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Ministry of the Environment

Results as of the FY2024 Estimated Amount of Marine Plastic Litter Discharged in Japan

Marine Plastic Pollution Control Office, Marine Environment Division

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Introduction

Introduction

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We started this project in FY 2021, and in FY2024, we examined **methods for estimating and evaluating the total amount of plastic litter discharged into the ocean and database (discharge inventory) from** the following three perspectives.

1. Buildup estimation method by sources and items (mainly in Japan)
2. Estimation method using macro-statistical data on plastic production, consumption, and disposal (mainly in Japan)
3. Globally applicable harmonized methodology for the amount of plastic litter discharged into the environment, including the oceans, based on the above two approaches

As for **the buildup estimation by sources and items in Japan, the results in FY2024** were 13,000～31,000 t (the results of estimation using macro-statistics data in FY2023 were 2,300～24,000 t). There was no significant difference between the results of two estimates (“1” and “2” above), and the number of orders of magnitude was similar to those of previous studies by Nihei et al. (2020) and Jambeck et al.

However, these results are not definitive values, and all estimation formulas and data used are provisional based on information available as of FY2024.

We will continue to refine and update the estimation based on the latest results of related surveys and research.

Expert Group in FY2024

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Objective: To update and refine the "Results of Estimation of Marine Plastic Litter Discharged in Japan" in FY 2023

Overview of Expert Group in FY2024

《Actions》

- To update and refine the results in FY 2023 (including provisional volume, calculation formula and using data)
- To consider the notes of this estimation method

《Members》

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Go Suzuki	Director, Office of Resource Recycling Technology, National Institute for Environmental Studies
Miki Sudo	Professor, University of Shiga Prefecture
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Fumiyuki Nakajima	Professor, The University of Tokyo
Hirofumi Nakayama	Professor, Graduate School of Engineering, Kyushu University
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2. Results of buildup estimation by sources and items

Information updated and refined from FY2023 to FY2024 is reflected in red, except “Littering: land and river” part which has been restructured entirely.

Scope of sources and items

- In FY 2020, we started to study the inventory method to estimate the amount of marine plastic litter discharged from Japan, referring to the source/category classifications and estimation methods by existing studies.
- The following pages provide details of the basic information related to this buildup estimate. Provisional figure are rounded.

Definition	Solid of which the polymer is the main constituent (including non-polymer components bound to or added to polymers and biodegradable plastics)
Size	1 µm or more in diameter at the time of emission into the environment
Pathway	Leakage to the ocean, either directly or through waster system (excluding those through the atmosphere or soil)
Sources and items	➢ Macroplastics (MacP) : Litttering, lost fishing gear ➢ Microplastics (MicP) : Intentionally added MicPs (4items), Unintentionally added MicPs (7items)

(Refer to sources and item classifications of UNEP, ICF&Eunomia, ECHA, etc.)

<table>
<tr><th colspan="2">Classification</th><th colspan="2">Source/Item</th></tr>
<tr><td colspan="2" rowspan="3">Macroplastics (MacP)</td><td rowspan="2">Littering</td><td>Land and River</td></tr>
<tr><td>Beach</td></tr>
<tr><td colspan="2">Lost fishing gears</td></tr>
<tr><td rowspan="11">Microplastics (MicP)</td><td rowspan="4">Intentionally added MicP</td><td colspan="2">Resin pellets</td></tr>
<tr><td colspan="2">Agricultural materials</td></tr>
<tr><td colspan="2">Detergents</td></tr>
<tr><td colspan="2">Cosmetic products</td></tr>
<tr><td rowspan="7">Unintentionally added MicP</td><td colspan="2">Automotive tyre wears</td></tr>
<tr><td colspan="2">Automotive brake wears</td></tr>
<tr><td colspan="2">Road Markings</td></tr>
<tr><td colspan="2">Synthetic textiles</td></tr>
<tr><td colspan="2">Building paints</td></tr>
<tr><td colspan="2">Marine Paints</td></tr>
<tr><td colspan="2">Artificial turf</td></tr>
</table>

<table>
<tr><td rowspan="4">Amount of macroplastics collected</td><td>River</td></tr>
<tr><td>Land</td></tr>
<tr><td>Coast</td></tr>
<tr><td>Ocean</td></tr>
</table>

Macroplastic

Waste from land and rivers, etc. (Summary of Estimation Method)

- Estimation based on the results of a survey of waste collected by dust collectors at drainage pumping stations, etc., and partially the results of image analysis using some interval cameras (waste not collected by dust collectors).
- At the drainage pumping stations where all the river water does not pass through the drainage pumping station (Otogo Drainage Pumping Station, Tsutaichi Drainage Pumping Station), interval cameras were installed and the amount of plastic waste not passing through the drainage pumping station was calculated by image analysis.
- The amount of litter discarded on land and in rivers that ends up in the ocean was firstly estimated for all of Japan in three cases: estimation Method ① (by type of land use), estimation Method ② (per person), and estimation Method③ (by catchment area).
- In addition, the results of the longitudinal survey revealed a correlation between the annual plastic runoff per unit area and the urbanization rate within the river basin of each point, and by multiplying this relationship by the urbanization rate and total land area of Japan, we established estimation method 4, "Estimation using the relationship between the amount of plastic waste per unit area and the urbanization rate ratio". Note that the calculation of the annual amount of plastic waste per unit area uses only the results of the survey of the waste collected by the dust collector at the drainage pumping station.

Field Survey

In the city center : Motogo, Shinkawa and Teshirogawa Drainage Pump Stations
Outside the city center : Hitotani River, Otogo, Tsutaichi and Shirone Drainage Pump Stations

Survey Results

(A) Amount of plastic waste discharged per volume of water processed by dust collector[kg/㎥]
(B) Garbage captured by cameras, not the drainage pump station.[kg]

Estimation Method	Survey results used	Step1	Step2	Step3	Step4
①	A [kg/㎥]	("A" is the average and median of the values obtained by dividing the weight [kg] of plastic waste collected at each survey point by the amount of water processed by the dust collector.)	Multiply the annual runoff volume from rainfall in urban and non-urban areas in Japan by A (or the sum of A and B') A (or A+B') [kg/㎥] ×Annual runoff volume associated with rainfall in urban and non-urban areas in Japan [㎥]	−	−
	B[kg]	(Conversion of units (from kg to kg/㎥)) Divide B by the annual runoff volume [㎥] from rainfall in the catchment area, and then align the units with A to calculate the amount of plastic waste runoff per unit of river volume that has passed through the survey point. B'= B[kg] ÷ Annual runoff volume due to rainfall in the catchment area [㎥]		−	−
②	A [kg/㎥]	Multiply by the annual runoff [㎥] from rainfall in the catchment area to calculate the annual plastic waste runoff at the study site. A' = A[kg/㎥] ×Annual runoff associated with precipitation in the watershed [㎥]	Multiply the ratio of the population of the catchment area to the population of Japan by A' (or the sum of A' and B) . A'[kg] ÷Catchment Area Population [person]× Population of Japan [person]	−	−
③	A [kg/㎥]	Multiply by the annual runoff [㎥] from rainfall in the catchment area to calculate the annual plastic waste runoff at the study site. A' = A[kg/㎥] ×Annual runoff associated with precipitation in the watershed [㎥]	Multiply the ratio of the catchment area to the area of Japan by A' (or the sum of A' and B) . A'[kg] ÷Catchment Area [㎢]× (total land) Area of Japan [㎢]	−	−
④	ɑ [kg]	("a" is the total weight [kg] of plastic waste collected at the survey site.) Divide the value of a by the catchment area (㎢) and the number of survey days (days), and multiply by 1 year (365 days) to calculate the annual amount of plastic runoff per unit area.	Finding a correlation between the results of a survey of the amount of waste collected by dust collectors at drainage pumping stations over time and the rate of urbanization in the catchment area of each location, and obtaining a formula for the relationship when the annual plastic runoff per unit area is on the vertical axis and the rate of urbanization in the catchment area of each location is on the horizontal axis.	Multiply this equation by the urbanization rate in Japan to obtain the annual plastic runoff per unit area in Japan.	Multiply the annual plastic runoff per unit area in Japan by the area of Japan.

Waste from land and rivers, etc. (Estimation Method①~③)

- Estimate based on the results of a survey of the waste collected by the dust collector at the drainage pumping station and the results of image analysis using an interval camera (waste not collected by the dust collector).
- The amount of waste flowing from land and rivers into the sea is calculated using three different methods: Method ① (by type of land use), Method ② (per person) and Method ③ (by catchment area).

In the city center : Motogo, Shinkawa and Teshirogawa Drainage Pump Stations
Outside the city center : Hitotani River, Otogo, Tsutaichi and Shirone Drainage Pump Stations

(A)Amount of plastic waste discharged per volume of water processed by dust collector[kg/m³]
(B)Garbage captured by cameras, not the drainage pump station.[kg]
At locations where not all river water passes through the drainage pump stations (Otogo and Tsutaichi Drainage Pump Station), (B) is used.

Method ①

Calculate the annual runoff volume [m³] from rainfall in urban and non-urban areas in Japan, and multiply by (A) to calculate the "Macroplastics leaking from land into the sea[t]".

Multiply A by the **annual runoff volume** [m³] from the catchment area to calculate the annual plastic waste volume at the survey site.[kg] (A')

Method ②

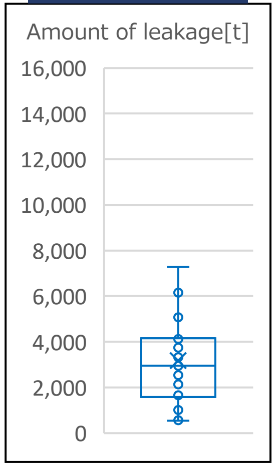
Multiply A' by the ratio of the catchment area population of the survey point to the population of Japan to calculate the " Macroplastics leaking from land into the sea[t]".

Method ③

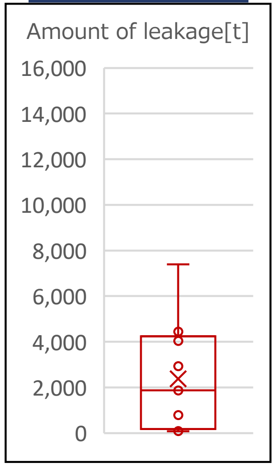
Multiply the ratio of the catchment area of the survey point to the area of Japan by A' to calculate the " Macroplastics leaking from land into the sea[t]".

