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Environmental Pollution

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Microbial plankton uptake enhances the degradation of a biodegradable microplastic[☆]

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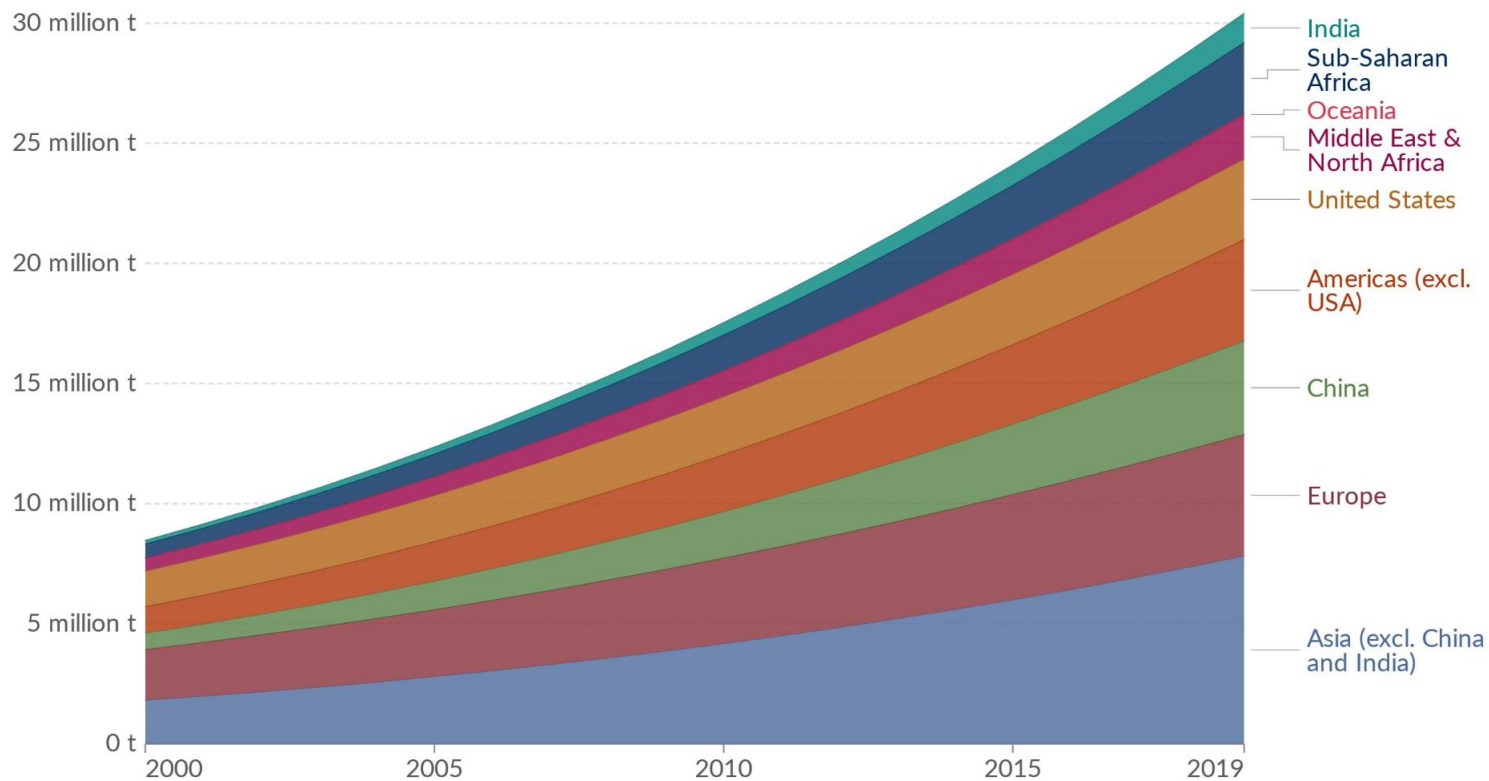
S Y K E



Plastic waste accumulated in the oceans, 2000 to 2019

Our World
in Data

The amount of plastic waste that has accumulated in the oceans since 1951. This is calculated as the running total of plastic flowing into the ocean each year.

