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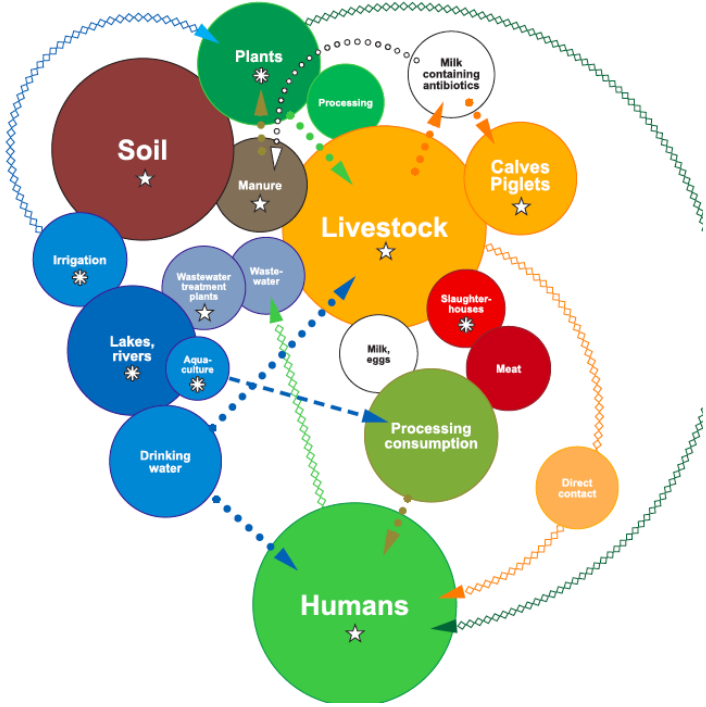
Unit for Environmental Sciences and Management

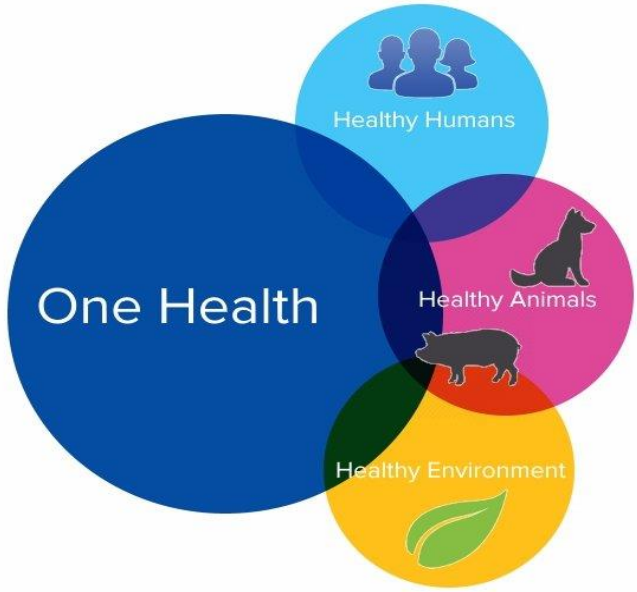
Microplastics and pharmaceuticals as drivers for antimicrobial resistance in the environment

Carlos Bezuidenhout

Session 13 12 September 2019

Why are we concerned about antimicrobial resistance drivers in the environment?





Huijbers et al. 2015. *Environ. Sci Techn*. 49, 11993-12004

WE NEED AND USE ANTIMICROBIAL SUBSTANCES!

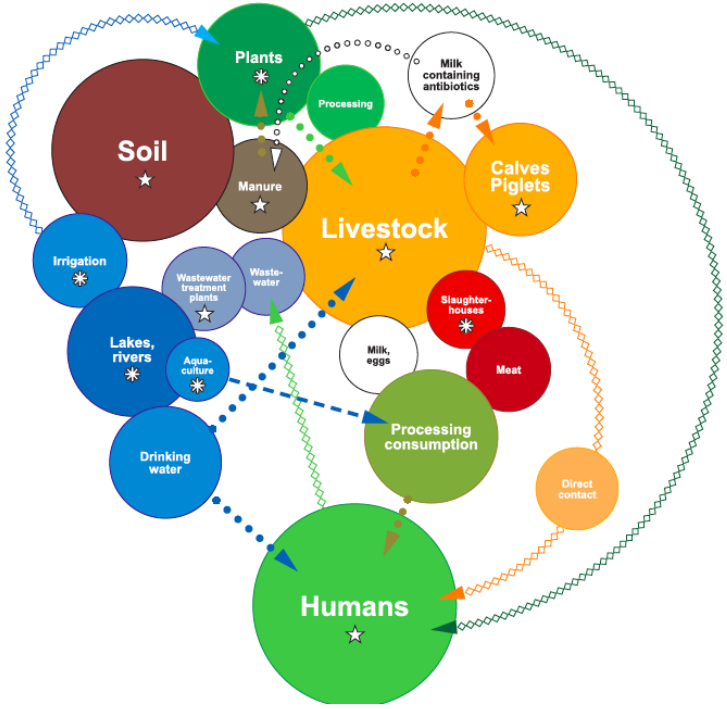
https://pxhere.com/en/photo/566564

https://commons.wikimedia.org/wiki/File:Canesten.jpg

https://www.nejm.org/doi/full/10.1056/NEJMp1714916

We use Antiseptics, disinfectants, other pharmaceuticals

A portion stay in the environment and come back to us!



Huijbers et al. 2015. *Environ. Sci Techn*. 49, 11993-12004

The role of aquatic ecosystems as reservoirs of antibiotic resistant bacteria and antibiotic resistance genes

P.T. Biyela*, J. Lin and C.C. Bezuidenhout*****

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** Dept of Microbiology, School of Biochemistry and Microbiology, University of Durban Westville, P/Bag X54001, Durban, South Africa

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Abstract The widespread and indiscriminate use of antibiotics has led to the development of antibiotic resistance in pathogenic, as well as commensal, microorganisms. Resistance genes may be horizontally or vertically transferred between bacterial communities in the environment. The recipient bacterial communities may then act as a reservoir of these resistance genes. In this study, we report the incidence of antibiotic resistance in enteric bacteria isolated from the Mhlathuze River and the distribution of genetic elements that may be responsible for the observed antibiotic resistance. The resistance of the enteric bacteria isolated over a period of one year showed that resistance to the older classes of antibiotics was high (94.7% resistance to one antibiotic and 80.8% resistance to two antibiotics). Furthermore, antibiotic resistance data of the environmental isolates showed a strong correlation ($r = 0.97$) with data obtained from diarrhoea patients. PCR based methods demonstrated that class 1 integrons were present in >50% of the environmental bacterial isolates that were resistant to multiple antibiotics. This class of integrons is capable of transferring genes responsible for resistance to β-lactam, aminoglycoside, sulfonamide and quaternary ammonium antimicrobial agents. Conjugate plasmids were also isolated, but from a small percentage of isolates. This study showed that the Mhlathuze River (a) is a medium for the spread of bacterial antibiotic resistance genes, (b) acts as a reservoir for these genes and (c) due to socio-economic pressures, may play a role in the development and evolution of these genes along this river system.

Keywords Antibiotics; enterobacteriaceae; integrons; resistance genes

Water Science and Technology Vol 50 No 1 pp 45–50 © IWA Publishing 2004

Environ Monit Assess (2015) 187: 652
DOI 10.1007/s10661-015-4879-6

High prevalence of multiple-antibiotic-resistant (MAR) *Escherichia coli* in river bed sediments of the Apies River, South Africa

Akebe Luther King Abia · Eunice Ubomba-Jaswa · Maggy Ndombo Benteke Momba

International Journal of *Environmental Research and Public Health*

MDPI

Article

Antibiotic-Resistant Pathogenic *Escherichia Coli* Isolated from Rooftop Rainwater-Harvesting Tanks in the Eastern Cape, South Africa

Mokaba Shirley Malema [1,*], Akebe Luther King Abia [2], Roman Tandlich [3], Bonga Zuma [3], Jean-Marc Mwenge Kahinda [1] and Eunice Ubomba-Jaswa [4,5]

Are these AR bacteria a threat to human health?

