12th Regional 3R and Circular Economy Forum, Jaipur, India
3-5 March 2025

Unveiling Microplastics Contamination in Thailand: Issues, Challenges and Solutions

Prof. Dr. Sandhya Babel

School of Biochemical Engineering and Technology,

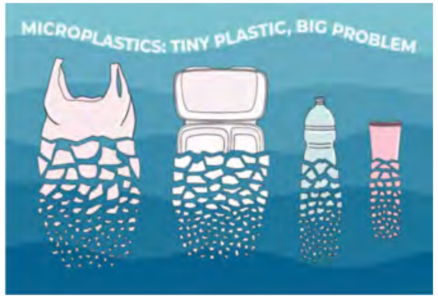
Sirindhorn International Institute of Technology, Thammasat University, THAILAND

Outline of Presentation

1 Plastic

- *What is plastic?*
- *Use and history of plastic*

2 Challenges with Plastics



Plastic to ***microplastic*** **(MP)**

- *How plastic become MP*
- *Exposure and pathways of MP*
- *Impacts of microplastics*

MP contamination in **drinking water**

MP abundance & removal **wastewater treatment** plant

MP in **mangrove forest** *(Bang Pu)*

3 Solutions

- Source Reduction
- Reuse and Recycling
- Circular economy
- Strategies and Policies

Plastics to microplastics

- Plastics are said to be the most versatile materials on earth. Almost all of the products we use in our daily lives contain plastics.
- Plastics break into smaller pieces and are transported through various environmental compartments

Photo degradation
Thermal degradation
Thermo oxidation
Biodegradation
Hydrolysis

+ Fragmentation

(Andrady, 2011)

Plastic-classification based on size

Mega-plastics
> 100 mm

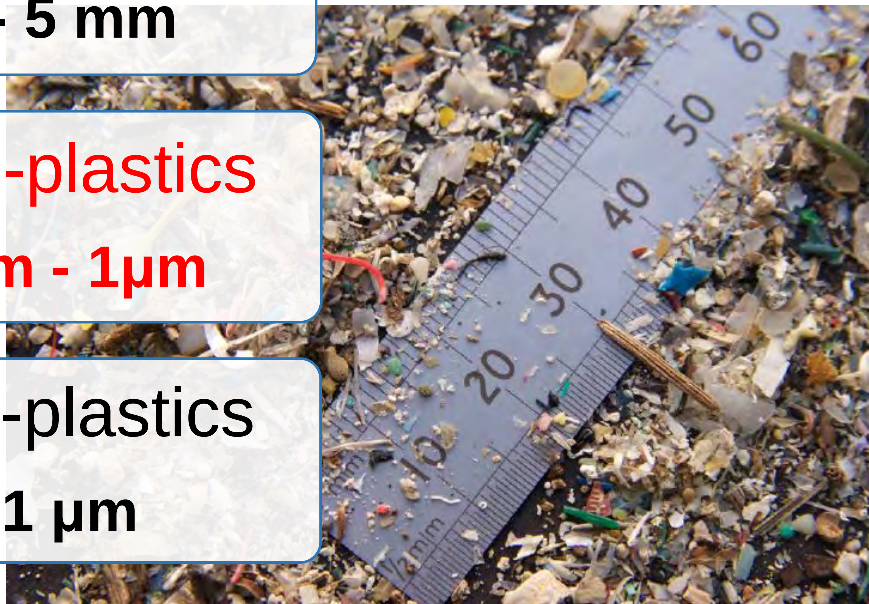
Macro-plastics
> 20 mm

Meso-plastics
20 - 5 mm

Micro-plastics
5 mm - 1µm

Nano-plastics
< 1 µm

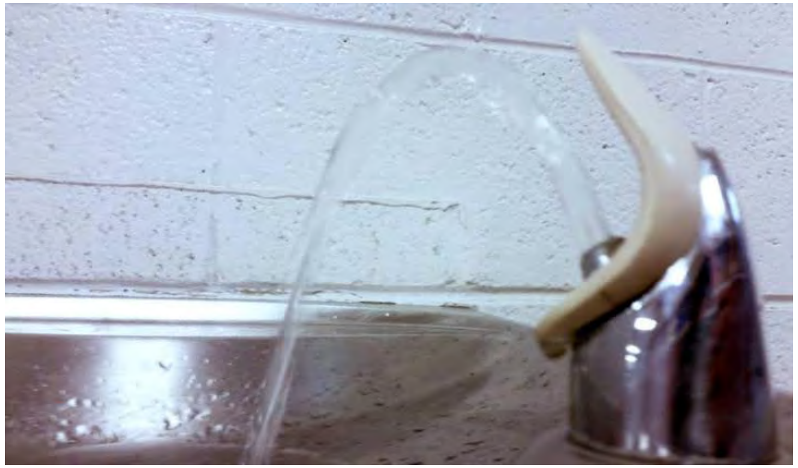
(GESAMP, 2015
Plastics Europe, 2017)



Microplastics in drinking water

Tap water-sampling events

Location	Sampling events (at 6 hour-intervals per day)		
	07:00 h	13:00 h	19:00 h
Green canteen	1L × 3	1L × 3	1L × 3
TU hospital	1L × 3	1L × 3	1L × 3
SIIT canteen	1L × 3	1L × 3	1L × 3
TSE canteen	1L × 3	1L × 3	1L × 3
SC canteen	1L × 3	1L × 3	1L × 3
Total sample volume = 45 L			



Bottled water samples

Brand	Case 1: Optical microscopic sorting	Case 2: Fluorescence microscopic sorting
Singha 8850999002675	2.64 L (330 mL × 8)	2.64 L (330 mL × 8)
Crystal 8851952350161	2.40 L (600 mL × 4)	2.40 L (600 mL × 4)
Chang 8851993338012	2.40 L (600 mL × 4)	2.40 L (600 mL × 4)
Mont Fleur 8851530111009	2.00 L (500 mL × 4)	2.00 L (500 mL × 4)
Evian 3068320055008	2.00 L (500 mL × 4)	2.00 L (500 mL × 4)
Minere 8850127006315	2.64 L (330 mL × 8)	2.64 L (330 mL × 8)
Namthip 8851959139714	2.20 L (550 mL × 4)	2.20 L (550 mL × 4)
H_2O 8854641002013	2.40 L (600 mL × 4)	2.40 L (600 mL × 4)
Volvic 3057640100178	3.00 L (1500 mL × 2)	3.00 L (1500 mL × 2)
Nestle Pure Life 8850124003850	2.40 L (600 mL × 4)	2.40 L (600 mL × 4)
Sprinkler 54010547250111	9.45 L (945 mL × 10)	9.45 L (945 mL × 10)
Singha 88509992220000	1.65 (330 mL × 5)	1.65 (330 mL × 5)
Chang 8851994612012	1.65 (330 mL × 5)	1.65 (330 mL × 5)
Perrier 3179730010041	1.65 (330 mL × 5)	1.65 (330 mL × 5)
Total sample volume	36.08 L	36.08 L