Using the results of Estimation Methods ①~③, Calculate Macroplastics leaking from land into the sea[t]

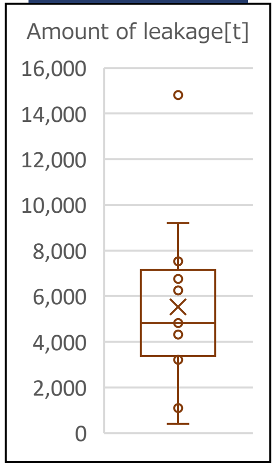
Method ①



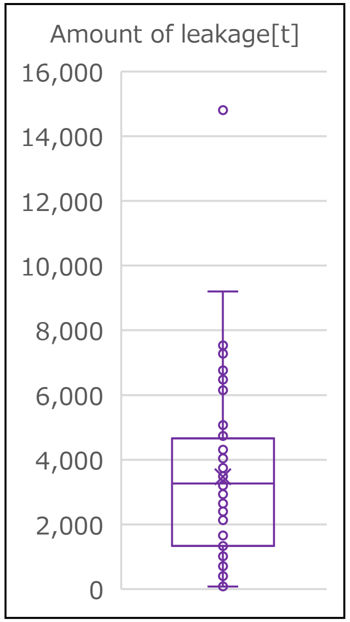
Method ②



Method ③



Calculate Macroplastics leaking from land into the sea[t]



Waste from land and rivers, etc. (Method①～③)

Method①～③ : Estimates based on the results of the Ministry of the Environment field survey project
Estimation based on the results of the drainage pump station survey and the results of the interval camera image analysis.

Method ①	A (or sum of A and B') Plastic waste leakage [kg/m³] (a) × Annual runoff volume associated with rainfall in urban and non-urban areas in Japan [m³] (b)	Data to be used (The latest available value)	a : Results of the survey of garbage collected by the dust collector at the drainage pumping station conducted as part of "Work to Understand the Situation of Plastic Garbage Flowing from Rivers, Lakes and Marshes to the Sea (FY2024) " (Includes survey data from FY2021 to FY2023.) and results of image analysis using interval cameras (garbage not collected by the dust collector). b : Analysis results of the water balance analysis method used in Nihei et al.(2020). Catchment area and Land Use 3rd Mesh (National Land Numerical Information Download Site)
Provisional	Average 3,180 t/y, Median 2,900 t/y		
Method ②	A' (or sum of A' and B) Plastic waste leakage [kg/m³] (a) × Annual runoff from precipitation in the Catchment area [m³] (b) × Population of Japan / catchment area population of survey points [person/person] (c)	Data to be used (The latest available value)	a : Results of the survey of garbage collected by the dust collector at the drainage pumping station conducted as part of "Work to Understand the Situation of Plastic Garbage Flowing from Rivers, Lakes and Marshes to the Sea (FY2024) " (Includes survey data from FY2021 to FY2023.) and results of image analysis using interval cameras (garbage not collected by the dust collector). b : Analysis results of the water balance analysis method used in Nihei et al.(2020). Catchment area (National Land Numerical Information Download Site) c : Population 3rd and 5th mesh (e-stat: The portal site for government statistics), Catchment area (National Land Numerical Information Download Site)
Provisional	Average 2,400 t/y, Median 1,900 t/y		
Method ③	A' (or sum of A' and B) Plastic waste leakage [kg/m³] (a) × Annual runoff from precipitation in the Catchment area [m³] (b) × Area of Japan / catchment area of survey point [km²/km²] (c)	Data to be used (The latest available value)	a : Results of the survey of garbage collected by the dust collector at the drainage pumping station conducted as part of "Work to Understand the Situation of Plastic Garbage Flowing from Rivers, Lakes and Marshes to the Sea (FY2024) " (Includes survey data from FY2021 to FY2023.) and results of image analysis using interval cameras (garbage not collected by the dust collector). b : Analysis results of the water balance analysis method used in Nihei et al.(2020). Catchment area and Land Use 3rd Mesh (National Land Numerical Information Download Site) c : Geospatial Information Authority of Japan Map (Geographical Survey Institute)
Provisional	Average 5,500 t/y、Median 4,800 t/y		

Waste from land and rivers, etc. (Method①～③)

Method①～③ : Estimates based on the results of the Ministry of the Environment filed survey project
Estimation based on the results of the drainage pump station survey and the results of the interval camera image analysis.

Issues and Notes

- The leakage volume is estimated using the average and median of each estimation formula based on the survey results, so the values may change when the survey results of large runoff events such as typhoons are added.
- The amount of leakage is based on the amount recovered from the land through drainage pump station surveys in specific areas (drainage pump station surveys are for items that leaked into the river after being recovered through land-based cleanup efforts, etc.).
- Although land use type, population, etc. are considered in the selection of data, the values are based on surveys conducted in specific regions and at specific times.
- It is necessary to accumulate the results of surveys on plastic waste, such as the results of surveys on plastic waste discarded at continuously operating drainage pump stations and the results of surveys using interval cameras and image analysis methods at continuously non-operating drainage pumping stations.
- In the case of a survey at a drainage pump station, plastic waste smaller than the mesh size of the screen will pass through the collector. Therefore, these values are not considered in this method.
- Factors other than land use type, population, and catchment area (such as the location of vending machines and convenience stores) are not considered.
- The range of provisional values is due to statistical processing.

Waste from land and rivers, etc. (Method ④)

- A correlation was found between the results of a survey of the amount of waste collected by dust collectors at drainage pumping stations over time and the rate of urbanization in the river basin of each location, and the amount of waste was estimated by multiplying this correlation by the rate of urbanization and the area of Japan.
- Since the study period was concentrated in a period when the monthly runoff due to rainfall was relatively large, we adjusted with correction factor (*) by considering the annual runoff volume for avoiding over estimation.

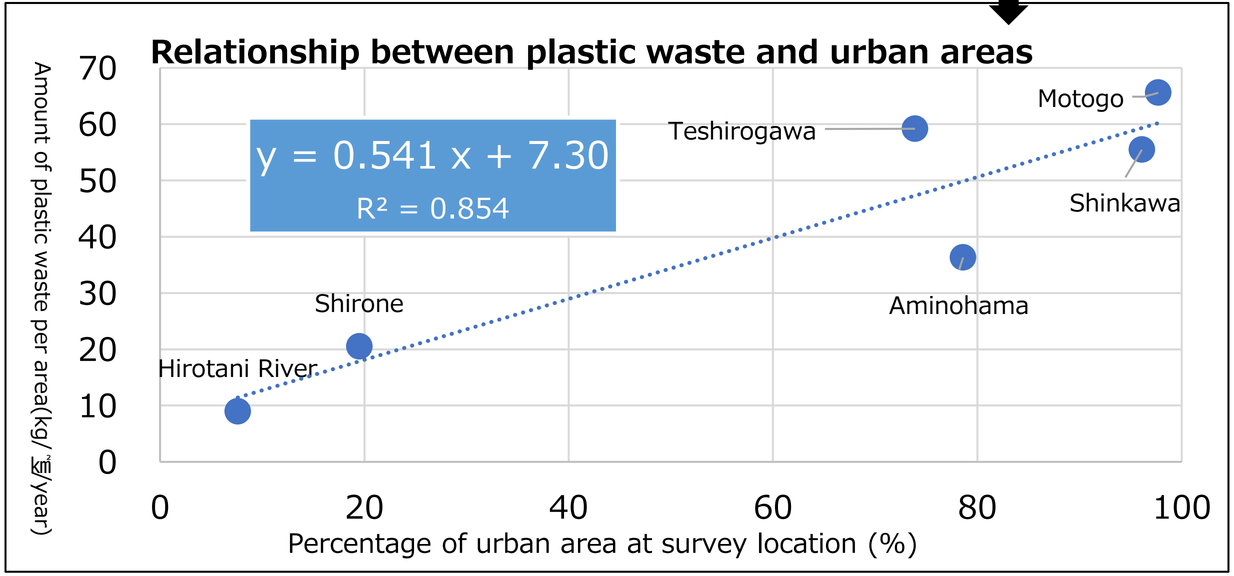
y : Estimate of plastic waste discharged per unit area per year. (kg/㎢/year)

α (total weight of plastic waste collected at the survey site [kg]) is divided by the catchment area of the survey site (km^2) and the number of days surveyed (days), and multiplied by 1 year (365 days) to calculate.

x : Percentage of urban area at survey location (%)

Use of "Land Use 3rd Mesh Data" from the National Land Numerical Information Download Site.

Obtain a relationship equation from the correlation between y and x ($y=0.541x+7.30$, $R^2 = 0.854$)



Method for Estimating the Annual Amount of Plastic Waste (kg/㎢/year) per Unit Area in Japan

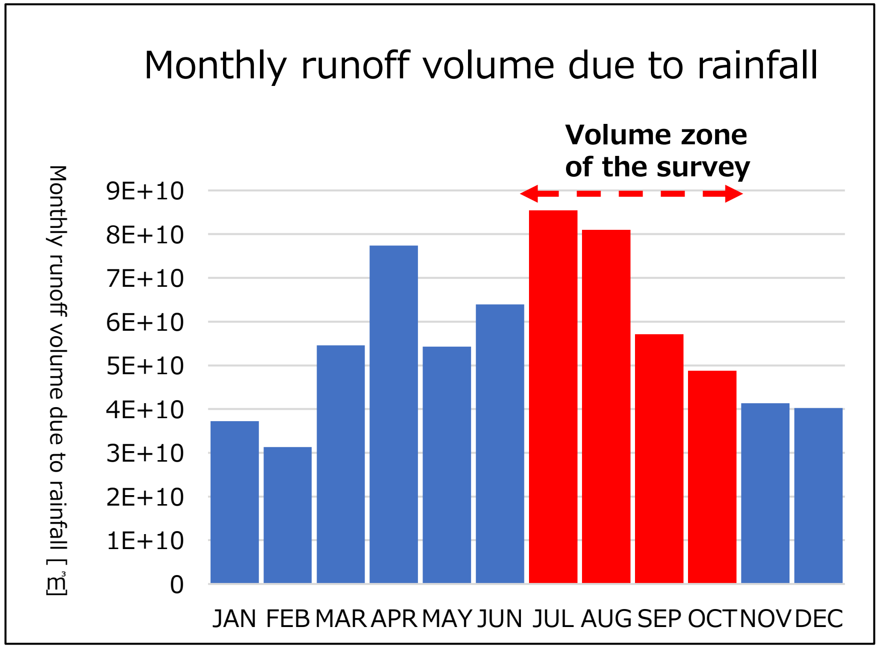
The percentage of urban areas in Japan is substituted for x in the formula “y=0.541x+7.30” to calculate the result.