1817 © IWA Publishing 2016 Water Science & Technology | 73.8 | 2016

Virulence determinants and production of extracellular enzymes in *Enterococcus* spp. from surface water sources

Lesego Gertrude Molale and Cornelius Carlos Bezuidenhout

1 © IWA Publishing 2014 Journal of Water and Health | in press | 2014

Management:

.za

Antibiotic resistant heterotrophic plate count bacteria and amoeba resistant bacteria in aquifers of the Mooi River, North West province, South Africa

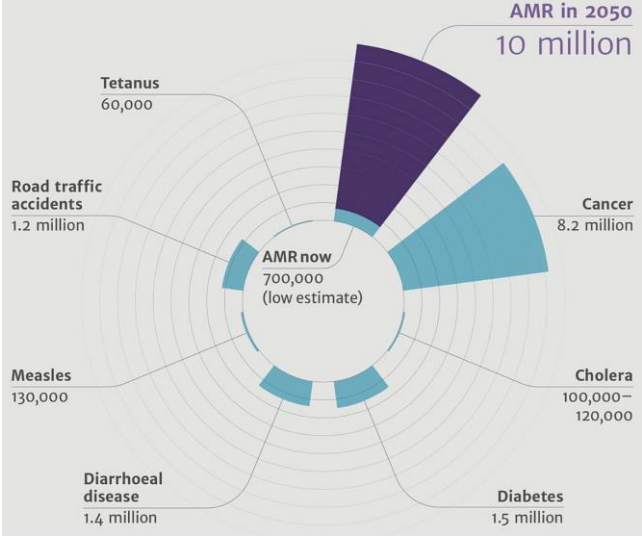
Alewyn Carstens, Catheleen Bartie, Rainier Dennis and Carlos Bezuidenhout

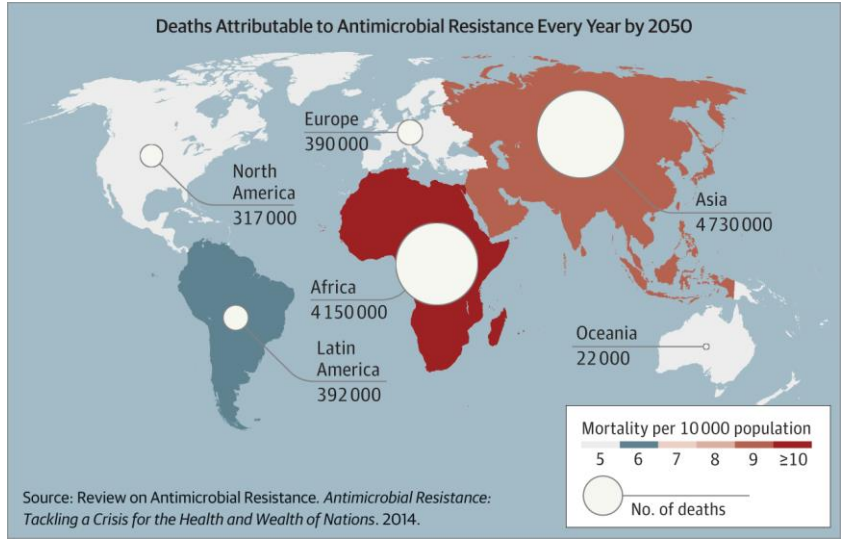
890 © IWA Publishing 2016 Journal of Water and Health | 14.6 | 2016

Pathogenic features of heterotrophic plate count bacteria from drinking-water boreholes

Suranie Horn, Rialet Pieters and Carlos Bezuidenhout

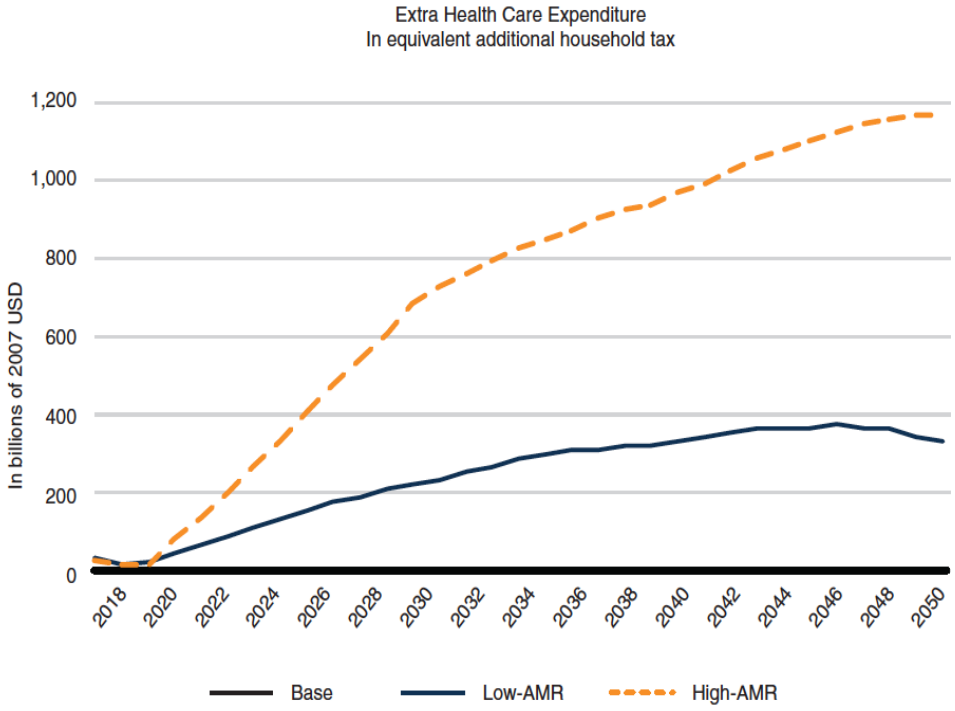
Antimicrobial Resistance (AMR) in Africa - Disaster looming





Source: https://www.wikitribune.com/article/28091/

AMR treatment - Unaffordable for Africans

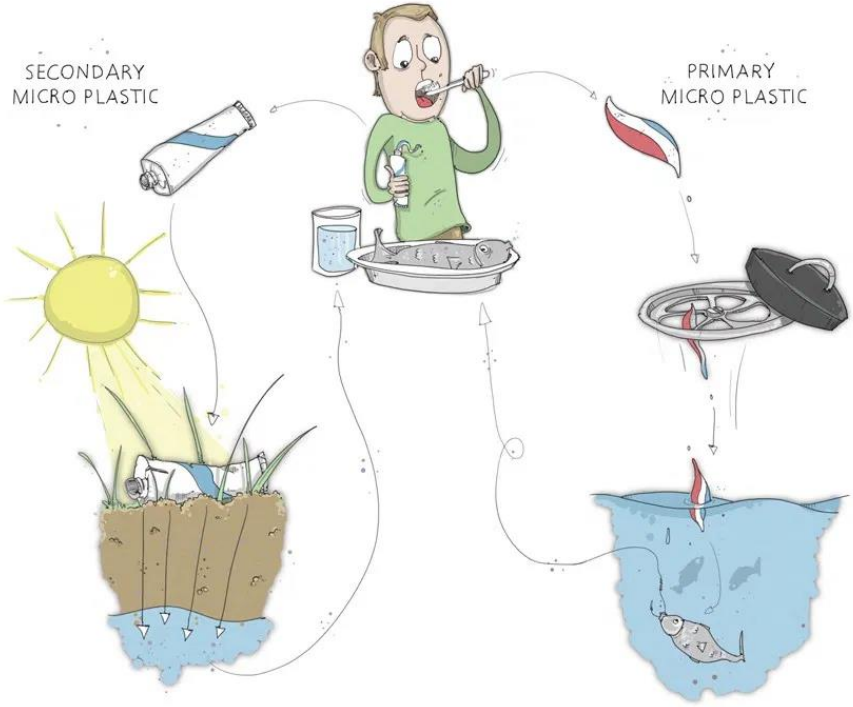


(World Bank, 2016)

Microplastics and pharmaceuticals as drivers for antimicrobial resistance in the environment

What are Micro-plastics?

