Research and monitoring of microplastics abundance in river runoff and coastal waters by the example of Russian part of Northwest Pacific

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NOWPAP POMRAC

The marine microplastic is proved to cause harm to the aquatic organisms (P. Davison et al., 2011; F. Murray et al., 2011) and seabirds (M. D. Robards et al., 1995), through both direct harm of ingestion (plastic particles, mistaken by food, may cause indigestion in adult individuals and underdevelopment in young organisms and reproductive disruption (Sussarellu et al., 2016)) and contamination with associated chemicals, such as POPs or plasticizers, involving these substances into the trophic chains (Teuten et al., 2009).

Understanding of the situation with microplastic pollution in the NOWPAP region, which is one of the most densely populated areas in the world, is necessary. Understanding microplastic contamination levels is very important, especially in the coastal areas because they sustain commercial near-shore fisheries and aquaculture.

River Discharge of microplastics project

in 2015, PGI FEB RAS carried out a peliminary work for microplastic distribution and concentration assessment in the coastal water of the Amur Bay. The work was continued by the survey in the Peter the Great Gulf in 2016-2017 (followed by the implementation report) and in 2018-2019 with the support of the Sea Protection Institute under NOWPAP RAP MALI initiative.

POMRAC activity 'Microplastics abundance in river runoff and coastal waters of the NOWPAP region' was approved by the 21 NOWPAP IGM in 2017 as part of the activities on WG2 – River and Direct inputs of contaminants into the marine environment of the NOWPAP region. Its basic idea is to assess inflow of microplastic particles with rivers discharging into the marine area of NOWPAP and finding relations with plastic contamination in the adjoining coastal waters.

Goal of this activity is to obtain background information on the distribution of different kinds of microplastics in the some major rivers within Russian part of the NOWPAP region, and to trace possible impact of river runoff on microplastics quantity and composition in the coastal waters within the Russian part of the NOWPAP region.

The following steps were supposed to achieve the objective of this activity:

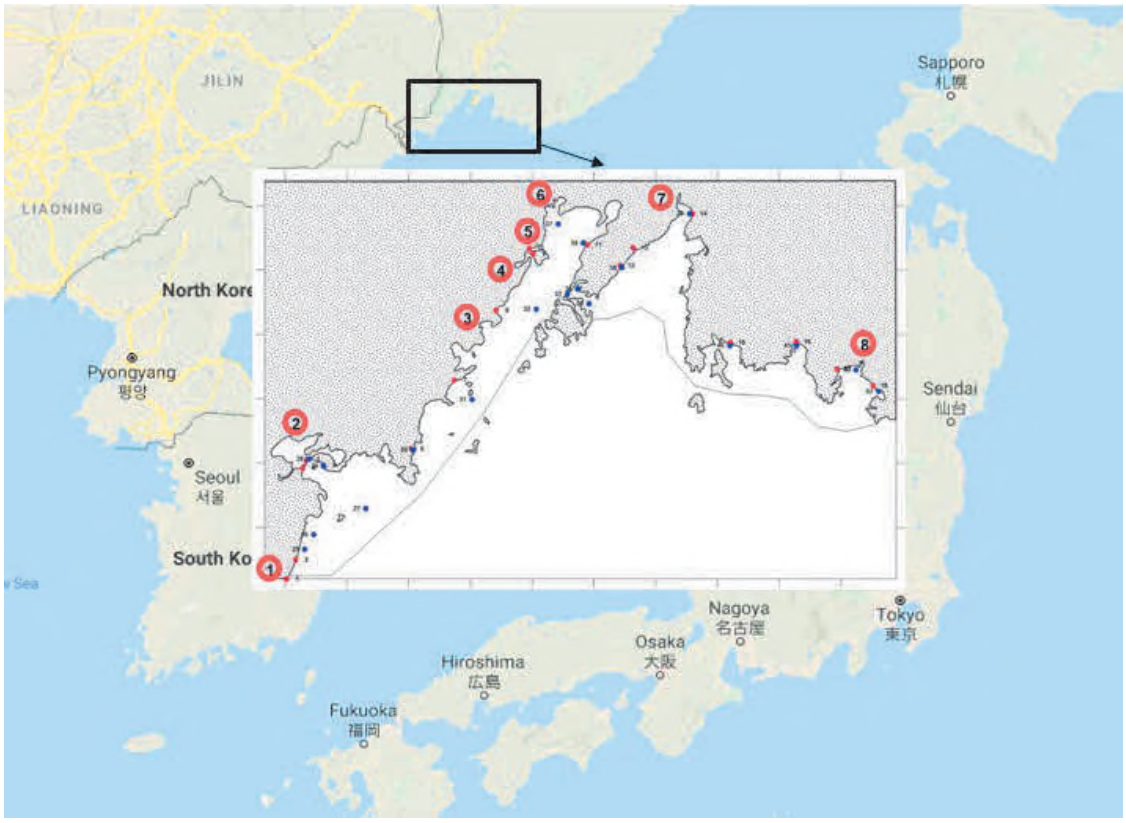
1) **To assess and analyze current methods of sampling** microplastics in the seawater and fresh water and the sample treatment protocols applied in NOWPAP countries, considering possible development of general guidelines/recommendations for microplastic monitoring in NOWPAP;

2) **To obtain data** on the concentrations of microplastics in the rivers of the Russian part of the NOWPAP region and try to assess the microplastics input to the sea with river runoff. Collecting similar existing data from other NOWPAP countries might allow to estimate the role of river runoff in the microplastics transport.