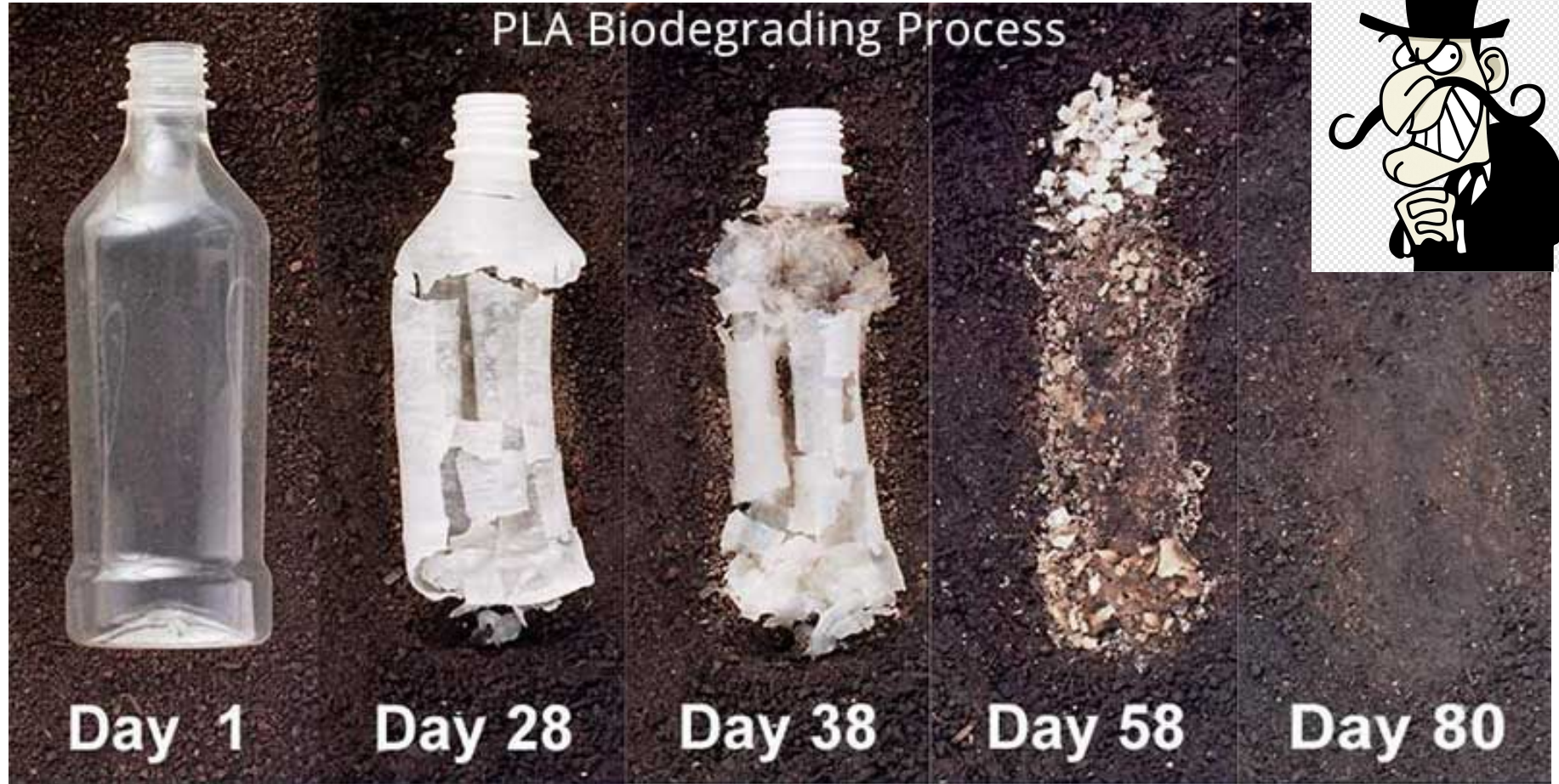


Data source: OECD (2022)

Note: Regional definitions adhere to those specified by the OECD.

OurWorldInData.org/plastic-pollution | CC BY

The villain: poly lactic-co-glycolic acid - PLGA



The two open questions:

- 1) To what extent and in which size ranges do ciliates and nanoflagelates communities uptake PLGA?

H1: We expect that ciliate communities would ingest more and bigger particles than nanoflagellate communities due to their higher feeding rates and bigger size

- 2) Does microbial plankton enhance PLGA degradation in water ?

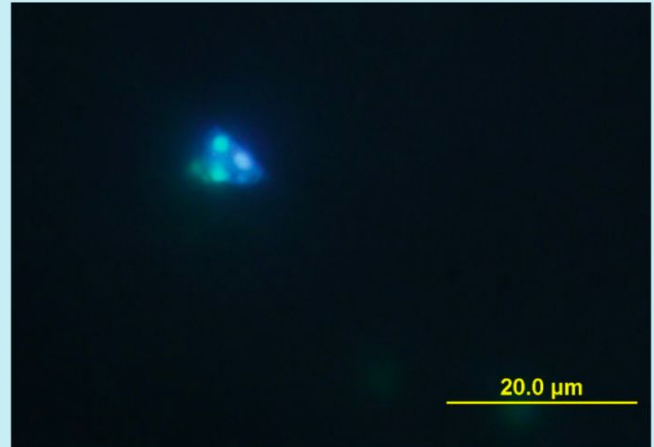
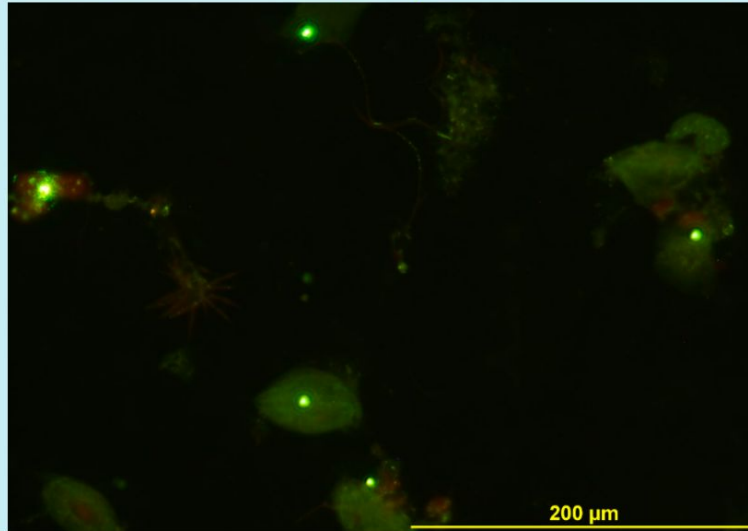
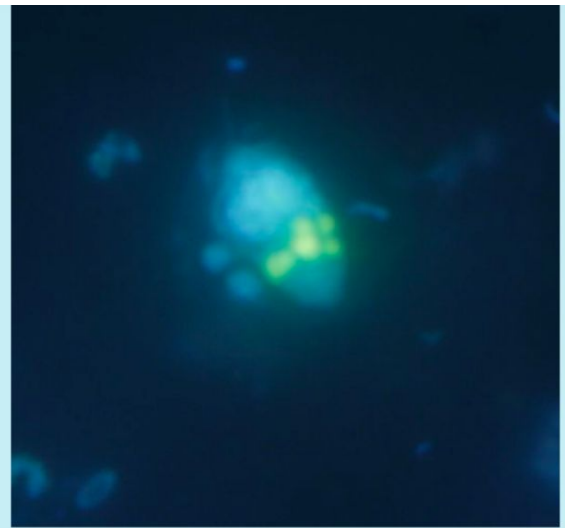
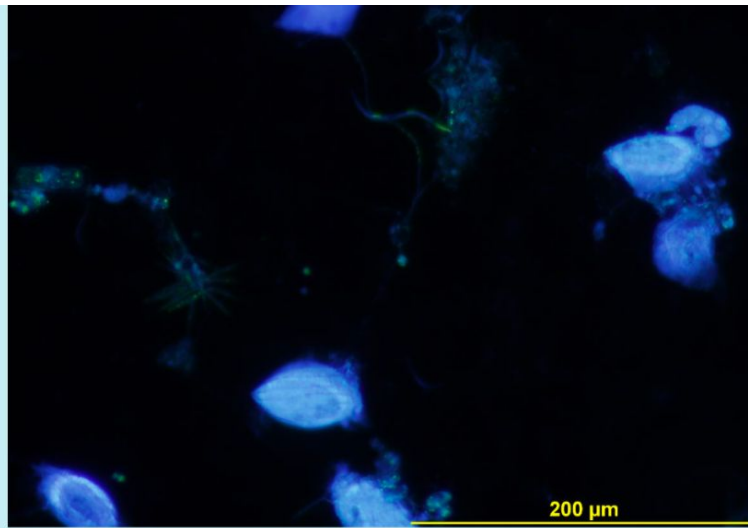
H2: We expect that microbial plankton would increase the degradation rate of PLGA through particle ingestion.



