National Microplastics Field Methodology Review

Abigail P.W. Barrows

College of the Atlantic
Adventure Scientists

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Objective

The purpose of this review is to assess quality assurance, quality control, instrumentation, affordability and accessibility of microplastics field sampling techniques. This review attempts to cover the commonly used methods for microplastics sampling in water, sediment, air and animals. It is intended to be a tool and starting point for improving methods standardization and data harmonization across research groups.

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Abigail P.W. Barrows*

College of the Atlantic, Bar Harbor, Maine
Adventure Scientists, Bozeman, Montana

The field of microplastic research has grown rapidly in the last decade as microplastics gained recognition as an "emerging issue of international concern" (GESAMP, 2015). Initially most research focused on sampling sea surface water but after widespread microplastic pollution was reported, studies expanded to include freshwater environments, sediment, varying depths throughout the water column, sea ice, the atmosphere, and aquatic animals. Field techniques have ranged from basic, in situ visual surveys to complex at-sea mechanical pumping systems. Due to the swift expansion of this field of research, there has been a lack of method standardization. There is a recognized need for the harmonization of microplastic field techniques, data collection, laboratory analysis and data reporting (GESAMP, 2017). Increasing standardization will allow for widespread comparison of microplastic pollution across different habitats, substrates and even political borders.

A wide range of academic, government, non-profit, and non-government organizations have engaged in microplastic research over the last few years. Many microplastic research projects are incorporated into existing water and beach monitoring programs, some of which are volunteer powered. Other techniques have been based more on capacity or ease of incorporation (e.g. addition of microplastic tally row in The Ocean Conservancy's international coastal cleanup data sheet) than on data compatibility, quality assurance or quality control (QA/QC). Although project personnel capacity/ability and QA/QC are essential considerations in a research project design, the end goal and use of the data is ultimately what will drive each of the following design steps.

Numerous studies focus on quantifying large microplastics visible to the naked eye, between 1-5 mm in size. This type of quantification does not rely heavily on spectroscopy for positive polymer identification. The smaller the microplastics (nano-sized particles to < 1 mm), the more difficult they are to confidently distinguish from non-plastics. Pieces that fall in the micron scale require some level of spectroscopy to determine synthetic polymer presence.

In the microplastics field of research there is a high potential of contamination by the sampler, the air or sample equipment, so a very high level of QA/QC is recommended for studies reliant on laboratory/microscopy analysis. Specific QA/QC steps must be taken to reduce contamination when sampling for plastics < 1 mm. including: limiting the use of plastic sampling equipment, as over time there is increased potential for the equipment to contaminate sample (e.g. lid threads on sample bottles, degraded or frayed plastic mesh in tow nets), or if avoidance is not possible identify the equipment polymer type and exclude if encountered in a sample; triple rinse all sampling equipment and take a control sample of rinse water for laboratory analysis; use photo or video to document sample collection and researcher clothing as synthetic clothing fibers can shed into sample; position researcher and assistants downwind while collecting sample; always

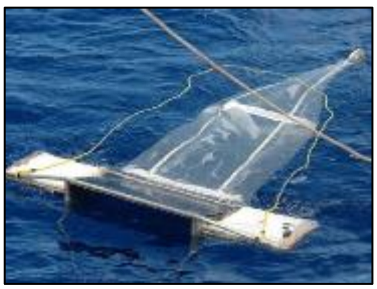
*Correspondence: abarrows@coa.edu

reduce sample air exposure and if air exposure is unavoidable, take an air blank which is a new, unused filter or jar of filtered water exposed to the air for the same duration as the sample.

The aim of this microplastics methodology review is to increase field design harmonization and data compatibility for future microplastic studies. The review covers a range of techniques used by citizen scientists and professional research scientists throughout the United States and makes suggestions for potential laboratory analysis. A comprehensive review of current laboratory techniques is still needed.

General sampling methods

Net sampling



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Manta net
The trawl is deployed off of a boat and towed on a linear course at a low speed of 3-5 knots for a set time (30-15 minutes depending on flow rates) or distance. The Manta net samples surface water and the net opening should be submerged while towing. Coordinates are recorded at trawl start and stop. Sea state, average boat speed and flow rate is also recorded. Trawl contents are rinsed into a sample jar for future analysis (alcohol is added as a preservative and samples are processed in a laboratory) or poured through a 1 mm sieve, and sorted visually using tweezers. Plastics are recorded by size and type (see Table 4) and may be weighed. If microscopy analysis is desired, additional quality assurance and quality control steps must be taken in the field.

Survey details/resources:

NOAA

Institute for Water of the Republic of Slovenia

Inland Seas Education Association

Photo Credit: NOAA

Neuston net
The trawl can use the same protocol as the Manta net. While towing, the neuston net opening sits partially out of the water. The neuston net can also be used as a stationary net to sample streams or rivers. When deployed as a stationary net, time or volume can determine sample duration. A flow meter or a flow tracker is used to determine volume of water sampled. GPS coordinates, water depth, wind speed, wind direction and water temperature may be recorded. Samples can be processed using

stacked sieves and visually sorted or preserved in samples jars for laboratory analysis. If visually sorted, plastic size, type (see Table 4) and weight may be recorded. If microscopy analysis is desired, additional quality assurance and quality control steps must be taken in the field.

