Review Note:

Microplastics Risk in the Water Industry

v5

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Scientific Committee Meeting, January 3, 2021

Developed with assistance from Chemonics Egypt's Review of Current Knowlwdge (ROCK) Team

Purpose Statement

- The purpose of this presentation is to share the results of a Critical Literature Review on microplastics in the water industry
- The fundamental question I am trying to address is: “what is the magnitude of the public health risk microplastics are posing via its presence in drinking water and wastewater, and what the water and wastewater companies can do to mitigate this risk?”

Outline

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3. Impact of microplastics release into soil
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1. Introduction

- The ECHA (European Chemicals Agency) defines microplastics as any (synthetic) polymer or polymer containing solid or semisolid particles that are not liquid or gas and having a size smaller than 5 mm in at least one external dimension.
- Primary microplastics are intentionally added to products
- Secondary microplastics are unintentionally released during the use or the subsequent life-cycle stages of plastic-containing materials and goods through wear and tear (broken down into ever smaller pieces)
- Microplastic particles can be spherical beads, fragments, fibers or films and can be made of a variety of polymers. Particles less than 100 nm are classified as nano-plastics

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Primary and Secondary Microplastics

	Primary microplastics	Secondary microplastics	Oxo-degradable plastics (not only microplastics)
Products	Cosmetics, detergents, paints, cleaning products, pharmaceuticals (nano-capsules), cosmetics, fertilisers, detergents	Tyres, synthetic textiles, pellet loses , plastic dust from shredders or dust from handling of plastics in landfills …	Agricultural films, rubbish and carrier bags, food packaging, landfill covers

(Cont;d) Introduction

- Microplastics is one of the emerging pollutants found almost everywhere on Earth
- Due to the chemical composition of plastics, these particles are resistant to degradation
- Their small size makes them easily accessible to a vast range of organisms and transferable along the food chain
- Microplastics mainly originate from sources such as synthetic fibers, automobile tire wear, industrial processes, household dust, and the deterioration of plastic surfaces

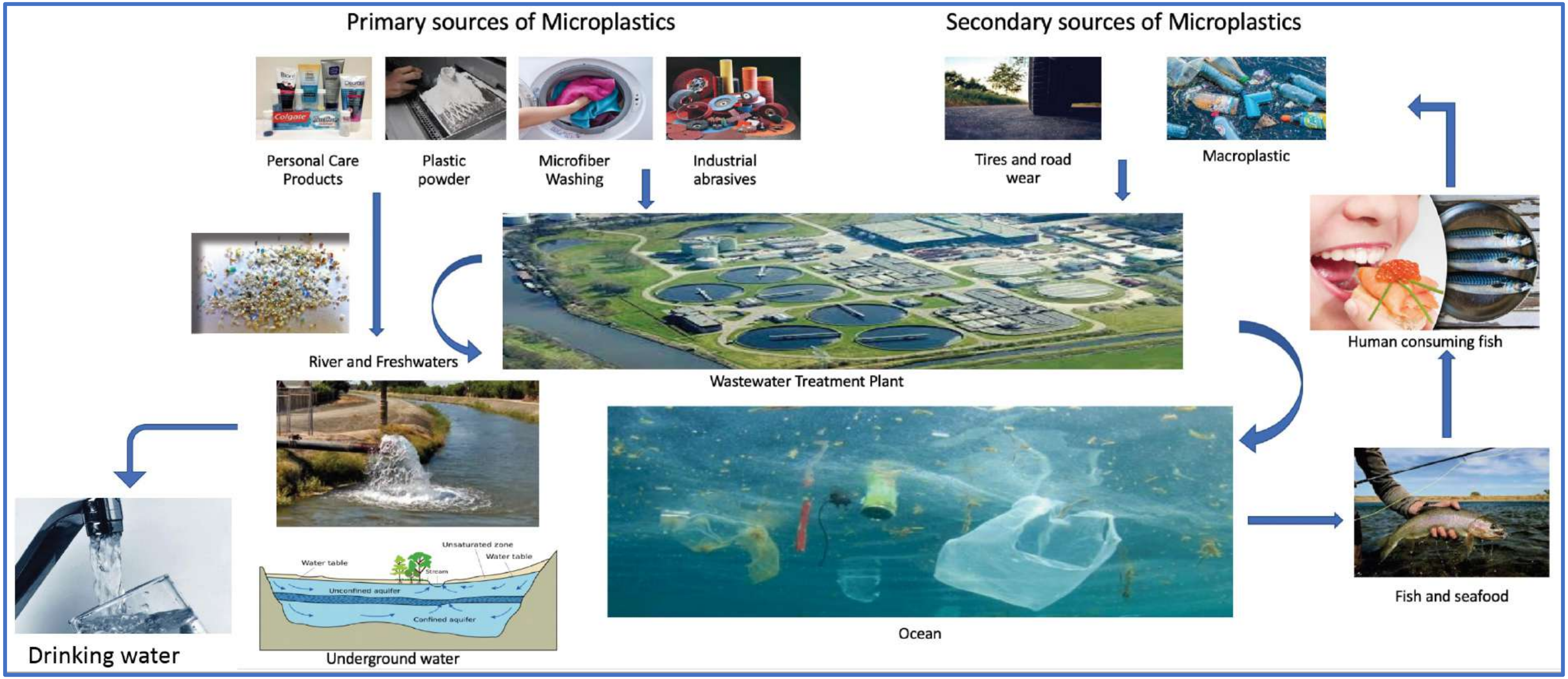
- Macroplastics as >5 mm
- Mesoplastics as <5 mm to >1 mm
- Microplastics as <1 mm to >0.1 µm
- Nanoplastics as <0.1 µm

