National Institute for Environmental Studies, Japan

# Towards microplastic prevention:

## Efforts for tackling plastic pollution

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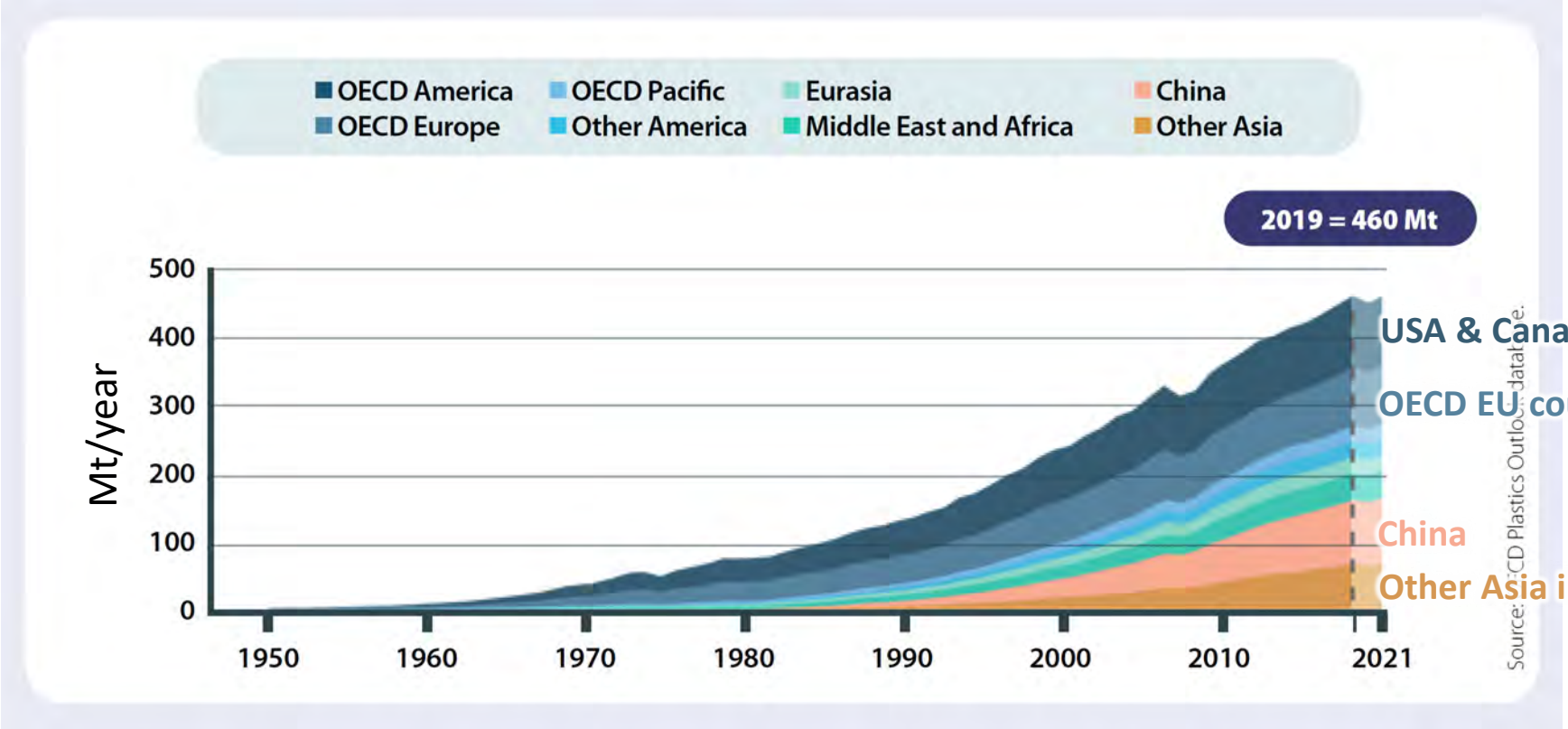
# Outlines

- Background
- Key research activities in NIES
  - ✓ Monitoring and emission control of river plastic wastes
  - ✓ Fate and behavior of plastic waste during recycling
  - ✓ Fate and behavior of plastic waste in the environment

# Background

# Global plastic production

OECD. (2022) Global Plastics Outlook




- ✓ Plastics have seen a remarkable increase in use the mid-20th century.
- ✓ Global plastic production has increased 230-fold from 2 Mt in 1950 to 460 Mt in 2019.

# Total amount of global plastic waste

OECD. (2022) Global Plastics Outlook

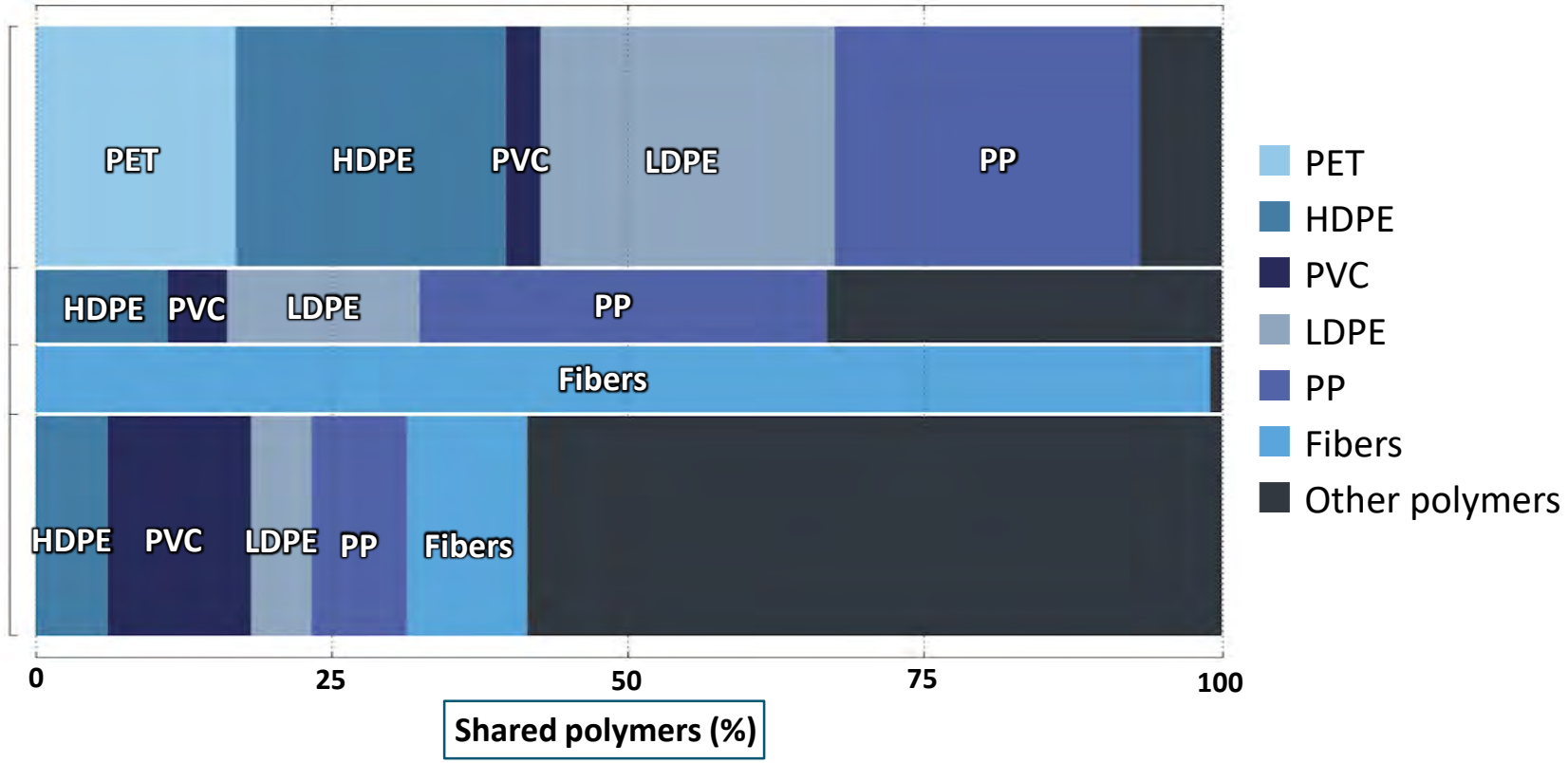
**Total plastic waste generated by application, in Mt**