3) **To compare existing data** on microplastics quantity and composition in the coastal water within the NOWPAP region, including further collection of the background information on the quantity and composition of plastic particles in the coastal water of the Russian part of the NOWPAP region.

4) **To assess the possible impacts of river discharge**, urban areas, landfills, tourism, fishery, etc. on contamination of marine ecosystems with microplastics; to share national data and to carry out related survey in the Russian part of NOWPAP.

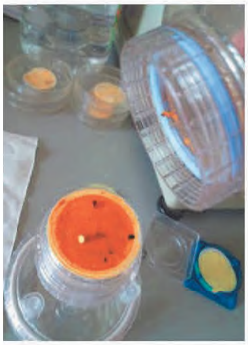
Rivers and coastal areas within Peter the Great area have been chosen for the study in this project due to maximal anthropogenic press compare with other NOWPAP areas within Russia. 8 typical rivers, including transboundary Tumen R. and Razdolnaya (Suifen) R. were studied.



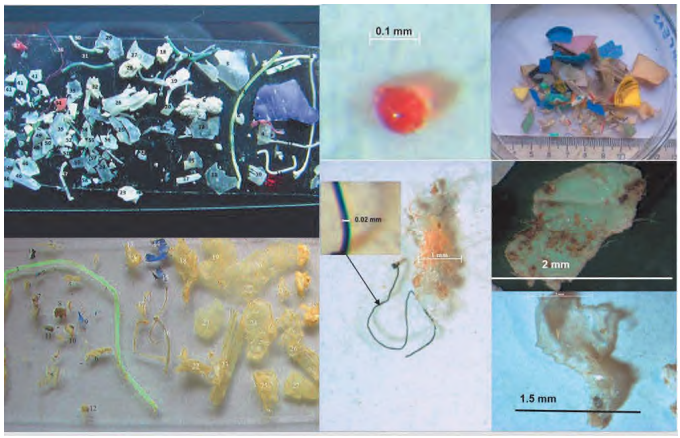
Sample collection, processing and assessment