Plastic

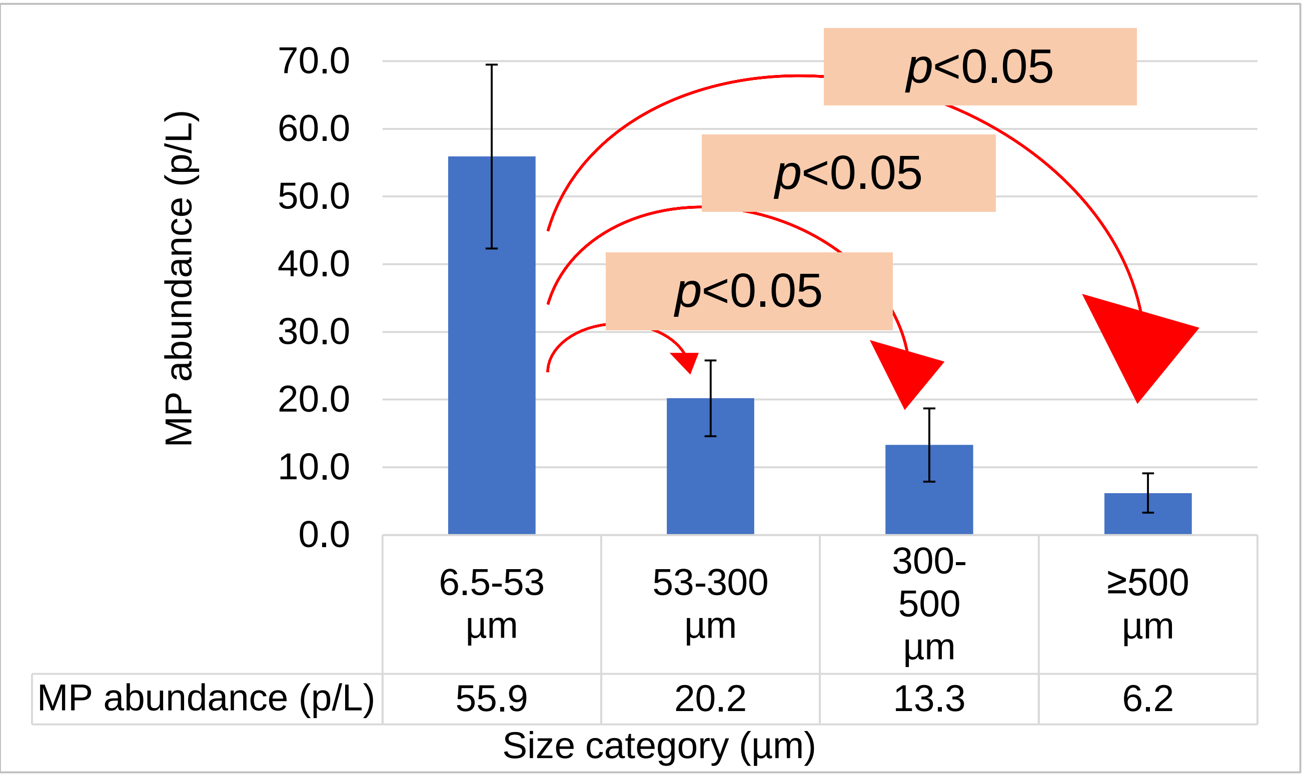
Glass



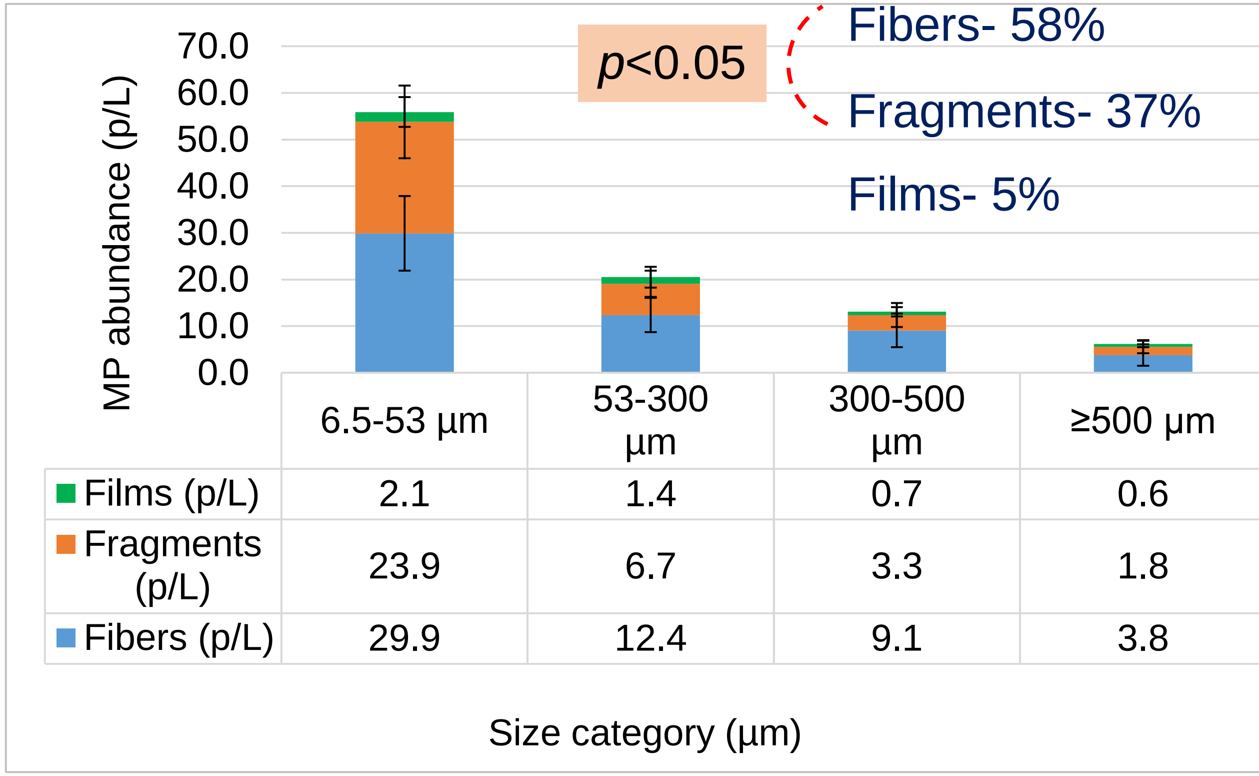


MP abundance in tap water

Size-based



Morphology-based

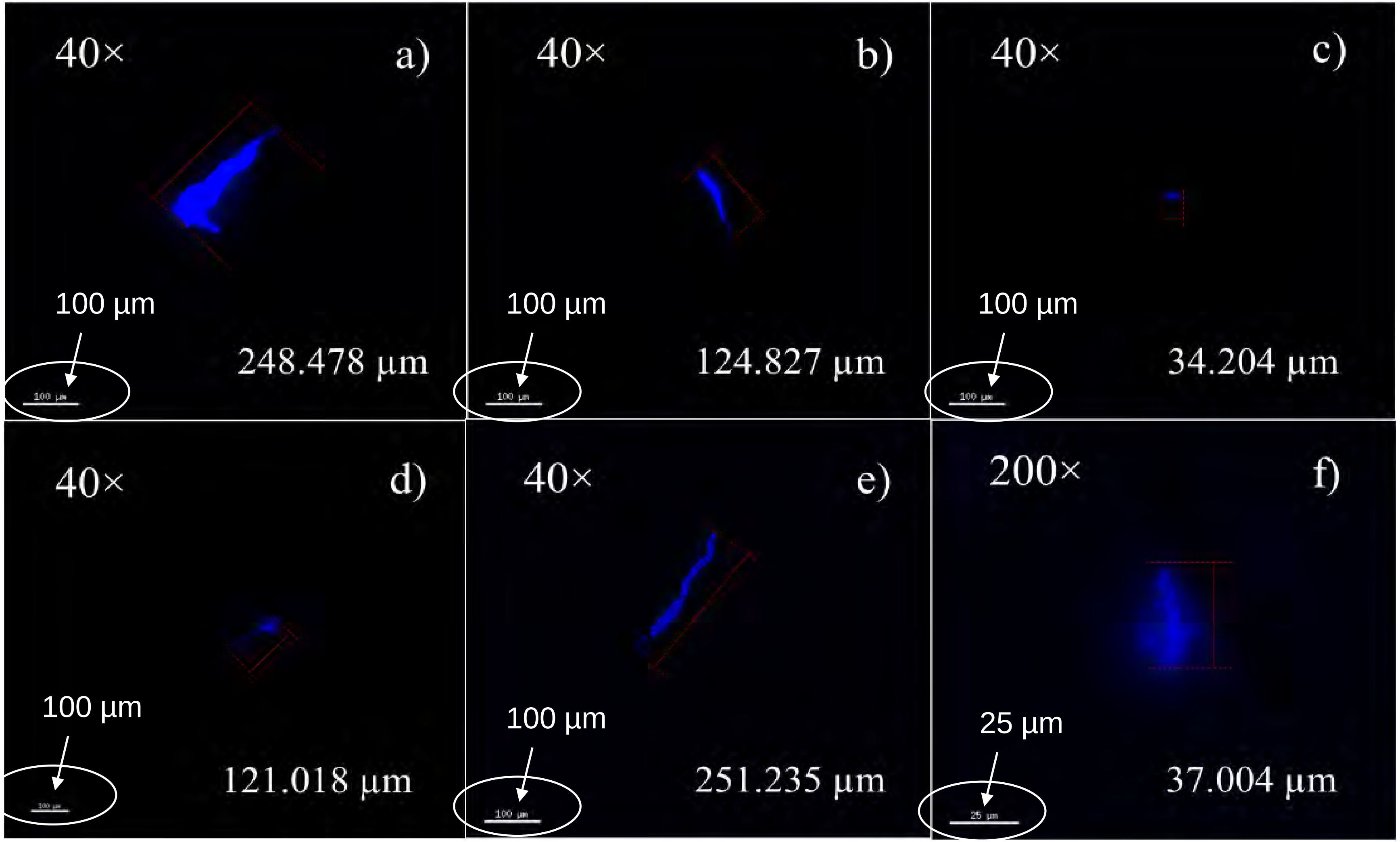


Average MP concentration in tap water = 95.4±8.9 p/L

- The 6.5-53 µm fraction reported the highest MP number, significantly exceeding other size categories ($p < 0.05$).
- Fiber MPs comprise nearly 58% of the total MPs, a significantly higher proportion than fragments and films ($p < 0.05$).

Kankanige, D. & Babel, S., Journal of Water Process Engineering (2021): 101765

Nile Red-tagged MPs - 6.5-300 µm



DAPI filter; excitation- 390/18 nm; emission- 435/48 nm

Carbon-resin filters (AQUA GUARD, double-column)

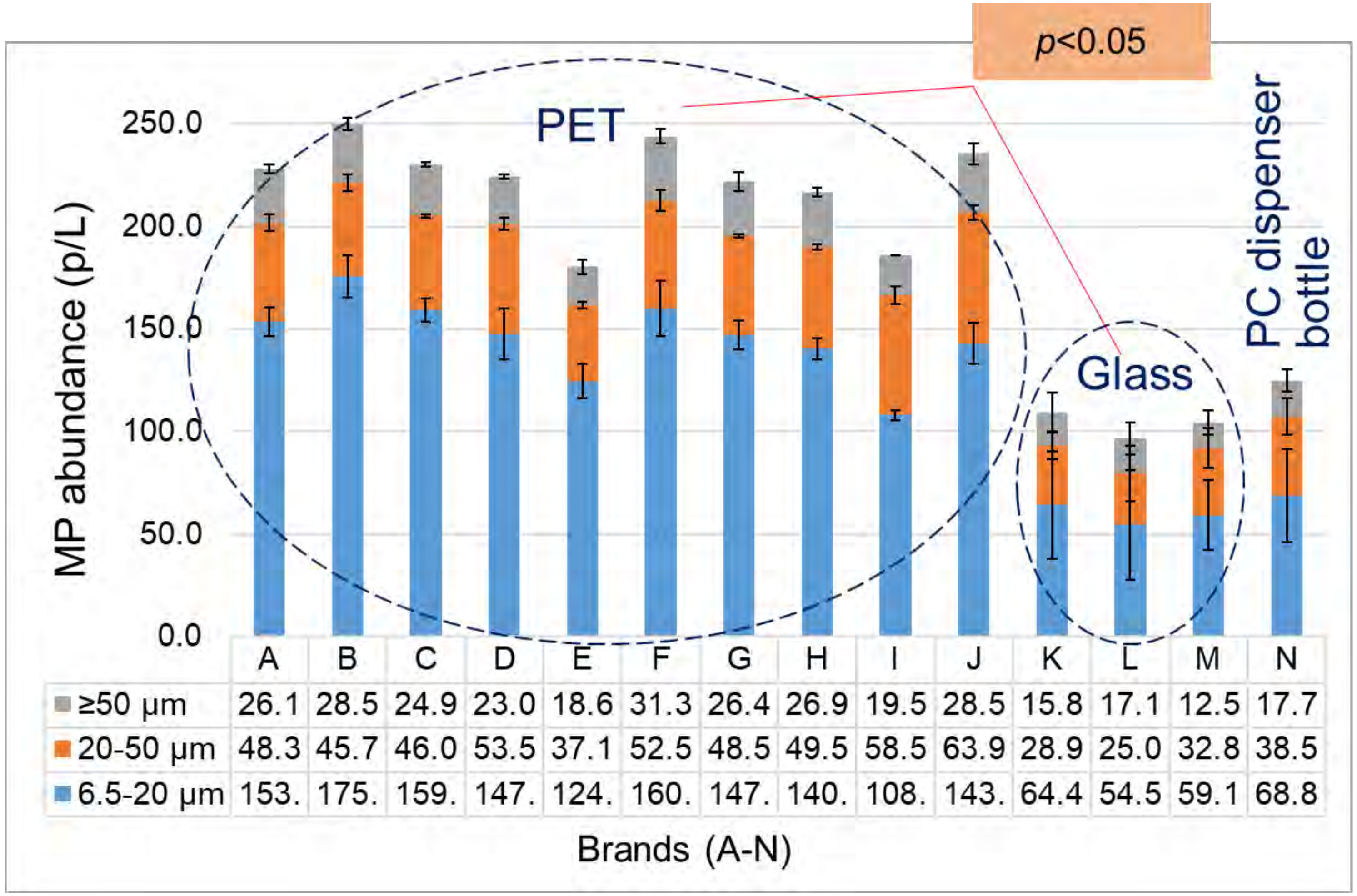
Green canteen	80 ± 22 p/L
TU hospital	92 ± 21 p/L
TSE canteen	102 ± 23 p/L
SC canteen	100 ± 26 p/L
SIIT canteen	104 ± 26 p/L

Filtered water showed high number

1. Filters did not contribute to reduction
2. Further contamination from the pipe/filter may have occurred

MP abundance in bottled water

Kankanige, D. & Babel, S. (2020). Science of the total environment, 137232



6	
2(	
≥5	

MP concentration significantly increases with decreasing size

Single-use PET	222±21 p/L
PC dis bot	
Pla bottled water	213±35 p/L
Glass-bottled water	103±5 p/L

