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Survey on Microplastic Leakage in the Mekong River Basin

1. Summary

This study reports the results of the survey on the leakage of microplastic and such in Vientiane (Lao PDR), Phnom Penh (Cambodia), and Can Tho (Vietnam) in the Mekong Basin, from January to March 2020, aiming to elucidate the actual situation of plastic leakage.

We also compared the data from each of the cities in the Mekong River basin, including the results from surveys in Chiang Rai (Thailand) and Ubon Ratchathani (Thailand) conducted by Pirika, Inc.

2. Project background and purpose

The leaking of plastics into our oceans has come to be recognized as a global problem. Microplastics refer to plastic fragments measuring less than 5mm in diameter, and there is a real concern over the adverse effect these have on our health as these microplastics are taken into the human body through our foods and beverages[1].

The Mekong River is an international river that spans multiple countries, with potential plastic leakage from each city in the basin. In this project, microplastics in the Mekong River and tributary rivers in the basin were collected to grasp the actual situation of the issue in terms of;

- Mass of floating plastics per region
- Source and route of the leakage
- Plastic items at risk of leakage

In addition to the above, measures and directions were explored to stop plastic leakage from the Mekong River basin.

[1] Since humans cannot digest and absorb plastic per se, it is excreted within a few hours after ingestion. However, plastic can absorb various harmful substances held in the environment (Persistent Organic Pollutants or POPs), as well as the additives originally contained in itself. Research on these effects are currently ongoing and the exact health effects are still unknown.

3. Methodology

In devising a methodology for this study that took purpose, safety, cost, simplicity, etc. into consideration, advice was sought from Tokyo University of Science's Professor Nihei (environmental hydraulics, river engineering, fluid dynamics) and Associate Professor Kataoka (coastal engineering, river engineering), and the survey method manual[2] published by the United States National Oceanic and Atmospheric Administration (NOAA) was used as reference.

Explanation of the survey method is provided below, in order of process.

3.1. Selection of survey location points

The survey points were selected with the following considerations in order to understand the state and tendency of floating microplastics and such.

Survey target areas

The Mekong River and its tributaries near major cities in the Mekong River basin (Chiang Rai, Vientiane, Ubon Ratchathani, Phnom Penh and Can Tho).

Survey target points

A minimum of six survey points was selected for each city while taking into account the following factors:

- Locations were neither privately owned nor restricted areas, and permission to survey could be obtained from related organizations.
- There needed to be enough depth of water to submerge the survey device (a minimum depth of 50 cm was required).
- Access to rivers needed to be easy and safe.

Table 1 List of survey location points

No	Country	Area	River or port	Detail location	Latitude	Longitude
1	Thailand	Chiang Rai	Ruak River	Anantara Golden Triangle Elephant Camp & Resort	20.36988	100.080489
2	Thailand	Chiang Rai	Mae Chan River	Crossing structure	20.140849	99.850237
3	Thailand	Chiang Rai	Mekong River	Pier	20.267873	100.090274
4	Thailand	Chiang Rai	Mekong River	Watchtower	20.242615	100.145058

[2] Laboratory Methods for the Analysis of Microplastics in the Marine Environment
https: //marinedebris.noaa.gov/sites/default/files/publications-files/noaa_microplastics_methods_manual.pdf

5	Thailand	Chiang Rai	Mekong River	Near the mouth of Ing river	20.204121	100.450322
6	Thailand	Chiang Rai	Ing River	Amphoe Thoeng	19.689366	100.187974
7	Lao PDR	Vientiane	Mekong river	Vientiane Night Street	17.955106	102.607425
8	Lao PDR	Vientiane	Mekong river	Donchan Road	17.946669	102.61519
9	Lao PDR	Vientiane	Mekong river	Lao Japan Friendship Port	17.929514	102.61535
10	Lao PDR	Vientiane	Mekong river	Near the mouth of Nam Mong river	17.855822	102.594025
11	Lao PDR	Vientiane	Mekong river	Homsavanh School	17.826053	102.64992
12	Lao PDR	Vientiane	Tributary of Mekong river	Thai–Lao Friendship Bridge	17.849537	102.670989
13	Lao PDR	Vientiane	Tributary of Mekong river	Ban Mak Nao	17.999896	102.91
14	Thailand	Ubon Ratchathani	Mun River	Raft	15.219534	104.8146906
15	Thailand	Ubon Ratchathani	Mun River	Restaurant	15.2147168	104.7979268
16	Thailand	Ubon Ratchathani	Mun River	Pier	15.2236184	104.8598795
17	Thailand	Ubon Ratchathani	Mun River	Restaurant	15.2431336	104.9563006
18	Thailand	Ubon Ratchathani	Mekong River	Restaurant	15.3190841	105.5002706
19	Thailand	Ubon Ratchathani	Mekong River	Raft	15.3171627	105.5137011
20	Cambodia	Phnom Penh	Mekong river	Prek Anhchanh college	11.736316	104.982114
21	Cambodia	Phnom Penh	Mekong river	Koh Dach Bak Kheng Ferry Dock	11.674183	104.920054
22	Cambodia	Phnom Penh	Tonle Sap rever	Institute for Cambodia Church History	11.689866	104.846031
23	Cambodia	Phnom Penh	Tonle Sap rever	Salar Khan Rusey Keo Bus Stop	11.6296	104.906398
24	Cambodia	Phnom Penh	Tonle Sap rever	Passenger Port	11.575972	104.927028
25	Cambodia	Phnom Penh	Mekong river	Ferry station	11.537702	104.991266
26	Cambodia	Phnom Penh	Bassac river	Near the 21A road	11.459554	105.025743
27	Vietnam	Can Tho	Can tho river	Cai Rang floating market	10.002034	105.74472
28	Vietnam	Can Tho	Hau river	Sonhau Park	10.050161	105.79
29	Vietnam	Can Tho	Hau river	Tạp Hóa Bền Hằng	9.947322	105.873675

30	Vietnam	Can Tho	Co Chien river	Vinh Long	10.257864	105.973899
31	Vietnam	Can Tho	Co Chien river	Tra Vinh	9.976348	106.353718
32	Vietnam	Can Tho	Ham Loung river	Ben Tre	10.220944	106.350056
33	Vietnam	Can Tho	Mekong river	My Tho	10.343796	106.335756