Method for estimating the amount of runoff (t/year) from all over Japan

Multiply the annual plastic waste discharge per unit area (kg/㎢/year) for all of Japan by the area of Japan.

*Correction of runoff volume due to rainfall to avoid overestimation

The correction factor is calculated by dividing the amount of runoff due to annual precipitation by the estimated amount of runoff due to precipitation ((Total amount of leakage/number of months surveyed) x 12) during the study period.



Estimated amount of leakage from all over Japan × Correction for runoff volume due to rainfall

Waste from land and rivers, etc. (Method ④)

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Method④ : Estimates based on the results of the Ministry of the Environment filed survey project
(Estimate based on the results of a survey of the waste collected by the dust collector at the pump station.)

Method ④	(1)Estimated amount of leakage from all over Japan The value obtained by substituting the percentage of urban areas in Japan (a) into the equation "y=0.541x+7.300". × Area of Japan [km^2] (b) (2) Estimated leakage after overestimation correction Estimated amount of leakage from all over Japan × Correction factor for runoff volume due to rainfall (c)	Data to be used (The latest available value)	a : Land Use data (1km grid) (National Land Numerical Information Download Site) b : Geospatial Information Authority of Japan Map (Geographical Survey Institute) C : Analysis results of the water balance analysis method used in Nihei et al.(2020). Results of the "Study on the current state of plastic waste in rivers, lakes and marshes and its flow into the ocean" in FY2024
Provisional	3,400 t/y		

Waste from land and rivers, etc. Summary of estimation Methods①～④

- Below are the ranges of average and median values for estimation method ①～③. The value for the estimation method ④ is also within this range.

Range of Average	2,400 t/y～5,500 t/y	Range of Median	1,900 t/y～4,800 t/y

Waste from land and rivers, etc. (Method ④)

Method④ : Estimates based on the results of the Ministry of the Environment filed survey project (Estimate based on the results of a survey of the waste collected by the dust collector at the pump station.)

Issues and Notes

- Regarding the percentage of urbanization zones at survey locations, it will be necessary in the future to accumulate data for locations with low percentages of urbanization zones and others where there are currently a small number of data points.
- Values may change as additional survey results are added for large-scale flooding caused by typhoons, etc.
- The amount of leakage is based on the amount recovered from the land through drainage pump station surveys in specific areas (drainage pump station surveys are for items that leaked into the river after being recovered through land-based cleanup efforts, etc.).
- Although land use type, population, etc. are considered in the selection of data, the values are based on surveys conducted in specific regions and at specific times.
- It is necessary to accumulate the results of surveys on plastic waste, such as the results of surveys on plastic waste discarded at continuously operating sewage pumping stations and the results of surveys using interval cameras and image analysis methods at continuously non-operating sewage pumping stations.
- In the case of a survey at a wastewater pump station, plastic waste smaller than the mesh size of the screen will pass through the collector. Therefore, these values are not considered in this method.
- Factors other than land use type, population, and catchment area (such as the location of vending machines and convenience stores) are not considered.

Littering on the beach

Estimation method 1: Estimation using the results of the MOEJ filed survey project (Estimation using the existing amount of beach litter)

Formula	National collected amount of waste (artifacts) washed ashore 【a】 × Rate of beach litter to the total waste【b】 × Rate of plastic waste in the artifacts【c】	Data used (latest available)	a: MOEJ filed survey project in FY2023 (2022 survey results) b: Kanagawa Coastal Beautification Foundation (1996) (1992 survey results) c: MOEJ filed survey project in FY2023 (2022 survey results)
Provisional figure	1,900 t/year		

Issues and Notes

- "Data a" and "data c" are representative data that can be expected to be updated regularly, as the country aggregate results that municipalities under the country-led filed survey project.
- "Data b" has the following points to note: the survey was conducted at an early date and the emission trend of litter may have changed; the survey covered only some beaches in Kanagawa Prefecture, which have issues of representativeness; and the data includes past data by illegal dumping.
- "Data a" and "Data c" could include litters from other countries, while "data b" takes into account the "percentage of abandoned litter that may be generated on the beach (in Japan)" among the plastic litter existing on the beach.
- Regarding litters on the beach, it can be divided into two concept: 1. The occurrence rate per unit time and unit area (also referred to as flux, which does not include potential accumulations from the past); and 2. The existing amount (the amount present at a certain point in time, which may include potential accumulations from the past). If the data used for the estimation corresponds to "2", accumulations from the past could be also accounted for.

Litterring on the beach

Estimation method 2: Estimation based on the results of ERTDF project S-19-3 (Estimation based on the "generation intensity of littering on the beach")

Estimation formula	{Amount of littering on the beach per person and per hour [a] × Number of users and hours per year at 135 coast [b]} × Rate of number of users on coasts 135 and 770 [c]	Data used (latest available)	a: Hinata, 2025, An estimation of the abundance of plastic litter generated by beach users nationwide in Japan. (Results of ERTDF project S-19-3) by Prof. Hidaka, Ehime University) b: Same as above c: Same as above
Provisional figure	13 t/year		

Issues and Notes

- "Data a" excludes past litters and litters from other countries, and the "number of users" and "user times" are also likely to be closer to the actual situation in that they are collected and analyzed through actual data.
- "Data a" is calculated for containers that are consumed and littered by daytime users on the spot, and does not cover littering at night or during events such as fireworks shows, or illegal dumping. In some areas, it is reported that the amount of littering at night is relatively high.
- The survey is also conducted at beaches with a large number of users in Japan, so it is unlikely to be an underestimate.
- Methodology has been established and can be deployed overseas (however may be difficult to implement in developing countries due to the need to clean up existing littering before the survey).

(*) New estimation method added in FY2024

Lost Fishing Gear

Estimation Method 1: Estimation using "the amount of fishing gear used per management unit by fishery type" and "the loss rate per fishing gear used by fishery type".

Based on the issues identified by the previous FY and the results of the discussion in the study group in FY2024 about, estimation method 1 will be excluded from this project in FY2025.

Estimation Method 2: Estimation using "Catch by Fishery Type" and "Gear Lost per Catch by Fishery Type".

Estimating equation	**Catch by fishery type (t) [a]** **× Amount of loss gear per catch by fishery type (kg/t) [b]**	Data used (latest available)	**a: MAFF "2021 Fishery and Aquaculture Production Statistics"** **b: Results of ERTDF project S-19-2 by Pro. Nakayama, Kyushu university**
Provisional figure	Under scrutiny		

Issues and Notes

- Regarding the estimation formula, the catch by species of 13 fishery species was estimated as the basic unit based on the survey of 9 fishery species.
- For "data b", see below.

Runoff intensity

- ➢ Fish catches vary widely from year to year, there is a possibility that the values may vary from year to year in the target years. **If it is possible to calculate the "per-business-unit, per-day outflow unit" through surveys in the future, it may be possible to update the estimation formula to take into account countermeasures that are more in line with the actual situation.**
- ➢ It is highly likely to overestimate the loss rate from longline gear. **It is necessary to update the leakage rate for longline fishing to reflect the actual situation through surveys targeting other fish species that are less likely to become entangled in longline gear.**
- ➢ The survey includes fisheries and fishing gear that have not lost any gear over a long period of time, so the loss rate may be overestimated.

Survey design

- ➢ Data representativeness needs to be improved due to limited sample size.
- ➢ The survey in nationwide by fishery type and size needs to be conducted and the survey method needs to be considered for fishery stakeholder
- ➢ The circumstances of loss also vary depending on the type and size of fishery (some fisheries may be entirely loss, while others may remain partially intact).
- ➢ The amount of fishing gear stored after purchase needs to be considered (actual conditions of storage and use vary by fishery type and size).

Lost Fishing Gear

Estimation method 3: Estimation using the "Input-Output Table"
(rough verification method for the validity of the provisional figures in method 1 and 2)

Estimation formula	**Input of plastic products in the fishery sector (t) [a] × Amount of plastic products disposed of in the fishery sector (t) [b].**	Data used (latest availale)	**a: Input-output table (Ministry of Internal Affairs and Communications, 2011)** **b: Input-output table for environmental sector analysis (Ministry of the Environment, 2011)**
provisional figure	Under scrutiny		

Issues and Notes

- It is relatively easy to roughly estimate the amount of fishing gear loss into the environment (the amount could be discharged into the ocean in the long term) with this method.
- The actual condition and behavior of stocks that do not discharge into the ocean, but remain in the environment are not taken into account.
- Although the value of fish boxes and other containers is included, the containers are often used as land transport and are very unlikely to discharge into the ocean.

Microplastics (Intentionally added microplastics)

Resin pellets (including polymeric beads)

Estimates based on ICF & Eunomia (2018)

Estimation formula	**Σ (Amount of resin pellets handled by business category [a]** **× Rate of discharge into the environment [b])** **× Leakage rate to the ocean by pathway [c]**	**Data used (latest available)**	**a: METI "Current Production Statistics (2024)", MOF"Trade Statistics (2024)", Plastic Waste Management Institute "Material Flow of Plastics (2022)", etc.** **b: Results of previous studies and interviews with plastics industry organizations (conducted in FY2021)** **c: Leakage rate to the ocean by rainwater drainage**
Provisional figure	110～860 t/year		

Issues and Notes

- The estimation formula is based ICF&Eunomia (2018).
- It is assumed that the rate considered as polymer weight of polymeric beads to resin pellets is 75%.
- With regard to "data a", based on the results of interviews with plastic industry associations (conducted in FY2021), 90% of the plastic raw material production volume is assumed to be produced by large-scale facilities, while 10% is by small-scale facilities.
- "Data b" is based on previous studies in Scandinavia and the results of interviews with plastic industry organization in FY2020 to FY2021, but there is insufficient information on the actual situation in Japan.
- With respect to "data c", the values are not specific to resin pellets (including polymeric beads).
- With respect to "data c", the rate is referred to ICF&Eunomia (2018), but it is need to consider the rate based on actual condition of road surrounding environment in Japan.
- The range of the provisional figure depends on the range of "data b".