RESULTS

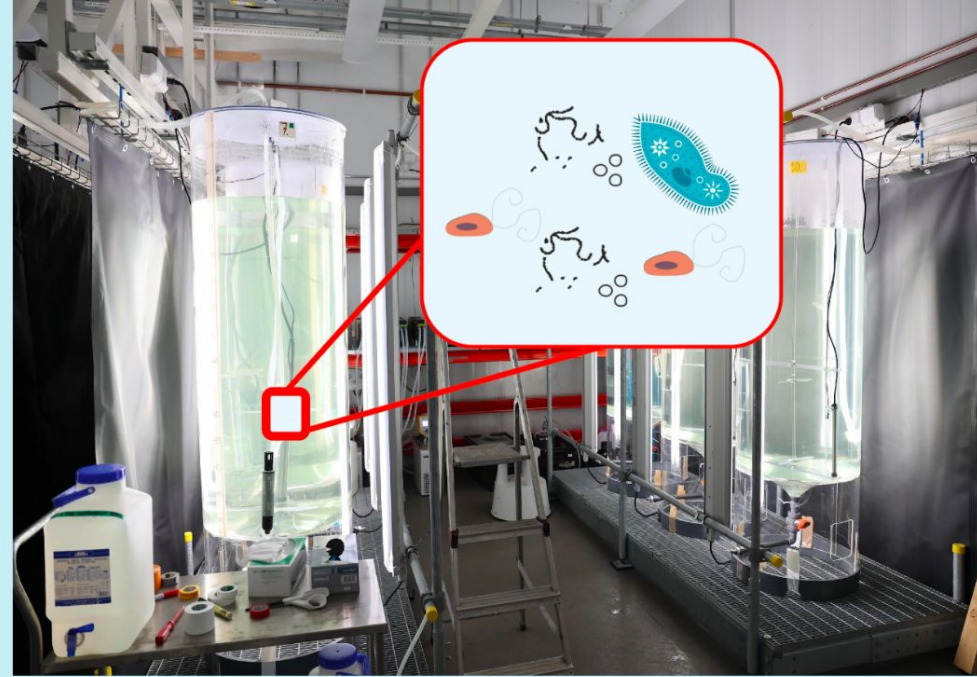
Photos taken with
epifluorescence
microscopy

□ PLGA inside ciliates
and nanoflagellates



□ Laboratory experiments in SYKE-MRC, Helsinki, Finland, using microbial planktonic community ($< 100 \mu\text{m}$) from the Baltic Sea

□ Green fluorescent PLGA microparticles of $\sim 10 \mu\text{m}$ initial diameter stored dry.



Q1 □ AQUACOSM-TA 2019:
Uptake experiments of PLGA microparticles by planktonic nanoflagellates and ciliates