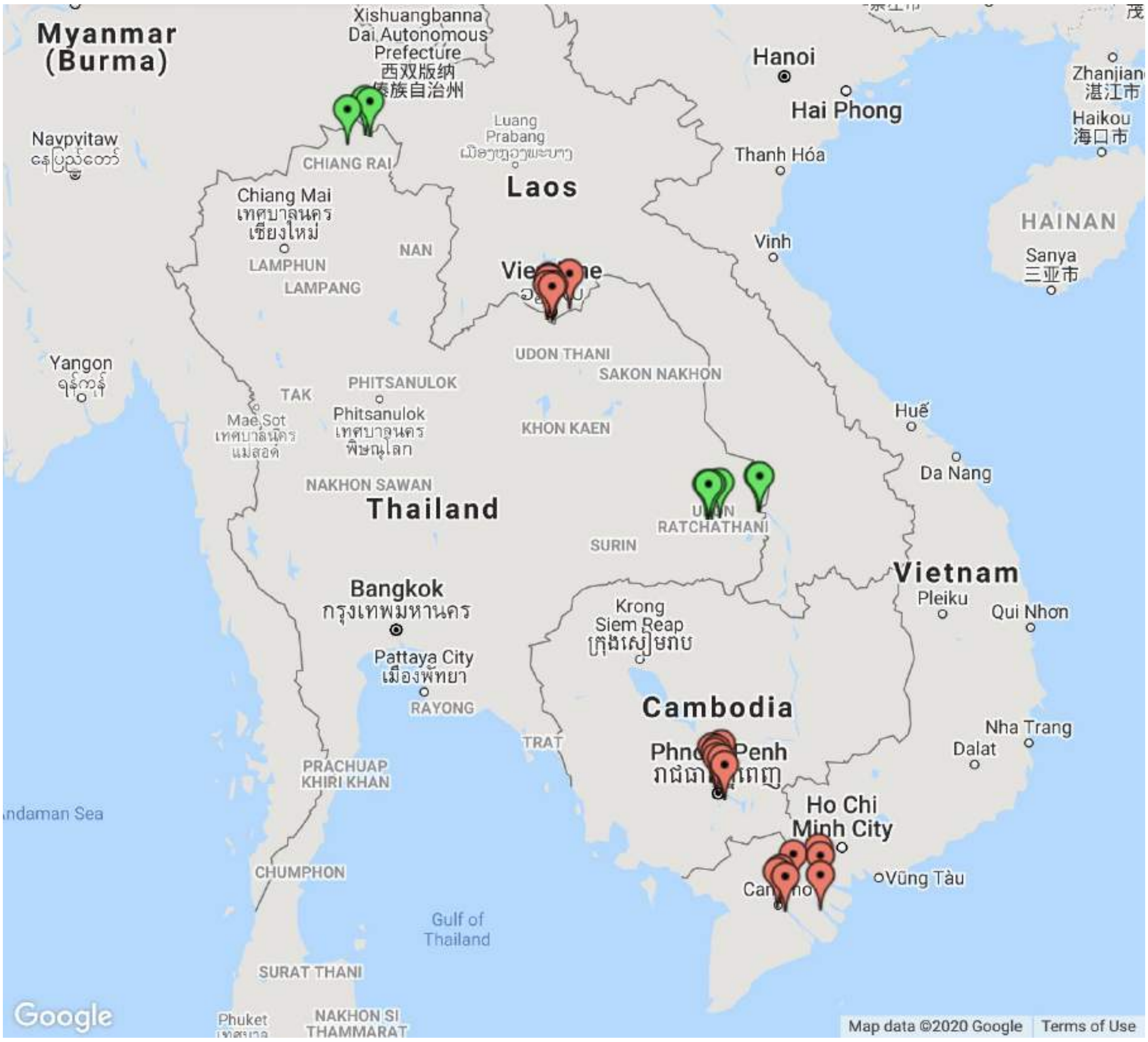


Figure 1 Overview of survey location points

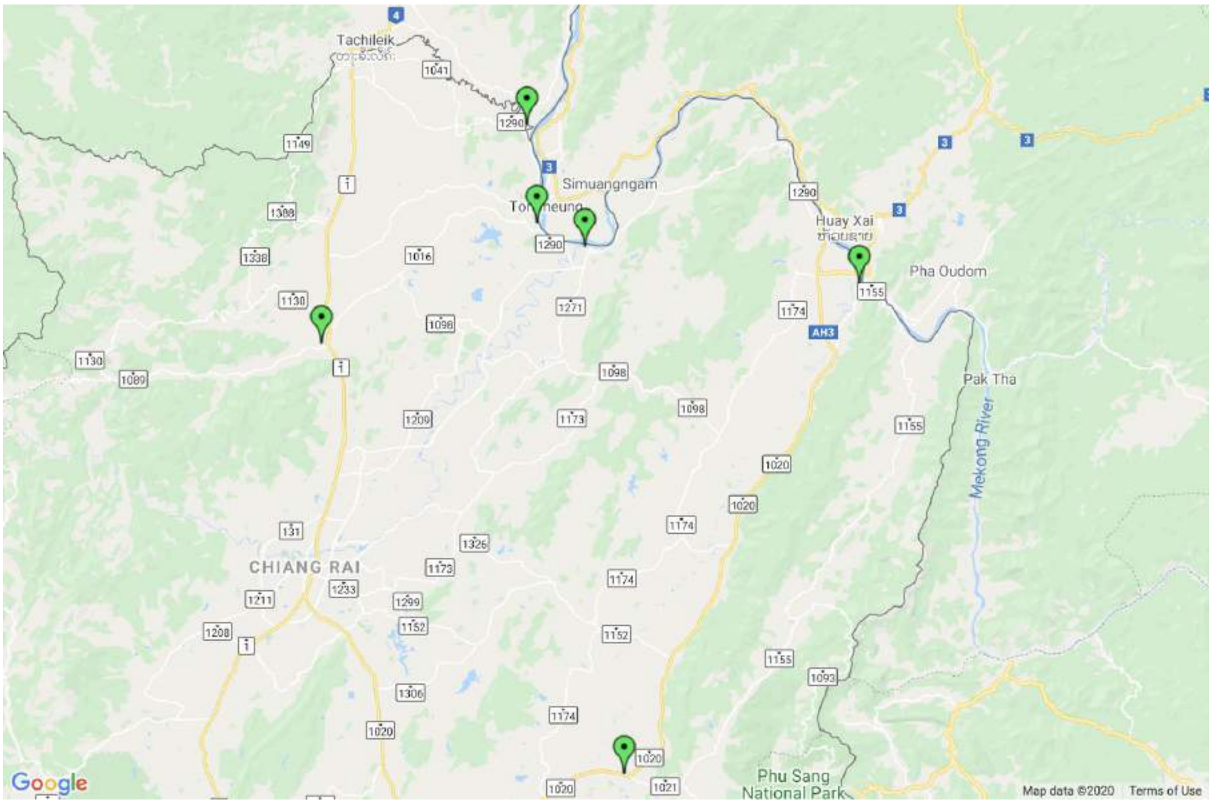


Figure 2 Survey locations for Chiang Rai (Thailand)

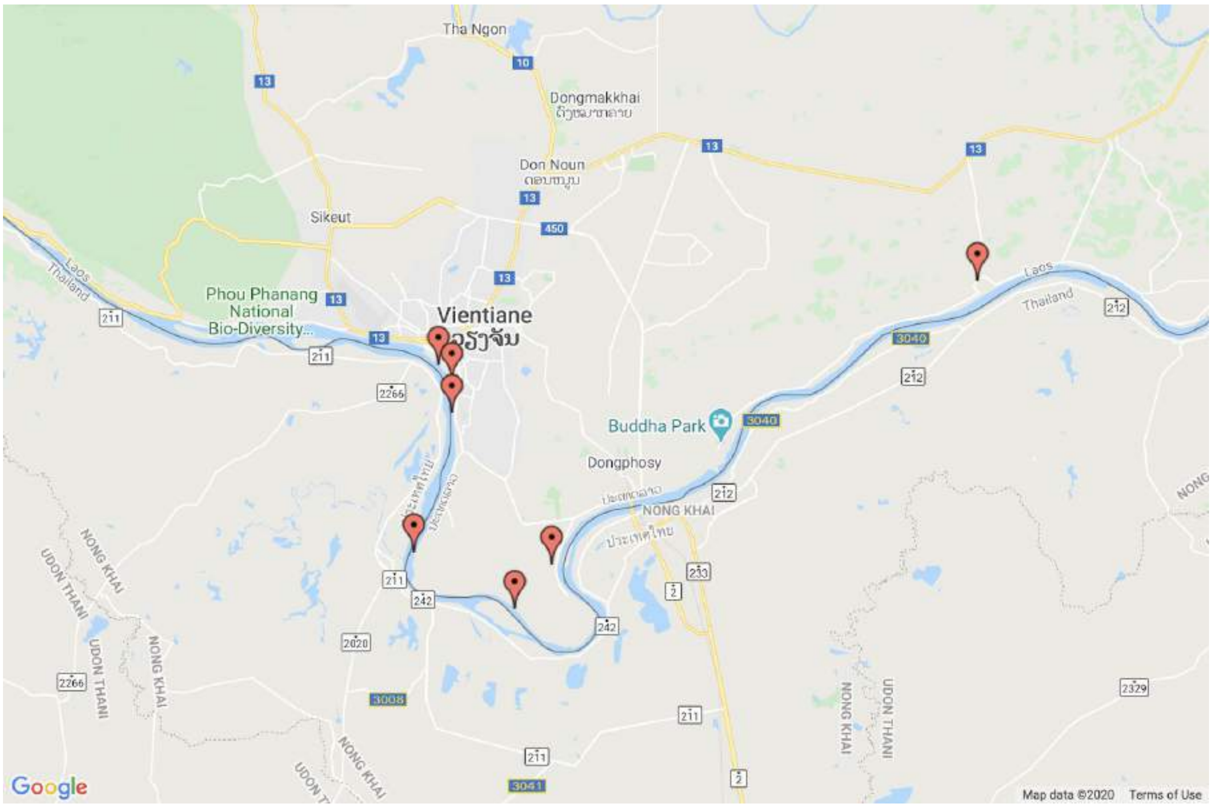


Figure 3 Survey locations for Vientiane (Lao PDR)