Survey details/resources:

Lippiatt, S., Opfer, S., and Arthur, C. 2013. Marine Debris Monitoring and Assessment. NOAA Technical Memorandum NOS-OR&R-46.

Morét-Ferguson, S., Law, K. L., Proskurowski, G., Murphy, E. K., Peacock, E. E., & Reddy, C. M. (2010). The size, mass, and composition of plastic debris in the Western North Atlantic Ocean. Marine Pollution Bulletin, 60 (10), 1873–1878.

Parsons School of Design - DIY Net Trawl


Photo Credit: ISOZOO

Bongo net
The bongo net is deployed into the water column at a 45-degree angle and can sample to approximately 200-meter depth. The net is towed at a low speed at the desired sample depth while maintaining a 45-degree net angle. Start and stop coordinates, sea state, boat speed, distance and flow rate is recorded. Net is brought aboard and washed down into a stacked sieve to be sorted visually or preserved in samples jars for laboratory analysis. If microscopy analysis is desired, additional quality assurance and quality control steps must be taken in the field.

Survey details/resources:

NOAA

SOKI Wiki (2014) *Bongo net - Methods - Confluence*, SOKI, Antarctic Climate and Ecosystems Co-operative Research Centre.

California Cooperative Oceanic Fisheries Investigations


Photo Credit: NOAA

Continuous Phytoplankton Recorder (CPR)
CPR is a small vehicle that is towed about 70 meters behind a ship and 10 meters below the sea surface. While the boat is moving, water enters the nose of the CPR and is filtered through a slow moving belt of silk mesh. Start/stop time and location is recorded. Designed to collect phytoplankton, the CPR also can be used to collect microplastics over long distance voyages. The silk mesh is removed for laboratory processing and analysis.

Survey details/resources:

Sir Alister Hardy Foundation for Ocean Science (SAHFOS)

Shore surveys

©Race for Water 2015

Transect/quadrat

Sediment sampling consists of running multiple transects at a right angle from the water line and placing quadrats along the transects. GPS coordinates and a photograph is taken at each quadrat and major features of the area are recorded (storm drains, rivers, etc.). Quadrats are either visually scanned for plastics or sediment is removed to an approximate depth (5 cm) or volume and processed through stacked sieves or in a laboratory. Sieved plastic material is measured (1-5 mm), and size and type is recorded (see Table 4). Total number of pieces and plastic weight is recorded for each quadrat. Plastics may also be separated from the sediment through density separation in the field. Samples are combined with a sodium chloride (NaCl) solution and agitated. Low density plastics will float to the surface and can be removed.

Survey details/resources:

Hidalgo-Ruz, V., Gutow, L., Thompson, R.C., Thiel, M., 2012. Microplastics in the marine environment: a review of the methods used for identification and quantification. Environ. Sci. Technol. 46, 3060–3075.

Lippiatt, S., Opfer, S., and Arthur, C. 2013. Marine Debris Monitoring and Assessment. NOAA Technical Memorandum NOS-OR&R-46.

Oregon State University/5 Gyres

Photo Credit: Grant Conzaman

Clean-up survey

Shore surveys begin by marking the start area with a stake and recording GPS coordinates. The length of sample area is measured along the midpoint of the shoreline. Environmental and land use data is recorded (tidal range, substrate type, access, nearest town distance, pipe/drain/river input). The shore area is systematically traversed and pieces of trash are removed. Trash items are identified and counted. Plastic pieces less than 2.5cm are tallied.

Survey details/resources:

NOAA

Ocean Conservancy

Ryan, P. G.; Moore, C. J.; van Franeker, J. A.; Moloney, C. L. (2009). Monitoring the abundance of plastic debris in the marine environment. Philos. Trans. R. Soc., B, 364 (1526), 1999–2012.

Sediment sampling

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Core sample

Core samples can be used to study potential microplastic trends in time. A core sampler is pushed into sediment to the desired depth (commonly to 5 cm) and sample is removed for laboratory analysis. Cores are taken at various distances from the water's edge. GPS coordinates and sample distance from water are recorded.

Survey details/resources:

Ballent, A., Corcoran, P.L., Madden, O., Helm, P.A., Longstaffe, F.J. (2016). Sources and sinks of microplastics in Canadian Lake Ontario nearshore, tributary and beach sediments. Marine Pollution Bulletin, 110 (1), 383-395.

Photo Credit: Eijkelkamp

Ekman and Van veen grab sample

The Van veen and Ekman grabs are used to study benthic sediment. They are deployed from a boat or dock. The volume and depth of sediment collected is determined by the equipment. GPS coordinates and water depth is recorded. Sediment is removed for laboratory processing and analysis. Plastics may also be separated from the sediment through density separation in the field. Samples are combined with a hypersaline sodium chloride (NaCl) solution and agitated. Low density plastics will float to the surface and can be removed.

Survey details/resources:

Census of Marine Life

Van Cauwenberghe, L., Vanreusel, A., Mees, J., & Janssen, C. R. (2013). Microplastic pollution in deep-sea sediments. Environmental Pollution, 182, 495–499.

Claessens, M., De Meester, S., Van Landuyt, L., De Clerck, K., & Janssen, C. R. (2011). Occurrence and distribution of microplastics in marine sediments along the Belgian coast. Marine Pollution Bulletin, 62 (10), 2199–2204.