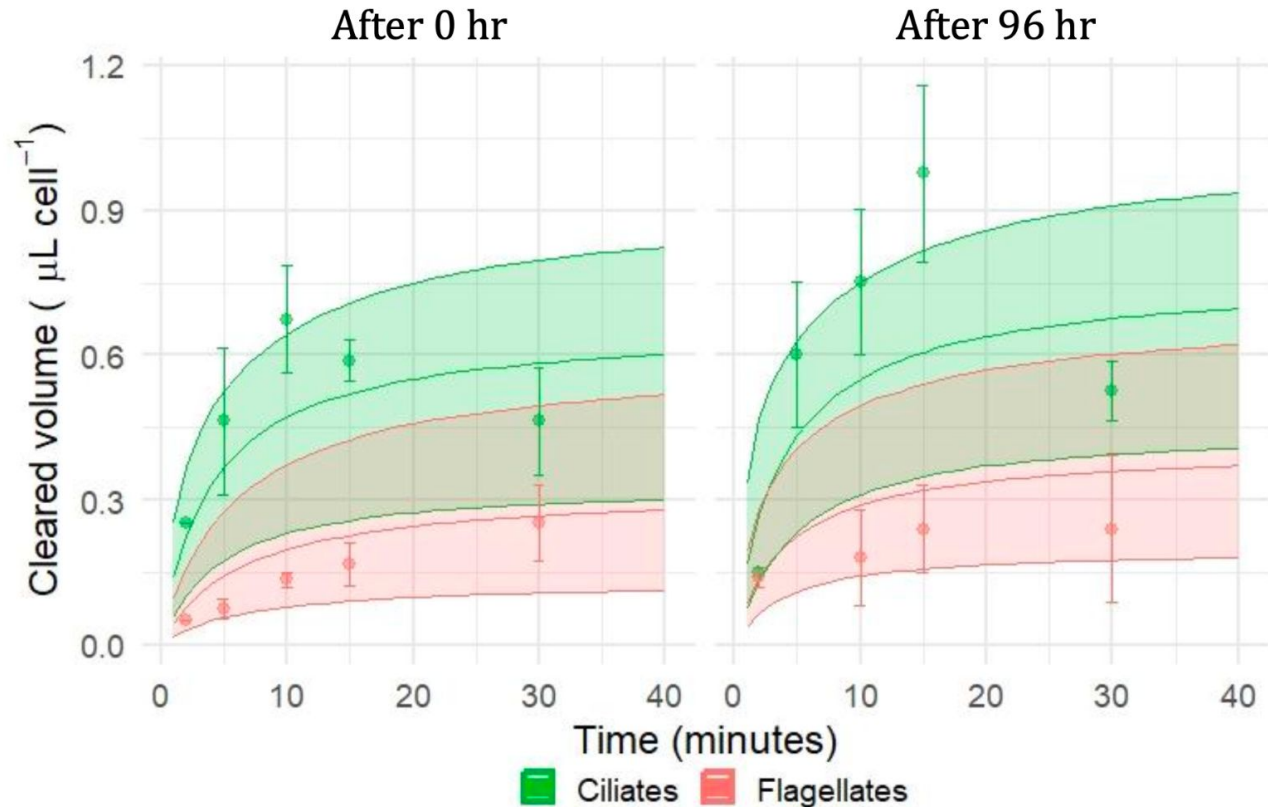
Q2 □ AQUACOSM-TA PLUS 2023:
Degradation experiments of PLGA microparticles under two $< 100 \mu\text{m}$ plankton communities

Q1: To what extent and in which size ranges do ciliates and nanoflagelates communities uptake PLGA?

RESULTS

PLGA captured per planktonic protists divided by the PLGA concentration in each solution stage

□ Per capita rates were higher for the ciliates



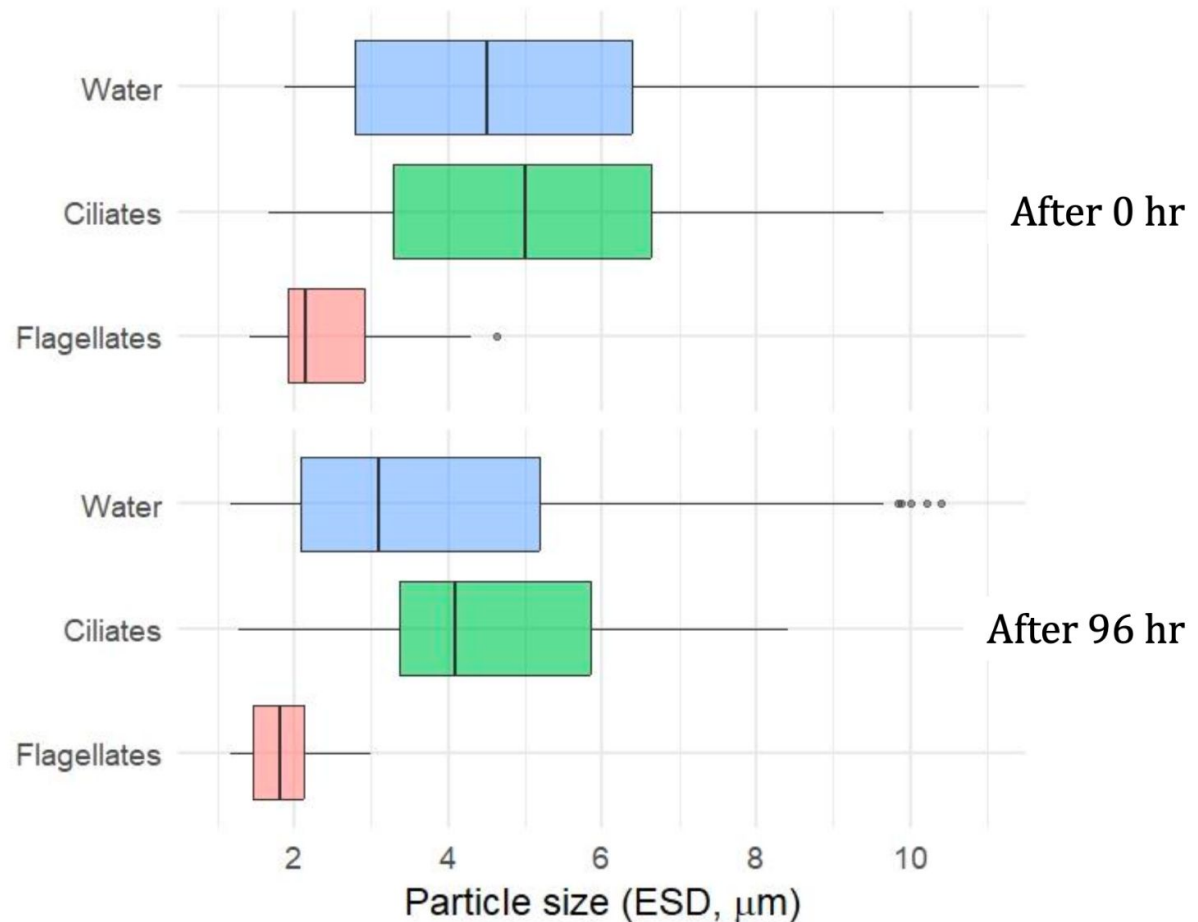
Q1: To what extent and in which size ranges do ciliates and nanoflagelates communities uptake PLGA?

