INTERACT

International Network for Terrestrial Research and Monitoring in the Arctic

Reducing Plastic Consumption and Pollution at Arctic Research Stations

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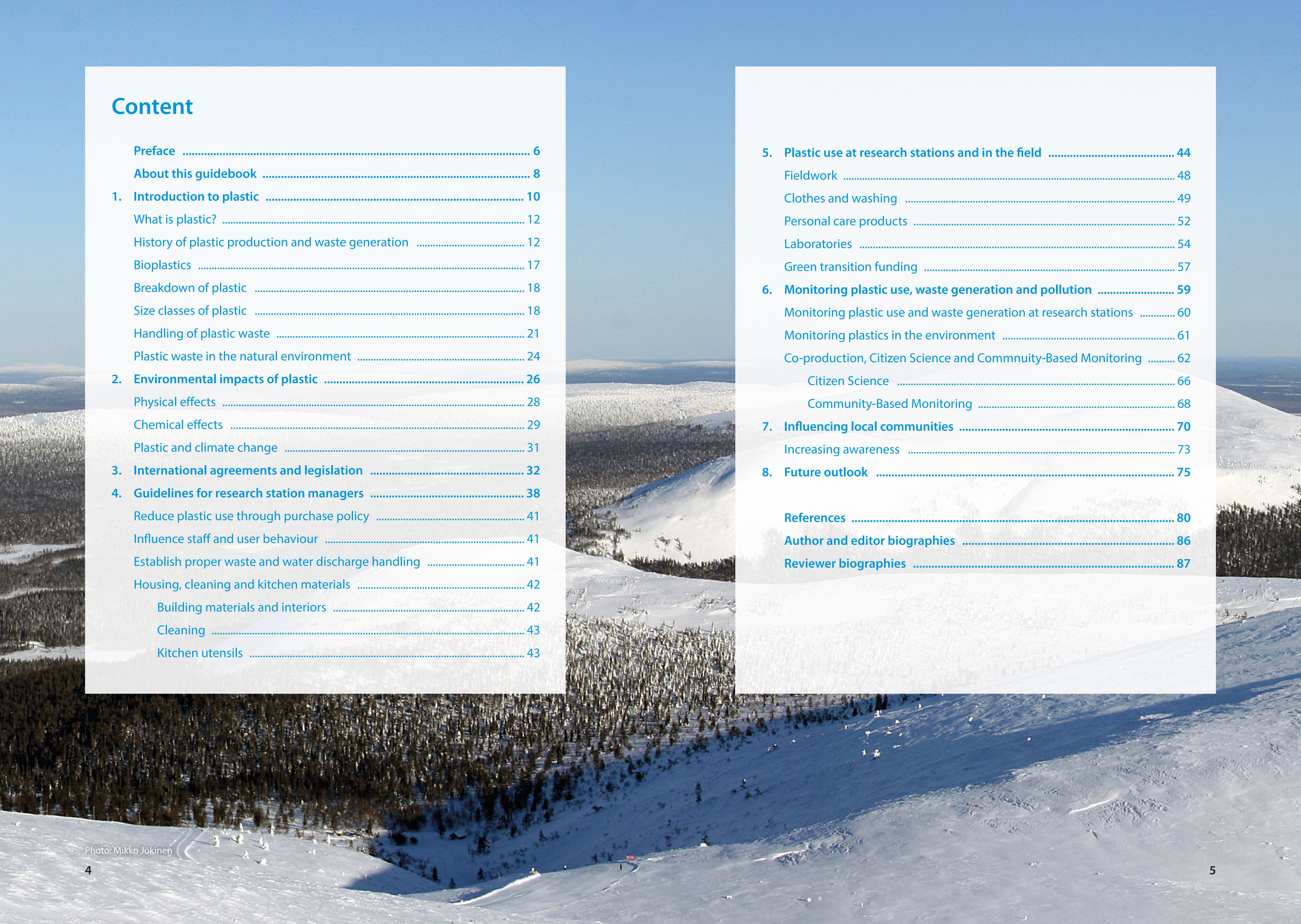


Photo: Mikko Jokinen

Content

INTERACT Reducing Plastic Consumption and Pollution at Arctic Research Stations

Preface

The advent of plastic in the mid-20th century marked a revolutionary shift in manufacturing, offering access to cheap, durable and versatile products for anything from packaging materials to consumer goods. As such plastic replaced a range of different formerly used materials like wood, copper, brass, paper, iron and rubber due to its superior qualities and low price.

The growth in plastic production since the 1950s has led to increasing volumes of plastic waste, particularly single-use items like bottles, bags and packaging that often accumulates in landfills, rivers and oceans, polluting ecosystems and endanger wildlife. Furthermore, chemical substances used as plastics additives or absorbed by plastics can be released when the plastic degrades, with potential negative consequences for human health and ecosystems.

The slow decomposition of plastic exacerbates the problem, with estimates suggesting that certain types of plastic can persist for even hundreds of years.

The Arctic, once considered a pristine wilderness, has not been spared from the scourge of plastic pollution. Adding to local emissions, ocean currents and atmospheric circulation transport plastic waste into the Arctic region, far from where it was produced and used. Microplastics (defined as plastic particles less than five millimeters in size) have been discovered in quite large concentrations in arctic ice, water and sediments, where it might pose a threat to marine life and the balance of the ecosystems.

The Arctic Monitoring and Assessment Programme (AMAP), a Working Group of the Arctic Council, aiming to monitor and assess pollution and climate change issues in the Arctic by coordinating circumpolar monitoring and research, documenting pollution levels and trends, and proposing actions to reduce pollution risks.

Concerns about microplastics and litter in the environment have been raised at global and regional levels like the Convention on Biological Diversity, UN Environment Programme, Arctic Council Ministerial Meetings and others. In 2019, The Arctic Monitoring and Assessment Programme (AMAP) established the AMAP Litter and Microplastic Expert Group to assess the status, trends and impacts of plastic pollution in the Arctic. In an effort to standardize observations across the region, the group has developed a comprehensive monitoring plan and technical guidelines for monitoring microplastics and litter in the Arctic - https://litterandmicroplastics.amap.no.

Plastic has many beneficial properties and is used for many purposes – but at the same time plastic also represents an important pollution challenge impacting our global ecosystems and people's health. We therefore need to be conscious about the amount of plastic we use and how we treat the resulting waste.

This INTERACT guidebook provides a tool for research stations, scientists and communities to reduce local plastic consumption and waste, and to monitor plastic pollution in the natural environment.

AMAP Executive Secretary

Rolf Rødven

Photo: POLAR/Donald McLennan

About this guidebook

The arctic, alpine and boreal environments are unique and vulnerable ecosystems that are undergoing dramatic changes. Temperatures are increasing 3-4 times faster in the Arctic than elsewhere on the globe (Rantanen *et al.,* 2022), alpine glaciers are disappearing at an alarming rate, species distributions are changing, environmental pollutants accumulate, sea ice is disappearing etc.

Plastic pollution and climate change share the same fossil origin: oil and gas. Plastic impacts climate change through the extraction of oil and gas for plastic, with respect to the energy used in the transport, the production, and the waste handling phases (recycling and disposal). Besides, plastic is a source of pollution impacting ecosystems through often unintended littering of e.g. macro- and microplastics. Plastics accounted for 3.4 % of global greenhouse gas emissions in 2019 (OECD, 2023a).

Plastics are now found in all environments all over the world, including the arctic, alpine and boreal environments, on land, in water, in the seabed, in glaciers and in the marine and terrestrial food chains.

We all have a share in generating the plastic pollution, and once it degrades into micro- or nanoparticles, it is virtually impossible to remove from the natural environment and could stay there for centuries to come.

This guidebook was made based on input from managers of INTERACT research stations to increase awareness of the problem and to provide guidelines for how stations, scientists and local communities can reduce the negative impacts of plastic use and pollution.

The aim of the guidebook is to:

- Increase awareness of the impacts of plastic use on climate and the natural environment.
- Provide guidelines for how to manage plastics at research stations.
- Provide guidelines for scientists to reduce the negative impacts of plastics.
- Provide information on how to monitor plastic use and pollution.
- Provide information on the importance of raising awareness about plastics and involving local communities in reducing plastic usage to mitigate plastic pollution.

Photo: Marie Frost Arndal.

1 Introduction to plastic

Photo: Yann Kolbeinsson.

Most people on the globe can't go through a day without encountering plastics. What used to be made of wood, metal, paper, cotton or leather is now often made entirely of plastic or contains parts made of plastic. The discovery of plastic (early 20th century) was revolutionary. At that time, manufacturing of plastic was not constrained by limited natural resources, and few were aware of the potential climate effects of fossil fuel use. The production of this new material was a huge benefit for many and remains a vital resource in modern day society, e.g. in health care, production industries, transport, agriculture and fisheries, telecommunication, clothing, packaging and storage and everyday utensils. Initially, it was also regarded as being good for the natural environment, as plastics could substitute natural and limited resources such as wood, metal, horn and ivory.

It was not until after World War II that plastic became more widely used. Polyester was introduced in the 1950s, and polypropylene, which is now one of the most used polymers in the world, was not available until 1954. Plastic began to replace the more expensive paper, glass and metal materials, and today there are thousands of types of plastics serving different purposes.

It is now difficult to imagine a life without plastic. It is used for so many purposes all around the globe, and we all have a share in the impacts it has on human health, the natural environment and the climate.

What is plastic?

Plastic polymers can be synthesised by using carbon atoms from fossil fuels. Different plastic types that are made from plastic polymers have different characteristics. Most polymers are used in common consumer products in the form of polypropylene (PP), polyethylene (PE) and polystyrene (PS). Shopping bags are made from polyethylene, food containers from polystyrene, and drink bottles from polyethylene terephtalate (a form of polyester) (see Table 1.1). Several chemicals or additives, such as softeners (phthalates), fire-retardants, dyes and sun filters are added to make the plastic very sturdy or flexible. There are more than 10,000 different chemicals known to be used as plastic additives throughout the manufacturing process (Hamilton *et al*., 2023).

History of plastic production and waste generation

The total amount of plastic produced since its invention is estimated to be 8,300 million tons (Mt) (Geyer *et al*., 2017). From 2000 to 2019 global annual plastic production doubled to 353 million tons (OECD, 2023b).

The unconcerned glory days of plastic are long gone, and the environmental concerns relating to the extraction, production, transport, recycling and disposal connected with the use plastics are building up, e.g.:

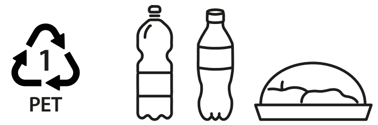
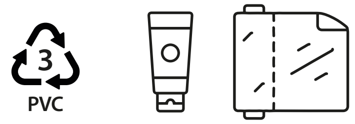
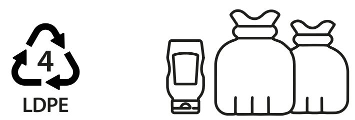
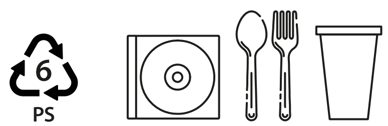
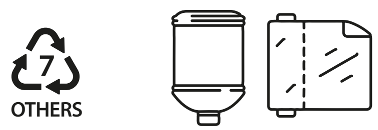
- The climate impacts related to the life cycle of plastics.
- The effects of nano-, micro- and macro-plastic entering the natural ecosystems.
- The chemical components of certain plastics known to have environmental and health effects.
- The durability (that has made plastic a success, but also means that it will stay in the environment for hundreds of years if not disposed of in the right way).

Box 1.1 Single use plastics

Many plastic products are only designed for single use, for example cotton bud sticks, cutlery, plates, straws, stirrers, balloon sticks, cups, food and beverage containers. Recent examples are products for handling the COVID-19 pandemic, which globally generated 1,600,000 tons of plastic waste per day (Benson *et al*., 2021), mainly due to the increased production of disposable personal protective equipment and testing kits. To sustain this demand for personal protective equipment, much single-use plastic legislation was withdrawn or postponed. In addition, lockdowns and restrictions on public gatherings all increased the demand for online shopping and, hence, an increased use of plastic packaging material.

Plastic is used for many purposes at research stations, e.g. personal care, kitchen, buildings and interior, laboratories, workshops, and cleaning products. Photo: Reynir Sveinsson.

Table 1.1: Main plastic types and their usage, recycling number and examples of recycled products (after World Economic Forum, 2016).

Plastic	Packaging types	Recycling number and examples
PET: Polyethylene terephthalate	Water and soft drink bottles, salad domes, biscuit trays, salad dressing and peanut butter containers	
HDPE: High-desity polyethylene:	Milk and juice bottles, freezer bags, dip tubs, shampoo, crinkly shopping bags, ice cream containers, chemical and detergent bottles	
PVC: Polyvinyl chloride:	Cosmetic containers, commercial cling wrap	
LDPE: Low-density polyethylene	Squeeze bottles, cling wrap, shrink wrap, rubbish bags	
PP: Polypropylene	Microwave dishes, ice cream tubs, potato chips bags and dip tubs	
PS: Polystyrene	CD cases, water station cups, plastic cutlery, video cases, imitation 'crystal glassware'	
EPS: Expanded polystyrene	Foamed polystyrene hot drinks cups, take-away clamshells, foamed meat trays, protective packaging for fragile items	
Mixed	Water cooler bottles, flexible films, multi-material packaging	

There has been a steady increase in plastic production since the 1950s. There are some uncertainties about the numbers, but OECD (2023b) estimates that globally only about 9 % of plastic waste is recycled, while 19 % is incinerated, 50 % ends up in landfills, and 22 % of waste bypasses waste management systems, ending up in unregulated dump-sites. If current production and waste management trends continue, Geyer *et al*. (2017) have estimated that roughly 12,000 million tons of plastic waste will end up in landfills or the natural environment by 2050 (Figure 1.1).

Unless we develop a global management strategy for plastic very soon, billions of tons of material will accumulate across all major terrestrial and aquatic ecosystems on the planet. The solutions require laws, regulations, new management practices and technology to set global standards for industrial production and design to maximise recycling, proper sorting, collection and proper disposal practices at a global scale. It also requires increasing awareness among those consuming plastic to make the right choices when buying, using, sorting and disposing of plastic products. By developing such standards and practices, we can minimise the use (and waste) of plastics and ensure that plastic products and materials are designed to be durable, reused, repaired, recycled and/or easily degradable. A future increased awareness of issues related to plastic use could as such lead to (i) a drastic reduction in overall plastic consumption, (ii) new designs allowing plastic products

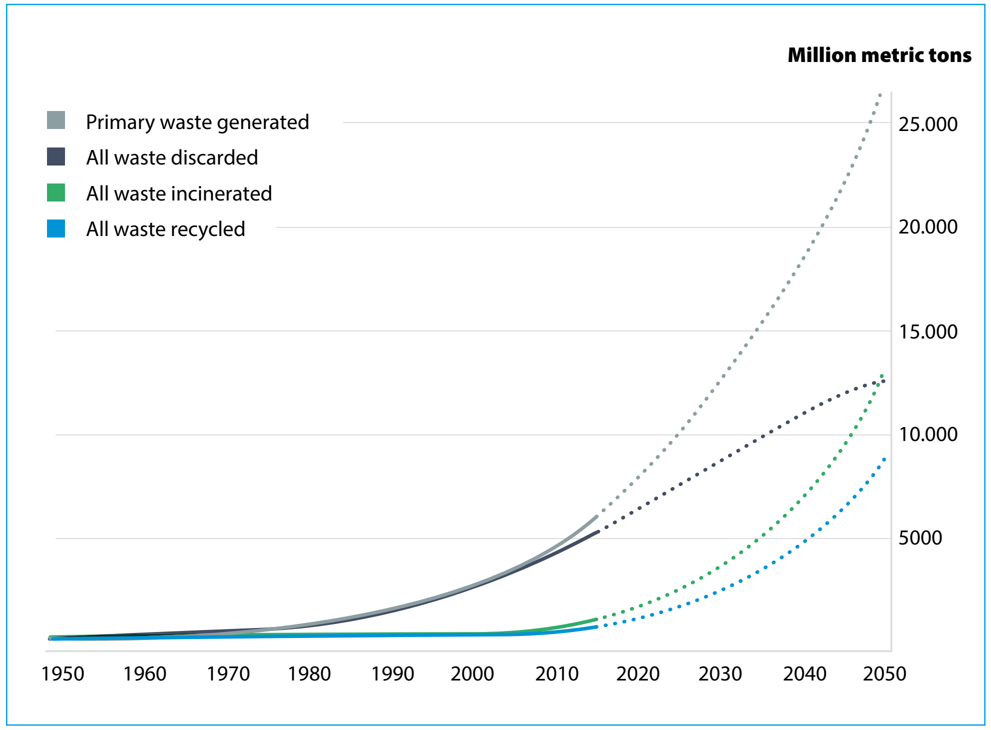


Figure 1.1: Cumulative plastic waste generation and disposal (in million tons). Solid lines show historical data from 1950 to 2015, while dashed lines show projections based on historical trends to 2050 (After Geyer *et al.*, 2017).