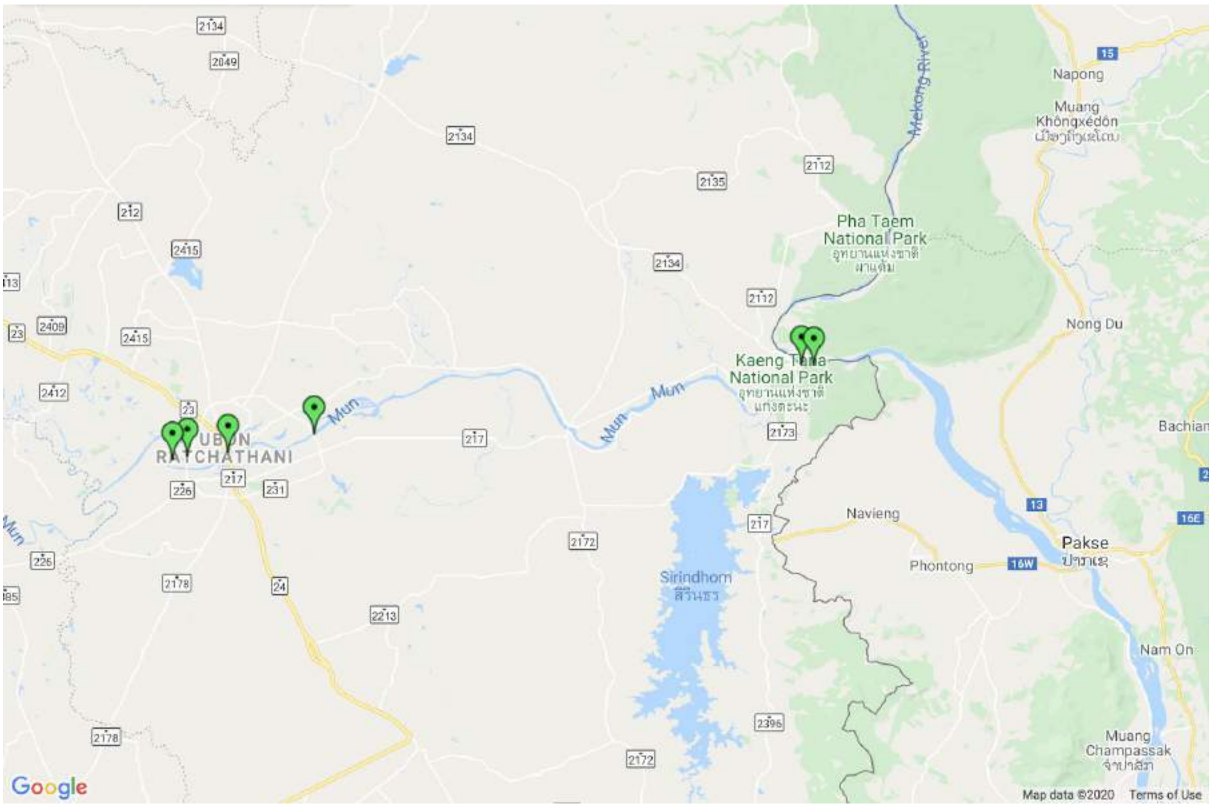


Figure 4 Survey locations for Ubon Ratchathani (Thailand)

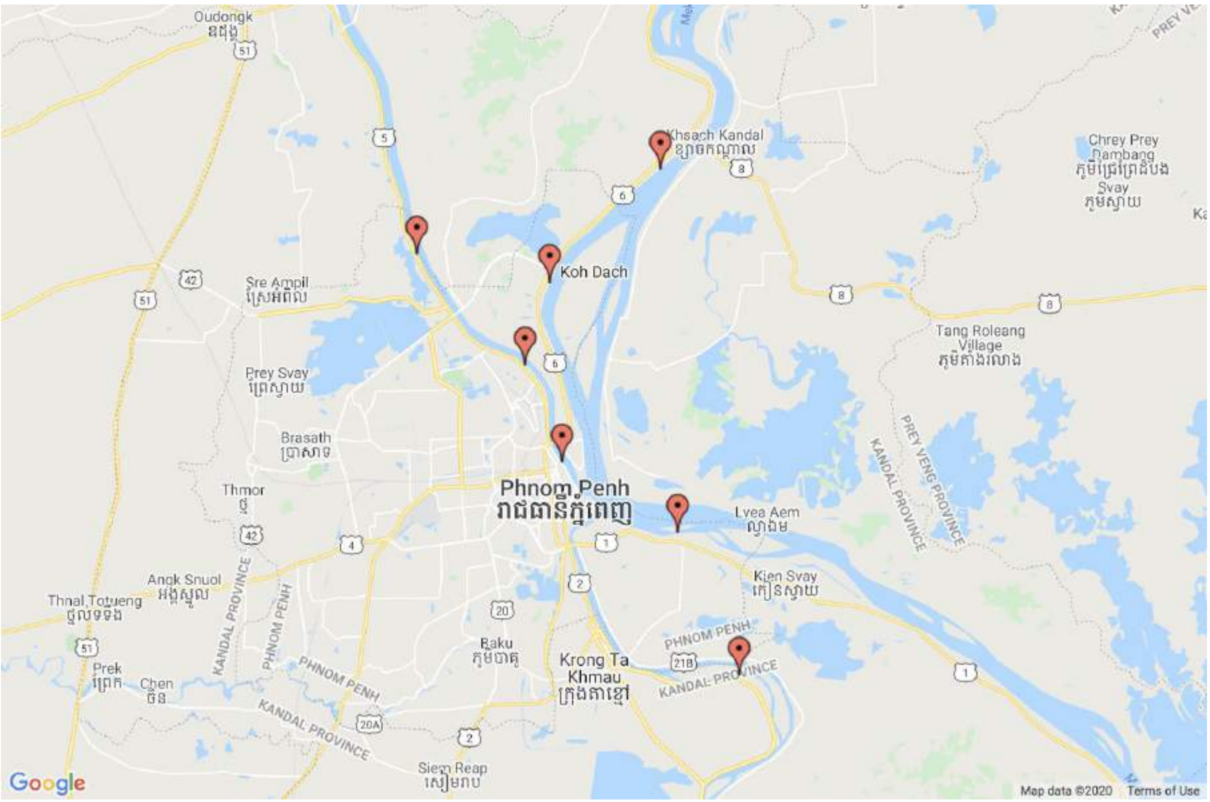


Figure 5 Survey locations for Phnom Penh (Cambodia)

