Nano-Carriers

Micro and nanoplastics as carriers for the spread of chemicals and antimicrobial resistance in the aquatic environment

A complementary and multi-disciplinary team

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South Africa

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A complementary and multi-disciplinary team

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Anchoring of the project

UN SDG 6
Understanding and reducing pollution and increased safe wastewater reuse (6.3), safeguarding of water resources and aquatic ecosystems (6.6)

UN SDG 3
Good health and well-being, particularly regarding illness and deaths related to hazardous chemicals and environmental pollution and contamination (3.9)

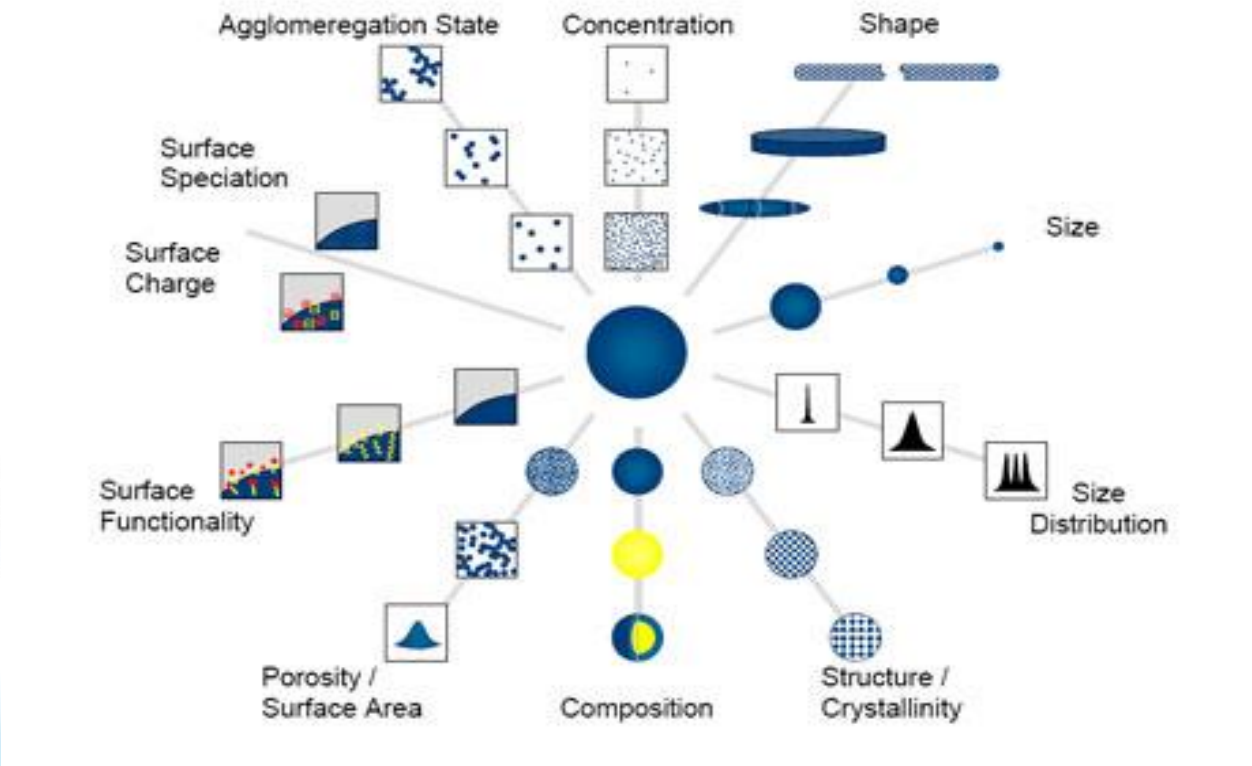
UN SDG 11
Sustainable cities with a target focusing on waste management