Figure 1.2: Characteristics of bioplastics (modified after Institute for Bioplastics and Biocomposites and European Bioplastics, https://www.european-bioplastics.org/bioplastics/).

to be reused and recycled, (iii) improved energy efficiency in plastic and bioplastic manufacturing processes (use of renewable power), and (iv) an increased collection of plastic waste and recycling/upcycling (Rosenboom *et al.*, 2022).

The current price of plastic products does not reflect the true costs incl. recycling or disposal. Holding plastic producers accountable for the costs, associated with plastic disposal could be a method to regulate the plastic industry and promote more sustainable plastic production.

Bioplastics

Bioplastics represent less than one percent of the plastic produced annually (www.bioplasticseurope.eu). Bioplastics are not just one single material. Bioplastics encompass a diverse range of materials that exhibit varied properties and serve different purposes. Bioplastic is biobased and/or biodegradable (Figure 1.3). Biobased plastics are made from plant or animal sources such as castor beans, soy, sugar cane, corn, potatoes, tapioca, wood fibres, shrimps, shells, etc. Through processing, the biomaterial is broken down into sugars that are changed through fermentation or chemical processes to form polymers. By adding resins (derived from plant sources or from petroleum products) to the polymers, manufacturers can create the type of plastic they need for a given project.

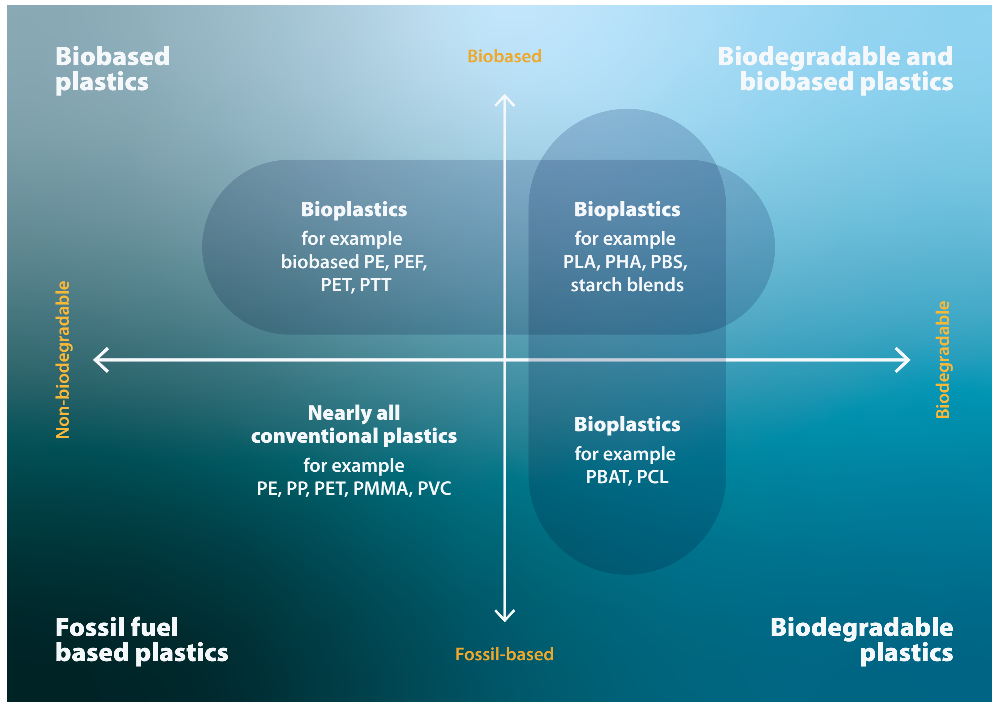


Figure 1.3: Material coordinate system for plastics. Strive to use biobased and biodegradable products (modified after Institute for Bioplastics and biocomposites and European Bioplastics, https://www.european-bioplastics.org/bioplastics/).

Bioplastics, primarily derived from carbohydrate-rich plants, are known as first-generation feedstock. First-generation feedstocks use crops and plants to produce bioplastics. This is, however, considered controversial due to ethical concerns about the potential competition with food resources. The second-generation feedstocks use various non-edible biowaste and are therefore a more sustainable conversion of local, non-food, renewable resources and biological waste into bio-based plastics.

Bio-based plastics are not by default more sustainable than fossil-based plastics, as sustainability is highly dependent on how the material is made, what additives have been added, where it is used and how it can be recycled. As the largest carbon footprint of plastics is associated with production, switching existing processes to a renewable energy supply could cut plastic-related emissions by 62% (Rosenboom *et al*., 2022). Further, not all bioplastics are biodegradable. Biodegradable plastic can be broken down completely into water, carbon dioxide and compost by microorganisms under the right conditions. However, biodegradable or compostable bioplastic often requires degradation processing under controlled conditions (i.e. at the industrial level) to be incorporated back into nature. Hence, biodegradable plastics often need to be handled by proper treatment facilities and disposal in the environment must never be an end-of-life option. Thus, biodegradable plastics generate the same pollution problems as those plastics derived from petroleum and also produce micro- and nano-plastics during their decomposition.

Breakdown of plastic

Most plastic types do not decompose. Instead, plastic items will break down over time into smaller and smaller particles through mechanical abrasion, hydrolysis or photo-degradation through UV from sunlight (Box 1.2). Fragmentation and weathering may proceed until the nanoscale (i.e., <0.000001 mm). Degradation rates are slow, especially under cold arctic or alpine temperatures. At the bottom of the sea, the breakdown of plastic will most likely happen more slowly due to cold temperatures and lack of sunlight. Half-lives range up to 1,200 years for tubes (Koelmans *et al*., 2022), meaning that it often takes hundreds to thousands of years for the plastic pieces to reach nanoscale (Table 1.2). This inevitably results in an accumulation of plastic pollution as more and more end up in the environment.

Size classes of plastic

Plastic pollution comes in many different sizes, and each size class has different environmental effects. Here, we describe particle sizes used by the Arctic Monitoring and Assessment Program (a Working Group under the Arctic Council), i.e. macro-, micro- and nanoparticles (AMAP, 2021b).

Macroplastic is generally defined as plastic items larger than 5 mm, e.g. bottles, bags, straws, string, rope pieces, fishing net, shotgun shells, buckets or pieces thereof. It can impact individual animals through, for example, entanglement, ingestion (blocking throat or accumulating in the stomach) and suffocation (blocking airways).

Box 1.2 Plastic degradation processes

Mechanical abrasion:
A tactile process of scuffing, scratching, wearing down, marring or rubbing.

Hydrolysis:
Any chemical reaction in which a molecule of water breaks one or more chemical bonds.

Photodegradation:
Degradation of a photodegradable molecule caused by the absorption of photons, particularly those with wavelengths found in sunlight, such as infrared radiation, visible and ultraviolet light.

Biodegradation:
Process by which microorganisms break down organic matter.

Beach litter collected in Svalbard. Photo: Maria Granberg.

Table 1.2: Decomposition time of selected plastic products (Villegas, 2018).

Kind of Plastic	Decomposition Time
Fishing Line	ca. 600 years
Plastic bottles	ca. 500 years
Plastic cutlery	ca. 400 years
Lighter	ca. 100 years
Plastic glasses	70-80 years
Plastic bag	ca. 60 years
Shoe sole	10-20 years
Cigarette butt	5-10 years
Balloon	ca. 2 years

Many researchers use plastic bags for sampling, as they prevent samples from drying out while being transported and stored. Photo: Western Arctic Research Centre.

Macroplastic waste further has a significant economic implication for a range of marine industries, for example aquaculture, fisheries, harbours, industrial seawater users, marinas, municipalities, power stations, rescue services, shipping and water authorities. These include costs related to cleaning, blockages, entanglement, contamination etc. Marine litter can also be a possible vector for the transfer of alien species such as bryozoans, barnacles and polychaete worms. Further, litter might lead to loss of aesthetic value and reduced recreational opportunities.

Microplastics are generally defined as less than 5 mm and come in different shapes, e.g. spheres, fragments, granules, pellets, flakes, beads, filaments and fibres. Microplastics in the environment are primarily a concern due to their small size, which means easy ingestion in marine life and food chains (see Chapter 2 on physiological effects).

Primary Microplastics are plastic pieces produced in sizes of less than 5 mm, e.g. nurdles (building blocks of most plastic products), cosmetic microbeads (used in lotion, hair products, toothpaste, etc.). Primary microplastics can also result from the abrasion of large plastic objects during manufacturing or maintenance. **Secondary Microplastics** come from the degradation of larger plastic objects. The vast majority of microplastics come from the breakdown of larger plastic waste.

Nanoplastics are generally defined as being smaller than 1 µm, but the identification of nanoplastic particles is still challenged by technical detection capabilities. Under laboratory conditions, a plastic particle of 1 mm in diameter would require about 320 years to reach a nanoscale diameter of 100 nm, but in the environment, degradation can be assumed to be faster (Koelmans *et al*., 2022). The actual amount and characteristics of nanoplastic particles in the environment remain largely unknown (Koelmans *et al*., 2022 and references herein).

Handling of plastic waste

Ideally, plastic should never become waste, but should be part of a circular economy where plastics are reused or recycled (Davidson *et al*., 2021). Currently, however, around 40 % of plastic products end up as garbage after less than a month of utilization, and it is estimated that only 9 % of plastic waste has been recycled since 2015 (Geyer *et al*., 2017). The majority of the waste has been disposed of in landfills.

There are essentially three different fates for plastic waste (Geyer *et al*., 2017):

- It can be recycled or reprocessed into a secondary material. Contamination and the mixing of polymer types generate secondary plastics of lower technical and economic value.
- It can be incinerated.
- It can be discarded and either contained in a managed way in, for example, sanitary landfills or left uncontained in open dumps or in the natural environment.

Landfills are widely used for disposal of plastic waste and receive close to half of all global plastic waste. Photo: Maria Granberg.

Worldwide, the most common way for disposal of waste is in landfills (50 %) followed by incineration (19 %), i.e. burning plastic trash to create energy. 22% of waste escapes proper disposal, entering unregulated dumpsites, being incinerated in open pits or polluting terrestrial and aquatic environments, particularly in poorer nations (OECD, 2023b).

A landfill can, in theory, act as a carbon sink if there are no leakages. This will require that CO_2 and other greenhouse gases emitted from decomposition processes are captured. However, landfills often leak and litter disperses different compounds and chemicals to the environment. Plastic in landfills is further lost from the value chain in a circular economy and accordingly results in continued extraction of fossil fuels for production of new plastic.

Burning plastic removes it from the value chain and can potentially produce harmful pollutants like dioxins, metal compounds and greenhouse gases. Thus, incineration should take place in proper treatment plants that remove harmful substances from emissions. Furthermore, there is a concern that the high investment cost for the larger incineration plants leads to a constant need for a waste influx that may jeopardize the adoption of recycling technologies, a so-called 'locking-in' effect (Rosenboom *et al*., 2022).

One of the biggest barriers towards plastic recycling is the separation into similar types of plastic and plastics with the same additives. When different polymers are mixed, the resulting material often does not have useful properties. Plastic and bioplastic recycling is, as such, generally complicated by the presence of additives in almost every finished plastic product.

It is possible to recycle plastic back into oil and then into other useful products like fuel (or other types of plastic). The main problem is that this process requires a lot of energy. It should not take more energy to recycle plastic than what is saved by recycling it.

Biodegradable/bio-based plastics are considered to be plastic under the EU's Single Use Plastic Directive (https://eur-lex.europa.eu/eli/dir/2019/904/oj). In accordance with the EU standard EN 13432, a product is classified as compostable if it satisfies specific requirements, including the following criteria when subjected to industrial composting facility conditions (from www.bioplasticseurope.eu):

- At least 90 % biodegradation into CO_2 within 6 months.
- No more than 1 % additives, which must be harmless (i.e. non-toxic and without negative effects on plant growth).

In the challenging terrain of Greenland, waste handling poses unique difficulties. The majority ends up in landfills, accentuating the urgent need for sustainable waste management solutions. Photo: Lis Bach.

Macroplastics can be found on beaches and in the stomachs of animals even if they are far from densely populated areas. Photo: Lis Bach.

Plastic waste in the natural environment

Plastic pollution can end up in the arctic, alpine and boreal environments from far away via wet (ocean currents, rivers, rain) or dry (air) deposition, or by waste emissions by industry and humans (tourists, researchers, locals).

Surface circulation models and field data show that the poleward branch of the Thermohaline Circulation transfers floating debris (incl. plastic) from the North Atlantic Ocean to the Greenland Sea and the Barents Sea, which is then a dead end for the plastic waste. Given the limited sea current transport of plastic debris out of the region, the arctic is hypothesised as a sink for plastic pollution (Cózar *et al.*, 2017). Scientists believe that 80 % of the plastic in the aquatic environment ends at the bottom of oceans. In the arctic deep sea, microplastic concentrations range between 0 and 16,041 particles per kilo of sediment and are, as such, among the highest concentrations measured globally (Bergmann *et al.*, 2022).

Plastic pollution of terrestrial soils can be between 4 and 23 times higher than in the sea, depending on the environment. Especially sewage (domestic wastewater) is an important factor in the distribution of microplastics, where sewage sludge is applied as fertiliser on agricultural fields.

Waste and wastewater treatment is often lacking in the Arctic and other remote locations. In some arctic communities, the traditional waste management solution still in use is simply to dump the garbage in the sea, in rivers and/or in landfills, sometimes next to the sea (Cowan *et al.*, 2022). This means that plastic litter and microplastics produced in the Arctic often more easily reach the environment as compared to plastic litter and microplastics being discarded in parts of the World with more controlled waste management.

When we wash synthetic fabrics and clothing like polyester, fleece, or jackets in washing machines, the clothing sheds tiny plastic fibres. It is shown that microfibres from fleeces are the most commonly detected type of fragments in various water bodies (Mishra *et al.*, 2019).

Most of the primary microplastic waste (98 %) is generated from land-based activities. Textile fibres and particles from car tire abrasion are the two main sources of primary microplastics in the ocean. The main pathways of these plastics into the ocean are through road runoff (66 %), wastewater treatment systems (25 %) and wind transport (7 %) (iucn.org). The International Union for Conservation of Nature (IUCN) divides the global contribution of different primary sources of microplastics into the marine environment into seven categories (Boucher and Friot, 2017) (Box 1.3).

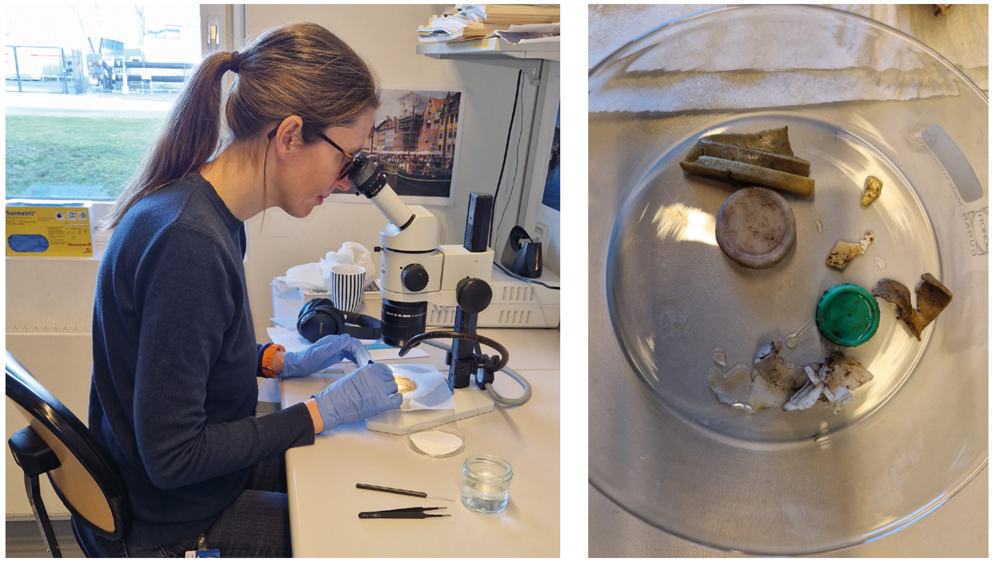
Box 1.3: Primary global microplastic sources according to IUCN

1. Synthetic textiles
2. Vehicle tires
3. Road markings
4. Personal care products and cosmetics
5. Plastic pellets
6. Marine coatings
7. City dust (a group of nine sources, including losses from the abrasion of objects and infrastructure and abrasive blasting of surfaces with sands sized particles)

As tires degrade over time, they shed tiny particles of synthetic rubber, contributing to the microplastics pollution in terrestrial and aquatic ecosystems. Photo: Marie Frost Arndal.

2 Environmental impacts of plastic

Photo: Colourbox.



Stomach contents of the Northern Fulmar serves as a biological indicator in monitoring of the prevalence and impact of plastic pollution in arctic marine ecosystems. Photo: Marie Frost Arndal.

