

Since the problem of microplastics pollution of freshwater bodies in Russia has not received sufficient attention, in July-August 2020 the non-profit foundation “Clean Hands, Clean Rivers” together with the Faculty of Geography of M.V. Lomonosov Moscow State University, conducted a comprehensive hydrological and environmental survey along the entire Volga river, from its source to its mouth.

Research methodology

Sampling for microplastics using the MANTA300 net



The contents of the MANTA beaker were transferred to pass through a series of 5 mm (top) and 0.3 mm (bottom) sieves made of stainless steel. Coarse debris stopped by the upper sieve was removed after the adsorbed particles of microplastics had been washed off and collected. The particles stopped by the lower sieve, which included a mixture of microplastics and biological residues 0.3 – 0.5 mm in size, were transferred into a glass container and preserved in a 70% alcohol solution for subsequent laboratory analysis. The samples contained a significant amount of organic material that had to be removed prior to the analysis for microplastics. To do this, they were transferred into a 2-liter glass beaker mounted on a magnetic stirrer with a heating element, a 30% sodium hydroxide solution was added and heated to a temperature of 75-80°C. A 30% solution of hydrogen peroxide was added to the heated sample in small portions under constant stirring until its complete discoloration.

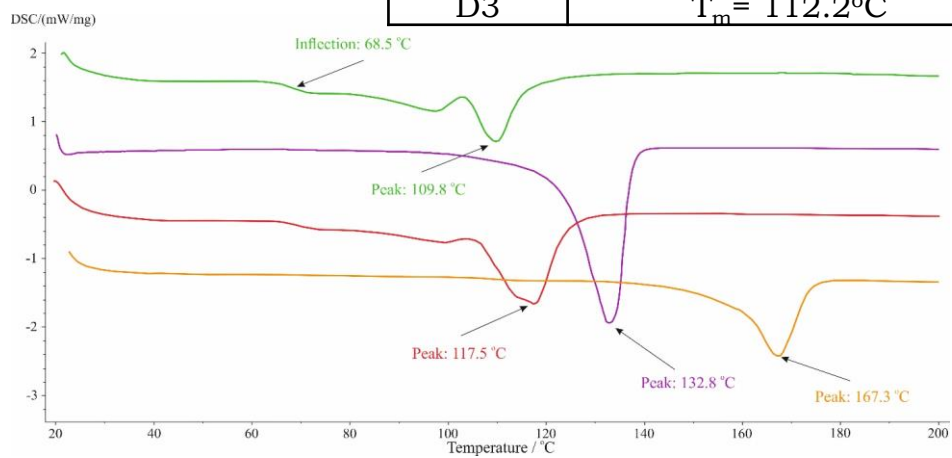
The particles, which did not react with peroxide, were filtered off on a sieve with a mesh size of 100 μm . The particles were examined using a stereo microscope with maximal 80x magnification for visual identification and counting of microplastic particles, which were then assigned to one of the six types: fragments, fibers, films, foams, pellets, granules.

Chemical composition of microplastics (using differential scanning calorimetry)

Glass transition temperature (T_g) and melting temperature (T_m)

For samples C1, C3, D1, no phase transitions were found within the defined temperature range

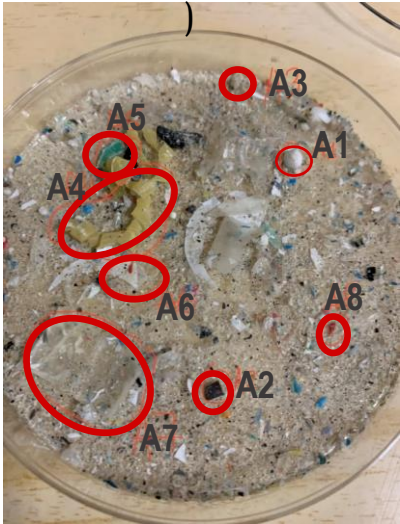
Sample ID	Temperature of phase transition*	The supposed nature of polymeric material
A1	$T_g = 107.7\text{ }^{\circ}\text{C}$	Polystyrene
A2	$T_g = 68\text{ }^{\circ}\text{C}$. $T_m = 109.8\text{ }^{\circ}\text{C}$	Polyvinyl chloride
A3	$T_m = 117.5\text{ }^{\circ}\text{C}$	Polyethylene
A4	$T_m = 131.7\text{ }^{\circ}\text{C}$	Polyethylene
A5	$T_m = 167.3\text{ }^{\circ}\text{C}$	Polypropylene
A6	$T_m = 125.7\text{ }^{\circ}\text{C}$	Polyethylene
A7	$T_m = 107\text{ }^{\circ}\text{C}$	Polyethylene
A8	$T_m = 132.8$	Polyethylene
B1	$T_m = 165\text{ }^{\circ}\text{C}$	Polypropylene
B2	$T_m = 159\text{ }^{\circ}\text{C}$	Polypropylene
B3	$T_m = 110\text{ }^{\circ}\text{C}$	Polyethylene
B4	$T_m = 108.1\text{ }^{\circ}\text{C}$	Polyethylene
B5	$T_m = 167.2\text{ }^{\circ}\text{C}$	Polypropylene
B6	$T_m = 130.7\text{ }^{\circ}\text{C}$	Polyethylene
B7	$T_m = 164.6\text{ }^{\circ}\text{C}$	Polypropylene
C2	$T_m = 107.8\text{ }^{\circ}\text{C}$	Polyethylene
C4	$T_m = 124.6\text{ }^{\circ}\text{C}$	Polyethylene
D2	$T_m = 124\text{ }^{\circ}\text{C}$	Polyethylene
D3	$T_m = 112.2\text{ }^{\circ}\text{C}$	Polyethylene