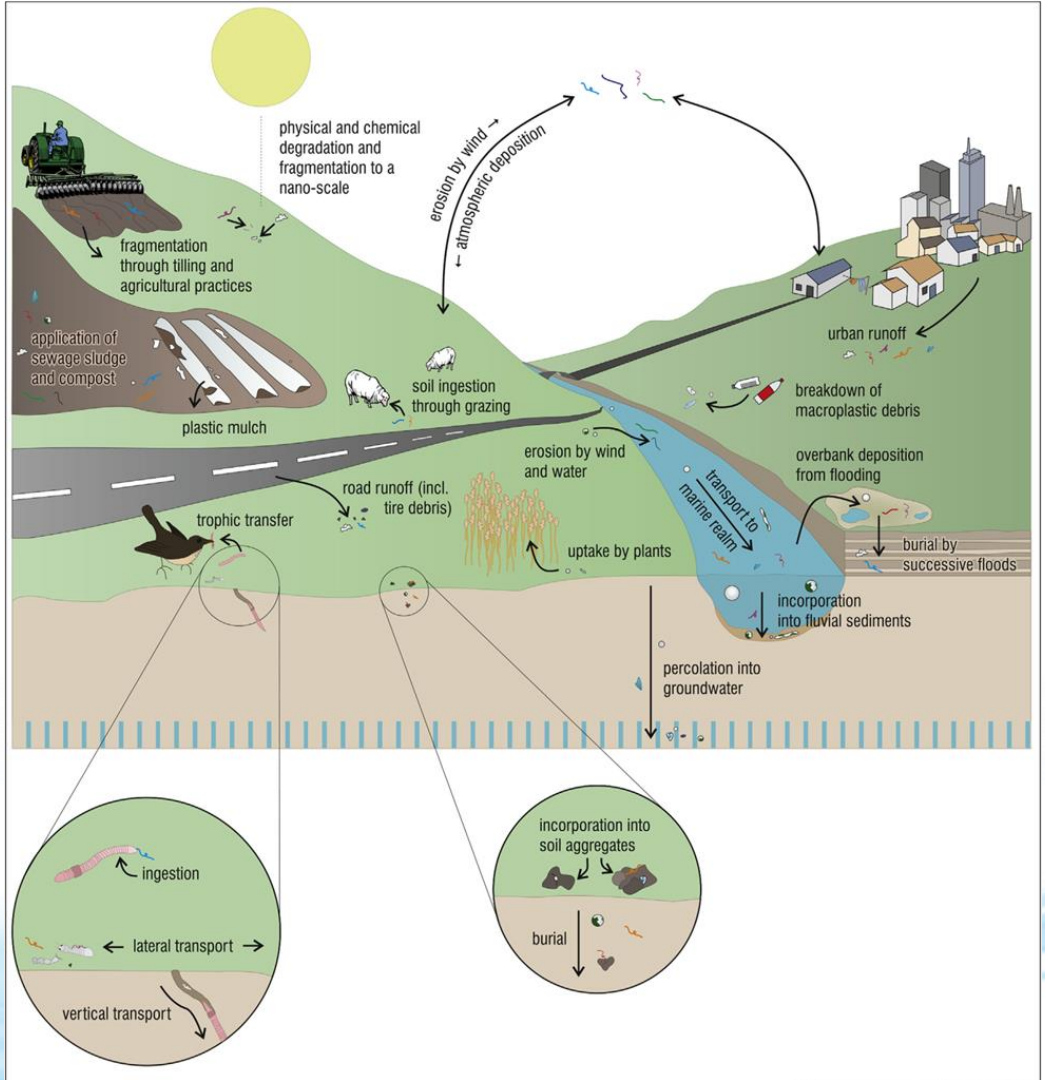
Draft UN resolution on environ. & health (Dec 2017)
Contribution to understanding the role of environmental pollution in the development of ARB, multidrug resistant bacteria also called “superbugs” resulting in increased mortality

Introduction: Context and challenge

- > 300 million tonns of plastic produced worldwide in 2015
- This plastic can reach the aquatic environment in the form of debris of various sizes
- Most efforts have focused so far on plastics at the macro and micro scales
- Nano size plastics however may potentially the most hazardous
- Wastewater treatment effluents may be a significant source of micro and nanoplastics to the aquatic environment

Micro and nanoplastics




physical and chemical degradation and fragmentation to a nano-scale
erosion by wind →
← atmospheric deposition
fragmentation through tilling and agricultural practices
application of sewage sludge and compost
plastic mulch
soil ingestion through grazing
urban runoff
breakdown of macroplastic debris
erosion by wind and water
overbank deposition from flooding
transport to marine realm
road runoff (incl. tire debris)
trophic transfer
uptake by plants
burial by successive floods
incorporation into fluvial sediments
percolation into groundwater
ingestion
lateral transport
vertical transport
incorporation into soil aggregates
burial