Plastic is present all around the globe in all size classes. Micro- and nano-plastics are present in air, water, and ice. It is ingested by animals, including commercially important species of fish and shellfish eaten by humans. There is also evidence that micro- and nano-plastics can be found in the internal organs of humans (e.g. lungs, livers, spleens and kidneys). However, the environmental impacts and health risks associated with human consumption of plastic are not yet well-known (Koelmans *et al*., 2022). There is, however, substantial evidence that plastics-associated chemicals such as methyl mercury, plasticisers and flame retardants can enter the body and are linked to health concerns (UNEP, 2021c). Therefore, there is a clear need for an improved understanding of the effects of plastic pollution and vector borne chemicals on ecosystems, species and human health.

Physical effects

Some effects of plastic waste on the environment are obvious to see, while others are less visible. Wildlife and fish can get entangled in plastic (get stuck or suffocate), eat plastic that fills up or blocks their digestive systems or have their airways blocked or gills destroyed by plastic pieces. The visible impact caused by macroplastic on larger animals is well documented. As an example, the AMAP Plastic Monitoring Plan recommends Northern Fulmar (bird species, *Fulmarus glacialis*) as one of eleven plastic monitoring compartments (AMAP, 2021a).

On the other hand, very little is known about what micro- and nanoplastics can do to the smallest organisms in the oceans, such as zooplankton, fish larvae and clams. It has been suggested that smaller particles are potentially more hazardous if ingested, but it may also be that very small particles in the nano-size range may pass into and out of organisms with relative ease (SAPEA, 2019). Microplastics often pass through the digestive systems

Plastic pollution poses a threat to wildlife. Photo: Kresten Hansen.

of living organisms, and as with many chemicals 'the poison is in the dose' – meaning that it is the number (and size) of particles and the possible chemicals attached to the particles that pose a threat (SAPEA, 2019). Microplastics may also adhere to smaller organisms in the soil, restricting their movements and, hence, their ability to find food (Kim and An, 2019).

The microscopic sizes of micro- and nano-plastics mean that it is almost impossible to filtrate sea water without also impacting ocean organisms. More work is needed to understand the differential retention and effects of plastic particle sizes.

Chemical effects

The role of chemical adherence to or release from plastic particles is of particular concern in the Arctic because of the dependency of the people living there on subsistence harvesting of natural resources. Monitoring of chemical contaminants in the Arctic has been conducted for several decades by the Arctic Council through the Arctic Monitoring and Assessment Programme (AMAP).

It has been hypothesised that the release of chemicals from microplastics after particle ingestion increases exposure to these chemicals and, subsequently, results in chemical risks to biota (the so-called 'microplastic vector effect'). Newer studies suggest that this effect is unlikely to play a major role (Koelmans *et al*., 2022), because the concentrations of toxins at sea are very low (Flint *et al*., 2012). There may, however, be a need to evaluate the effects of plastic additives under arctic and alpine conditions, as the migration of chemicals (e.g. through leaching, adsorption/desorption) is slower in colder regions than elsewhere (Hamilton, 2023).

The effects of nanoplastics are even more uncertain than microplastics due to the lack of studies on their effect on the environment. Currently, limited data are available for nanoplastics in food, and toxicity data are lacking for both micro- and nanoplastics (EFSA, 2016). As the distribution and concentrations of nanoplastics in the environment remains largely unknown, we do not know enough about the role of nanoplastics in the total chemical risks posed by fragmenting microplastics (Koelmans *et al.*, 2015). Neither do we know much about the effects small plastic particles can have on humans.

Some chemicals in plastic, such as Bisphenol A (BPA) and phthalates, can have harmful effects on humans. Phthalates (a group of chemicals used to make plastics more durable and often called plasticizers) can easily leach out or evaporate, as they are not chemically bound in the materials they are added to. People are exposed to phthalates by handling or otherwise being in contact with items stored in such plastic types (e.g. eating and drinking food that has been in contact with products containing phthalates). Phthalates are frequently used in raincoats, sports clothing and even children's toys. It is scientifically shown that phthalates have harmful effects on the human body, including, for example, earlier onset of puberty, reduced male reproductive system development, impaired hormone system function as well as reproductive and genital defects (Mishra *et al.*, 2019).

Small plastic pieces extracted from the stomach of a Northern Fulmar, shedding light on the profound impact of plastic pollution. Photo: Jannie Linnebjerg.

BPA (Bisphenol A) is used primarily in the production of polycarbonate plastics and can damage female reproductive hormones. The BPA in food packaging materials is now regulated more strictly in many countries, for example in infant feeding bottles. The general 'background exposure' to BPA through, for example, other food and food packaging is 40 million times higher than from eating blue mussels that may contain microplastics (Rist *et al.*, 2018). This means that eating blue mussels with associated microplastics with BPA is completely insignificant compared to the exposure to BPA through other sources. What should be in focus here is our total exposure to plastics and microplastics in our everyday lives.

To fully understand the chemical effects of micro- and nanoplastics, we need an improved understanding of the chemical properties of different plastic types:

- Their distribution and concentration in the natural environment.
- The volatility of their chemical compounds.
- Their effects on ecosystems, species and humans (including their role in cumulative effects).

The Arctic Monitoring and Assessment Programme (AMAP) provides recommendations for monitoring of plastics and chemical additives, including persistent organic pollutants (POPs). AMAP is currently developing monitoring recommendations for emerging pollutants (new chemical compounds used in industry). Further standardisation of sampling and detection methods, health effect studies etc. are key to fully understanding the scale of impact of chemicals associated with micro- and nanoplastics.

Plastic and climate change

Since the modern plastic industry relies on fossil fuels as a raw material for transport, for manufacturing processes and recycling or treatment of plastic waste (incineration), the production of plastic has an impact on climate change, contributing to global CO_2 production. Currently, a total of 6 % of the global raw oil extraction is used for plastic production (World Economic Forum, 2016). This number does not include the oil that is used afterwards in transportation, processing, handling, etc. or the CO_2 emitted when the plastic is degraded. Furthermore, greenhouse gases, such as methane, ethylene, ethane and propylene, are released during the degradation of some common plastic polymers throughout their lifetime (Royer *et al.*, 2018).

Plastic might also have effects on climate that are not related to their production, use and removal. When darker particles (for example dark plastic particles) are deposited on snow and ice, they affect the ability of the snow and ice to reflect the sunlight, resulting in increased heat absorption that can/will be used for melting of snow and ice (Geilfus *et al.*, 2019) and thereby potentially contribute to the accelerating melt of glaciers in the Arctic. In the atmosphere, microplastic particles can serve as condensation nuclei for water vapour and thereby affect cloud formation and, hence, the climate.

3 International agreements and legislation

Photo: Marcos Porcires.

The plastic problem has been on the political agenda for some time and several international fora have launched initiatives to combat plastic pollution. Photo: Emily Cowan.

Numerous policy instruments currently address plastic pollution to varying extents, but significant challenges persist concerning enforcement, coordination, and the comprehensive consideration of plastics' complete life cycle impacts (Maes *et al.*, 2023). Various multi-level governance instruments have been introduced to regulate plastic pollution from both marine and terrestrial perspectives (UNEP, 2021), but policies are implemented inconsistently across regions, which is not sufficient when it comes to the transboundary nature of this pollution. These governance frameworks have been characterized as lacking specificity and comprehensiveness in addressing plastic pollution across its entire life cycle. The efficacy of these policies is contingent upon the commitment of governments, industries, and communities to their implementation and adherence. To reduce plastic pollution, international collaboration is needed to implement standardised policies (legislation and management practices) and long-term monitoring programmes (Linnebjerg *et al.*, 2021).

At the global level, in 2022, United Nations Member States endorsed a resolution to end plastic pollution and forge an international legally binding agreement by 2024 (UNEP/EA.5/Res.14). The resolution encompassed the full lifecycle of plastic, including its production, design and disposal. Negotiations regarding this matter have occurred in three out of five UN sessions thus far, with the final session anticipated to take place in December 2024. Notably, the treaty does not currently include specific provisions explicitly addressing the arctic environment. However, it is important to note that the treaty will accommodate the unique requirements of distinct ecosystems and economies, recognizing the absence of universally applicable approaches to mitigating plastic pollution (UNEP, 2023).

At the regional level, the AMAP Regional Action Plan on Marine Litter (2021) will enable the Arctic Council to take targeted and collective action to address problems with marine litter in the Arctic. The overall objective of the Regional Action Plan is to 'support the efforts of Arctic States to reduce marine litter in the arctic marine environment, prevent the potential negative impacts and mitigate the risks it may pose, and to improve cooperation on and awareness of this shared objective'. The plan is not legally binding and relies on national implementation of its actions, addressing activities both in the sea and on land by outlining strategic actions within eight thematic areas. Until the completion of the Arctic Council Regional Action Plan on Marine Litter, there is no pan-Arctic framework to address plastic pollution (Linnebjerg et al., 2021).

In January 2018, the European Union (EU) adopted a European strategy for plastics aiming to reduce marine litter. Since 2020 it has been part of the EU's circular economy action plan (CEAP), which builds on existing measures to reduce plastic waste. The 'Directive on the reduction of the impact of certain plastic products on the environment', commonly referred to as the Single-Use Plastics (SUP) Directive, entered into force in 2021. It aims to tackle pollution from single-use plastic items (straws, cutlery, plates etc.) as the items most commonly found on European beaches. Moreover, since 2022, EU Member States have been obliged to report on fishing gear containing plastic on the market and on fishing gear recovered at sea.

The AMAP Regional Action Plan on Marine Litter aims to collectively reduce plastic pollution in the Arctic, by fostering cooperation and awareness among Arctic States. Photo: Marie Frost Arndal.

The EU's circular economy action plan aims to make sustainable products the norm in the EU and ensure less waste. A central initiative of the plan is also to improve the science on the distribution of microplastics in the environment, tap water and food as well as on how to reduce their environmental pollution and potential health risks. The EU also seeks to tighten rules on pollutants other than carbon dioxide (CO_2) from vehicles (through the so-called Euro 7 emission standards) that will set additional limits for particulate emissions from brakes and microplastic emissions from tyres.

There are also 'soft law' or non-legally binding regulations that influence the governance of plastic pollution. Some business sectors work to reduce their use and disposal of plastics. The tourism industry is contributing a large amount of plastic waste to our environment. The Global Tourism Plastics Initiative aims to reduce this plastic pollution through an agreement to be developed by 2025. Their commitments include the elimination of unnecessary single-use plastics, transition to reuse models and use of reusable, recyclable or compostable plastic packaging and items. The Association of Arctic Expedition Cruise Operators (AECO) is working to combat marine plastic pollution by sharing best practices and lists of alternative products with its operators.

Table 3.1: International instruments related to plastic pollution and their main gaps. Improved from Cowan and Tiller, 2021. List is not exhaustive, the major global instruments are highlighted.

International Instrument	How it addresses plastic	Main regulatory gaps
United Nations Convention on the Law of the Sea (UNCLOS)	No specific legally binding obligation to address marine plastic pollution as its prime focus is broader in nature (see Pollution Prevention article 194; Environmental Impact Assessment Article 206; Marine Scientific Research Part XIII; Marine Pollution Regulations; and Liability and Compensation for Pollution Damage Article 235).	Fails to address accountability and penalties.
Annex V of MARPOL 73/78	Only marine based waste is addressed, not specific for plastics. (e.g., Discharge Restrictions; Special Area Designation; Exceptional Circumstances; Placards and Procedures; and Record-keeping).	Lack of enforcement and monitoring capabilities.
London Convention / London Protocol (LC/LP)	Indirectly addresses marine pollution but does not specially target plastic pollution.	Plastic pollution requires more specific and international comprehensive efforts.
Basel Convention (including 2019 plastics amendments)	Enhances the control and prevention of disposal and dumping of plastic waste (e.g., Prior and Informed Consent (PIC) Procedure, Legal Framework for Plastic Waste Trade, Enhanced Reporting and Monitoring). Amendments encourage parties to build capacity.	Only one aspect of the plastic pollution problem (waste trade), production and consumption are not addressed.
Stockholm Convention	Covers certain toxic additives and its related chemicals commonly found in plastic products (e.g. lists several chemicals used in plastics, maps environmental impacts, and investigates negative effects of pollution).	Does not specifically target plastics and only addresses' elimination and restriction of certain chemicals.
United Nations Framework Convention on Climate Change (UNFCCC)	The UNFCCC and its related agreements, such as the Paris Agreement, address the reduction of greenhouse gas emissions, including those related to the production, incineration and distribution of plastic items, which can contribute to climate change.	Only has the ability to focus on emissions across parts of the plastics life-cycle.
Biodiversity Beyond National Jurisdiction Treaty (BBNJ)	Recognises the problem of plastic pollution based on its impacts on marine ecosystems and includes provisions that indirectly address plastic pollution (e.g., Environmental Impact Assessments, Area-based Management Tools, Cross-cutting Issues, Capacity Building and Technology Transfer).	Focuses on marine diversity and management – more comprehensive approach is required to adequately address plastics.
Convention on Biological Diversity (CBD)	Primary focus is on biodiversity, however, indirectly addresses plastics within the unsuccessful Aichi Biodiversity Targets (T14), Cartagena Protocol, Global Biodiversity Outlook Report which includes considerations related to environmental risks of certain technologies that could contribute to plastic pollution.	Need for more specific targeted agreements when it comes to plastics.

4 Guidelines for research station managers

Toolik Field Station, Alaska, USA. Photo: Syndonia Bret-Harte.

Plastics are used for many purposes at research stations. For example, plastic is present in research instruments, in laboratories, in containers for scientific samples, in packaging, in clothing and in vehicles. Plastic has many useful properties, including being lightweight, durable, easily cleaned/sterilized and inexpensive. However, some plastic products are made for single use (or short-term use), and some easily degrade or shed microfibres. Thus, despite the fact that plastic is sturdy and has long durability, large amounts of it end up in the environment as litter (macroscale to nanoscale) or as waste that needs proper treatment or disposal after only having been used for a very short time.

Reducing the use of plastic is the first step towards reducing plastic waste generation and pollution. For this, research stations need to consider (i) the durability of plastic products, (ii) reuse and recycling potentials, and (iii) alternative products in purchase policies. Secondly, research stations should develop plastic use policies and implement proper waste management systems to limit emissions to the environment. This includes implementing sorting procedures and proper disposal mechanisms with minimal impacts on the natural environment and human health. Furthermore, research stations should also consider monitoring plastic pollution and guiding the behaviour of staff, visiting scientists and the local communities they are situated in.

Research stations can work with plastics on several levels, for example (i) in their internal policies, (ii) through scientific monitoring of local environmental problems associated with plastics and (iii) by influencing human behaviour through education.

Waste bins designated for specific types of waste at Toolik Field Station play a crucial role in maintaining responsible disposal practices at the station. Photo: Marie Frost Arndal.

Reduce plastic use through purchase policy

An efficient way of minimising plastic use at research stations is to develop a purchase policy that can guide station management and staff in relation to buying plastic products or products containing plastics.

A purchase policy may prioritise:

- Sturdy and durable plastic products.
- Products with no harmful chemicals.
- Reusable or repurposed plastic products.
- Recyclable plastic products.
- Alternative products with no plastic, where possible.
- Re-use of products for the same or other purposes.
- Reuse of packaging materials (or return to supplier).

Influence staff and user behaviour

Staff, scientists and other visitors at research stations might need guidance/information to change their habits in relation to the use of plastic. To do this, research stations could consider:

- Establishing increased awareness of plastic pollution, for example through the distribution of this guidebook to relevant staff, scientists and other visitors.
- Developing rules and guidelines for staff, scientists and other visitors related to:
  - Allowed/prohibited use of certain products.
  - Expected behaviour in relation to the use, collection, sorting and disposal of plastic products.
- Offering certified environmental cleaning agents, toothpaste etc. not containing plastics and/or other environmental pollutants.

Establish proper waste and water discharge handling

Research stations should prioritise proper plastic waste handling by:

- Collecting, sorting and storing plastic waste in relevant fractions for reuse, recycling or disposal.
- Delivering recyclable and disposable plastic to a municipal treatment system (if these follow good environmental practices) or transport it to a proper treatment facility.
- Purchasing proper treatment equipment (e.g. an incinerator that burns at required high temperatures, i.e. > 850 °C), when on-site treatment is necessary.
- Installing filters on outlets to rivers, oceans etc. to collect microplastic.

Housing, cleaning and kitchen materials

Household utensils and consumables often include a lot of plastic. The following sections provide guidance on appropriate use and handling. It is crucial to establish a waste sorting system incorporating a dedicated bin for plastics and to ensure the proper disposal or recycling of waste.

Building materials and interiors

Building materials, interiors and utensils may all include plastics. This is not necessarily a problem. It all depends on the types of plastic and the degradation processes they are subjected to. The important thing is that the products are durable, sturdy, free of harmful chemicals, reusable and recyclable.