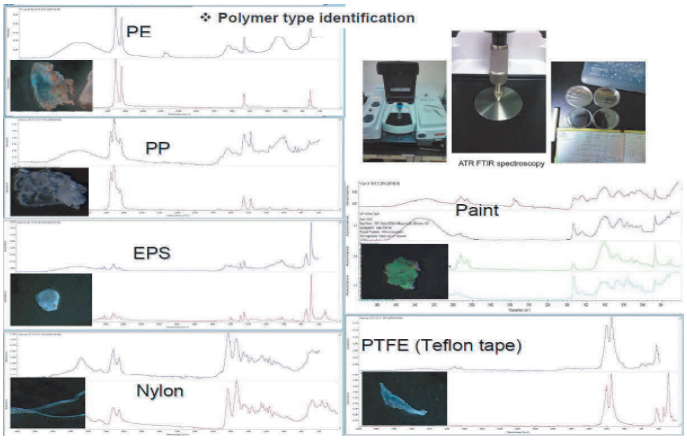
Pump+plankton net

Neuston net sampling.
Net directly towed by boat

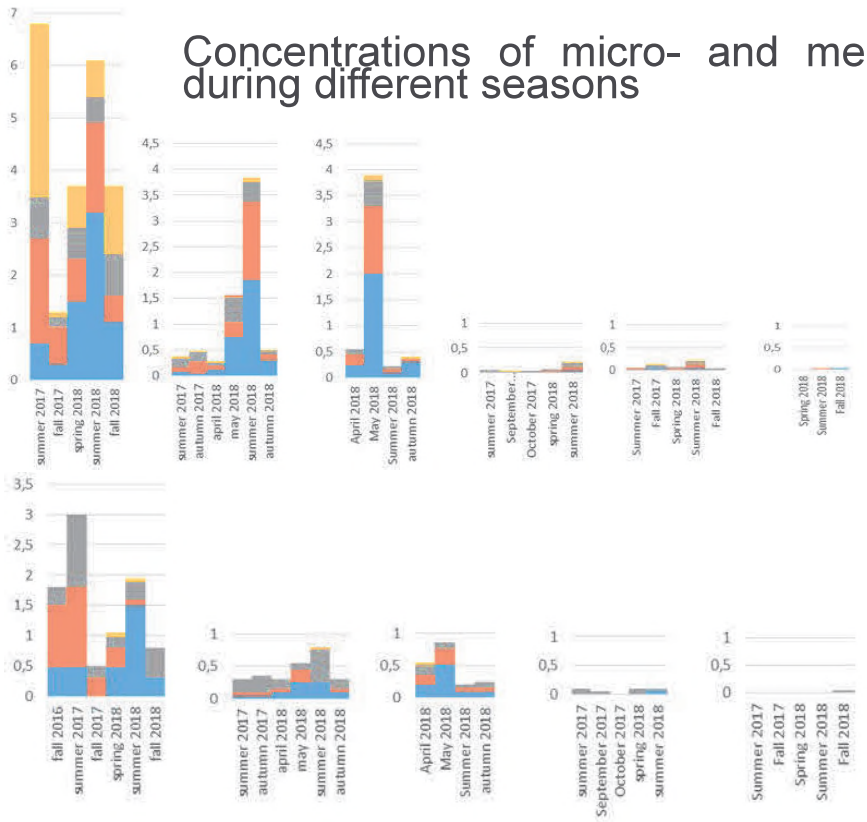


After density separation in a funnel, samples are transferred to polycarbonate filters.





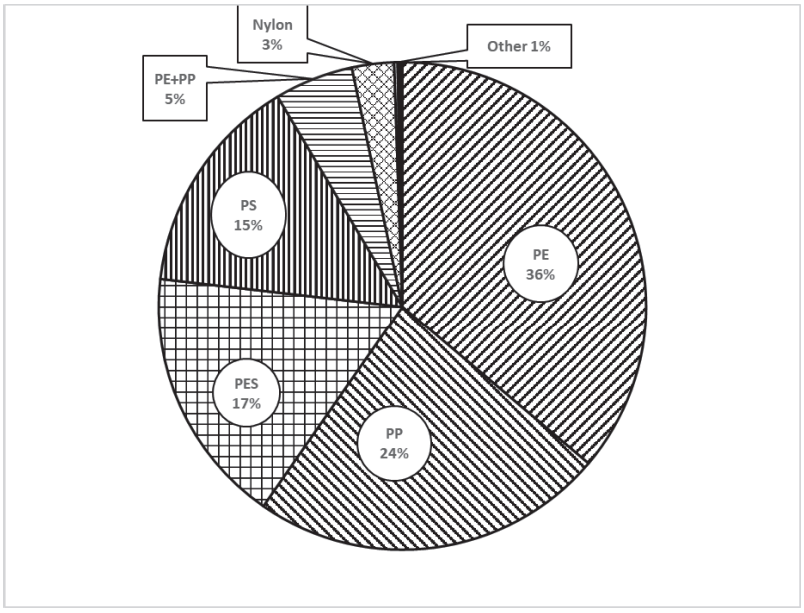
Concentrations of micro- and mesoplastics in river water during different seasons



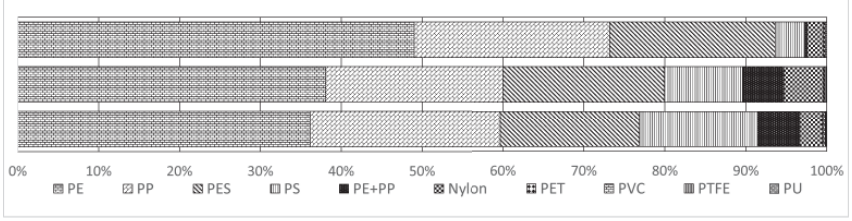
Upper line: Micro- and mesoplastics collected with neuston net in the surface layer in rivers 1) Tumen, 2) Razdolnaya/Suifenhe station 1, 3) Razdolnaya/Suifenhe station 2, 4) Artemovka, 5) Partizanskaya station 2, 6) Partizanskaya station1

Lower line: Micro- and mesoplastics collected with pump+plankton net in the sub-surface layer in rivers 1) Tumen, 2) Razdolnaya/Suifenhe station 1, 3) Razdolnaya/Suifenhe station 2, 4) Artemovka, 5) Partizanskaya station 2 (due to shallow depth of the river at station 1, no pump was applied)

Polymer types in rivers and coastal water
Polyethylene
Polypropylene
Polystyrene
Polyester
Polyethylene + Polypropylene
Nylon
Polyvinylchloride
Teflon
Polyethylene terephthalate
Polyurethane



Ratio of basic polymer types detected in all selected rivers



Comparison of polymer composition in coastal water of the Peter the Great Gulf (upper line) with this parameter in littoral water (middle line) and rivers (lower line).