RESULTS

Size distribution of PLGA microparticles in the MilliQ water and inside the protists

□ The size of the ingested PLGA was different

□ PLGA concentrations in water at 0 and 96 hours were 1200 and 800 particles mL⁻¹



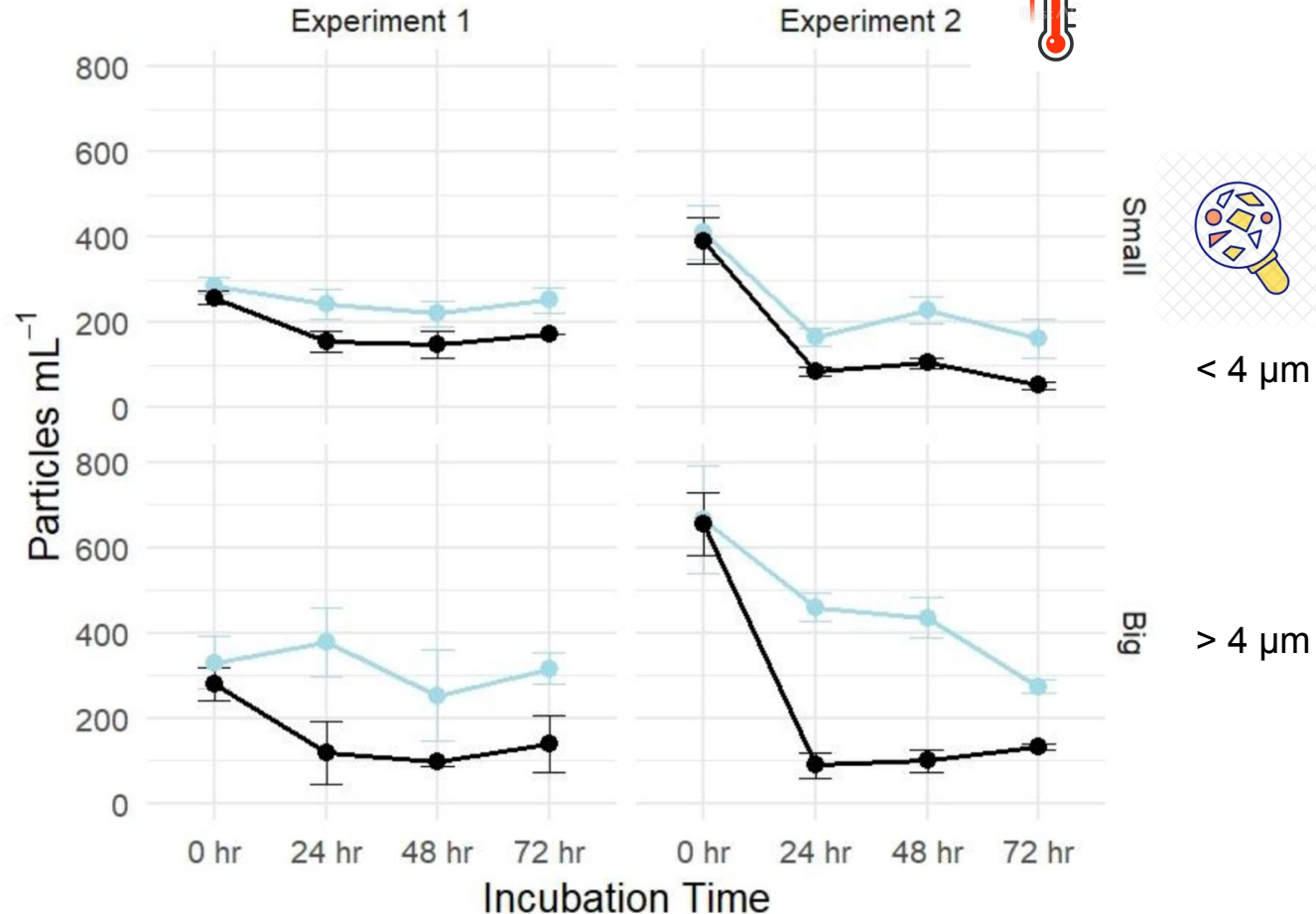
Q2: Does plankton enhance PLGA degradation in water ?

RESULTS

Concentration of PLGA microparticles in milliQ water (**blue lines**) and seawater with plankton (**black lines**)

□ Higher decrease of free PLGA in seawater with plankton.

