%)</th>
<th>Fiber (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mediterranean Sea</td>
<td>88%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>9%</td>
<td>9%</td>
</tr>
<tr>
<td>Subtropical Gyres</td>
<td>86%</td>
<td>4%</td>
<td>9%</td>
<td>1%</td>
<td>9%</td>
<td>1%</td>
<td>9%</td>
</tr>
<tr>
<td>UK Tamar Estuary</td>
<td>91%</td>
<td>9%</td>
<td>1%</td>
<td>9%</td>
<td>9%</td>
<td>1%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Distribution

- Marine Environments

- 15-51 Trillion MPs

- Floating MPs (0.33 – 5.00 mm)

- Mediterranean Sea

- 5 gyres

- Items per km²: 10^0 10^1 10^2 10^3 10^4 10^5 10^6

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Distribution

- Marine Environments

Floating MPs

- Open ocean waters: 39.0%
- Coastal ocean waters: 26.8%
- Coastline and seafloor: 33.7%
- Floating MPs: 0.5%

"Just the tip of the iceberg"

UNEP & GRID-Arendal (2016)
Distribution

• Marine Environments

Sediments

- Worldwide
  - Browne et al. (2011): 13% Fiber, 87% Other Plastics
  - Woodall et al. (2014): 15% Fiber, 85% Other Plastics
- UK Tamar Estuary
  - Browne et al. (2010): 17% Fiber, 83% Other Plastics

Definitions
Sources’ Estimations
Distribution
Impacts

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Distribution

- **Marine Environments**

  **Sediments**

  - Fibers: most abundant (x4)

  **Microplastics / 250 ml of sediment**
  - 1 – 10
  - 11 – 20
  - 21 – 30
  - 31 – 40

  **Fibers / 50 ml of sediment**
  - 1 – 10
  - 11 – 20
  - 21 – 30
  - 31 – 40

  **Coral specimens**
  - Fibers presence

  **Mostly “rayon”**

*Woodall et al. (2014)*

*Browne et al. (2011)*
Distribution

- Marine Environments

Sediments

Proximity to cities

Microplastics / 250 ml of sediment
- 1 – 10
- 11 – 20
- 21 – 30
- 31 – 40

Fibers / 50 ml of sediment
- 1 – 10
- 11 – 20
- 21 – 30
- 31 – 40

Coral specimens
- Fibers presence

Woodall et al. (2014)

Cellulose: toilet paper

Browne et al. (2011)

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Impacts

- **Marine organisms**

  MPs > 100 species [plankton to whales]
  - Gastrointestinal blockages
  - Starvation
  - Immobilization
  - Decreased growth
  - Increased mortality
  - Translocation
  - Chemical transfer
  - …

Measured under lab conditions in critical environments
Impacts

- **Humans**

  Impacts: no studies made

  - In fish and shellfish for human consumption
  - Tap water
  - Sea salt
  - Air
  - …

  11,000 MPs per year from eating shellfish!
Impacts

• Other impacts
  – Adsorption of chemical compounds
  – Space for alien species
  – Change in physical properties of beach sediments

Non-synthetic polymers also!

J. Wang et al. (2016)
# Textile Microfibers

## Measured Microfibers’ Detachment

<table>
<thead>
<tr>
<th>Work</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Browne et al. (2011)</td>
<td>170 MF / l</td>
</tr>
<tr>
<td>Napper &amp; Thompson (2016)</td>
<td>500,000 MF / 6 kg of garment washed</td>
</tr>
<tr>
<td>Pirc et al. (2016)</td>
<td>135,000 MF / 6 kg of garment washed</td>
</tr>
<tr>
<td>Bruce et al. (2016)</td>
<td>8,500 – 250,000 MF / garment washed</td>
</tr>
<tr>
<td>Astrom (2016)</td>
<td>7,360 MF / m² l</td>
</tr>
</tbody>
</table>
Textile Microfibers

• Measured Microfibers’ Detachment
  - Direct
  - Replicability: \( E = 8\% \); \( CV = 11\% \)
Textile Microfibers

• Measured Microfibers’ Detachment

Total MFs

MF/g

MF/m²
Textile Microfibers

• “Solutions”

Better practices
  - Less synthetic
  - Full washing machine
  - Liquid soap
  - Colder water
  - Front-loading
  - …

(plasticpollutioncoalition.org)
Textile Microfibers

• INTEXTER Future works

- Normalized methods
- Indoor microfibers
- Industrial, evaluate:
  - Quantity
  - Solutions

![Graph showing the decrease of MF/l in 5 washes for different washing cycles and materials: F4, P1, PE3.](image)
Conclusions

- Not well defined
- Presented everywhere, ubiquitous in marine environments
- High potential risks for organisms
- Risks for humans? Food, tap water,…
- Main primary: textile, tires, city dust
- Fibers are the most abundant?
Conclusions – Questions

- Type, shape,…  WHAT
- Water column, air,…  WHERE
- Risks  WHICH
- Detachment, erosion,…  HOW

SOLUTIONS
THANKS!