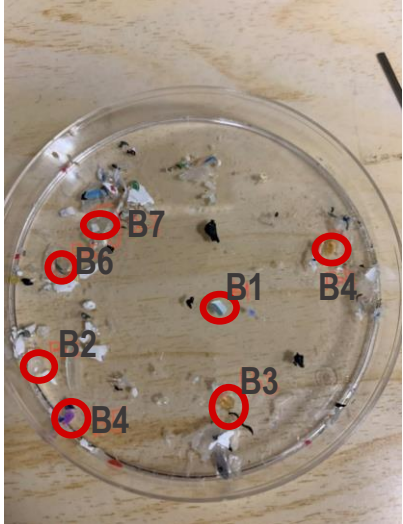
DSC thermograms for plastic fragments in the sample A

- 71% Polyethylene
- 24% Polypropylene
- 5% Polyvinyl chloride

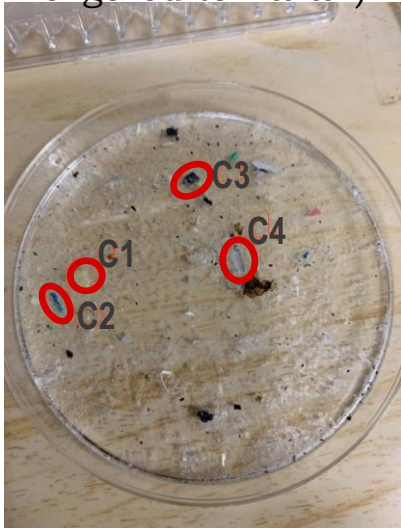
Sample A. the Upper Volga (from Selizharovo to Gorodnya)



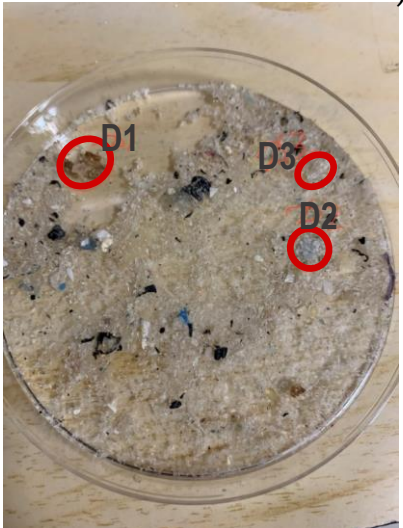
Sample B. the Upper Volga (from the Ivankovskoye reservoir to Kostroma)



Sample C. the Middle Volga (from Nizhny Novgorod to Kazan)