**Packaging**
**142 Mt**

**Consumer products**
**43 Mt**

**Textiles**
**39 Mt**

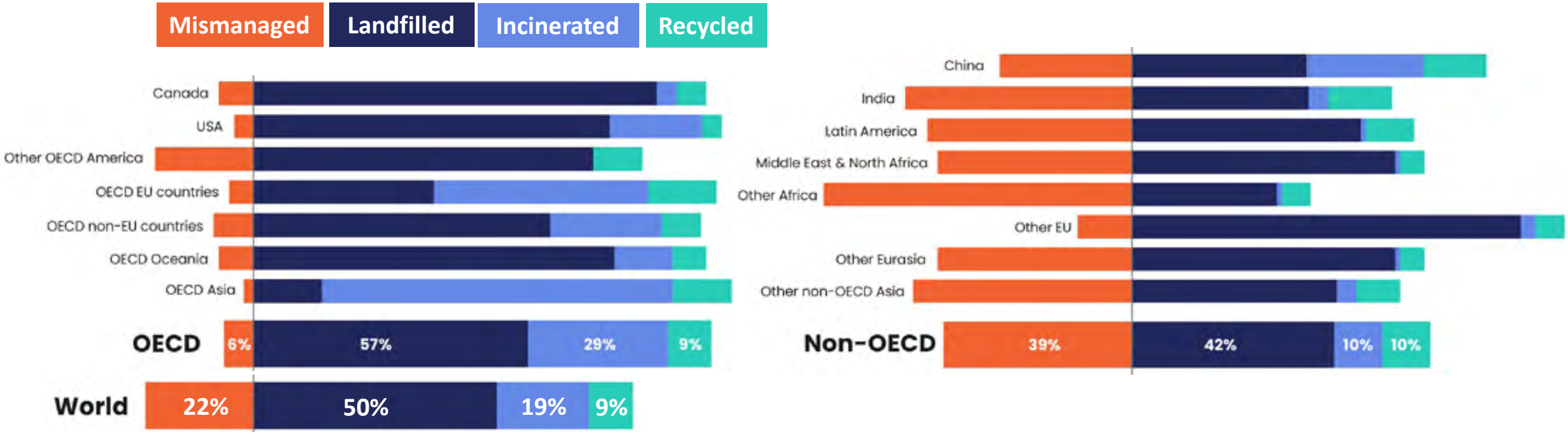
**Other applications**
**130 Mt**




- ✓ In 2019, total amount of global plastic waste was 353 Mt.
- ✓ Packaging, consumer products and textiles accounted for around 60% of plastic waste.

# Global plastic waste management

OECD. (2022) Global Plastics Outlook




- ✓ Among 353 Mt of global plastic waste in 2019, only 9 % of plastic waste was recycled, while 19% was incinerated and almost 50% went to sanitary landfills.
- ✓ The remaining 22% was disposed in uncontrolled dumpsites, burned in open pits or leaked into the environment.