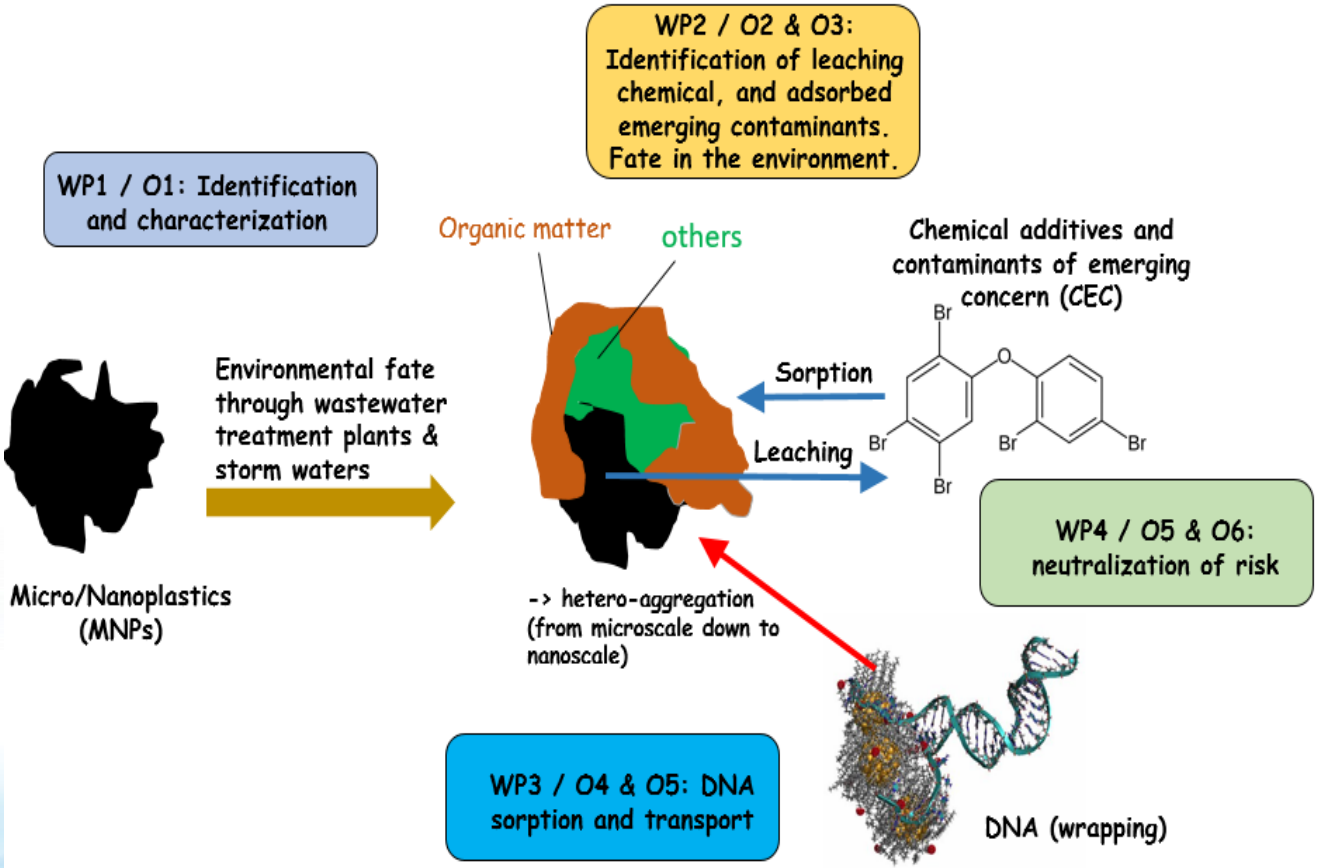
Aim of Nano-Carriers

This project proposes to address two threats related to the potential for these MNPs to act as trojan horse for:

(i) Chemical additives and contaminants of emerging concern (CECs)

(ii) Antibiotic-resistance genes (ARGs) into aquatic ecosystems through wastewater reuse applications.