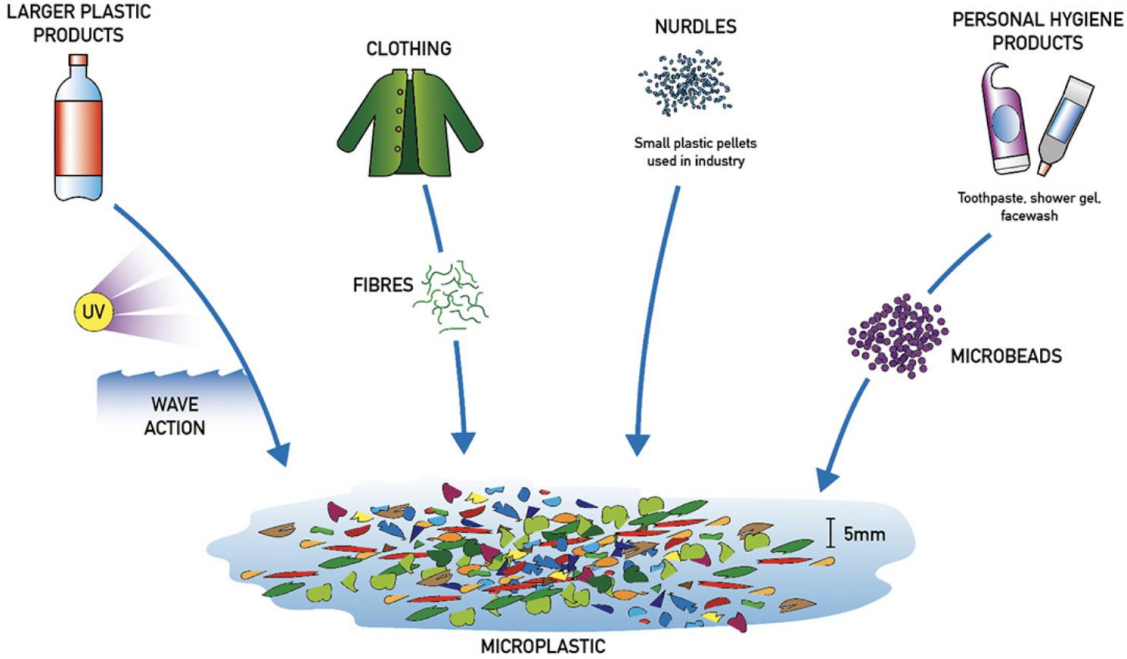
- Plastics <5 – 0.33 mm
- Primary and secondary microplastics



https://i0.wp.com/moocs.southampton.ac.uk/oceans/wp-content/uploads/sites/5/2017/11/1460404090765_140626-biowachspartikelen160px.jpg

Micro-plastics - Sources?

- Break-up (physical and biological)
- Fibres (synthetic textiles)
- Synthetic (abrasives, personal care, etc)



- https://encounteredu.com/discover/images/sources-of-microplastics

Type of plastics and uses

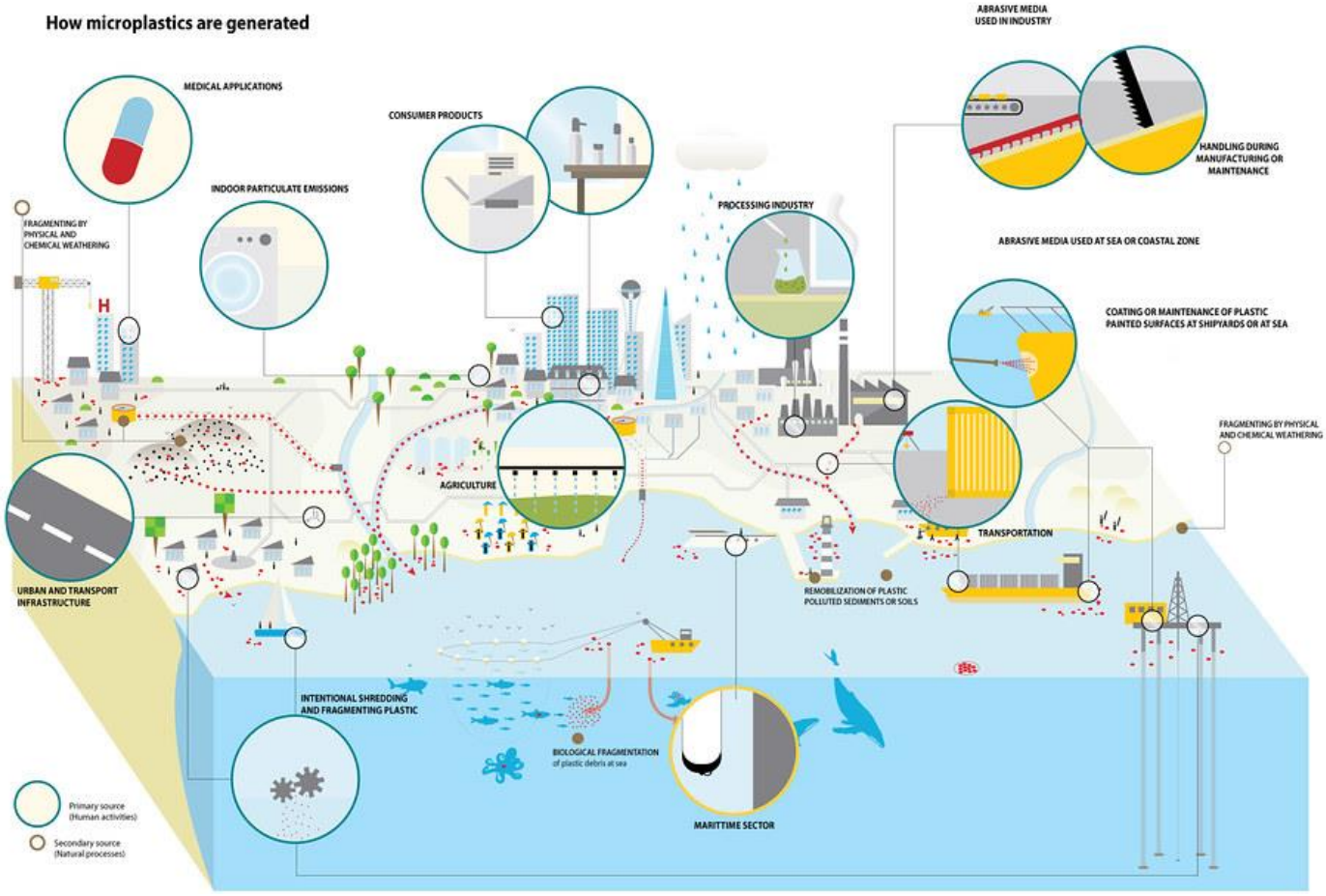
Natural rubber	**Vehicle tyres**
Polyethylene* - low density	Plastic bags, outdoor furniture
Polyethylene* - high density	Bottles, pipes
Polypropylene	Rope, bottle caps, gear, strapping
Polystyrene (expanded)	Cool boxes, floats, cups
Polystyrene	Utensils, containers, microbeads
Polystyrene (high impact)	Shelves, printed graphics
Polyamide (Nylon)	Fishing nets, rope
Polycarbonate (bisphenol-A)	CDs, glass alternative, lenses
Polyurethane	Foams
Metacrylate (acrylic)	Alternative for plate glass
Cellulose acetate	Cigarette filters, fabric fibre
Cellulose nitrate	Printing inks, nail polish, foil
Polyvinyl chloride	Film, pipe, containers
Polylactic acid (biodegradable)	Packaging, cups
Polyethylene terephtelate	Bottles, strapping
Melamine	Flooring, dinnerware, dry boards

Micro-plastics?

- Microplastics <5 mm
- Nano-plastics (<100 nm)

