

Global patterns and predictors of microplastic occurrence and abundance in lentic systems

VERONICA NAVA¹, Maria Luce Frezzotti¹, Julian Aherne², María B. Alfonso³, Ana M. Antão-Geraldes⁴, Katrin Attermeyer⁵, Abdou R. Bah⁶, Roberto Bao⁷, Mireia Bartrons⁸, Stella A. Berger⁹, Marcin Biernaczyk¹⁰, Florian Breider¹¹, Justin Brookes¹², Miguel Cañedo-Argüelles¹³, Moisés Canle⁷, Camilla Capelli¹⁴, Rafael Carballeira⁷, José Cereijo⁷, Søren T. Christensen¹⁵, Kirsten S. Christoffersen¹⁶, Francois Clayer¹⁷, Elvira De Eyto¹⁸, Lisette N. De Senerpont Domis¹⁹, Martín Jordi Delgado⁷, Jonathan P. Doubek²⁰, Ashley Eaton²¹, Seyda Erdogan²², Oxana Erina²³, Zeynep Ersoy²⁴, Heidrun Feuchtmayr²⁵, Vincent Fugère²⁶, Silvia Galafassi²⁷, Vitor Gonçalves²⁸, Hans-Peter F. Grossart⁹, David Hamilton²⁹, Paul C. Hanson³⁰, Ted Harris³¹, Gökben Başaran Kankılıç³², Rebecca Kessler³¹, Stéphan Jacquet³³, Külli Kangur³⁴, Christine Kiel⁹, Lesley Knoll³⁵, Ilga Kokořite³⁶, Isabelle Lavoie³⁷, Àngels Leiva-Presa⁸, Fabio Lepori¹⁴, Amy Lusher¹⁷, Sally Macintyre³⁸, Miguel Matias²⁴, Shin-Ichiro S. Matsuzaki³⁹, Valerie Mccarthy⁴⁰, Yvonne Mcelarney⁴¹, David Mcnally⁴², Berte Mekonen Belay¹⁹, Beata Messyas⁴³, Musa Mlambo⁴⁴, Sarma Nandini⁴⁵, Emily Nodine⁴⁶, Arda Özen⁴⁷, Deniz Ozkundakci⁴⁸, Ricardo Vazquez Perez⁷, Agnieszka Pocięcha⁴⁹, Pedro Raposeiro²⁸, Eva-Ingrid Rööm⁵⁰, Nico Salmaso⁵¹, Singaraju S. S. Sarma⁵², Émilie Saulnier-Talbot⁵³, Facundo Scordo^{54,55}, Claver Sibomana⁵⁶, Katarzyna Stepanowska¹⁰, Ü. Nihan Tavşanoğlu⁵⁷, Monica Tolotti⁵¹, Abel Udoh⁵⁸, Pablo Urrutia Cordera⁵⁹, Amanda Valois⁶⁰, Marcus Vandergoes⁶¹, Piet Verburg⁶², Pietro Volta²⁷, Danielle Wain⁶³, Brian Wesolek⁶⁴, Gesa Weyhenmeyer⁵⁹, Ryan Wightman⁴¹, Susie Wood⁶⁵, Naicheng Wu⁶⁶, Izabela Zawiska⁶⁷, Edyta Zawisza⁶⁸, Lauren Zink⁶⁹, Barbara Leoni¹

¹ Department Of Earth And Environmental Sciences, University Of Milano-Bicocca, Milano, MI, ITALY

² Trent University, School Of The Environment, 1600 West Bank Drive, Peterborough, Ontario, Canada.

³ Argentine Institute Of Oceanography, Florida, 8000 Bahía Blanca, Buenos Aires, Argentina.

⁴ Centro De InvestigaçãO De Montanha (CIMO), Instituto PolitécNico De Bragança, Campus De Santa Apolónia, 5300-253 Bragança, Portugal.

⁵ Wassercluster Lunz, Dr. Carl Kupelwieser Promenade 5, 3293 Lunz Am See, Lower Austria, Austria.

⁶ City University Of New York, Earth And Environmental Sciences, 365 5th Ave New York City, New York, USA.

⁷ University Of A Coruña, E-15071 A Coruña, Spain.

⁸ University Of Vic - Central University Of Catalonia, Biosciences Department, Carrer De La Laura 13, 08500 Vic, Spain.

⁹ Leibniz-Institute Of Freshwater Ecology And Inland Fisheries, Department Of Experimental Limnology, Alte Fischerhuetten 2, Stechlin, Germany.

¹⁰ West Pomeranian University Of Technology In Szczecin, Faculty Of Food Science And Fisheries, Av. Piastów 17, Szczecin, Poland.

¹¹ Swiss Federal Institute Of Technology Lausanne - EPFL, Institute Of Environmental Engineering, EPFL-ENAC-IIE-GRCEL Station2, Lausanne, Switzerland.