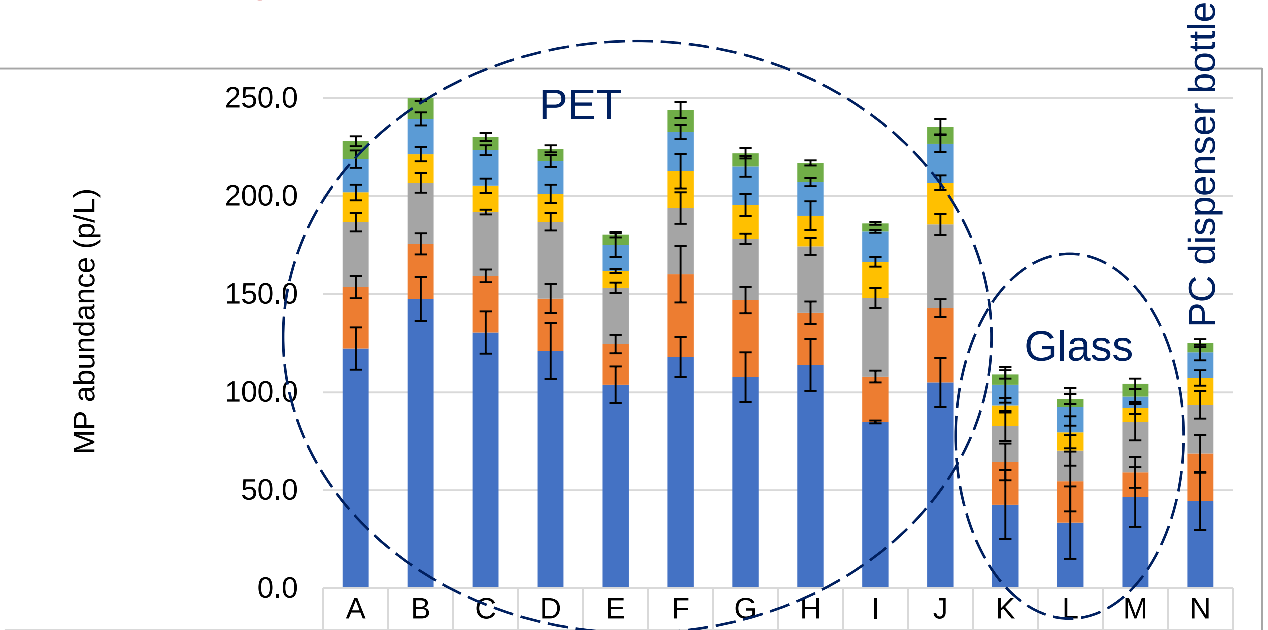
p<0.05

p<0.05

Packaging plays a significant role in MP contamination

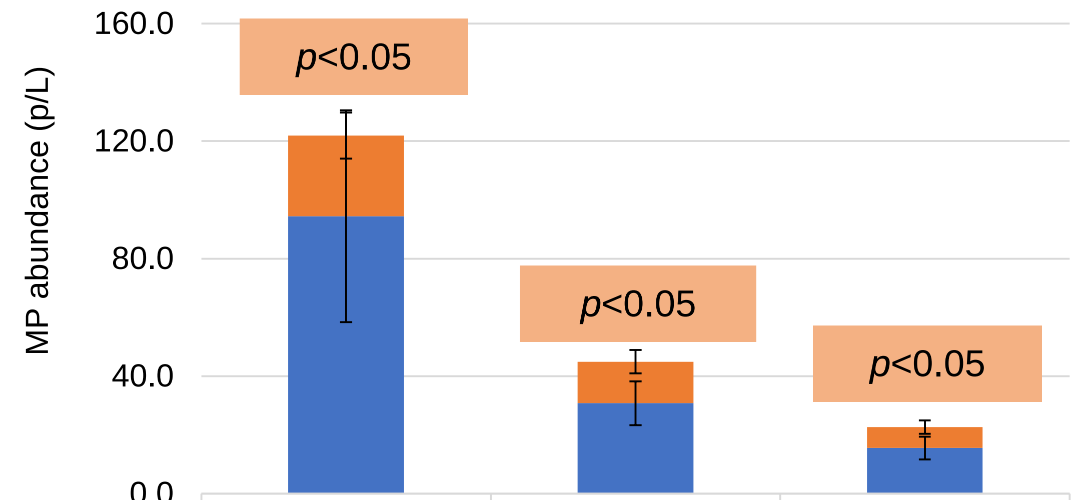
- **Average MP concentration in bottled water = 190±54 p/L**
- MPs in size range of 6.5–20 µm was significantly higher than other size ranges

Morphology-based MP abundance in bottled water



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
≥50 µm Fragments	9.1	10.5	6.8	6.2	5.4	11.3	6.8	9.8	4.1	8.6	5.3	3.9	6.6	4.7
≥50 µm Fibers	17.0	18.0	18.1	16.8	13.2	20.0	19.6	17.1	15.5	19.9	10.5	13.1	5.9	13.0
20-50 µm Fragments	15.2	14.7	13.4	14.2	8.5	18.7	17.3	15.6	18.5	21.3	10.5	9.2	7.2	13.7
20-50 µm Fibers	33.1	31.0	32.6	39.2	28.7	33.8	31.2	33.9	40.0	42.7	18.4	15.8	25.6	24.8
6.5-20 µm Fragments	31.3	28.2	28.8	26.7	20.7	42.2	39.3	26.5	23.2	37.9	21.7	21.0	12.5	24.4
6.5-20 µm Fibers	122.	147.	130.	121.	103.	118.	107.	114.	84.8	105.	42.7	33.5	46.6	44.4

Brand (A-N)



	6.5-20 µm	20-50 µm	≥50 µm
Fragments	27.5	14.1	7.1
Fibers	94.4	30.8	15.6

Size fraction

Fibers	141±45 p/L	**76%**
Fragments	49±13 p/L	24%

Fibers show a significant dominance in bottled water samples

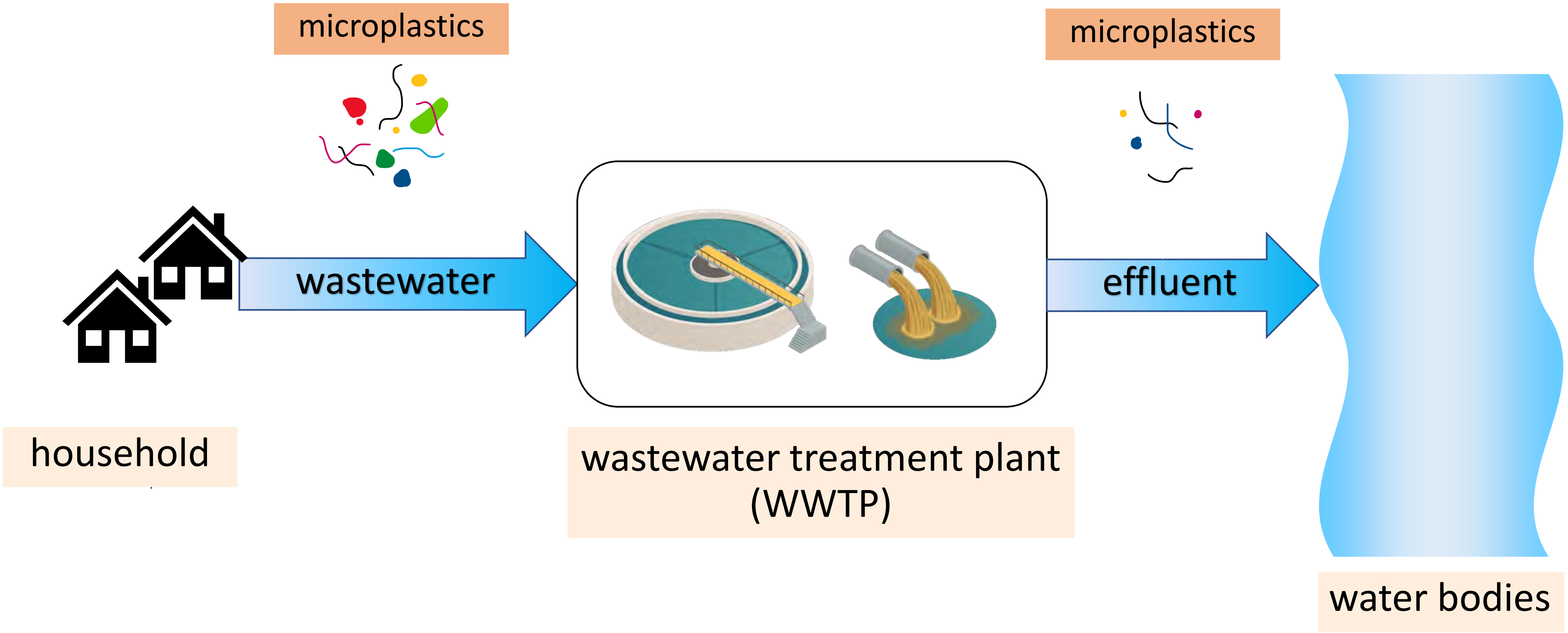
Kankanige, D., & Babel, S. (2020). Science of the total environment, 137232

Polymer distribution based on FT-IR analysis

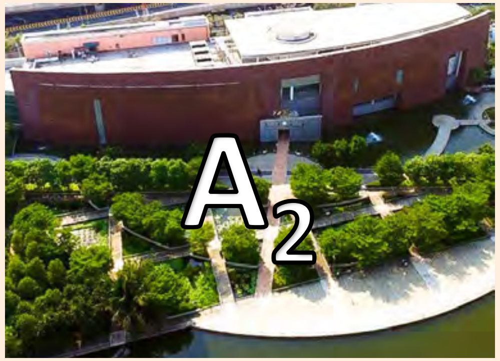
Nile Red-tagging (≥50 μm)		Optical microscopy (≥50 μm)	
Polyethylene terephthalate- 33.5%	Teflon- 4.9%	Polyethylene terephthalate- 33.6%	Teflon- 4.8%
Polypropylene- 16.9%	Cellophane- 3.5%	Polypropylene- 16.7%	Rutile- 4.5%
Polyethylene- 16.68%	Polyvinyl fluoride- 2.2%	Polyethylene- 16.2%	Polysilicate- 2.0%
Polyamide- 6.6%	Bakelite- 2.1%	Polyamide- 6.7%	Polyvinyl fluoride- 1.1%
Rutile- 6.4%	Polymethyl methacrylate- 1.2%	Cellophane- 5.8%	Copolymers- 0.7%
Polyvinyl chloride- 5.2%	Copolymers:	Polyvinyl chloride- 5.0%	-
Identification rate: 41.8% (331/792 particles)		Identification rate: 52.3% (590/1128 particles)	

PET was found to be dominant, followed by PE, PP, and PA

Wastewater treatment plant as a pathway of microplastics



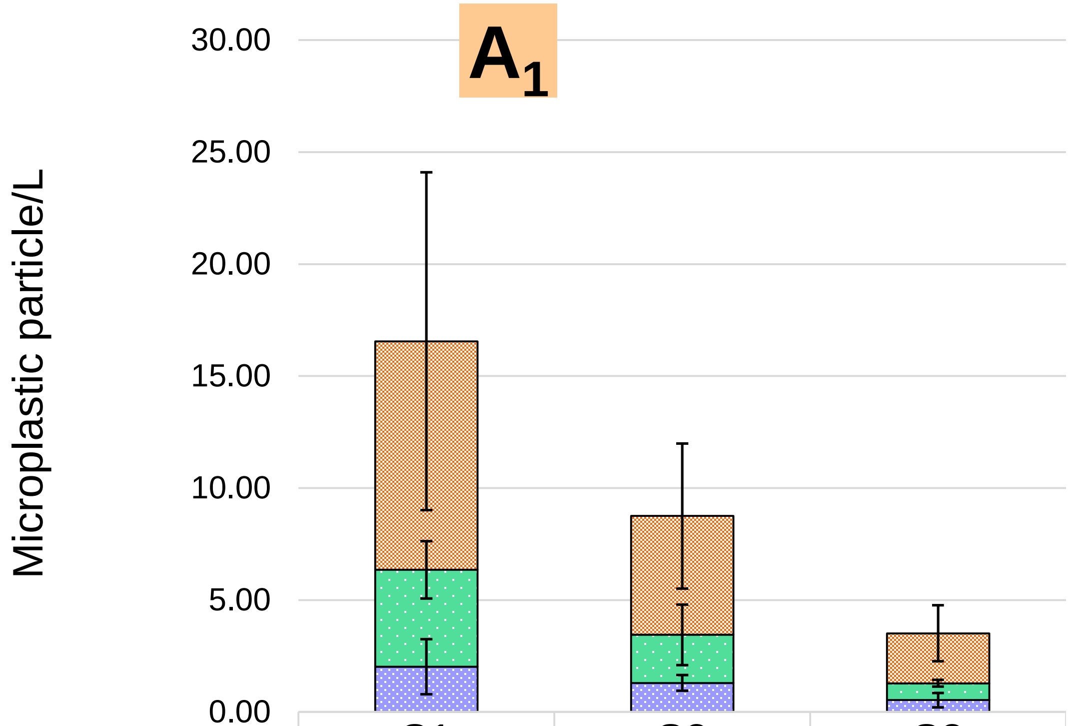
Study sites

Wastewater treatment plant (WWTP)	Treatment capacity (m^3/day)	Population served	Treatment technology
	350,000	1,080,000	Biological activated sludge
	120,000 (dry season) 300,000 (rainy season)	227,660	• Anaerobic-anoxic-oxic (A^2O) with a pilot-scale ultrafiltration (UF) • Closed underground system