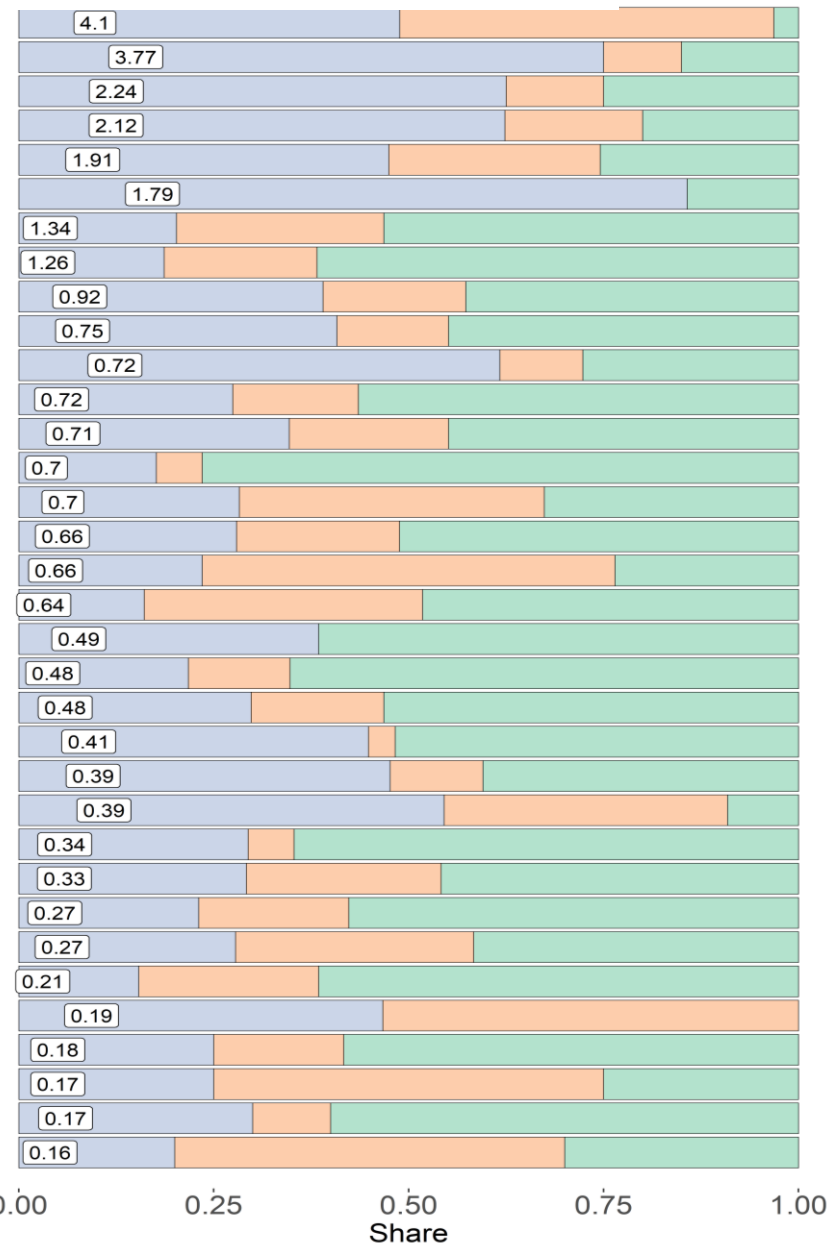


Sample D. the Lower Volga (from Samara to Astrakhan)



Distribution of microplastics in samples by type

Microplastics concentration, (particles/m³)



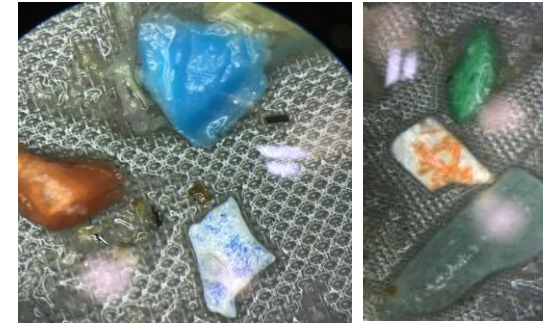
The different ratio of the types

An increase in the total abundance → the share of fragments also increased.

For samples with microplastics concentration exceeding 1 part./m³, fragments on average accounted for 53% of all particles, while for concentrations of less than 1 particle/m³ their share was around 32%

An increase in the proportion of fragments indicates the emergence of new pollution sources