¹² Water Research Centre, University Of Adelaide, Benham Building, South Australia, Australia

¹³ Freshwater Ecology, Hydrology And Management Group (FEHM), Departament De Biologia Evolutiva, Ecologia I Ciències Ambientals, Institut De Recerca De L'Aigua (Idra), Av. Diagonal 643, 08028, Universitat De Barcelona, Barcelona, Spain.

- 14 University Of Applied Sciences And Arts Of Southern Switzerland, Institute Of Earth Sciences, Via Trevano, CH-6952 Canobbio, Switzerland.
- 15 Cphbusiness Laboratory And Environment, Peder Oxes Alle 2, Hillerød, Denmark.
- 16 University Of Copenhagen, Department Of Biology, Universitetsparken 4, Copenhagen, Denmark.
- 17 Norwegian Institute For Water Research, Gaustadalléen 21, Oslo, Norway.
- 18 Marine Institute, Furnace, Newport, Co. Mayo.
- 19 Netherlands Institute Of Ecology, Aquatic Ecology, Droevendaalsesteeg 10, 6708 PB, Wageningen, Gelderland, The Netherlands.
- 20 Lake Superior State University, School Of Natural Resources & Environment And Center For Freshwater Research And Education, 650 W. Easterday Ave., Sault Sainte Marie, Michigan, USA.
- 21 University of Vermont, Burlington, VT, USA.
- 22 Bozok University, Dept Of Biological Sciences, Adnan Menderes Ave No:118, 66200, Yozgat, Turkey.
- 23 Lomonosov Moscow State University, Faculty Of Geography, GSP-1, 1 Leninskiye Gory, Moscow, 119991, Russian Federation.
- 24 Rui Nabeiro' Biodiversity Chair, MED- Mediterranean Institute For Agriculture, Environment And Development, Universidade De Évora, Cátedra Rui Nabeiro – Biodiversidade, Casa Cordovil 2º Andar, Rua Dr. Joaquim Henrique Da Fonseca, Évora, Portugal.
- 25 UK Centre For Ecology & Hydrology, Lake Ecosystems Group, Library Avenue, Lancaster, United Kingdom.
- 26 University Of Québec At Montréal, Dept Of Biological Sciences, 141 Av. President Kennedy, Montreal (QC), Canada.
- 27 Water Research Institute - National Research Council, Largo Tonolli 50, Verbania, Italy.
- 28 Centro De Investigação Em Biodiversidade E Recursos Genéticos - CIBIO, Pólo Açores, Universidade Dos Açores, Faculdade De Ciencias E Tecnologia, Rua Mãe De Deus, Ponta Delgada, Açores, Portugal.
- 29 Griffith University, Australian Rivers Institute, 170 Kessels Road, Brisbane, Queensland, Australia.
- 30 University Of Wisconsin-Madison, Center For Limnology, Hasler Laboratory Of Limnology, 680 N. Park Street, Madison, Wisconsin.
- 31 Kansas Biological Survey, University Of Kansas, Lawrence, Kansas, USA.
- 32 Kırıkkale University, Biology Department, Kırıkkale, Turkey.
- 33 INRAE CARTEL Thonon, AQUA 75bis, Avenue De Corzent, Thonon-Les-Bains, France.
- 34 Estonian University Of Life Sciences, Centre For Limnology, EE-61117, Rannu, Tartumaa, Estonia.
- 35 University Of Minnesota Twin Cities, Itasca Biological Station And Laboratories, 28131 University Circle, Lake Itasca, Minnesota, USA.
- 36 University Of Latvia, Riga, Latvia.
- 37 Institut National De La Recherche Scientifique, Centre Eau Terre Environnement, 490 Rue De La Couronne, Quebec City, Quebec, Canada.
- 38 University Of California, Santa Barbara, Santa Barbara, USA.
- 39 National Institute For Environmental Studies, Center For Environmental Biology & Ecosystem Studies, 16-2 Onogawa, Tsukuba, Ibaraki, Japan.
- 40 Dundalk Institute Of Technology, Centre For Freshwater And Environmental Studies, Dublin Rd., Dundalk, Louth, Ireland.
- 41 Agri - Food And Bioscience Institute (AFBI), Fisheries And Aquatic Ecosystems, 18a Newforge Lane, Belfast, Antrim, Northern Ireland.
- 42 Winooski High School, High School Science Department, 60 Normand St, Winooski, Vermont, USA.
- 43 Adam Mickiewicz University In Poznan, Institute Of Environmental Biology, Department Of Hydrobiology Uniwersytetu Poznanskiego 6, 61-614 Poznań, Poland.
- 44 Albany Museum, Department Of Freshwater Invertebrates, Somerset Stret, Grahamstown, Eastern Cape, South Africa.
- 45 Universidad Nacional Autónoma De México, Ciudad De México, Mexico.