Whole water sampling

Photo Credit: Courtney Neumann

Grab sample

A grab sample collects a fixed amount of water and can be taken from a variety of sampling platforms: small vessels, shore, dock, snorkel, scuba, etc. GPS coordinates, sea state, wind speed, wind direction, water/air temperature, depth and a photograph of the sampler may be recorded. The sample jar is submerged and filled with surface water for laboratory analysis. Only identification through microscopy is possible.

Survey details/resources:

Barrows, A.P.W., Neumann, C.A., Berger, M.L., Shaw, S.D. 2016. Grab vs. neuston tow net: a microplastic sampling performance comparison and possible advances in the field. Anal. Methods, 2017, 9, 1446

Florida Microplastic Awareness Project

Photo Credit: Young Kyong Song

Bulk water sample
A bulk water sample consists of manually collecting surface water using a bucket and storing the water in a large volume container. GPS coordinates, sea state, wind speed, wind direction, water/air temperature and a photograph of the sampler may be recorded. The sample water volume varies, but is usually a minimum of 10 liters. Bulk water samples are processed and analyzed in a laboratory. Additional quality assurance and quality control steps must be taken in the field.

Survey details/resources:

Hidalgo-Ruz, V., Gutow, L., Thompson, R.C., Thiel, M. 2012. Microplastics in the marine environment: a review of the methods used for identification and quantification. Environ. Sci. Technol. 46, 3060–3075.

Song Y.K., Han G.M., Jang M. 2014. Large Accumulation of Micro-sized Synthetic Polymer Particles in the Sea Surface Microlayer. Environ. Sci. Technol., 2014, 48, 9014–9021.

Photo Credit: Andrew Foote/CBC

Volume-reduced bucket sample
A volume-reduced bulk water sample is similar to the bulk water sample in that it consists of manually collecting surface water using a bucket. The sample can be collected from a variety of sampling platforms: large or small vessels, shore, dock. GPS coordinates, start and stop time, sea state, wind speed, wind direction, water/air temperature and a photograph of the sampler may be recorded. The sample water volume varies: the higher the volume, the greater likelihood of successful visual sorting. The sample is directly poured through a sieve or stacked sieves. Plastics are visually sorted and recorded by size, type and may be weighed.

Survey details/resources:

Hidalgo-Ruz, V., Gutow, L., Thompson, R.C., Thiel, M. 2012. Microplastics in the marine environment: a review of the methods used for identification and quantification. Environ. Sci. Technol. 46, 3060–3075.

Photo Credit: Marcus Eriksen

Volume-reduced pump sample

A volume-reduced bulk water sample consists of pumping water (manually or using a motor) through an inline filter and out through a flow meter. The sample can be collected from a variety of sampling platforms: large or small vessels, shore, sample volume, sea state, wind speed, wind direction, water/air temperature and a photograph of the sampler may be recorded. Quality assurance and quality control steps must be taken in the field. The filter is removed and stored for future laboratory analysis.

Survey details/resources:
Available upon request.

Photo Credit: oceanecology.ca

Niskin/Nansen bottle sample

Niskin or Nansen bottles are used to sample the water column. GPS coordinates are recorded and bottle is deployed to desired sample depth. Bottle is closed at depth and brought back onboard. Depending on the bottle capacity, the sample water can be poured through stacked sieve (if large volume) for visual sorting and identification or preserved in a sample jar for future laboratory analysis. If microscopy analysis is desired, additional quality assurance and quality control steps must be taken in the field.

Survey details/resources:

The Center for Coastal Margin Observation & Prediction - DIY

Atmospheric fallout

Photo Credit: Rachid Dris

Passive sampler

A long-term passive sampler is designed to collect microplastics that are deposited from the air. Multiple study sites house a funnel and collection bottle. During periodic sample collection, funnel is rinsed into the sample bottle and bottle is capped, removed and replaced. Laboratory analysis of sample is required. Rainfall is recorded at sample site.

Survey details/resources:

Dris, R., et al., Synthetic fibers in atmospheric fallout: A source of microplastics in the environment?, Marine Pollution Bulletin (2016), http://dx.doi.org/10.1016/j.marpolbul.2016.01.006

Dris, R., Gasperi, J., Mirande, C., Mandin, C., Guerrouache, M., Langlois, V., Tassin, B., 2017. A first overview of textile fibers, including microplastics, in indoor and outdoor environments. Environ. Pollut. 221, 453–458.

©Deltanov

Active sampler

A pump is used to sample air over a filter for a period of 4 to 40 hours. The pump can be situation in or outdoors. The volume of air is recorded and filters are analyzed in a laboratory.

Survey details/resources:

Dris, R., Gasperi, J., Mirande, C., Mandin, C., Guerrouache, M., Langlois, V., Tassin, B., 2017. A first overview of textile fibers, including microplastics, in indoor and outdoor environments. Environ. Pollut. 221, 453–458.

Dissection

Photo Credit: Marcus Eriksen

Digestive tract

If only relying on visual identification of plastics, animal must be large enough to have consumed plastic larger than 1 mm. Collected animal can either be dissected fresh, stored in a preservative or frozen for future dissection. Species is identified, and specimen is measured and weighed. If possible location of collection is recorded. The gastro-intestinal tract of the animal is removed and cut length-wise. Contents are visually sorted and plastics are recorded by size, type and may be weighed. If relying on laboratory quantification of microplastics, additional quality assurance and quality control steps must be taken and entire gut contents should be removed and stored for analysis.