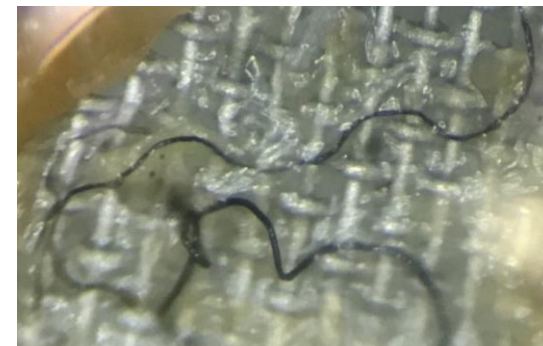
Fragments



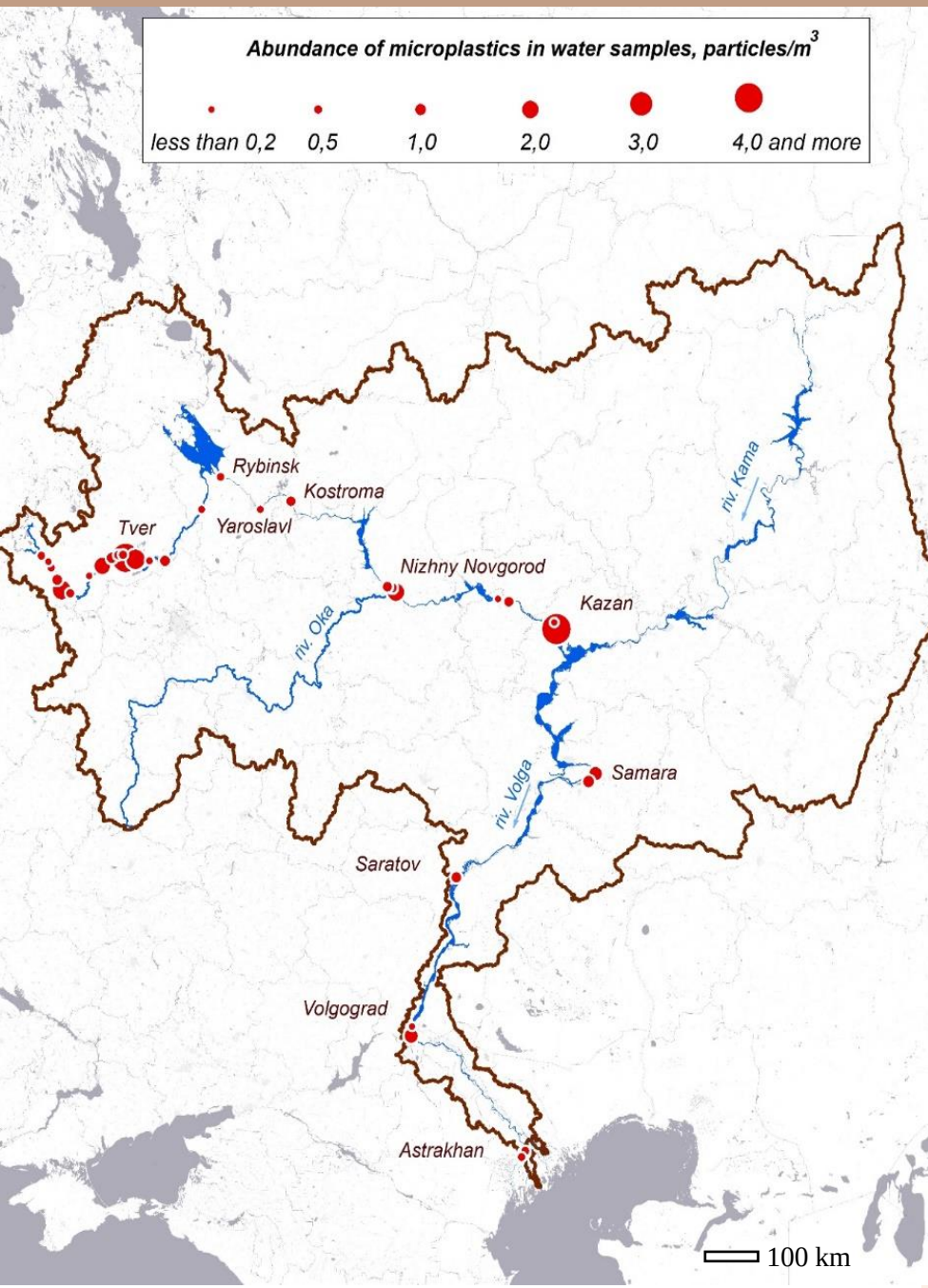
Films



Fibres



Microplastics abundance in the water samples



- Microplastic particles were found in all the collected water samples
- Analysis of 34 water samples allowed us to determine the average concentration of microplastics in the Volga river, which was equal to 0.901 particles/m³ with the median value of 0.649 particles/m³ and a range of 0.156 to 4.100 particles/m³.
- To assess the role of urban areas in the pollution of the Volga river by microplastics, their concentrations were measured upstream and downstream of several cities. Microplastics concentration downstream of Tver compared to the upstream location increased more than 21 times, from 0.193 to 4.100 particles/m³, the increase of more than 7 times (from 0.184 to 1.344 particles/m³) was observed in Volgograd
- The maximum concentrations of microplastics were recorded downstream of the wastewater treatment facilities of large cities, particularly in Volgograd (1.344), Nizhny Novgorod (1.907), Tver (3.769) and Kazan (4.100 part./m³).
- The minimum concentrations were observed upstream of large cities and, in general, were around 0.25 particles/m³. The lowest concentration of 0.156 particles/m³ was observed downstream of the Cheboksary reservoir near Cheboksary.
- Water samples were taken in different phases of the Volga river hydrological regime: during a flood in the Upper Volga and in low-water conditions in the Middle and Lower Volga.
- Urban wastewater treatment plants are one of the main sources of microplastics in the Volga river.
- The microplastic abundance in the Volga river turned out to be significantly lower than that in other large rivers.