- Exposed building materials prone to degradation (e.g. from weather and sunlight) should, if possible, be durable and long-lasting non-plastic (and environmentally friendly) based materials.
- If using plastic products in the interior building design, prioritise plastic products and types that can be reused or recycled.
- Furniture, carpets etc. should preferably be made from natural fabrics (e.g. wool, cotton and sisal) to avoid accumulation of plastic particles in indoor air and house dust).
- Use plastic-free interior and exterior building paints.
- Remember that any construction work comes with huge amounts of packaging, producing huge amounts of garbage, including plastic. Therefore, carefully plan any construction work to be prepared for the handling of the unusually large amount of garbage, including plastics, during the normally quite hectic building or renovation phase.

Renovating Zackenberg Research Station in Northeast Greenland involves removing old paint with a 'razor' and a vacuum cleaner to ensure that the old paint is not spread into the environment. Photo: Torben R. Christensen.

Cleaning

Cleaning tools, cloths and detergents may be made of or contain plastics. While sturdy reusable tools may not degrade easily, the use of synthetic cloths, sponges and detergents containing plastics add microplastic to the wastewater.

- Buy durable plastic cleaning equipment that can be reused and recycled.
- Use reusable natural scrubbers instead of plastic scrubbers and synthetic sponges.
- Consider cleaning tablets instead of liquid soap, shampoo, bodywash and cleaning detergents – this helps decrease the amount of plastic containers used.
- Use detergents without plastic components.
- Use natural, reusable and washable cotton cloths or flannels for washing up and cleaning rather than disposable cleaning cloths or microfibre cloths.

Kitchen utensils

Kitchens include a wide variety of plastic products in relevant machinery, in kitchenware and as packaging of food.

- Use environmentally friendly alternatives to plastic where possible, e.g.:
  - Store food in glass, metal or sturdy reusable and recyclable plastic containers.
  - Use glass containers to microwave food.
  - Drink tap water out of a glass (where safe to do so).
  - Use matches instead of disposable plastic lighters or invest in a refillable metal lighter.
  - Use chopping boards made of wood or marble instead of plastic to avoid microplastic in the food when chopping vegetables etc.
- Avoid single-use plastics, e.g.:
  - Reduce takeaway cups of plastic or with plastic coating.
  - Avoid plastic cutlery – use metal or wooden cutlery.
  - Avoid using plastic bags.
  - Do not use plastic straws.
  - Avoid excessive food packaging in plastic.
  - Use reusable bags for shopping. Have some non-plastic bags or backpacks at the station that visitors can use to do their shopping.
  - Buy loose tea and use a tea egg or a teapot filter, as many tea bags contain plastic (many tea brands and supermarkets use a plastic called polypropylene to seal their tea bags).

5 Plastic use at research stations and in the field

Photo: Ruth Vingerhagen.

While stations can influence user behaviour through rules and guidelines, individual scientists can also take responsibility for minimising use of plastics and stopping emissions to the natural environment. Plastics are often part of science equipment, e.g. sampling boxes, jars, tubes, bags, wrapping, pegs, laboratory equipment, field equipment, etc., and personal items and care products.

INTERACT has developed the 8R principles for how to reduce consumption and minimize waste. These are intended for planning, use and end-of-use phases for research projects and activities at research stations and in the field (see Box 5.1).

This chapter includes inspirational recommendations related to:

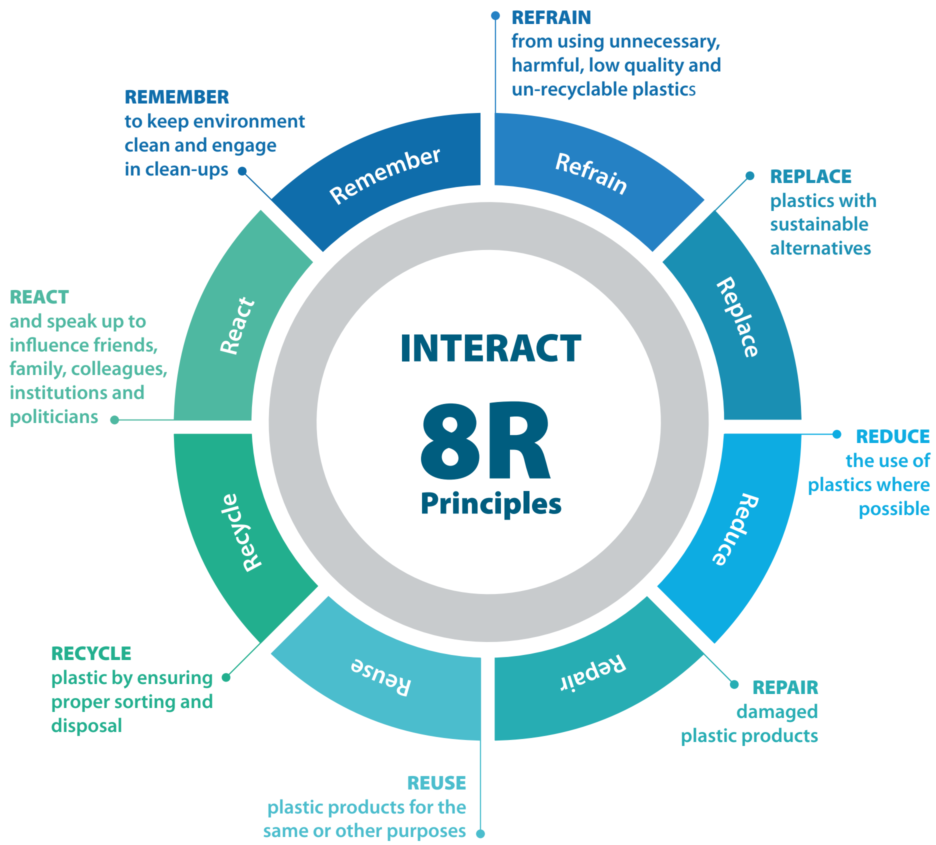
- Field work
- Clothes and washing
- Personal care products
- Laboratories

Plastic is used in many aspects of station management and field work potentially impacting the environment and the science unless proper use and waste handling systems are in place. CEN Salluit Research Station. Photo: Denis Sarrazin.

Box 5.1 INTERACT 8R Principles

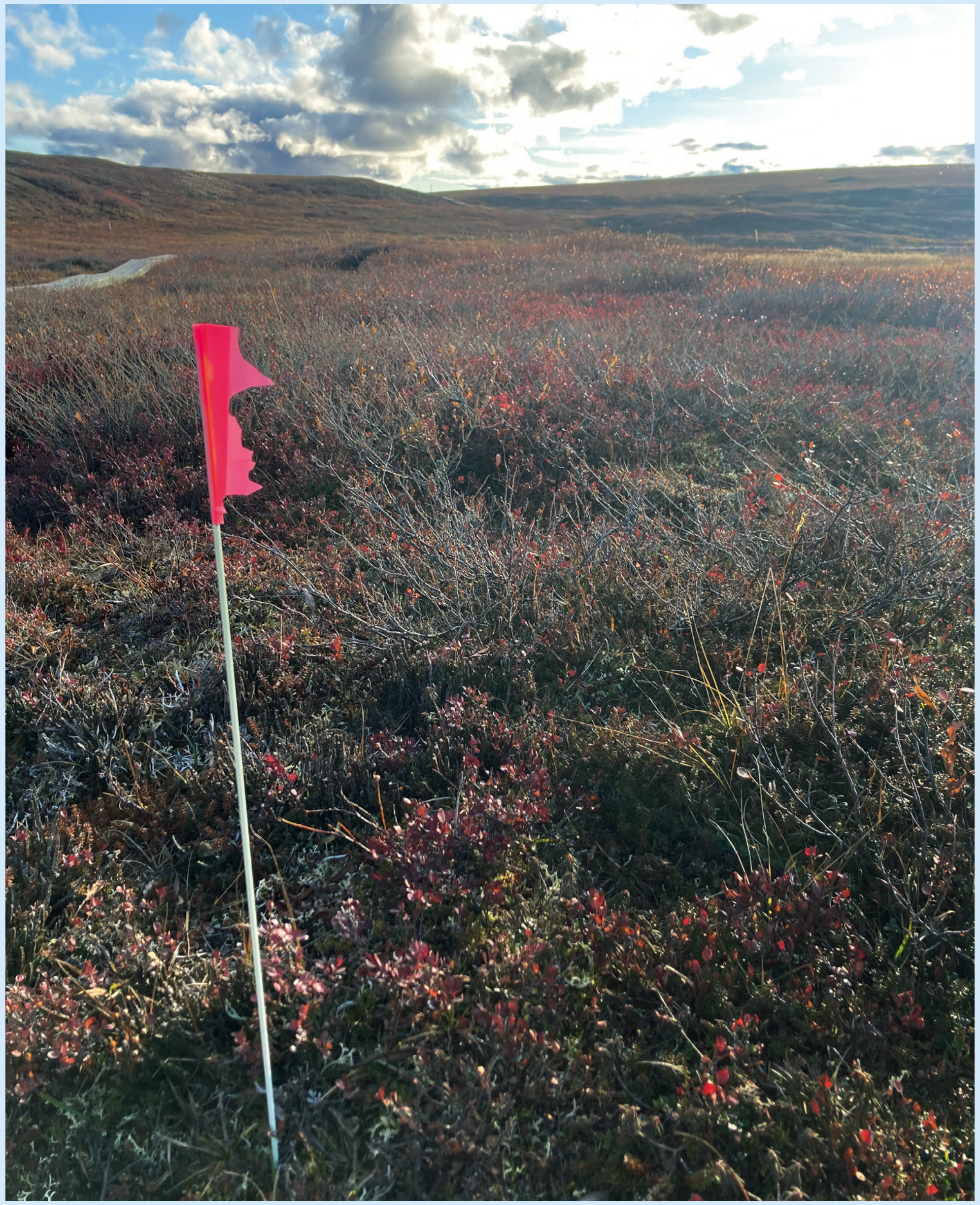
The 'INTERACT 8R Principles' for reducing plastic use and pollution:

- Refrain from using unnecessary, harmful, low quality and un-recyclable plastics.
- Replace plastics with sustainable alternatives.
- Reduce the use of plastics, where possible.
- Repair damaged plastic products.
- Reuse plastic products for the same or other purposes.
- Recycle plastic by ensuring proper sorting and disposal.
- React and speak up to influence friends, family, colleagues, institutions and politicians.
- Remember to keep the environment clean and engage in clean-ups.

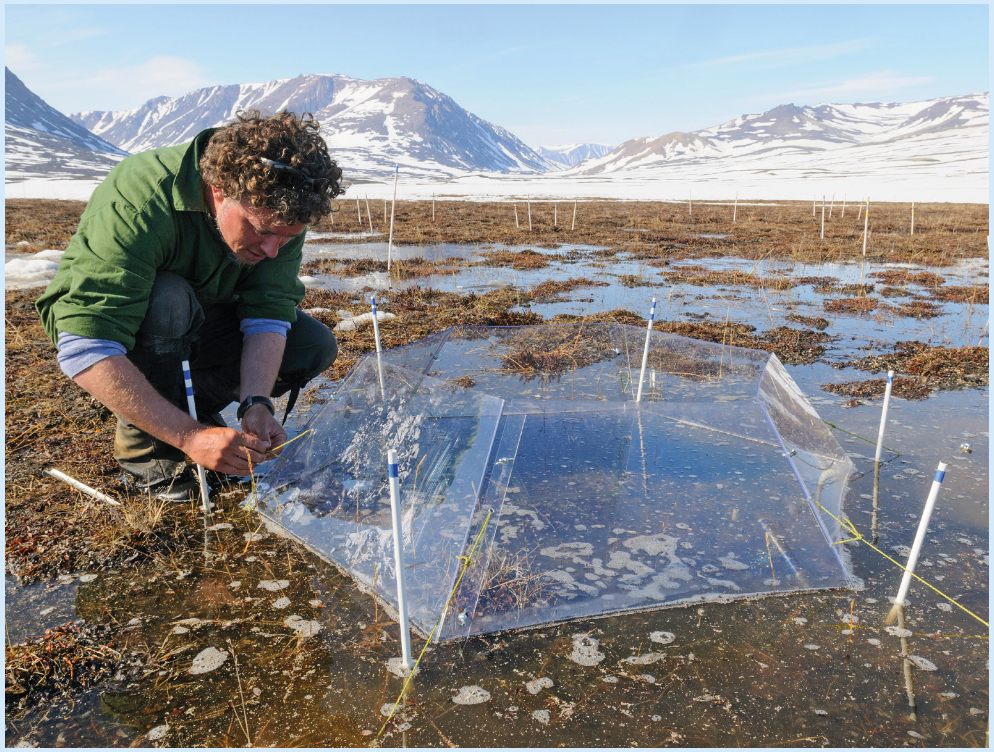


Field work

Make sure not to contribute to plastic pollution in the environment by using only sturdy, durable and recyclable plastic for your fieldwork. Plastic markers can easily be broken down or destroyed by the harsh weather in the Arctic or by curious animals – and then unintentionally lead to plastic pollution. Plastic pollution left behind by researchers will stay in the ecosystems for many years.



If plastic usage is necessary, prioritize robust, long-lasting, and eco-friendly materials that do not degrade or spread into the environment. Photo: Elmer Topp-Jørgensen.



Plastic chambers used in standard ITEX experiments, Zackenberg Research Station, Greenland. Photo: Lars Holst Hansen.

Recommendations for field work

- Do not litter.
- Pick up the trash that you find in the environment.
- Bring a refillable water bottle to avoid single-use bottles.
- Bring a lunch box and food paper/beeswax cloth, instead of packing food in plastic bags, foil or food wrap/cling wrap.
- Replace plastic bags used for sample collection with paper bags if possible.
- If the use of plastic is needed, prioritise sturdy, durable and environmentally friendly plastic that does not deteriorate and/or spread to the environment.
- When possible, consider alternatives to plastic, for example metal or wood sticks and pegs for plot identification.
- Duct tape will not last in the field during the arctic winter! Do not leave it in the field for longer periods and bring it back for proper sorting.
- When using plastic in the field, make sure that it does not blow away during a storm or spread to the environment.
- Repack laboratory or field equipment before sending it to a research station - to avoid excess plastic (and cardboard) packaging at the station.

Clothes and washing

Much of our modern winter clothes for use in the Arctic are made from artificial fibres like fleece. Fleece is commonly made of polyester, and polyester is a synthetic fabric releasing microplastics. These synthetic fabrics provide numerous benefits, i.e. they are lightweight, quick-drying, highly insulating and remarkably resistant to wear. But those benefits come at a cost to the natural environment.

More than one-third of the microplastics in the ocean originate from synthetic clothing. A recent study (Ross *et al.*, 2021) found that 73 % of synthetic fibres found in the Arctic were polyester. The most likely origin of this released polyester is laundry. The powerful currents and winds out on the open sea make it difficult for even advanced technology to clean it, once it is in the aquatic environment.

Clothes pollute more the first few times we wash them, so consider buying less new clothing and keeping your old clothing for as long as possible. Never buy very cheap fleece products, as their fibres are extra vulnerable. Garments of a higher quality shed less in the wash than low-quality synthetic products, illustrating the importance for manufacturers and consumers alike to invest in gear built to last.

Studies show that synthetic jackets laundered in top-load washing machines shed approximately seven times as many microfibres as the same jacket in front-load washers.

Putting your synthetic clothing into a filter bag before washing by hand or machine can significantly reduce the flow of microfibres into your drain. Several types of laundry filter devices have been developed, including some that are built into the washing machine, some that can be retrofitted into older machines and devices that are placed in the drum of the machine during the laundry cycle.

Air drying clothes where possible not only saves energy but also promotes sustainability, especially when using wooden clothespins. Photo: Marie Frost Arndal.

Recommendations

Plastic fibres from fleece materials is a source of plastic contamination at research stations and in the field. Photo: Celine Madsen.

Box 5.2 Recommendations for clothes and washing:

- Buy natural fabrics (wool, cotton, silk, linen, cashmere) or environmentally certified clothing.
- Remove single stains on the fleece by hand instead of using a washing machine.
- Use a front-loaded washing machine equipped with filters or use a microplastic washing bag when washing synthetic materials (e.g. acrylic, nylon and polyester).
- Fill up your washing machine – a full load results in less friction between the clothes and less fibres will be released.
- Use washing liquid instead of powder – the powder will through the 'scrub' function loosen the fibres of the clothes.
- Wash at lower temperatures – some fabrics will be damaged in high temperatures and result in looser fibres.
- Avoid long washing cycles that will cause more friction of the clothes and more fibres released. Dry spin at low speed to decrease the friction of clothes.
- Air dry clothes where possible (which also saves energy) and use wooden clothespins.
- Consider donating old fleeces as well as other old clothing, if in good quality. If you donate your old fleece, you prevent others from buying new ones.

Personal care products

Losses from personal care products are the only losses that can be considered intentional losses, where the product containing microplastics is poured into wastewater on purpose. This could be in products like facial and body scrubs, sunscreen, lotion or toothpaste. An IUCN report estimates that personal care products make up 2 % of total primary microplastics entering the global marine environment (Boucher and Friot, 2017). Unfortunately, there do not appear to be widely accepted and naturally occurring alternatives for the polymers in personal care products and cosmetics performing functions, beyond exfoliation.