# Plastic leakage into marine environment

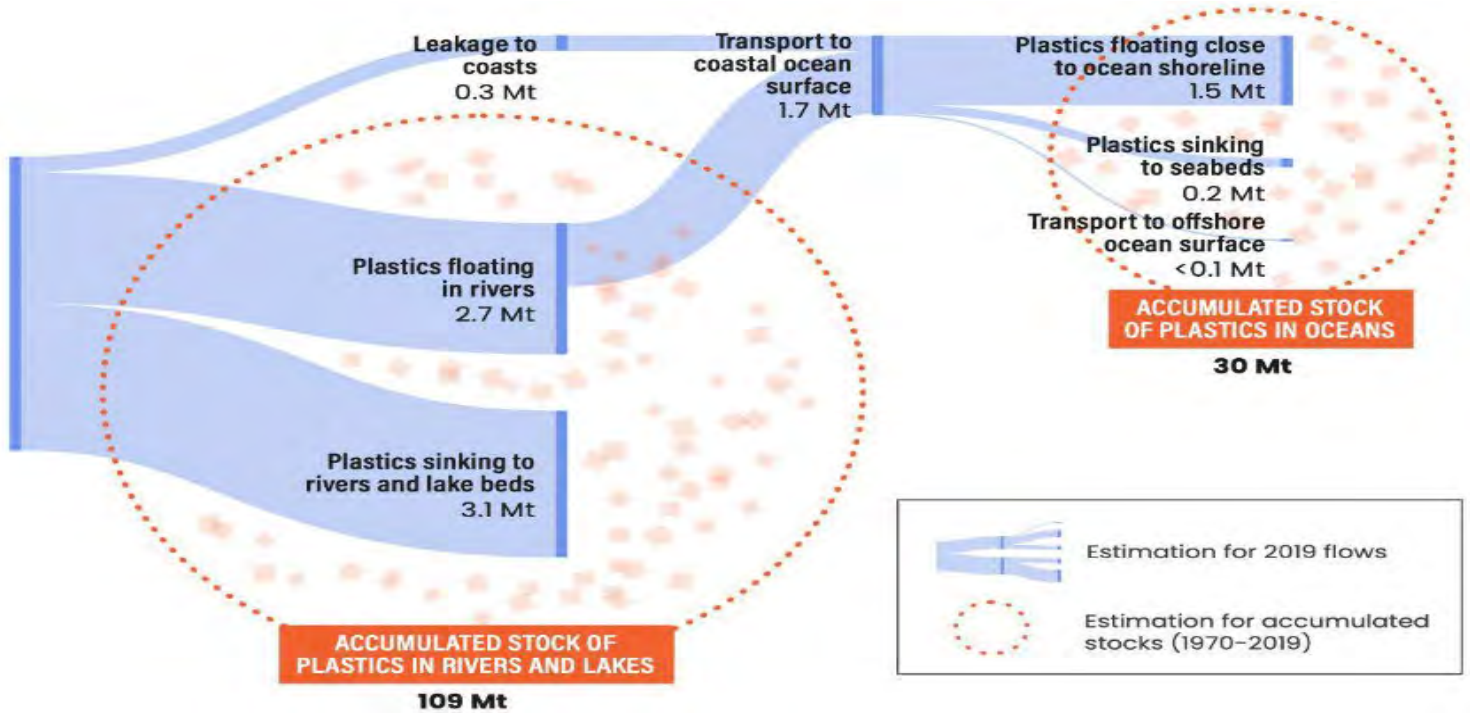
OECD. (2022) Global Plastics Outlook

Plastic leakage into the environment

**22 Mt**

Plastic leakage into aquatic environment

**6.1 Mt**

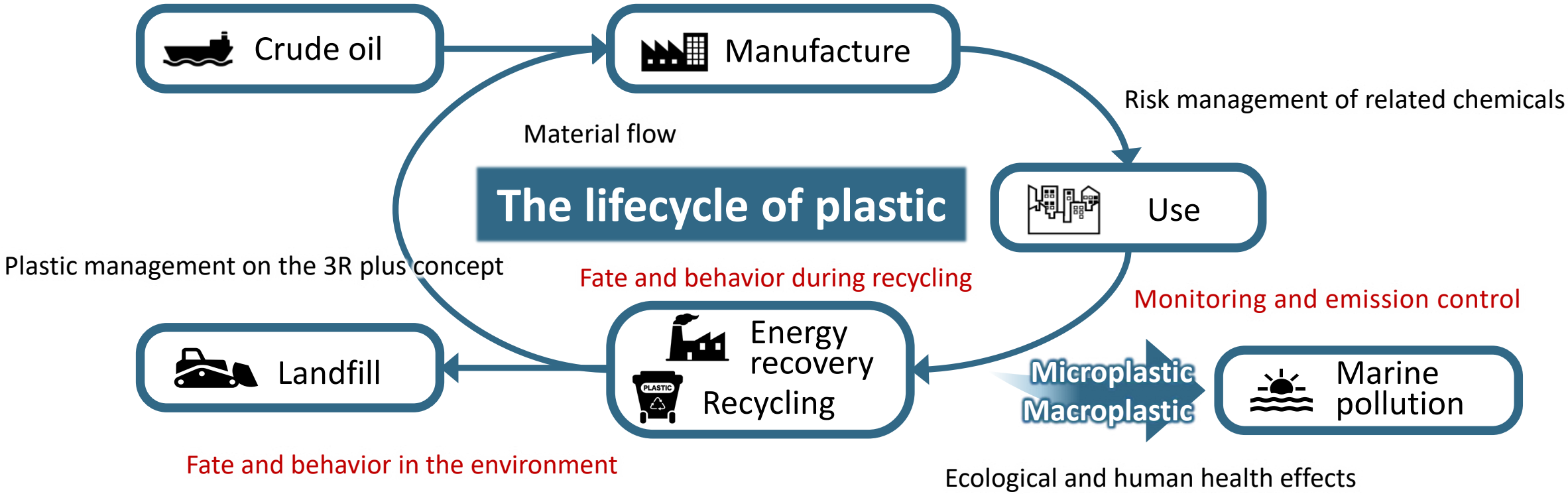



- ✓ In 2019, 6.1 Mt of plastic waste into aquatic environments such as rivers, lake, and the ocean.
- ✓ An estimated 109 Mt and 30 Mt of leaked plastics have accumulated in rivers and the ocean.
- ✓ Accumulated stock of plastics in rivers implies that leakage into the ocean will continue for decades to come even if mismanaged plastic waste was significantly reduced.

# Key research activities in NIES

国立研究開発法人
国立環境研究所
National Institute for Environmental Studies

# Overview | Plastic research activities in NIES



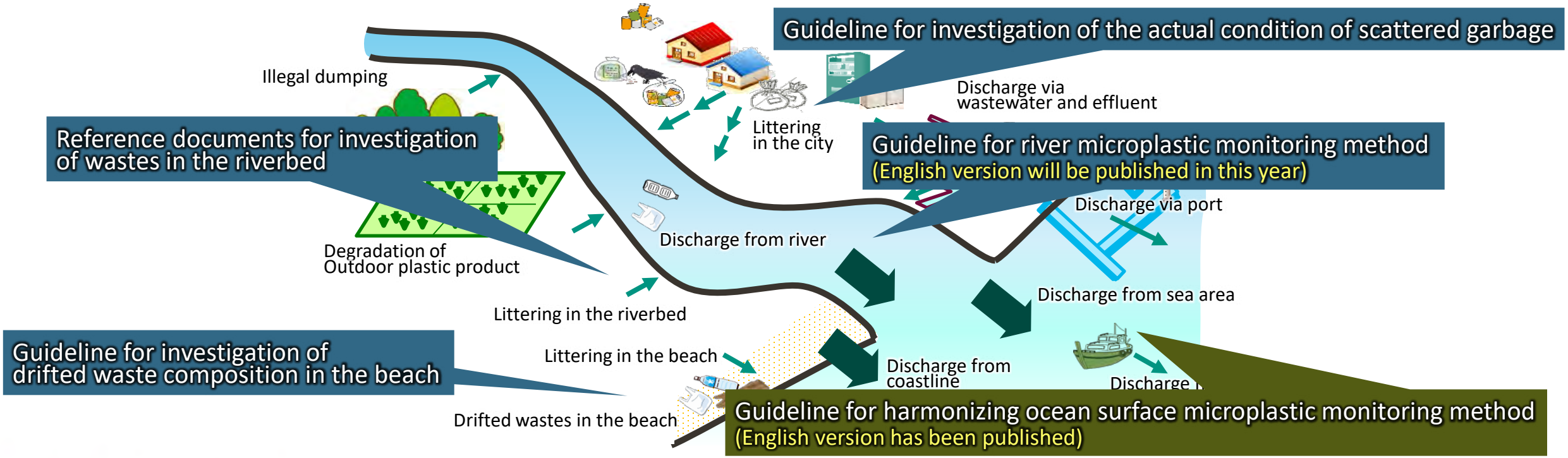

➔ Contributing to effective and efficient control of plastic pollution based on the integrated assessment system on the basis of fact-finding.

# Monitoring and emission control

# Motivation | Guidelines for plastic measurement

http://www.env.go.jp/water/marine_litter/post_118.html (in Japanese)

- National publication of various guidelines
  - ✓ To promote standardization on measurement/investigation methods for collecting comparable data for the subsequent measures.

