Synthesis of chemicals from marine litter: addressing Ocean's pollution

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SINTOL – marGnet project

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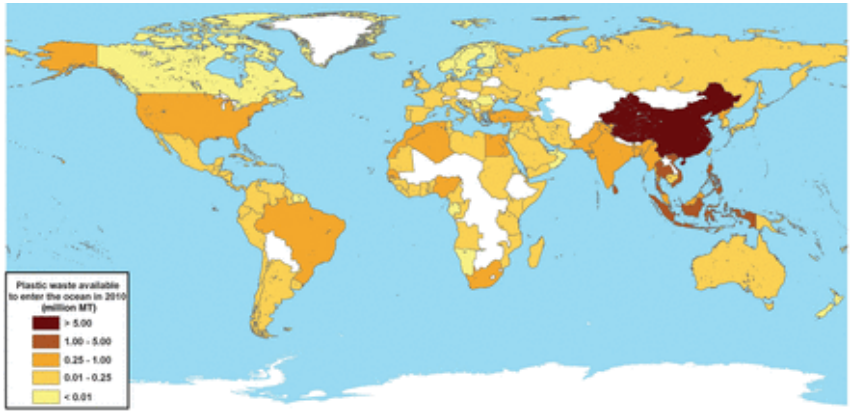
Plastic flowing into the Oceans: waste mismanagement



275 million metric tons (MT) of plastic waste was generated in 192 coastal countries in 2010, with 4.8 to 12.7 million MT entering the ocean*.

From 32 to 86 MBOE (barrel oil equivalent) flowed into the sea in 2010: an equivalent of 2 to 5 Billion USD value

Without waste management infrastructure improvements, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025

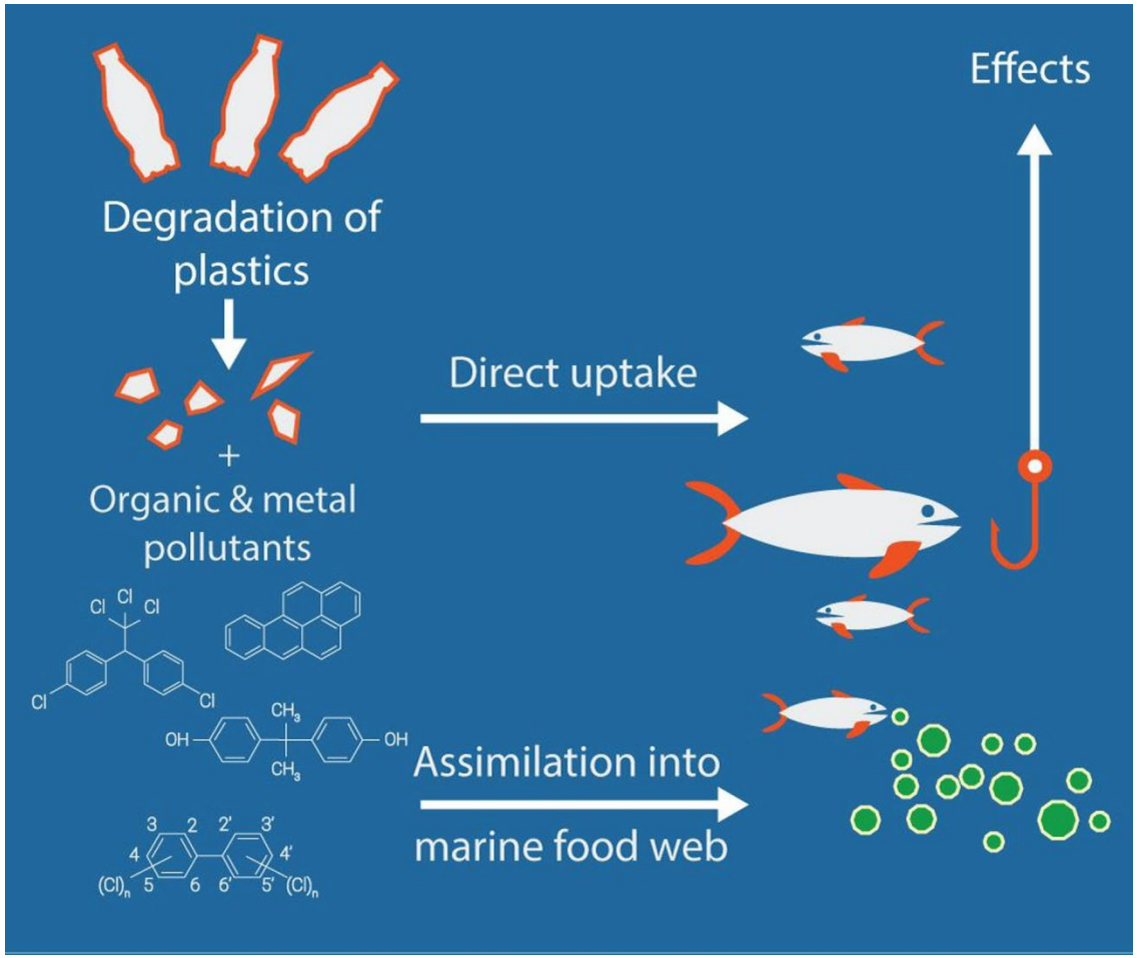
**Jambeck, Jenna R., et al. "Plastic waste inputs from land into the ocean." Science 347.6223 (2015): 768-771.*