Several apps can help you scan products for plastic (for example 'Beat the microbead') where you can find out if your personal care products contain microplastics.

BEAT THE MICRO BEAD

Furthermore, female hygiene products like tampons, tampon applicators and pads are the fifth largest contributor to plastic pollution along the coastline of Europe (European Parliament, 2021, Snekkevik *et al.*, 2023). It is estimated that up to 45 billion disposable menstrual hygiene products are used and disposed of each year (Barth, 2021). The production of these products is estimated to account for approximately 245,000 tonnes of carbon dioxide emissions per year (Cabrera and Garcia, 2019). An additional problem is that these products are not properly discarded, which may lead to sometimes costly problems in treatment plants.

Based on a meta-analysis from the United Nations Environment Program (UNEP, 2021a), it has been concluded that reusable menstrual cups had a significantly lower environmental impact than the disposable options. Other options include menstruation underwear and reusable/washable pads (Snekkevik *et al.*, 2023). Since one of the problems is incorrect disposal of hygiene products and other products, posters about proper disposal with a bit of background information on why this is important are advised.

Box 5.3 Recommendations on personal care products:

- Avoid using personal care products that contain microplastics.
- Do not throw plastic of any kind in toilets (water closets and bag toilets).
- Choose plastic-free chewing gum and never dispose chewing gum in the environment.
- Use plastic-free toothpaste or use toothpaste tablets.
- Use a razor with replaceable blades instead of a disposable razor.

Box 5.4 Cigarette butts and vape pens:

According to the World Health Organization (WHO), a minimum of 4.5 trillion cigarette filters, made mostly out of cellulose acetate (a plastic), are discarded every year and as such represent the most littering items. In addition, packaging waste from cigarette boxes accounts for two million tonnes of packaging waste (WHO, 2022). Cigarette filters contain microplastics and are the second-highest form of plastic pollution worldwide (by weight) and the top polluting items found in marine environments.

It is recommended to establish strict policies at research stations to discourage littering of cigarette butts and to advertise biodegradable filters.

There are many different brands of environmentally friendly personal care products. Select one with a trusted certificate before buying. Repack adequate amounts in reuseable containers. Photo: Josefine Lenz and Svenja Holste.

Laboratories are full of plastic products. Photo: Espen Aarnes.

Laboratories

Laboratories are high consumers of plastics (as well as energy and water). As responsible researchers working with some of the most vulnerable ecosystems on Earth (and for many of us with a research focus on climate change, other pollution and its related problems), we should cut back on disposable plastics as much as possible.

In 2015, a team at the University of Exeter did a back-of-the-envelope calculation to estimate how much plastic waste scientific laboratories generate in a year. The answer was over 5.5 million tons (Urbina *et al.*, 2015). Plastic products for use in laboratories are diverse, including pipet tips, gloves, weighing boats, tubes, flasks, reagent bottles, cuvettes, etc.

There are many ways to make laboratories more sustainable, to save resources and to certify them (Durgan *et al.*, 2023). Several standards for environmentally good practices for laboratories exist with guidelines and certification (for example ISO 14001). The Laboratory Efficiency Assessment Framework (LEAF) is a new independent standard for good environmental practice in laboratories (from 2018). LEAF recommends ways in which laboratory users can reduce waste, and save plastics, water, energy and other resources.

Box 5.5 Recommendations for laboratories:

- Where contamination is less of an issue, consider reusing items, for example weighing boats, petri dishes, dispensers and gloves when possible.
- Reuse plastic tubes following chemical decontamination and autoclaving.
- Use alternatives to plastics where possible or prioritise recyclable plastics, for example:
  - Replace plastic pots with compostable paperboard pots, where possible.
  - Use natural rubber gloves.
  - Use pipette tips that can be washed before reuse.
  - Use glass centrifuge tubes instead of those made of plastic.
  - Use glass syringes instead of the plastic versions.
  - Replace plastic petri dishes for cell culture with glass ones.
- Use sustainable materials such as reusable wooden sticks for patch plating and metal loops for inoculation.
- Store and reuse packaging material like styrofoam boxes (good for shipping of material that needs to be cooled) and packaging material like styrofoam chips, bubble wrap and air cushions.

(Adapted from Kilcoyne *et al.*, 2022)

Some of the above recommendations come with an extra cost. For instance, the costs of using glass dishes for cell culture are around 30 times higher than using plastic petri dishes (Urbina *et al.*, 2015). However, other developments, e.g. lighter and more compact petri dishes that save plastic waste, may offer alternatives, where the switch to glass petri dishes is not feasible (Réu *et al.*, 2019).

Reduce

- Switch to glass containers and tools, where possible.
- Buy in bulk to avoid excess packaging.
- Downsize the plastic containers you use.

Reuse

- Send packaging back to be reused.
- Use leftover containers for something else.
- Wash and reuse what is considered "single use".

Recycle

- Find suppliers that recycle lab plastics, including gloves.
- Decontaminate used plastics so they can be recycled.

Solar panels installed as part of a green transition at Zackenberg Research Station, Greenland. Photo: Torben R. Christensen.

Green transition funding

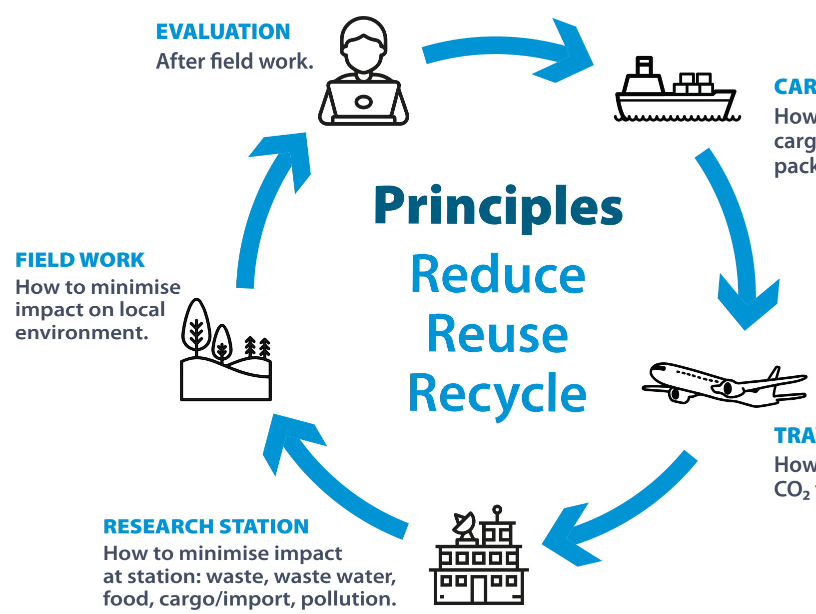
Extra external funding may be required to pay for e.g. more sustainable laboratory equipment. Grant agencies should therefore be encouraged to introduce incentives to reduce plastic waste. This could include funding for new laboratory washing-up and recycling facilities and supporting higher laboratory costs due to transition to sustainable laboratory equipment instead of the current single-use plastic items. A way of facilitating such a transition is to speak out, either to the leadership of your university or directly to the funding agencies.

A transition to a more sustainable run will always require the support of the employees at the research station, the hosting university/research institute, the visiting scientists and the relevant funding agencies. A good way to start could be to distribute this guidebook or relevant sections from it to the relevant stakeholders. A good overview of how scientific institutions can become more sustainable is also given by Durgan *et al.* (2023).

Find more detailed guidelines on how to minimise climate and environmental impacts in:

- INTERACT Reducing the Environmental Impact of Arctic Fieldwork
- INTERACT Reducing CO_2 Emissions from Arctic Science

Box 5.6 Project phases where environmental impacts should be minimised.



Recommendations

6 Monitoring plastic use, waste generation and pollution

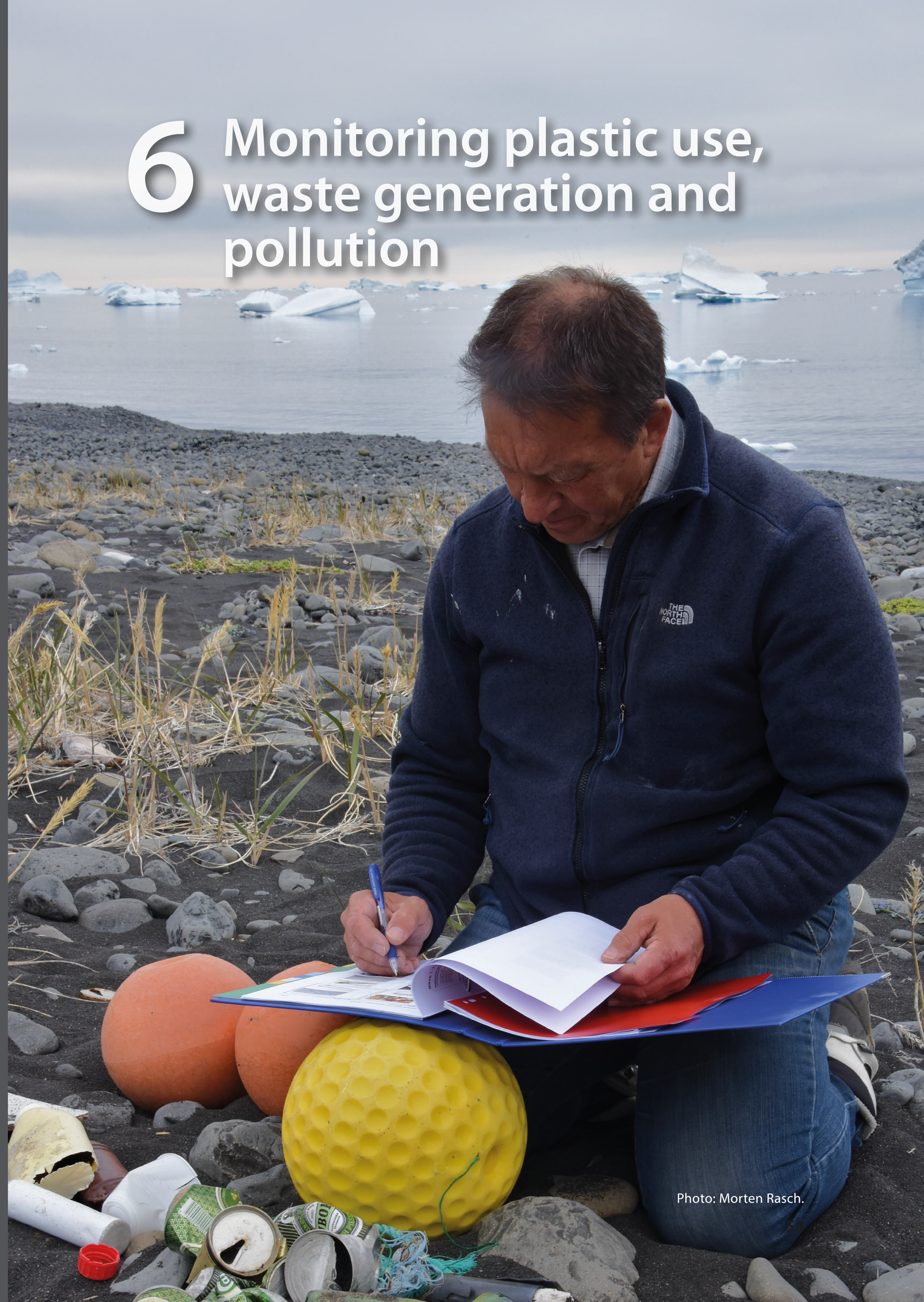


Photo: Morten Rasch.

Monitoring plastic consumption, waste generation, and emissions to the natural environment is essential for improving research station procedures and guidelines to minimise the impacts of plastic use on the natural environment and the climate. Furthermore, research stations can play a significant role (i) in assessing general plastic pollution in their repective local areas, (ii) by working with local communities to increase awareness and (iii) by providing input to local decision-makers regarding the magnitude and trends of plastics in the natural environment.

Monitoring plastic use and waste generation at research stations

Elsewhere in this guidebook, we describe what research stations can do to minimise the use of plastic and reduce its emission to the natural environment. Monitoring of plastic use and plastic waste production is essential to assess whether implemented rules and guidelines are efficient. This, together with awareness of new environmentally friendly materials and technologies, will allow research stations to continually work to minimise plastic consumption and to improve its re-use and recycling options.

Below, we give some examples of how this could be done. However, it is important that you adapt the monitoring strategy of your research and/or research station to what is feasible at your station or in your research. It is more important to have a monitoring that can be continued (and keep focus on plastic use/disposal) than to develop a monitoring that will soon be considered too complicated to pursue in a busy work environment.

- Provide adequate waste management infrastructure with labelled recycling bins and disposal areas, facilitating easy separation of recyclables from general waste.
- Begin with an assessment of current plastic use and waste production at the research station or in research projects at the station.
- Identify sources, types and quantities of plastics being used.
- Establish a simple but effective data recording system to track monthly or quarterly plastic usage and waste production.
- Monitor how much is being reused, sorted for recycling or sorted for incineration/disposal.

Use the monitoring information to regularly assess where you can improve policies, rules, and guidelines to minimise the use and emissions of problematic plastics at the station or in your research. Implement training and awareness initiatives for both staff and researchers, emphasizing the significance of minimizing plastic usage and promoting proper waste disposal practices. Note that when it comes to sorting for recycling purposes, there may be specific requirements for what types of waste can be handled together and which need to be separated. There may also be requirements for how clean the plastic should be. Contact your waste handling/recycling plant to know what options are available to you.

Water sampling with a pump to detect microplastics in sea water in Svalbard. Photo: Maria Granberg.

Monitoring plastics in the environment

On a global scale, there is still much to be done to standardise/harmonise data collection and improve our knowledge of the distribution and effects of plastics in the natural environment. According to Balton *et al*. (2020), the scientific community should focus on:

Improve method development and standardisation

- Developing standardized protocols for consistent data colletion to track trends over time, promoting data sharing.
- Establishing baselines for progress measurement.
- Improving use of satellite imagery and Artificial Intelligence to assess where sea ice forms and how it moves, thereby providing information about where sea ice picks up microplastics.
- Exploring initiatives for remote sensing to detect large debris at sea and install sensors opportunistically on vessels for monitoring plastics in the water column.
- Enhancing collaboration between arctic communities and scientists for community-based monitoring of plastic pollution.

Improve temporal coverage (year round)

- Monitoring consistently throughout the year to address seasonal fluctuations.

Improve geographical coverage

- Improving data collection in specific Arctic Ocean regions, including the Central Arctic Ocean and the coastal areas in Siberia, Arctic Alaska and Canada.
- Increasing sampling of snow on ice floes to improve estimates of atmospheric transport of litter.
- Monitoring seafloor sediments to address the accumulation of plastics.

Specific knowledge gaps

- Identifying 'hotspots' with acute contamination to prioritize conservation efforts.

Plastic debris density has been identified as an indicator, including beach litter and microplastics (SDG 14.1.1.b), under the United Nations Sustainable Development Goal 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development). The United Nations Environmental Program (UNEP) is the unit responsible for monitoring this indicator on a global scale. UNEP has developed methods for monitoring key indicators, including methods that can be used by scientists and citizens alike (UNEP, 2021b).

In the arctic domain, Arctic Monitoring and Assessment Programme (AMAP) has published an ecosystem-scale litter and microplastics monitoring plan and associated monitoring guidelines (AMAP, 2021a and 2021b, Provencher *et al.*, 2023). The guidelines provide information on state-of-the-art approaches to monitoring plastics, based on information from, for example, UNEP, OSPAR and scientific publications. The focus is on monitoring the distribution of plastics in the environment and on documenting its origin through collaborative science efforts to enable robust plastic pollution assessments and management interventions on an arctic, national and local levels. The guidelines cover eleven compartments (of which the first four have high priority), i.e.:

1. Water column
2. Sediments
3. Beaches
4. Birds
5. Air
6. Seabed
7. Invertebrates
8. Fish
9. Mammals
10. Terrestrial soils
11. Ice and snow

Plastics in the environment are a current focus of scientific research. Despite progress in monitoring, a comprehensive understanding of its distribution and effects in the natural environment is still incomplete. Continued global efforts are needed to build a global monitoring programme and align monitoring methods or harmonize data – but we already know enough to say that the problem needs to be addressed now by individuals, communities, industries and societies all over the World.