2.Microplastics in the Water Cycle

Throughout the water cycle, there are several points where microplastics can be introduced:

- Water treatment and distribution network can introduce microplastics into drinking water through contact with plastic machine accessories, membranes, tanks and pipes
- Water use at home can introduce plastics and microplastics through personal hygiene, toilet flushing, clothes washing, etc. This can happen intentionally, accidentally, passively (e.g. through a washing machine while washing synthetic clothes, or through the feces of humans who have accidentally ingested plastic)
- During wastewater treatment, microplastics can be introduced by pipes, equipment, biofilters or biocarrier media, by membranes and tank

Microplastics sources and connection to water



Source: http://www.newea.org/wp-content/uploads/2019/02/AC19_DElkhatib_26.pdf

2.1 Microplastics in WTPs

- Treatment processes for surface water removes living or inert particles in the same size range as microplastic particles by physical treatment steps such as sedimentation, coagulation – flocculation, flotation, filtration
- The physical processes as applied in surface water treatment to remove small (e.g. Cryptosporidium, algae) and large particles are effective for microplastics removal
- The turbidity measurements and other monitoring tools help to control the removal of all kind of particles in the micron range

2.2 Microplastics in WWTPs

- Municipal wastewaters are considerably polluted by microplastics, with concentrations ranging from $10–10^7$ particles/ m^3.
- Microplastics enters sewer systems from domestic sources, mainly consist of synthetic textile fibers, cosmetic microbeads and disintegrated parts of larger consumer products that are flushed down the toilet
- Treated effluent from WWTPs may contain only few microplastics per liter, the total load of microplastics can still be high, due to the large volume of treated wastewater
- Higher concentrations of microplastics have been reported in rivers and streams downstream of WWTPs in comparison to upstream

(Cont;d) Microplastics in WWTPs

- Over 90 percent of microplastics in the influent stream are retained in sewage sludge
- Because sewage sludge is used as a fertilizer, microplastics can thereafter be spread on agricultural lands and food chain. The magnitude of these inputs is only partially known. Several studies have investigated which wastewater treatment technologies generate the highest removal rates for microplastics in wastewater streams. Other studies have researched which sludge handling technologies have the highest potential for destroying microplastics
- New research work is directed to identify scenarios in which WWTPs limit the release of microplastics into the environment in a way causing minimum effect on the water-energy-nutrient nexus

(Cont;d) Microplastics in WWTPs

- A significant part of the microplastics that enter WWTPs are captured by the screens and grit removal units
- These microplastics are supposed to be incinerated or landfilled (?)
- The remaining microplastics most probably end up in the primary sludge if a primary settler is in place or in the secondary sludge
- There are speculations about the possibility of microplastics degradation in sludge digestors, but more research is needed to confirm this

Sample studies that investigate microplastic contamination in sewage sludge

NR: Not reported
NCR: No characterization reported
DW: Dry weight
WW: wet weight

Source: Microplastics in Water and Wastewater, edited by Hrissi Karapanagioti, and Ioannis K. Kalavrouziotis, IWA Publishing, 2019.

Location	WWTP Type (Population Equivalent)	Reported Trapping Efficiency	Treatment Type	Mean Sludge MP Concentrations	MP Size Range Analysed (μm)	Dominant MP Types Shape	Polymer
Italy	Tertiary (1.2 million)	84%	NR	113 particles g^{-1} (DW)	10–5,000	Films	Acrylonitrile-butadiene
Australia	NR (NR)	NR	Aerobic & anaerobic digestion	966 microbeads kg^{-1}	<1,000	Only microbeads investigated	NR
China	28 WWTPs: Mixed types (51,900–705,000)	NR	Various	1,565–56,386 particles kg^{-1} (DW)	37–5,000	Fibres	Polyolefin
China	NR (NR)	NR	NR	240.3 ± 31.4 particles g^{-1} (DW)	60–4,200	Fragments	Nylon
Korea	3 treatment plants (A: 67,700) (B: 235,700) (C: 245,200)	98%	A, B: Sludge thickening and dehydration C: Thickening, anaerobic digestion and dehydrator	A: 14.9 particles g^{-1} (DW) B: 9.6 particles g^{-1} (DW) C: 13.2 particles g^{-1} (DW)	106–5,000	Fragments	NR
Finland	Tertiary (55,000)	98%	Anaerobic digestion (and dewatering)	4.2–28.7 particles g^{-1} (DW)	250–5,000	Fibres	Polyester
Canada	Secondary (NR)	98%	NR	14.9 (primary) & 4.4 (secondary) suspected particles g^{-1} (DW)	<5,000	Fibres	NCR
Norway	2 tertiary, 4 secondary, 2 primary (18,150–615,000)	NR	Various	1,701–19,837 particles kg^{-1} (DW)	50–5,000	Beads	Polyethylene
Netherlands	1 tertiary, 1 secondary WWTP, 1 STW (NR)	72%	NR	370–950 particles kg^{-1} (WW)	10–5,000	NR	NR

3. Impact of Microplastics Release into Soil

- Only a small number of published studies have investigated the interaction between microplastics and terrestrial organisms.
- Reported adverse effects include reduction in growth and reproduction in Collembola histopathological damage in earthworm guts, and transfer of polybrominated diphenyl ethers (PBDEs) to earthworms
- Other studies report no effects or only demonstrate negative impacts at concentrations beyond environmentally relevant levels
- Microplastics accumulative effect and persistence in soils would happen due to successive sludge application, it is evident from the current literature that the potential impacts of microplastics to soil biota are not yet clear