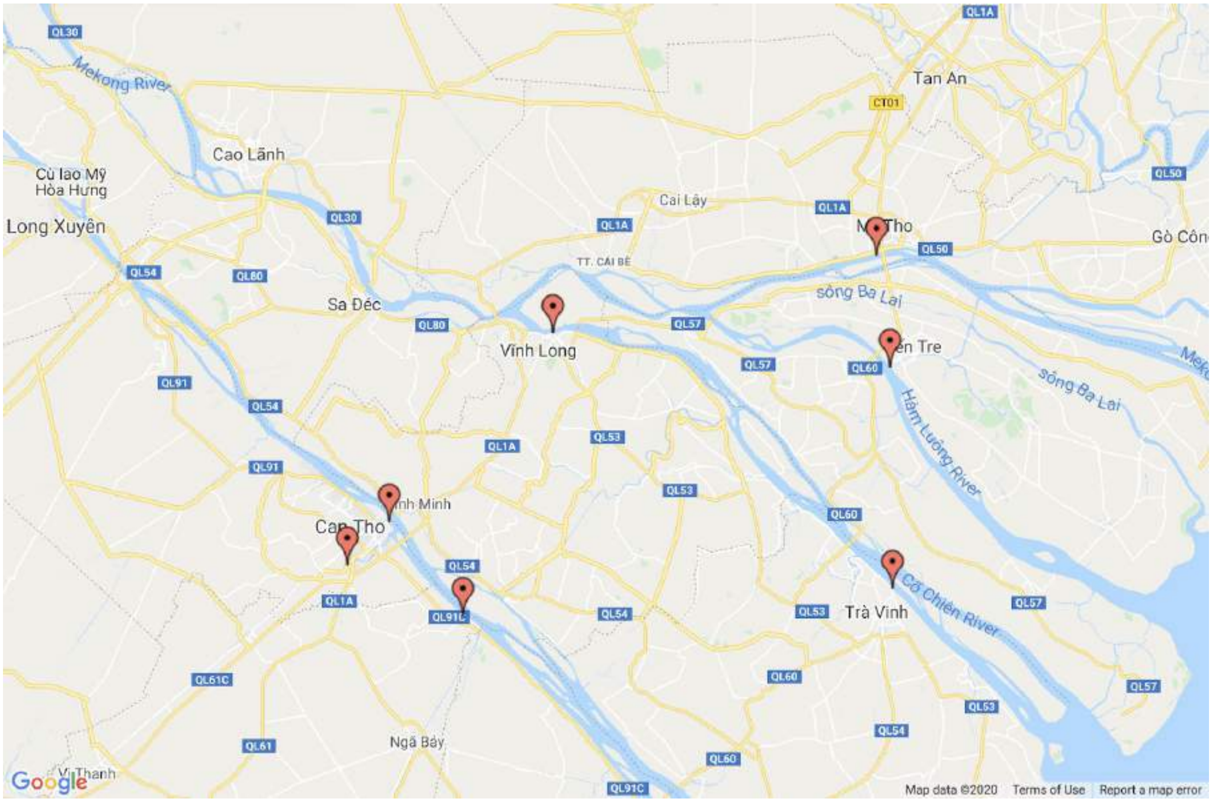


Figure 6 Survey locations for Can Tho (Vietnam)

3.2. Collecting solids

Collecting the solids in the river from shores and such was necessary for this study and, as such, the following requirements needed to be met.

- Sufficient amounts of solids thought to be plastic needed to be collected.
- The sampling area needed to be measurable (volume of water or surface area of beaches).
- The survey needed to be implemented in various places.

Using a battery-driven propeller to pass surface-level water through a net, we developed a specialized sample collecting device with all the required functions; the Albatross Mark V lite. Water at each survey point was filtered by the net and solid particles were collected.

However, since plastic is collected near the water surface with this survey design, it is more likely to collect floating plastics with a lower density than water. As a result, a higher number of low-density plastics, such as PE and PP, and plastics which contain air to be expanded, such as PS, are collected while higher density plastics such as PET are harder to find as they sink.

[Specs for the Albatross Mark V lite]

- Uses a 0.3mm net
- 5~15m^3 of water is filtered in 3 minutes to collect solid particles
- Battery-powered

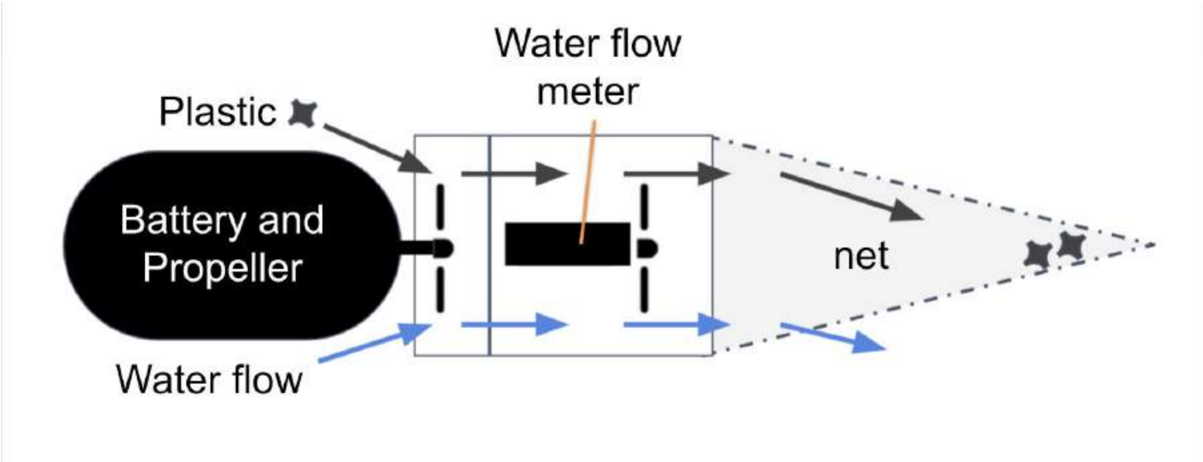


Figure 7 Structure of the sample collecting device (Albatross Mark V lite)

Figure 8,9 Collecting solids with the device (Albatross Mark V lite)

3.3. Extraction of solid particles

In this process, particles that seemed to be plastic were extracted from the collected solids for analysis. In this study, particles that seemed to be plastic were extracted using tweezers following a visual inspection.

Figure 10 Extraction in progress

3.4. Analysis of extracted items

In this process, the extracted solids are analyzed to identify their components. Component analysis was conducted using an FT-IR (Fourier transform infrared) spectrometer, the appearance was photographed using a microscope, and the thickness was measured with calipers. For the Thailand survey results, only the component analysis was conducted.

However, if more than 60 plastic-like solids were extracted in the process of 3.3, only 60 were analyzed to reduce the time and cost required for analysis, and the number of microplastics that could be collected at that point was calculated from the ratio of the obtained components. In this survey, this was applicable for No.28, Sonhau Park.

In terms of the process of identifying components by reading the solid spectrum using FT-IR, we asked for advice from Associate Professor Fukuhara, Tokyo Institute of Technology (analytical chemistry) to ensure the test quality.

Figures 11,12 Analysis of components using FT-IR

4. Results

4.1. Component ratio

449 of the 570 solids collected/extracted from the 33 survey points were analyzed. Regarding survey location No.28 (Sonhau Park, Can Tho), only 60 of the 181 collected solids were analyzed, and the number of plastics contained in the unanalyzed solids was estimated and added up.

As a result, the proportion of plastic components at the 33 survey points in the Mekong River basin was as follows.

