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Fate and removal of plastic in wastewater treatment

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Contents

- Plastic is a POP (Persistent Organic Pollutant)

- Wastewater treatment plants (WWTPs):
  - Behavior and removal of micro- and nanoplastics in WWTPs follows well established concepts for TSS removal
  - Elimination efficiencies range between 80% and >99%
  - Plastic emissions from WWTP are of minor importance regarding mass flows to surface waters
  - Micro- and nanoplastics from other sources dominate inputs into surface waters.

- .Adressing the MP challenge:
  - Source control: focus for load reduction
  - WWTP techniques for better elimination are known
  - Sludge disposal: alternatives to incineration?

Plastic is a Persistent Organic Pollutant (POP)

- Global plastics production: $350 \cdot 10^6$ tonnes/a = 350'000'000 t/a
  - ~50 kg/person/year
  - 3rd most abundant man made material (after steel and concrete)
- Globally: 60% of the production emitted to the environment
  - Plastic litter averaged over the globe: 0.4 g/m^2/year
  - But plastic litter is not evenly distributed

Locally:
plastic pollution is a problem

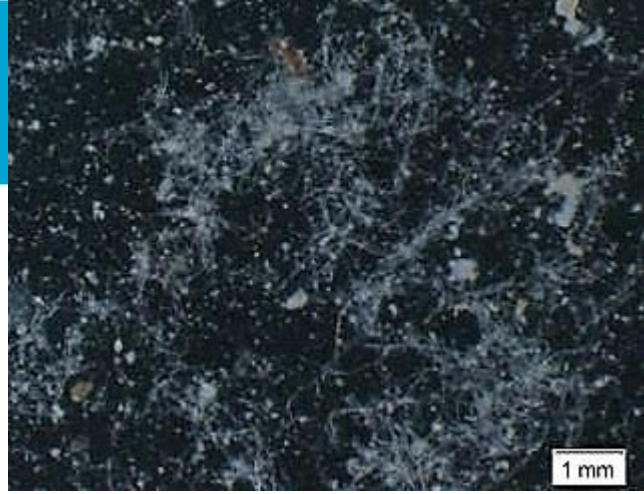
Plastocene = our era?

Europ.Comm. SAM, 2019
www.plastocene.com

Definitions

NP
- Nanoplastics < 0.0001 mm (1 – 100 nm)

MP
- Small microplastics 0.0001 - 1 mm
- Large microplastics 1 - 5 mm
- Mesoplastics 5 - 200 mm
- Macroplastics >200 mm



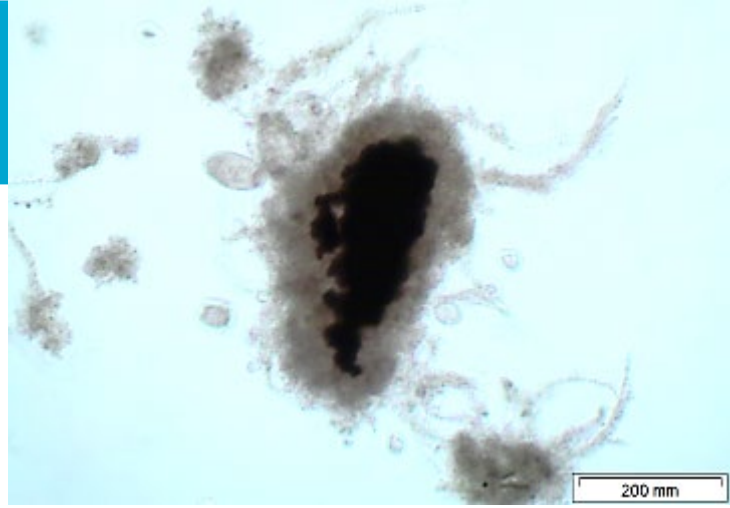
Primary sludge with MP-fibres

Primary MP: intentionally produced as MP
Secondary MP: formed by decay of biger plastic fragments

In wastewater treatment plants (WWTP): MP and NP of interest.