Plastics in the Oceans: wide family

- Floating or stranded macroplastics (PE, PP)
- Ghost nets, fishing gears, acquaculture (nylon, PE)
- Plastic debris from few µm to few mm (microplastics)
- Sunk plastics (thermosets, resins, etc..)

- Contaminated feedstock difficult to recover and recycle
- It is litterally a sunk cost

Direct and indirect ecotoxicology



All plastic is generated on land

In 2015, 4.1 million tons of plastic "bags, sacks, and wraps" were generated (including PS, PP, HDPE, PVC, & LDPE) in USA with a recycling rate of just 12.8%*

In 2016, 27,1 million tons of plastic waste were reclaimed in EU with a recycling rate of 31%**

The Gulf of Mexico contains some of the highest concentrations of microplastics worldwide, with the majority of which being plastic microfibers. Researchers hypothesize the large drainage basin of the Mississippi River, which outflows into the Gulf, is the main transporter of land based plastics***

*US EPA. 2018. Advancing Sustainable Materials Management 2015 Tables and Figures: Assessing Trends in Material Generation, Recycling, Composting, Combustion with Energy Recovery and Landfilling in the United States. Pp. 9

**PlasticsEurope report 2018

***Abundant plankton-sized microplastic particles in shelf water of the northern Gulf of Mexico, Rosana Di Mauro, Matthew J. Kupchik, and Mark C. Benfield, Environmental Pollution November 2017: 230, 798-809.

Recycled plastic's fate

31.1 % Recycled*

ARE WE SURE ??

37% outside EU

63% inside EU

Malaysia
Plastic pollution: One town smothered by 17,000 tonnes of rubbish
By Yvette Tan
BBC News, Jenjarom
February 13, 2019

America's grungy 'recycled' plastic is creating wastelands in Asia
PRI's The World
June 13, 2019 · 9:00 AM EDT
By Patrick Winn

Greenpeace After 'The Recycling Myth' Report: Updates from the Field
Kedah
April 18, 2019

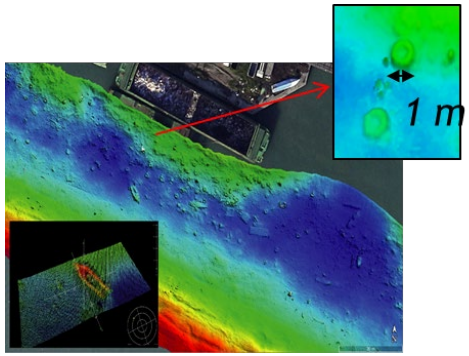
*Sources: PlasticsEurope report 2018

Main problems to address

- **Technical challenge to recycle ML**
- Mechanical recycling cannot be widely applied to ML: (need for washing, cleaning, etc..)
- Large volume solutions required: not to shift one problem to another
- **Economic challenge**
- How to create value ? «Circular Economy» concept set by EU
- **New challenges:**
- 700,000 fibers could be released from an average 6 kg wash load of acrylic fabric (Napper et al, 2016)