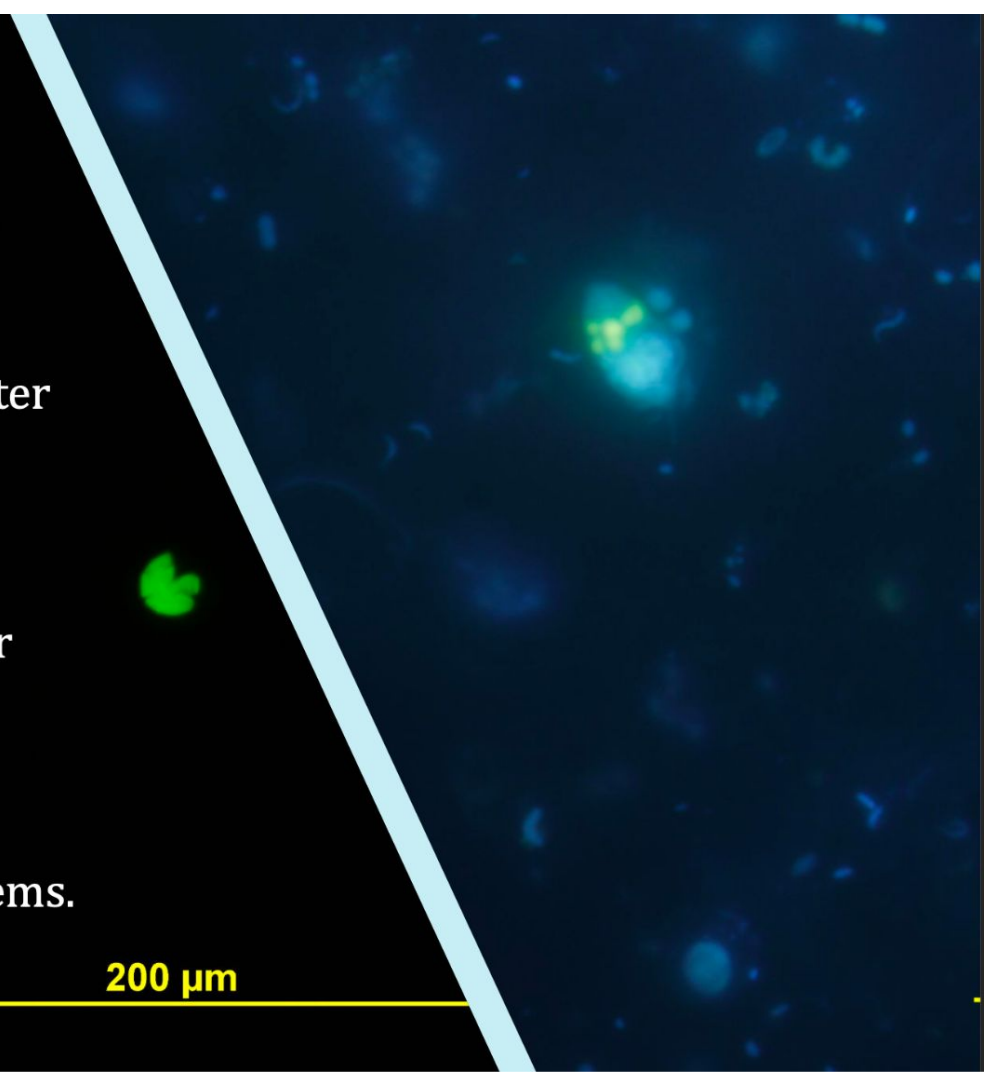
□ The decrease was more pronounced in particles higher than 4 μm



Key results:

- Planktonic ciliates and nanoflagellates can ingest PLGA microplastics < 15 μm .
- PLGA concentration and size decreased faster in presence of microbial plankton.
- Planktonic protists would enhance degradation of PLGA microparticles in water through particle uptake
- Findings highlight the short-term fate of biodegradable microplastics in marine systems.

200 μm

A fluorescence microscopy image showing a dark blue background with numerous small, bright blue and green spots. These spots represent PLGA microplastics and plankton. A prominent, bright green spot is visible in the lower-left quadrant, and a cluster of bright green and yellow spots is visible in the upper-right quadrant. A white diagonal line runs from the top-left towards the bottom-right, separating the text area from the image. A yellow horizontal line is located at the bottom of the image, with the text '200 μm' centered above it.