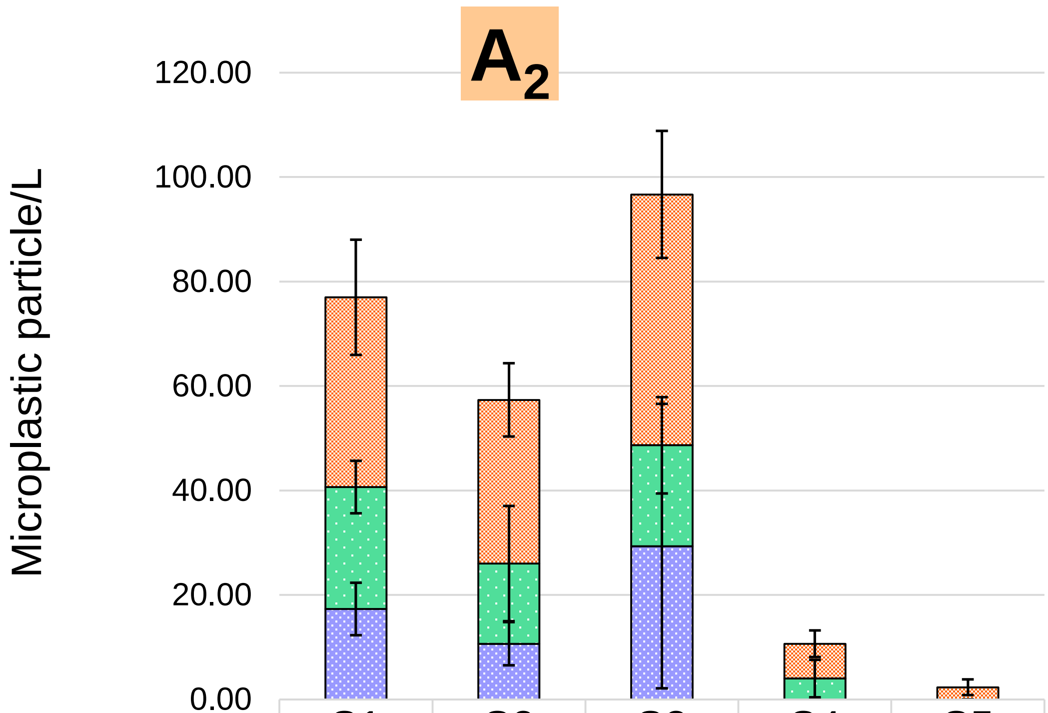
A1 – Din Daeng WWTP

A2- Bang Sue WWTP

Microplastic abundance based on size fractions



	S1	S2	S3
0.05 - 0.5 mm	10.2	5.3	2.23
0.5 - 1 mm	4.33	2.15	0.75
1 - 5 mm	2.02	1.3	0.53

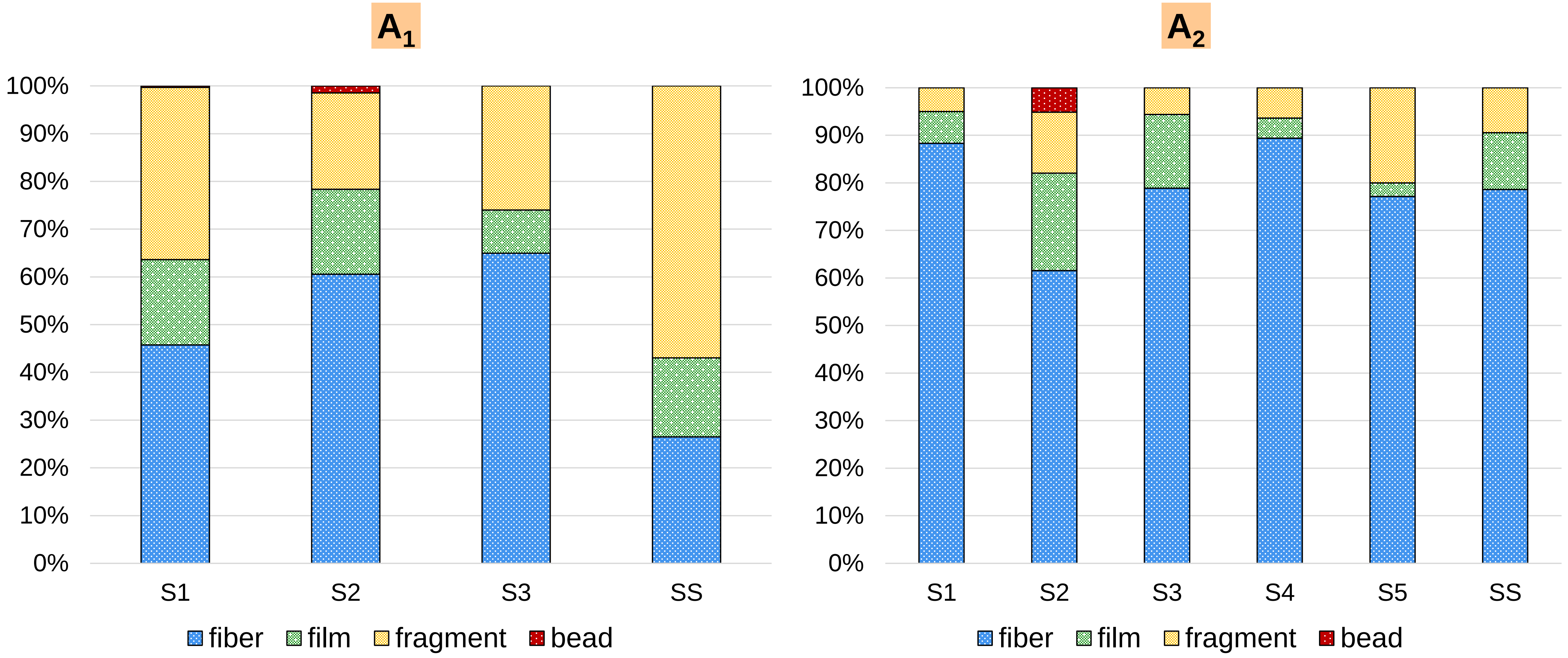


	S1	S2	S3	S4	S5
0.05 - 0.5 mm	36.33	31.33	48.00	6.67	2.33
0.5 - 1 mm	23.33	15.33	19.33	4	0
1 - 5 mm	17.33	10.67	29.33	0	0

- The group of 0.05-0.5 mm MPs was the most abundant.
- Bang Sue completely removed 1-5 mm MPs after final clarification and 0.5-1 mm MPs after the UF unit.

Tadsuwan, K., & Babel, S. (2022). Chemosphere, 135733.

Percentage distribution of shapes



- **Fibers** were the most dominant group and the most difficult type to remove from wastewater.
- Fibers were found to escape with final effluents even from the UF unit.

Summary - Microplastic removal by treatment units

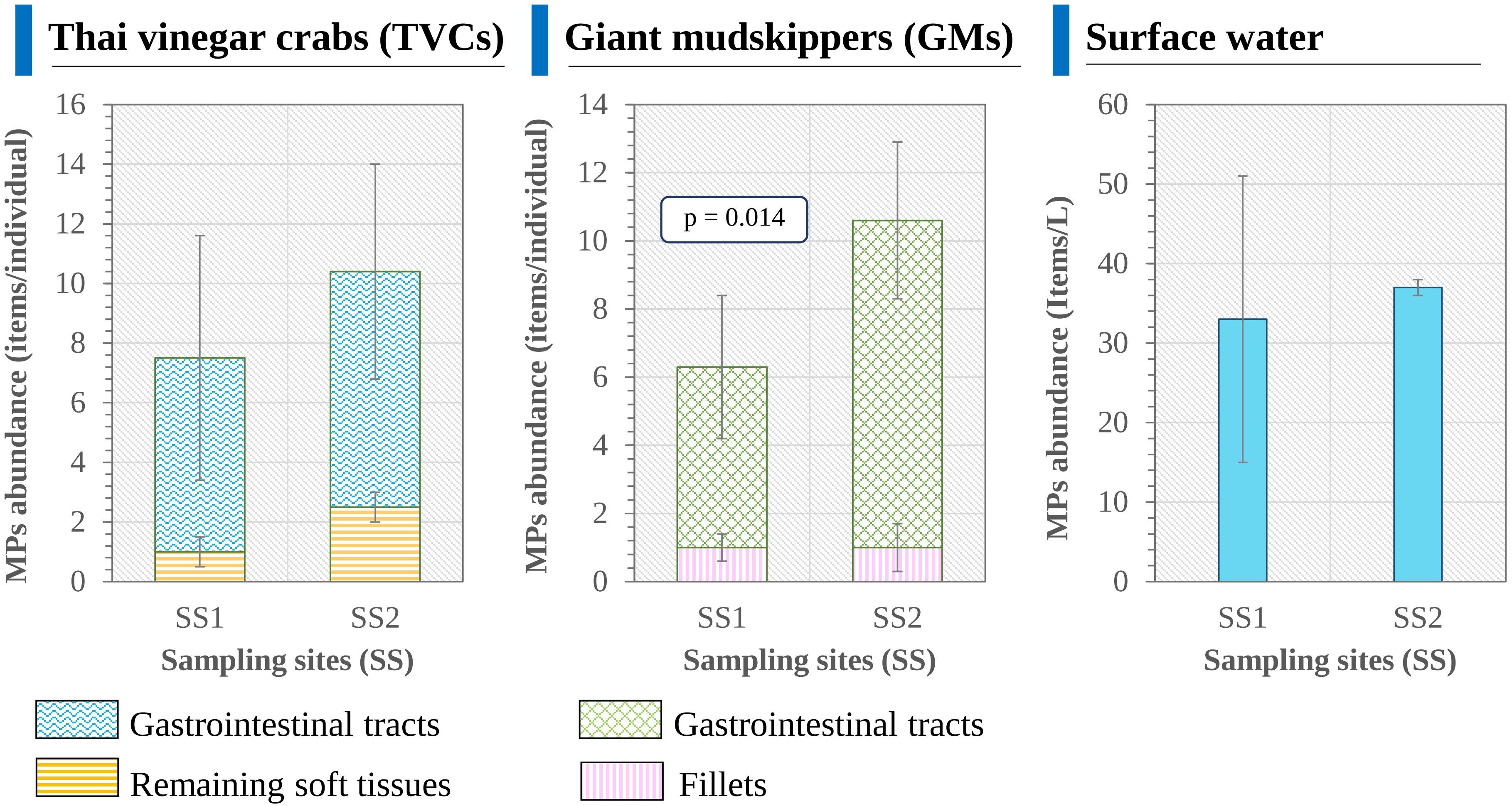
WWTPs	MPs removal efficiency (%)						
	Influent	After grit	Aeration tank (A^2O)*	Effluent from final clarifier	Effluent from UF	Overall	MPs discharge to the environment (million MPs/day)
A_1	-	47.13	-	59.77	-	78.73	**1,231**
A_2	-	25.55	-	81.91	78.16	86.14 (96.97)**	**1,280** **(280)[a]**

*A^2O in A2
** Removal efficiency with UF unit
a - effluent of UF

Microplastics abundance (Banpu Mangrove forest)

- o **TVCs** → 7.5 ± 3.8 to 10.4 ± 3.9 items/individual
- o **GMs** → 6.3 ± 2.3 to 10.6 ± 2.6 items/individual
- o **Surface water** → 33 ± 18 to 37 ± 1 items/L

- ▶ MPs were detected in all samples.
- ▶ Contamination level in SS2 was higher than in SS1.
- ▶ MPs were found in edible tissues of both species (Remaining soft tissues of TVCs and fillets of GMs)



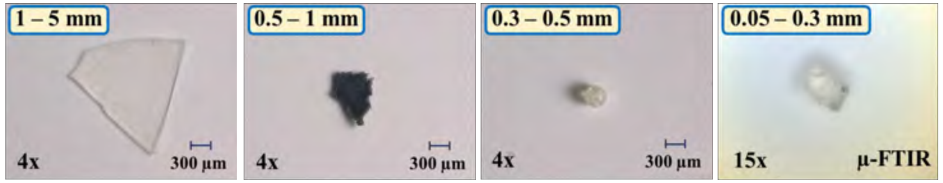
Jittalerk, R., & Babel, S. (2024) Marine Pollution Bulletin, 115849.