- Besides prevention, making fuel is part of the answer: global annual marine fuel demand is >400 Mton

marGnet concept: mapping and recycle



Mapping ML

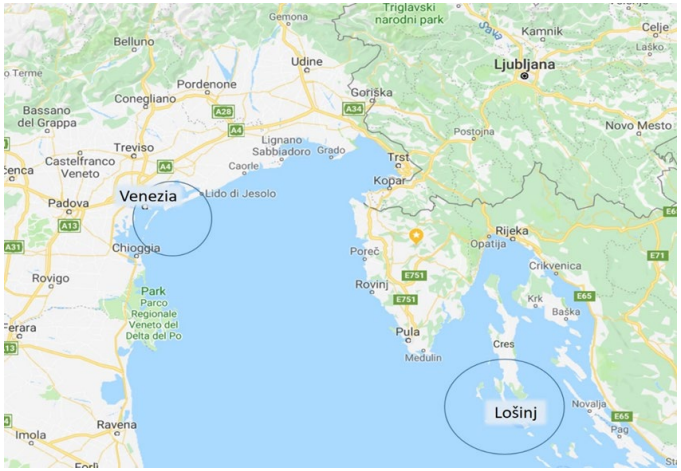
ML

marGnet

Reduce

MARINE FUEL

Marine Fuel



- Taxation or punishment policies are ineffective to deal with ML
- Find a feasible way to create value from ML collection
- Understand environmental impact of this approach
- Get engagement of fishermen
- Inherent incentive for pollution prevention – <u>No public subsidies</u>
- <u>Inherent Incentives for Sea cleaning</u>
- Improve policies to make it legally possible

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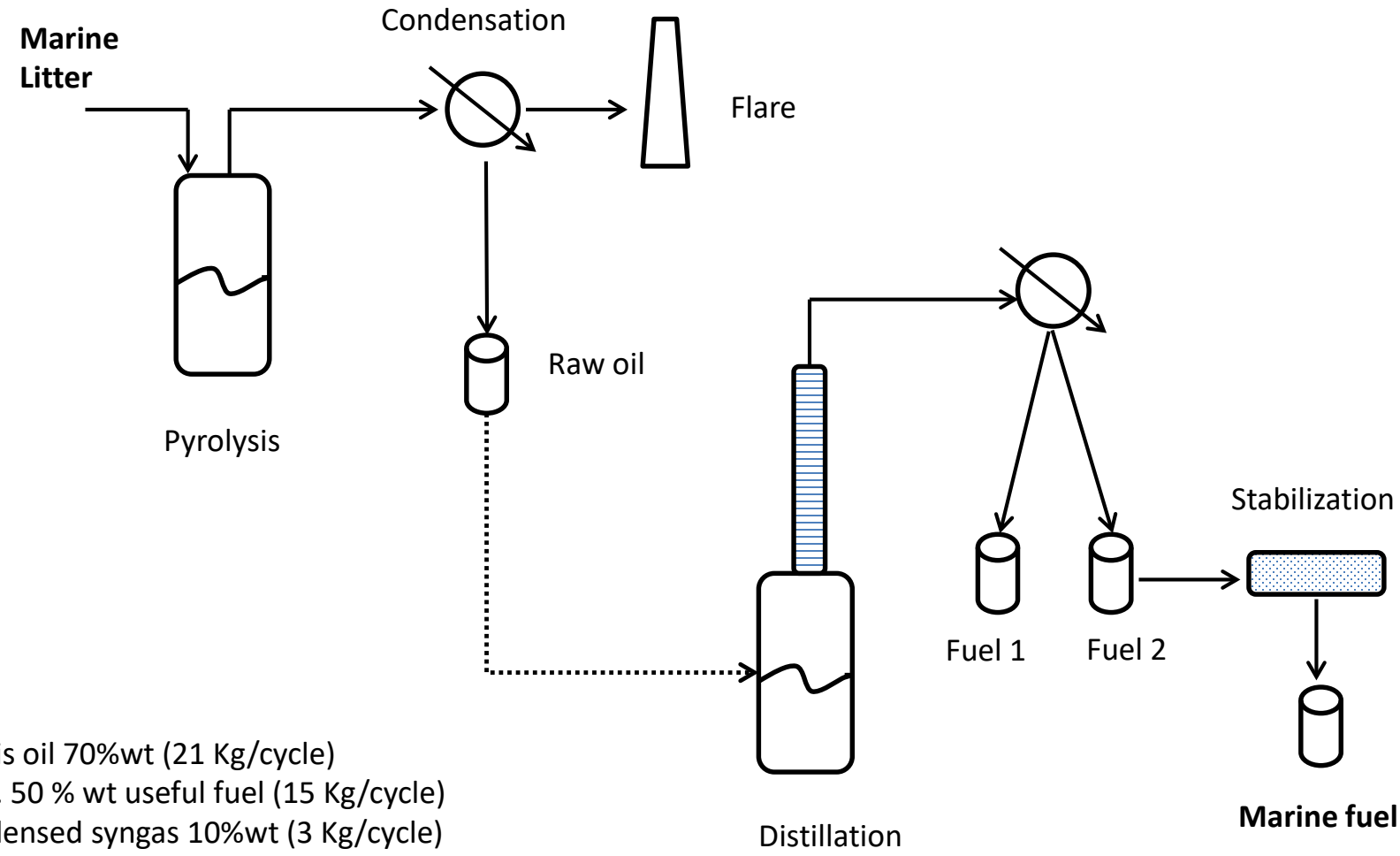
Experimental set up