(Cont;d) Impact of microplastics release into soil

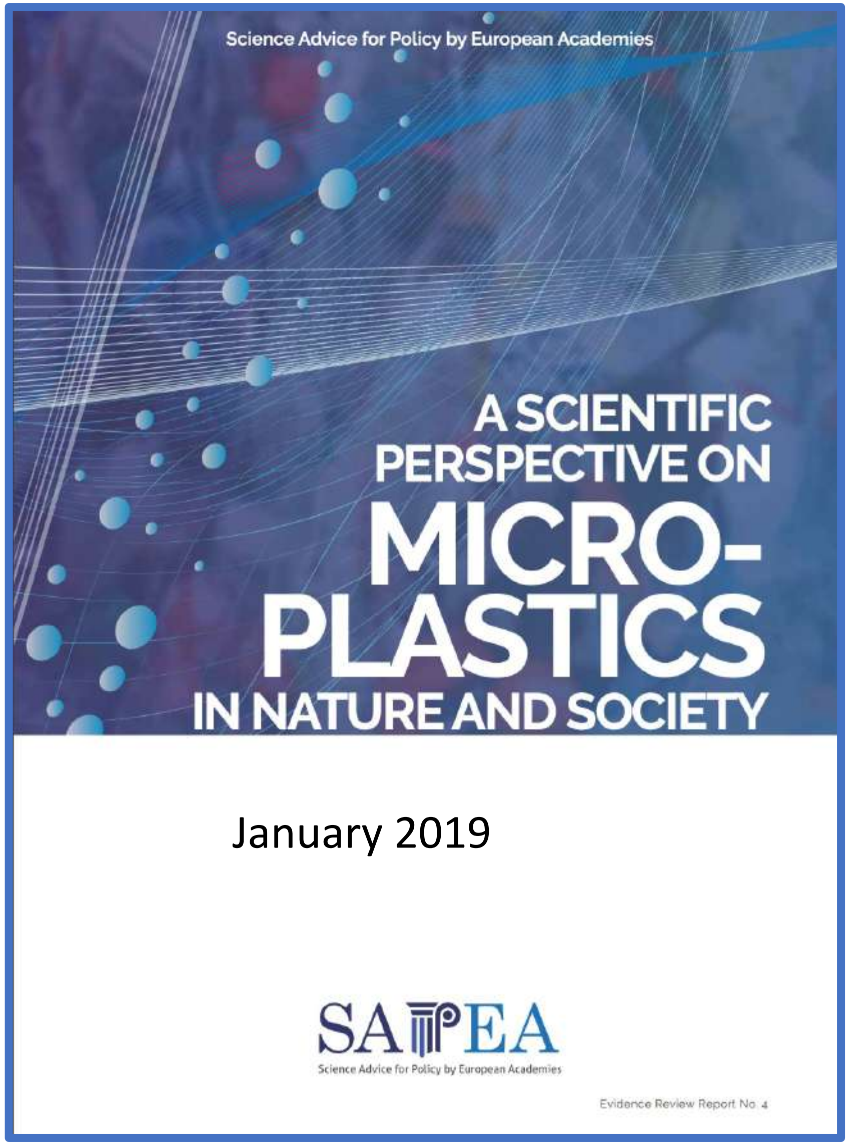
- Several studies have demonstrated that microplastics can act as a vector for contaminants, such as metals or persistent organic pollutants (POPs). Microplastics may become contaminated due to sorption to the particle surface or development of a biofouling layer. Once released, microplastics from sludge may carry these contaminants into different environmental compartments.
- microplastics have been described as ‘reservoirs’ for antibiotic resistance in the marine environment. So, the role of microplastic particles must be appropriately evaluated against a range of conditions.