Identification and quantification of MP:
- mostly based on microscopic techniques (light microscope, u-RAMAN or u-FTIR) -> detection limits are method dependent (~1-10 µm).
- Lack of standards for quantification
- Results span over orders of magnitude, due to choice of method (collection, preparation, analytical technique)
- Pyrolysis and GC-MSMS (total plastic mass): method in preparation (T. Ternes, Germany)

WWTPs eliminate MPs / NPs as predicted based on TSS removal



S-Select: microplastics added to trigger granulation

		Untreated	Conv.Act.Sludge	Elimination	Literature
Susp. Solids	mg/L	120 – 400	5 – 25	80% – 99%	1)
Microplastics	counts/L	100 – 250	3 – 28	75% – 99%	2), USA
Microplastics	counts/L	640±240	50±30	92%±6%	3), Switzerl.

Options to further improve the removal of particulates:

WWTP with sand filter	95% - 99.5%
WWTP with membrane filter	>99%

Effluent filtration: >99% feasible
Costs for filtration: 5 to 20 $/p/a
MP load is transferred to sludge

1) Metcalf & Eddy, 2014
2) Conley et al., 2019
3) Cabernard et al., 2016

MPs in WWTP effluent: µg/L

		Influent	Effluent Conv.Act.Sludge	Literature
Microplastics	gMP/person/year	100 – 250	0.34 – 0.6	2), USA
Microplastics	gMP/person/year		0.15	3), Switzerland

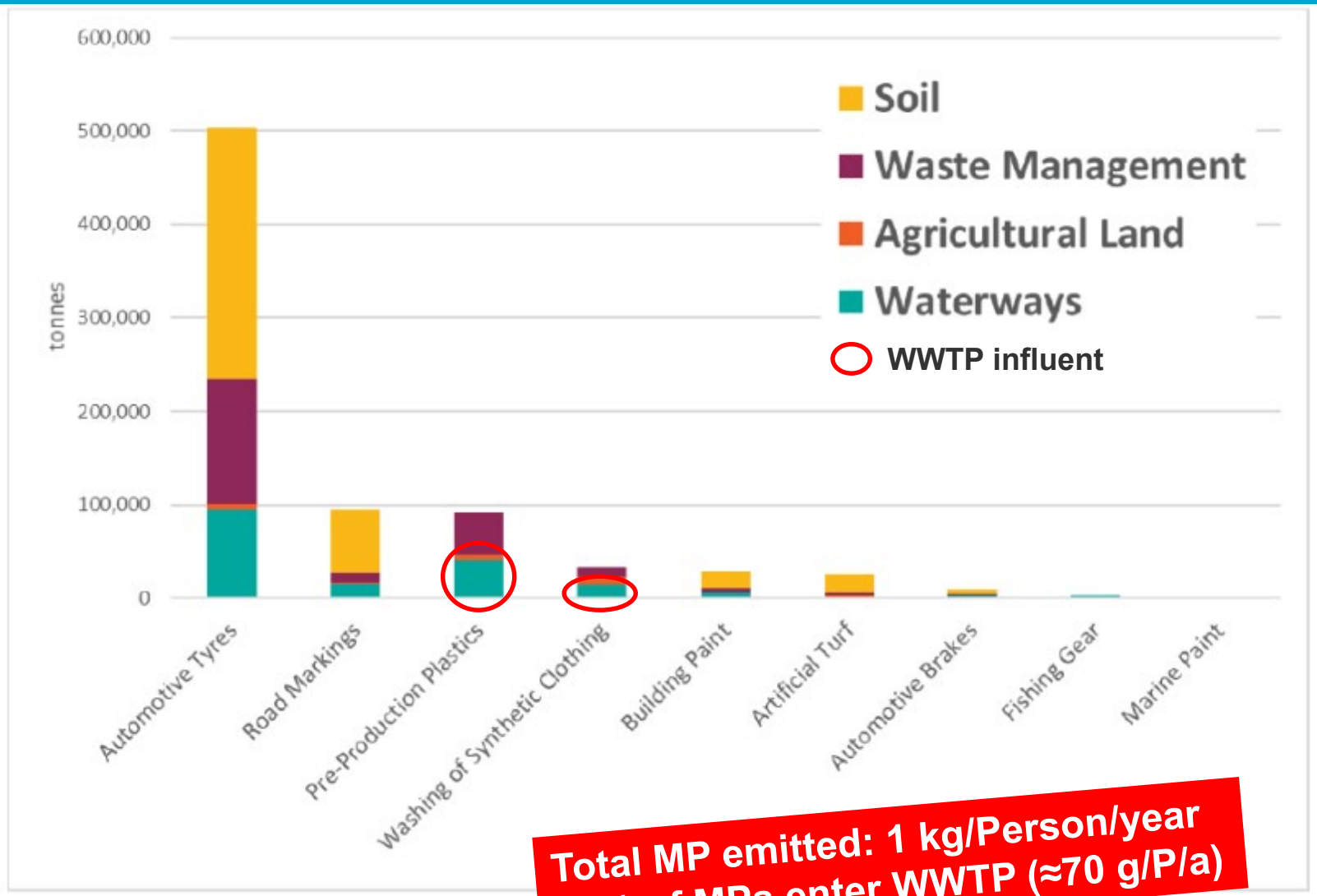
Wastewater treated: 100 to 200 m^3/person/year 1)