Average concentrations of micro- and mesoplastic particles in rivers discharging into the Russian part of NOWPAP (particles per 1m3)

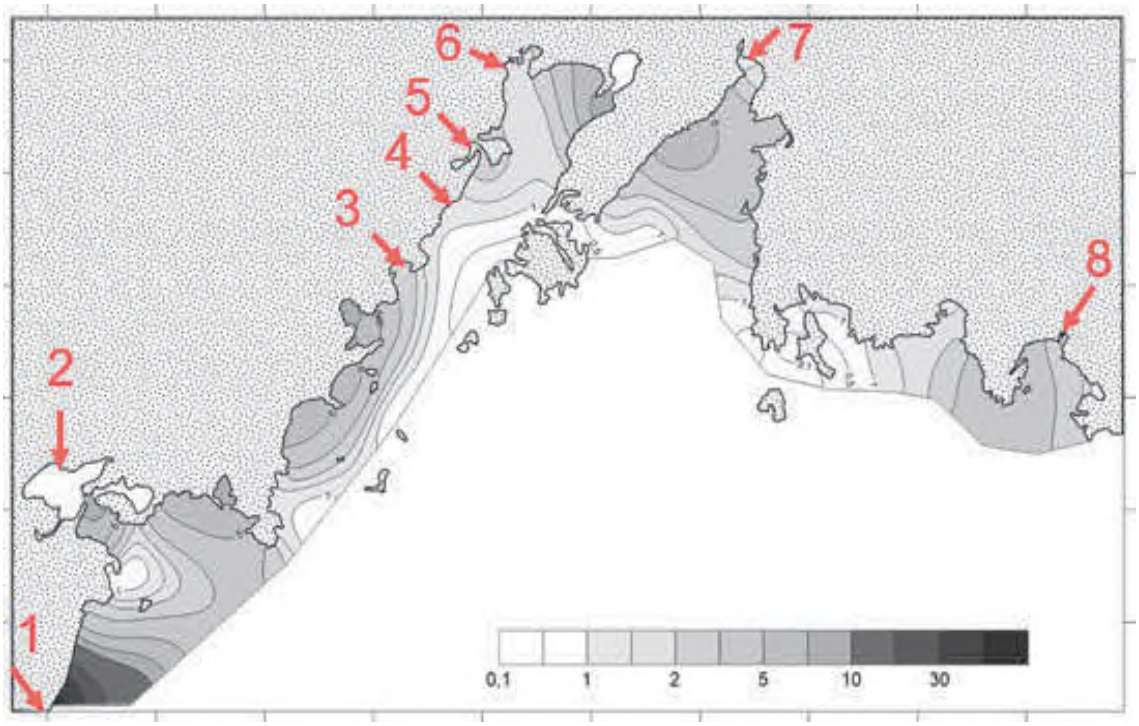
River	Total amount per 1m3
Tumen	2.765
Tsukanovka	0
Narva	0
Barabashevka	0
Amba	0
Razdolnaya/Suifenhe (site 1)	1.105
Razdolnaya/Suifenhe (site 2)	0.821
Artemovka	0.060
Partizanskaya (site 1)	0.024
Partizanskaya (site 2)	0.029

Transboundary river basins with population exceeding 0.5 mln. people and extensive economic activities

Local river basins with population <0.5 mln. people and some economic activities

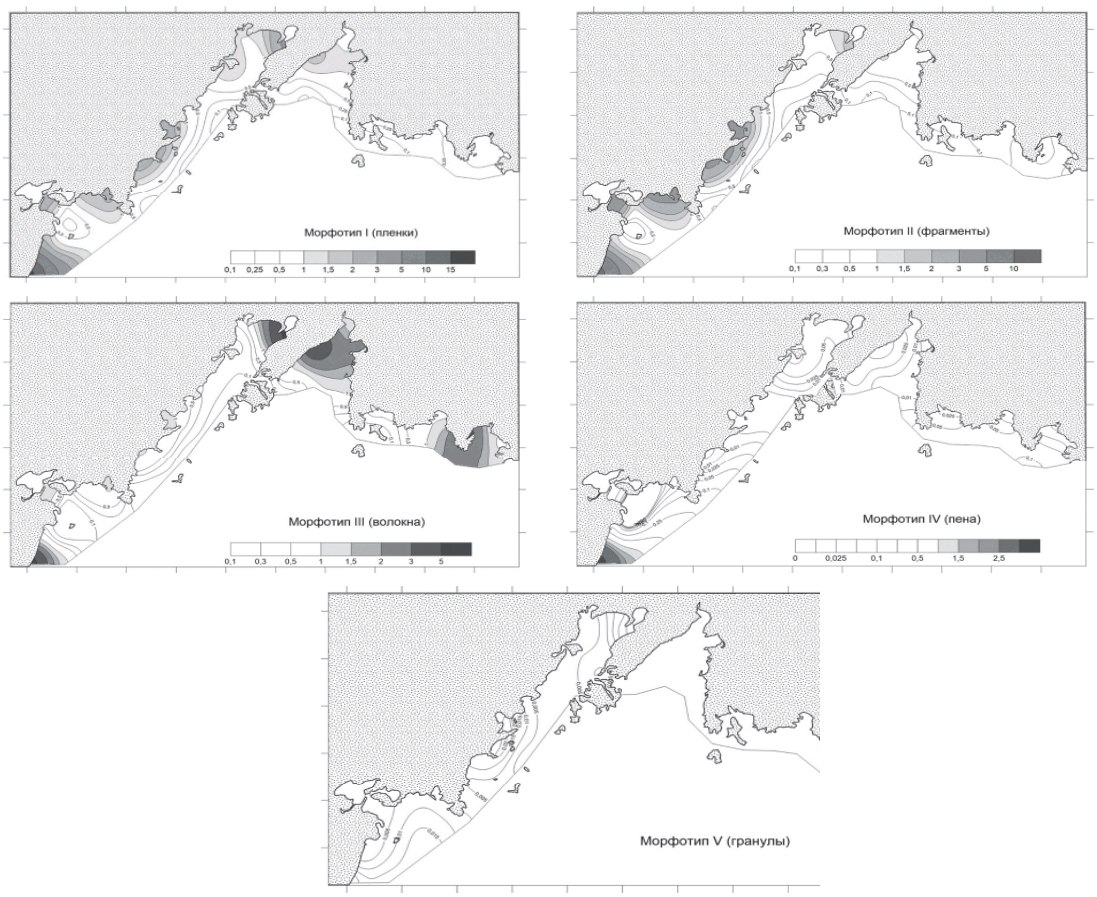
Local river basins with low population and natural reserves