Co-production of knowledge, Citizen Science and Community-Based Monitoring

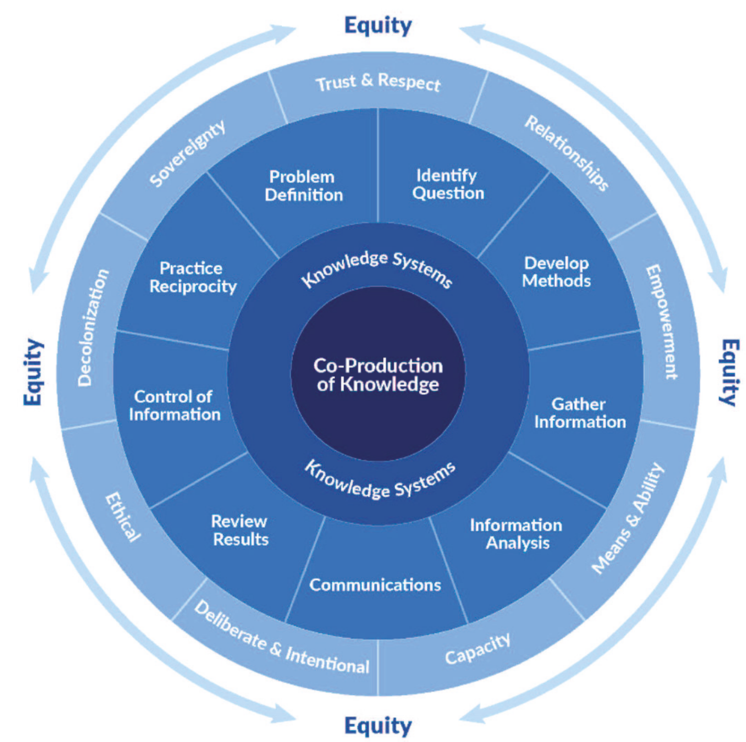
Successfully addressing plastic pollution demands actions at the individual, societal and decision-maker levels. Key to this effort is information sharing, with monitoring programmes playing a dual role in documenting pollution levels and increasing awareness among the public and decision-makers at various scales.

Here involvement of local people may have an important role to play, both to increase the geographical coverage of monitoring efforts and to raise awareness and thereby empower people to act. Engaging local communities offers the advantage of generating data from multiple sites by the local people, facilitating a swift response from observation to decisions mitigating the problem.

Co-production of Knowledge is a broad term used to describe collaborations between scientists and Indigenous and local knowledge holders. True co-production of knowledge aims at equal involvement of science and local community stakeholders in all phases of a project – e.g. developing the idea, identifying key research questions, identifying methods, analyses and discussion of results, drawing up conclusions and recommendations, and dissemination to relevant target groups.

In real life, projects span a spectrum of involvement, from mostly community driven (Community-Based Monitoring) to mostly scientist driven and with varying involvement in the different phases (Citizen Science). When working with local communities it is important to be conscious about equity and ethical engagement issues (e.g. Inuit Circumpolar Council's Circumpolar Inuit Protocols for Equity and Ethical Engagement (Inuit Circumpolar Council, 2022 and Ellam Yua *et al.*, 2022), see Box 6.1).

Box 6.1: A framework for co-production of knowledge.



(Developed by Inuit Circumpolar Council (ICC) (Ellam Yua *et al.*, 2022).

Box 6.2: Clean-up events

Clean-up events are initiatives for local involvement that has become popular all over the World to engage local people in collecting plastics. These efforts boost local awareness and might contribute with locally relevant information for decision-making processes. https://csr.gl/ka/2021/03/04/saligaatsoq-2021-imut-peqataagitsi/

Participation of local communities in research projects can be voluntary and based on the individual's interest in contributing to a specific project or it can be paid work. Unless there is a direct benefit (or keen interest) for locals to engage in co-production of knowledge efforts, it is appropriate and advisable to pay locals for the time they spend on the project. This is especially important in small remote communities with few alternative income opportunities - you can and should not expect that local people can work for free.

'Research fatigue' is a growing problem in small communities in the Arctic. It describes the situations where indigenous and local people are used as volunteers (e.g. either to collect data or share their knowledge) by an increasing number of scientists who wants to interact. This takes away time for livelihood activities and may lead to 'research fatigue'. Compensations for local time and service is only fair and will help prevent fatigue and may also help set a certain standard for the work being done.

Securing enough funding to allow equal engagement processes can therefore be a crucial aspect for many collaborative initiatives and it is important to communicate this need to funding agencies and decision makers. Such funding mechanisms are starting to appear, e.g. 'The Indigenous Fund for Community-Based Environmental Monitoring' established by the Government of Canada.

Plastic monitoring on the south coast of Disko Island in West Greenland carried out by local staff from Arctic Station, University of Copenhagen. Photo: Morten Rasch.

Citizen Science

Citizen Science is an activity involving the public in science activities. It is led by scientists with varying degrees of local involvment. Citizen Science has recently been explored as one way of engaging non-experts in plastic litter research while, at the same time, raising awareness and nurturing behavioural changes towards sustainability (Pierini *et al.*, 2021, Popa *et al.*, 2022). Citizen Science projects in the context of plastic pollution have spanned from marine plastic litter research (Zettler *et al*., 2017), research on plastic pollution in rivers and on streets (e.g. Forrest *et al*., 2019, Kiessling *et al*., 2019, 2021, Lynch, 2018, Rech *et al.*, 2015), evaluation of household waste and recycling (e.g. Kala *et al.*, 2021, Pierini *et al.*, 2021) and littering (e.g. Nelms *et al.*, 2022).

In a recent literature review, it became apparent that there are three major plastic research areas in which citizen scientists have collaborated with researchers (Popa *et al.*, 2022), i.e.:

- Litter distribution, including density and types.
- Recycling of litter.
- Plastic management practices.

However, there is a clear lack of standardisation regarding data collection for quantification of plastic pollution in these studies (Nelms *et al*., 2022).

The most common citizen science projects that deal with plastic pollution are connected to clean-up initiatives (Nelms *et al.*, 2022). Due to the public's involvement in clean-up operations, participants may not necessarily have an interest in more detailed assessments, such as identifying plastic types or providing density estimates. As a result, such initiatives are good for establishing local awareness, but generally not so good for producing scientific data.

Collecting beach litter on Svalbard. Photo: Maria Granberg.

Students actively participate in the two annual beach clean-ups outside Nuuk in Greenland. Photo: Thomas Juul-Pedersen.

Other challenges (and some solutions) for Citizen Science projects targeting plastic pollution include:

Data quality: A common concern is the accuracy of data collected by non-experts, particularly younger participants like school children. However, studies have shown that school children conducted tasks with similar accuracy as untrained professionals (Castagneyrol *et al.*, 2020). Hence, data collected by school children can be valuable if researchers are involved in thorough training and data quality checks (Popa *et al.*, 2022).

Ease of data collection: Volunteers may feel overwhelmed if data collection is too complex. Recent technological advancements, such as mobile phone apps, can expedite this process by allowing direct submission of data to a database. This minimises the complications associated with hard copies and their transcription, which may introduce errors. Mobile phones also enable the inclusion of photographs taken simultaneously with data points for additional verification. However, the lack of internet connections in remote areas, such as the Arctic, could pose a challenge. Therefore, careful consideration is essential to determine the most effective approach for ensuring robust data collection.

Temporal consistency/loss of interest over time: Motivation of volunteers may decrease over time, and this may lead to discontinued data collection. Therefore, a strategy for continued communication and engagement needs to be developed. This can be in the form of financial compensation for local services or or non-monetary motivating activities (but remember it is appropriate and advisable to pay for local services). Motivating activities may include producing newsletters to the community, lotteries to distribute prices and local knowledge sharing events, exhibitions, joint publications, etc. Further, follow-up meetings in communities to update on the progress of the project(s) are important to maintain motivation.

The EU has produced a report on best practices in Citizen Science for environmental monitoring: https://data.consilium.europa.eu/doc/document/ST-9973-2020-INIT/en/pdf.

Community-Based Monitoring

Community-Based Monitoring (CBM) can be defined as "*a process whereby non-government organisations, community groups or individuals lead or participate in long-term monitoring of selected species, habitats or ecosystem processes with the ultimate goal of improving management of ecosystems and natural resources*" (Yarnell and Gayton, 2003). In an arctic context, these community-based monitoring projects will often include or be initiated by individuals, NGO's or local communities that live and work in the respective areas. They often possess valuable knowledge about the local area, for example on sources of plastic pollution and sinks for plastic pollution.

Numerous obstacles impede the advancement of community-based monitoring programmes. These challenges encompass insufficient funding, not enough support for the locals overseeing and managing the community-based monitoring programmes and inadequate training of community members in utilizing equipment and data collection methods. Additionally, issues related to data sharing and usage rights pose constraints on the sustained success of community-based monitoring initiatives (Mamun and Natcher, 2023).

Further information on Community-Based Monitoring and Citizen Science initiatives dealing with various aspects of plastic pollution can be found elsewhere (Locritani *et al.*, 2019, Sidorova and Virla, 2022, Walker 2022, Wichmann *et al.*, 2022).

In the arctic landscape, the presence of plastic waste underscores the ecological consequences of human activity in even the most remote regions. Photo: Jakob Strand.

7 Influencing local communities

Photo: Thomas Juul-Pedersen.

The INTERACT 8R principles (Refrain, Replace, Reduce, Repair, Reuse, Recycle, React, Remember) can be applied to the reduction of plastic waste in individual households and in local communities. This may be particularly relevant in the Arctic, where proper waste management systems are rare. With few options for proper treatment of plastic waste, engagement and information campaigns targeting local communities may be one way to raise awareness and motivate actions at individual and community levels.

Previous studies have found three main problems related to citizen awareness when it comes to plastic pollution:

1. **Litter blindness:** In several studies, it has been found that people tend to ignore plastic pollution unless it poses a direct threat to them or is perceived as a nuisance. This leads to an underestimation of the risks linked to plastic pollution. Many rural regions also lack proper plastic waste disposal facilities and, thus, plastic is often inefficiently burned (De Veer *et al.*, 2022, Kerber and Kramm, 2022).

2. **Lack of knowledge:** Unawareness of (i) how to sort and recycle different types of plastic, (ii) recycling symbols, (iii) how to avoid plastic pollution and (iv) reuse of plastics (Popa *et al.*, 2022).

3. **Underestimation of own contribution to plastic pollution:** It has been shown that citizens miscalculate the amount of plastic waste they generate and dispose of (Zikali *et al.*, 2022).

Beach clean-up around Nuuk, Greenland. The collected waste is identified and categorized according to an international protocol. Photo: Thomas Juul-Pedersen.

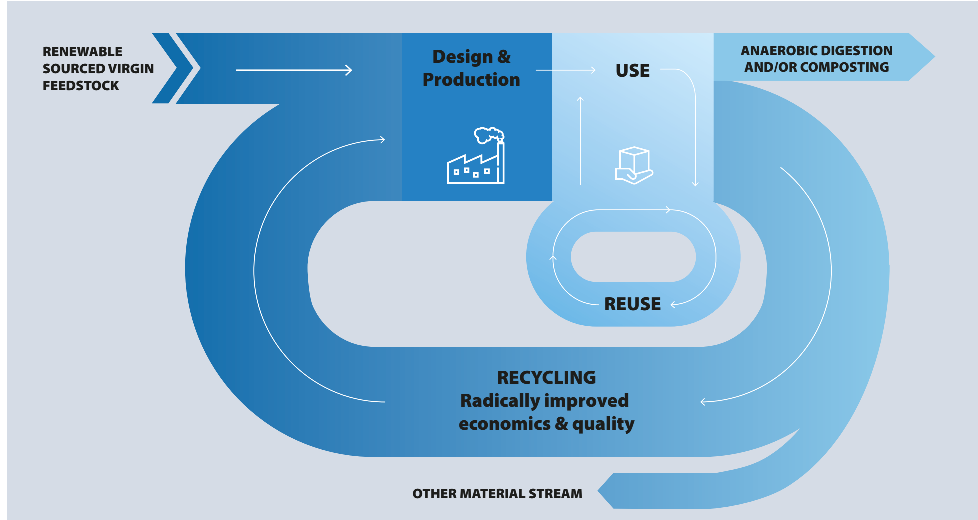


Figure 7.1: Striving for a circular plastic economy entails eliminating unnecessary packaging and promoting reuse models, ensuring all plastics are reusable, recyclable, or compostable, and free of hazardous chemicals (redrawn from https://ellenmacarthurfoundation.org/plastics-and-the-circular-economy-deep-dive).

Increasing awareness

There are several ways to increase awareness of plastic pollution in local communities. This could be done either by the local administration/municipality, by local citizens or by individual researchers or research stations.

Information sharing targeting specific audiences, e.g.:

- Posters/brochures on plastic pollution in community centres, malls, museums, churches etc. Inform about local/global problems or prepare citizens for clean-up days.
- Storytelling has been used to increase awareness about marine debris among school children (Praet *et al.*, 2023). It can probably also work for other audiences.
- Lectures or open station events aim to inform a targeted or general audience about local and global problems related to plastic.
- Use of social media such as Facebook and X (previously Twitter) can be an effective way to reach audiences at both local and global levels (Abreo *et al.*, 2019, Otero *et al.*, 2021).

Getting involved in Citizen Science or Community-Based Monitoring projects as well as clean-up programmes provides different ways for people to participate. Short-term clean-up programmes can work well for many rural communities. Ideally, local authorities should collaborate in these efforts to bridge citizen observations with decision-making processes. This teamwork can help create plastic management systems that fit the community, making people more likely to follow them. Also, working together to make simple guidelines and campaigns is important to reach more people. This approach helps bridge the gap between knowledge and decision-making, ensuring the implementation of effective actions.

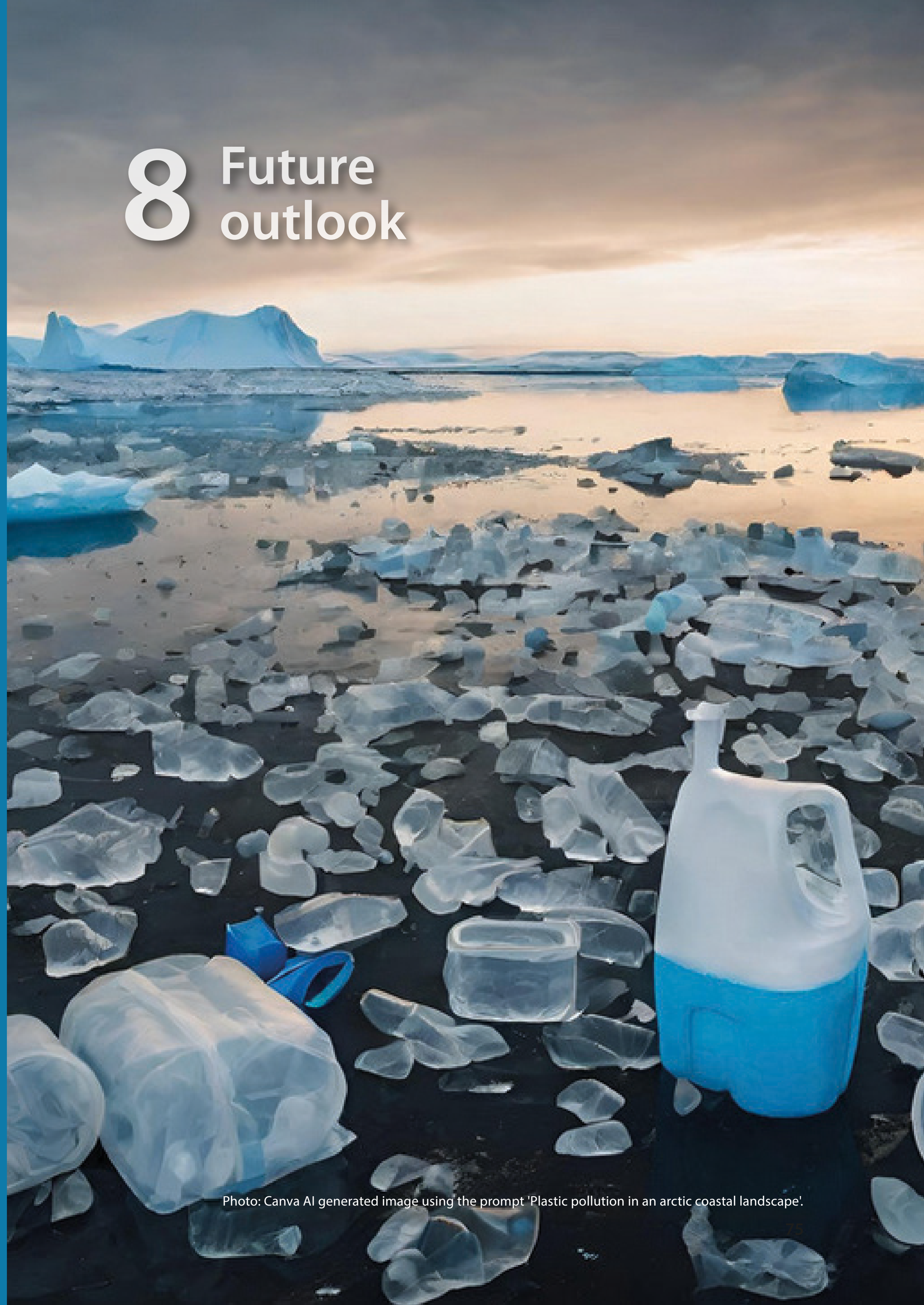


Photo: Canva AI generated image using the prompt 'Plastic pollution in an arctic coastal landscape'.