Estimated global plastic input to the environment: 20 – 30 kg/person/y 4)

MP effluent concentration: 1 – 5 µg/L
Plastic: most constituents are inert
slow release of additives
MP less relevant than micropollutants
micropollutants: confirmed effects on biota

1) Metcalf & Eddy, 2014
2) Conley et al., 2019
3) Cabernard et al., 2016
4) Europ.Comm. SAM, 2019

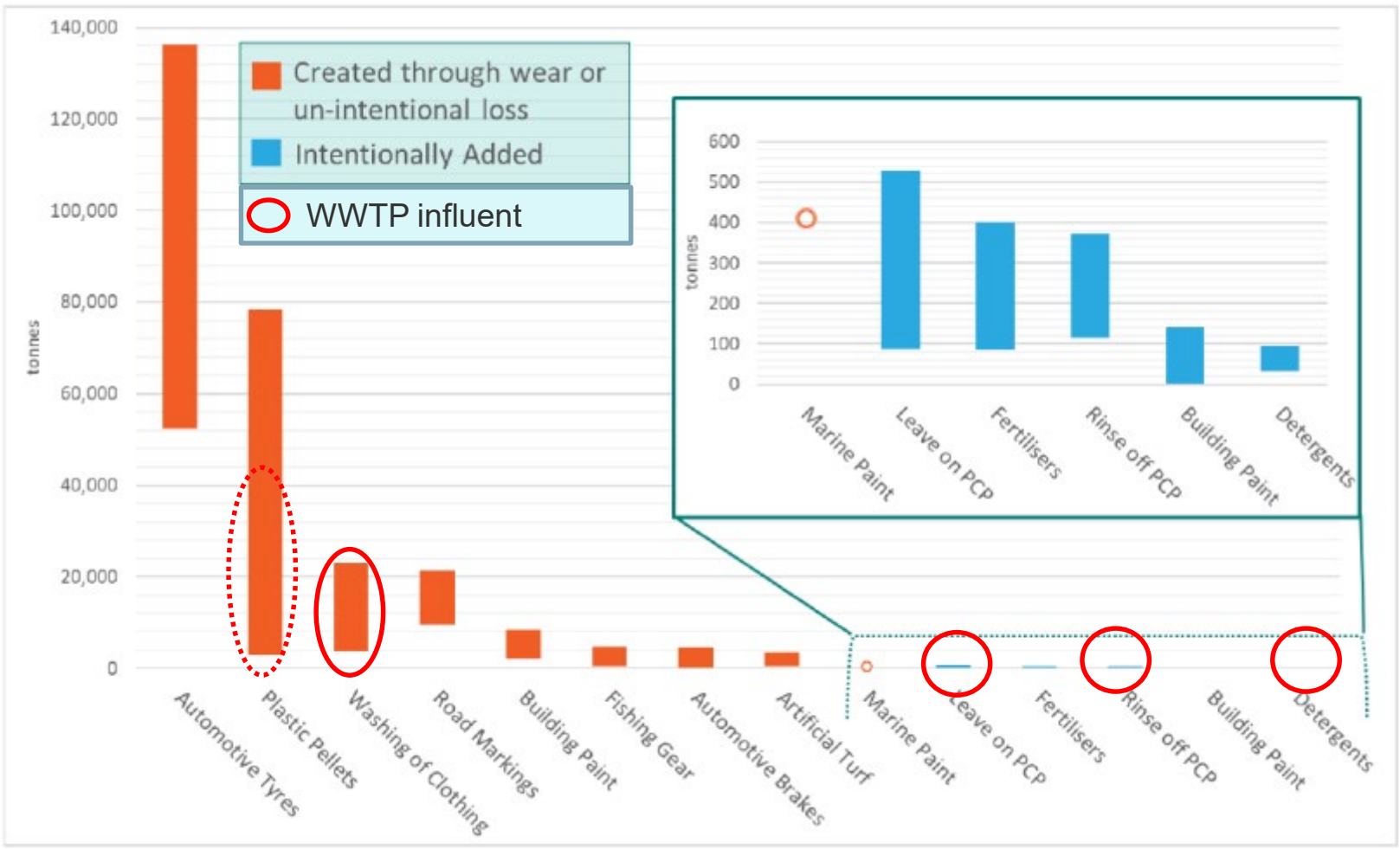
MPs sources and quantities in the EU



Total MP emitted: 1 kg/Person/year
~7% of MPs enter WWTP (≈70 g/P/a)

Eunomia, 2018

MPs sources



Primary MPs: <0.05% of plastics disposed to the environment

- **Secondary MP formation relevant**

Eunomia, 2018

Upshot

Kaldnes on a beach in Italy

WWTP effluent contain MPs in low µg/L

- Compared to dissolved organic micropollutants (antibiotics, pharmaceuticals):
  - Similar concentrations
  - Lower relevance, since plastics mostly inert

Plastic input to the environment (~25 kg/P/a) 10'000 x higher than MPs in wastewater

- Focus on source control to address the MP challenge.

WWTPs transfer 80% - 99% of MPs to sludge

- Agricultural sludge disposal brings MP load to soils (0.002 to 0.06 kg/P/a)
- Sludge disposal via incineration destroys MPs
- ~10 times less than tyre wear

WWTP post treatment with filtration (sand or membrane)

- WWTP upgrading for better MP removal well established