Survey details/resources:

Civic Laboratory

Torre, M., Digka, N., Aikaterini, A., Tsangaris, C., Mytilineou, C. 2016. Anthropogenic microfibres. pollution in marine biota. A new and simple methodology to minimize airborne contamination. Marine Pollution Bulletin. (133) 55-61. http://doi.org/10.1016/j.marpolbul.2016.07.050

Table 1. Assessment of microplastic water sampling field methods.

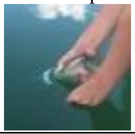
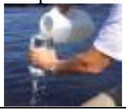
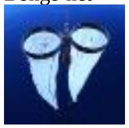
Location	Technique	Specialized equipment necessary?	Pros	Cons	Quality Assurance
Marine/Fresh Surface Water	Manta/Neuston Tow Net 	Yes, but DIY options	Visual sorting possible Can couple with other research Large area/volume sampled Comparative data	Equipment cost Plastic size limited Lab processing	Field control Rinse water control Photograph of samplers Non-laboratory processed samples only quantify plastics > 2mm
	Grab Sample 	No	Low cost equipment Low contamination Point source sampling Simple protocol	Lab processing No visual sorting Volume limited	Field control Duplicates Photograph of samplers Non-laboratory processed samples only quantify plastics > 2mm
	Bulk water sample 	No	Large volume sampled	Logistically difficult Lab processing No visual sorting	Field control Rinse water control Photograph of samplers
	Bucket volume-reduced bulk water sample 	No	Visual sorting possible Large volume sampled Point source sampling Simple protocol	Lab processing Plastic size limited	Field control Rinse water control Photograph of samplers Non-laboratory processed samples only quantify plastics > 2mm
Marine/Fresh Depth/water column	Niskin/Nansen bottle 	Yes, but DIY options	Simple protocol	Equipment cost Lab processing	Duplicates Field control Photograph of samplers
	Scuba/Snorkel (Grab sample only) 	No-snorkel Yes-scuba	Simple protocol Low contamination	Volume limited Lab processing Certification	Duplicates Field control Photograph of samplers
	Bongo net 	Yes	Visual sorting possible Can couple with other research Comparative data Large area/volume sampled	Equipment cost Contamination potential Mesh size Lab processing Plastic size limited	Field control Rinse water control Photograph of samplers Non-laboratory processed samples only quantify plastics > 2mm
	Continuous Phytoplankton Recorder 	Yes	Can couple with other research Comparative data Large area sampled	Equipment cost Contamination potential Mesh size Lab processing Plastic size limited	Field control Photograph of samplers

Table 2. Assessment of microplastic sediment field sampling methods.

Location	Technique	Specialized field equipment necessary?	Pros	Cons	Quality Assurance
Beach/shore zone	Sieve, stacked sieve, sediment removal 	No	Simple Low tech *In situ* processing Comparative data	Physically intensive Only captures large size class Plastic size limited	Photograph of samplers Photograph of plastic Sample archived Non-laboratory processed samples only quantify plastics > 2mm
	Density separation 	No	Simple Low tech *In situ* processing Comparative data	Physically intensive Slow Only captures low density plastic Plastic size limited	Photograph of samplers Hypersaline solution control Photograph of plastic Sample archived Non-laboratory processed samples only quantify plastics > 2mm
	Survey 	No	Simple Low tech Comparative data	Potential bias Plastic size limited	Photograph of samplers Photograph of plastic Sample archived Non-laboratory processed samples only quantify plastics > 2mm
Benthos	Core sample 	No	Simple protocol Low equipment cost	Labor intensive sorting Lab processing Non-standardized	Duplicate Rinse water control Photograph of samplers Non-laboratory processed samples only quantify plastics > 2mm
	Core/bottom trawl/grab sample 	Yes	Potential visual sorting of larger (1-5 mm) plastic	Expensive equipment Labor intensive Lab processing Non-standardized	Rinse water control Photograph of samplers Non-laboratory processed samples only quantify plastics > 2mm

Table 3. Assessment of air and animal microplastic field sampling methods.

Sample Target	Technique	Specialized field equipment necessary?	Pros	Cons	Quality Assurance
Air	Passive collector 	Yes, but DIY options	Simple protocol Low cost equipment	Lab processing Non standardized	Rinse water control Photograph of samplers
	Active collector 	Yes, but DIY options	Simple protocol	Lab processing Non standardized	Duplicate Control filter
Digestive tract	Dissection 	No	Simple protocol Potential visual sorting of larger (1-5 mm) plastic	Lab processing Non standardized Sourcing/cost of animals	Rinse water control Photograph of samplers Non-laboratory processed samples only quantify plastics > 2mm

Table 4. Field metadata and plastic categorization suggestions.

Field data:

- Sampling level (depth)
- Wind speed
- Beaufort scale
- Current speed and current direction (when applicable)
- Filtered volume (when applicable)
- Log (location & time)
- Video/photo of sampling

Visual sorting data sheet for >100nm-5mm plastic: 5 broad categories[*1]

- Fragments (flakes, etc.)
- Films
- Foams (expanded polystyrene)
- Pellets (nibs, nurdles, beads)
- Fibers (filaments, lines, strings, etc.)