- Pyrolysis oil 70%wt (21 Kg/cycle)
- Approx. 50 % wt useful fuel (15 Kg/cycle)
- Uncondensed syngas 10%wt (3 Kg/cycle)
- Char (solid residue) 20%wt (6 Kg/cycle)

Produced fuel

Parameter	Value	Unit	Limits ISO 8217 DMA (ECAs)	DMB (ECAs)
Cetane number	60.7	--	--	--
Cetane index	66.7	--	--	--
Density @ 15 °C	802.7	kg/m^3	<890	<900
S	42.9	mg/kg	<10000 (1000)	<10000 (1000)
Flash point	48	°C	>60	>60
Carbon residue	0.05	% (w/w)	<0.3	<0.3
Ash	<0.005	% (w/w)	<0.01	<0.01
Lubricity @60 °C (HFRR)	276	µm	<520	<520
Cinematic viscosity @40C	2.3	mm^2/s	>2; <6	>2; <11
Pour point	-6	°C	0	6
% recovered @ 250C	36.3	% (V/V)	--	--
% recovered @ 350C	93.8	% (V/V)	--	--
95 % (V/V)	354.5	°C	--	--

Marine Gas Oil (DMA) average quotation (Sept. 24 2019): 672,5 USD/ton *

Low S fuel demand growing due to IMO ANNEX VI: max 1000 ppm ECAs areas

Values obtained by processing unsorted plastic waste mined from landfill

*source: Ship&Bunker.com

Hydrogenated produced fuel

Property	Value	Unit	Limits EN590 min	Limits EN590 max
Density at 15 °C	790.6	kg/m³	820.0	845.0
Viscosity at 40 °C	2.377	mm²/s	2.000	4.500
Sulfur Content	12.1	mg/kg		10.0
Polyaromatic Hydrocarbons	–	% wt		8
Distillation				
Recovered at 250 °C	41.0	% vol		65
Recovered at 350 °C	95.2	% vol	85	
95% (V/V) Recovered at	349.5	°C		360
Derived Cetane Number	74.7		51	
Cetane Index	71.5		46	
Flash Point	52.5	°C	55	
Copper Corrosion (3h at 50 °C)	1A		1A	
Cloud Point	8	°C		
Pour Point	2	°C		
CFPP	2	°C		
Lubricity Corrected WSD1.4 at 60 °C	552	µm		460
Calorific Value				
Gross	46,98	MJ/kg		
Net	43,83	MJ/kg		

Values obtained from hydrogenated fuel made from landfill plastic waste

Take home message

- Fuels production is a pragmatic approach to deal with ML:
  - Circular economy concept and value generation
  - Marine fuel market volume matches available feedstock
  - Depollution cycle w/o public subsidies is possible
- Low S fuels:
  - Meet environmental policies at no extra cost
- Drop in fuels:
  - MF readily available, terrestrial with mild HDS

Acknowledgment

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Thank you!

"There could be more plastic than fish in the ocean by 2050"*

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Sewage surfer © Justin Hofman. Wildlife Photographer of the Year 2017
*Ellen MacArthur Foundation, World Economic Forum Dec.2017