Plastic pollution knows no boundaries, reaching even the remote arctic landscapes. Let's take responsibility and reduce our plastic footprint for the sake of these vulnerable ecosystems. Photo: Marie Frost Arndal.

The world faces significant challenges with the anticipated increase in plastic production and resulting pollution. Rather than trying to remove all plastics, our focus should be on preventing their entry into the natural environment. Individuals must recognize their responsibility and influence those around them. The scientific community should act as role models by reducing their own consumption and waste while studying the impacts of the problem. Due to the size and ubiquity, there are currently no cost-efficient mechanisms to collect microplastic from the environment at a large scale once it has been introduced. Therefore, the most efficient way to mitigate microplastic pollution is to prevent microplastics from entering the environment in the first place and by targeting actions to reduce emissions at the source.

Some plastic types contain chemicals with known negative effects on the natural environment and human health, and there is also mounting evidence of the physical effects on wildlife. Our knowledge of the long-term effects of plastic particles found in the environment is less well understood. More research into sources, sinks and effects of different types of plastic is therefore needed.

When considering alternatives to plastics, it is important to consider the climate impacts and other environmental impacts of the entire lifecycle of the materials, i.e. extraction, production, transport, use, reuse, recycling, treatment, emissions to the natural environment and impacts on society, landscape, the environment and species. Finding alternatives to common items like plastic bottles and plastic packaging is becoming easier. However, unlike other eco-friendly initiatives, efforts to phase out plastics have not shown immediate financial benefits for many consumer companies. Plastic packaging is unlikely to

be substituted soon in various applications due to its advantages over alternatives like paper or glass. It is more plausible that adjustments will occur in plastic production, possibly involving a gradual rise in the use of recycled plastic.

Biodegradable plastics offer promising alternatives to traditional, persistent plastics, particularly in areas like packaging, single-use items, and agricultural plastic mulches. However, their effectiveness relies on appropriate disposal methods, with a crucial emphasis on avoiding environmental disposal, adherence to international standards for intrinsic biodegradability, and careful consideration of additives to prevent potential environmental hazards.

Examples of plastic substitutes include the replacement of microspheres and microfibres in building paint with either glass beads or cellulose-based microspheres or replacing microplastics used in industrial abrasives with coconut shells, dry ice, silicon or glass beads. Sustainable alternatives must be developed and used at a significant scale to decrease the production and waste of plastics because the increasing use of plastic based products also shows that there is a need for these types of products.

The biodegradation of synthetic plastics is a slow process, influenced by environmental factors and the activity of wild microbial species. The maturation of enzyme degradation technology will take a considerable amount of time. Relying on enzymes alone is unlikely to resolve the global plastics problem, given the overwhelming amount of plastic flooding the world marketplace each year. Instead, the ultimate goal should be to design plastic polymers with a chosen additive that is non-toxic and easily degradable. How to achieve this objective is one of the key questions that the plastic industry and the plastic-consuming world economy must address.

Contaminants are known to affect reproductive systems in marine mammals, including Beluga whales (*Delphinapterus leucas*). Photo: Churchill Northern Studies Centre.

Societies and industries should take responsibility for developing a legal framework to minimise plastics in the environment and reduce their health effects on humans and wildlife. Eliminating plastic waste depends, in part, on changing behaviour. Achieving this goal requires widespread systemic changes and a transition from a linear to a circular plastics economy, where plastic ideally circulates in 'closed-loop' systems, with products being reused, repurposed, recycled and recovered (Allison *et al*., 2022). In a circular economy, materials are designed for reuse and recycling rather than ending up in landfills or in the environment (Figure 7.1). Ideally, no materials are lost, and no toxins are leaked. All plastic items should ideally circulate to keep them in the economy, and efforts should be made to avoid any loss to the environment. To do this, involvement of societies, science, industry and individuals is needed, for example by following the INTERACT 8R principles:

Refrain, Replace, Reduce, Repair, Reuse, Recycle, React, Remember

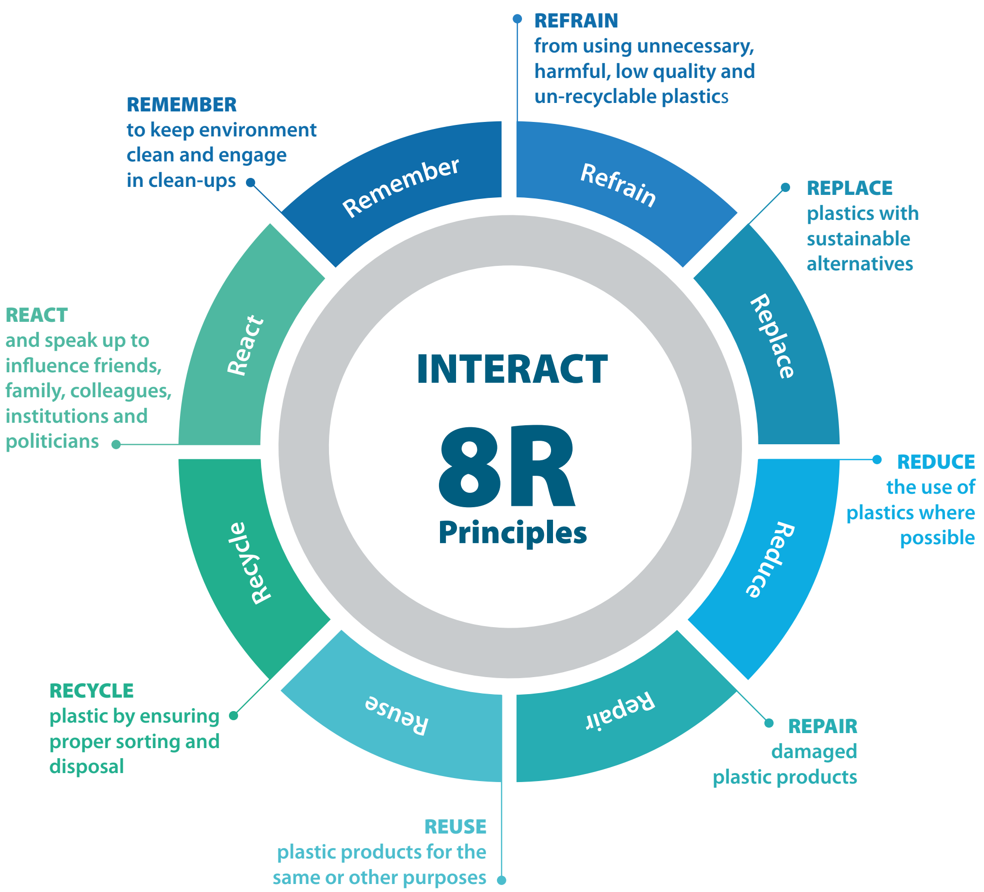


Photo: Marie Frost Arndal.

References

Abreo, N. A. S., *et al.* (2019).
Social Media as a Novel Source of Data on the Impact of Marine Litter on Megafauna: The Philippines as a Case Study. Marine Pollution Bulletin, vol. 140, Mar. 2019, pp. 51–59. https://doi.org/10.1016/j.marpolbul.2019.01.030

Allison, A. L., *et al.* (2022)
Reducing Plastic Waste: A Meta-Analysis of Influences on Behaviour and Interventions. Journal of Cleaner Production, vol. 380, Dec. 2022, p. 134860. https://doi.org/10.1016/j.jclepro.2022.134860

AMAP (2021a).
AMAP Litter and Microplastics Monitoring Plan. Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway, 23pp. https://www.amap.no/documents/download/6713/inline

AMAP (2021b).
AMAP Litter and Microplastics Monitoring Guidelines. Version 1.0. Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway, 257pp. https://www.amap.no/documents/download/6761/inline

Barth, T. (2021).
Making Menstruation Products Eco Friendly. Plastics Oceans International.
https://plasticoceans.org/making-menstruation-products-eco-friendly/

Benson, N. U., *et al.* (2021).
COVID Pollution: Impact of COVID-19 Pandemic on Global Plastic Waste Footprint. Heliyon, vol. 7, no. 2, Feb. 2021, p. e06343. https://doi.org/10.1016/j.heliyon.2021.e06343

Bergmann, M., *et al.* (2022).
Plastic Pollution in the Arctic. Nature Reviews Earth & Environment, vol. 3, no. 6, May 2022, pp. 420–420.
https://doi.org/10.1038/s43017-022-00305-9.

Bioplastics Europe. (N.D.).
What are "Bio-plastics"? – https://bioplasticseurope.eu/about *(accessed June 12, 2023)*

Balton, D., *et al.* (2020).
Policy and Action on Plastic in the Arctic Ocean: October 2019 Workshop Summary & Recommendations.
https://www.belfercenter.org/sites/default/files/2020-04/Plastic%20Pollution%20Case%20Studies.pdf
(accessed December 15, 2023)

Boucher, J., and Friot, D. (2017).
Primary Microplastics in the Oceans: A Global Evaluation of Sources. IUCN International Union for Conservation of Nature, 2017. https://doi.org/10.2305/IUCN.CH.2017.01.en.

Cabrera, A. and Garcia, R. (2019).
The Environmental & Economic Costs of Single-use Menstrual products, Baby Nappies & Wet Wipes: Investigating the impact of these single-use items across Europe. Available at: https://zerowasteeurope.eu/wp-content/uploads/2019/12/bffp_single_use_menstrual_products_baby_nappies_and_wet_wipes.pdf *(accessed December 2023).*

Castagneyrol, B., *et al.* (2020).
Can School Children Support Ecological Research? Lessons from the Oak Bodyguard Citizen Science Project. Citizen Science: Theory and Practice, vol. 5, no. 1, Mar. 2020, p. 10. https://doi.org/10.5334/cstp.267.

Cózar, A., *et al.* (2017).
The Arctic Ocean as a Dead End for Floating Plastics in the North Atlantic Branch of the Thermohaline Circulation. Science Advances, vol. 3, no. 4, Apr. 2017, p. e1600582. https://doi.org/10.1126/sciadv.1600582.

Cowan, E., *et al.* (2022).
Global Governance in Arctic Waters – New Times. New Stressors. Catching up with Pharmaceuticals. The Polar Journal, Aug. 2022, pp. 1–20. https://doi.org/10.1080/2154896X.2022.2096865.

Davidson, M. G., *et al.* (2021).
Developments in the Life Cycle Assessment of Chemical Recycling of Plastic Waste – A Review. Journal of Cleaner Production, vol. 293, Apr. 2021, p. 126163. https://doi.org/10.1016/j.jclepro.2021.126163.

De Veer, D., *et al.* (2022).
How Do Schoolchildren Perceive Litter? Overlooked in Urban but Not in Natural Environments. Journal of Environmental Psychology, vol. 81, June 2022, p. 101781. https://doi.org/10.1016/j.jenvp.2022.101781.

Durgan, J., *et al.* (2023).
Green Labs: A Guide to Developing Sustainable Science in Your Organization. Immunology & Cell Biology, vol. 101, no. 4, Apr. 2023, pp. 289–301. https://doi.org/10.1111/imcb.12624.

EFSA Panel on Contaminants in the Food Chain (CONTAM) (2016).
Presence of Microplastics and Nanoplastics in Food, with Particular Focus on Seafood. EFSA Journal, vol. 14, no. 6, June 2016. https://doi.org/10.2903/j.efsa.2016.4501.

Ellam Yua, *et al.* (2022).
A framework for co-production of knowledge in the context of Arctic research. Ecology and Society vol. 27, no. 1, pp. 34.
https://doi.org/10.5751/ES-12960-270134

Eriksen, M., *et al.* (2020).
Mitigation Strategies to Reverse the Rising Trend of Plastics in Polar Regions. Environment International, vol. 139, June 2020, p. 105704. https://doi.org/10.1016/j.envint.2020.105704.

European Parliament (2021).
Plastic in the ocean: the facts, effects and new EU rules. Parliament https://www.europarl.europa.eu/news/en/headlines/society/20181005STO15110/plastic-in-the-ocean-the-facts-effects-and-new-eu-rules *(accessed 18 December 2023).*

Flint, S., *et al.* (2012).
Bisphenol A Exposure, Effects, and Policy: A Wildlife Perspective. Journal of Environmental Management, vol. 104, Aug. 2012, pp. 19–34. https://doi.org/10.1016/j.jenvman.2012.03.021.

Forrest, S. A., *et al.* (2019).
Citizen Science Sampling Programs as a Technique for Monitoring Microplastic Pollution: Results, Lessons Learned and Recommendations for Working with Volunteers for Monitoring Plastic Pollution in Freshwater Ecosystems. Environmental Monitoring and Assessment, vol. 191, no. 3, Mar. 2019, p. 172. https://doi.org/10.1007/s10661-019-7297-3.

Geilfus, N. X., *et al.* (2019).
Distribution and Impacts of Microplastic Incorporation within Sea Ice. Marine Pollution Bulletin, vol. 145, Aug. 2019, pp. 463–73. https://doi.org/10.1016/j.marpolbul.2019.06.029.

Geyer, R., *et al.* (2017).
Production, Use, and Fate of All Plastics Ever Made. Science Advances, vol. 3, no. 7, July 2017, p. e1700782.
https://doi.org/10.1126/sciadv.1700782.

Hamilton, B. M., *et al.* (2023).
Plastics as a Carrier of Chemical Additives to the Arctic: Possibilities for Strategic Monitoring across the Circumpolar North. Arctic Science, vol. 9, no. 2, June 2023, pp. 284–96. https://doi.org/10.1139/as-2021-0055.

Inuit Circumpolar Council (2022).
Circumpolar Inuit Protocols for Equitable and Ethical Engagement, pp. 36. https://www.inuitcircumpolar.com/wp-content/uploads/EEE-Protocols-LR-WEB.pdf

Kala, K., and Nomesh, B. B. (2021).
Analysis of Citizen's Perception towards Segregation and Composting. Environment, Development and Sustainability, vol. 23, no. 7, July 2021, pp. 10763–86. https://doi.org/10.1007/s10668-020-01084-3.

Kerber, H., and Kramm, J. (2022).
From Laissez-Faire to Action? Exploring Perceptions of Plastic Pollution and Impetus for Action. Insights from Phu Quoc Island. Marine Policy, vol. 137, Mar. 2022, p. 104924. https://doi.org/10.1016/j.marpol.2021.104924.

Kiessling, T., *et al.* (2019).
Plastic Pirates Sample Litter at Rivers in Germany – Riverside Litter and Litter Sources Estimated by Schoolchildren. Environmental Pollution, vol. 245, Feb. 2019, pp. 545–57. https://doi.org/10.1016/j.envpol.2018.11.025.

Kiessling, T., *et al.* (2021).
Schoolchildren Discover Hotspots of Floating Plastic Litter in Rivers Using a Large-Scale Collaborative Approach. Science of The Total Environment, vol. 789, Oct. 2021, p. 147849. https://doi.org/10.1016/j.scitotenv.2021.147849.

Kilcoyne, J., *et al.* (2022).
Reducing Environmental Impacts of Marine Biotoxin Monitoring: A Laboratory Report. PLOS Sustainability and Transformation, edited by Semra Benzer, vol. 1, no. 3, Mar. 2022, p. e0000001. https://doi.org/10.1371/journal.pstr.0000001.

Kim, S. W., and An, Y. (2019).
Soil Microplastics Inhibit the Movement of Springtail Species. Environment International, vol. 126, May 2019, pp. 699–706. https://doi.org/10.1016/j.envint.2019.02.067.

Koelmans, A. A., *et al.*. (2015).
Nanoplastics in the Aquatic Environment. Critical Review. Marine Anthropogenic Litter, edited by Melanie Bergmann et al., Springer International Publishing, 2015, pp. 325–40. https://doi.org/10.1007/978-3-319-16510-3_12.

Koelmans, A. A., P. E., *et al.* (2022).
Risk Assessment of Microplastic Particles. Nature Reviews Materials, vol. 7, no. 2, Jan. 2022, pp. 138–52. https://doi.org/10.1038/s41578-021-00411-y.

Linnebjerg, J. F., *et al.* (2021).
Review of Plastic Pollution Policies of Arctic Countries in Relation to Seabirds. FACETS, vol. 6, no. 1, Jan. 2021, pp. 1–25. https://doi.org/10.1139/facets-2020-0052.

Locritani, M., *et al.* (2019).
Assessing the Citizen Science Approach as Tool to Increase Awareness on the Marine Litter Problem. Marine Pollution Bulletin, vol. 140, Mar. 2019, pp. 320–29. https://doi.org/10.1016/j.marpolbul.2019.01.023.

Lynch, S. (2018).
OpenLitterMap.Com – Open Data on Plastic Pollution with Blockchain Rewards (Littercoin). Open Geospatial Data, Software and Standards, vol. 3, no. 1, Dec. 2018, p. 6. https://doi.org/10.1186/s40965-018-0050-y.