Project description and WPs

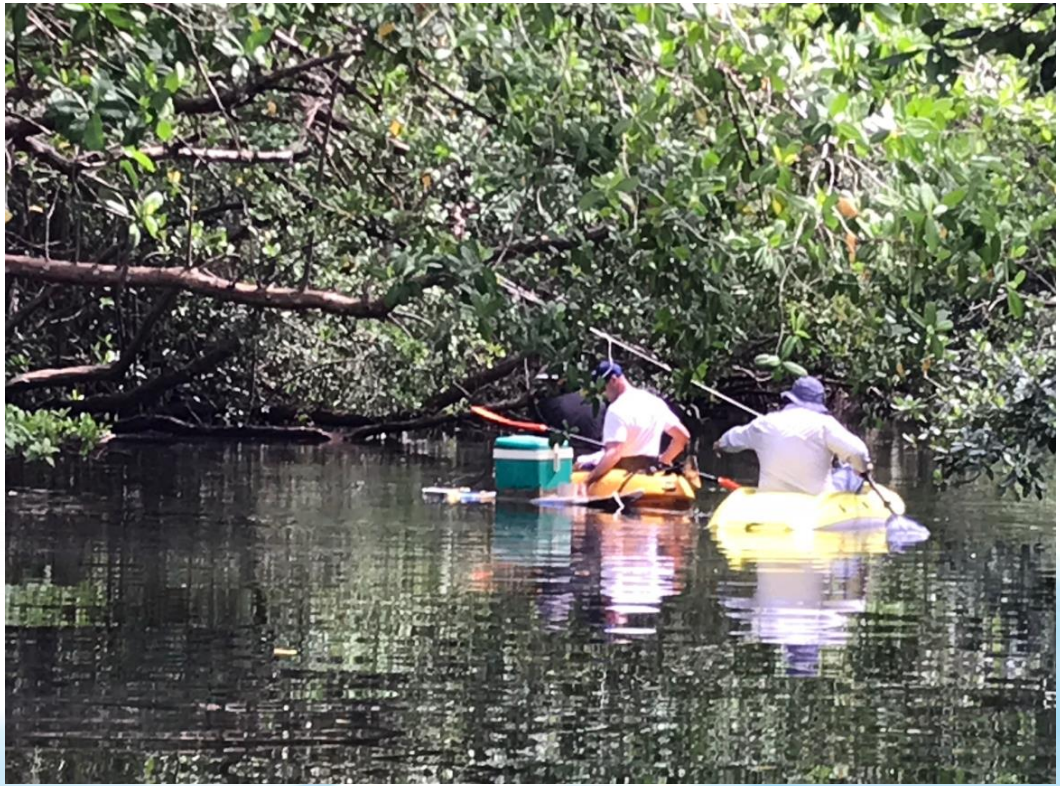


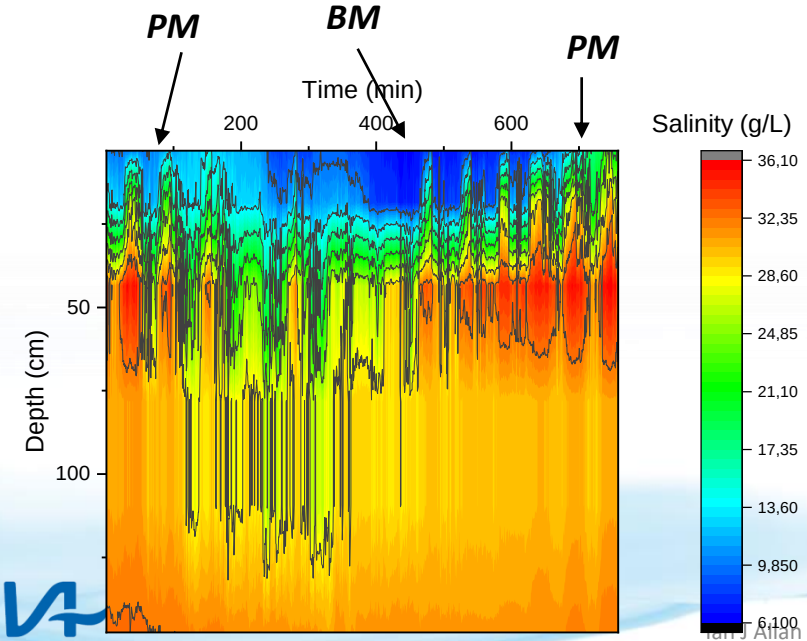
O1. Emission loads of MNPs under various scenarios and particle characterisation (WP1)