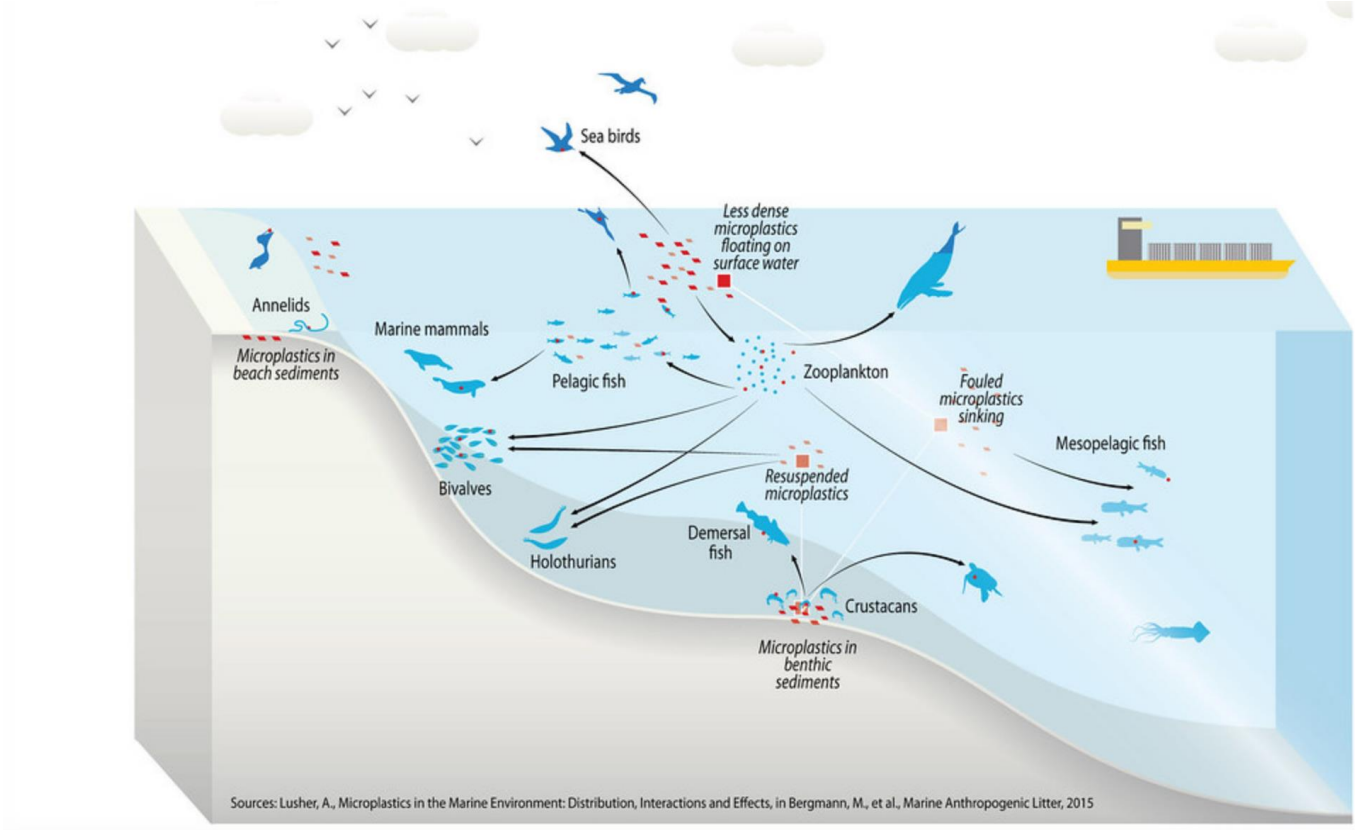
- Durable, buoyant, degrades slowly and persistent,
- Ubiquitous in aquatic (marine and fresh) environment

Microplastics generation is complex

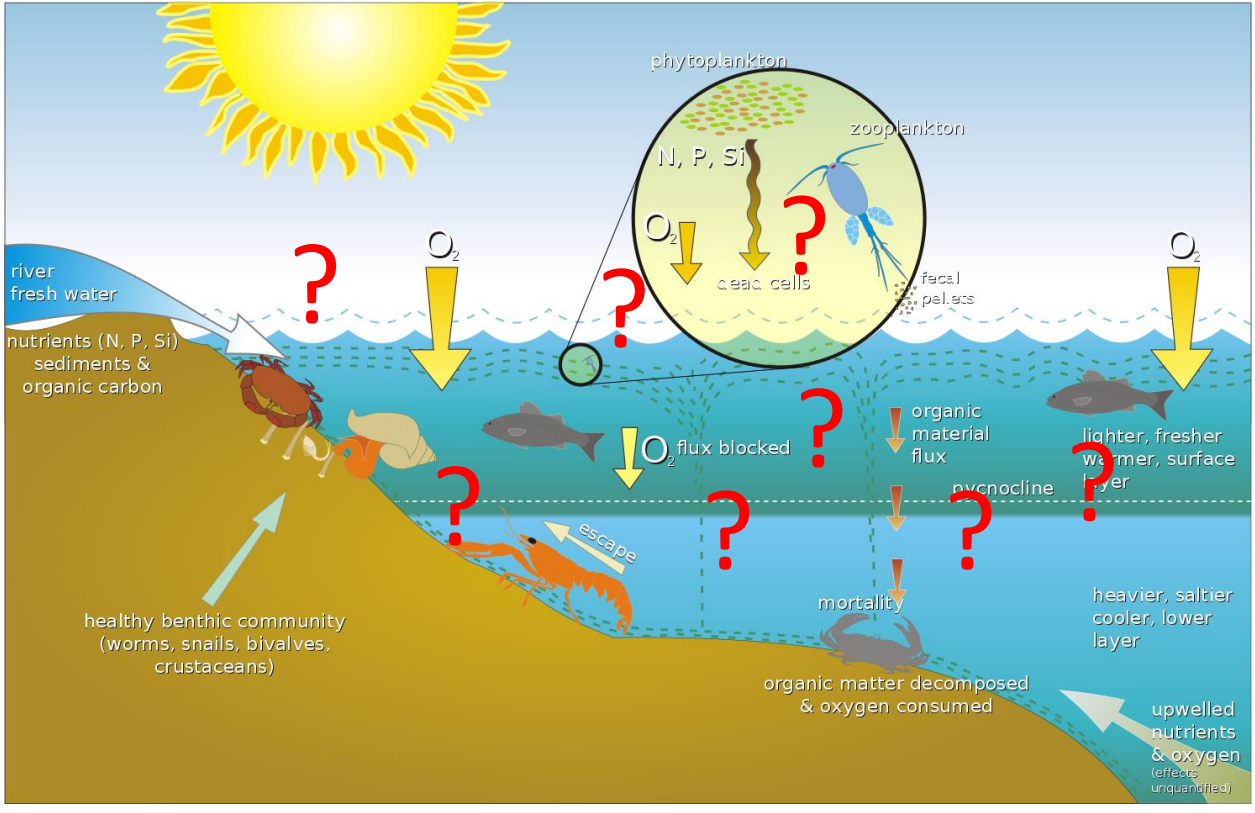


http://www.grida.no/resources/6929

When it enters **OUR** food chain, we listen!!!