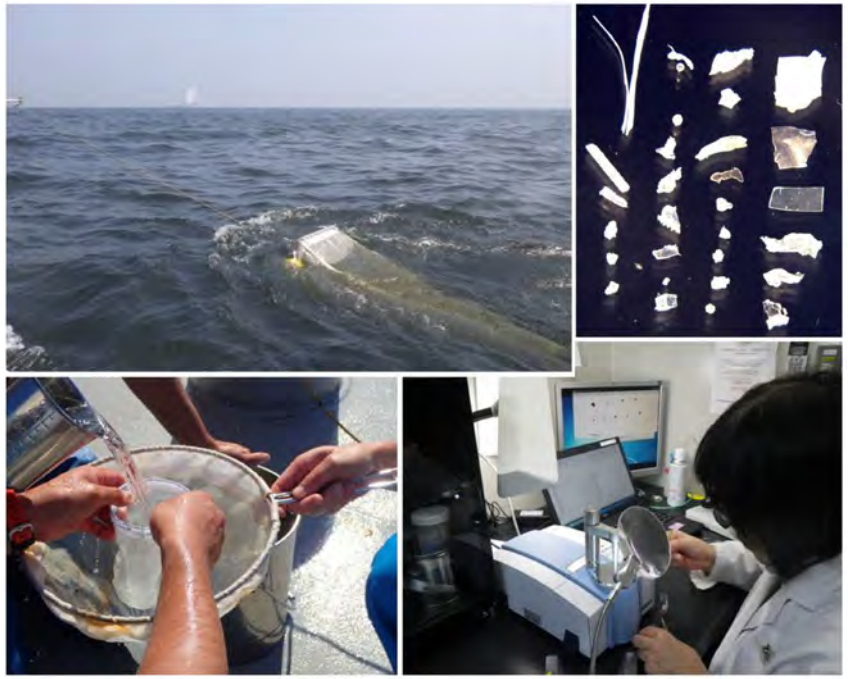


# Motivation | Guideline for ocean microplastic

https://www.env.go.jp/content/900515659.pdf

Guidelines for Harmonizing Ocean Surface Microplastic Monitoring Methods

Version 1.1, June 2020



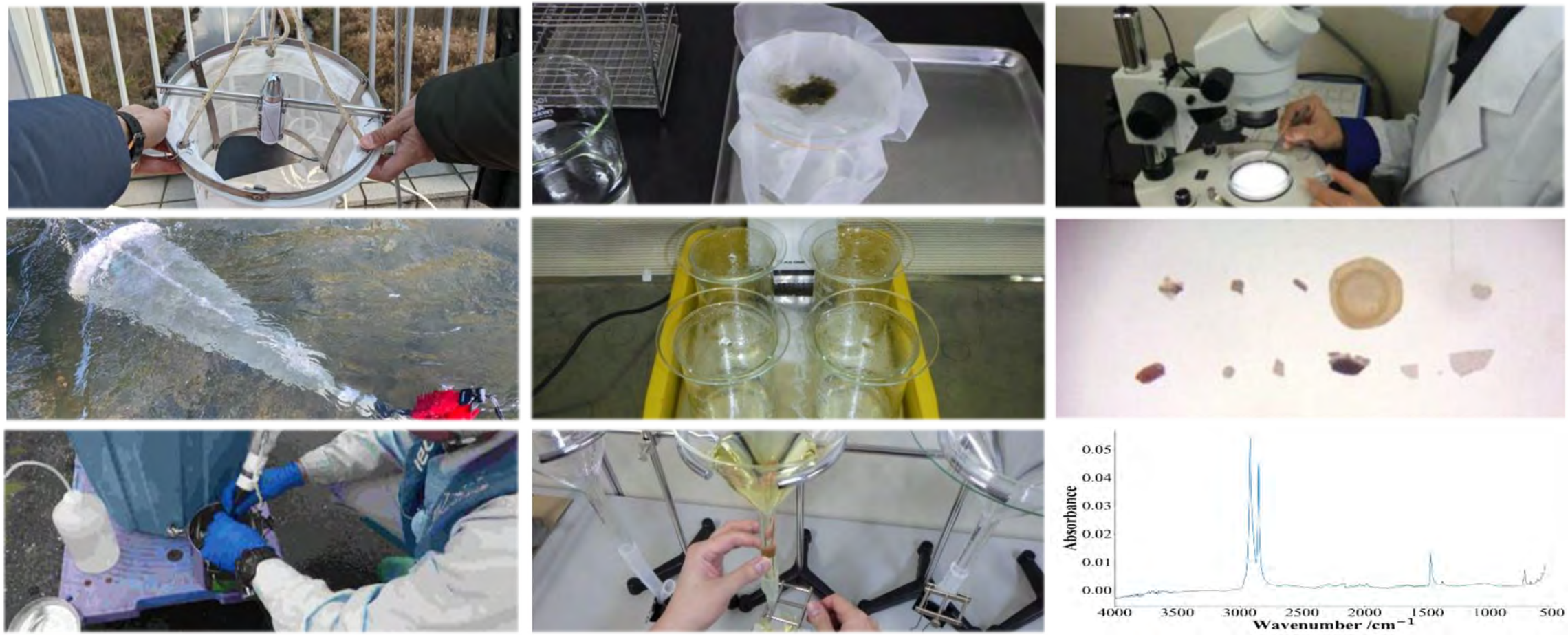
Ministry of the Environment, JAPAN
June, 2020

## Contents

# Motivation | Guideline for river microplastic

Coming soon on the website of MOEJ

- Guidelines for River Microplastic Monitoring Methods (English version)



# Content | Monitoring and emission control

Suzuki et al. (2022) Chikyu Kankyo (in Japanese)

- Study on “Monitoring of actual status and emission control of river plastic wastes” has been conducted since April 2021.
  - ✓ In cooperation with 31 municipal institutes for environmental studies.
  - ✓ To investigate actual status of river plastic litter by the MOEJ-based guideline method.
  - ✓ To propose method for verifying the effect of related policies.

# Content | Monitoring and emission control

Suzuki et al. (2022) Chikyu Kankyo (in Japanese)

- The major achievements in FY2021
  - ✓ Harmonized the method for sampling and measurement of microplastics in river with collaborators based on the MOEJ guideline.
  - ✓ Conducted on-site and on-line demonstrations for sampling and measurement of microplastics to share “Know How”.