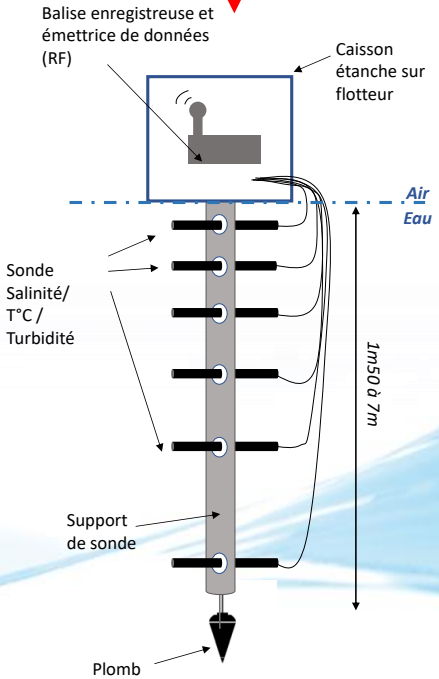
- Development of protocols for preparation and extraction of MNPs from wastewater effluents (sequential filtration, ultrafiltration, DLS…)
- Characterisation of MNPs present in wastewater effluents using a combination of techniques (Py-GC/MS, micro-IR spectroscopy, Asymmetrical flow field flow fractionation…etc)
- Assessment of the speciation and transport mechanism for MNPs released into the environment

Case study –La Gabarre (Guadeloupe)

- A 36ha open air landfill site with 215 000 tonns of waste deposited
- Effluents released into a mangrove
- Strong salinity gradients with depth in the mangrove




PM
BM
PM
Time (min)
200
400
600
Depth (cm)
50
100
Salinity (g/L)
36,10
32,35
28,60
24,85
21,10
17,35
13,60
9,850
6,100


Balise enregistreuse et émettrice de données (RF)
Caisson étanche sur flotteur
Air
Eau
Sonde Salinité/ T°C / Turbidité
1m50 à 7m
Support de sonde
Plomb

Case study – Norway (VEAS)

- VEAS is one of Oslo's sewage treatment plants (700 000 population equivalents)
- Receives sewage and urbanstorm waters
- Treatment consisting of sedimentation/filtration and biological treatment
- Release of effluent in the fjord
- A study in 2014:

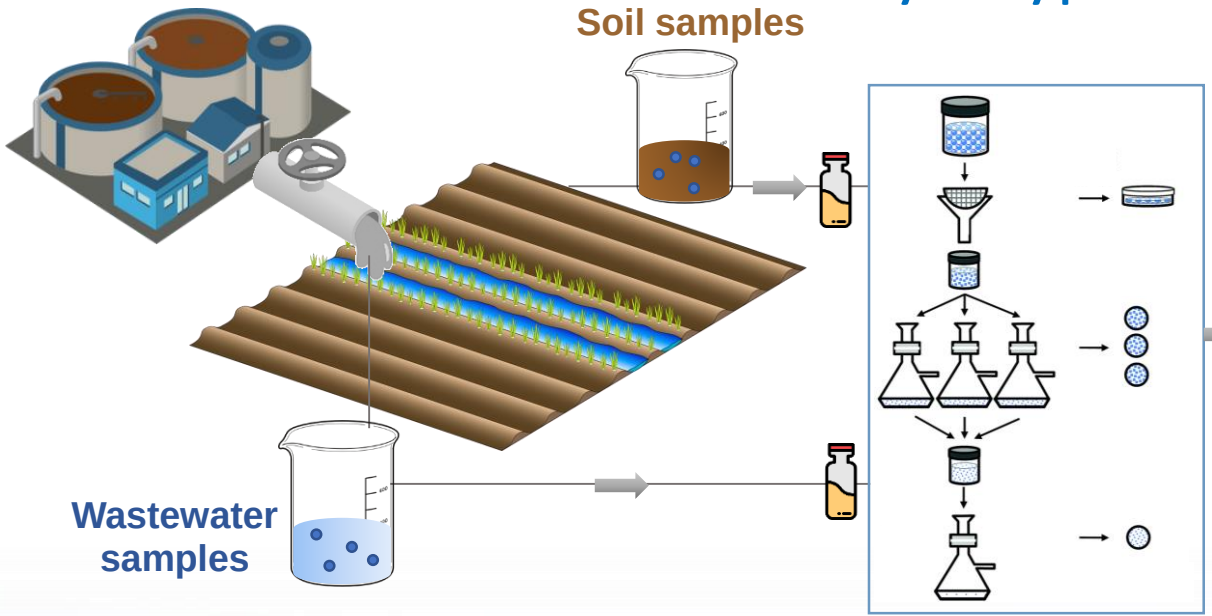
~ 35 million plastic particles > 20 μm and 350k particle > 300 μm released into the Oslofjord every hour