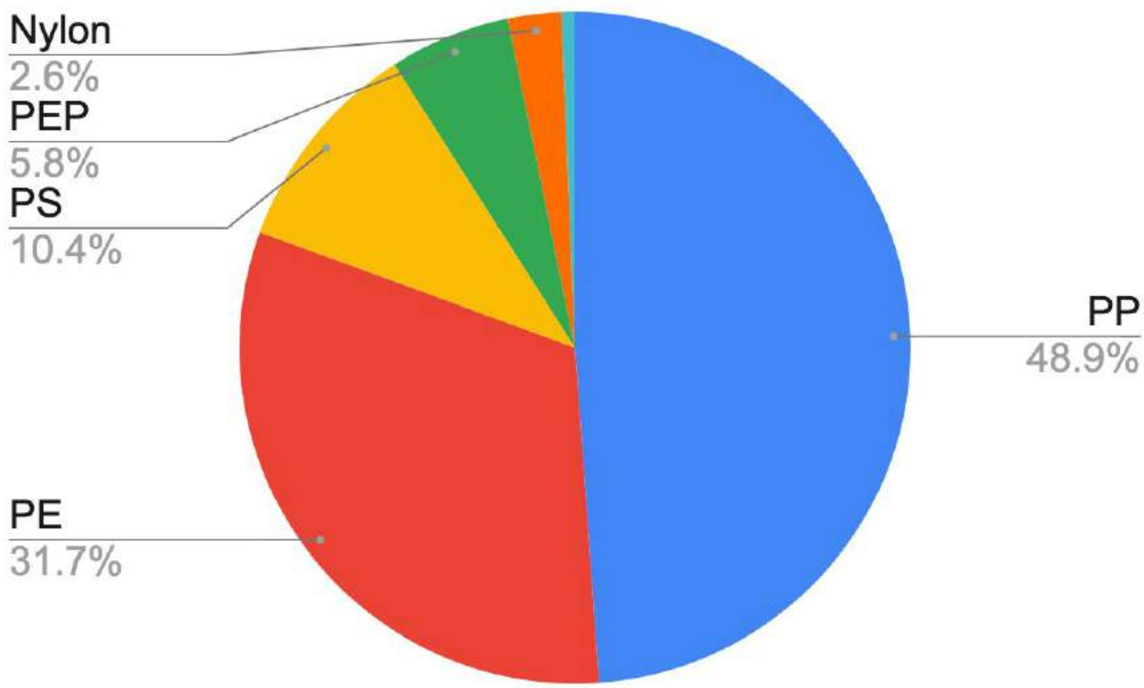


Figure 13 Percentage of plastic components (%)

PP was used in some parts of the sample collecting device used for this study (the Albatross Mark V lite) and it is possible that surface damage to the device during sampling (getting scraped against rocks for example) may have caused some data contamination to the collected solids. Especially in the Mekong basin, there were many survey environments such as rocky areas where the device could be easily damaged, so the risk of contamination was considered to be higher than in Japan. (The effect of contamination on the results will be described later in 4.4.1, Comparison of plastic components.)

PET used for beverage bottles, etc., was not found in this survey. This is thought to be caused by PET having a higher density than water and sinking to the bottom of the river (PET beverage bottles float on the river because of the air it contains), In the same survey conducted in Japan, PET again accounted for just 16 out of 2,224 pieces, accounting for only 0.7% of the total.

4.2. Quantity of component per volume of sampled water (for each survey point)

The number of plastic pieces per sampled water at the 33 locations is summarized in the table below.

Table 2 Quantity of component per volume of sampled water (item/ m³)

No	Country	Area	River or port	Location	PP	PE	PS	PEP	Nylon	Other plastics	Total
1	Thailand	Chiang Rai	Ruak River	Anantara Golden Triangle Elephant Camp & Resort	0.06	0	0	0	0	0	0.06
2	Thailand	Chiang Rai	Mae Chan River	Crossing structure	0.17	0	0	0	0	0	0.17
3	Thailand	Chiang Rai	Mekong River	Pier	0.37	0.09	0	0	0	0	0.46
4	Thailand	Chiang Rai	Mekong River	Watchtower	0.1	0	0	0	0.1	0	0.2
5	Thailand	Chiang Rai	Mekong River	Near the mouth of Ing river	0	0	0	0	0	0	0
6	Thailand	Chiang Rai	Ing River	Amphoe Thoeng	0.08	0.25	0	0	0	0	0.34
7	Lao PDR	Vientiane	Mekong river	Vientiane Night Street	0	0	0	0	0	0	0
8	Lao PDR	Vientiane	Mekong river	Donchan Road	0	0	0	0	0	0	0
9	Lao PDR	Vientiane	Mekong river	Lao Japan Friendship Port	0.45	0	0	0	0	0	0.45
10	Lao PDR	Vientiane	Mekong river	Near the mouth of Nam Mong river	0.23	0.11	0	0	0	0	0.34
11	Lao PDR	Vientiane	Mekong river	Homsavanh School	0	0	0	0	0	0.12	0.12
12	Lao PDR	Vientiane	Tributary of Mekong river	Thai–Lao Friendship Bridge	0.5	0	0	0	0	0	0.5
13	Lao PDR	Vientiane	Tributary of Mekong river	Ban Mak Nao	0	0.69	0	0	0	0	0.69
14	Thailand	Ubon Ratchathani	Mun River	Raft	0.12	0.12	0	0	0	0	0.25
15	Thailand	Ubon Ratchathani	Mun River	Restaurant	0.08	0	0	0	0.17	0	0.25

16	Thailand	Ubon Ratchathani	Mun River	Pier	0.68	0	0	0	0	0	0.68
17	Thailand	Ubon Ratchathani	Mun River	Restaurant	0.17	0.08	0.17	0	0.17	0	0.58
18	Thailand	Ubon Ratchathani	Mekong River	Restaurant	0.16	0	0	0	0	0	0.16
19	Thailand	Ubon Ratchathani	Mekong River	Raft	0.08	0.08	0	0	0.17	0	0.33
20	Cambodia	Phnom Penh	Mekong river	Prek Anhchanh college	1.22	0.3	0	0	0	0	1.52
21	Cambodia	Phnom Penh	Mekong river	Koh Dach Bak Kheng Ferry Dock	0.26	0	0	0	0	0	0.26
22	Cambodia	Phnom Penh	Tonle Sap rever	Institute for Cambodia Church History	0.84	0.84	0	0.84	0	0	2.52
23	Cambodia	Phnom Penh	Tonle Sap rever	Salar Khan Rusey Keo Bus Stop	1.28	0.7	0.23	0.12	0	0	2.32
24	Cambodia	Phnom Penh	Tonle Sap rever	Passenger Port	0.21	1.65	0.21	1.86	0	0	3.92
25	Cambodia	Phnom Penh	Mekong river	Ferry station	0.93	1.04	0.12	0.12	0	0	2.2
26	Cambodia	Phnom Penh	Bassac river	Near the 21A road	0.71	0.56	0.14	0.14	0	0	1.55
27	Vietnam	Can Tho	Can tho river	Cai Rang floating market	0.97	0.12	0	0	0	0	1.09
28	Vietnam	Can Tho	Hau river	Sonhau Park	8.36	6.16	3.08	0.44	0	0	18.05
29	Vietnam	Can Tho	Hau river	Tạp Hóa Bền Hằng	0.21	0.11	0.11	0	0	0.11	0.53
30	Vietnam	Can Tho	Co Chien river	Vinh Long	0.54	0.45	0.09	0	0	0	1.07
31	Vietnam	Can Tho	Co Chien river	Tra Vinh	0.62	0.16	0.08	0	0.08	0	0.93
32	Vietnam	Can Tho	Ham Loung river	Ben Tre	0.32	0.65	0.16	0.16	0	0	1.3
33	Vietnam	Can Tho	Mekong river	My Tho	0.58	0.14	0	0	0	0	0.72

*With 181 plastic particles, there was a significantly higher number of samples from No.28 than at other locations and, as such, only 60 pieces were analyzed to calculate the overall figures.