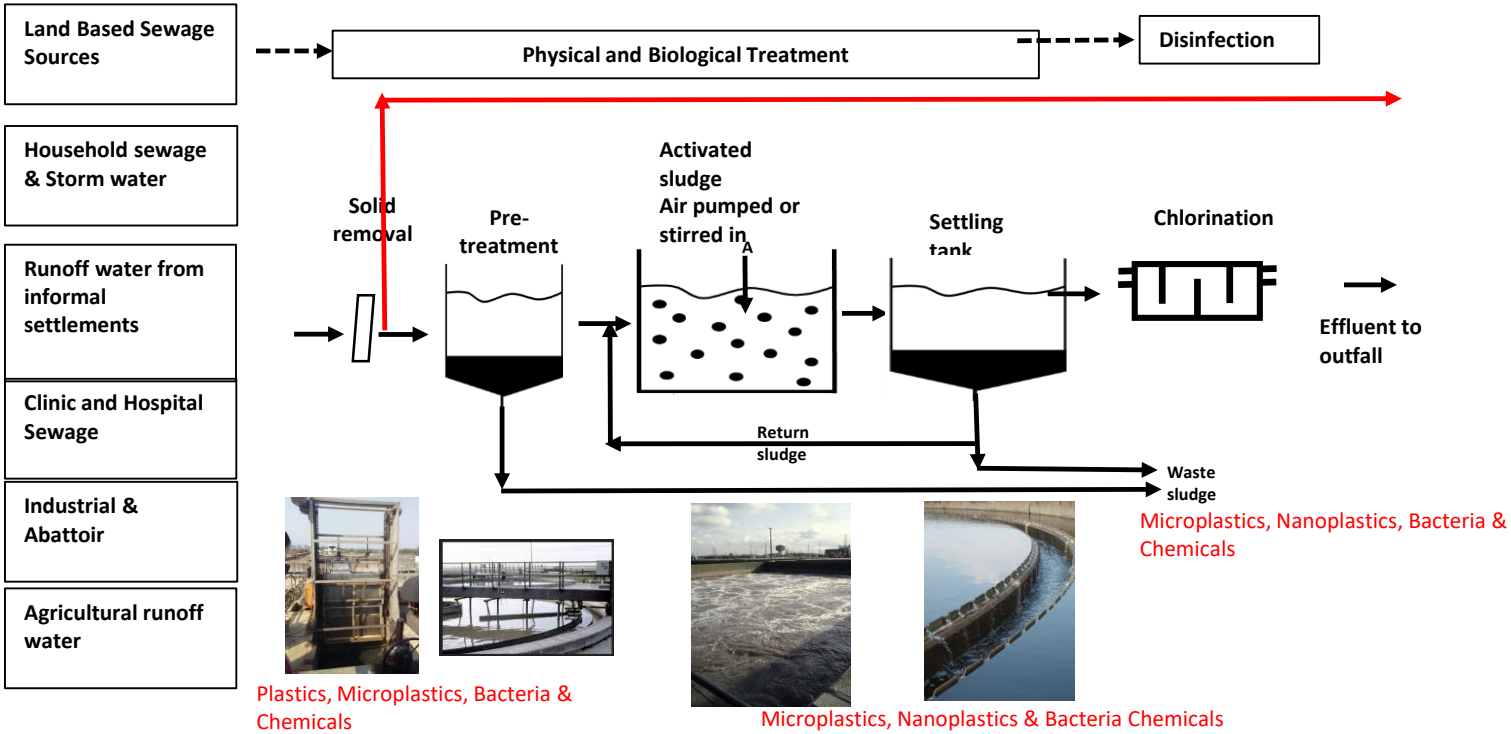


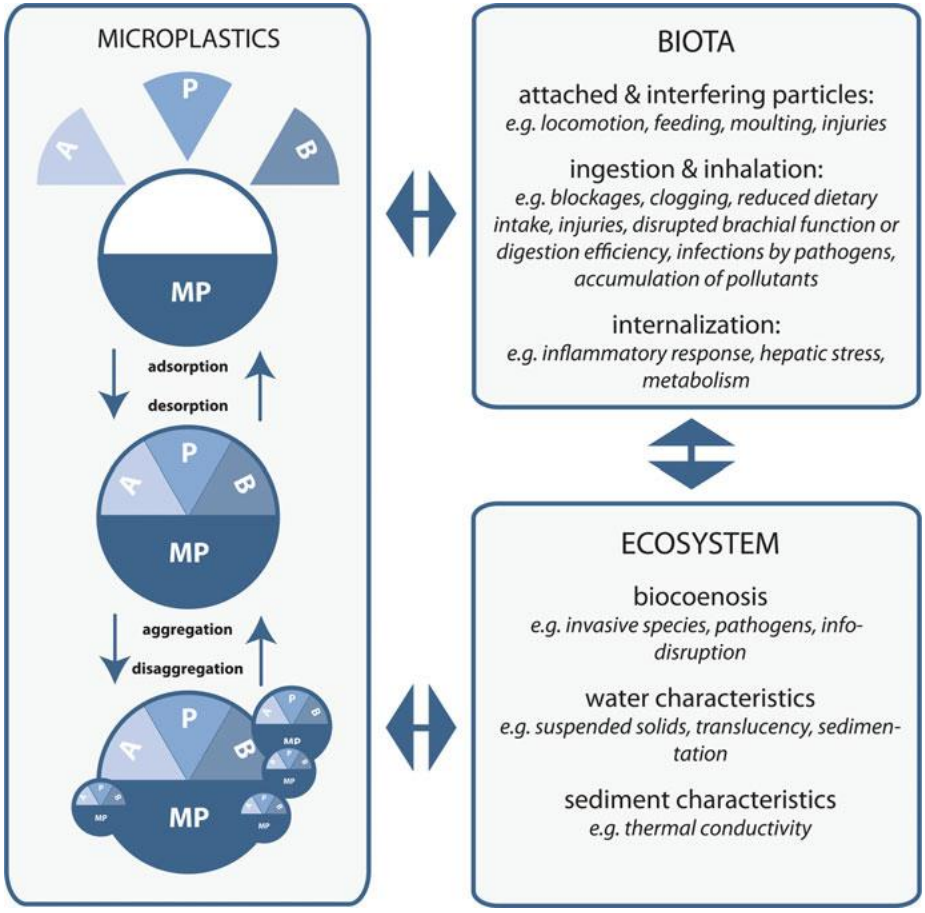
So what happens to the bacteria, chemicals and microplastics in aquatic environments and what are the impacts?



https://en.wikipedia.org/wiki/Marine_pollution#/media/File:Scheme_eutrophication-en.svg

Plastics and antimicrobials substances accumulate/breaks up or down in Waste Water Treatment Plants in urban settings

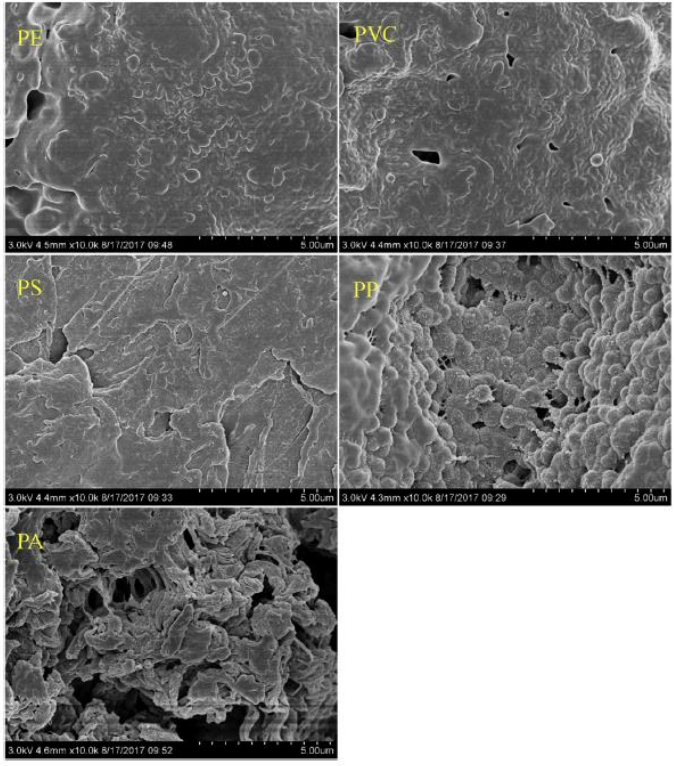



MICROPLASTICS
P
A
B
MP
adsorption
desorption
P
A
B
MP
aggregation
disaggregation
P
A
B
MP
BIOTA
attached & interfering particles:
e.g. locomotion, feeding, moulting, injuries
ingestion & inhalation:
e.g. blockages, clogging, reduced dietary intake, injuries, disrupted brachial function or digestion efficiency, infections by pathogens, accumulation of pollutants
internalization:
e.g. inflammatory response, hepatic stress, metabolism
ECOSYSTEM
biocoenosis
e.g. invasive species, pathogens, info-disruption
water characteristics
e.g. suspended solids, translucency, sedimen-tation
sediment characteristics
e.g. thermal conductivity

Environmental Pollution 237 (2018) 460–467

Contents lists available at ScienceDirect

Environmental Pollution



5 types of microplastics and 5 types of antibiotics
Adsorption varied among antibiotics, plastic types and environmental conditions

Chemosphere 215 (2019) 846–857

Contents lists available at ScienceDirect

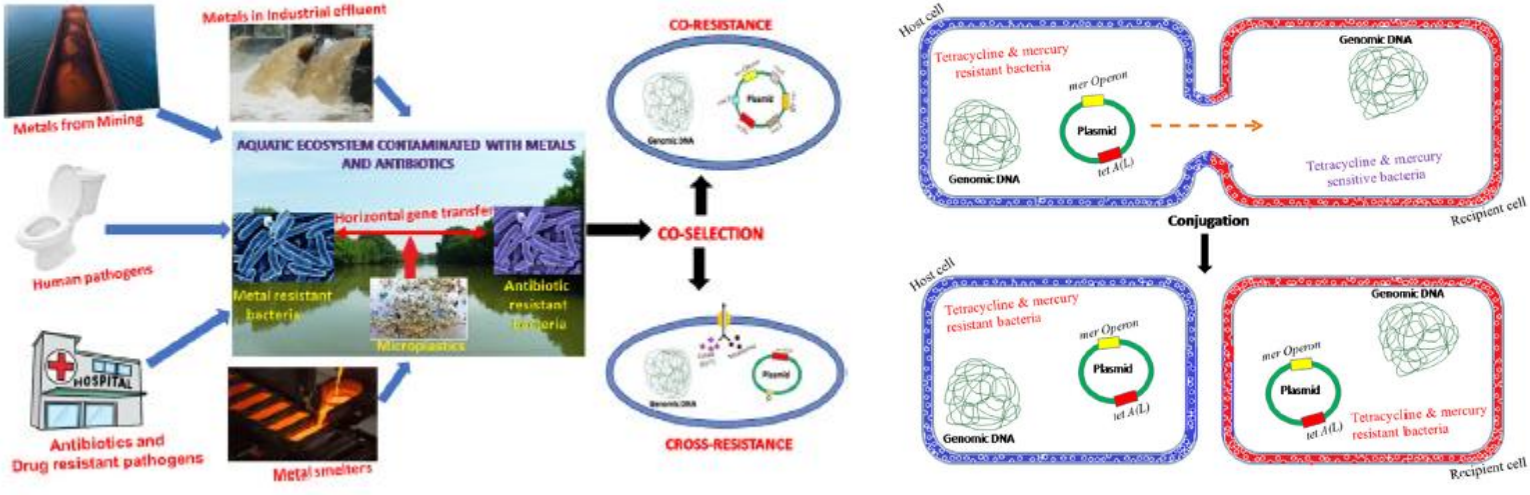
Chemosphere

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

Review

Co-selection of multi-antibiotic resistance in bacterial pathogens in metal and microplastic contaminated environments: An emerging