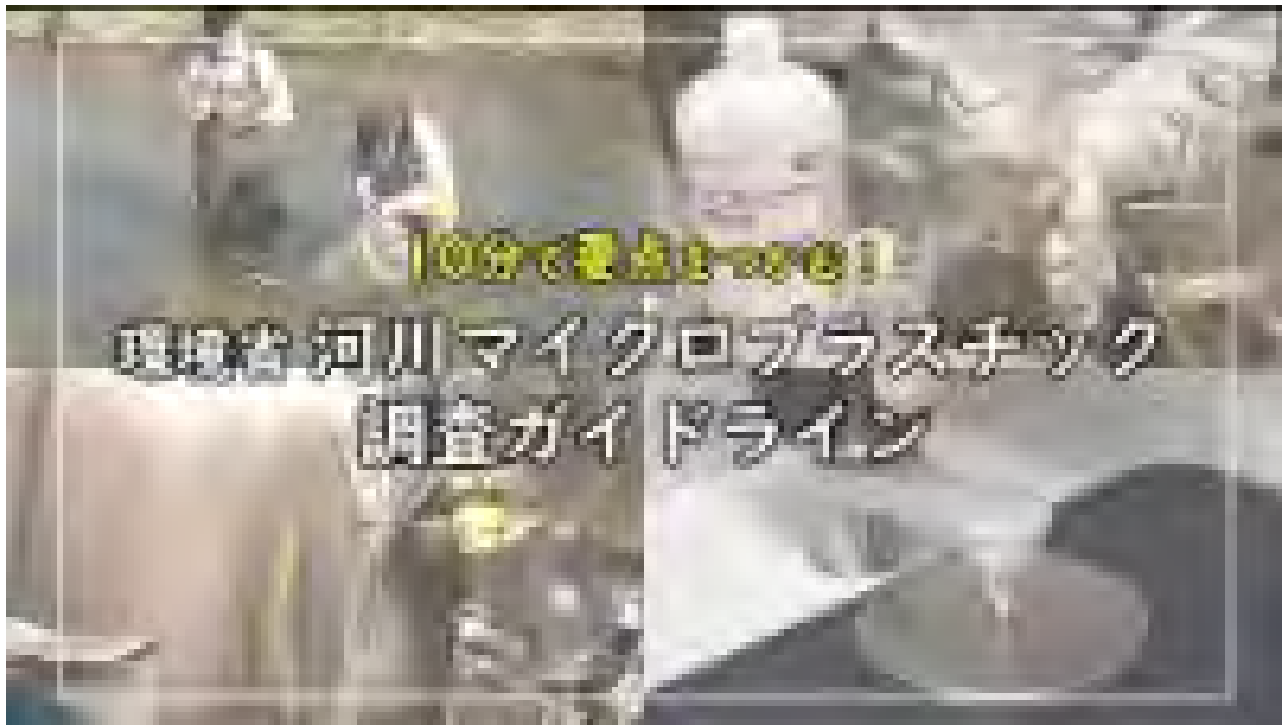
On-site demonstration of sampling in river (Nov 2021)

On-line demonstration of measurement (Feb 2022)

# Content | Monitoring and emission control

Suzuki et al. (2022) Chikyu Kankyo (in Japanese)

- The major achievements in FY2021
  - ✓ Transmitted the MOEJ guideline-based manual using a text and a moving image via the NIES homepage. (in Japanese)

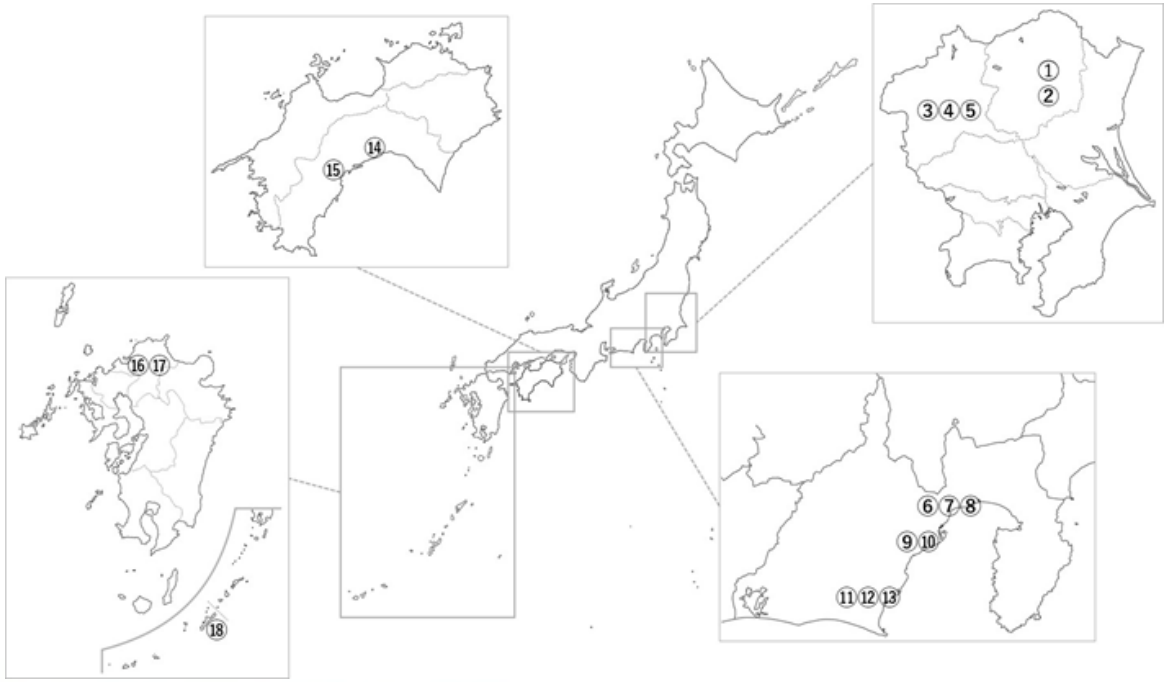


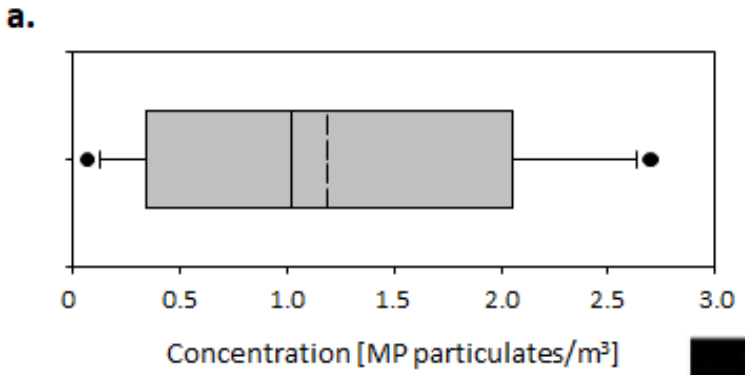

**Content**

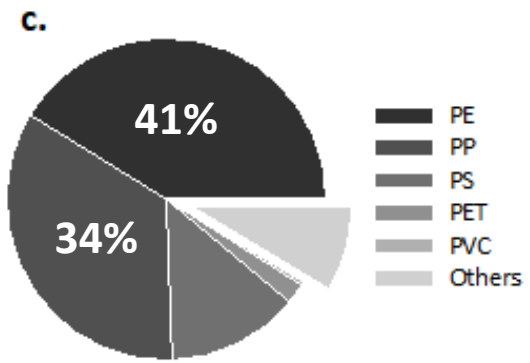
Sampling from bridge
Sampling in river
Collection
Oxidation treatment
Density separation
FT-IR (ATR)

Suzuki et al. (2022) Chikyu Kankyo (in Japanese)

- The major achievements in FY2021
  - ✓ Started investigating microplastic concentration at 18 points in 7 Japanese rivers.
  - ✓ Revealed the range of 0.065 to 2.7 MP (1 to 5 mm)/$m^3$, suggesting river is likely to be one of marine microplastic sources.



