A novel framework for improving plastic management

- Modern society relies on plastics, but poor management of plastic waste has damaging environmental and societal consequences.
- To address waste mismanagement in Norway, scientists at the Climate and Environmental Research Institute NILU investigated the lifecycle of seven most used plastic polymers, from production to waste treatment.
- They recommend strategies that produce higher-quality recycled plastics, limit plastic production, lower consumption, and prevent plastic waste generation.
- Their framework can help authorities implement efficient systems for plastic waste reuse and recycling.

Plastics are integral to modern society. Since plastic mass production began in 1950, enough has been produced to generate a small plastic water bottle for every square metre of Earth's surface. Mismanagement of plastic waste means that it is now found in almost all environments on the planet. The low-cost, durable, and convenient nature of plastics makes them a primary source of pollution – including micro- and nanoplastics found in waterways, air pollution from plastic waste combustion, and greenhouse gas emissions produced during manufacturing. Many countries have recycling schemes to give plastics another life, but the plastic monomers that are the building blocks of plastic polymers have different properties, and mixing them creates low-quality recyclates (secondary plastics).

Dr Golnoush Abbasi and colleagues from the Climate and Environmental Research Institute NILU identified Norway as having one of the world's largest plastic waste production rates: 85kg per person, every year. Most waste is incinerated and not reused or recycled. By studying plastic use within Norway's industrial sectors, Abbasi's team have developed a framework to devise effective mitigation strategies for plastic waste management, which encourages a circular economy by increasing reuse and recycling.

Plastic building blocks

Most plastic polymers are chains of molecules and have a petroleum-based origin. Common polymers include polypropylene, low-density polyethylene, polyvinyl chloride, polystyrene, and polyethylene terephthalate. Sometimes packaging is labelled with the plastic type to help consumers recycle responsibly, but the challenge then lies in generating high-quality recyclates when different plastic polymers are mixed at plastic waste management facilities.

Plastics have a service life of between less than a year to up to 80 years, depending on use (for example, packaging and construction materials). Low-, medium-, and high-density polyethylene (LDPE/HDPE), polypropylene (PP), and polyethylene terephthalate (PET) are the most frequently manufactured polymers used in environmentally damaging single-use plastics, which are often not effectively managed. As of 2019, around 10% of all plastic produced worldwide was recycled, generating low-quality recycled products (such as plant pots and garden furniture) that are even harder to recycle.

Norway's recycling challenges

Limited knowledge about plastic types and chemical additives in plastic polymers, as well as lack of waste management capacities make reuse and recycling of plastics challenging. Only one quarter of the seven most common polymers are effectively recycled in Norway. Abbasi and colleagues investigated the major uses of plastics in nine

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By tracking plastic life cycles from production to disposal more effective waste management plans can be implemented.

industrial sectors. These included packaging, construction, agriculture, automotive, electronics, boats, clothing, household textiles, technical textiles and others (such as toys and furniture). They further classified these sectors into forty plastic product categories.

Material flow analysis (MFA) generated models which quantified plastic flow through society over time. Abbasi's team created an MFA model to highlight the stocks (plastic accumulated during use over time), flows (plastic moving over time), and sinks (end-of-life treatment) of the seven most common polymers used in Norway between 2000 and 2020 and their projected use until 2050.

The study revealed that plastic used in Norway has increased by 110% since 2000. It is predicted to rise by another 65% by 2050 if business continues as usual. Plastic waste generation could increase up to 90% in this timeframe, too. The researchers also found that plastic packaging contributes to 40% of the Norwegian plastic market, where 50% of plastic used is separately collected, but only 25% of waste is recycled. The rest is incinerated (50%), exported (15%), or landfilled (10%). These findings highlight two key points: recycling rates must increase, but demand for plastics also needs to decline.

Effective plastic waste management

The study led to recommendations for improving plastic waste management and increasing reuse and recycling of plastics. The recommendations include a reduction in the number of plastic polymers and chemical additives for each product type, and separate collection of plastic products by each industrial sector. In 2019, 460 million tonnes of plastic were produced worldwide, with predictions of manufacturing output to double in the next two decades. By understanding the flows of plastic in society and how different industrial sectors can reuse polymers, waste can be reduced, extended producer responsibility promoted, and a circular economy business model created. Appropriate management of plastic waste is essential if we are to achieve a more sustainable and environmentally conscious society.