4. Five Important Reports and Studies

4.1 Science Advice for Policy by European Academies, 2019

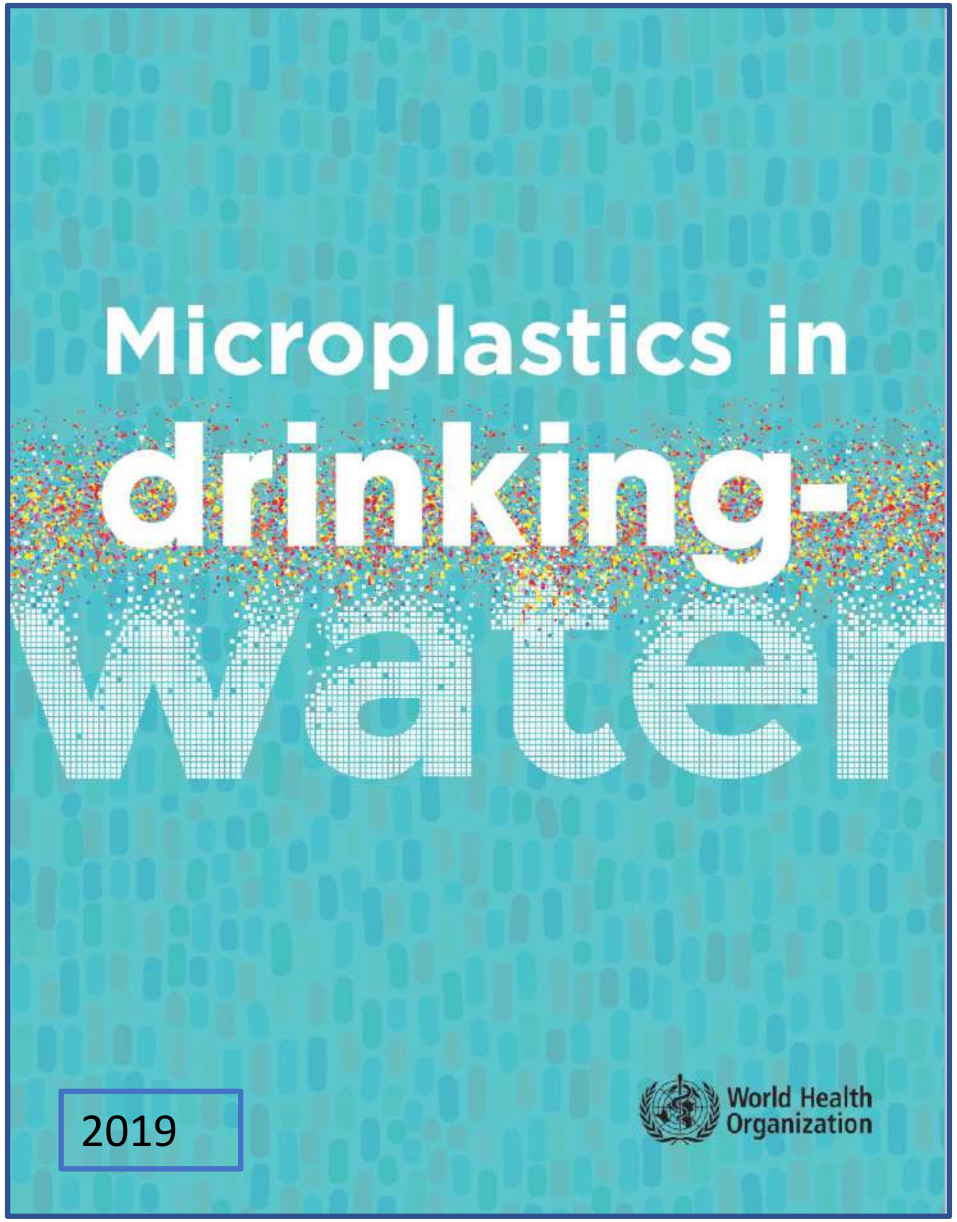
The Science Advice for Policy by European Academics (SAPEA) wrote in a recent report for the European Commission “the best available evidence suggests that microplastics and nano plastics do not pose a widespread risk to humans or the environment, except in small pockets”

However, SAPEA also hints at knowledge gaps and the risk that the situation could change if current release levels would not be reduced



4.2 World Health Organization (WHO), August 2019

<u>The WHO report does not conclude that microplastics are safe</u>. However, it does acknowledge that there are significant uncertainties related to the quality and breadth of available data pertaining to human exposure to microplastics in drinking-water and that our knowledge regarding both exposure and toxicological effects require the acquisition of more robust 'evidence'.



(Cont;d) World Health Organization (WHO), August 2019

"The human health risk from microplastics in drinking-water is a function of both hazard and exposure. Potential hazards associated with microplastics come in three forms: the particles themselves which present a physical hazard, chemicals (unbound monomers, additives, and sorbed chemicals from the environment), and microorganisms that may attach and colonize on microplastics, known as biofilms. <u>Based on the limited evidence available, chemicals and microbial pathogens associated with microplastics in drinking-water pose a low concern for human health</u>. Although there is insufficient information to draw firm conclusions on the toxicity of nanoparticles, <u>no reliable information suggests it is a concern".</u>

(Cont;d) World Health Organization (WHO), August 2019 -Research Gaps:

- The need to better understand microplastics occurrence throughout the water supply chain, using quality-assured methods to determine the numbers, sizes, composition and sources of microplastics and to better characterize the effectiveness of water treatment
- The development and application of quality-assured toxicological data on the most common forms of plastic particles relevant to human health risk assessment
- Improved understanding of the uptake and fate of both micro- and nano-plastic following ingestion
- More robust data on exposure to both micro- and nano-plastic from all exposure pathways, including inhalation, food and beverages and an overall better assessment of exposure to microplastics from the broader environment

(Cont;d) World Health Organization (WHO), August 2019 - Recommendations:

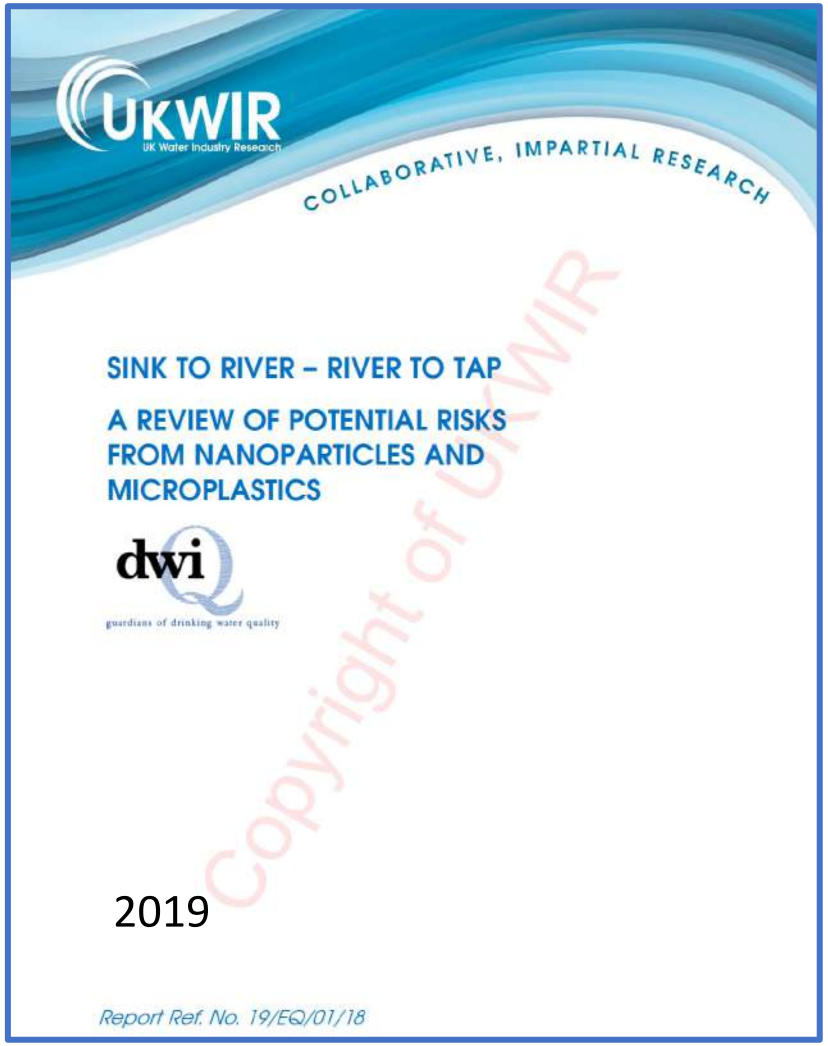
"Routine monitoring of microplastics in drinking-water is not recommended at this time, as there is no evidence to indicate a human health concern. Concerns over microplastics in drinking-water should not divert resources of water suppliers and regulators from removing *microbial pathogens*, which remains the most significant risk to human health from drinking-water along with other chemical priorities. As part of water safety planning, water suppliers should ensure that control measures are effective and should optimize water treatment processes for particle removal and microbial safety, which will incidentally improve the removal of microplastic particles."

4.3 UK Water Industry Research Limited, 2019

- The results of the project found that for WATER, >99.99% of microplastic particles are removed through the treatment processes, with raw water having an average of 4.9 microplastic particles/l and potable water having on average 0.00011 microplastic particles/l

- For WASTEWATER, the treatment processes were able to remove 99.9% of the microplastic particles with levels of 5.1 microplastic particles/l being found in final effluent

- For SLUDGE, microplastic particles are present in sludge, with levels of 2,000 - 4,000 particles/g dry weight of sludge being typically found.


UKWIR
UK Water Industry Research
COLLABORATIVE, IMPARTIAL RESEARCH

SINK TO RIVER – RIVER TO TAP

A REVIEW OF POTENTIAL RISKS FROM NANOPARTICLES AND MICROPLASTICS

dwi
guardians of drinking water quality

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2019

Report Ref. No. 19/EQ/01/18

Sample size: samples were taken from eight water treatment works (WTW) and eight wastewater treatment works (WwTW) from different companies across Great Britain

4.4 IWA Publishing 2019. Microplastics in Water and Wastewater
Editors: Hrissi K. Karapanagioti and Ioannis K. Kalavrouziotis