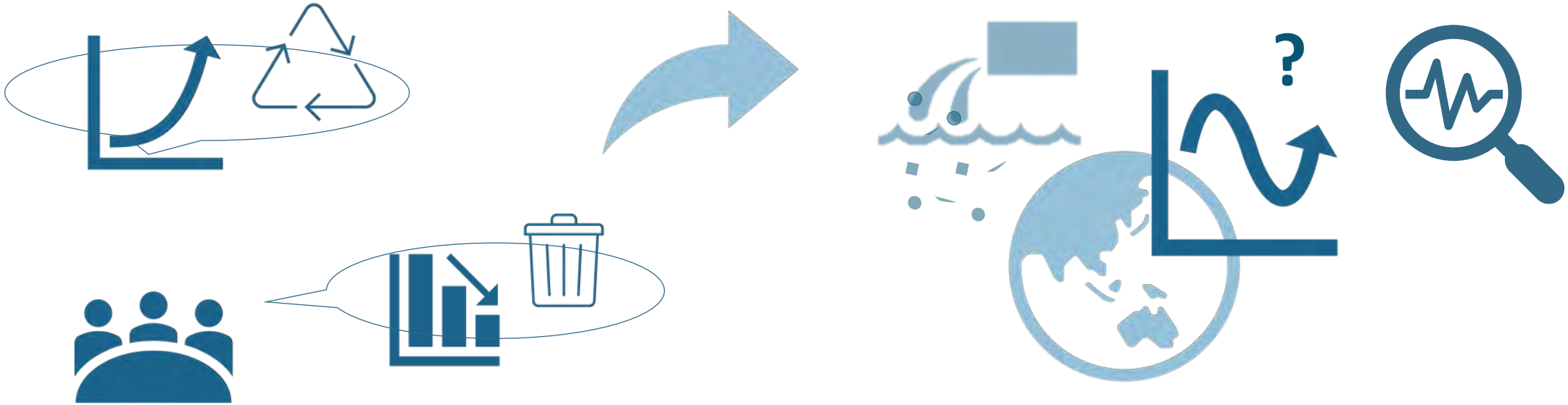




Artificial turf

# Challenge | Monitoring and emission control

- Future works
  - ✓ MOEJ and local governments actively promote the policy to curb plastic waste.
  - ✓ To evaluate the effectiveness of related policies based on results of the MOEJ guideline-based monitoring by municipal institute for environmental studies.




**How do we assess plastic policies?**

# Fate and behavior during recycling

# Motivation | Policy approaches to reduce plastic leakage

OECD. (2022) Global Plastics Outlook


Note: EPR = Extended Producer Responsibility; MSW = municipal solid waste; WWTP = waste water treatment plant.

- Plastic recycling as measures against plastic pollution
  - ✓ To reduce the release of plastic waste and litter into the environment, there are essentially five policy approaches that can be used.
  - ✓ One of important approach is to enhance plastic recycling.

# Motivation | Mechanical recycling for plastic waste


Ellen MacArthur Foundation. (2016) The New Plastics Economy
Garcia and Robertson. (2017) Science; Al-Salem et al. (2009) Waste Manag; Ragaert et al. (2017) Waste Manag


- Mechanical recycling
  - ✓ The most widely adopted technology for large-scale recycling waste is currently mechanical recycling.
  - ✓ General mechanical recycling process generates large amounts of untreated water that may contain marked quantities of microplastics posing toxicological risks to aquatic environment.

# Content

## Fate and behavior during recycling

Suzuki et al. (2022) Environ Pollut

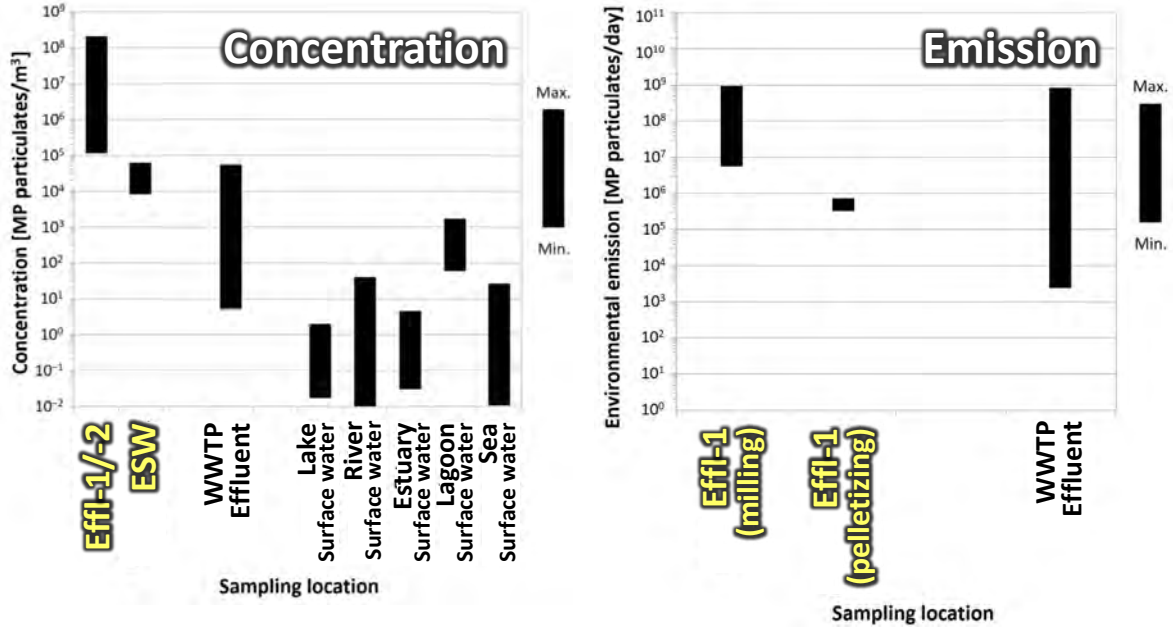

- ○ Effl-1, effluent samples collected directly from the wastewater generated during recycling
- □ Effl-2, effluent samples collected in drainage side-ditches into which Effl-1 was discharged
- △ ESW, samples of environmental surface water collected from the rivers or marsh

- Study on “Fate and behavior of microplastics generated from plastic recycling” has been conducted since Sep 2019.
  - ✓ In cooperation with VNU Hanoi University of Science and Ehime University.
  - ✓ To investigate whether microplastics released to the aquatic environment during recycling process because recycling is a potential means of reducing plastic pollution.