50% of plastic used in Norway is separately collected, but only 25% of waste is recycled.

Circular strategies for plastic management

A circular economy allows plastics to stay in closed loops within an industrial sector, preventing cross-contamination with other industries. This improves recyclate quality and ensures it remains suitable for future use. It also increases the sustainability of plastic by reducing demands on primary raw materials.

Abbasi and colleagues recommend targeting individual polymer types by industrial sector, rather than plastic in general, to allow industries to concentrate waste management efforts on the product categories which generate the largest volumes of plastic waste (such as packaging). The researchers also highlight that targeted recycling rates for product category encourage better tracking of industrial plastic waste by ensuring that the same plastic polymers are recycled together. In addition, improved reporting on plastic product composition and monitoring of plastic waste would allow tracking and management of chemical additives that are added to plastic products to enhance some characteristics such as colour, plasticity, or durability.

By tracking plastic life cycles from production to disposal, more effective waste management plans can be implemented to reduce plastic pollution and reliance on virgin plastic. To meet European Commission targets by 2030, Norway must increase its 2020 recycling capacity by 120%. Ultimately, taking action to develop effective plastic waste management strategies will conserve natural resources, reduce carbon emissions, generate more sustainable industrial sectors, and create a shared goal to improve plastic polymer reuse and recycling in Norway.

Abbasi and colleagues conclude, 'By establishing inventories of polymer types for different product categories and each industrial sector, we can implement circular strategies to keep plastics in a closed-loop, limit production, lower consumption, and prevent waste generation. This study provides an effective framework for reporting and monitoring plastic waste generation that can be adopted at a global scale. The outcome of this study offers guidance for authorities to facilitate effective planning for reducing plastic production and increase plastic waste recycling.'

Personal response

What inspired you to conduct research into Norway's recycling problem?

The global problem of plastic waste pollution urges action at national and regional scales. To devise a proper action plan, we need a comprehensive and systematic understanding of the problem. Norway has one of the highest rates of plastic waste generation per capita in the world. Today, only a small fraction of all waste generated in Norway is effectively collected or recycled. We wanted to implement a data and modelling framework providing the necessary knowledge to define the best strategies to reduce the production and waste generation of plastics in Norway and globally. The framework developed for Norway in this study is one of the few 'best practice' case studies in the world. This therefore provides a good basis to develop guidelines on how to track and map plastic flows, which will be required under future UN plastic treaties. This work could be repeated for any other country that reports plastic production and trade.

Did any of your findings surprise you?

Yes! Firstly, the low rate of recycling in Norway. The higher recycling rate in certain sectors, such as PET bottles, agriculture or automotive, indicates that closed loop recycling within polymer-product applications is a good alternative. We were also surprised to learn about the low quality of reported data on waste, which seriously hinders any kind of thorough analysis of the system and assessment of strategies and actions.

Your framework to set up inventories of polymer types will allow appropriate management of plastic use. What action needs to be taken now to implement this framework in the industrial sector in Norway?

- Increase requirements on reporting of waste collection (more accurate data on plastic waste composition).
- With improved knowledge on what ends up in waste streams, an extended producer responsibility scheme should be deployed, to connect producers with actual waste generated.
- Increase regulatory obligations on use of recycled raw material in plastic products.
- Increase regulatory obligations on collection and processing plastic waste to improve quality and quantity of recyclates.

This framework can be used as a guideline to design an effective extended producer responsibility scheme, so that the cost of waste management of each polymer from each industrial sector will be levied on specific producers. This can incentivise industries to finance the cost of treatment of their waste, and invest in new technology to recycle and reuse their polymer products.

What research would you like to conduct next to further this field?

Looking into chemical additives' flows within plastic products for regulatory purposes to minimise the potential risks to human health and environment. We are also interested in the socio-economic aspects of plastic waste management practices and the impact of system changes for future generations.

Details

e: goa@nilu.no **t:** +47 63 89 82 94
Plastcycle project website: plastcycle.nilu.no/

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Collaborators

- Marina Hauser
- Cornelis Peter Baldé
- Evert A Bouman
- Miguel Las Heras Hernández

Bio

Golnoush Abbasi is a senior scientist at the department of Environmental Impacts and Sustainability at NILU and the project leader of Plastcycle. Her research focuses on the interface of science and policy towards the Green Transition.

Further reading

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