Case study -Svalb

- Longyearbyen in Svalbard
- Average temperature in the range of -15 to 7 °C
- No sewage treatment and release to the sea
- Passive sampling with silione rubber in 2016 revealed the presence of many flame retardants in the effluent

	Compound	pg/sampler
PBDEs	PBDE28	1480
	PBDE47	53900
	PBDE99	30600
	PBDE100	5720
	PBDE153	1990
	PBDE154	1250
	PBDE183	320
Novel brominated flame retardants (NBFRs)	PBBZ	964
	BTBPE	788
	HBB	1280
	PBEB	276
	pTBX	204
	PBT	5040
	alphaTBCO	<7
	alphaTBECH	26500
	HCDBCO	<0.6
	DPTE	<6.9
	antiDP	4910
	synDP	3210
	TBCT	36
	betaTBCO	<1.9
	betaTBECH	17600
	gama+deltaTBECH	5630
HBCD	aHBCD	2050
	bHBCD	630
	gHBCD	2990.0

Case study - Cyprus



Extraction, separation and characterisation of MNPs

Three UWTPs employing different treatment technologies (wastewater samples):
-UWTP1: conventional activated sludge treatment, sand filtration and chlorination
-UWTP2: membrane bioreactor treatment (MBR)
-UWTP3: MBR and chlorination
Soil samples will be also collected from the areas where wastewater effluents are being discharged.

Case study - Cyprus

Treated wastewater effluents deriving from the three UWTPs are used for agricultural irrigation

Risk of releasing MPNs and MNP-sorbed chemical and biological contaminants of emerging concern (e.g. pharmaceutical compounds, antibiotic resistance genes) to the receiving environment

Case study – South Africa

- Two sewage treatment plants with activated sludge in Durban
- Treatment of domestic and industrial wastewaters
- Discharge in rivers
- Water reuse by various local industries

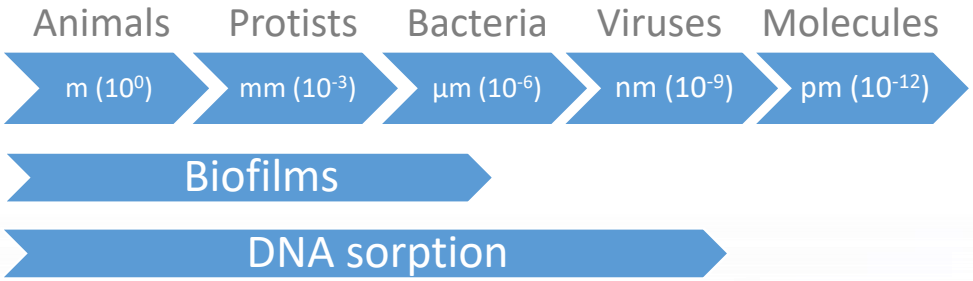
O2 /O3. Identification and risk evaluation of relevant chemical additives associated with MNPs and adsorbed CECs (WP2)

Work with increasing system complexity:

- Preparation of well characterised/relevant MNPs in the laboratory
- Method development for the extraction of chemical additives and CECs from MNPs
  - Exhaustive and non-exhaustive extraction techniques to evaluate the accessibility of the chemicals sorbed to MNPs
  - Evaluate the impact of relevant environmental factors on the fate of these chemicals
- Application of these methodologies within the case studies
  - To effluents and receiving environments (freshwater, fjord/seawater, mangrove, soil/water reuse…)

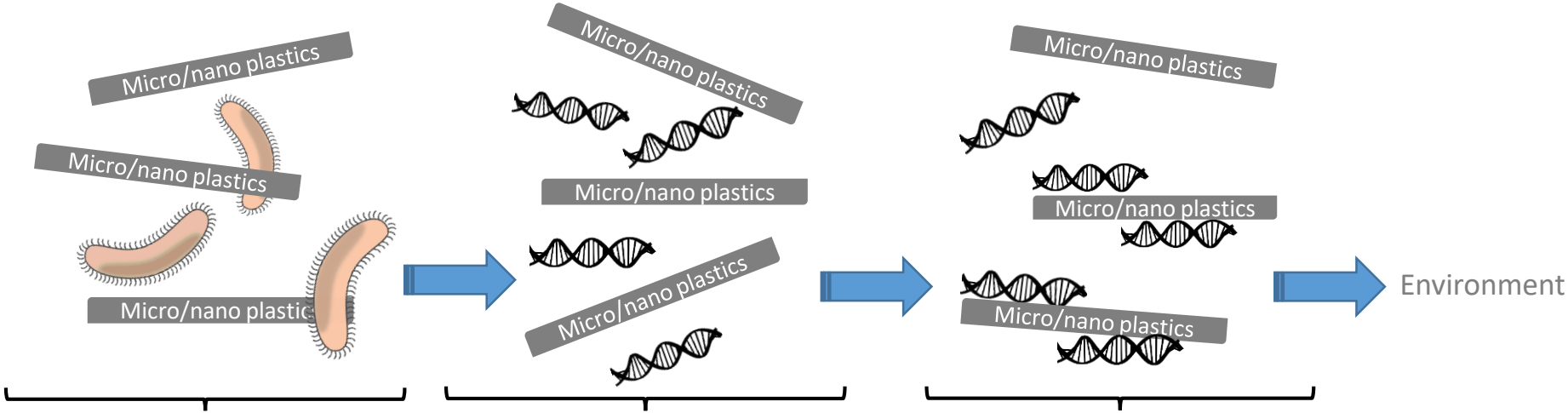
DNA-MNP interactions

- DNA sorption and transport: ARGs Interaction with plastic



Plastic in the environment: scaling view and size interactions

O4 and O5. DNA-MNP interactions (WP3)



Waste Water Influent: bacteria, including ARBs, and MNPs

Waste Water Treatment: bacteria are lised and DNA released

Waste Water Effluent: free DNA, including ARGs, are associated to MNPs

O4: Evaluate DNA sorption to MNPs, test on different plastic types and sizes, assess possible increased half lives, assess bioavailability

O5: Identify whether MNPs act as carriers of common DNA in UWTPs effluents and the aquatic environment and evaluate factors influencing sorption

O6. Review treatment and risk management options for our case studies (WP4)

- Review of the available wastewater treatment and risk management options, according to the specific conditions of the investigated case studies (e.g. reuse of treated effluents and discharges into freshwater bodies…)
- Conduct preliminary experimental assessments to investigate the fate of MNP-bound DNA in UWTPs during lab-scale UV-C and UV-C/H2O2 treatments
- Identification of technological solutions best suited to minimise the release of MNP-sorbed chemicals and ARGs, for the different scenarios

WP5. Stakeholder concertation

- Stakeholders:
  - Water development department of the Ministry of Agriculture, Rural Development and Environment oft he Republic of Cyprus (CYP)
  - Norwegian Environment Agency (NO)
  - VEAS wastewater treatment plant (NO)
  - ADEM – French Environment & Energy Management Agency (FR)
  - UMGENI Water (SA)
  - Longyearbyen Town Council (NO)
- Two restitution seminars with stakeholders at national level
- Continuous communication, meetings at regular intervals, reports to disseminate project results
- Use of industry communication channels (industry meetings, webpages sectorial magazines…)