Agricultural materials (Coated fertilizers)

Estimates based on ECHA (2019)

Estimation formula		Data used (latest available)	
Estimation formula	**Coated fertilizer consumption [a]** **× Polymer concentration [b]** **× Leakage rate to the ocean by pathway [c]**	Data used (latest available)	**a: Statistics data by MAFF website (Production and Input Amounts by type of standard fertilizer 2022).** **b: Results of interviews with fertilizer industry organizations (conducted in FY2021)** **c: Leakage rate to the ocean from fields**
provisional figure	58～1,900 t/year		

Issues and Notes

- The estimation formula is based on ECHA (2019). As differences in timing of fertilizer application and leakage are not taken into account, provisional figure may be overestimated. Estimates utilizing representative leakage intensity are needed.
- While ECHA (2019) considers the total amount of fertilizer applied to agricultural fields as leakage in the environment, this project covers only leakages to the ocean from fields.
- For “data a”, the figure is based on ongoing studies and are updated periodically. Note that some of the paddy fields may be used as land fields through shifting cultivation, and the data would be closer to the actual situation if the amount shipped to and leakage from the land fiels could be taken into account.
- For “data c”, updated rates are obtained from the expert interviews in FY2023 on the results of Katsumi et al. (2021) and others.
- It is likely that most of the coated fertilizer applied to the field is leakage from snowfall rain, and the leakage rates may also vary by region.
- No information on the rate of coated fertilizer that remain in the soil without decomposition or the actual state of soil micronization of coated fertilizer has been obtained.
- The rates of sludge used in agricultural fields are assumed based on the data from the Sewerage Business Management Center.

Agricultural materials (Fertilizer additives)

Estimates based on ECHA (2019)

Estimation formula		Data used (latest available)	
	Fertilizer imports [a] × Percentage of fertilizer containing additives [b] × Polymer concentration per ton of fertilizer [c] × Leakage rate to the ocean by pathway [d]		a: Statistics data by MAFF website (Import volumes of Nitrogen, Phosphoric Acid, Potassium, and compound fertilizer) B: ECHA (2019) c: ECHA (2019) d: Leakage rate to the ocean from fields
provisional figure	1～94 t/year		

Issues and Notes

- The estimation formula is based on ECHA (2019).
- Fertilizer additives are added to fertilizers as anti-solidifiers, granulation accelerators, etc. Detailed information is not provided in ECHA (2019), and ECHA (2019) only addresses anti-solidifiers.
- Although information on the actual situation in Japan is lacking, it is estimated that only a small percentage of fertilizers use additives. The rate of polymers used as fertilizer additives is estimated to be very small.
- The range of the provisional figure depends on “data b” and “data d”.

Agricultural materials (Microcapsules for agrochemicals)

Microcapsule formulations (formulations containing a capsule in which the agrochemical active ingredient is uniformly coated with a polymer film, etc.) are used to provide the active ingredient of an agrochemical to crops in a slow-acting manner. By controlling the release of the ingredients to an appropriate amount, it is believed that the environmental impact can be reduced and economic efficiency can be achieved.

Estimates based on ECHA (2019)

Estimation formula	**Pesticide shipments [a]** **× Share of capsule formulations [b]** **× Polymer concentration [c]** **× Leakage rate to the ocean by pathway [d].**	Data used (latest available)	**a: Pesticide Handbook 2022 (Japan Plant Protection Association)** **b: ECHA (2019)** **c: ECHA (2019) and interview with fertilizer manufacturer (conducted in 2020)** **d: Leakage rate to the ocean from fields**
provisional figure	Less than 0.5 t/year		

Issues and Notes

- The estimation formula is based on ECHA (2019).
- It is assumed that 100% of the pesticides are used in fields.
- Information on the actual situation in Japan is lacking.
- The range of the provisional figure depends on “data b” and “data d”, but is less than 0.5 t.

Agricultural materials (Coated seeds)

- In Japan, "coated seeds" are considered to following three types as pelleted seeds, seed tapes and film-coated seeds.
- Based on interviews with agricultural material manufacturers, some of the above mentioned insoluble resins may be used as part of the materials in the processing of film-coated seeds, and therefore, this project cover resins for film-coated seeds.

Estimates based on ECHA (2019)

Estimation formula	**Σ {Amount of wheat, soybeans, and feed crops for processing [a]** **× Polymer concentration per unit amount of seed [b]}** **× Leakage rate to the ocean by pathway [c]**	Data used (latest available)	**a: Statistic data by MAFF** **b: ECHA (2019)** **c: Leakage rate to the ocean from fields**
provisional figure	Less than 0.5 t/year		

Issues and Notes

- The estimation formula is based on ECHA (2019).
- It is assumed that all will be applied in the field.
- Information on the actual situation in Japan is lacking.
- The range of the provisional figure depends on “data b”, but is less than 0.5 t.

Detergents

Estimates based on ECHA (2019)

Estimation formula		Data used (latest available)	
	Domestic sales of detergents and fabric softeners (t) [a] **× Rate of products using aromatic capsules (%) [b]** **× Polymer concentration [c]** **× Leakage rate to the ocean by pathway [d]**		**a: Statistic data by Japan Soap and Detergent Association (2023)** **b: Data by International Fragrance Association (2018)** **c: Data by International Fragrance Association (2018)** **d: Leakage rate to the ocean by sewage drainage**
provisional figure	1～8 t/year		

Issues and Notes

- The estimation formula is based on ECHA (2019).
- For “data d”, the figure are not specific to detergents.
- Information on the actual situation in Japan is lacking.
- The range of the provisional figure depends on “data b” and “”data c.

Cosmetic products

Estimates based on ECHA (2019)

Estimation formula		Data used (latest available)	
	Σ (Shipment volume per product [a] **× Rate of products in which MicP is used [b])** **× Polymer concentration [c])** **× Leakage rate to the ocean by pathway [d]**		**a: METI "Current Production Statistics" (2023)"** **B: ICF & Eunomia (2018)** **c: ICF & Eunomia (2018)** **d: Leakage rate to the ocean by sewage drainage and from waste disposal process**
provisional figure	300～480 t/year		

Issues and Notes

- The estimation formula is based on ECHA (2019).
- For "data d", the figure are not specific to personal care products.
- For "data d", 5% is assumed to remain in the container and be discharged as waste with reference to ECHA (2019). The remaining 95% is assumed to be discharged by sewage drainage for rinse-off products. For leave-on product, 50-90% as waste and 10-50% by sewage drainage.
- The range of the provisional figure depends on the range of "data b" and "data c".
- For personal care products, MOE conducted a survey in 2020 to confirm the use of microbeads in rinse-off products, and as a result, for the companies surveyed (51 companies), there were no products using microplastic beads as a scrubbing agent.
- On the other hand, information on the actual microplastics contained in leave-on products is lacking.

Microplastics (Unintentionally added microplastics)

Automotive tyre wears

Estimation method 1: Estimation based on ICF & Eunomia (2018)

Estimation Formula1	**Σ{Mileage by vehicle type (km) [a] × Amount of wear by vehicle type (mg/km) [b]} × Polymer concentration (%) [c] × Leakage rate to the ocean by pathway (%) [d]**	Data used (latest available)	**a: NIES "Japan's Greenhouse Gas Inventory Report 2024" b: SPM Prediction Manual by Environment Agency (1997) c: JATMA "Japan's Automotive Tire Industry 2024" d: Leakage rate to the ocean by rainwater drainage**
provisional figure	5,700 t/year		

Issues and Notes

- The estimation formula is based on ICF & Eunomia (2018).
- For "data a", the data is considered to be reliable and representative, updated on a regular basis.
- For "data b", the data is tentatively adopted because there is no other data available in Japan, but this data is only by vehicle type and does not include information by road. In addition, the data is based on the results of a survey conducted in the 1990s, and may not be in line with the current situation given the latest tire performance and road conditions. Although the new research on tire ware volume was conducted in FY2024, the result is not adopted in this estimation due to reasons such as the limited types of vehicles surveye,d and the relatively short driving distances covered in the survey.
- It is need to obtain data for the amount of tire wear generated on the road and its subsequent behavior, taking into account differences in vehicle type, road type, and driving method.
- For "data c", the data was estimated based on JATMA public data, but other information (information on higher polymer concentration than in the case of Japanese tires) also exists for tires made overseas. If the domestic market shares of Japanese and foreign tires could be taken into account, it is possible that the figure may be closer to the actual situation.
- For "data d", it is based on ICF&Eunomia (2018), but it is need to update the rate based on the actual situation of road surrounding environment in Japan.

Estimation method 2: Estimation based on PRTR emission estimation

Estimation Formula2	**Σ{Annual tire usage (kg) [a] × Annual tire wear rate (%) [b]} × Polymer concentration (%) [c] × Leakage rate to the ocean by pathway (%) [d]**	Data used (latest available)	**a: Calculated based on statistic data by AIRIA and LCCO2 guideline by JATMA b: Calculated based on 2015 road traffic census and JATMA guideline c: JATMA "Japan's Automotive Tire Industry 2024" d: Leakage rate to the ocean by rainwater drainage**
provisional figure	9,400 t/year		

Issues and Notes

- The estimation method is based on PRTR emission estimation. (https://www.env.go.jp/press/press_04462.html)
- "Data a" in method 2 is **differs from method 1 in that the figure is calculated based on the number of vehicles owned. This data is considered to be reliable and representative of the data published by industry associations.**
- "Data b" in method 2 **includes units that are owned but not actually run, and the run life may be more conservative than it actually is.**
- It is need to obtain data for the amount of tire wear generated on the road and its subsequent behavior, taking into account differences in vehicle type, road type, and driving method.
- Issues and Notes for "data c" and "data d" in method 2 are same as method 1.

Automotive brake wear

Estimates based on ICF & Eunomia (2018)

Estimation formula	Σ{Mileage by vehicle type (km) [a] × Amount of wear by vehicle type (mg/km) [b]} × Polymer concentration (%) [c] × Leakage rate to the ocean by pathway (%) [d]	Data used (latest available)	a: NIES "National GHG inventory document of Japan 2024" b: ICF & Eunomia (2018) c: Based on previous studies d: Leakage rate to the ocean by rainwater drainage
provisional figure	4～120 t/year		

Issues and Notes

- Basically, the same estimation method for automotive tire wear is used.
- For "data b", it is based the previous overseas surveys refereed by ICF&Eunomia (2018). It is considered that it is often generated together with the tire-wear, and the data on such brake wear rate should be updated in conjunction with the new data on wear rate of tire-wear in Japan in the future.
- For "data c", it is based on previous studies.
- For "data d", the figure are not specific to brake wear. Based on previous studies, it is assumed that 68%～98% is released into the atmosphere.
- For "data d", it is based on ICF&Eunomia (2018), but it is need to update the rate based on the actual situation of road surrounding environment in Japan.
- The range of the provisional figure depends on the range of "data d" and release rate to the atmosphere.