Size distribution

Predominant sizes
- **0.3 – 0.5 mm**
- **0.05 – 0.3 mm**

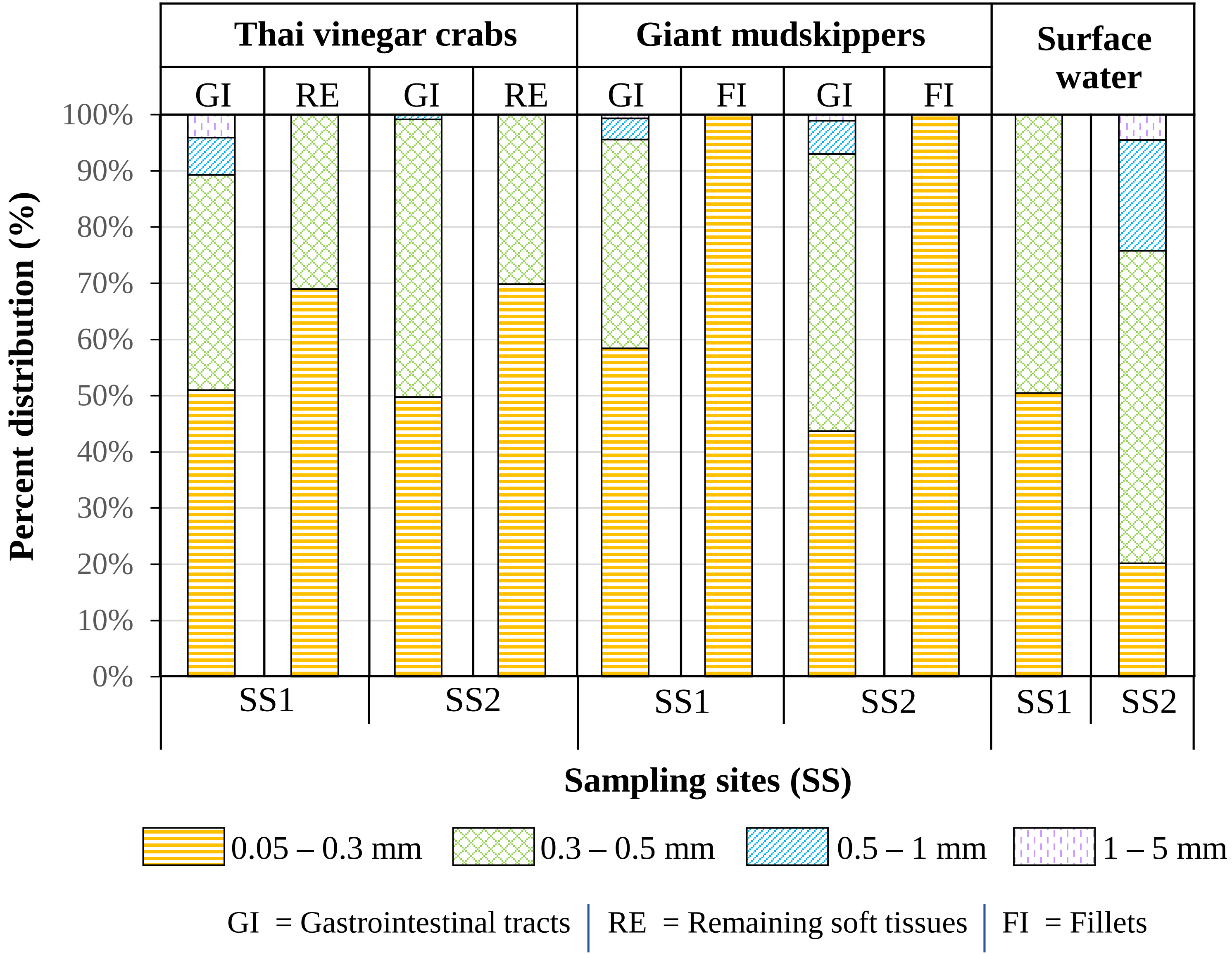
▌ Four size ranges detected.

▌ Only small-size microplastics (0.05 – 0.3 and 0.3 – 0.5 mm) were found in remaining soft tissues and fillets.



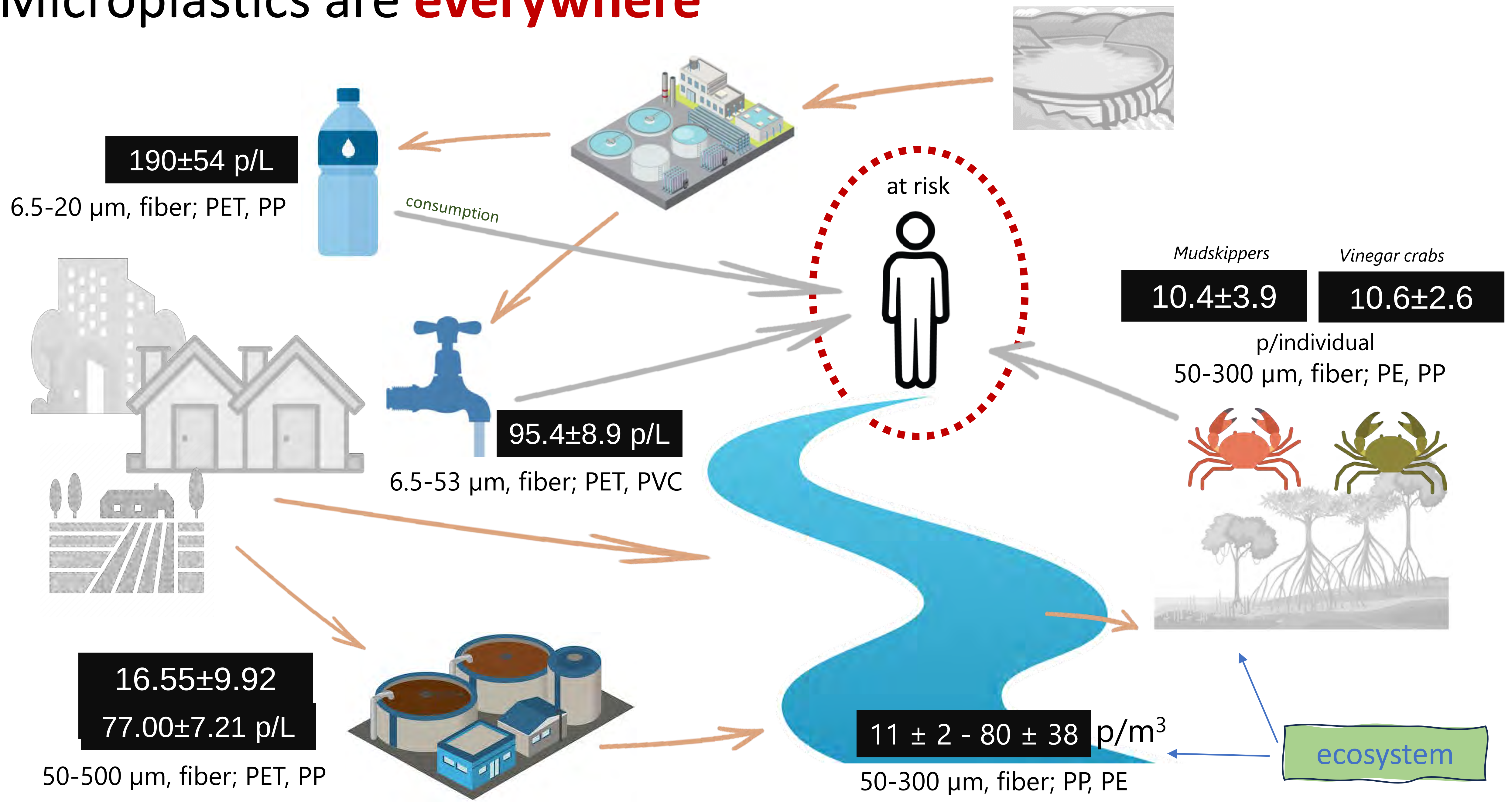
Possible reasons

- Weathering process (Ta & Babel, 2020)
- Animal activities, such as biting, burrowing, or leaf shredding (Harada & Lee, 2016)
- Biofilm formation (Yan et al., 2021)



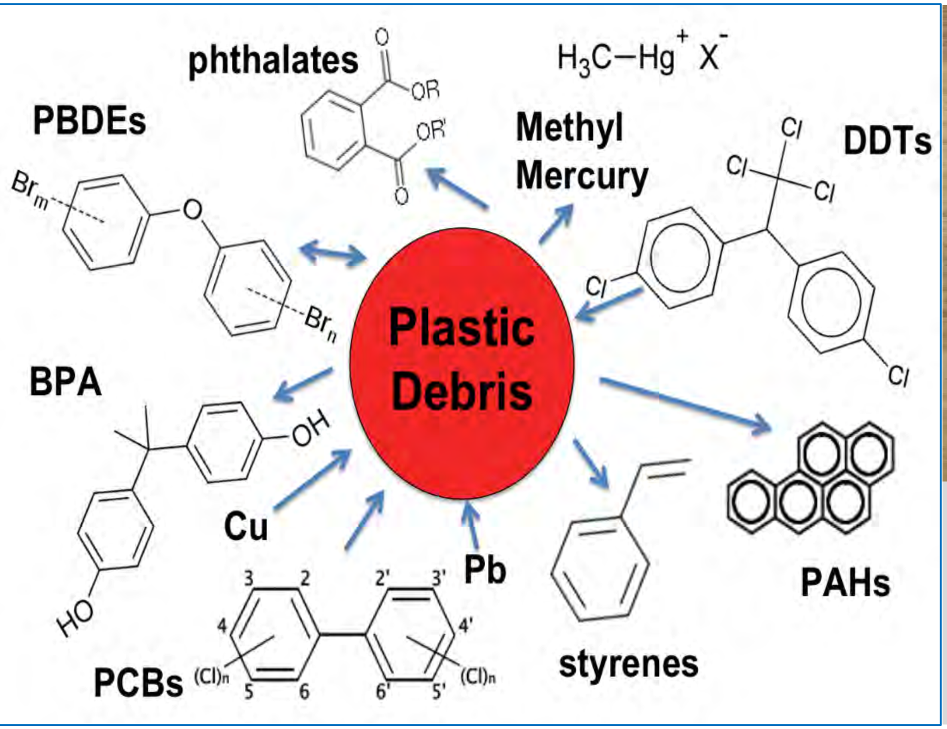
Jittalerk, R., & Babel, S. (2024) Marine Pollution Bulletin, 115849.