Concentration of all micro and mesoplastic particles (in particles per 1 m^3) in the Peter the Great Gulf with indication of rivers discharging into the area.



1 – Tumen River. 2- Tsukanovka River, 3- Narva River, 4 – Barabashevka River, 5 – Amba River, 6 – Razdolnaya/Suifenhe River, 7 – Artemovka River, 8 – Partizanskaya River.

Concentration of micro and mesoplastic particles (in particles per 1 m^3) in the Peter the Great Gulf by fragment type



Comparison of microplastic concentrations in the study area and in other areas of Northwest Pacific

Water area	Mesh size (μm)	Average concentrations (p. /m^3)	Ссылки
PRC, Yangtze estuary	333	0.167 ± 0,138	Zhao et al., 2014
RoK, south-east coastal waters (Nakdong River estuary)	330	1.911± 2,587(May) 5.502±12,798 (July)	Kang et al., 2015
RoK, north-west coastal water (Yellow Sea)	330	0.19 ± 0,14	Chae et al., 2015
	20	1602 ± 1274	
	250	2.68 ± 2.95	
PRC, Bohai Sea	330	0.33 ± 0.36	Zhang et al. (2017)
Japan, Kyushu coastal waters	350	0.4	Isobe et al., 2014
Japan/East sea and Pacific Ocean area of Japan	350	0.3-5 mm: 3.74 >5 mm: 0.38	Isobe et al., 2015
Peter the Great Gulf	100	0.74	This survey

Conclusion

Coastal water contamination

- It was discovered that concentrations of the contaminant in the littoral water exceeds its concentrations in the coastal water almost 20 times, which can evidence that the tidal area is the hotspot of accumulation of plastic particles.

- Specific differences in coastal water distribution of microplastic particles in relation to river mouths were not clearly traced except one river (Tumen River)