# Content

## Fate and behavior during recycling

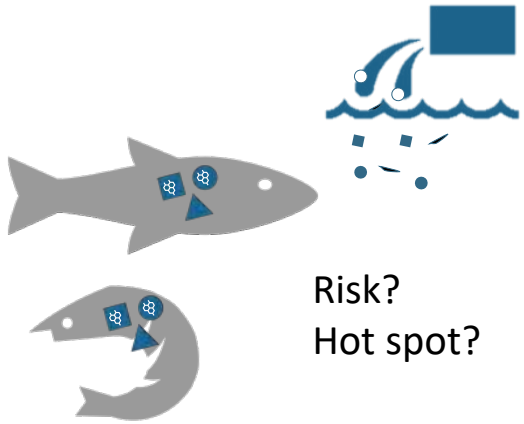

Suzuki et al. (2022) Environ Pollut




- Highlights
  - ✓ Mechanical recycling <u>"without wastewater treatment"</u> was a source of microplastics.
  - ✓ Effluent microplastic concentrations collected through a plankton net (pore size 315-µm) were from $1.1 \times 10^5$ to $2.0 \times 10^8$ MP particulates/$m^3$.
  - ✓ Annual microplastic emissions from facilities were from 0.014 to 5.8 t/year, which were comparable to total discharge from WWTPs in Denmark (3 t/year of MP in the size range of 10 to 500 µm).

# Challenge | Fate and behavior during recycling


**What should we do for environmentally sound recycling?**




**How harmful are microplastics in the worst case?**

- Future works
  - ✓ With mechanical recycling likely to increase as we move to a circular plastics economy, greater microplastics emissions can be expected.
  - ✓ To understand the scale of microplastic generation and release from plastic mechanical recycling as well as their environmental risk in the aquatic environment for the subsequent measures.

# Fate and behavior in the environment

# Motivation | Plastics degradation in the environment

Andrady. (2011) Mar Pollut Bull

**Are plastic litter in the environment major source of microplastic?**

- Plastic waste as microplastic sources
  - ✓ Significant stocks of plastics have already accumulated in aquatic environments.
  - ✓ Proportion of microplastics and nanoplastics to total marine plastics may continue to rise.
  - ✓ It is important to understand the fate and behavior of marine plastic litter to predict microplastic and nanoplastic generation in the environment.

# Content

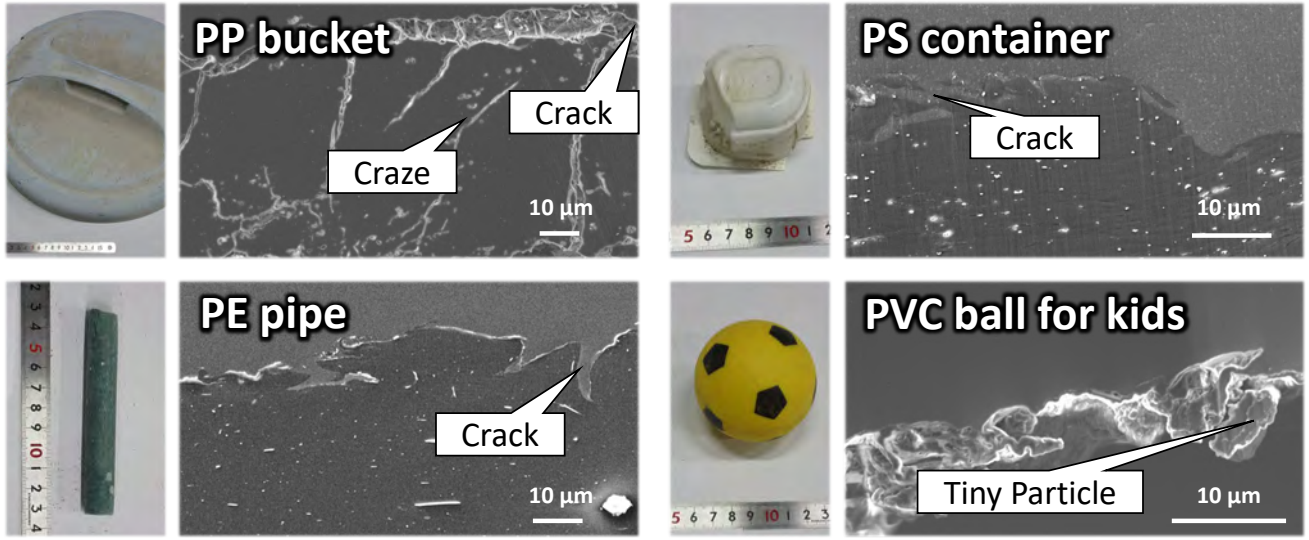
## Fate and behavior in the environment

- Study on “Fate and behavior of plastic litters in the environment” has been conducted since April 2021.
  - ✓ In communication with the Japan Plastic Industry Federation.
  - ✓ To investigate the mechanism and generation factors of microplastic due to plastic degradation in the environment.

# Content

## Fate and behavior in the environment

Takahashi et al. (Submitted)
Tanaka et al. Mar Pollut Bull (Accepted)

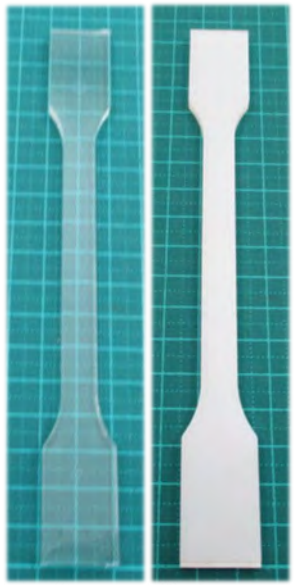



**What do these characteristics mean?**


**Are chemical composition related to plastic degradation?**

- Highlights
  - ✓ Internal structural changes of plastic litter were characterized using SEM/EDS, suggesting that degradation tendencies vary by polymer type.
  - ✓ FT-IR and GC-QMS measurement of microplastics revealed that PE and PP having phthalates and antioxidants tend to be detected.

# Challenge | Fate and behavior in the environment

**Test piece for plastic degradation**

**Accelerated UV tester**


**Outdoor weathering tester**

- Future works
  - ✓ Accelerated UV testing and outdoor weathering test for plastics will be useful for understanding mechanism of plastic degradation leading to microplastic generation.
  - ✓ To provide the mechanism and generation factors of microplastic due to plastic degradation in the environment.
  - ✓ To improve emission inventory of plastic waste for subsequent their control.