Microplastics are **everywhere**

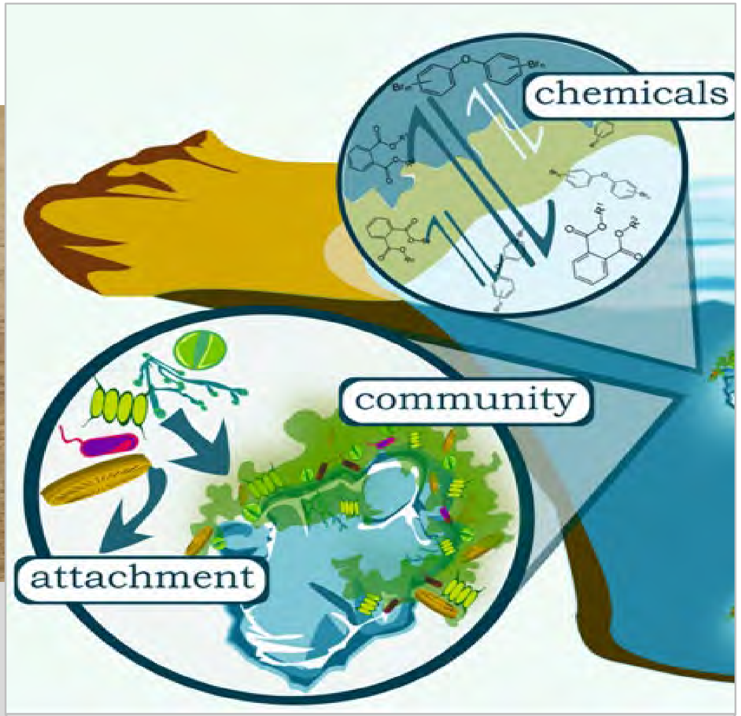


How can microplastics be a threat?

- 8 M t of plastic enter ocean/year. At present, 50 M t of plastics.
- By 2050, weight of plastics will be more than fish.
- 15% of the marine species affected by ingestion and entanglement of plastic litter are endanger.
- 24.4 trillion MPs on ocean surface

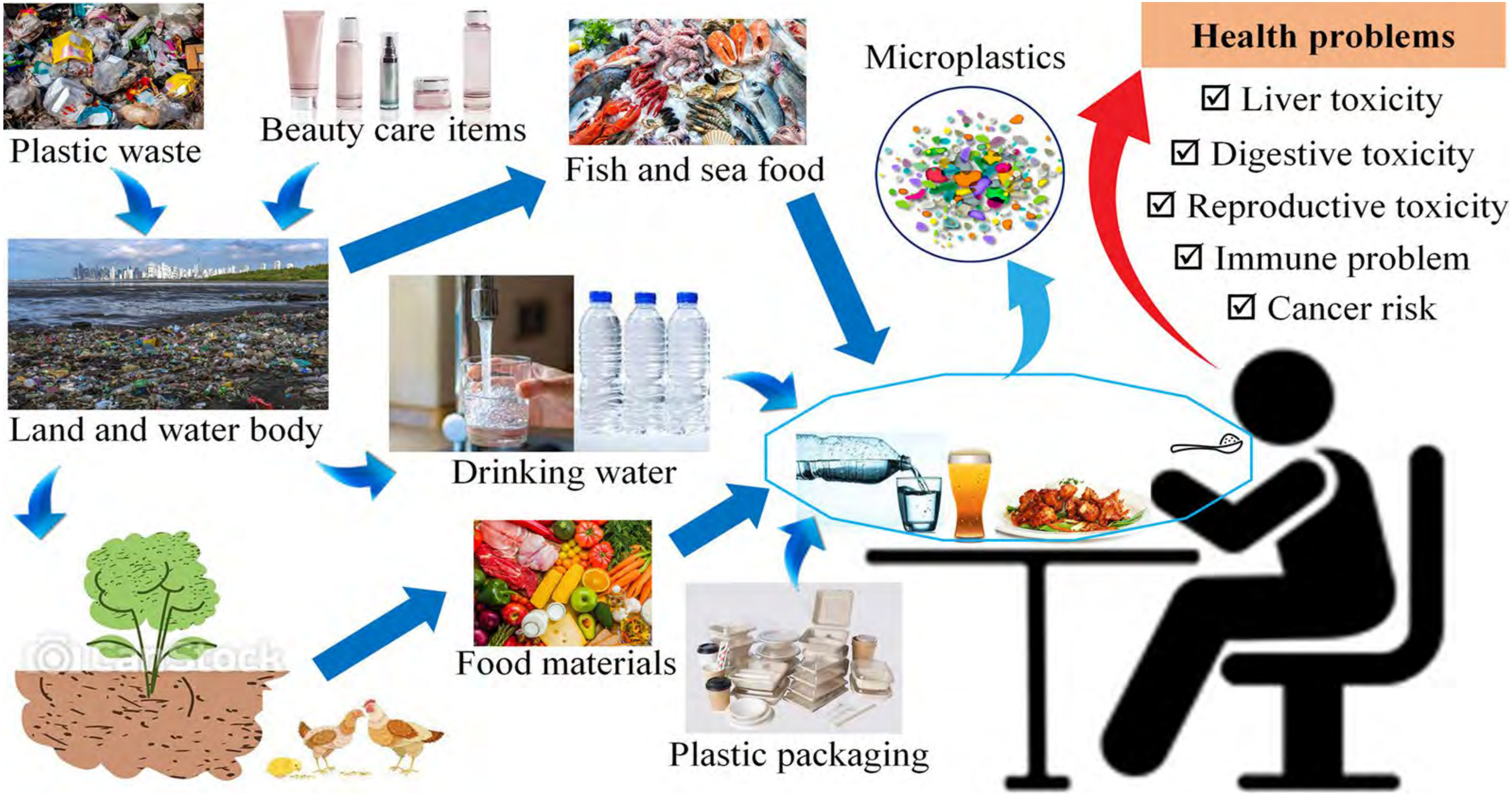


A rainbow runner ingested by microplastic fragments (FAO, 2017)



Carrier of pathogens
(Rummel, et al. 2017)

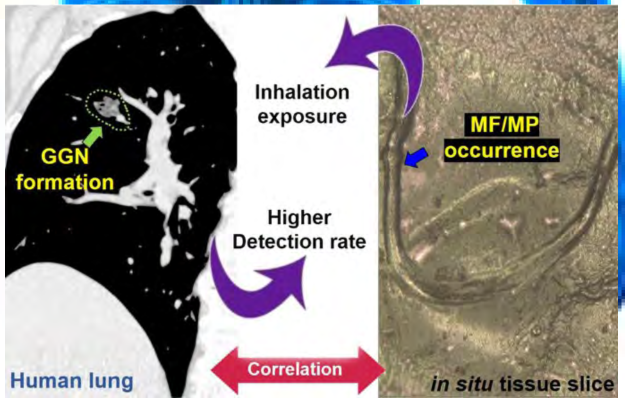
Microplastics in human food chains



(A.A. Mamun et al. 2023)


Plastics
Microplastics found in human blood for first time
Exclusive: The discovery shows the particles can travel around the body and may lodge in organs

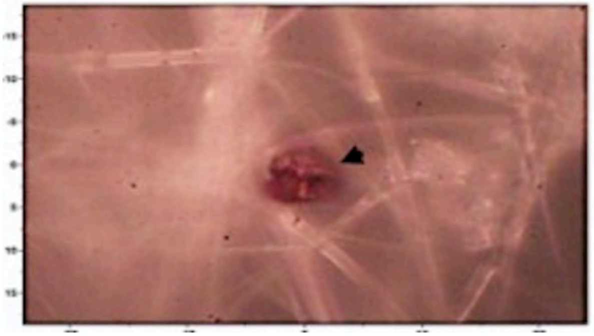
GGN - Ground glass nodule



(Bhuyan, Md Simul., 2022)

Each organ may contain 300-600 µg/gm
Adult brain – 5-10 gm of plastics (size of a spoon)
Microplastics in blood vessels – potential heart attacks

MPs in Human Placenta

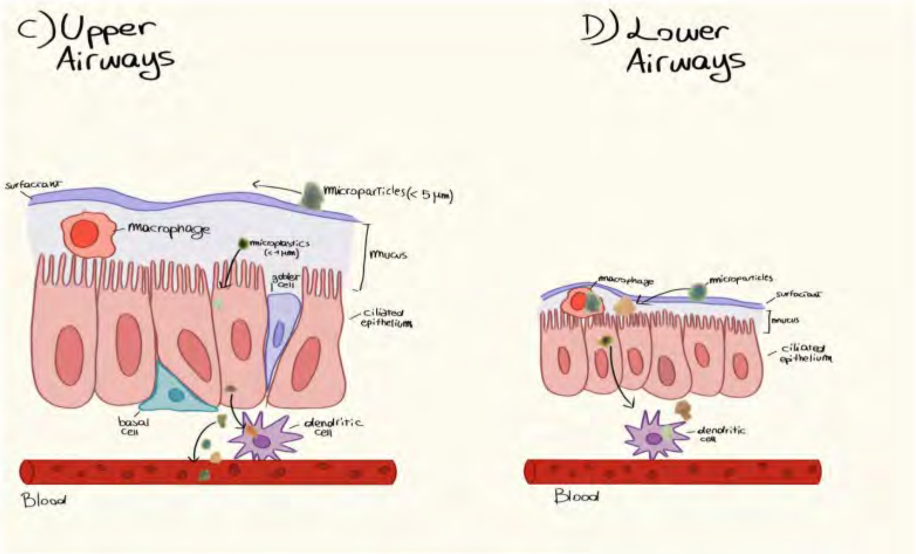


The Washington Post
Democracy Dies in Darkness

Microplastics have been found in breast milk. Will that hurt my baby?

Contaminants, including pesticides, are showing up, too. Is the breast-is-best saying now wrong?