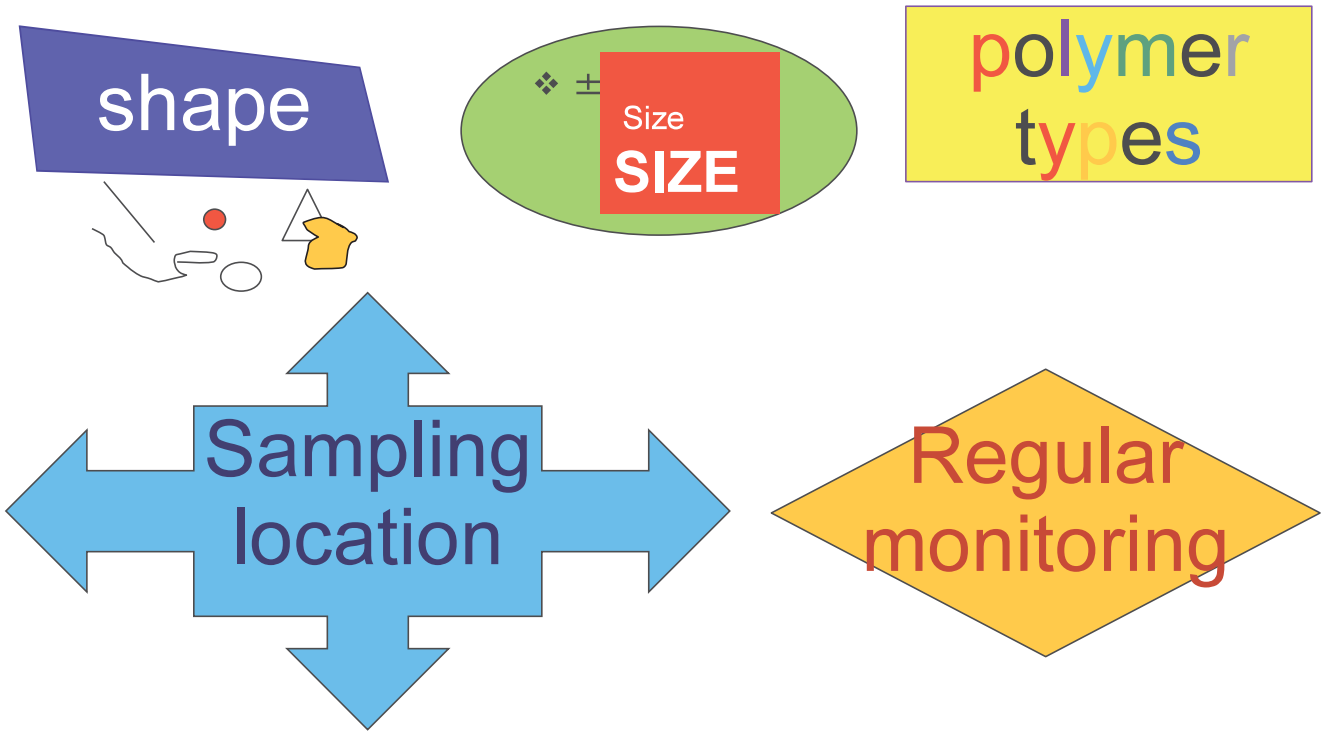
Contamination in the rivers

- According to the current survey results, transboundary transport is an important factor in the distribution of plastic particles in the coastal marine water area of the Russian Far East. Besides, its impact is reflected in the river discharge, by the example of such rivers as Tumen and Razdolnaya/Suifen due to the economic importance and high concentration of population of their basins.

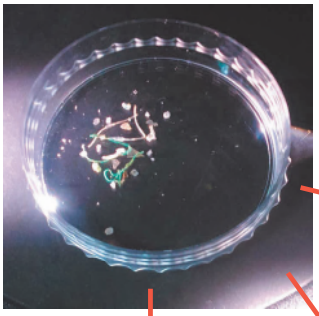
- Rivers flowing in less populated but urbanized areas are still considerable source of contamination, however the numbers of microplastic particles is much lower there that in larger rivers covering wide areas.

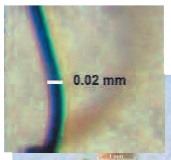
- The rivers flowing in almost unpopulated areas and crossing protected natural areas are noted for absence of registered contamination, at least within the lowest size range applied in this survey (100 micrometers).

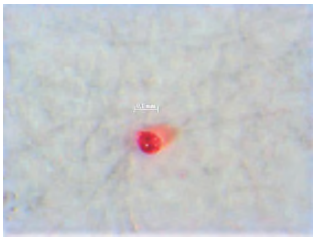
Why these things matter?