GRAPHICAL ABSTRACT



International Journal of Hygiene and Environmental Health 222 (2019) 89–100

Contents lists available at ScienceDirect

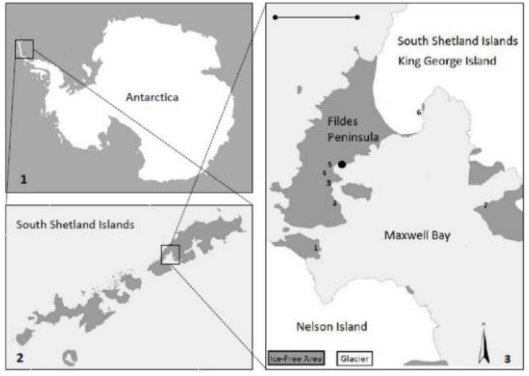
International Journal of Hygiene and Environmental Health

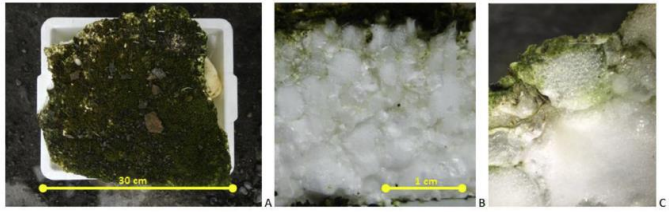
journal homepage: www.elsevier.com/locate/ijheh

Do plastics serve as a possible vector for the spread of antibiotic resistance? First insights from bacteria associated to a polystyrene piece from King George Island (Antarctica)

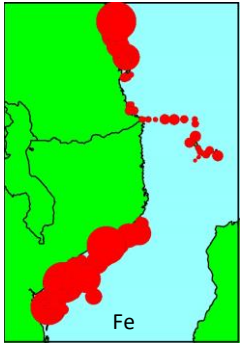
Pasqualina Laganà[a,1], Gabriella Caruso[b,*,1], Ilaria Corsi[c], Elisa Bergami[c], Valentina Venuti[d], Domenico Majolino[d], Rosabruna La Ferla[b], Maurizio Azzaro[b], Simone Cappello[b]

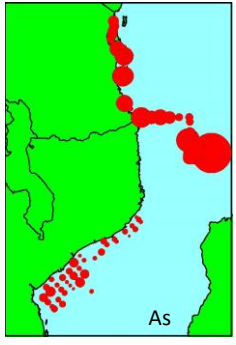
[a] Dept. of Biochemical and Dental Sciences and of the Morphological and Functional Images, University of Messina, Messina, Italy
[b] Institute for Coastal Marine Environment (IAMC), National Research Council (CNR), Messina, Italy
[c] Dept. of Physical, Earth and Environmental Sciences, University of Siena, Siena, Italy
[d] Dept. of Mathematical and Computer Sciences, Physical Sciences and Earth Sciences, University of Messina, Messina, Italy



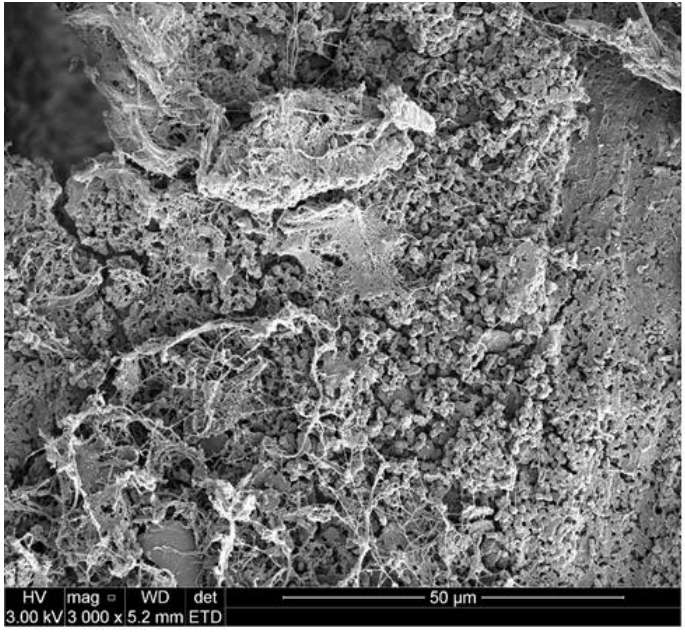


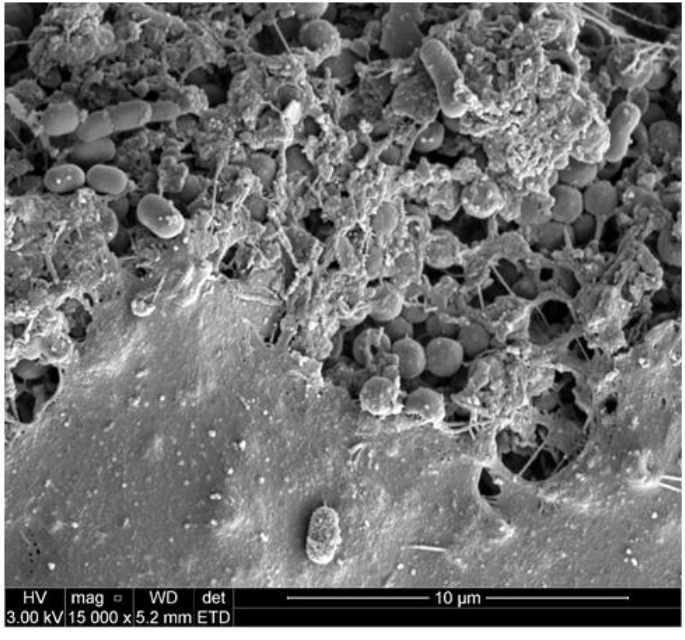
Parallel study SA Agulhas 11 – H Bouwman





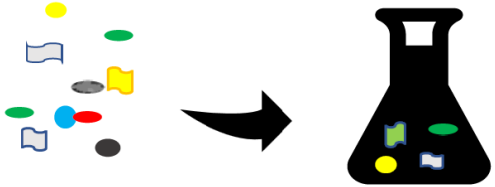
Biofilms on surface of microplastics





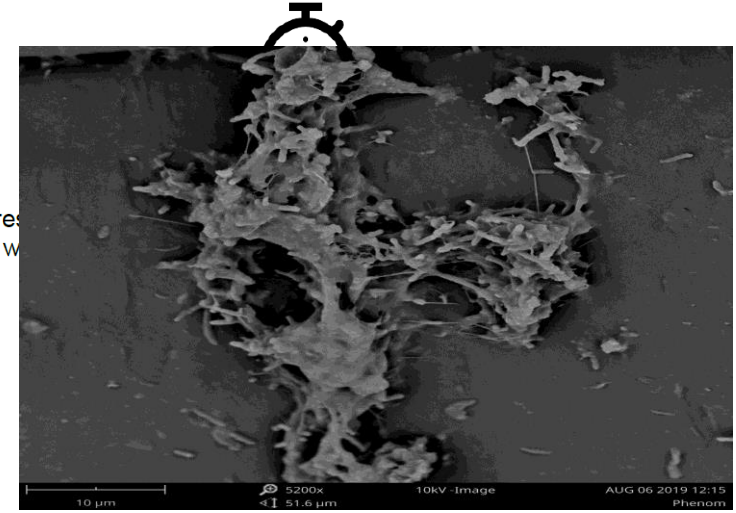
Biofilms on surface of microplastics
MicroPlastResist - SANOCEANS

WWTe will be pre-filtered to remove large solids using a steel mesh



Microplastic particles of sizes 2mm- 5mm (PE, PP, PS)- exposure to UV and Sonication