Maes, T., *et al.* (2023).
A Little Less Conversation: How Existing Governance Can Strengthen the Future Global Plastics Treaty. Cambridge Prisms: Plastics, vol. 1, 2023, p. e22. https://doi.org/10.1017/plc.2023.22

Mamun, A. A., and Natcher, D. C. (2023).
The Promise and Pitfalls of Community-Based Monitoring with a Focus on Canadian Examples. Environmental Monitoring and Assessment, vol. 195, no. 4, Apr. 2023, p. 445. https://doi.org/10.1007/s10661-022-10841-y.

Mishra, S., *et al.* (2019).
Marine Microfiber Pollution: A Review on Present Status and Future Challenges. Marine Pollution Bulletin, vol. 140, Mar. 2019, pp. 188–97. https://doi.org/10.1016/j.marpolbul.2019.01.039.

MSFD Technical Group on Marine Litter, Galgani, F., *et al.* (2023).
Guidance on the Monitoring of Marine Litter in European Seas An update to improve the harmonised monitoring of marine litter under the Marine Strategy Framework Directive, EUR 31539 EN, Publications Office of the European Union, Luxembourg, 2023, ISBN 978-92-68-04093-5. https://publications.jrc.ec.europa.eu/repository/handle/JRC133594.

Zikali, N. M., *et al.* (2022).
Household Solid Waste Handling Practices and Recycling Value for Integrated Solid Waste Management in a Developing City in Zimbabwe. Scientific African, vol. 16, July 2022, p. e01150. https://doi.org/10.1016/j.sciaf.2022.e01150.

Nelms, S. E., *et al.* (2022).
The Role of Citizen Science in Addressing Plastic Pollution: Challenges and Opportunities. Environmental Science & Policy, vol. 128, Feb. 2022, pp. 14–23. https://doi.org/10.1016/j.envsci.2021.11.002.

OECD (2023a).
https://www.oecd.org/environment/plastics/increased-plastic-leakage-and-greenhouse-gas-emissions.htm *(accessed on 15 June 2023).*

OECD (2023b).
https://www.oecd.org/newsroom/plastic-pollution-is-growing-relentlessly-as-waste-management-and-recycling-fall-short.htm *(accessed on April, 2023).*

Otero, P., *et al.* (2021).
Twitter Data Analysis to Assess the Interest of Citizens on the Impact of Marine Plastic Pollution. Marine Pollution Bulletin, vol. 170, Sept. 2021, p. 112620. https://doi.org/10.1016/j.marpolbul.2021.112620.

Pierini, V. I., *et al.* (2021).
Waste Generation and Pro-Environmental Behaviors at Household Level: A Citizen Science Study in Buenos Aires (Argentina). Resources, Conservation and Recycling, vol. 170, July 2021, p. 105560. https://doi.org/10.1016/j.resconrec.2021.105560.

Popa, C. L., *et al.* (2022).
Role of Citizen Scientists in Environmental Plastic Litter Research—A Systematic Review. Sustainability, vol. 14, no. 20, Oct. 2022, p. 13265. https://doi.org/10.3390/su142013265.

Praet, E., *et al.* (2023).
Bottle with a Message: The Role of Story Writing as an Engagement Tool to Explore Children's Perceptions of Marine Plastic Litter. Marine Pollution Bulletin, vol. 186, Jan. 2023, p. 114457. https://doi.org/10.1016/j.marpolbul.2022.114457.

Provencher, J. F., *et al.* (2023).
Future Monitoring of Litter and Microplastics in the Arctic—Challenges, Opportunities, and Strategies. Arctic Science, vol. 9, no. 1, Mar. 2023, pp. 209–26. https://doi.org/10.1139/as-2022-0011.

Rantanen, M., *et al.* (2022).
The Arctic Has Warmed Nearly Four Times Faster than the Globe since 1979. Communications Earth & Environment, vol. 3, no. 1, Aug. 2022, pp. 1–10. www.nature.com, https://doi.org/10.1038/s43247-022-00498-3.

Rech, S., *et al.* (2015).
Sampling of Riverine Litter with Citizen Scientists — Findings and Recommendations. Environmental Monitoring and Assessment, vol. 187, no. 6, June 2015, p. 335. https://doi.org/10.1007/s10661-015-4473-y.

Réu, P., *et al.* (2019).
A 61% Lighter Cell Culture Dish to Reduce Plastic Waste. PLOS ONE, vol. 14, no. 4, Apr. 2019, p. e0216251.
https://doi.org/10.1371/journal.pone.0216251.

Rist, S., *et al.* (2018).
A Critical Perspective on Early Communications Concerning Human Health Aspects of Microplastics. Science of The Total Environment, vol. 626, June 2018, pp. 720–26. https://doi.org/10.1016/j.scitotenv.2018.01.092.

Rosenboom, J. G., *et al.* (2022).
Bioplastics for a Circular Economy. Nature Reviews Materials, vol. 7, no. 2, Jan. 2022, pp. 117–37.
https://doi.org/10.1038/s41578-021-00407-8.

Ross, P. S., *et al.* (2021).
Pervasive Distribution of Polyester Fibres in the Arctic Ocean Is Driven by Atlantic Inputs. Nature Communications, vol. 12, no. 1, Jan. 2021, p. 106. https://doi.org/10.1038/s41467-020-20347-1.

Royer, S. J., *et al.* (2018).
Production of Methane and Ethylene from Plastic in the Environment. PLOS ONE, vol. 13, no. 8, Aug. 2018, p. e0200574. https://doi.org/10.1371/journal.pone.0200574.

SAPEA. (2019).
A Scientific Perspective on Microplastics in Nature and Society. SAPEA, 2019. https://doi.org/10.26356/microplastics.

Sidorova, J. and Virla, D. (2022).
Community-Based Environmental Monitoring (CBEM) for Meaningful Incorporation of Indigenous and Local Knowledge Within the Context of the Canadian Northern Corridor Program. The School of Public Policy Publications, June 2022, p. Vol. 15 No. 1 (2022). https://doi.org/10.11575/SPPP.V15I1.73981.

Snekkevik, V. K., *et al.* (2023).
Miljøvennlige menstruasjonsprodukter i Osloskolene. Norsk institutt for vannforskning, 2023. niva.brage.unit.no,
https://niva.brage.unit.no/niva-xmlui/handle/11250/3050789.

UNEP 2021a.United Nations Environment Programme (2021).
Single-use menstrual products and their alternatives: Recommendations from Life Cycle Assessments.
https://www.lifecycleinitiative.org/wp-content/uploads/2021/07/UNEP-LCISingle-use-vs-reusable-Menstrual-Products-Meta-study.pdf

UNEP 2021b. United Nations Environment Programme (2021).
Understanding the State of the Ocean: A Global Manual on Measuring SDG 14.1.1, SDG 14.2.1 and SDG 14.5.1. Nairobi.
https://wedocs.unep.org/handle/20.500.11822/35086

UNEP 2021c. United Nations Environment Programme (2021).
*From Pollution to Solution: A global assessment of marine litter and plastic pollution. Nairobi. ISBN: 978-92-807-3881-0. Visual Feature | Pollution to Solution: Accessing marine litter and plastic pollution (*unep.org*)*

UNEP (2023).
Intergovernmental negotiating committee to develop an international legally binding instrument on plastic pollution, including in the marine environment. Revised draft text of the international legally binding instrument on plastic pollution, including in the marine environment. https://wedocs.unep.org/bitstream/handle/20.500.11822/44526/RevisedZeroDraftText.pdf *(accessed January 15, 2024)*

Urbina, M. A., *et al.* (2015).
Labs Should Cut Plastic Waste Too. Nature, vol. 528, no. 7583, Dec. 2015, pp. 479–479. https://doi.org/10.1038/528479c.

Villegas, P. J. (2018).
Challenges to Solve Our Plastic Waste Problems. International Journal of Organic & Medicinal Chemistry (2474-7610). 7. 1. 10.19080/OMCIJ.2018.07.555713.

Walker, T. (2022).
Communicating Threats and Potential Opportunities to Reduce Microplastic Pollution with Key Stakeholders. Microplastics, vol. 1, no. 2, June 2022, pp. 319–21. https://doi.org/10.3390/microplastics1020023.

Wichmann, C. *et al.* (2022).
Promoting Pro-Environmental Behavior through Citizen Science? A Case Study with Chilean Schoolchildren on Marine Plastic Pollution. Marine Policy, vol. 141, July 2022, p. 105035. https://doi.org/10.1016/j.marpol.2022.105035 .

World Economic Forum (2016).
*The New Plastics Economy. Rethinking the future of plastics. Report downloaded from: The New Plastics Economy: Rethinking the future of plastics | World Economic Forum (*weforum.org*), April 2023.*

WHO (2022).
Tobacco: poisoning our planet. ISBN 978-92-4-005128-7 (electronic version).
https://www.who.int/publications/i/item/9789240051287

Yarnell, P. and Gayton, D. (2003).
*Community-Based Ecosystem Monitoring in British Columbia [DesLibris e-Book]., FORREX, 2003. Canadian Electronic Library. Retrieved from Community-based ecosystem monitoring (*ecoreserves.bc.ca*) January 2024.*

Zettler, E. R., *et al.* (2017).
Incorporating Citizen Science to Study Plastics in the Environment. Analytical Methods, vol. 9, no. 9, 2017, pp. 1392–403. https://doi.org/10.1039/C6AY02716D.

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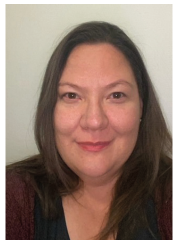

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Cornelya is a research scientist working at the interface of molecular ecology and conservation at the Norwegian Institute of Bioeconomy Research (Nibio), Norway. Her main research interests includes the use of genetic and genomic tools to address applied and basic conservation and eco-evolutionary questions in wildlife species. She holds a PhD and has completed Post Docs at several European research institutions.

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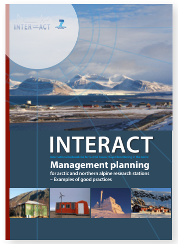
Emily Cowan
Emily's expertise in social and political sciences fits well with transdisciplinary research projects focusing on her favourite topics - plastics and arctic multi-level governance. She has a PhD on the UN plastic treaty negotiations and today works for SINTEF Ocean in Norway that conducts research and innovation related to the ocean space for national and international industries.

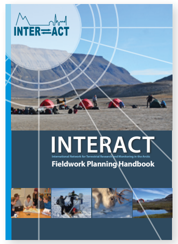
Photo: Klemens Weisleitner.

Other INTERACT books of relevance for reducing environmental impacts or arctic research. Available on www.eu-interact.org.



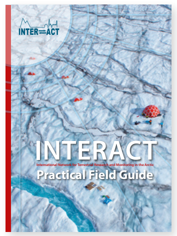
INTERACT Management Planning for Arctic and Northern Alpine Research Stations

Managing a research station in a cold and often remote environment is a complex operation requiring a broad set of skills. Research stations also operate under very different legal regimes, financial, environmental and climatic conditions, as well as remoteness, making it difficult to identify specific best practices that fit all stations. This handbook describes key issues that should be considered and addressed by station management, and it provides examples of good practices from stations operating under different conditions (e.g. different climate, remoteness or size).



INTERACT Fieldwork Planning Handbook

Fieldwork planning is key to safe, efficient and relevant science. INTERACT and APECS have jointly produced this handbook that covers all aspects of fieldwork from capturing the idea through the actual fieldwork to getting safely back home with samples and data to wrap up the project. A particular focus is put on all planning aspects until you venture into the field and safety aspects when working at INTERACT stations or in the field. We point out the most common challenges you need to prepare for in the field and outline important environmental considerations.



INTERACT Practical Field Guide

Working in cold environments under often challenging conditions necessitates attention to safety in the field. The INTERACT Practical Field Guide has been developed by INTERACT and APECS and contains information on best practices and safety aspects in relation to fieldwork in the Arctic. The book was developed as a handy tool to be used both during the preparation of fieldwork and particularly for use while in the field.

INTERACT Reducing CO_2 Emissions from Arctic Science

While many environmental impacts are systemic and thus beyond the control of the individual, there are numerous opportunities to reduce CO_2 emissions that are within the capacity of both institutions and researchers alike. This guidebook developed by INTERACT and APECS attempts both to summarize existing knowledge and to offer solutions for researchers who want to reduce CO_2 emissions related to their research activities.

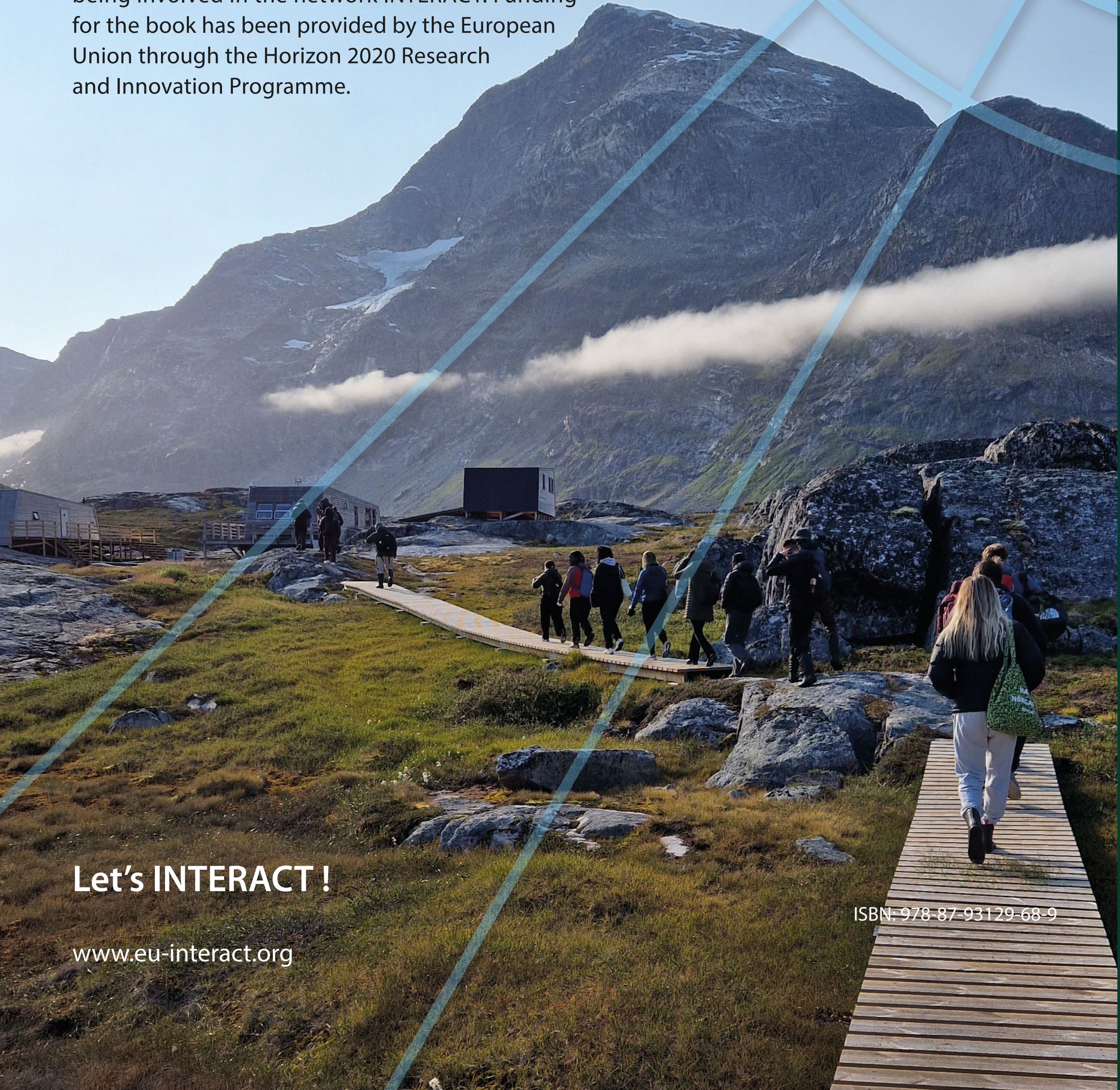
INTERACT Reducing the Environmental Impact of Arctic Fieldwork

All fieldwork comes with an environmental impact and scientist have a moral obligation to minimise this for ethical reasons and for ensuring pristine environments for future research. This guidebook provides advice on how scientists can conduct fieldwork with the least consequences for the environment. It contains chapters about general principles in relation to environmental awareness, transport, actions at research stations, actions in the field, and actions after the fieldwork.

Photo: Dorthe Dahl-Jensen.

The INTERACT Reducing Plastic Consumption and Pollution at Arctic Research Stations guidebook contain an introductory section on what plastic is, production and waste levels, how it impacts the environment and what is done internationally to regulate plastic consumption and waste. This is followed by thematic chapters focusing on how research station managers and scientists can reduce the environmental impacts of plastic use at and around research stations. The guidebook also includes a chapters on plastic monitoring and the importance of involving and raising awareness in arctic communities. Finally, the guidebook contains an extensive reference list, which can be used to go into more details with specific issues.

The guidebook is is based on input from the managers of arctic, alpine and northern boreal research stations being involved in the network INTERACT. Funding for the book has been provided by the European Union through the Horizon 2020 Research and Innovation Programme.



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