Chapter 12

Possible effects of microplastics on human health

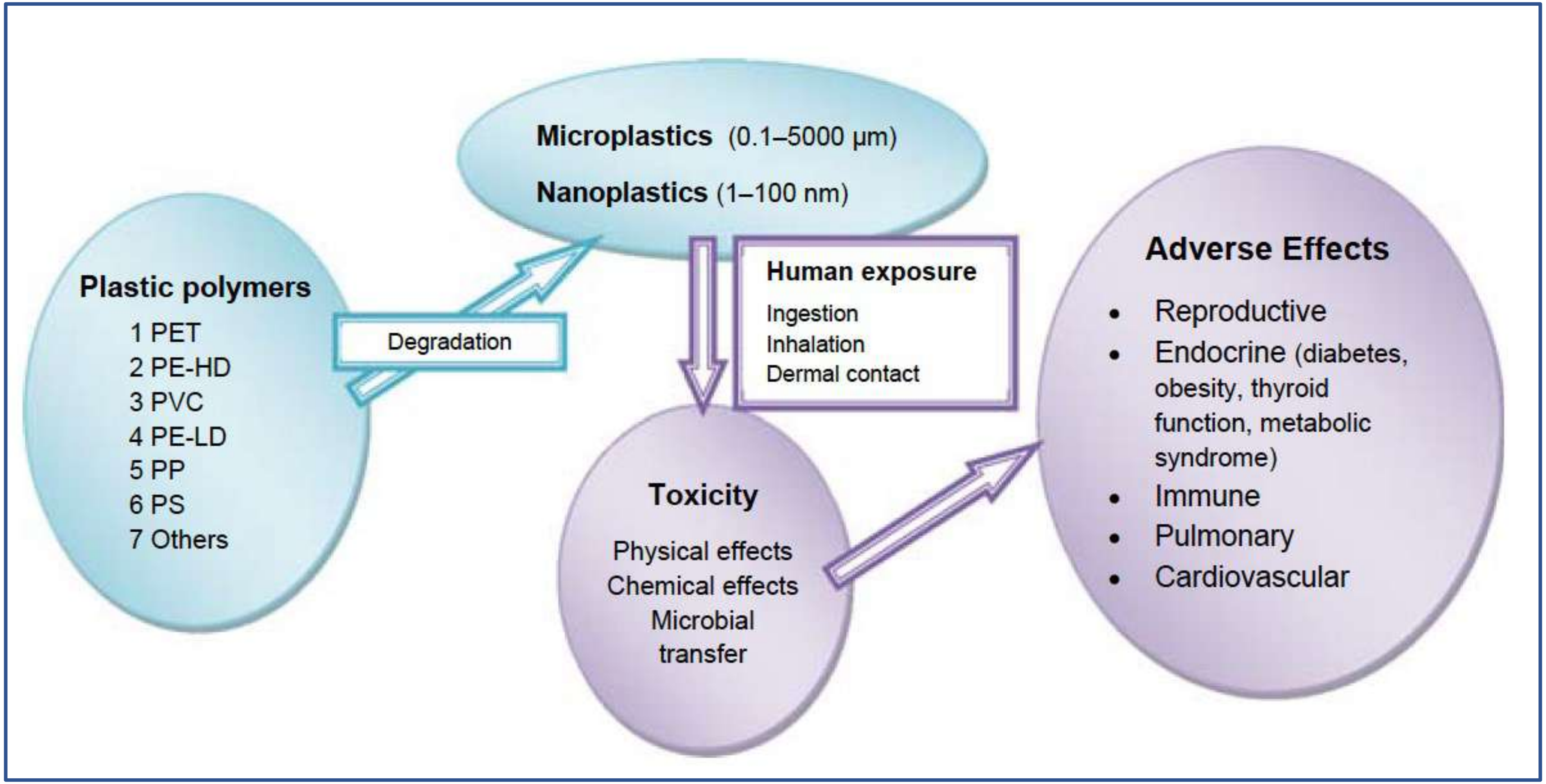
E. Sazakli and M. Leotsinidis

University of Patras, Lab of Public Health, Medical School, Patras, Greece

Keywords: Bisphenol A, Effects, Health impact, Nanoplastics, Particles, Phthalates, Toxicity

The beginning is a horrifying story

Flowchart showing the possible health effects of plastics on humans



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Then, it ends with this

12.3 CONCLUSIONS

Micro- and nanoplastics attack almost every single tissue, organ, organism and, eventually, the whole biosphere. For the impact of microplastics on human health, there are still many questions pending. At the same time, increased public awareness leads occasionally to exaggerated reactions not actually based on scientific findings. To avoid response bias, risk assessment models must be employed and results should be communicated to the general public by experts in the field (Kontrick, 2018). The expertise of medical toxicologists will contribute to efficient future actions. In addition, focus should be directed towards creating sustainable means of production, use and disposal of plastic materials.

4.5 Critical Review, 2019

Water Research 155 (2019) 410–422

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Review

Microplastics in freshwaters and drinking water: Critical review and assessment of data quality

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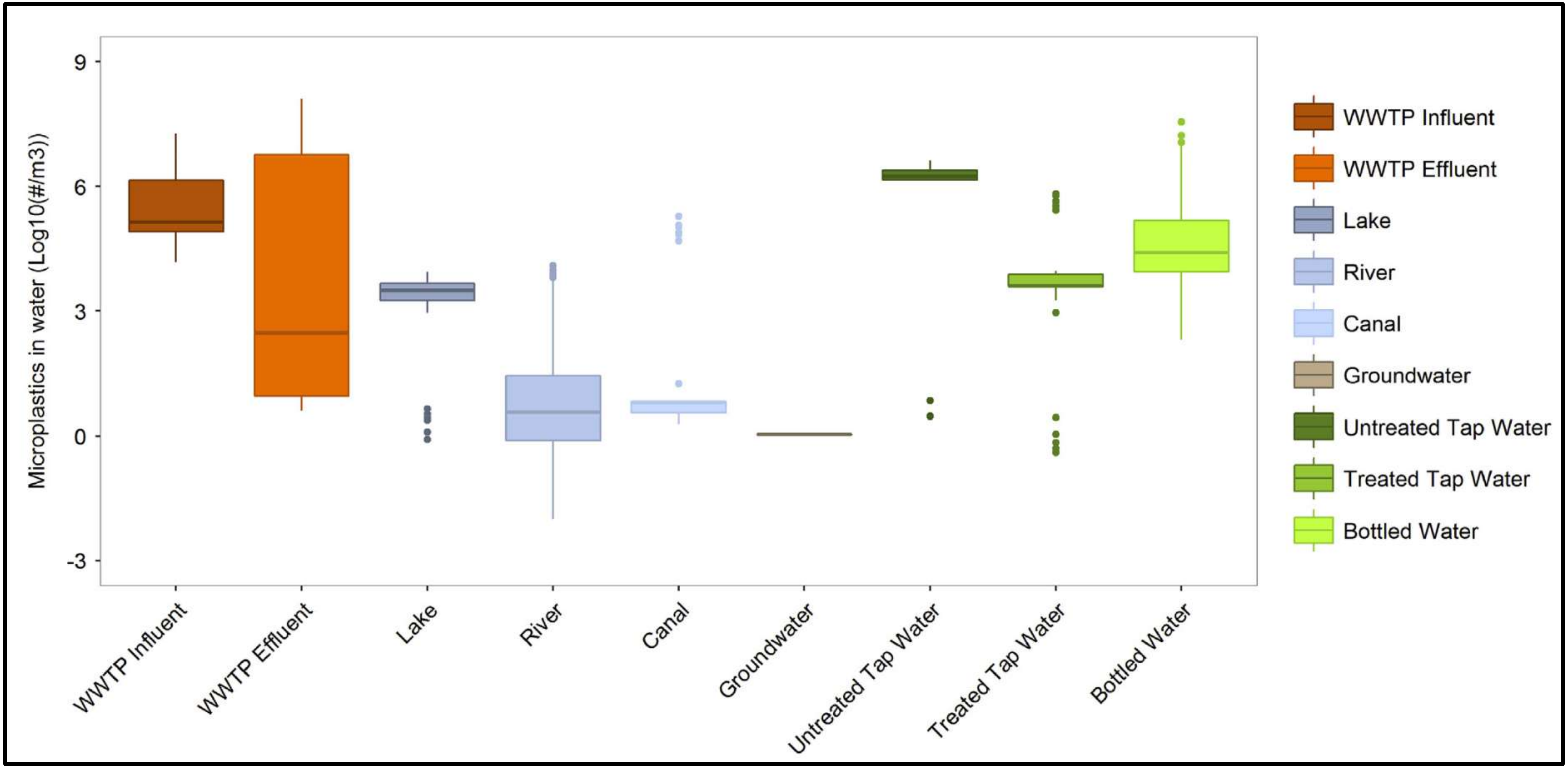