[*1] *Based on the categories as defined at the IMO Conference*

Recommendations

Due to the elevated potential of contamination of a sample when conducting microplastic field research, it is recommended that studies are designed to maintain a high level of QA/QC. Any studies that rely on laboratory processing and microscopy analysis must consider field controls and additional measures (filtered rinse water, non-synthetic clothing and sample equipment) in order to produce usable data. It is recommended that any studies that do not intend to analyze samples in a laboratory setting restrict plastic quantification to pieces larger than 2 millimeters. With the goal of increasing methodology standardization and data comparability, studies should replicate successful published research methodology, use common volume/area data extrapolations, collect similar metadata and record plastic types using agreed upon categories.

Glossary

Adsorb: to gather on a surface in a condensed layer.

Beaufort Scale: a scale in which the force of the wind is indicated by numbers from 0 to 12 based on visual cues.

Benthic: relating to, or occurring at the bottom of a body of water; often associated with sediments and the organisms living within them.

Bioaccumulation: the gradual build up over time of a chemical in a living organism via its diet.

Biofouling: colonization of an underwater surface by sessile organisms such as barnacles, mollusks or algae. These organisms can block, clog, or otherwise hinder the function of underwater equipment.

Biomagnification: the process by which a compound (such as a pollutant or pesticide) increases in concentration in the tissues of organisms as it travels up the food chain.

Bongo tow/net: an oblique tow which is deployed at a 45-degree wire angle to approximately 210 meters (300 meters wire out). The net mesh can range from 50 microns – 3 millimeters in size. The Bongo frame is retrieved with the same 45-degree wire angle.

Bulk sampling: Bulk samples refer to samples where the entire volume of the sample is taken without reducing it during the sampling process. Bulk samples are most appropriate when microplastics cannot be easily identified visually because (i) they are covered by sediment particles, (ii) their abundance is small requiring sorting/filtering of large volumes of sediment/water, or (iii) they are too small to be identified with the naked eye.

Cellulose acetate: any of several compounds obtained by treating cellulose with acetic anhydride. Cellulose acetate is used in lacquers, photographic film, transparent sheeting, and cigarette filters.

Chemical digestion: the process of reducing an organic substance through chemical reaction. Often used in microplastic studies to diminish organic material (e.g. gastro-intestinal tract, whole shellfish) in order to quantify microplastic ingestion.

Citizen science: The collection or analysis of samples and data by the general public, usually in partnership with professional scientists. The project may be designed by citizens.

Coastal zone: a region where interaction of the sea and land processes occurs. Can be defined as the territorial waters within 12 nm of land.

Core sample: a cylindrical section of (usually) a naturally occurring substance. In the coring process, the sample is pushed more or less intact into the tube. The sample can be analyzed in the field or lab.

Ekman grab: a sediment grab sampler designed for sampling in soft-bottomed substrate free from plant growth. As the sampler is lowered from the boat, two hinged upper lids swing open to let water pass through and close upon retrieval on the substrate preventing sample washout.

EPS: Expanded Polystyrene, a synthetic thermoplastic material obtained by polymerizing styrene; used as a white rigid foam for insulating and packing and as a glasslike material in light fittings and water tanks.

Equipment Blank: A sample of contaminant free water poured over or through decontaminated field sampling equipment prior to the collection of environmental samples. Used to assess the adequacy of the decontamination process and to assess contamination from the total sampling, sample preparation and measurement process, when decontaminated sampling equipment is used to collect samples.

Estuary: a partially enclosed coastal body of brackish water with one or more rivers or streams flowing into it and with a free connection to the open sea.

Field blank: Used to assess contamination from field conditions during sampling. A sample of contaminate free water poured into a container in the field and shipped to the laboratory with field samples.

Film: a thin, flexible sheet.

Foam: synthetic resin converted into a sponge-like mass which may be flexible or rigid.

Fragment: an irregular and incomplete piece resulting from a larger item breaking into smaller pieces.

FT-IR: Fourier transform infrared spectroscopy is a technique which is used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. An FT-IR spectrometer simultaneously collects high spectral resolution data over a wide spectral range.

Gas chromatography/Mass spectroscopy (GC/MS): a technique for analyzing a mixture of volatile substances in which the mixture is carried by an inert gas through a column packed with a selective adsorbent and a detector records on a moving strip the conductivity of the gas leaving the tube. Peaks on the resulting graph indicate the presence of a particular component.

Grab sample: a water grab sample is a sample of river, stream or freshwater wetland water collected for the purpose of analyzing its constituent water chemistry or pollution content. Samples are taken in a bottle and large surface debris and sediment is avoided when collecting a sample.

Hypersaline: containing more dissolved salts than seawater.

Instrument blank: a blank analyzed with field samples to assess the presence or absence of instrument contamination.

Laboratory air blank: the process of exposing a filter or petri dish surface to laboratory air to ascertain potential airborne plastic contamination during sample processing.

Laboratory water blank: a blank prepared to represent the sample matrix as closely as possible. The method blank is prepared/extracted/digested and analyzed exactly in the same way as a field sample.

Leachate: a solution resulting from leaching, as of soluble constituents from soil, landfill, etc., by downward percolating ground water.

Macroplastic: plastic 200 mm in length and larger.

Manta net/trawl: a net system for sampling the surface of the ocean. It resembles a manta ray, with metal wings and a broad mouth. The net it pulls is made of thin mesh, often 333 or 335 μm and the whole trawl is towed behind a vessel.