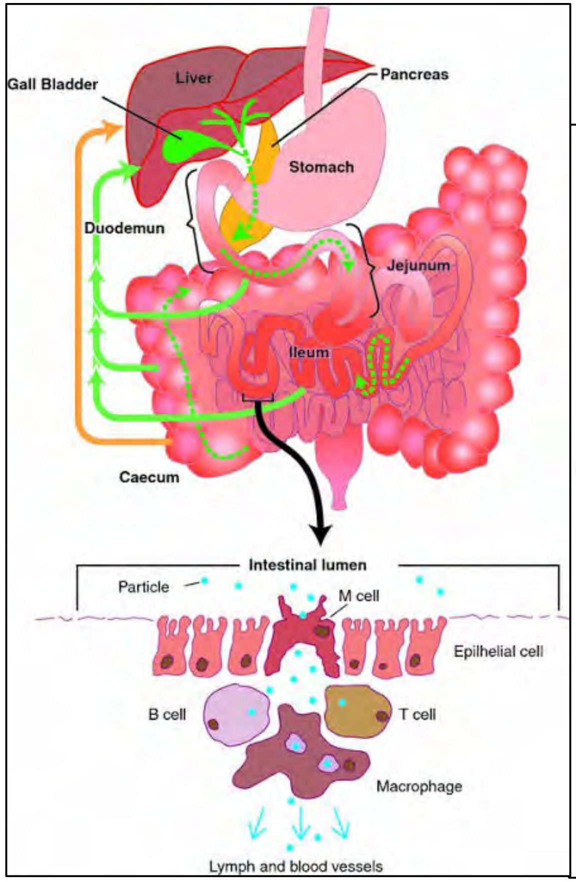
By Jillian Pretzel
February 5, 2024 at 7:00 a.m. EST



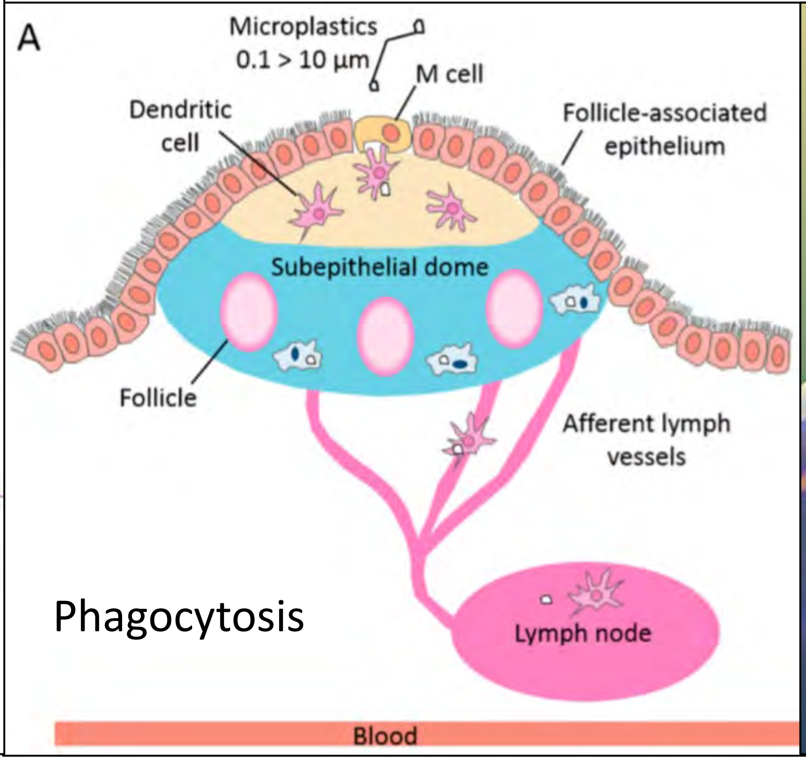
Possible ways of entry and transport of the MPs from the respiratory and gastric organs to the placenta (Ragusa et al., 2021)

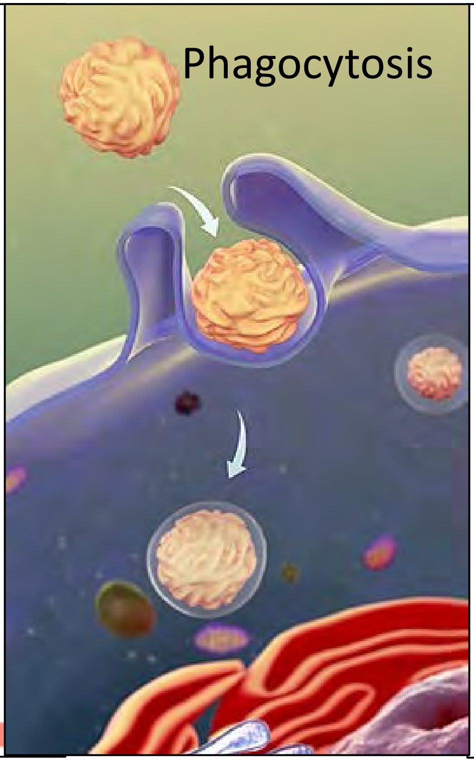
As for microplastics, a small 2022 study found tiny plastic particles, less than five millimeters in diameter, in 75 percent of 34 breast milk samples studied (Previous studies found microplastics in placentas, heart tissue and blood.)

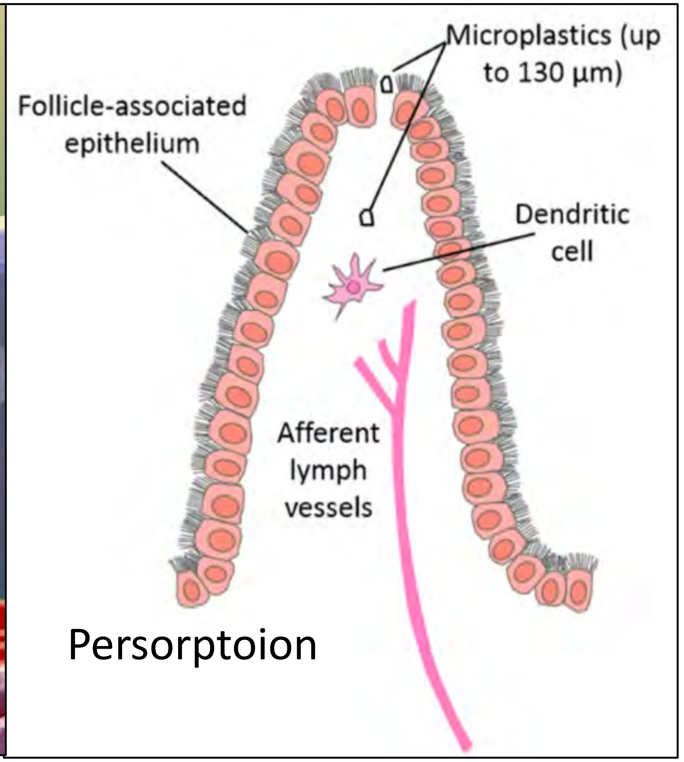
MP uptake by Gastro-intestinal Tract (GIT)



MP uptake from GIT: Predicted pathway *Wright & Kelly (2017). En. Sci. & Tech.*







GIT is the most vulnerable site (WHO, 2019). Cellular uptake of MPs occurs by two mechanisms: Phagocytosis and per-sorption (Wright & Kelly, 2017; En. Sci. & Tech.). MPs that translocate to lymphatic & circulatory system via cells in GIT, can accumulate in secondary organs (liver, spleen, kidneys). This translocation efficiency increases with decreasing size. (Wright & Kelly, 2017).

Plastics are an **integral** and **important** part of the Thai economy

Petrochemical sector is the largest in Southeast Asia and the 16th largest in the world, producing 11.8 million tonnes of downstream products — including plastic resins — in 2018.

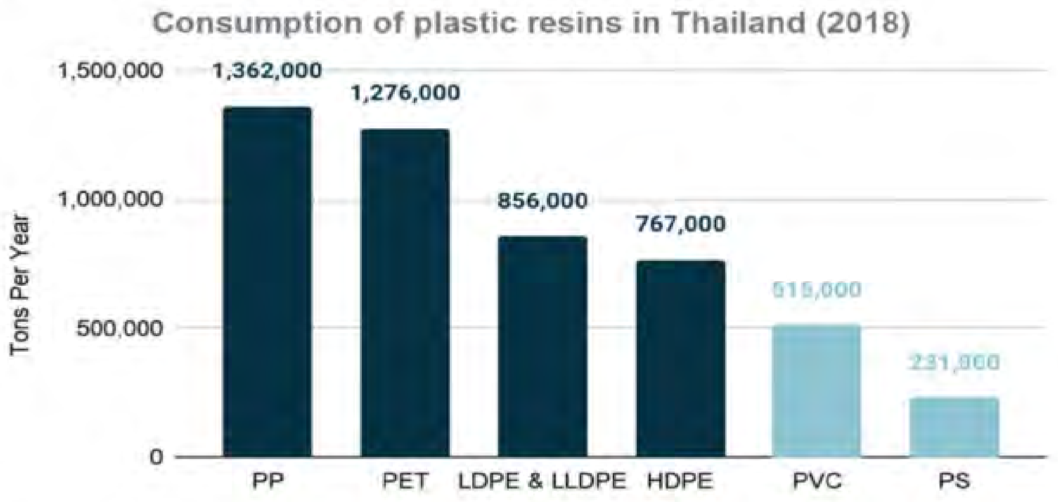
Plastic waste makes up **12%** of Thailand's total waste, around **2 million tons** annually *(ESCAP)*.

Asia is responsible for over **80% of plastic leakage** into marine environments

Thailand is the **sixth-largest** marine plastic polluter (*SEA Circular)*.

Figure 6.

BREAKDOWN OF RESIN CONSUMPTION IN THAILAND FOR 2018 (BEFORE ACCOUNTING FOR PRODUCT LIFESPANS AND IMPORT / EXPORT OF SEMI-FINISHED PRODUCTS)



Source: Plastics Institute of Thailand

26 | Market Study for Thailand: Plastics Circularity Opportunities and Barriers

Thailand Policy-Driven Strategies for Plastic Waste Reduction

Source Reduction: Reducing plastic waste through better design, efficient production, and responsible consumption.

Reuse and Recycling: Extending the life of plastics by reusing products and converting waste into new materials.

Eco-friendly Material Substitution: Replacing traditional plastics with biodegradable or sustainable alternatives.

Thailand's Plastic Waste Management Policies

Thailand integrates plastic waste management into public policies through a three-level strategic plan *(Jirapornvaree et al., 2023)*:

- **First-level Plan:** **National Strategy (2018–2037)** focuses on biodiversity and environmental sustainability *(National Strategy Secretariat Office)*.
- **Second-level Plan:** **The 13th Development Plan (2023–2027)** promotes a circular economy and low-carbon society *(NESDC, 2023)*.
- **Third-level Plan:** **Roadmap on Plastic Waste Management (2018–2030)** provides a framework for plastic waste prevention and management *(PCD)*.

(NESDC, 2023)

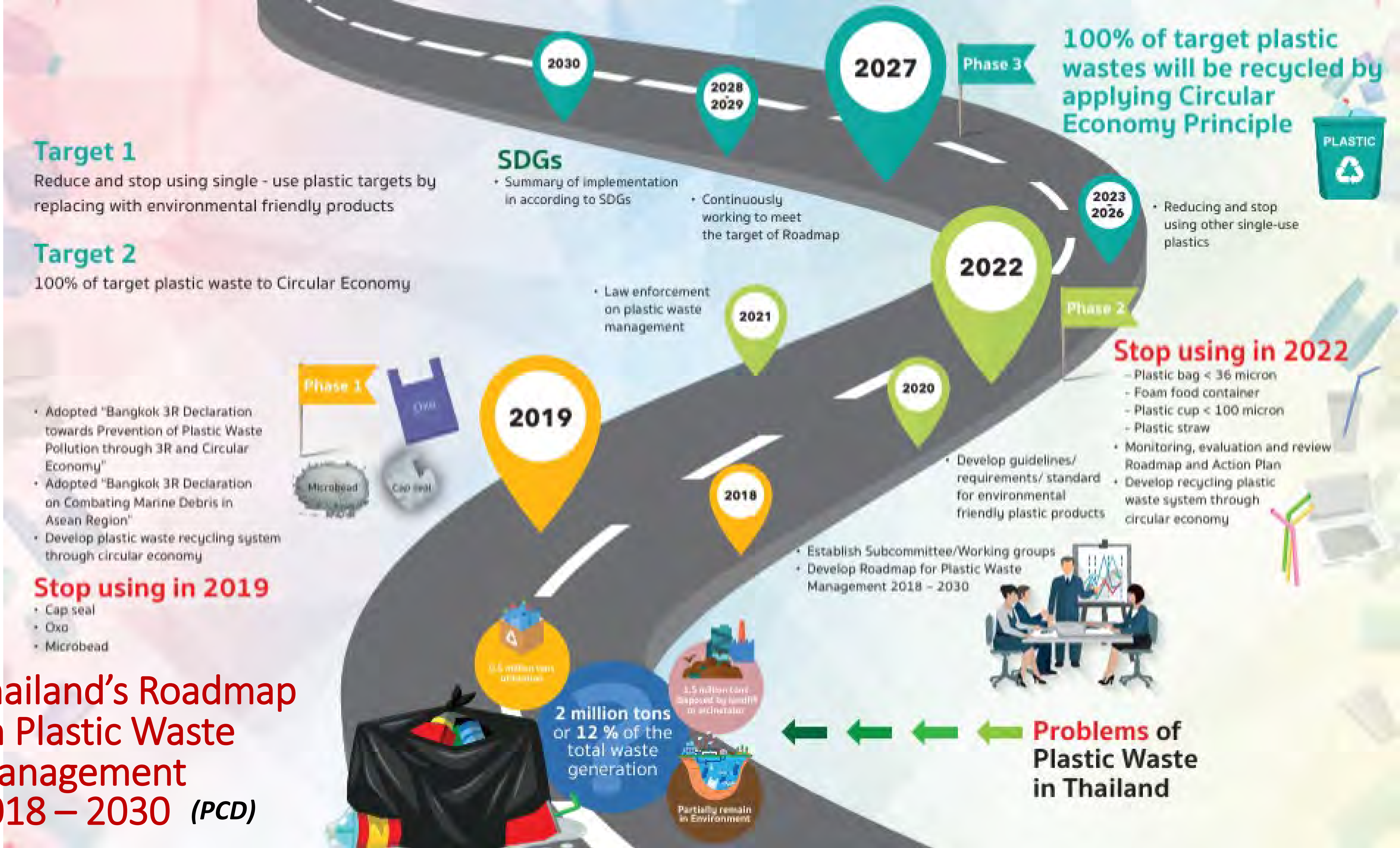
Thailand's Action Plan on Plastic Waste Management (Phase I: 2020-2022)