Road markings

Estimates based on ICF & Eunomia (2018)

Estimation formula	**Paint shipments (t) [a]** **× Solid concentration (%) [b]** **× Polymer concentration (%) [c]** **× Leakage rate to the ocean by pathway (%) [d]**	Data used (latest available)	**a: Interview with road marking industry organization (conducted in 2020)** **b: Interview with road marking industry organization (conducted in 2020)** **c: Interview with road marking industry organization (conducted in 2020)** **d: Leakage rate to the ocean by rainwater drainage**
provisional figure	3,600～4,300 t/year		

Issues and Notes

- Based on the results of interview with road marking industry organization, in Japan it is assumed that new road marking materials are purchased and used for maintenance purposes.
- Overall, publicly available information is limited, and much of the information can only be obtained through interviews with industry associations. Data b and c are unlikely to be updated on a regular basis, there is little data directly related to the update of the estimates.
- Road markings are regarded as relative large sources among microplastics generated on roads. It is expected to refine the figures thorough getting data specific to road markings on their behavior after generation.

Synthesis textiles

Estimates based on ICF & Eunomia (2018)

Estimation formula	Σ {Average weight per wash (kg)(a) × Percentage of each fiber type (%)(b) × Amount of fiber generated per kg of each fiber type (mg/kg)(c)} × Washing machine ownership rate (%)(d) × Average number of laundry cycles per household (times/year)(e) × Number of households (f) × Collection rate by filter (%)(g) × Factor based on laundry use (h) × Leakage rate to the ocean by pathway (%)(i)	Data used (latest available)	a: Statistic data by Japan Soap and Detergent Association b: Korean Chemical Fiber Association "Chemical Fiber Handbook" c: Interview with chemical fiber industry organization (conducted in 2020) d: Ministry of Internal Affairs and Communications “National Survey of Family Income and Expenditure in 2014" e: Statistic data by Japan Soap and Detergent Association f: Ministry of Internal Affairs and Communications "Basic Resident Register” G: MOEJ project in FY2019 h: Statistic data by JAPAN CLEANING CHEMICALS ASSOCIATION i: Leakage rate to the ocean by sewage drainage
provisional figure	350 t/year (this does not have a range, but is not definitive)		

Issues and Notes

- The estimation formula is based on ICF & Eunomia (2018).
- “Data g” is taken from MOEJ project on floating microplatics in FY 2019.
- “Data i” is not specific to fiber.

Building paints

For architectural paints, in addition to cases where painted coatings on buildings deteriorate and spill into the environment (case (i)), ICF&Eunomia (2018) and ECHA (2019) state that there are also cases where paints used in the home spill into the environment (case (ii), such as when used brushes are cleaned) The project will address case (1) and case (2). Cases (1) and (2) will be covered in this project.

Estimates based on ICF & Eunomia (2018)
Case 1: When painted coating on buildings deteriorates and leaks into the environment

Estimation formula		Data used (latest available)	
Estimation formula	**Σ {paint solids amount (t)[a] - polymer degradation amount (t)[b]} ×(Degradation rate (%)[c] + Microplastic generation rate upon coating removal (%)[d]) × Polymer concentration (%)[e] × Leakage rate to the ocean by pathway (%)[f]**	Data used (latest available)	**a: Interview with paint industry association (conducted in FY2021)** **b: ICF & Eunomia (2018) and interview with paint industry association (conducted in FY2021)** **c: ICF & Eunomia (2018) and interview with paint industry association (conducted in FY2021)** **d: ICF & Eunomia (2018)** **e: Interview with paint industry association (conducted in FY2021)** **f: Leakage rate to the ocean by rainwater drainage**
provisional figure	120～2,300 t/year		

Issues and Notes

- The estimation formula is based on ICF & Eunomia (2018).
- For “data b”, based on the paint industry association hearing (conducted in FY2021), 36% is set for finish paints and 23% for other materials.
- For “data c”, ICF & Eunomia (2018) reported at 2.5%, while in Japan, the degradation rate is assumed to be low and therefore set at 0-2%.
- For “data d”, it is based on ICF&Eunomia (2018) and OECD (2009).
- Throughout, there is a lack of surveys and research on the actual situation.
- For “data f”, it is not specific to paint.
- For “data f”, it is based on ICF&Eunomia (2018), but it is need to update the rate based on the actual situation of road surrounding environment in Japan.
- The range of the provisional figure depends on the range of “data d” as well as “data e”.

Building paints

Estimates based on ECHA (2019)
Case 2: Paint used at home leakage into the environment

Estimation formula		Data used (latest available)	
Estimation formula	**Household water-based paint usage (t) [a]** **× Polymer concentration (%) [b]** **× Rate of leakage from households (%) [c]** **× Leakage rate to the ocean by pathway (%) [d]**	Data used (latest available)	**a: Interview with paint industry association (conducted in FY2021)** **b: Interview with paint industry association (conducted in FY2021)** **c: ECHA (2019)** **d: Leakage rate to the ocean by sewage drainage**
provisional figure	2～6 t/year		

Issues and Notes

- The estimation formula is based on ECHA (2019)
- For “data a”, since it is assumed that waterborne paints are used to wash brushes after painting at home, the volume of shipments of waterborne paints is targeted.
- Throughout, there is a lack of surveys and research on the actual situation.
- The range of the provisional figure depends on the range of “data b”.

Marine Paints

- For marine paints, based on previous studies, this project cover the case 1: where painted coating on ships deteriorates and leaks into the ocean and case 2: where paints are leaked into the environment during the process of painting ships.
- Among marine paints, "inorganic store primer" is excluded because it does not contain synthetic polymers.

Estimates based on ICF & Eunomia (2018)
Case 1: When painted coating on a vessel deteriorates and leaks into the environment

Estimation formula	**Paint solids (t) [a]** **× Degradation rate (%) [b]** **× Polymer concentration (%) [c]** **× Leakage rate to the ocean by pathway (%) [d]**	Data used (latest available)	**a: Interview with paint industry association (conducted in FY2021)** **b: ICF & Eunomia (2018)** **c: Interview with paint industry association (conducted in FY2021)** **d: It is assumed that the entire amount is discharged directly into the sea**
provisional figure	75～160 t/year		

Issues and Notes

- The estimation formula is based on ICF & Eunomia (2018).
- Overall, surveys and research on the actual situation is insufficient.
- The range of the provisional figure depends on the range of “data c”.

Marine paints

Estimates based on ICF & Eunomia (2018)
Case 2: Leakage into the environment from the coating process on ships

Estimation formula	**Paint usage (t) [a]** **× Polymer concentration (%) [b]** **× Rate of leakage into the environment (%) [c]** **× Leakage rate to the ocean by pathway (%) [d]**	Data used (latest available)	**a: Interview with paint industry association (conducted in FY2021)** **b: Interview with paint industry association (conducted in FY2021)** **c: Interview with paint industry association (conducted in FY2021) and OECD (2009)** **d: Leakage rate to the ocean from waste disposal process**
provisional figure	230～790 t/year		

Issues and Notes

- The estimation formula is based on ICF & Eunomia (2018).
- Throughout, there is a lack of surveys and research on the actual situation.
- It is assumed that the removed paint will be categorized into those that leaks to water system, those that leaks to soil, and those that are disposed of as waste.
- The range of the provisional figure depends on the range of “data b”.

Artificial turf (Pile)

Estimates based onLassen et al. (2015)

Estimation formula		Data used (latest available)	
Estimation formula	Σ {Total area of artificial turf for sports (m2) [a] × Pile usage rate (kg/m2) [b] × Pile wear rate (%) [c]) +a little more than usual (Sales volume of artificial turf for exterior use (kg) [d] × Pile wear rate (%) [c]} × Transition rate to leakage pathway (%) [e] × Leakage rate to the ocean by pathway (%) [f]	Data used (latest available)	a: Statistics data by Sports Agency, etc. b: Interview with Artificial turf manufacturer (conducted in FY2022) c: Interview with Artificial turf manufacturer (conducted in FY2022) d: Statistics data by Japan Plastics Industry Federation e: Interview with sports facility industry associations and artificial turf manufacturer (conducted in FY2022) f: Leakage rate to the ocean by rainwater drainage, by sewage drainage and from waste disposal process, respectively
provisional figure	240 t/year (This does not have a range, but is not definitive)		

Issues and Notes

- Regarding the estimation formula, it was adopted through interviews with relevant stakeholders (the same approach taken by Lassen et al. (2015)).
- For “data c”, there is an uncertainty in the accuracy of measurement for artificial turf for sports. For artificial turf for exterior use, there are few surveys and studies on the actual status, and there is a lack of information that can be used for estimation.
- For “data e”, there is a lack of surveys and research of actual situation. Based on interviews with sports facility industry associations and artificial turf manufacturers (conducted in FY2022), it is assumed that 70% is transferred to rainwater drainage, 5% to sewage drainage, 5% to waste disposal process, and 20% remains in the soil.
- For “data f”, is is not specific to artificial turf.
- For “data f”, it is based on ICF&Eunomia (2018), but it is need to update the rate based on the actual situation of road surrounding environment in Japan.

Artificial turf (Infill (intentionally added microplastics))

Estimates based on ICF&Eunomia (2018)

Estimation formula	Total area of long-pile artificial turf (m2) [a] × Density of filler material (kg/m2) [b] × Filler annual generation rate (%) [c] × Transition rate to leakage pathway (%) [d] × Leakage rate to the ocean by pathway (%) [e]	Data used (latest available)	a: Related materials b: Interview with artificial turf manufacturer (conducted in FY2022) c: ICF & Eunomia (2018) d: Interviews with sports facility industry associations and artificial turf manufacturer (conducted in FY2022) e: Leakage rate to the ocean by rainwater drainage, by sewage drainage and from waste disposal process, respectively.
provisional figure	540～2,700 t/year		

Issues and Notes

- The estimation formula is based on ICF & Eunomia (2018).
- There is a lack of research and investigation to accurately understand the data c and d.
- For "data d" based on interviews with sports facility industry associations and artificial turf manufacturers (conducted in FY2022), it is assumed that 70% will be transferred to rainwater drainage, 5% to sewage drainage, 5% to waste disposal process, and 20% remains in the soil.
- For "data e", it is not specific to artificial turf.
- For "data e", it is based on ICF&Eunomia (2018), but it is need to update the rate based on the actual situation of road surrounding environment in Japan.
- The range of the provisional figure depends on the range of "data c".