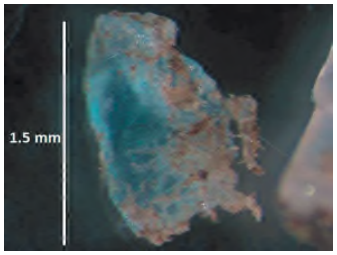
Shape



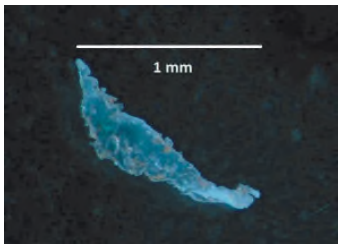




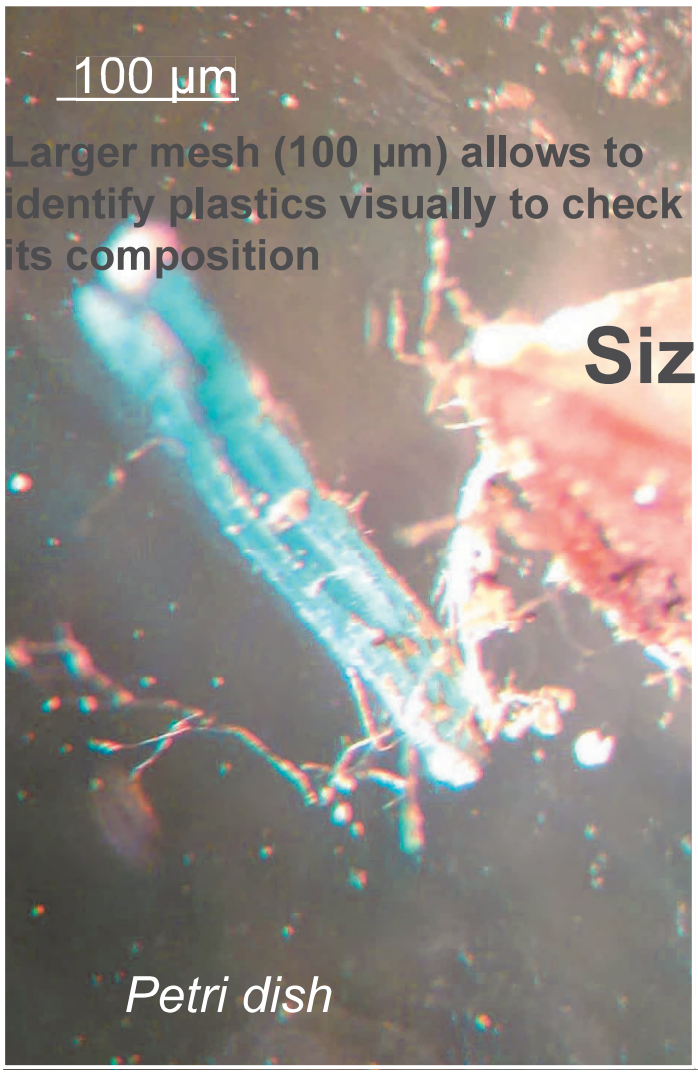
Microbeads and fibers: confined mainly to domestic activities (Isobe et al., 2016)

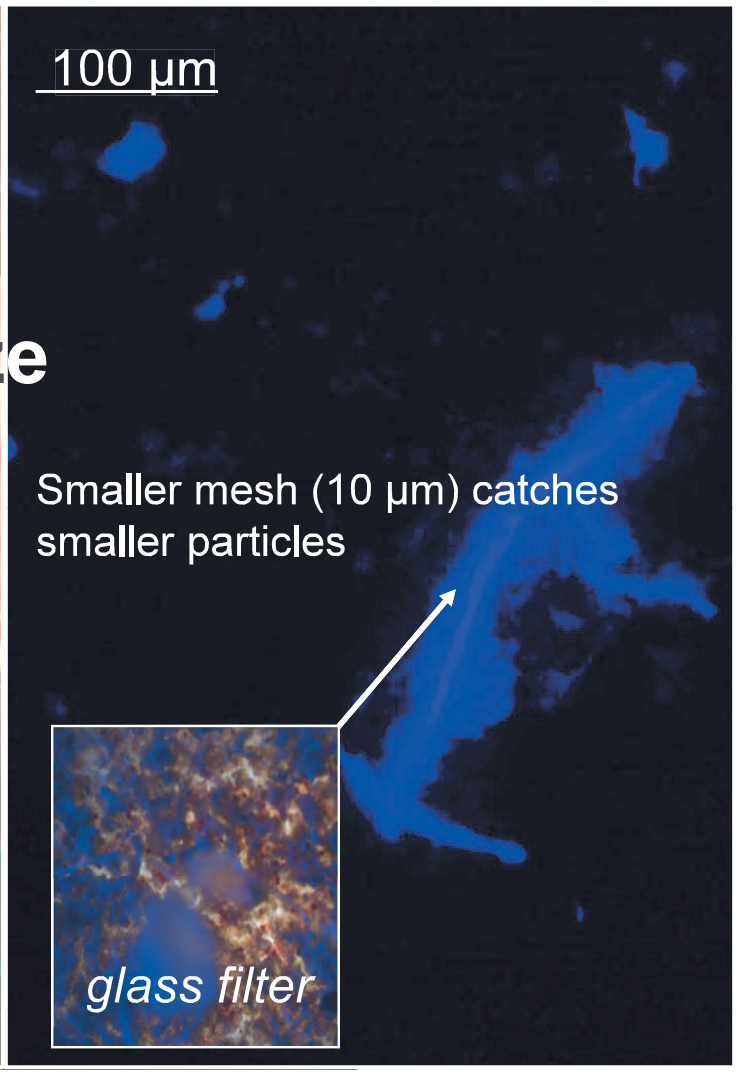


Expanded polystyrene: fisheries and aquaculture (Kang et al., 2015)



Films and fragments: sources are not easy to identify.
Based on the river contamination survey, high amount of films is revealed in river basins covering agricultural areas (possibly due to destroyed plastic mulching)