Incubate in WWTe vs fres
WWTe v/s artificial sea w
Conical flasks



Microorganisms from Microcosm Microplastics

Isolation using selective media

- *E. coli*
  - +60 isolates
  - Many positive for virulence features (produce haemolysin, Dnase, protease, lipase)
  - Analyses underway, antibiotic resistance patterns, molecular identification, ARG detection
- Clostridia
- Yeasts
  - 65 isolates
  - Many positive for virulence features (produce haemolysin, Dnase, protease, lipase)
  - Antifungal resistance patterns – resistance to several antifungals
  - Analyses underway, molecular identification, ARG detection

A SCOPING STUDY ON MICROPLASTICS IN WATER ENVIRONMENTS

Final report to the
WATER RESEARCH COMMISSION

15 January 2018

by

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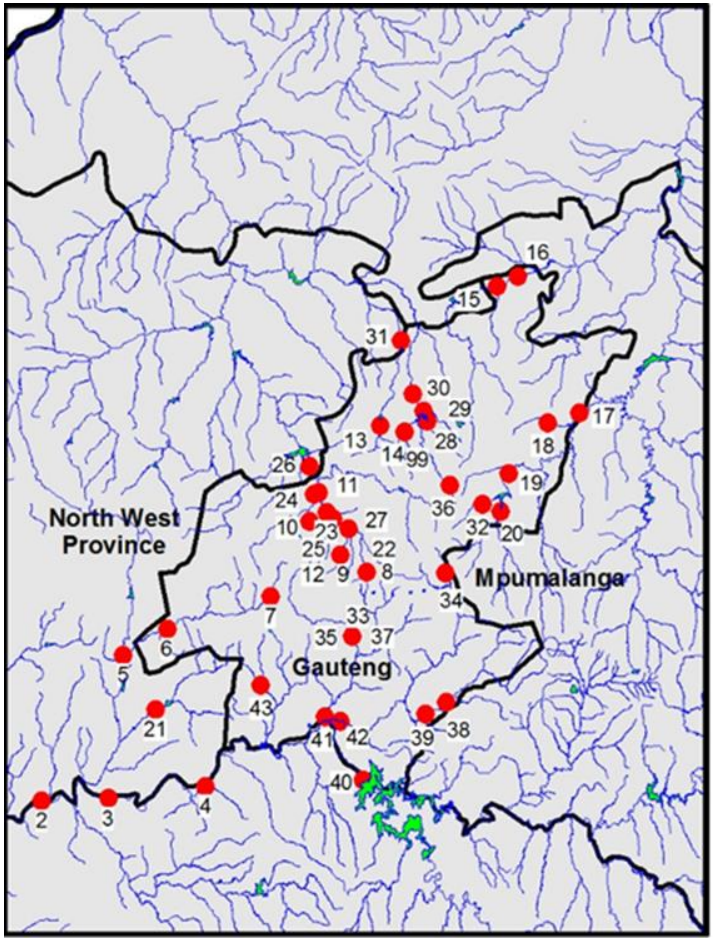
K Minnaar
C Bezuidenhout
C Verster

North-West University

WRC Report No 1004803
ISBN No


North West
Province
Gauteng
Mpumalanga
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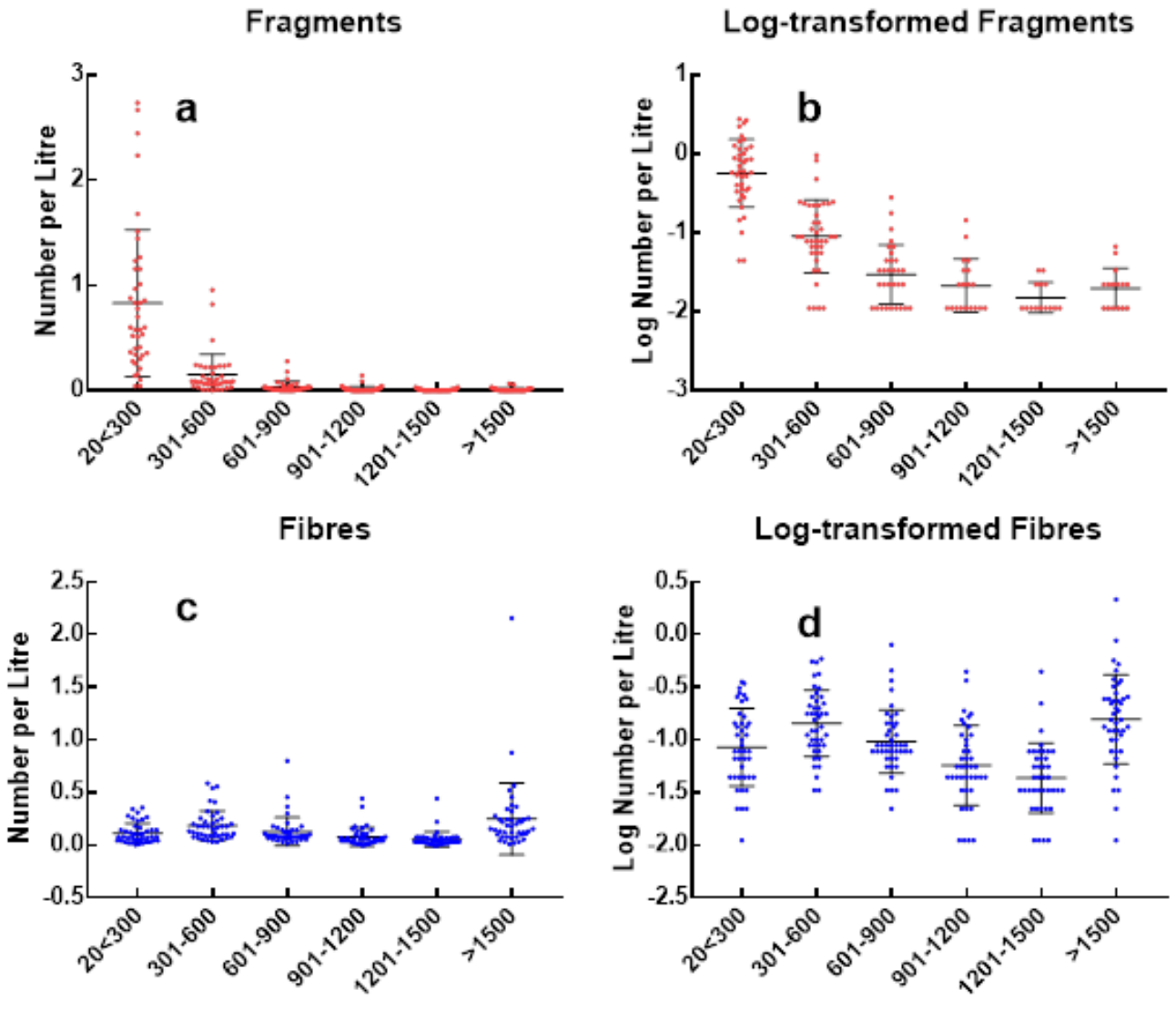
Fragments
a
Number per Litre
3
2
1
0
20<300
301-600
601-900
901-1200
1201-1500
>1500
Log-transformed Fragments
b
Log Number per Litre
1
0
-1
-2
-3
20<300
301-600
601-900
901-1200
1201-1500
>1500
Fibres
c
Number per Litre
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
20<300
301-600
601-900
901-1200
1201-1500
>1500
Log-transformed Fibres
d
Log Number per Litre
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
20<300
301-600
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901-1200
1201-1500
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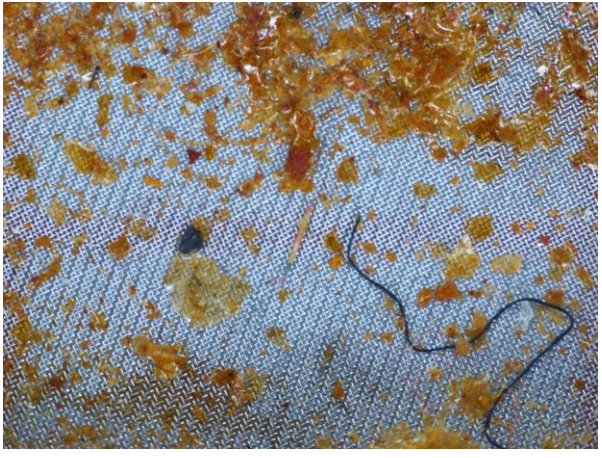
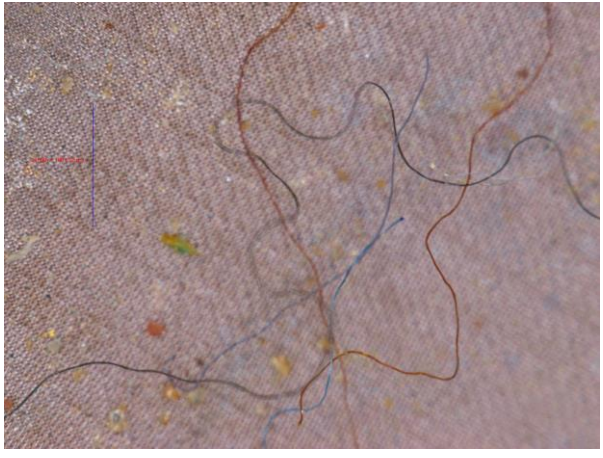
Examples of microplastics from surface water