Thank you

References

Cabernard L, Durisch-Kaiser E, Vogel J-C, Rensch D, Niederhauser P, 2016, Mikroplastik in Abwasser und Gewässer, Aqua&Gas 7/8

Conley K, Clum A, Deepe J, Lane H, Beckingham B, 2019: Wastewater treatment plants as a source of microplastics to an urban estuary: Removal efficiencies and loading per capita over one year, Wat. Res. X(3)

Eunomia, Hann S, Sherrington C, Jamieson O, Hickman M, Kershaw P, Bapasola A, Cole G, 2018, Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products, DG Environment of the European Commission

Europ. Commission SAM, 2019: Environmental and Health Risks of Microplastic Pollution, ISBN 978-92-76-02423-1

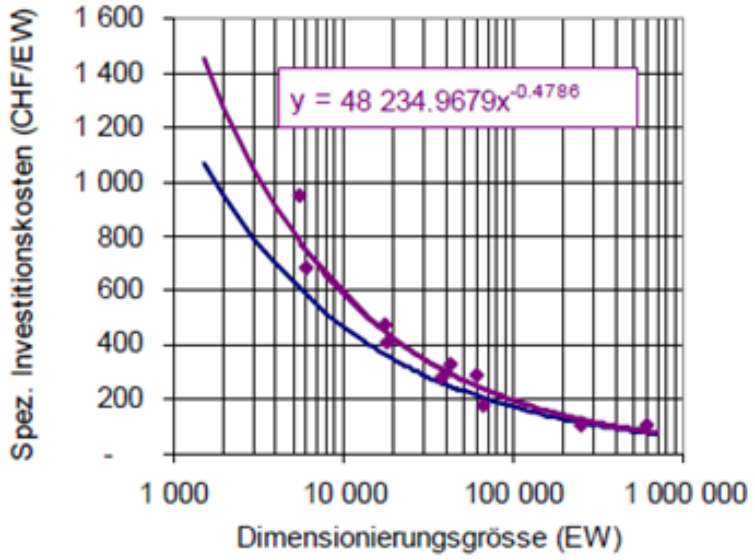
Hu Y, Gong M, Wang J, Bass A., 2019, Current research trends on microplastic pollution from wastewater systems: a critical review, Rev Environ Sci Biotechnol 18:207–230

Metcalf & Eddy, Tchobanoglous G, Stensel HD, Tsucihashi R, Burton F, 2014, Wastewater Engineering Treatment and Resource Recovery, 5th ed. Mc Graw Hill

Prata JC, 2018, Microplastics in wastewater: State of the knowledge on sources, fate and solutions, Marine Pollution Bulletin 129: 262-265

Invest costs estimation for micropollutant removal with/without existing filtration

PAK mit neuer Filtration



PAK mit bestehender Filtration