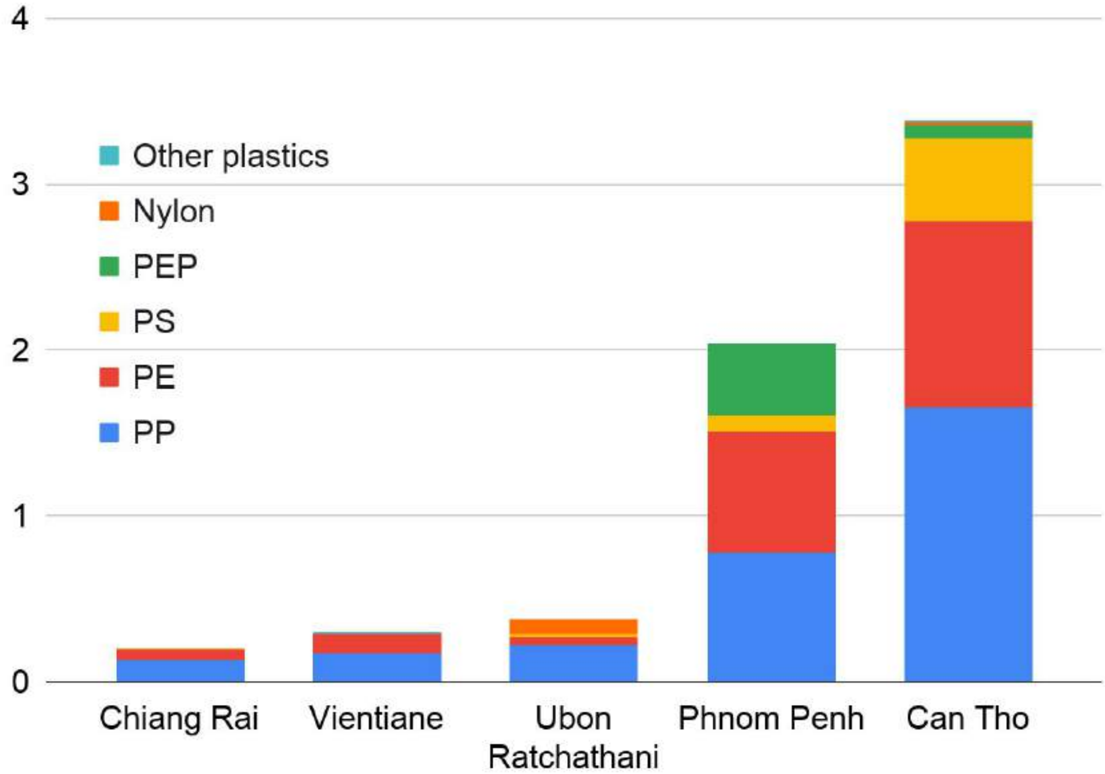


Figure 14 Average Number of microplastics per ㎥ in rivers

The survey results for each location led to the following insights;

- Plastic fragments were found at 30 out of 33 survey locations. The survey revealed the prevalence of microplastics in the Mekong River basin.
- The most common component in all regions was PP.
- Small amounts of plastic pieces were also found in Chiang Rai, Vientiane and Ubon Ratchathani.
- The amount per volume tended to gradually increase further downstream.
- Since the amount of plastic leakage = flow rate × amount of plastic per volume, we can consider increases to the amount of plastic leakage to be in an even greater range (a river's flow rate generally increases further downstream).
- The increase in values between Ubon Ratchathani and Phnom Penh, and between Phnom Penh and Can Tho were remarkable. It is highly likely that there are large plastic leakages between each city.

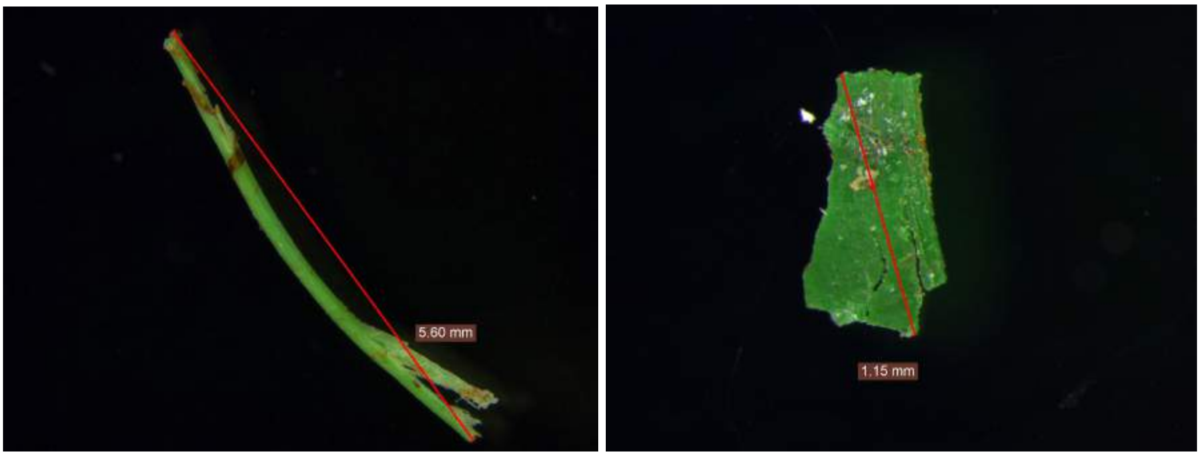
4.3 Deduction of original products

The original products were deduced for the 187 plastic samples collected from Vientiane, Phnom Penh and Can Tho.

*It should be noted that the deduction is based on insights from Japan. Considering the possibility of there being regional tendencies to plastic usage, it would be desirable to consult local plastics companies and take into account the actual use of plastics in each region in order to conduct a more accurate analysis.

4.3.1. Artificial turf

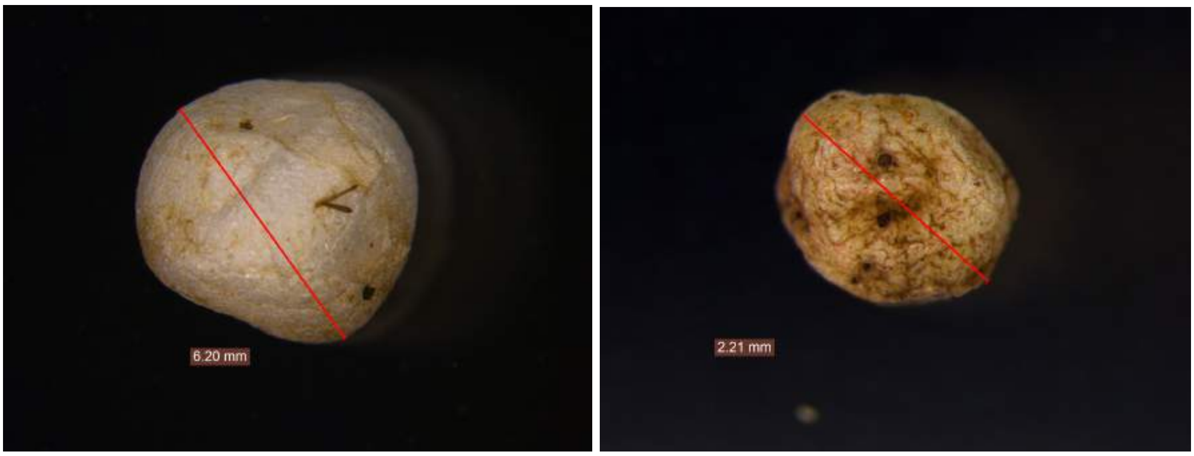
10.7% of the total collection was identified as having a high probability of originating from artificial turf (green color, made of either PE, PP or PEP).