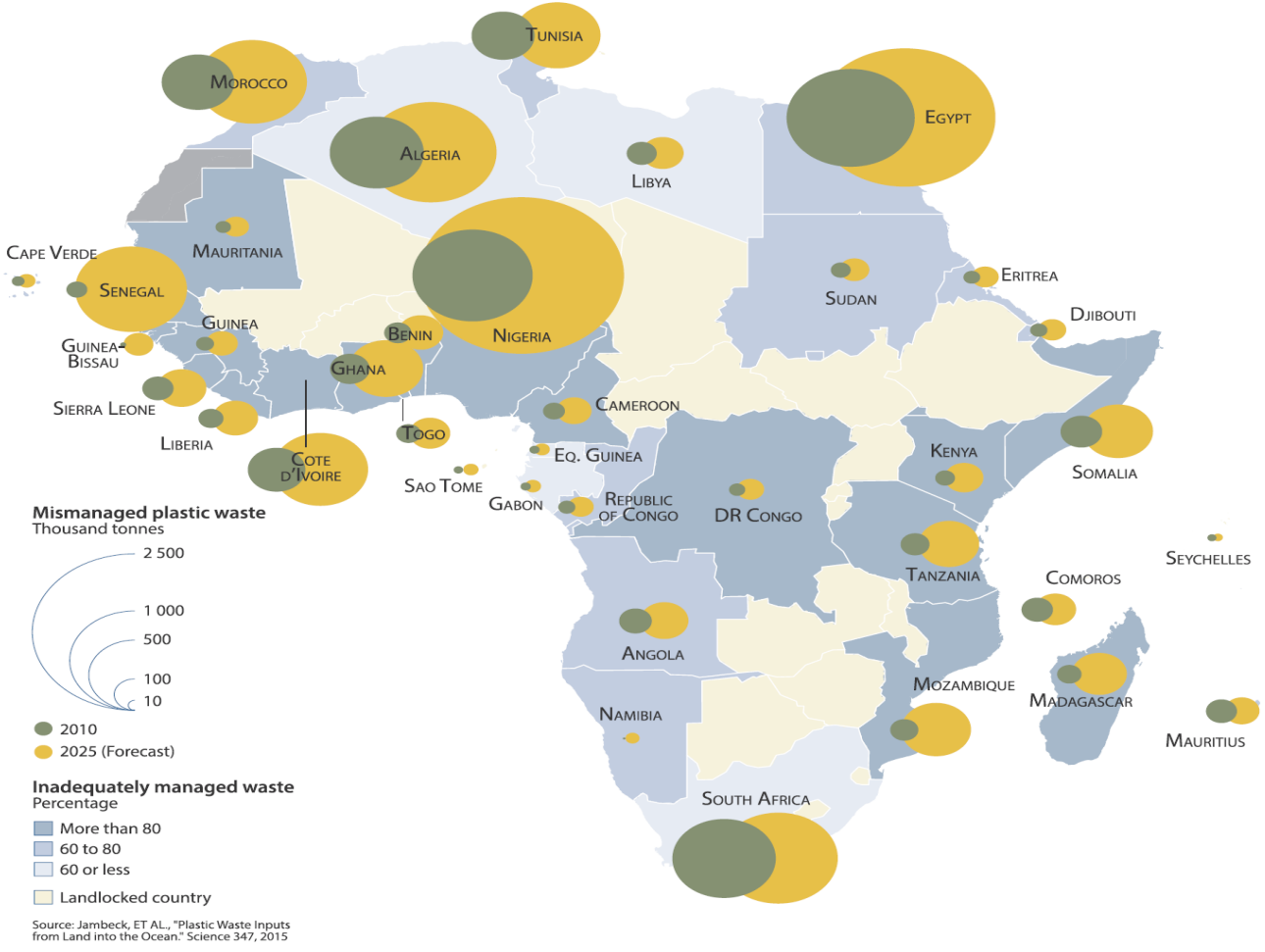
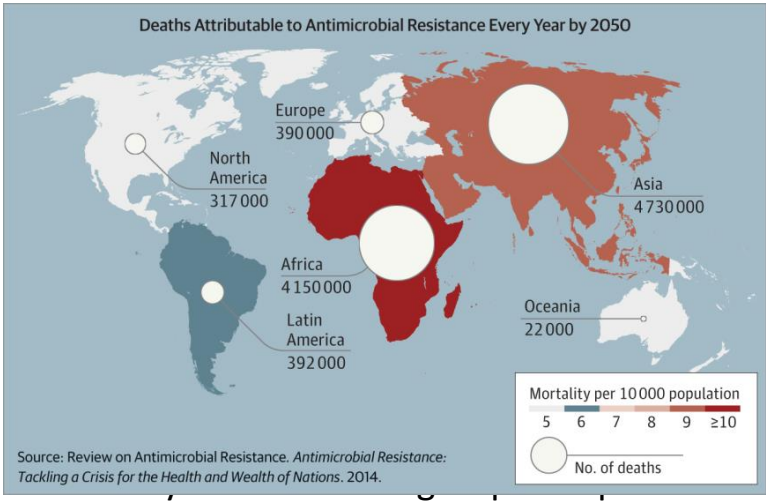
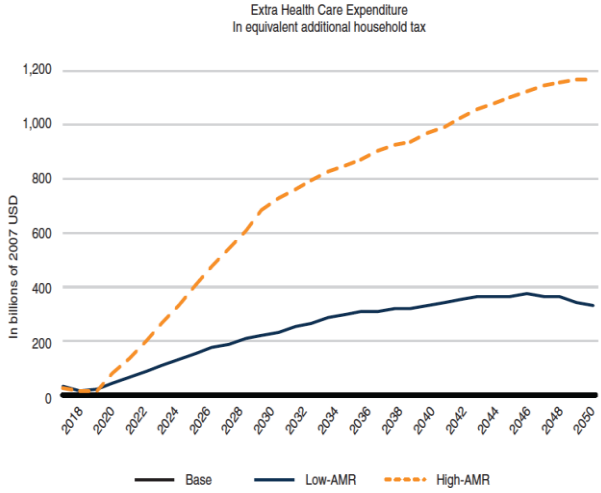


Fig. 3. Mismanaged plastic in Africa in thousands of tonnes as of 2010 (green circles) and projection of waste mismanagement forecast in 2025 given current practices (yellow circles). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

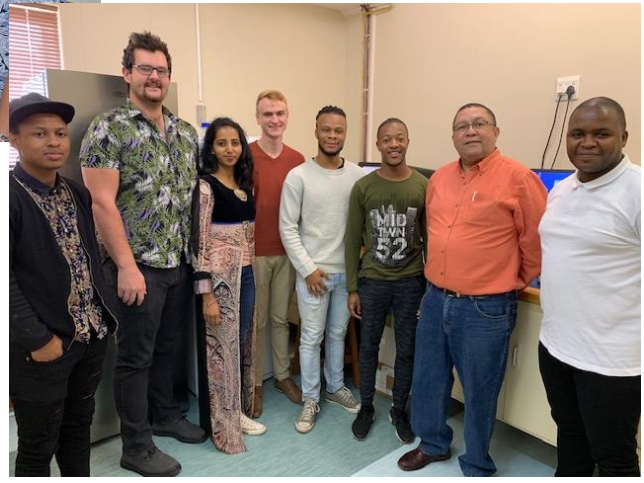
Take home message





- **Finally**
  - **Combinations of Microplastics and Pharmaceuticals in aquatic system could speed-up and accentuate the threat of AMR**
  - **Both are Drivers of AMR**
  - **Interventions are needed**

Acknowledgement to the microbiology microplastics team



Thank you

Dankie

Nkosi

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