Thanks to



Suomen ympäristökeskus
Finlands miljöcentral
Finnish Environment Institute



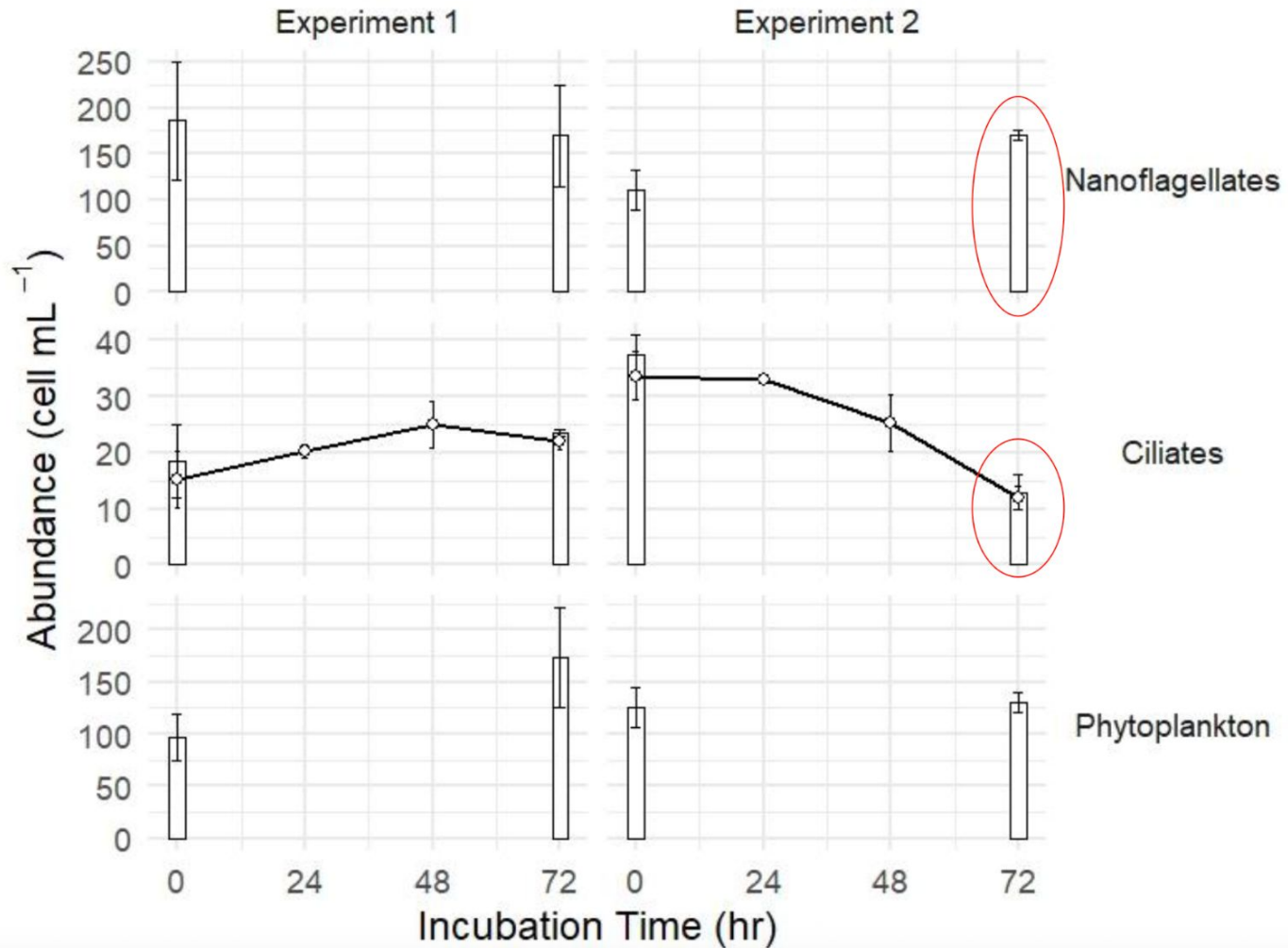
Supplementary materials

RESULTS

Concentration of planktonic groups at the beginning and end of the degradation experiments.

Decrease in ciliates and increase in nanoflagellates in E2.

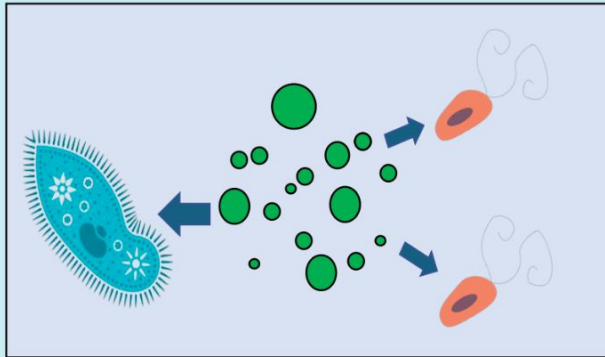
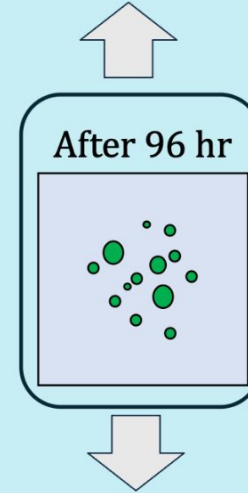
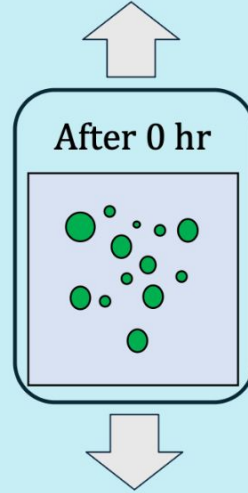
No changes in E1 and phytoplankton.



Uptake experiments 2019

Quantification and size measurement of PLGA particles
on 0.2 μm polycarbonate filters using imageJ