Box and whisker plot showing median and variation in microplastic number concentrations in individual samples taken from different water types. Data relate to individual samples unless only means were reported, in which case the mean value was taken into account n times, with n being the number of samples which the mean was based on.

5. Need for a Monitoring Study in the Egyptian Water Industry

- I recommend to build the capacity for monitoring microplastics in the water cycle in Egypt (to start with a baseline study)
- The HCWW central labs can develop a plan for conducting an ongoing monitoring study
- Accurate monitoring would require advanced instrumentation (usually 2 types) such as:
  1)Raman micro-spectroscopy,
  2) Fourier transform infrared spectroscopy (FTIR)
  3)Focal plane array-based reflection FTIR
  4)Combining atomic force microscopy and infrared spectroscopy,
  5)Field flow fractionation

The Plastic Nile: First Evidence of Microplastic Contamination in Fish from the Nile River (Cairo, Egypt), Farhan R Khan et al

ABSTRACT:

The presence of microplastics (MPs) in the world's longest river, the Nile River, has yet to be reported. This small-scale study aimed to provide the first information about MPs in the Nile River by sampling the digestive tracts of two fish species, the Nile tilapia (*Oreochromis niloticus*, *n* = 29) and catfish (*Bagrus bayad*, *n* = 14). Fish were purchased from local sellers in Cairo, and then their gastrointestinal tracts were dissected and examined for MPs. Over 75% of the fish sampled contained MPs in their digestive tract (MP prevalence of 75.9% and 78.6% for Nile tilapia and catfish, respectively). The most abundant MP type was fibers (65%), the next most abundant type was films (26.5%), and the remaining MPs were fragments. Polyethylene (PE), polyethylene terephthalate (PET) and polypropylene (PP) were all non-destructively identified by attenuated total reflectance Fourier transform infrared spectroscopy. A comparison with similar studies from marine and freshwater environments shows that this high level of MP ingestion is rarely found and that fish sampled from the Nile River in Cairo are potentially among the most in danger of consuming MPs worldwide. Further research needs to be conducted, but, in order to mitigate microplastic pollution in the Nile River, we must act now.