Focuses on the 3R principles (**Reduce, Reuse, Recycle**) and **circular economy** strategies.

Expected Outcomes:

- 50% reduction in SUPs consumption.
- Increase recycling rates & waste-to-energy initiatives.
- Lower plastic pollution in land & marine environments.
- Sustainable waste management practices across industries & communities.

Key Strategies *(PCD, 2021)*



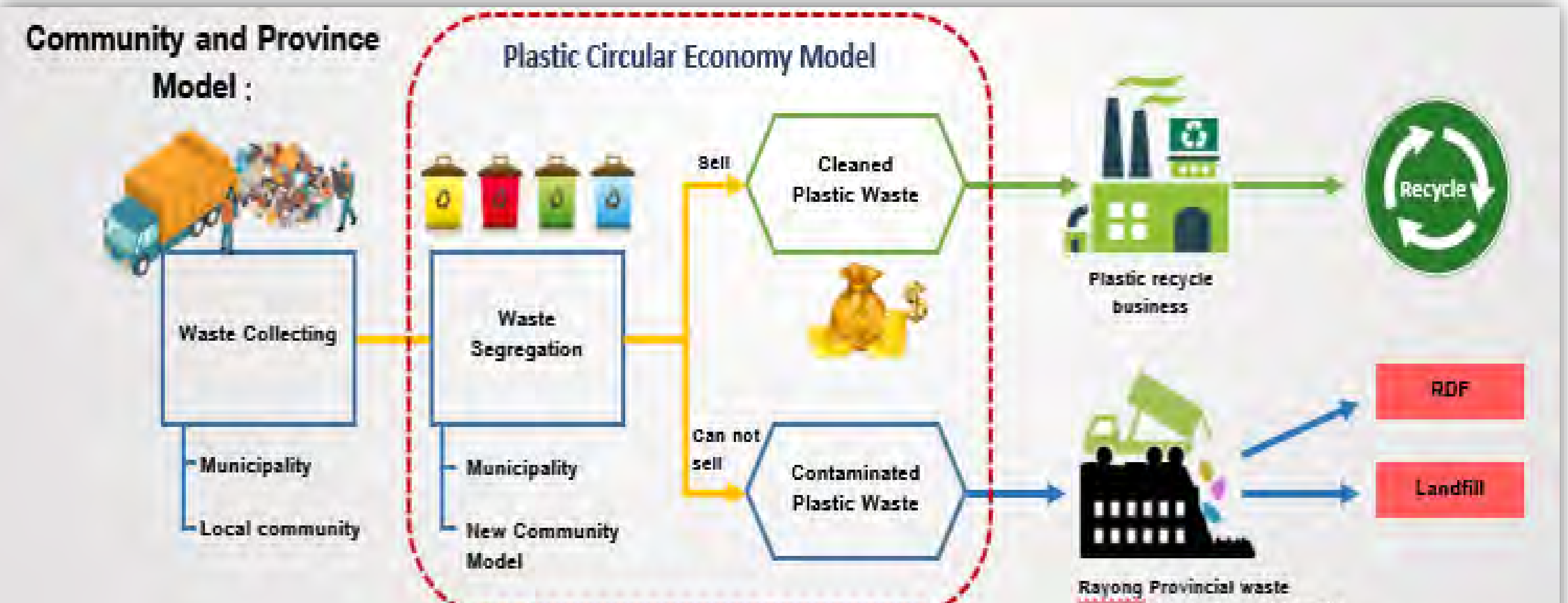
Thailand's Roadmap on Plastic Waste Management 2018 – 2030 *(PCD)*

Public-Private Partnerships (PPP)

- Founded on June 5, 2018, PPP Plastics promotes sustainable plastic waste management through cross-sector collaboration.
- One initiative, the **Rayong Model**, brings together schools, communities, businesses, and government agencies to enhance plastic waste separation, recycling, and value-added production *(Thai Environment Institute, 2021)*.

PPP Plastics Partners:

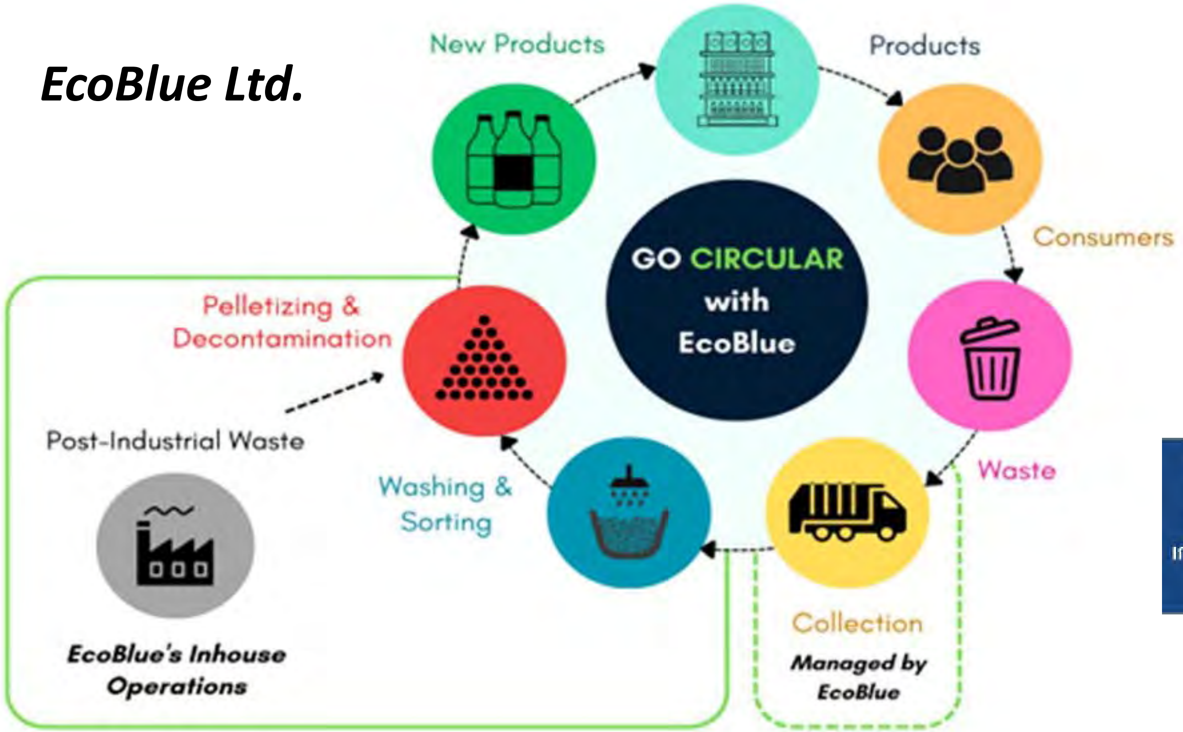
- Thailand Business Council for Sustainable Development (TBCSD)
- Plastic Industry Club, Federation of Thai Industries (FTI)



(Energy News Center)

Private Recycling Companies

EcoBlue Ltd.



ThaiPlastic Recycle Group Co., Ltd.

Seven Clean Seas

Challenges in Achieving Thailand's Plastic Waste Management Goals

- **Weak Policies & Enforcement:** Limited packaging-related regulations and weak enforcement (SEA Circular, 2019).
- **Recycling Challenges:** Limited facilities and the need for complex sorting make lightweight plastic waste recycling difficult (RRC.AP, 2024).
- **Consumer Behavior:** Low waste sorting, low awareness, and increased online shopping worsen plastic waste (Thailand Environment Institute, 2022).
- **Circular Economy Barriers:** Economic and institutional challenges hinder progress (Friedrich-Ebert-Stiftung, 2023).
- **Cost of Alternatives:** High costs of renewable materials lead businesses to prioritize cost efficiency (Fine, 2019).
- **Lack of EPR Laws:** No Extended Producer Responsibility (EPR) laws for post-consumer packaging limit resource reutilization (Pollution Control Department, 2022).

Thank you

sandhya@siit.tu.ac.th

References

- United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). (n.d.). Closing the Loop on Plastic Pollution in Nakhon Si Thammarat, Thailand: Baseline Report. Retrieved February 13, 2025, from https://www.unescap.org/sites/default/d8files/event-documents/NST%20Baseline%20Report_0.pdf
- SEA Circular. (n.d.). Thailand: Addressing plastic pollution for a circular economy. Retrieved February 13, 2025, from https://www.sea-circular.org/country/thailand/
- World Bank. (2022). Plastic waste material flow analysis for Thailand: Summary report. World Bank. Retrieved February 13, 2025, from https://www.worldbank.org/en/country/thailand/publication/plastic-waste-material-flow-analysis-for-thailand
- Jirapornvaree, I., Kreeratiratanalak, A., & Mangmeechai, A. (2023). Assessing the economic and environmental effects of plastic bag management in Thailand: Bangkok and Phuket provinces. Journal of Cleaner Production, 428, 139565. https://doi.org/10.1016/j.jclepro.2023.139565
- National Strategy Secretariat Office. (n.d.). National Strategy 2018-2037 (Summary). Office of the National Economic and Social Development Board, Thailand. Retrieved February 13, 2025, from http://bic.moe.go.th/images/stories/pdf/National_Strategy_Summary.pdf
- National Economic and Social Development Council (NESDC). (2023). The 13th National Economic and Social Development Plan (2023–2027). Retrieved February 13, 2025, from https://www.nesdc.go.th/article_attach/article_file_20230615134223.pdf
- Pollution Control Department. (n.d.). Thailand's roadmap on plastic waste management (2018–2030). Ministry of Natural Resources and Environment, Thailand. Retrieved February 13, 2025, from https://www.pcd.go.th/wp-content/uploads/2021/10/pcdnew-2021-10-19_08-59-54_995414.pdf
- Pollution Control Department. (2021). Thailand's Action Plan on Plastic Waste Management (Phase I: 2020-2022). Ministry of Natural Resources and Environment. Retrieved February 13, 2025, from https://www.pcd.go.th/publication/15038/