Amount of macroplastics collected

Amount of macroplastics collected

Amount collected in rivers

Estimation formula	Amount of litter collected in 109 first class water systems nationwide managed by the government (m3) [a] × Proportion of plastic waste (%) [b] × Volumetric mass conversion factor (t/m3) [c]	Data used (latest available)	a: Tanaka et al., 2024, Country-wide assessment of plastic removal rates on riverbanks and water surfaces. b: Same as above c: Same as above
provisional figure	763～1,177 t/year		

Issues and Notes

- "Data a" is data on cleanup activities conducted by the public, river managers, and local governments from 2016-2020 (provided to researchers by the MLIT).
- "Data b" and "data c" are calculated by applying the conversion factor to wet and dry weights of litter collected.

Amount collected on land

Issues and Notes

- The provisional figure for "litterring in land and rivers," in the leakage inventory is calculated based on the amount collected by drainage pump station. It means the leakage amount is already considered caught amount at the pump station (= land areas). Therefore the caught amount at the drainage pump station is not accounted for collection. (On the other hand, the "amount collected rivers" above is accounted for collection because this is the result of river clean up activity at downstream side to the drainage pump station.)

Amount of macroplastics collected

Amount collected at the beach

Estimation formula	**Amount of beach litter (artifacts) collected nationwide (t) [a]** **× Rate of plastic litter out of the above amount (%) [b]**	Data used (latest available)	**a: MOEJ litter composition analysis project in FY2023(2022 survey results)** **b: MOEJ litter composition analysis project in FY2023(2022 survey results)**
provisional figure	6,441 t/year		

Issues and Notes

- This data is compiled by local governments under a government-led project and is expected to be updated regulary.
- The beach litter amount may include beach litter from other countries. The current liter composition analysis project surveys the language of beach litter items to identify its origin, but limited to several items such as PET bottle and its caps.)

Amount collected at sea

Estimation formula	**Amount of floating litter (artifacts) collected nationwide (t) [a]** **× Rate of plastic litter in Tokyo Bay, Ishikari Bay, and Genkai Sea (%) [b]**	Data used (latest available)	**a: MOEJ filed survey project in FY 2023 (2022 survey results)** **b: MOEJ filed survey project in FY 2021**
provisional figure	701 t/year		

Issues and Notes

- For “data a”, it is compiled by local governments under a government-led project and is expected to be updated regularly.
- On the other hand, for “data b”, there is a lack of updated surveys and researches that indicate the rate of plastic litter out of floating litter.

Summary of results of buildup estimation by sources and items

	Classification	Estimation Formula	Data used (latest available)	Issues and notes	Provisional figure (t/year)
Buildup estimation by sources and items	Macroplastic	**Subtotal (1): Total of items listed on the right**	Littering on land and in rivers Litterring on the beach Lost fishing gear*2	Refer to the list of basic information related to the buildup estimation by sources and items	1,900～7,500
	Intentionally added microplastic	**Subtotal (2): Total of items listed on the right**	Resin pellets, agricultural materials, detergents, cosmetic products	Refer to the list of basic information related to the buildup estimation by sources and items	460～3,400
	Unintentionally added microplastic	**Subtotal (3): Total of items listed on the right**	Automotive tire weas, automotive brake wears, road markings, synthesis textiles, building paints, marine paints, artificial turf (pile, filler)	Refer to the list of basic information related to the buildup estimation by sources and items	11,000～20,000
	Microplastic*1	**Subtotal (4): Sum of subtotal (2) and subtotal (3)**			11,000～24,000
	Total amount	**Total: (1)+(4)**			13,000～31,000

Amount of macroplastics collected	**Subtotal (5): Total amount collected on the right**	Rivers, beaches, and seas	Refer to the list of basic information related to the buildup estimation by sources and items	7,905～8,319

Note 1 Considered polymer concentration and removal rate in sewage system

Note 2 Includes secondary microplastics generated from macroplastic

Note 3 For information on the leakage rate to the ocean of microplastics, see “Leakage rates to the ocean by pathway" on the following pages.

Leakage rate to the ocean by pathway

- The pathways through which microplastics are released into the environment and then into the ocean for each item are summarized in Appendix 1 based on ECHA (2019) and ICF & Eunomia (2018).
- The leakage rate to the ocean by each pathway was calculated based on the situation in Japan.

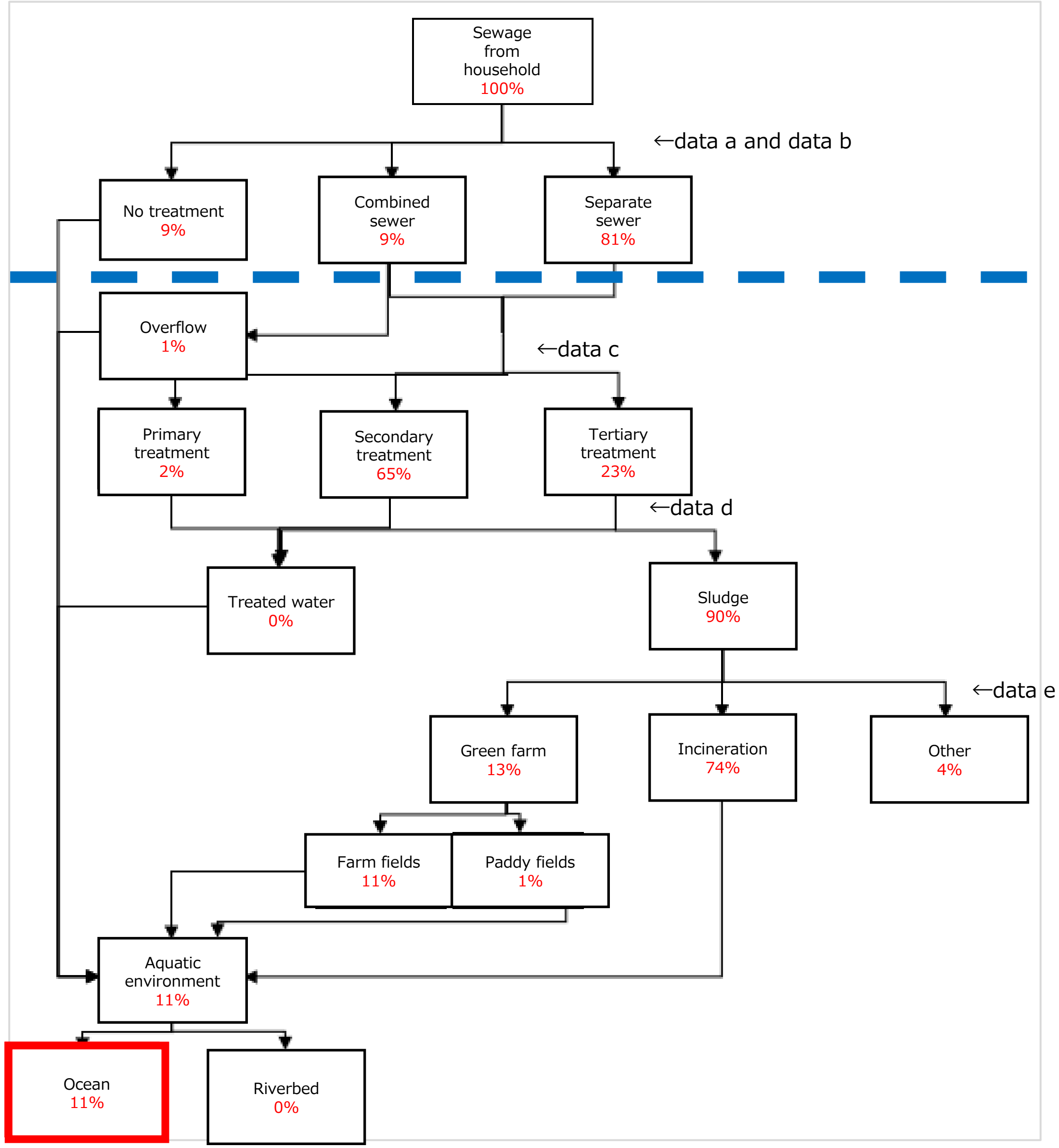
Appendix 1: Leakage rate of microplastics by pathway (%)

Items \ Pathways	(1)Sewage	(2)Rainwater	(3)Waste	(4)Soil	(5)Atmosphere	(6)Direct waters
Resin pellets		100				
Agricultural materials				100		
Detergents	100					
Cosmetic products (rinse-off)	95		5			
Cosmetic products (leave-on)	10-48		91-53			
Automotive tire wears						
Automotive brake wears		100			Depends on the item	
Road markings						
Synthetic fibers	100					
Building paints		100				
Marine paints (abrasion)						100
Marine paint (removal)			90	5		5
Artificial turf (filler)	5	70	5	20		
Artificial turf (pile)	5	70	5	20		

Leakage rate to the ocean by pathway (1)