Source: Toxics 2020 Mar 25;8(2):22

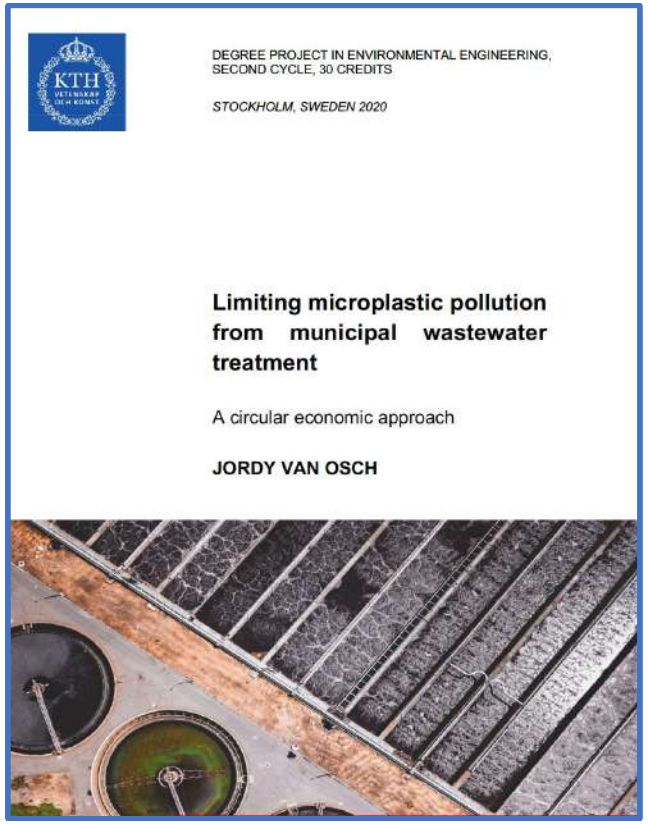
6. Conclusions

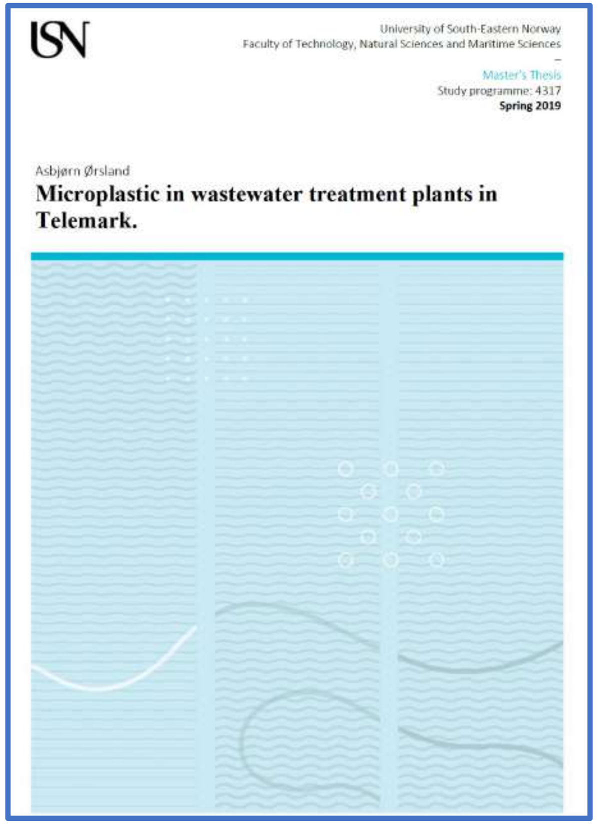
- Microplastics are man-made particles found in the environment and that can make their way to surface waters which may be used for drinking water production. Evidence of microplastics in water for human consumption is sporadic and not systematically based on recognized analytical methods
- There is no evidence that microplastics at current concentration levels do pose a risk to human health BUT this does not mean that it is safe!
- The wastewater treatment infrastructure, including sewerage pipes, combined sewer overflows (CSOs) and effluents from wastewater treatment plants (WWTPs), is a pathway for microplastics to the aquatic environment. Several studies point at CSOs as one of the most common pathways for microplastics to enter the aquatic environment

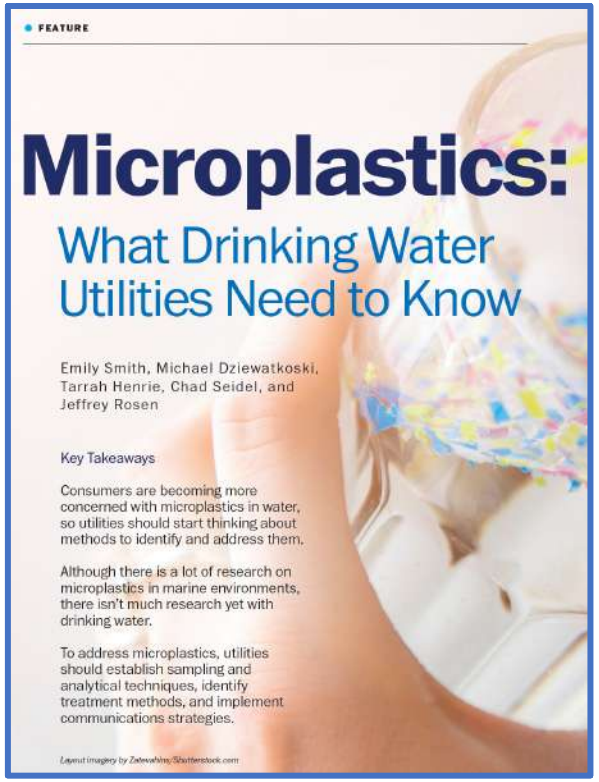
(Cont;d) Conclusions

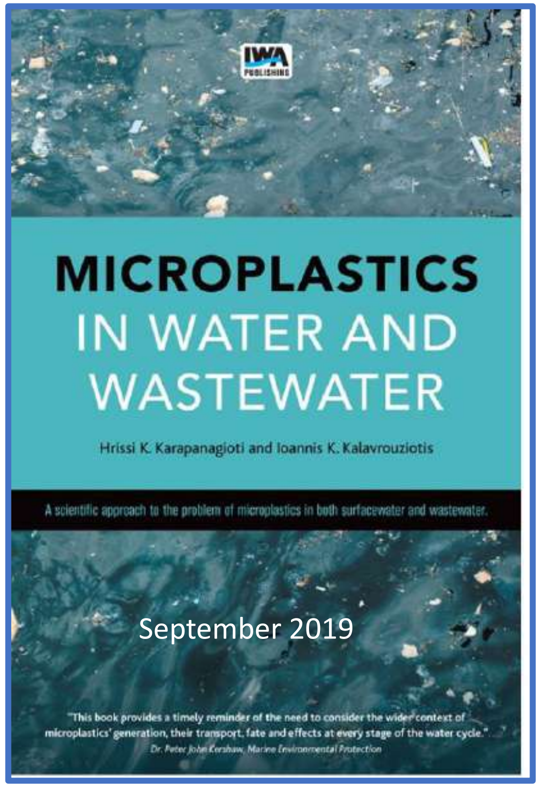
- Only a minor share of the total microplastics released from various sources enter wastewater infrastructure. Conventional WWTPs can efficiently remove up to 80-95% of microplastics, mostly in the preliminary and primary treatment steps. Part of the microplastics found in soil can be attributed to the use of sludge as an organic fertilizer, but other sources, such as air deposition and mineral fertilizers, seem to be equally important
- Requiring additional action at the WWTPs would therefore offer very limited benefits but come at a high cost
- Control at source measures are both more sustainable and effective. They bring direct benefits for the water sector through fewer microplastics in drinking water resources, wastewater and sludge and other residual products

For Further Reading









What is known

What is partially known

What is unknown

We don’t know that we don’t know!