# Topics for upcoming researches

# Topic | Towards understanding importance of nanoplastic

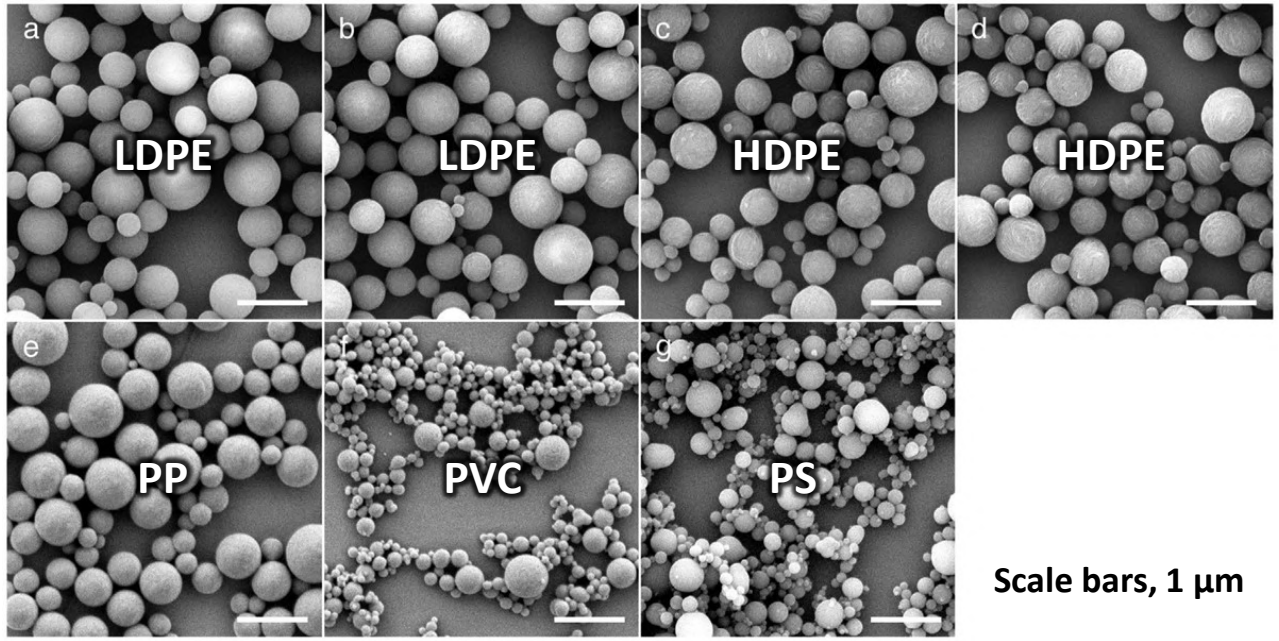
RESEARCH ARTICLE

small
www.small-journal.com

## Preparation of Nanoscale Particles of Five Major Polymers as Potential Standards for the Study of Nanoplastics

*Kosuke Tanaka,* Yusuke Takahashi, Hidetoshi Kuramochi, Masahiro Osako, Shunsuke Tanaka, and Go Suzuki*

Tanaka et al. (2021) Small



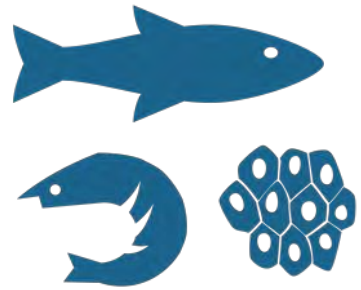

Scale bars, 1 µm

**Py-GC/MS analysis**

- ✓ Identification
- ✓ Quantification

**Hazard assessment**

- ✓ NOEC
- ✓ LOEC
- ✓ PNEC



➔ To conduct quantification of the concentrations of nanoplastics and evaluate their hazards.

# Topic | Towards understanding high-priority microplastic

National Institute for Environmental Studies, Japan

**Sampling**
- ✓ Ocean surface
- ✓ River surface
- ✓ Sediment
- ✓ Beach

**Physico-chemical evaluation**
- ✓ Size, shape, and color
- ✓ Polymer
- ✓ Degree of deterioration
- ✓ Additives content
- ✓ In vitro toxicity

**Exposure characterization**

**Monitoring of microplastics (5 µm to 5 mm)**

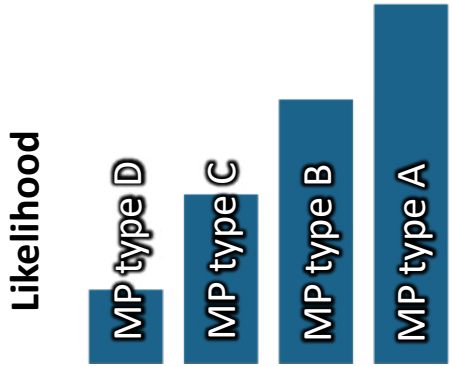
**Environmentally relevant microplastic**
- ✓ PP
- ✓ Tyre
- ✓ Fiber

**Preparation based on physico-chemical characteristics**
- ✓ Size, shape, and color
- ✓ Polymer
- ✓ Degree of deterioration
- ✓ Additives content
- ✓ In vitro toxicity

**Hazard characterization**

**Toxicity test of microplastics (5 µm to 300 µm)**

Polymer type? Size? Shape? What is the main cause? Deterioration? Hazardous chemicals?




**Priority microplastic based on ecological risk assessment**

➔ To propose high-priority microplastics based on ecological risk assessment.

# Acknowledgements | Collaborators


- National Institute for Environmental Studies

  Ms. UCHIDA Natsuyo, Ms. SHIBANUMA Naoko, Ms. MICHINAKA Chieko, Ms. YONEOKA Kyoko, Mr. NARITA Seiji, Mr. HASHIMOTO Seiichi

- 31 municipal institute for environmental studies

  Mr. ONO Osamu, Mr. ASAKURA Ken, Mr. ASANUMA Hideaki, Mr. KASAHARA Shogo, Mr. JINNO Kenichi, Mr. SATO Keishi, Mr. UNO Yusuke, Mr. MIZUI Ryota, Mr. SHIMIZU Akira, Mr. TSUTSUMI Katsuhiro, OISHI Osamu, Ms. SAKAMOTO Hiromi, Mr. NAKAYAMA Shunichi, Ms. WATANABE Tetsuko, Mr. ITO Akira, Mr. MORIMOTO Masatoshi, Ms. KONDO Emika, Mr. AIKO Nobuyuki, Mr. KASHIHARA Hiroyuki, Ms. MORI Ikuko, Mr. NAKAO Satoshi, Mr. FUJIWARA Yasuhiro, Mr. AKITA Kosuke, Ms. KIMURA Tomomi, Mr. URANISHI Katsuo, Ms. NITTA Nobuko, Mr. ARITA Masakazu, Mr. BABA Yasuhiro, Mr. OKI Takuya, Mr. NAKAHIRO Kenta, Mr. SHIMODA Yoshinori, Mr. KAJIWARA Takehiro, Mr. YOKOI Koji, Ms. TAKAHASHI Saki, Ms. KOGA Tomoko, Mr. TANIZAKI Joji, Mr. OISHI Hisashi, Mr. YOKOTA Tetsuro, Ms. SAKAGUCHI Misuzu, Mr. TAKEHARA Hirokazu, Mr. NISHIOKA Ryoki, Mr. FUKUDA Yoshihide, Mr. HIGA Yoshinori

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  No. 18KK0300

  No. JP21K17903

# Thank you very much for your kind attention!

If you have any questions, please feel free to contact me at g-suzuki@nies.go.jp.