Figures 15,16 Plastic pieces that are likely to be from artificial turf

4.3.2. Styrofoam

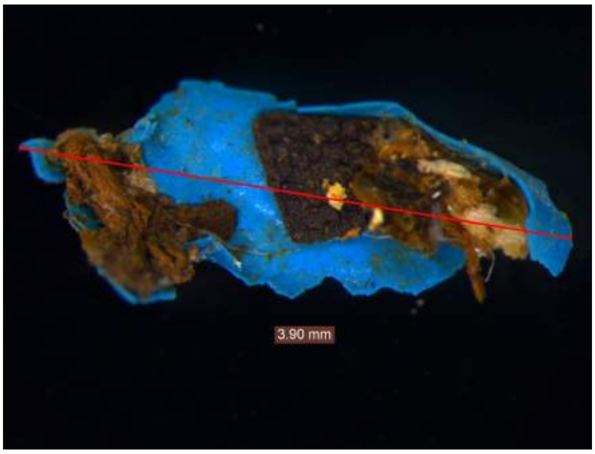
Often used for food trays and containers, Styrofoam (white, elastic and made of PS) was also found and accounted for 8.6% of the total. With its high density making it sink to the bottom of the water, PS was considered unlikely to show up with the method used for this study of collecting from the water's surface. It is conceivable that these pieces were able to float due to a lower density caused by the foaming of plastic.

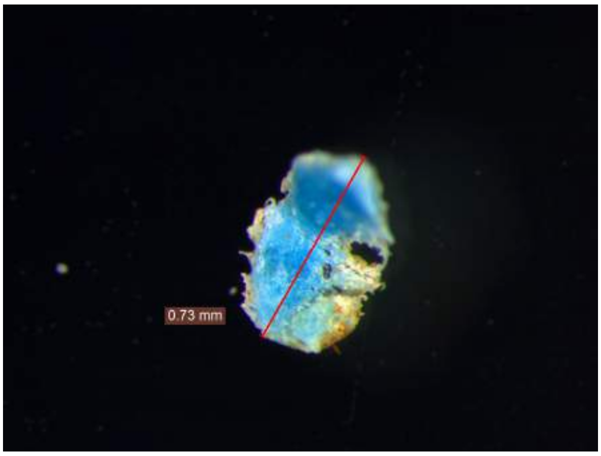


Figures 17,18 Plastic pieces that are highly likely to be styrofoam

4.3.3. Plastic sheets etc.

We also found plastics that seemed to be from blue tarpaulin. However, no assertion could be made as it is quite possible they were from other plastic products.





Figures 19, 20 Plastic pieces likely to be from sheets

4.4. Comparison with Japan

The results were compared with those of surveys conducted by Pirika Association in 2019 in the Kanto, Chubu, Kansai, Kyushu, Hokuriku and Okinawa regions of Japan.

However, the survey method used in Japan comprised of two different processes for collecting and extracting solids, and, as such, the comparison of results should only be used as reference.

Collection of solids:

The Albatros Mark VI used for the collection was improved over its predecessor, the Albatros Mark V.

[Specs for the Albatross Mark VI]

- Uses a 0.1mm or 0.3mm net
- 5~15m^3 of water is filtered in 3 minutes to collect solid particles
- Battery powered
- Compared to the Mark V Lite, the volume of sampled water could be measured more accurately.
- With a larger battery size, it is difficult to transport by air.

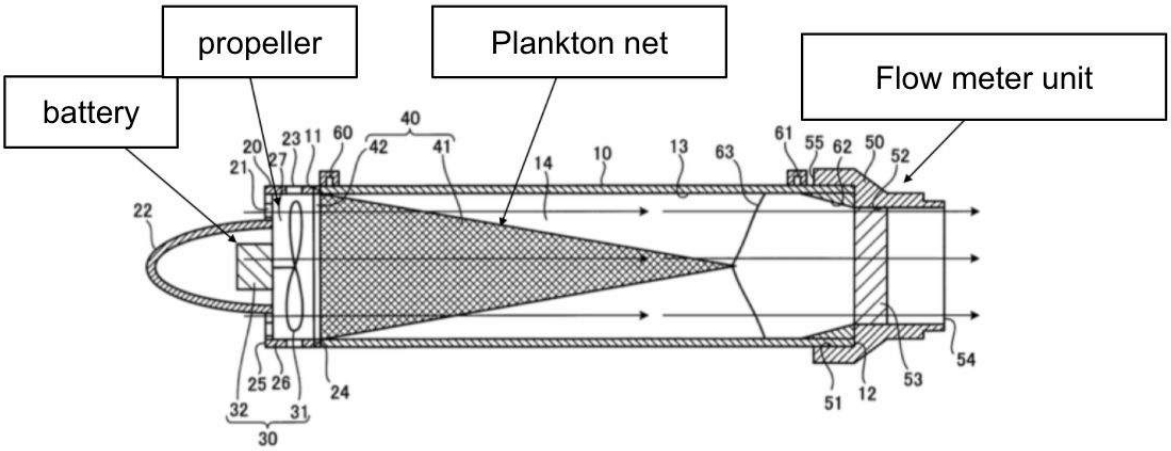


Figure 21 Structure of the sample collecting device (Albatross Mark VI)

Figure 22 Collecting solids with the device (Albatross Mark VI)

Extraction of solids

In addition to extraction by visual inspection, some samples were extracted by hydrochloric acid treatment and filtration.

Extraction by hydrochloric acid treatment and filtration is more effective at extracting plastics but has the particularity of requiring chemicals and waste liquid treatment.

Figure 23 Extracting by hydrochloric acid treatment and filtration

4.4.1. Comparison of plastic components

A big difference was observed in the proportion of plastic components. In the Mekong River, PP recorded the largest amount per volume and PE was second. The opposite was true in Japan where PE came first, followed by PP. PP and PE are relatively similar in nature, and some products such as artificial turf could be made with either PP or PE materials. Therefore, the different components of collected plastic pieces may reflect regional differences in the use and proportion of plastic materials.

39.3% of the PP collected in this survey project were red-colored debris that could have been mixed in from the sample collecting device. If we set the assumption that all of these were from the sample collecting device, then there would be an approximately comparable percentage of PP and PE among the microplastics collected from the Mekong River.

However, the conclusion that the Mekong River basin has a higher percentage of PP compared to Japan remains for the following reasons:

- PP was also used for the sample collecting device used in Japan.
- Japan's results clearly show more PE than PP.

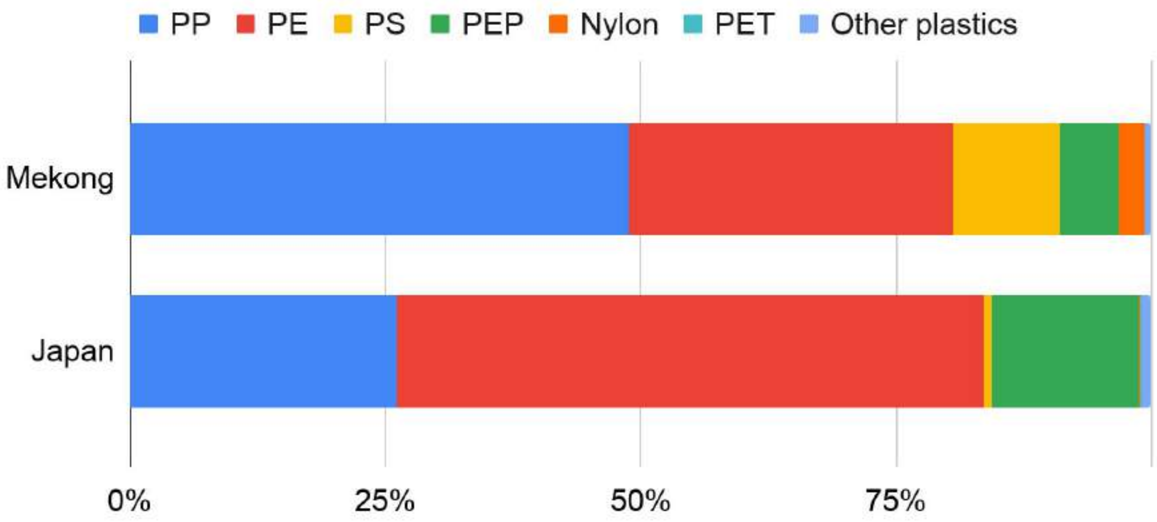


Figure 24 Comparison in component types

4.4.2. Comparison of plastic quantity per volume

Plastic quantity per water volume for the Mekong River basin and each region of Japan were compared (Japan's values include results from lakes).