Leakage rate to the ocean by sewage drainage from household

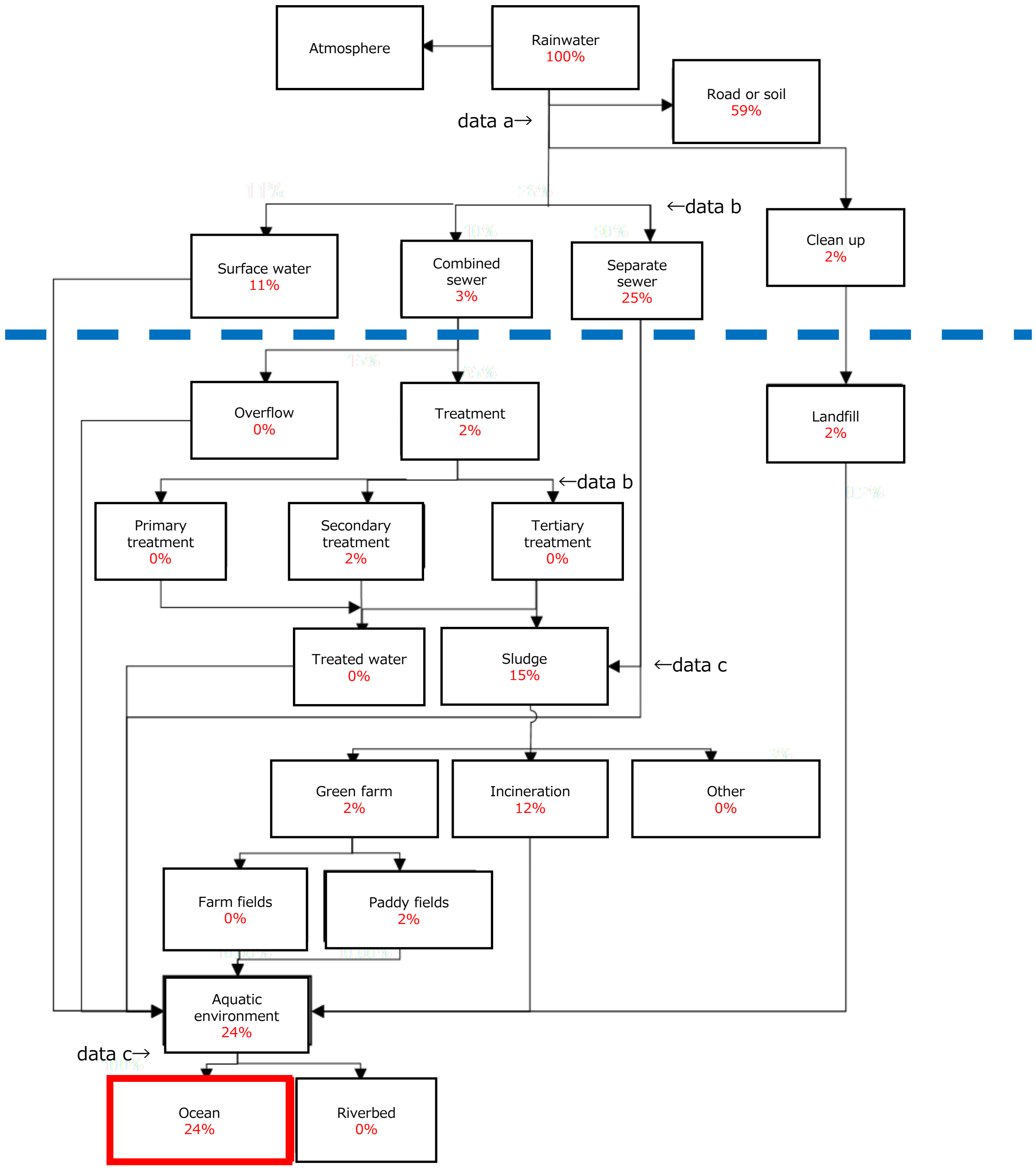
Data used (latest available)	
	a: Japan Sewage Works Association "Sewerage Statistics in FY2017" b: Statistic data on sewage treatment population in FY2017 by MOE c: Japan Sewage Works Association "Sewerage Statistics in FY2017" d: Interview with KAKENHI project 19H00783 (conducted in FY2021) e: Statistic data on treatment of sewage sludge on a dry weight basis by MLIT (FY2023).
provisional figure	11%



Leakage rate to the ocean by pathway (2)

Leakage rate to the ocean by rainwater drainage

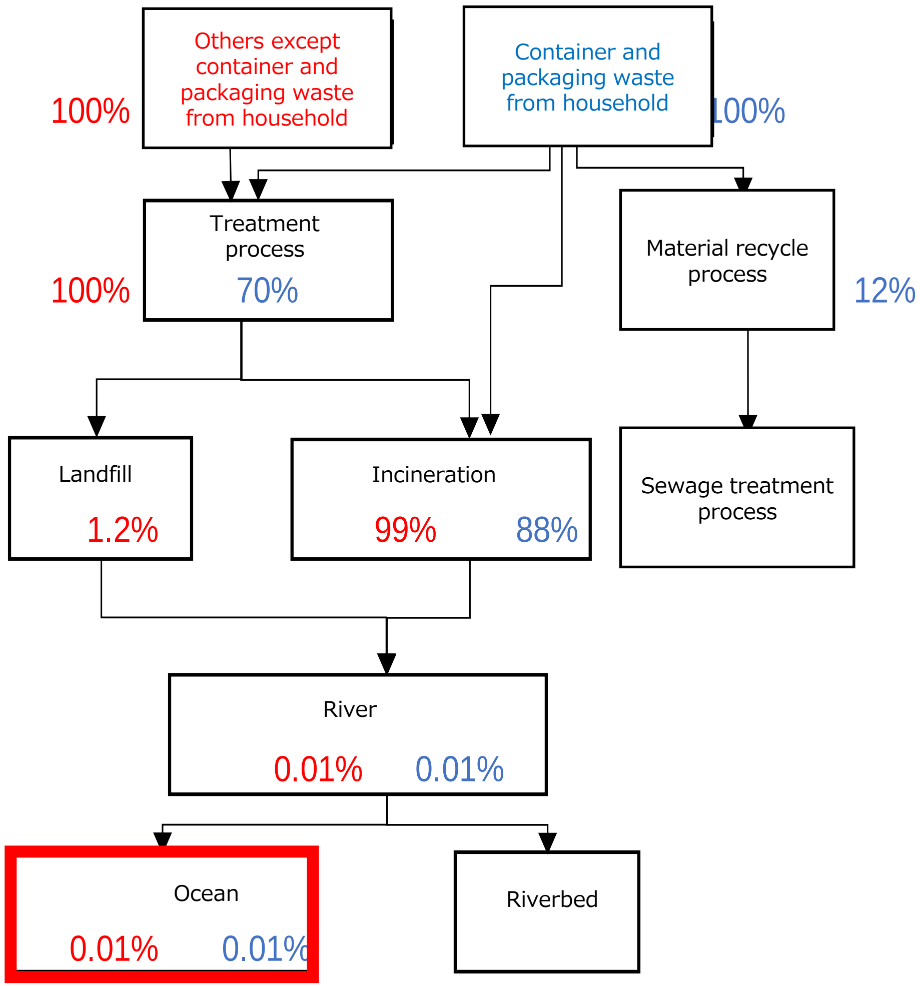
Data used (latest available)	**a: Statistics data by MLIT on traffic census in FY2015** **b: Japan Sewage Works Association "Sewerage Statistics in FY2017"** **c: Interview with KAKENHI project 19H00783 (conducted in FY2022)**
provisional figure	<u>24%</u>



Leakage rate to the ocean by pathway (3)

Leakage rate to the ocean from waste disposal process

Data used (latest available)	a: Statistic data on amount and treatment of general waste by MOE (FY2021)". b: Summary of Survey on Use and Discharge of Container and Packaging Waste (FY2021) c: Japan Containers and Packaging Recycling Association Annual Report 2021
provisional figure	0.01%



Leakage rate to the ocean by pathway (4)

Leakage rate to the ocean from land fields and paddy fields

Data used (latest available)	Katsumi et al. (2021) and expert interviews on these studies (conducted in FY2023).
Tentative rate from paddy fields	1～28%
Tentative rate from land fields	0.01～0.08%

3. Results of estimation by using macro-statistical data (Results in FY2023:Repost)

Estimation by using macro-statistical data

The purpose of this study is to **estimate the amount of plastic released into the environment (ocean) in Japan** by organizing methods for estimating the amount of plastic released based on macro-statistical data on plastic in Japan.

Production amt. (Used amt.) → Disposal amt. → Discharge amt. to the env. → Discharge amt. to the ocean

Scope of study up to last FY

・Conducted a survey at pump stations in Japan using sampling and interval cameras.
・Conducted a built-up calculation by using data from studies conducted in Japan by an expert.

Scope of this FY's study

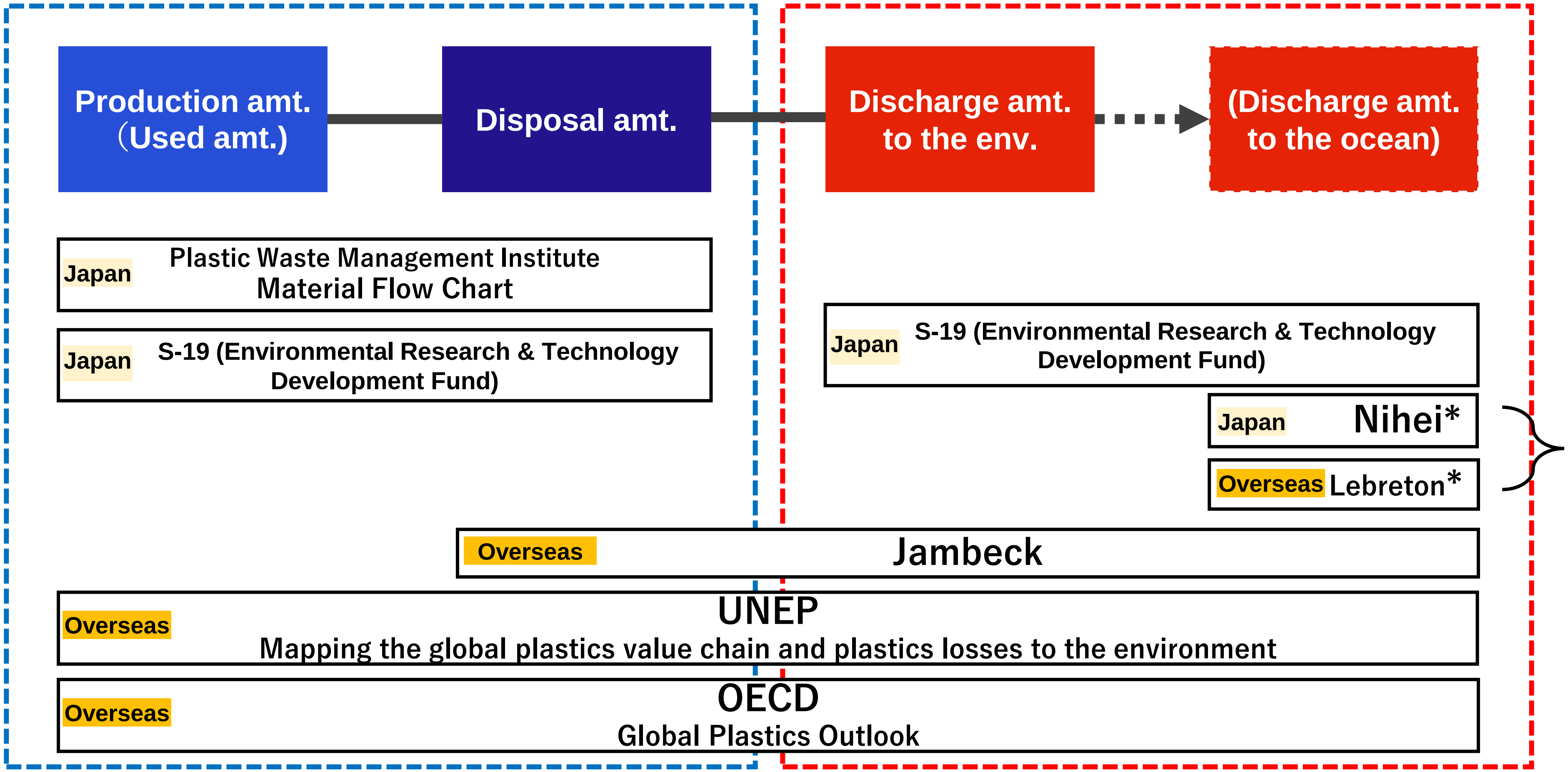
・Summarized issues in estimating the amount of plastic waste discharged, such as the accuracy of the macro-statistical data in Japan and the method of calculating the amount of plastic waste discharged.
・Estimated the amount of plastic waste discharged into the environment/marine areas in Japan by using the macro-statistical data on plastics in Japan. (It was also considered whether it would be possible to expand overseas)

Calculation of the amt. of plastics production/disposal

Calculation of the amt. discharged to the env. (the ocean)

(Reference) Estimation range of previous studies

The following is a representative range of estimates from previous studies. At this time, there are no national examples that use the material flow by applying the macro-statistical data to estimate the amount discharged to the environment and the ocean.