Mass spectroscopy (MS): an instrumental method for identifying the chemical constitution of a substance by means of the separation of gaseous ions according to their differing mass and charge.

Mesoplastic: plastic between 5 mm and 200 mm in length.

Microbead: a manufactured solid plastic particle of less than five millimeters in its largest dimension. Microbeads are most frequently made of polyethylene but can be of other petrochemical plastics such as polypropylene and polystyrene. They are used in exfoliating personal care products, toothpastes and in biomedical and health-science research.

Microfiber: a threadlike piece of plastic with a length between 100 μm and 5 mm and a width approximately 1.5 orders of magnitude shorter.

Micron: the millionth part of a meter or the one-thousandths part of a millimeter; also called micrometer (μm).

Microplastic: a piece of plastic measuring less than 5 mm in size and larger than 100 nm in dimension.

Nanoplastic: plastic particles <100 nanometers in at least one dimension.

Nansen bottle: a device for obtaining samples of seawater at a specific depth. The bottle, more precisely a metal or plastic cylinder, is lowered on a cable into the ocean, and when it has reached the required depth, a brass weight called a "messenger" is dropped down the cable. When the weight reaches the bottle, the impact tips the bottle upside down and trips a spring-loaded valve at the end, trapping the water sample inside. The bottle and sample are then retrieved by hauling in the cable.

Niskin bottle: a development of the Nansen bottle patented by Shale Niskin in March 1966. Instead of a metal bottle sealed at one end, the 'bottle' is a tube, usually plastic to minimize contamination of the sample, and open to the water at both ends. Each end is equipped with a cap which is either spring-loaded or tensioned by an elastic rope. The action of the messenger weight is to trip both caps shut and seal the tube.

Nurdle: a pre-production microplastic pellet about the size of a pea; also called a pellet.

Neuston net: a trawl device for sampling the surface of the water. Mouth opening is rectangular and net tapers into a removable cod end. Net mesh size varies but is often 335 µm.

Oceanic gyre: a spiral oceanic surface current driven primarily by the global wind system and constrained by the continents surrounding the three ocean basins (Atlantic, Pacific, and Indian). Each ocean basin has a large gyre in the subtropical region, centered around 30° north and south latitude. Smaller gyres occur at 50° north latitudes in the North Atlantic and Pacific Oceans. The direction of a gyre's rotation is determined by the prevailing winds in the region, with the large subtropical gyres rotating clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere.

Open ocean: the marine zone beyond 12 nm of coastline, usually beyond the continental shelf, without obvious stationary structures such as reefs.

Pelagic: relating to or living in or on oceanic waters. The pelagic zone of the ocean begins at the low tide mark and includes the entire oceanic water column.

Pellet: a pre-production microplastic pellet about the size of a pea; also called a nurdle.

Persistent Organic Pollutant (POPs): organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. Because of their persistence, POPs bioaccumulate with potential significant impacts on human health and the environment.

Photo-degradation: the alteration of materials by light. Typically, the term refers to the combined action of sunlight and air. Photo-degradation is usually oxidation and hydrolysis.

"Plasticene": a term used to define the 'age of plastic' in which we are currently living.

"Plastisphere": a term used to refer to ecosystems that have evolved to live in human-made plastic environments.

Polyamide: a polymer produced by the reaction of the amino group (NH_2) from one molecule with the carboxylic acid group (CO_2H) from another molecule. The resulting structure is similar to that of a protein. Silk is a naturally occurring polyamide, and nylon is a synthetic polyamide.

Polycarbonate: any of a class of strong transparent thermoplastic resins used in molded products, films, and non-breakable windows.

Polyethylene (PE): a synthetic thermoplastic polymer of ethylene used chiefly for containers, electrical insulation, and packaging. Polyethylene is easily molded and is resistant to other chemicals.

Polymer: any of various chemical compounds made of smaller, identical molecules (called monomers) linked together. Some polymers, like cellulose, occur naturally, while others, like nylon, are artificial.

Polypropylene (PP): a plastic polymer of propylene, (C_3H_5), used chiefly for molded parts, electrical insulation, packaging, and fibers for clothing apparel. Thermoplastic.

Polystyrene (PS): a synthetic thermoplastic material obtained by polymerizing styrene; used as a white rigid foam (expanded polystyrene) for insulating and packing and as a glasslike material in light fittings and water tanks.

Positive control: a sample containing a known quantity of plastics available for training/practicing microplastic counting and sorting.

Primary microplastic: particles of plastics that are purposefully manufactured to be microscopic. They are often used in facial cleansers and cosmetics, or in air blasting technology

Procedural recovery: an experiment performed to estimate proportional systematic error. Analytical accuracy can be assessed by analyzing a sample with known/predetermined concentrations (for example, a control sample or other reference material) and comparing the measured value with the true value.

Quality assurance (QA): a program for the systematic monitoring and evaluation of the various aspects of a project, service, or facility to ensure that standards of quality are being met.

Quality control (QC): a process by which entities review the quality of all factors involved in production. In project management, quality control requires the project manager and/or the project team to inspect the accomplished work to ensure its alignment with the project scope. QC places an emphasis on three aspects: 1. Elements such as controls, job management, defined and well managed processes, performance and integrity criteria, and identification of records 2. Competence, such as knowledge, skills, experience, and qualifications 3. Soft elements, such as personnel, integrity, confidence, organizational culture, motivation, team spirit, and quality relationships.