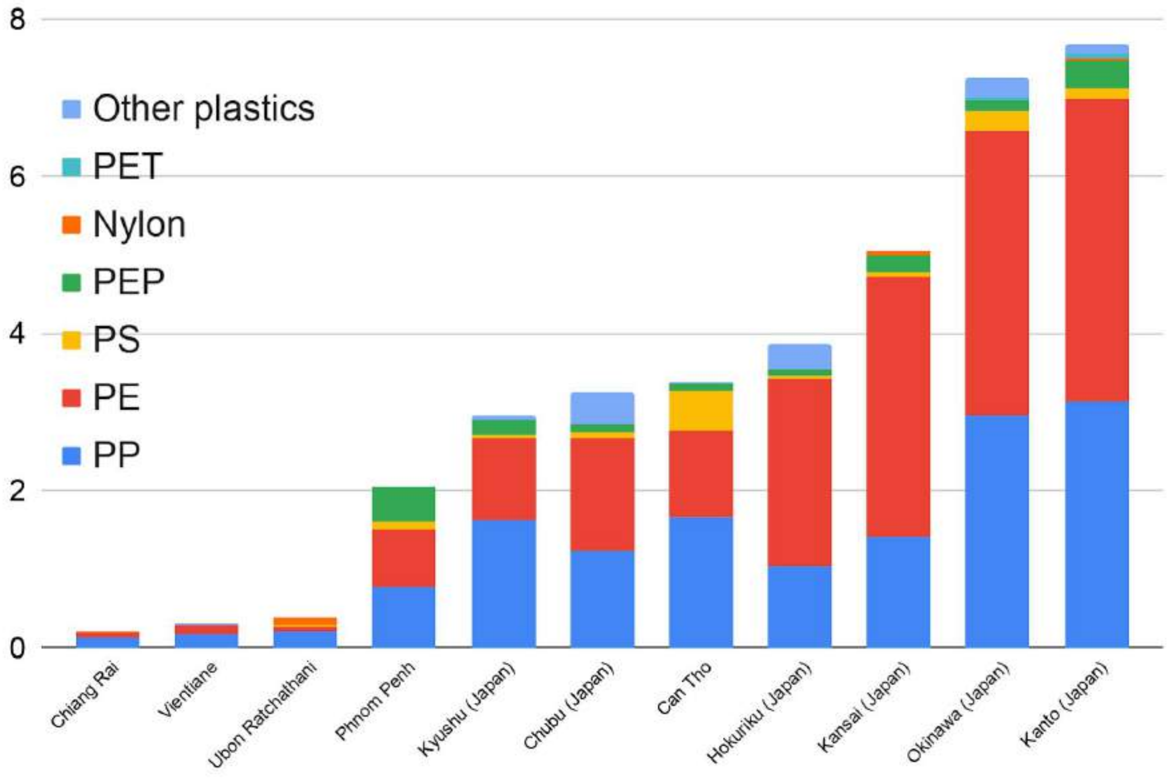


Figure 25 Average Number of microplastics per ㎥ in rivers

The microplastic quantity per water volume in the Mekong River basin was comparatively smaller than in each of the Japanese regions. However, it is difficult to rigorously compare results achieved with different extraction methods and water samplings, as was the case here, as microplastic quantity per water volume can vary depending on the survey method.

4.4.3. Comparison of estimated causal products

Debris from artificial turf was found in both the Mekong River basin and Japan. The percentage was 10.7% in the Mekong River and a slightly higher 14.3% in Japan. The difference could be considered to be within the margin of error taking into account the insufficient sample size of the Mekong River basin.

The percentage of styrofoam varied greatly: 8.6% in the Mekong River basin and 0.9% in Japan. Possible causes for the disparity include differences in consumption amount itself and a higher risk of leakage due to differences in the process of styrofoam consumption, collection and disposal.

No plastic-coated fertilizers (used in rice fields in Japan and 1.4% of the microplastics found in Japan) were found in this Mekong River basin survey. Variations in rice species, production methods, and fertilizer types may be influencing the result.

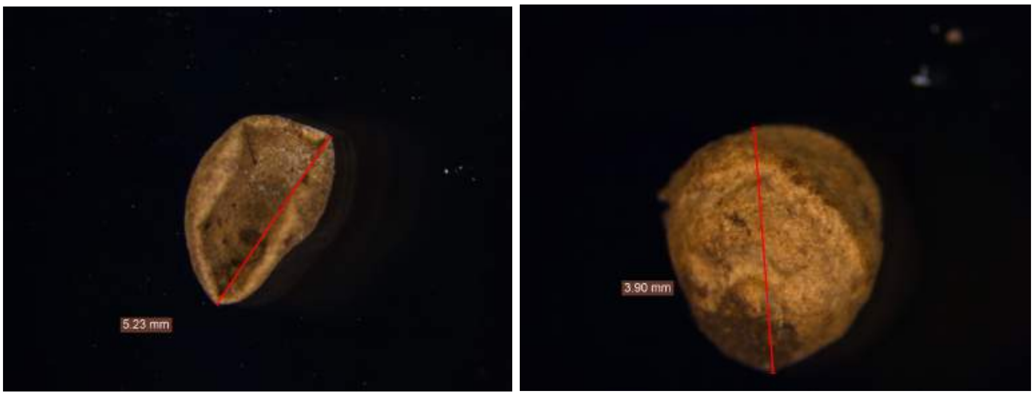


Figure 26,27 Plastic coated fertilizer found in Japan

5. Future challenges for the survey method

This study has identified the following future needs:

- **Expansion of survey target areas**
  Increasing the number of survey points and narrowing down high-risk areas may lead to better suggestions for effective countermeasures. In particular, it is highly probable that there are great plastic leakages between Ubon Ratchathani and Phnom Penh, and Phnom Penh and Can Tho.
- **Survey of underwater plastics**
  High-density plastics that sink to the bottom of the water should also be sampled and analyzed to clarify the actual leakage situation of PET and other plastics.
- **Improvement of survey method**
  There is scope for improvements such as by reducing the risk of plastic contamination by the sampling device (e.g. protecting the device with non-plastic materials such as cloth or metal) or reducing material and transportation costs.

- **Unified method**
  In this survey, the same water sampling and extraction methods couldn't be used in the Mekong River basin and Japan due to restrictions on batteries that could be brought into aircrafts and cost. It would be desirable for future surveys to select a highly accurate method that can be implemented across all regions and allow rigorous regional comparisons.
- **Survey of seasonal factors**
  The surveys were conducted exclusively under dry conditions for this study, and future studies should incorporate seasonal surveys such as during the rainy season in which the river's water levels rise.
- **Implementation system for local partners**
  To reduce the survey cost and expand the frequency and survey area, it is necessary to establish a system that allows for cooperation and implementation by local partners.
- **Detailed deduction of products at the source of the leakage**
  Plastic production and use are likely to vary from region to region. Original products at the source of the plastic leakage may be deduced with more accuracy through interviews with local plastic distributors and molders.

6. Pirika's proposal for controlling plastic leakage

Based on the results of this survey and past experiences, we have summarized the proposal for controlling plastic leakage in the Mekong River basin.

- **Measures against the leakage of artificial turf**
  The leakage of artificial turf was also observed in the Mekong River basin. The leakage source needs to be identified and provided management guidance to, and deterrence measures need to be taken.
- **Focus on high-risk areas**
  The majority of plastic leakage occurs between Ubon Ratchathani and Can Tho. Effective problem solving can be expected by concentrating budgets and counter measures in these high-risk areas.