*Nihei, Lebreton uses a monitoring style based on values from field surveys in rivers to estimate the amount of discharge to the ocean.

Calculation of the amt. of plastics production/disposal

Calculation of the amt. discharged to the env. (the ocean)

Methods

In theory, there are two methods using macro statistical data:

1. Estimating the outflow volume by subtracting macro statistical data such as disposal amounts from macro statistical data such as usage amounts.
2. Estimating the outflow volume by multiplying macro statistical data such as usage amounts by parameter/coefficients (e.g., outflow rates).

■ Method (1) is calculating by using macro statistical data obtained for different purposes (which may contain errors), raising concerns about high uncertainty. Therefore, Method (2) was chosen for consideration.

・**The calculation of the discharge amount using the macro-statistical data is done by multiplication, not subtraction.**

A （Macro-statistical data） × B （Discharge rate） ＝ C （Discharge amount to the env./ocean

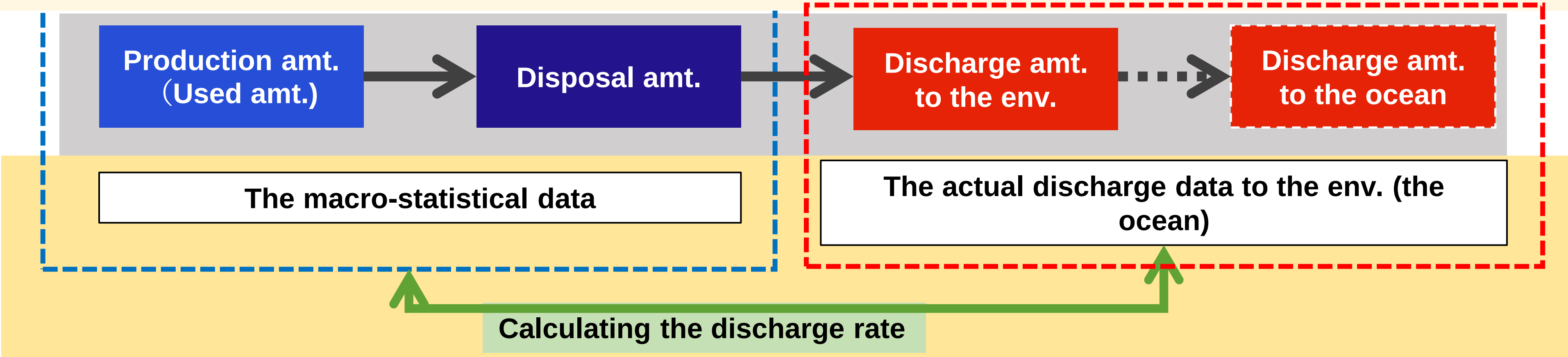
・For **"Calculation of discharge rate"** and **"Consideration of estimation methods by (the macro-statistical data ×discharge rate)", item (product) whose "macro-statistical data" and "data of the actual discharge amount to the environment" are considered relatively easy to obtain should be selected**

・

【Item (product) example】 PET bottles

【Candidates for obtaining the macro-statistical data】 Data from the Council for PET Bottle Recycling, results of input-output analysis

【Actual data on the amount discharged to the environment】 Results of a survey of the amount of waste collected at a pump station (using results from a separate operation).



Methods

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For the macro-statistical data on PET bottles (and each polymer), the available data on production amount (used amount) were targeted. For the data on the amount of plastic waste discharged into the environment (the ocean), since data on "plastic waste flowing into rivers" could be obtained as actual measurement data, the discharge rate was calculated as "plastic waste discharged into the ocean via rivers" rather than the discharge into the environment.

Procedure to calculate the discharge rate

① **The "discharge amount" of** PET bottles is estimated for the entire Japan using the observation results of three rivers.

② **The "discharge rate"** calculated by dividing the obtained results by the amount of PET bottles used.

（For polymers used for containers and packaging, the "discharge rate" was calculated in the same way using the research results of Dr. Nihei and Dr. Nakatani. Comparison)

③ The amount of plastic discharged into the ocean was calculated by multiplying the **"discharge rate"** obtained in ② above by the macro data, the "amount of plastic used" for the entire domestic plastic industry.

④ Comparison of the amount of plastic discharge obtained from ③ with previous literature data such as Nihei et al. (2020), to confirm the discharge rate and the validity of this estimation method.

Targeted discharge rate	Macro data	Measured data of amt. discharged into the ocean
(a) PET bottles	The Council for PET Bottle Recycling	Data for Ongagawa river estuary barrage, Motogo pump station and Shinkawa pump station
(b) each polymer	Dr. Nakatani's research results	Dr. Nihei's Research Results

For PET bottles, the **calculations are based on waste collected** at the estuary barrage and pump stations; therefore, the condition was "neither estuary barrage nor pump stations". Also, the polymer by material is based on the **results of surveys in freshwater areas**; therefore, the discharge behavior in brackish water/estuarine areas was not taken into account. As a result, the results calculated in this study are likely to be an overestimate.

Results

- The discharge rate for plastic bottles was calculated to be 0.108%, which was not significantly different from the polymer-specific discharge rates (0.050-0.533%).
- The discharge rate was approximately four times higher when comparing the case where only normal conditions were considered with the case where runoff was also considered.
- Assuming that "containers and packaging, daily necessities, tableware, etc." are assumed to be the same as plastic bottles, the amount of plastic used in Japan as a whole was calculated from the Nakatani et al. (2020) and multiplied by the above discharge rate, resulting in an estimate of 2,300 to 24,000 tons. As a result, it was calculated to be between 2,300 and 24,000 tons.
- The results are comparable to the buildup estimation by sources and items and to previous studies such as Nihei et al. (2020) and Jambeck et al. (2015).

Subject (of taxation, etc.)			Amount used [t]	Normal times		Normal + flooding	
				Amount discharged to the ocean [t].	Spill rate (use→ocean)[%].	Amount discharged to the ocean [t].	Spill rate (use→ocean)[%].
PET bottle			583,000	-	-	629	**0.108**
polymer	Using the Input-Output Table	PE	1,434,326	1,503	0.105	6,596	0.460
		PP	1,097,955	1,116	0.102	4,896	0.446
		PET	1,094,845	548	0.050	2,406	0.220
	Using statistical data by METI, MOF and individual companies	PE	2,057,175	1,503	0.073	6,596	0.321
		PP	918,779	1,116	0.121	4,896	0.533
		PET	603,339	548	0.091	2,406	0.399

Total amount		Discharge rate (use → ocean area)		Min～PET bottles～Max
Products purchased by households & industries + containers & packaging associated with the products purchased by them	4,558,433t	×	**0.050～0.108～0.533%**	= **2,300～4,900～24,000 t**
Amount of plastic use published by Plastic Waste Management Institute	8,950,000	×	**0.050～0.108～0.533%**	= **4,500～9,700～48,000 t**

Summary

Comparison of the results of our study with previous studies

Estimation	Overview	Amount (t/year)
Buildup estimation by sources and items under this project (FY2024)	The amount of MacP and MicP discharged to the ocean was calculated using the amount of activity per item and the rate of discharge by pathway, based on previous studies and available data.	13,000～31,000
Estimation by using macro-statistical data under this project (FY2023)	The discharge rate was calculated using statistical data on the amount of plastic bottles and PE, PP, and PET used and measured data on their discharge, and multiplied by the amount of plastic used in Japan as a whole, which could discharge in the same way as plastic bottles, to calculate the "total amount of plastic waste discharged into the ocean via rivers" from Japan.	2,300～24,000
Jambeck et al. (2015)	The amount of MacP discharged from land areas to the ocean within 50 km of the coast is calculated from the annual per capita litter generation, the percentage of improperly managed litter, the rate of littering, the rate of plastic litter, and the rate of discharge into the ocean.	21,000 ～57,000
Lebreton et al. (2017)	MacP and MicP discharges from rivers to the ocean are calculated from observed data and relational equations based on population, MPW, and hydrologic volume.	188 ～1,050
Meijer et al. (2021)	The amount of MacP discharged from rivers to the ocean is calculated from the transportation process of plastic waste utilizing an original model.	1,835
Nihei et al. (2020)	The amount of MacP and MicP discharged to the ocean is calculated using normal monitoring results and water balance analysis results (rainfall and evapotranspiration).	210 ～4,776
Nakayama and Osako (2023a, 2023b, 2024)	The amount of MacP and MicP discharged to the ocean is calculated by the transport process of plastic waste utilizing a grid-type 3D NICE model.	1,100 ～3,500
UNEP (2018)	Estimated by source and category of MacP and MicP based on the amount of Municipal Solid Waste (MSW) per country, percentage of population and percentage of products consumed per region and country, and discharge rates shown in previous studies.	112,900
OECD (2022)	Global plastic production and disposal volumes, and the amount of MacP and MicP discharged into the ocean based on an independently developed model (OECD ENV-Linkages model).	88,510

(Reference) Amount of macroplastic collected	Total amount of microplastic collected on the rivers, beaches and at seas.	7,905～8,319

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