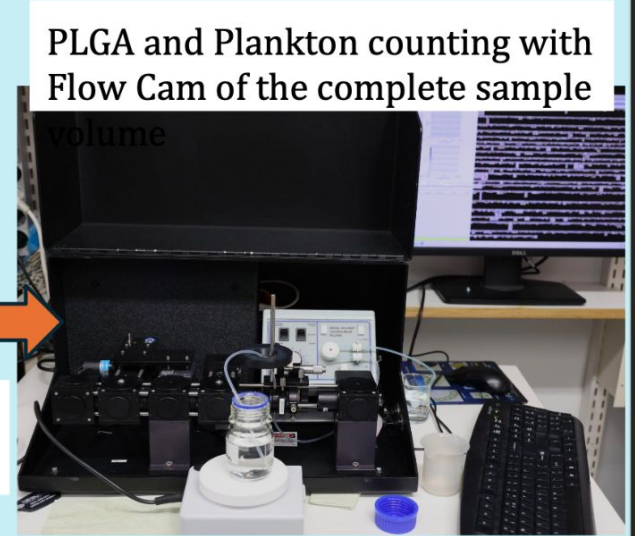
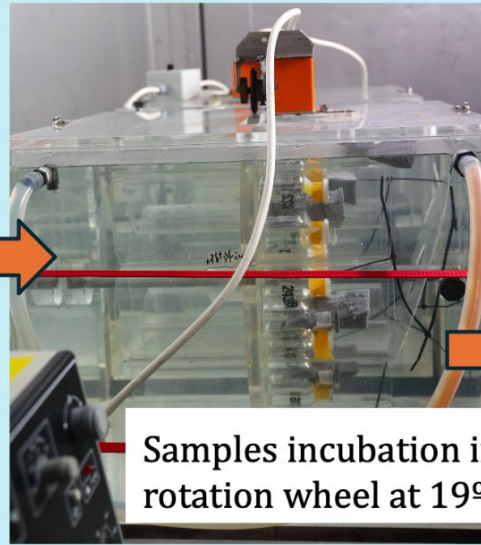
Stock incubations: PLGA + Milli Q
water at 2 incubation times



Uptake experiments adding 100 μL of PLGA stock to
the < 100 μm plankton community

- ✓ Uptake curves for flagellates and ciliates
- ✓ Number and size of PLGA captured by each group

Degradation experiments 2023

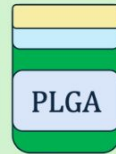


2 Experiments:

- Natural seawater
- Temperature treated (mesocosm) **X**
- ≠ plankton

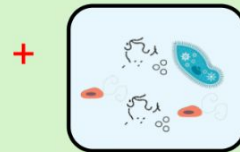
Treatments

"Control"



+ Pure (MilliQ) water

"Plankton"



Time steps (hours):

0

24

48

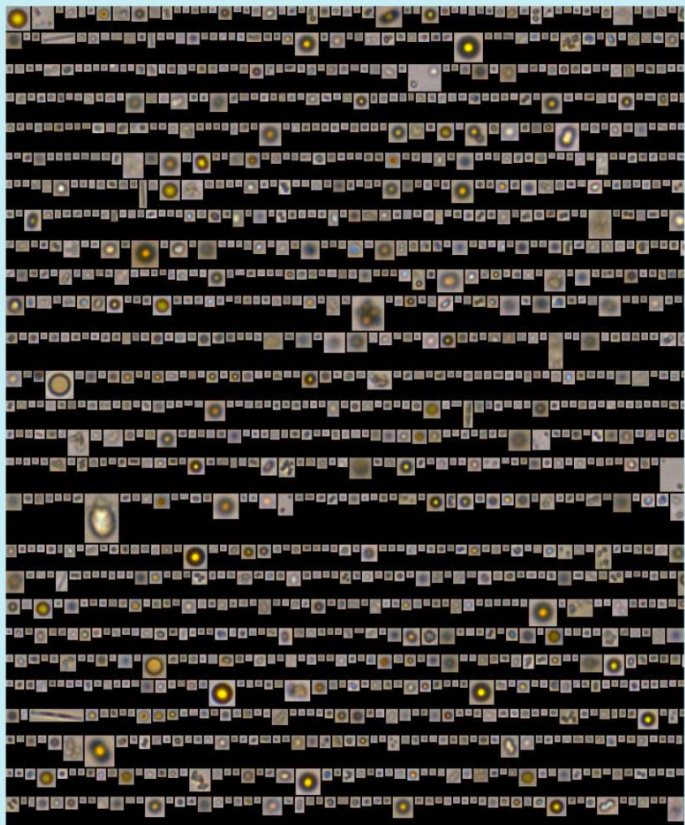
72

X

3 Replicates

Data analysis

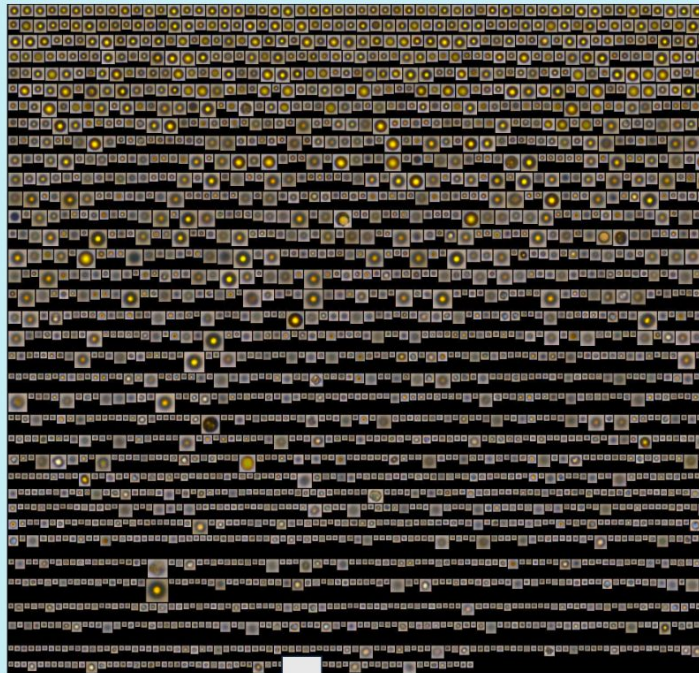
Flowcam sampling mosaic



Flowcam's
machine learning



Flowcam filtered mosaic



Mosaic split and...

...manual final selection



✓ Concentration, size, volume, all flowCam data.