- ⁴⁶ Rollins College, Environmental Studies, 1000 Holt Ave., Winter Park, Florida, Usa.
- ⁴⁷ Çankırı Karatekin University, Forestry Engineering, Watershed Department, Çankırı, Turkey
- ⁴⁸ Waikato Regional Council Science, 401 Grey Street, Hamilton 3216, Hamilton, Waikato, New Zealand.
- ⁴⁹ Institute Of Nature Conservation, Polish Academy Of Sciences, Department Of Freshwater Biology, Av. Adama Mickiewicza 33, Kraków, Poland.
- ⁵⁰ Estonian University Of Life Sciences, Institute Of Agricultural And Environmental Sciences, Chair Of Hydrobiology And Fishery Kreutzwaldi, 5 Tartu, Tartumaa, Estonia.
- ⁵¹ Research And Innovation Centre, Fondazione Edmund Mach (FEM), Via E. Mach, 1, S. Michele All'adige, Trento, Italy.
- ⁵² Facultad De Estudios Superiores Iztacala, Tlalnepantla, Mexico.
- ⁵³ Université Laval, Centre D'études Nordiques, 2405 Rue De La Terrasse, Québec City, Québec, Canada.
- ⁵⁴ University Of Nevada Reno, 1664 N Virginia St, Reno, Nevada, USA.
- ⁵⁵ Instituto Argentino De Oceanografía, Biology Department, Florida 8000, Bahia Blanca Buenos Aires, Argentina.
- ⁵⁶ Center For Research In Natural Science And Environment, Faculty Of Sciences, University Of Burundi, PO Box 2700 Bujumbura, Burundi.
- ⁵⁷ Çankırı Karatekin University, Environmental Health Program.
- ⁵⁸ Gazi University, Dept Of Biology Education, Besevler, Ankara, Ankara, Turkey.
- ⁵⁹ Uppsala University, Dept. Ecology And Genetics/Limnology, Norbyvägen 18D, Uppsala, Sweden.
- ⁶⁰ National Institute Of Water And Atmospheric Research, Freshwater Ecology, Wellington, Wellington, New Zealand.
- ⁶¹ GNS Science, Department Of Paleontology & Environmental Change, 1 Fairway Drive, Avalon, Lower Hutt, Wellington, New Zealand.
- ⁶² National Institute Of Water And Atmospheric Research, Freshwater Ecology, Gate 10 Silverdale Road, Hamilton, Waikato, New Zealand.
- ⁶³ 7 Lakes Alliance, 138 Main Street, Belgrade Lakes, Maine, Usa.
- ⁶⁴ Bay Mills Indian Community, Biological Services Department, 11801 Plantation Rd, Brimley Michigan, Usa
- ⁶⁵ Cawthron Institute, Coastal And Freshwater Group, 98 Halifax St East, Nelson Tasman, New Zealand.
- ⁶⁶ Department Of Geography And Spatial Information Techniques, Center For Land And Marine Spatial Utilization And Governance Research, Ningbo University, 315211 Ningbo, China.
- ⁶⁷ Institute Of Geography And Spatial Organization, Polish Academy Of Sciences, Twarda 51/55, Warsaw, Poland.
- ⁶⁸ Institute Of Geological Sciences, Polish Academy Of Sciences, Twarda 51/55, Warsaw, Poland.
- ⁶⁹ University Of Lethbridge, Department Of Biological Sciences, AWESB, 4401 University Drive West, Lethbridge, Alberta, Canada.

The majority of microplastic research has focused on seawater, with fewer than 4% of microplastics-related studies occurring on freshwaters. The limited available information suggests that the abundance of microplastics in freshwaters is often as high or even higher than marine environments. However, comprehensive investigations on occurrence and fate of microplastics in freshwaters are scarce and highly fragmented, partly because detection and identification of microplastic particles is rather complex. In addition, up to now, harmonized and standardized protocols for the sampling and analysis of microplastics in freshwaters do not exist, and studies with different research aims and hypotheses often report unstandardized results, making comparison among studies difficult. In the present study, we performed the first global standardized sampling and analysis effort to investigate the occurrence and distribution of microplastics in surface water of lakes and reservoirs with different anthropogenic impacts. Participants aim to collect water samples of freshwater systems with different features (e.g., area, depth, thermal behavior, watershed), following a common protocol. This

establishes the collection of samples by horizontal trawling of a plankton net and, after treatment with hydrogen peroxide, the polymer identification through micro-Raman spectroscopy. This GLEON project will allow obtaining comparable data about microplastic contamination in different freshwater systems around the globe. With this global dataset, our goals are to determine whether a relationship exists between the abundance of microplastics and the waterbody/watershed attributes and understand which factors are likely to influence the occurrence of microplastics in surface water of lentic systems.