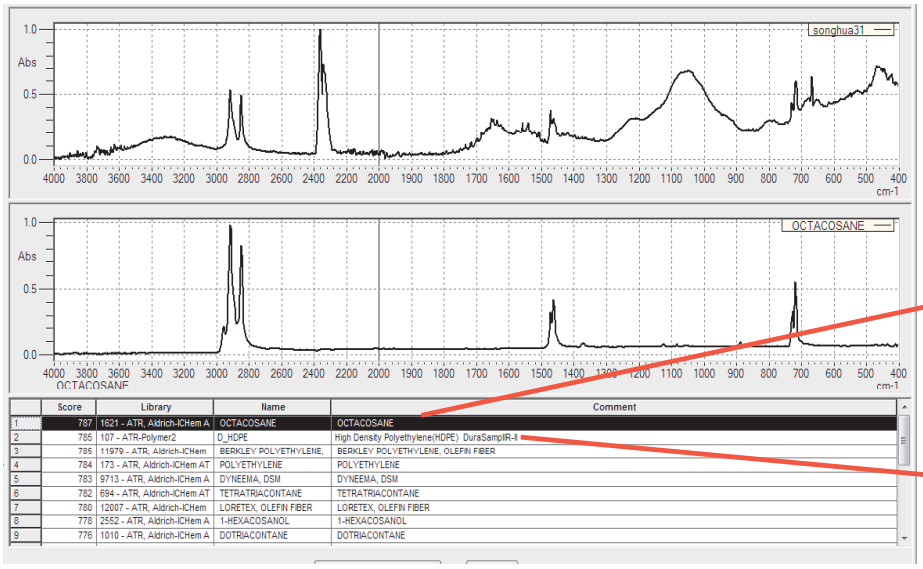


Size

Polymer types

Very small plastics is not easy to remove from sample and it requires identification, because usual sample treatment and optical devices can be useless to show it in the sample.

In natural environment, degradation of polymers results in changes in their spectra.



	Score	Library	Name	Comment
1	787	1621 - ATR, Aldrich-IChem A	OCTACOSANE	OCTACOSANE
2	785	107 - ATR-Polymer2	D_HDPE	High Density Polyethylene(HDPE) DuraSamplIR-II
3	785	11979 - ATR, Aldrich-IChem	BERKLEY POLYETHYLENE,	BERKLEY POLYETHYLENE, OLEFIN FIBER
4	784	173 - ATR, Aldrich-IChem AT	POLYETHYLENE	POLYETHYLENE
5	783	9713 - ATR, Aldrich-IChem A	DYNEEMA, DSM	DYNEEMA, DSM
6	782	694 - ATR, Aldrich-IChem AT	TETRATRIACONTANE	TETRATRIACONTANE
7	780	12007 - ATR, Aldrich-IChem	LORETEX, OLEFIN FIBER	LORETEX, OLEFIN FIBER
8	778	2552 - ATR, Aldrich-IChem A	1-HEXACOSANOL	1-HEXACOSANOL
9	776	1010 - ATR, Aldrich-IChem A	DOTRIACONTANE	DOTRIACONTANE

Which one to choose?

1. Octacosane
(a hydrocarbon lipid):
78.7% correspondence

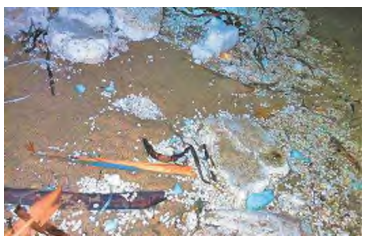
2. Polyethylene:
78.5% correspondence

Sampling location

Natural reserves,

Fisheries & aquaculture,

Inhabited Localities,



Recreation,

Industries,

Etc.

Regular Monitoring

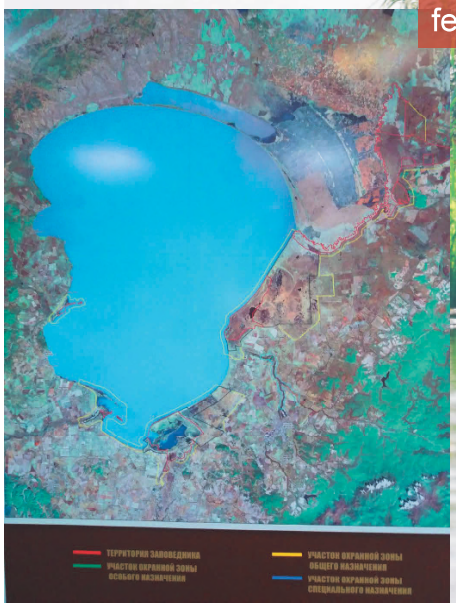
Why in the end long term monitoring is important?

It would show positive or negative effects of policies implemented in the area of plastic waste management, how it changes over time.

For example, tracing the effects of restriction of single use plastic production policy, plastic import bans, etc.

Sampling in Lake Khanka (a lake between Northeast China and Far Eastern Russia)

Pacific Geographical Institute in cooperation with NSCMB currently carries out assessment of microplastic contamination in the Amur River (under research grant from National Geographic Society) and Lake Khanka (which feeds one if its tributaries via Ussuri River).



Sampling in River Amur/Heilong