Quadrat: a square or rectangular plot (often one square meter) of land marked off for the study of plants and animals or plastics.

Raman spectroscopy: a spectroscopic technique used to observe vibrational, rotational, and other low-frequency modes in a system. Raman spectroscopy is commonly used in chemistry to provide a fingerprint by which molecules can be identified.

Replicate: a duplicate pertaining to a copy or a representative from a group to undergo the same (exact) procedure. For instance, a treatment group would consist of three replicates (called triplicates) to test for the deviation of the results.

Pyrolysis: Decomposition or transformation of a chemical compound caused by heat.

Scanning electron microscopy (SEM): a type of electron microscope capable of producing high-resolution images by scanning a sample surface with a focused beam of electrons.

Sea surface: definition varies according to measurement method used, but is between 1 millimeter (0.04 inches) and 20 meters (70 feet) below the sea surface.

Sonde: a probed instrument that transmits ambient data, such as dissolved oxygen or temperature, to the user.

Secchi disk: a typically white and black disk used to gage the turbidity, or clarity, of the water by measuring the depth at which the user loses sight of the disk.

Secondary microplastics: microscopic plastic pieces derived from the chemical or mechanical breakdown of larger plastic debris.

Surface Microlayer (SML): the top 1000 micrometers (or 1 millimeter) of the ocean surface.

Sorption: the process in which one substance takes up (absorption) or holds on the surface (adsorption) another.

Thermoplastic: soft and pliable when heated, without any change of the inherent properties. Have the ability to be remolded.

Thermosetting: relating to a compound that softens when initially heated, but hardens permanently once it has cooled. Thermosetting materials are made of long-chain polymers that cross-link with each other after they have been heated, rendering the substance permanently hard.

Transect: a sample area usually in the form of a long continuous strip.

Van veen grab: an instrument to sample sediment in water environments. Usually it is a clamshell bucket made out of stainless steel. Up to 20 cm deep samples of roughly 0.1 m^2 can be extracted with this instrument. It can be light-weight (roughly 5 kg) and low-tech. A draw-back of the use of this sampler is that it tends to disturb the sediments more than a box corer does.

Volume reduced sample: refer to samples where the volume of the bulk sample is usually reduced during sampling, preserving only that portion of the sample that is of interest for further processing.

Reference

Adsit, D. 2007. What the Call Center Industry Can Learn from Manufacturing: Part II" (PDF). National Association of Call Centers. Accessed: April 14, 2017.

Arthur, C., Baker, J., Bamford, H. 2009. Proceedings of the International Research Workshop on the Occurrence, Effects, and Fate of Microplastic Marine Debris. National Oceanic and Atmospheric Administration Technical Memorandum. NOS-OR&R-30. Silver Spring.

Barrows, A.P.W., Neumann, C.A., Berger, M.L., Shaw, S.D. 2016. Grab vs. neuston tow net: a microplastic sampling performance comparison and possible advances in the field. Analytical Methods, 2017, 9, 1446.

Ballent, A., Corcoran, P.L., Madden, O., Helm, P.A., Longstaffe, F.J. 2016. Sources and sinks of microplastics in Canadian Lake Ontario nearshore, tributary and beach sediments. Marine Pollution Bulletin, 110(1), 383-395.

Bussière, P.O., Peyroux, J., Chadeyron, G., & Therias, S. 2013. Influence of functional nanoparticles on the photostability of polymer materials: Recent progress and further applications. Polymer Degradation and Stability, 98, 2411–2418.

Claessens, M., De Meester, S., Van Landuyt, L., De Clerck, K., & Janssen, C. R. 2011. Occurrence and distribution of microplastics in marine sediments along the Belgian coast. Marine Pollution Bulletin, 62(10), 2199–2204.

California Cooperative Oceanic Fisheries Investigations. Bongo (CalBOBL) Net. http://www.calcofi.org/field-work/152-net-sampling/265-bongo-calbobl-net.html Accessed: March 4, 2017.

The Center for Coastal Margin Observation & Prediction. DIY Niskin Bottle Activity. http://www.stccmop.org/files/diyniskinbottle.pdf Accessed: March 3, 2017.

Dris, R., Gasperi, J., Mirande, C., Mandin, C., Guerrouache, M., Langlois, V., Tassin, B., 2017. A first overview of textile fibers, including microplastics, in indoor and outdoor environments. Environmental Pollution. 221, 453–458.

Dris, R., Gasperi, J., Saad, M., Mirande, C., Tassin, B., 2016. Synthetic fibers in atmospheric fallout: a source of microplastics in the environment? Marine Pollution Bulletin, 104, 290e293. http://dx.doi.org/10.1016/j.marpolbul.2016.01.006.

Environmental Protection Agency (EPA). Region III Fact Sheet. Quality Control Tools: Blanks. https://www.epa.gov/sites/production/files/2015-06/documents/blanks.pdf Accessed: April 14, 2017.

Eriksen, M., Lebreton, L.C., Carson, H.S., Thiel, M., Moore, C.J., Borerro, J.C. 2014. Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. PLoS One, 9:e111913.

Gardiner, D.J. 1989. Practical Raman spectroscopy. Springer-Verlag. ISBN 978-0-387-50254-0.

GESAMP 2015. "Sources, fate and effects of microplastics in the marine environment: a global assessment" (Kershaw, P. J., ed.). (IMO/FAO/UNESCOIOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 90, 96 p.

GESAMP 2016. "Sources, fate and effects of microplastics in the marine environment: part two of a global assessment" (Kershaw, P.J., and Rochman, C.M., eds). (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep.Stud. GESAMP No. 93, 220 p.

Hidalgo-Ruz, V., Gutow, L., Thompson, R.C., Thiel, M., 2012. Microplastics in the marine environment: a review of the methods used for identification and quantification. Environmental Science & Technology, 46, 3060–3075.

Inland Seas Education Association. Microplastics Station. http://schoolship.org/wp-content/uploads/2015/04/MicroplasticsManual2016FINAL.pdf Accessed: March 4, 2017.

Klaine, S. J., Koelmans, A. A., Horne, N., Handy, R. D., Kapustka, L., Nowack, B., et al. 2012. Paradigms to assess the environmental impact of manufactured nanomaterials. Environmental Toxicology and Chemistry, 31, 3–14.

Kovač Viršek, M., Palatinus, A., Koren, Š., Peterlin, M., Horvat, P., Kržan, A. Protocol for Microplastics Sampling on the Sea Surface and Sample Analysis. 2016. Journal of Visual Experimentation, (118), e55161, doi:10.3791/55161.

Liboiron, M. Civic Laboratory. How to collect fish guts for science. https://civiclaboratory.nl/2016/07/24/how-to-collect-fish-guts-for-science/. Accessed: February 23, 2017.

Lippiatt, S., Opfer, S., and Arthur, C. 2013. Marine Debris Monitoring and Assessment. NOAA Technical Memorandum NOS-OR&R-46.

Morét-Ferguson, S., Law, K. L., Proskurowski, G., Murphy, E. K., Peacock, E. E., & Reddy, C. M. 2010. The size, mass, and composition of plastic debris in the Western North Atlantic Ocean. Marine Pollution Bulletin, 60 (10), 1873–1878.

National Oceanic and Atmospheric Administration. How to Do a Manta Tow. http://www.swfsc.noaa.gov. Accessed: March 4, 2017.

Northwestern Hawaiian Islands Multi-Agency Education Project. Census of Marine Life, Census of Coral Reefs Expedition to French Frigate Shoals. Oct 2006. http://www.hawaiianatolls.org/research/CoML/collection/ekman.php Accessed: March 4, 2017.

Ocean Conservancy. Volunteer Ocean Trash Data Form. http://www.oceanconservancy.org/our-work/international-coastal-cleanup/2015-data-card.pdf Accessed: March 2, 2017.

Opfer, S., Arthur, C., Lippiatt, S., 2012. NOAA Marine Debris Shoreline Survey Field Guide. NOAA draft protocol. https://marinedebris.noaa.gov/sites/default/files/ShorelineFieldGuide2012.pdf

Oregon Coast STEM Hub, Oregon State University. How to Carry out a Beach Transect. 5Gyres-Rainy Day Kit DIY. http://oregoncoaststem.oregonstate.edu/sites/oregoncoaststem.oregonstate.edu/files/MD/5gyres-plastic-beach-project.pdf Accessed: March 4, 2017.

Phillips, J. 2008. "Quality Control in Project Management". The Project Management Hut. Accessed: March 4, 2017.

Ritter L; Solomon KR; Forget J; Stemeroff M; O'Leary C. "Persistent organic pollutants" (PDF). United Nations Environment Programme. Retrieved 2007-09-16.

Ryan, P. G.; Moore, C. J.; van Franeker, J. A.; Moloney, C. L. 2009. Monitoring the abundance of plastic debris in the marine environment. Philosophical Transactions of the Royal Society, B, 364 (1526), 1999–2012.

Sir Alister Hardy Foundation for Ocean Science (SAHFOS). The Continuous Plankton Recorder. https://www.sahfos.ac.uk/services/the-continuous-plankton-recorder/ Accessed: March 4, 2017.

SOKI Wiki 2014. Bongo net - Methods - Confluence, SOKI, Antarctic Climate and Ecosystems Co-operative Research Centre. http://www.soki.aq/display/StandMeth/Bongo+net Accessed: March 4, 2017.

Song, Y.K., Han, G.M., Jang, M. 2014. Large Accumulation of Micro-sized Synthetic Polymer Particles in the Sea Surface Microlayer. Environmental Science & Technology, 2014, 48, 9014–9021.

Torre, M., Digka, N., Aikaterini, A., Tsangaris, C., Mytilineou, C. 2016. Anthropogenic microfibres. pollution in marine biota. A new and simple methodology to minimize airborne contamination. Marine Pollution Bulletin. (133) 55-61. http://doi.org/10.1016/j.marpolbul.2016.07.050

Trawling Newtown Creek With Parsons Sustainable Systems. http://www.testingourwaters.net/ Accessed March 4, 2017.

Van Cauwenberghe, L., Vanreusel, A., Mees, J., & Janssen, C. R. (2013). Microplastic pollution in deep-sea sediments. Environmental Pollution, 182, 495–499.

Zettler, E.R., Mincer, T.J., Amaral-Zettler, L.A. 2013. Life in the “Plastisphere”; microbial communities on plastic marine debris. Environmental Science & Technology, 2013, 47, 7137-7146.